TM 9-1659

WAR DEPARTMENT TECHNICAL MANUAL

ORDNANCE MAINTENANCE

DIRECTORS M5, M5A1, AND M6

RESTRICTED DISSEMINATION OF RESTRICTED MATTER—
The information contained in restricted documents and the essential characteristics of restricted materiel may be given to any person known to be in the service of the United States and to persons of undoubted loyalty and discretion who are cooperating in Government work, but will not be communicated to the public or to the press except by authorized military public relations agencies. (See also paragraph 23, AR 380-5, 15 March 1944.)

WAR DEPARTMENT • *8 MAY 1944*

FOR ORDNANCE PERSONNEL ONLY

WAR DEPARTMENT TECHNICAL MANUAL

TM 9-1659

This Technical Manual supersedes TM 9-1659, dated 7 November 1942, Changes No. 1, dated 31 March 1943, and Changes No. 2, dated 24 September 1943; TB 1659-2, dated 30 June 1943; and OS 9-58, dated December 1942.

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WAR DEPARTMENT
Washington 25, D. C., 8 May 1944

TM 9-1659, Ordnance Maintenance: Directors M5, M5A1, and M6, is published for the information and guidance of all concerned.

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BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
J. A. ULIO,
Major General,
The Adjutant General.

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T/O & E 44-127, Btry, AAA A-Wpns Bn (S-M)

(For explanation of symbols, see FM 21-6.)

CONTENTS

ORDNANCE MAINTENANCE – DIRECTORS M5, M5A1, AND M6

This Technical Manual supersedes TM 9-1659, dated 7 November 1942, Changes No. 1, dated 31 March 1943, and Changes No. 2, dated 24 September 1943; TB 1659-2, dated 30 June 1943; and OS 9-58, dated December 1942.

Section I

INTRODUCTION

1. PURPOSE.

a. This Technical Manual is published for the information and guidance of ordnance maintenance personnel. It contains detailed instructions for inspection, disassembly, assembly, maintenance, and repair of the Directors M5, M5A1, and M6, supplementary to those in the Field Manuals and Technical Manuals prepared for the using arms. Additional descriptive matter and illustrations are included to aid in providing a complete working knowledge of the materiel.

b. This manual is supplementary to TM 9-659, which should be consulted for information on operation, adjustment, and maintenance normally performed by the using arms.

c. This manual differs from TM 9-1659, dated 7 November 1942, chiefly in the addition of the Director M5A1.

2. SCOPE.

a. The operations described in this manual may be performed by authorized ordnance personnel only, except as authorized in subparagraph **b**, below.

b. In general, battery operating personnel are limited to adjustments, repairs, and maintenance of directors and similar intricate materiel which can be performed with facilities available and which do not require access to the interior of the instrument through removal of cover plates. Adjustments, repairs, and maintenance which require removal of the cover plates may be performed by local personnel, either of the using arms or of the Ordnance Department, who have been qualified for this work either through the successful accomplishment of a recognized course of instruction in director maintenance, or through adequate experience in the type of operation to be undertaken. A recognized course of instruction is defined as one having the approval of the Chief of Ordnance and The Commanding General, Army Ground Forces, for qualification in director repair (subpar. **c**, below). Determination of adequate experience will be made in each case by the responsible ordnance officer. The responsible ordnance officer will take necessary action for maintenance requiring facilities beyond those available locally.

c. Personnel possessing certificates of successful accomplishment of any of the following courses of instruction are authorized to perform routine maintenance and servicing of antiaircraft directors:

INTRODUCTION

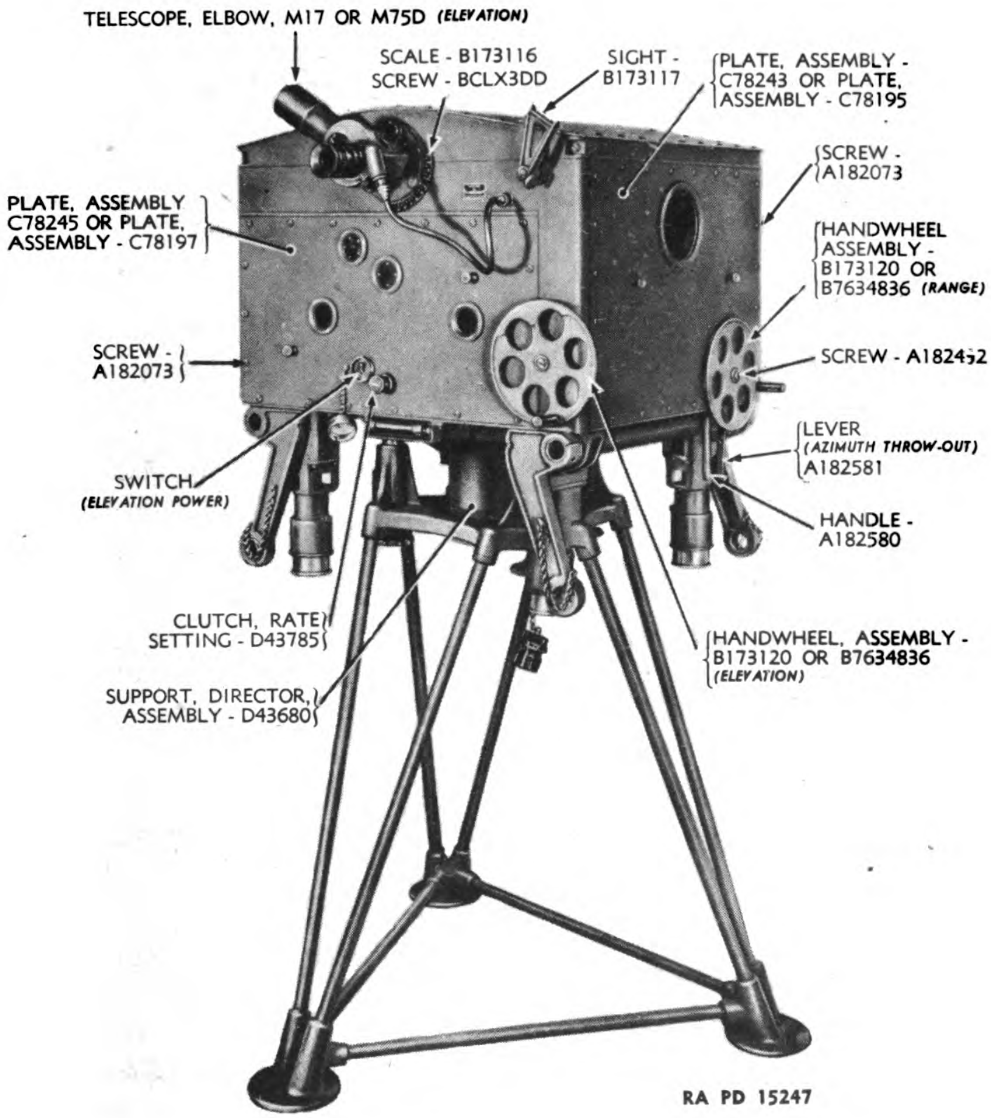

Figure 1 — Director M5, M5A1, or M6 — Rear Left View

(1) Antiaircraft Fire Control Course, Enlisted Specialists' Division, The Coast Artillery School.

(2) Instruction course in director repair at the Ordnance School.

(3) Director Maintenance Course conducted at place of manufacture of Directors M5, M5A1, or M6.

3. CHARACTERISTICS.

a. The directors are used to direct fire on aerial targets and mechanized ground targets, particularly on low flying airplanes and dive bombers which fly within the minimum effective range of large antiaircraft guns.

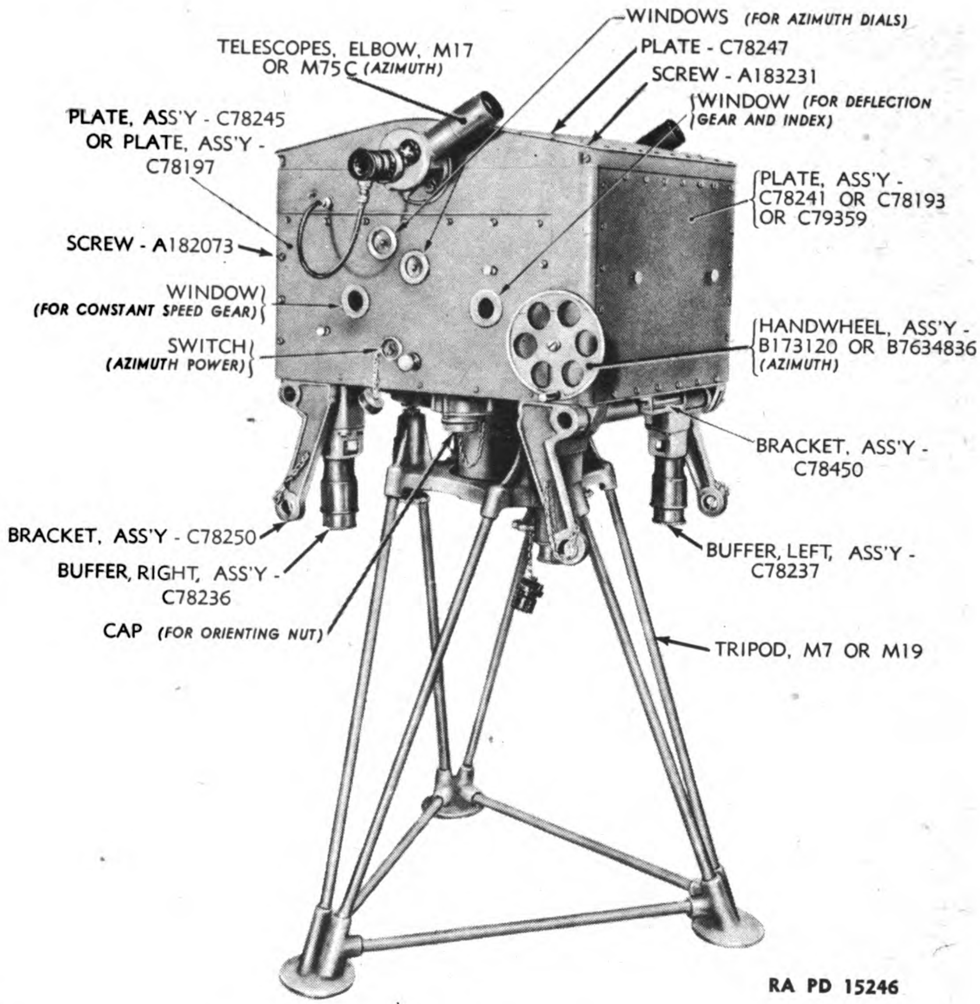

Figure 2 — Director M5, M5A1, or M6 — Right Front View

b. Each director includes two elbow telescopes. One telescope is used for tracking in azimuth, the other in elevation, but both are always parallel and sight the same target.

c. The director itself is operated by a crew of three men. The man in charge selects the target and sets in the range. One man tracks the target in azimuth and a third man tracks the target in elevation, using identical telescopes and hand controls. The director calculates the gun position mechanically and transmits this information electrically to the gun control mechanism.

4. DIFFERENCES AMONG MODELS.

a. Directors M5 and M6 are identical in mechanical detail, theory, and operation, the only difference being in certain electrical components. Director M5 operates on a 115-volt, 60-cycle power supply (American standard); while the M6 operates on a 50-volt, 50-cycle power supply (British standard). This necessitates the use of different output transmitters, lighting transformers, and fuses (when fuses are used). Both directors use the same type of dual-voltage motors, which can be connected for either power supply.

b. Director M5A1 operates on the same principle and the same power supply as Director M5, but its variable speed mechanism runs at a higher speed and transmits more torque, which eliminates the necessity for the torque amplifier unit. Maintenance of this model is therefore simpler. This model has also an additional elevation transmitter which permits self-synchronization with the gun when used with Remote Control System M9 or M10.

c. Director M5A1 may be distinguished from the M5 or by looking in the left-hand window of either side cover plate. The M5A1 has an indicator dial bearing the number "M5A1," while the M5 has an open worm gear at this point (figs. 3 and 4).

d. Most of the description and instructions in this manual apply to all three models and may be assumed to apply unless specific reference is made to particular models.

5. APPLICATION.

a. Director M5 is used with the 37-mm AA Gun Carriage M3A1 equipped with Remote Control System M1, or with the 40-mm AA Gun Carriage M2 equipped with Remote Control System M5. These systems are not self-synchronous. Power is supplied by Generating Unit M5 *adjusted to give 115-volt, 60-cycle supply* at the director.

b. Director M5A1 is used with the 37-mm AA Gun Carriage M3A1 equipped with Remote Control System M9, or with the 40-mm AA Gun Carriage M2 or M2A1 equipped with Remote Control System M10. Power is supplied by Generating Unit M5 *adjusted to give 115-volt, 60-cycle supply* at the director.

c. Director M5A1 may also be used with Remote Control Systems M1 and M5, and Director M5 may be used with Remote Control Systems M9 and M10, but fully self-synchronous operation of the gun can be obtained only with both Director M5A1 and Remote Control System M9 or M10.

d. Director M6 is used with the 37-mm AA Gun Carriage M3A1 and Remote Control System M4, or with the 40-mm AA Gun Carriage M1 and Remote Control System M3. These systems are not self-synchronous. Power is supplied by Generating Unit M5 *adjusted for 130-volt, 50-cycle supply,* which is reduced in a junction box transformer to 50 volts, 50 cycles at the director.

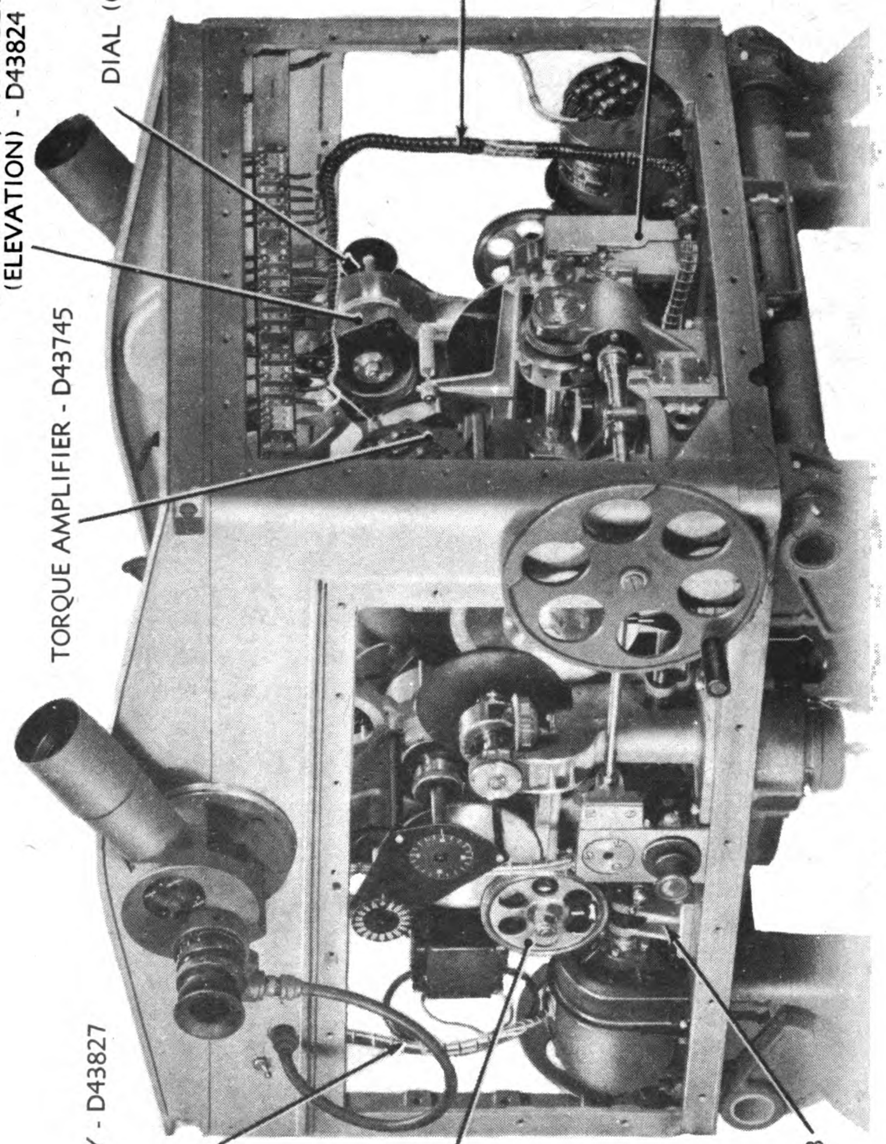

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Figure 3 — Director M5 or M6, Showing Important Parts Not Found on Director M5A1 — Right Front View

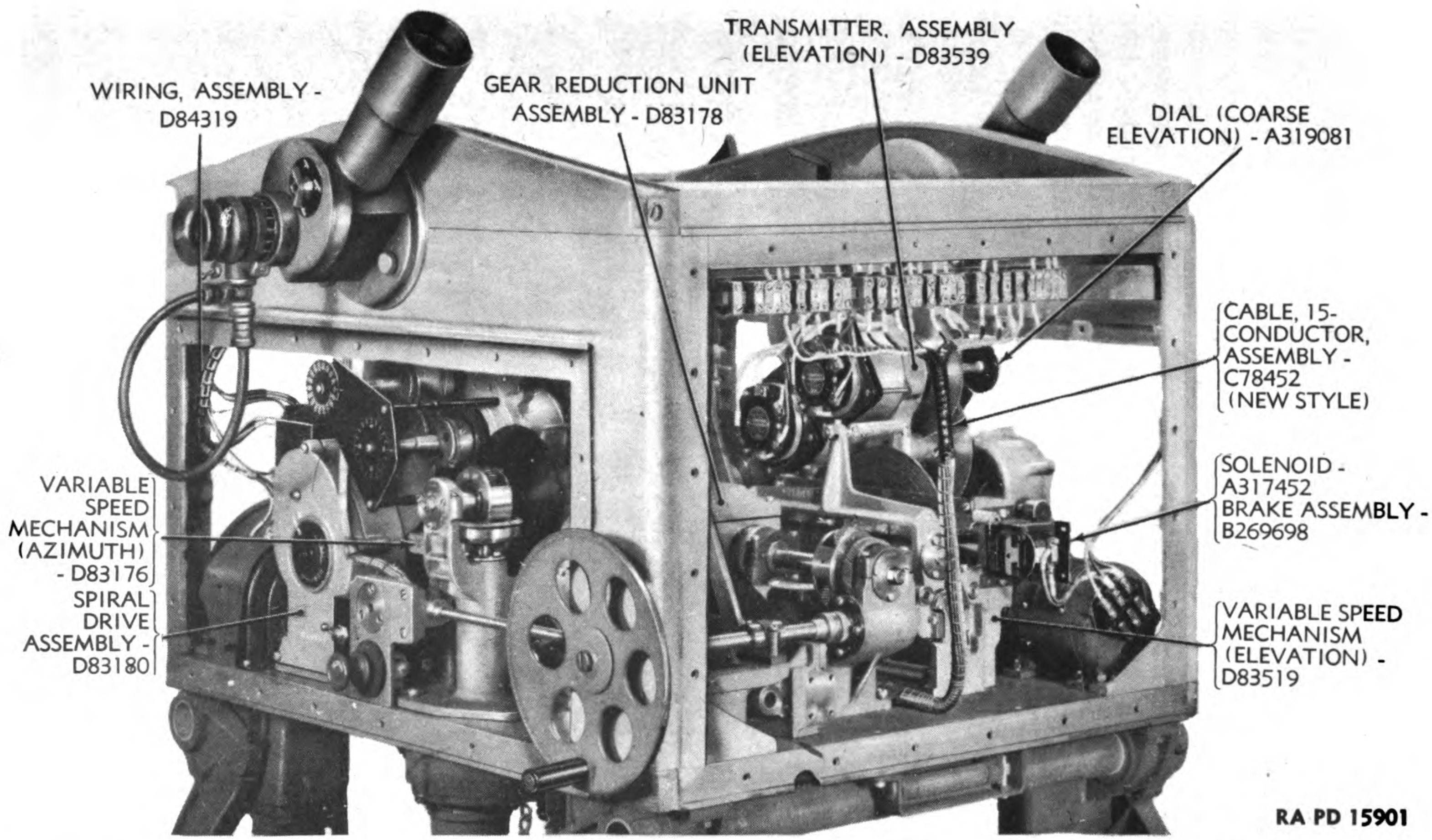


Figure 4 — Director M5A1, Showing Important Parts Not Found on Directors M5 and M6 — Right Front View

6. DATA.

a. Directors M5, M5A1, and M6, calculate and transmit to the gun two elements of firing position, namely quadrant elevation and firing azimuth. The data introduced into the instruments are the rates of angular travel of the target in elevation and in azimuth (supplied by visual tracking in elevation and azimuth) the present angular position in elevation and azimuth (supplied by position of the telescope at any instant) and the slant range or approximate distance in yards to the target (supplied by estimate or observation of tracer fire). No fuze data is required because the ammunition is fuzed with a point-detonating superquick fuze. Any nonstandard ballistic conditions are corrected in the range setting and by slight alterations in tracking.

b. The directors (all three models) operate within the following limits:

Azimuth position	No limits to position or number of turns
Elevation of telescopes:	
Electrical limits	Minus 5 deg to plus 85 deg
Mechanical stops	Minus 10 deg to plus 92 deg
Maximum angular rate of tracking in azimuth or elevation	20 deg per sec
Range (effective):	
37-mm (muzzle velocity—2,600 ft per sec)	400 to 2,600 yd
40-mm (muzzle velocity—2,750 ft per sec)	400 to 2,800 yd
Electric supply required:	
M5 and M5A1	115 volts, 60 cycles
M6	50 volts, 50 cycles
Weight, less tripod (approx)	480 lb
Weight, in packing chest (approx)	690 lb
Dimensions, in packing chest	48 x 36½ x 38 in.
Distance between telescope centers	29⅜ in.

Section II

DESCRIPTION

7. PRINCIPLE OF OPERATION AND FLOW OF DATA.

a. The purpose of a director is to compute the firing direction of a gun so that it will hit a rapidly moving target. This firing direction is divided into its elevation above horizontal and its azimuth angle. It differs from the observed direction of the *target* by an amount known as the lead angle, which depends on how far the target will travel before the projectile reaches it. The lead angle may in turn be divided into a *vertical deflection* angle and a *lateral deflection* angle, each of which varies with the *speed* of the target (in elevation or azimuth) and the *time* for the projectile to reach it.[1] Each angle is computed by a separate mechanism.

b. In the director, there are two separate mechanisms, one for azimuth and one for elevation, each of which operates as follows (see schematic diagram fig. 5):

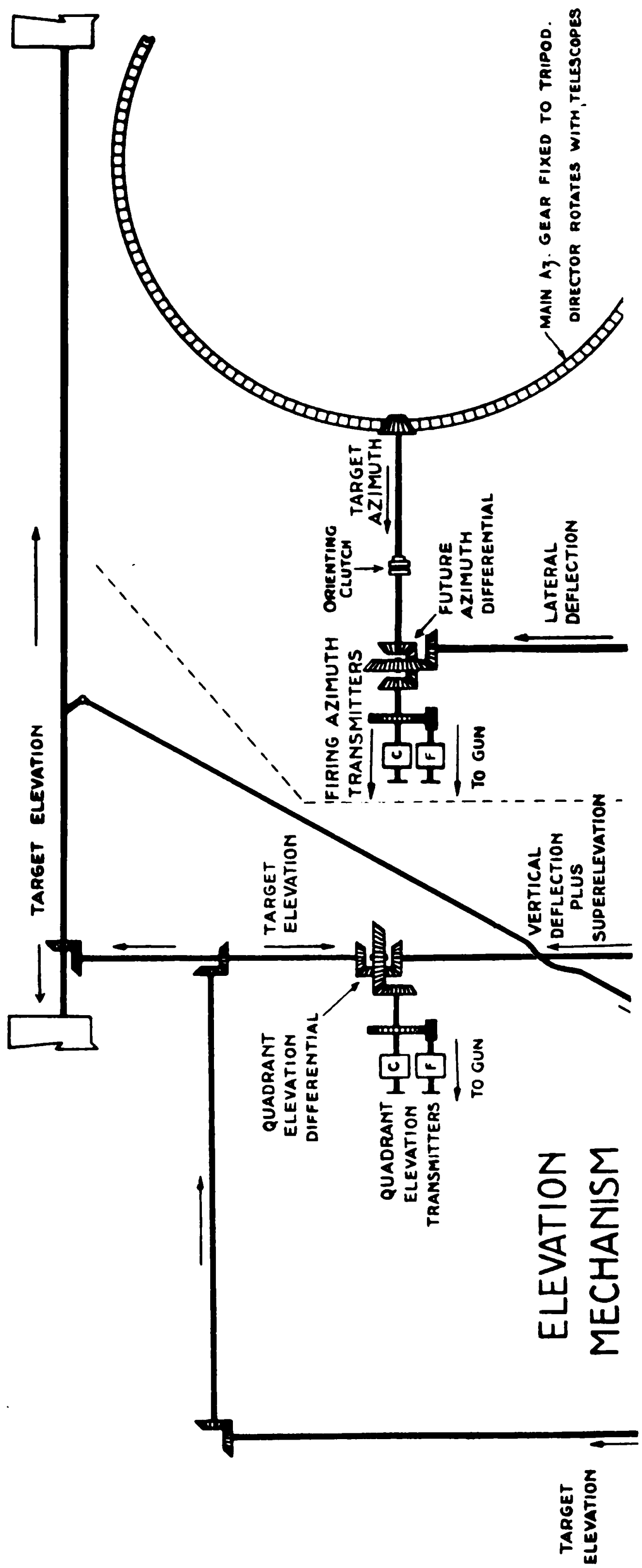
(1) A variable-speed mechanism drives the telescopes in elevation or azimuth, controlled by the tracker to follow the target. The main body of the director moves with the telescopes in azimuth. Each variable-speed mechanism consists of a constant-speed smooth disk which faces the side of a cylindrical roller and drives it through two rotating balls which may be moved outward from the center of the disk to increase smoothly the speed of the roller (fig. 25). The angular travel of the telescopes (and the target) at any instant is indicated by the manually controlled position of these balls. This, then, is one of the elements of the deflection angle (either azimuth or elevation, as the case may be).

(2) The element of time may be expressed in a distance of yards to the target and is estimated by the range setter. The action of the *multiplying mechanisms* connected to the range handwheel is shown in figure 25. The range setting changes the fulcrum of the slotted link so that any movement of the bar assembly carrying the balls of the variable-speed mechanism is *multiplied* in its effect on the crank at the top. The crank actuates the future azimuth (or quadrant elevation) differential so as to keep the gun-positioning transmitter leading the director telescopes in azimuth or elevation. The time element represented by the ratio of the angular travel of the telescopes to the desired deflection is determined by the fulcrum.

c. In addition to the vertical deflection angle, the gun must be elevated to allow for the effect of gravity on the projectile. This *superelevation* angle depends on the target elevation and also on time or range. Therefore, a cam or eccentric connected to the telescopes displaces the bar of the elevation variable sped mechanism slightly from the actual ball position (fig. 40), and this additional factor is automatically multiplied by the time factor in the *elevation* multiplier.

d. Besides changing the angular *rate* at which the telescopes are driven, the trackers' handwheels actually move them in the required direction momentarily. This is known as aided tracking, and helps

[1]Correction for curving path of the projectile must also be introduced by the director and constitutes another factor in the deflection and vertical angles (subpar. c, below).


MAIN Az. GEAR FIXED TO TRIPOD.
DIRECTOR ROTATES WITH TELESCOPES
TARGET AZIMUTH
ORIENTING CLUTCH
FUTURE AZIMUTH DIFFERENTIAL
LATERAL DEFLECTION
FIRING AZIMUTH TRANSMITTERS
C
F
TO GUN
TARGET ELEVATION
TARGET ELEVATION
VERTICAL DEFLECTION PLUS SUPERELEVATION
QUADRANT ELEVATION DIFFERENTIAL
C
F
TO GUN
QUADRANT ELEVATION TRANSMITTERS
ELEVATION MECHANISM
TARGET ELEVATION

DESCRIPTION

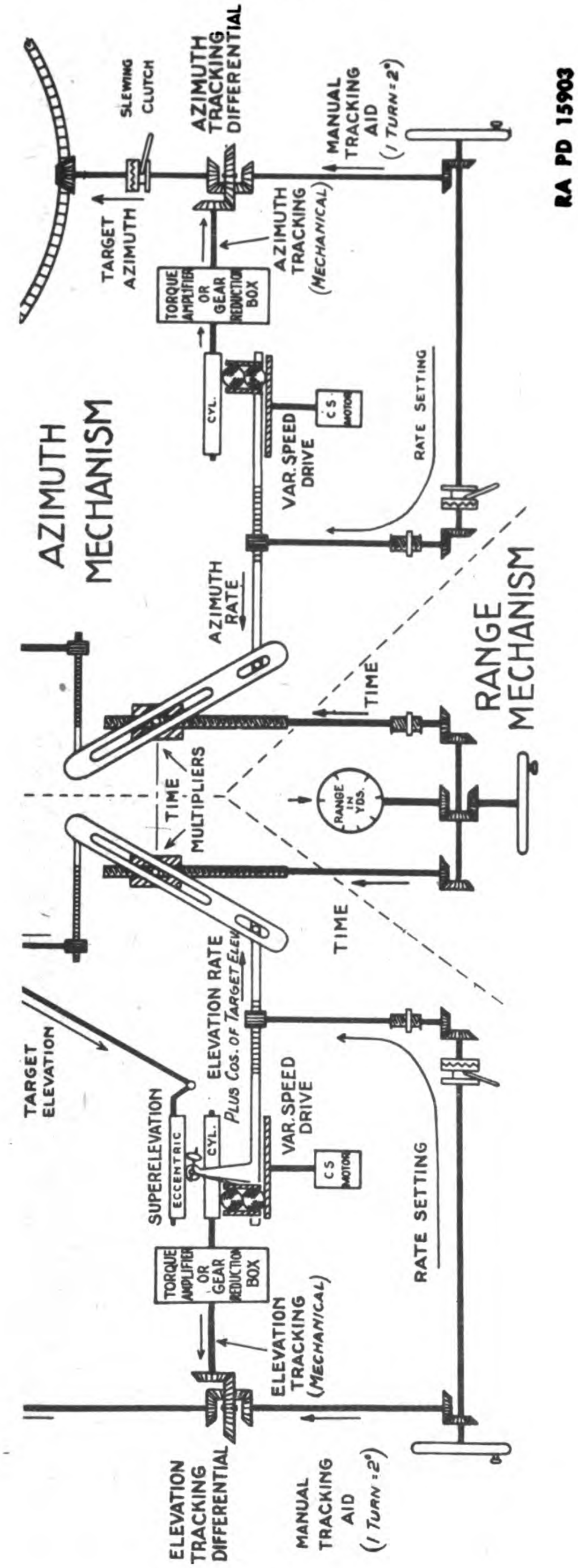
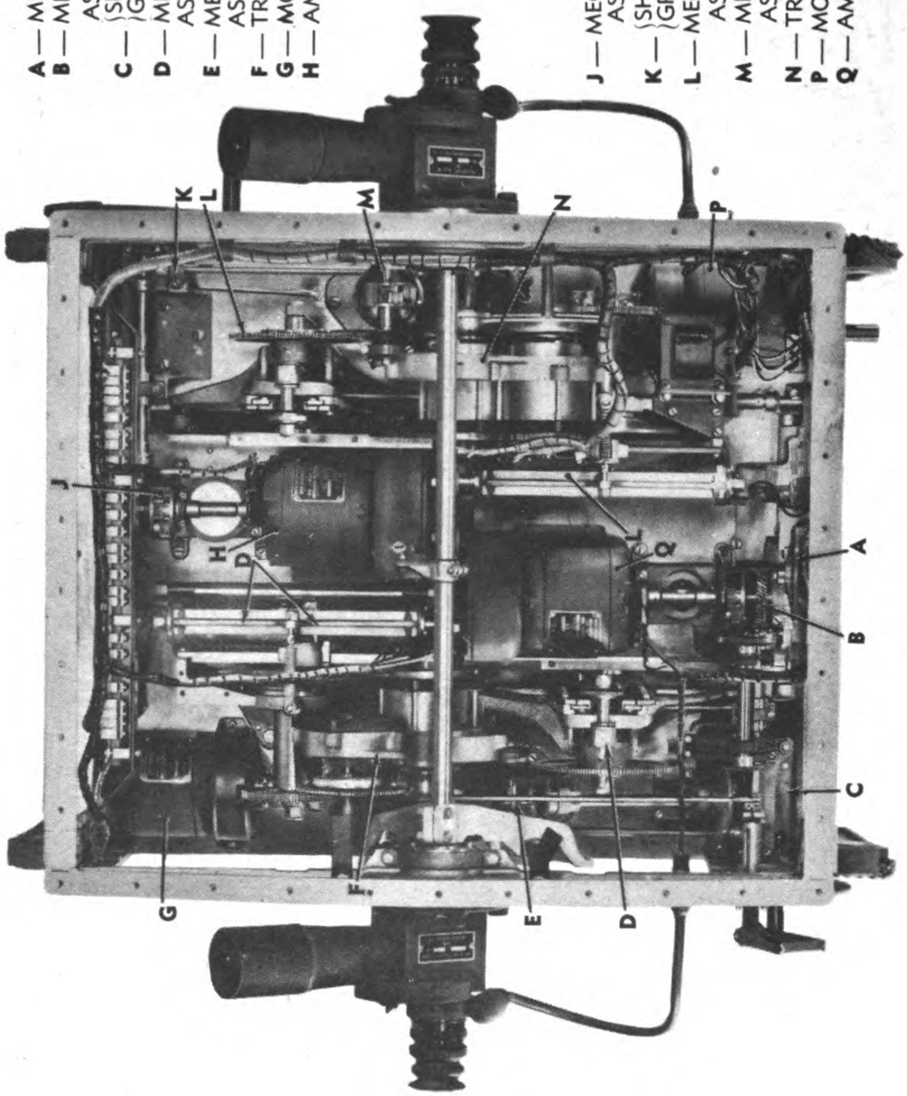


Figure 5 — Schematic Diagram — Flow of Data



A — MECHANISM, RANGE, ASSEMBLY - D43789
B — MECHANISM, ELEVATION TRACKING ASSEMBLY - D43775
C — SHAFT, ELEVATION DIFFERENTIAL DRIVE, GROUP ASSEMBLY - D43779
D — MECHANISM, VERTICAL DEFLECTION, ASSEMBLY - D43767
E — MECHANISM, QUADRANT ELEVATION, ASSEMBLY - D43783
F — TRANSMITTER, ELEVATION, ASSEMBLY - D43824
G — MOTOR, ASSEMBLY (CONSTANT SPEED) - C78432
H — AMPLIFIER TORQUE, ASSEMBLY - D43745

J — MECHANISM, AZIMUTH TRACKING, ASSEMBLY - D43772
K — SHAFT, AZIMUTH DIFFERENTIAL DRIVE, GROUP ASSEMBLY - D43778
L — MECHANISM, LATERAL DEFLECTION, ASSEMBLY - D43758
M — MECHANISM, FUTURE AZIMUTH, ASSEMBLY - D43780
N — TRANSMITTER, AZIMUTH ASSEMBLY - D43821
P — MOTOR, ASSEMBLY (CONSTANT SPEED) - C78432
Q — AMPLIFIER, TORQUE, ASSEMBLY - D43745

RA PD 15261

Figure 6 — Director M5 or M6, Showing Symmetrical Lay-out of Azimuth and Elevation Units — Top View

A — MECHANISM, RANGE, ASSEMBLY - D43789
B — MECHANISM, ELEVATION TRACKING, ASSEMBLY - D43775
C — SHAFT, ELEVATION DIFFERENTIAL DRIVE, GROUP ASSEMBLY - D43779
D — MECHANISM, VERTICAL DEFLECTION, ASSEMBLY - D83412
E — MECHANISM, QUADRANT ELEVATION, ASSEMBLY - D43783
F — TRANSMITTER, ELEVATION, ASSEMBLY - D83539
G — DRIVE, SPIRAL, ASSEMBLY - D83180
H — MOTOR, ASSEMBLY (CONSTANT SPEED) - C78432
J — MECHANISM, AZIMUTH TRACKING ASSEMBLY - D43772
K — GEAR REDUCTION UNIT, ASSEMBLY - D83178
L — SHAFT, AZIMUTH DIFFERENTIAL DRIVE, GROUP ASSEMBLY - D43778
M — MECHANISM, LATERAL DEFLECTION, ASSEMBLY - D83410
N — MECHANISM, FUTURE AZIMUTH, ASSEMBLY - D43780
P — TRANSMITTER, AZIMUTH, ASSEMBLY - D43821
Q — DRIVE, SPIRAL, ASSEMBLY - D83180
R — MOTOR, ASSEMBLY (CONSTANT SPEED) - C78432
S — GEAR REDUCTION UNIT, ASSEMBLY - D83178

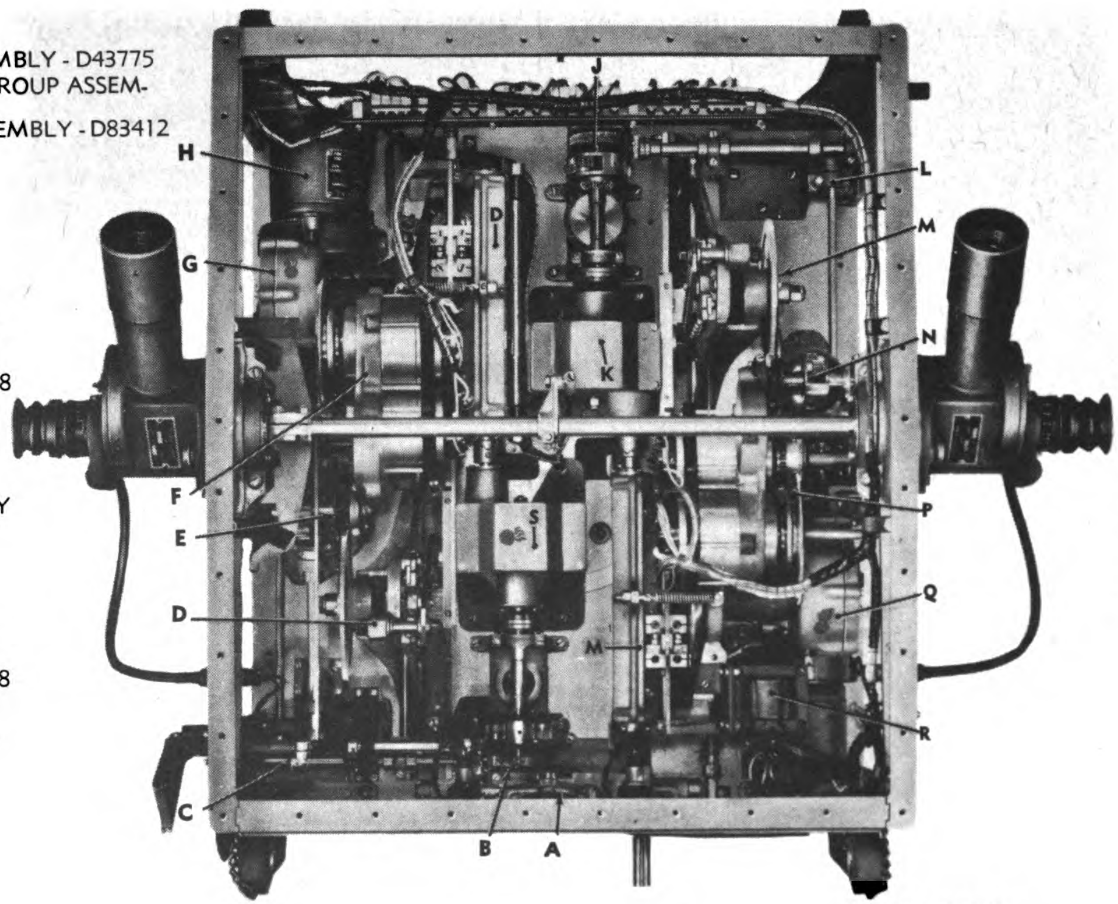


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Figure 7 — Director M5A1, Showing Symmetrical Lay-out of Azimuth and Elevation Units — Top View

to get on a target quickly without overcontrolling. This manual movement is added to the mechanical drive through the azimuth and elevation tracking differentials. Clutches are also provided to disconnect and lock the variable-speed mechanism controls so that the telescopes may be positioned by hand when desired.

8. GENERAL ARRANGEMENT OF DIRECTOR PARTS.

a. To facilitate description, the director may be divided into the following groups: the case and support assembly, the azimuth mechanism, the elevation mechanism, the range mechanism, the buffers and carrying brackets, the electrical components, the tripod, the telescopes, and the accessories.

b. The azimuth, elevation, and range mechanisms constitute the working components of the director. They are supported by and housed in the case. The electrical components drive the variable-speed mechanisms, transmit the firing data to the gun, and provide illumination. The director is supported by the tripod when in use, or is carried and supported by the buffers and carrying brackets when in transportation. Two carrying bars are provided for lifting the director from its shipping box and for carrying it short distances by hand.

c. The azimuth and elevation mechanisms are similar, several of the units being identical.

9. CASE.

a. The case includes the base casting, frames, tie bars, and the cover plates which form the sides and top of the case (fig. 8).

10. SUPPORT ASSEMBLY.

a. The support assembly D43680 rests on the tripod and supports the director (fig. 9). It contains the ball bearings in which the director rotates, the stationary main azimuth gear, and the contact ring and brush arrangement which permits rotation of the director without injury to the transmission cable.

b. Support and Body Assembly. This is the inner or rotating member of the support assembly. The two large ball bearings which carry the director are pressed onto its outside diameter. It is bolted to the director base (fig. 9). The support contains the contact body consisting of fifteen electrical contact rings in an insulating cylinder. Terminals on the outside of this body are numbered and are accessible through openings in the support.

c. Housing Assembly C78346. This is the outer or stationary member of the support assembly (fig. 9). It has sockets for the

DESCRIPTION

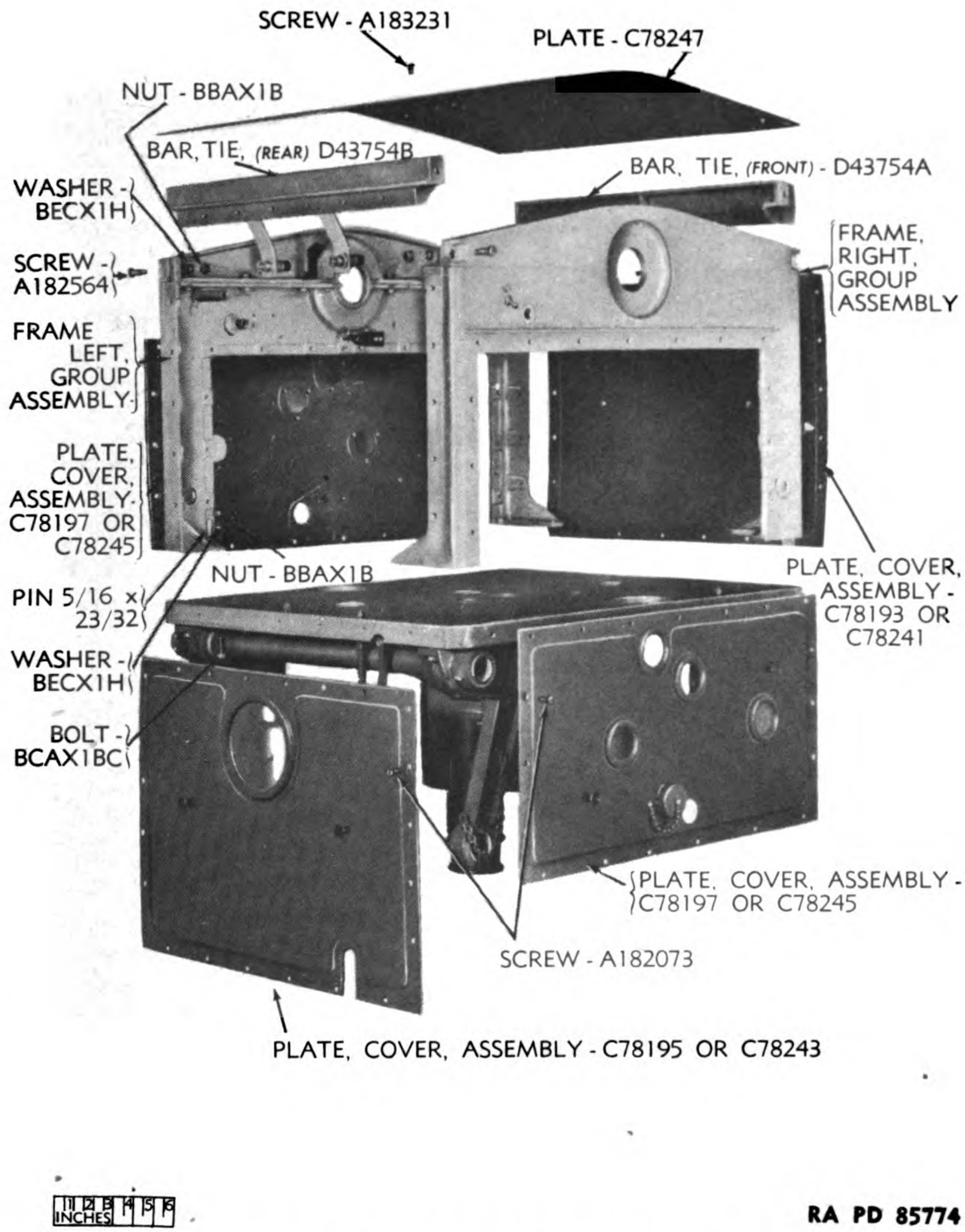

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Figure 8 — Base Assembly and Other Parts Which Make Up the Case

tripod plungers. It encloses the support and body assembly. It also carries the stationary azimuth gear and the brush support assembly. A rectangular cover permits access to the contact body terminals and a smaller cover gives access to the bolts which hold the support to the base.

d. Brush Support Assembly C78344. This is the group of 15 stationary contact brushes which contact the inside of the rings in the

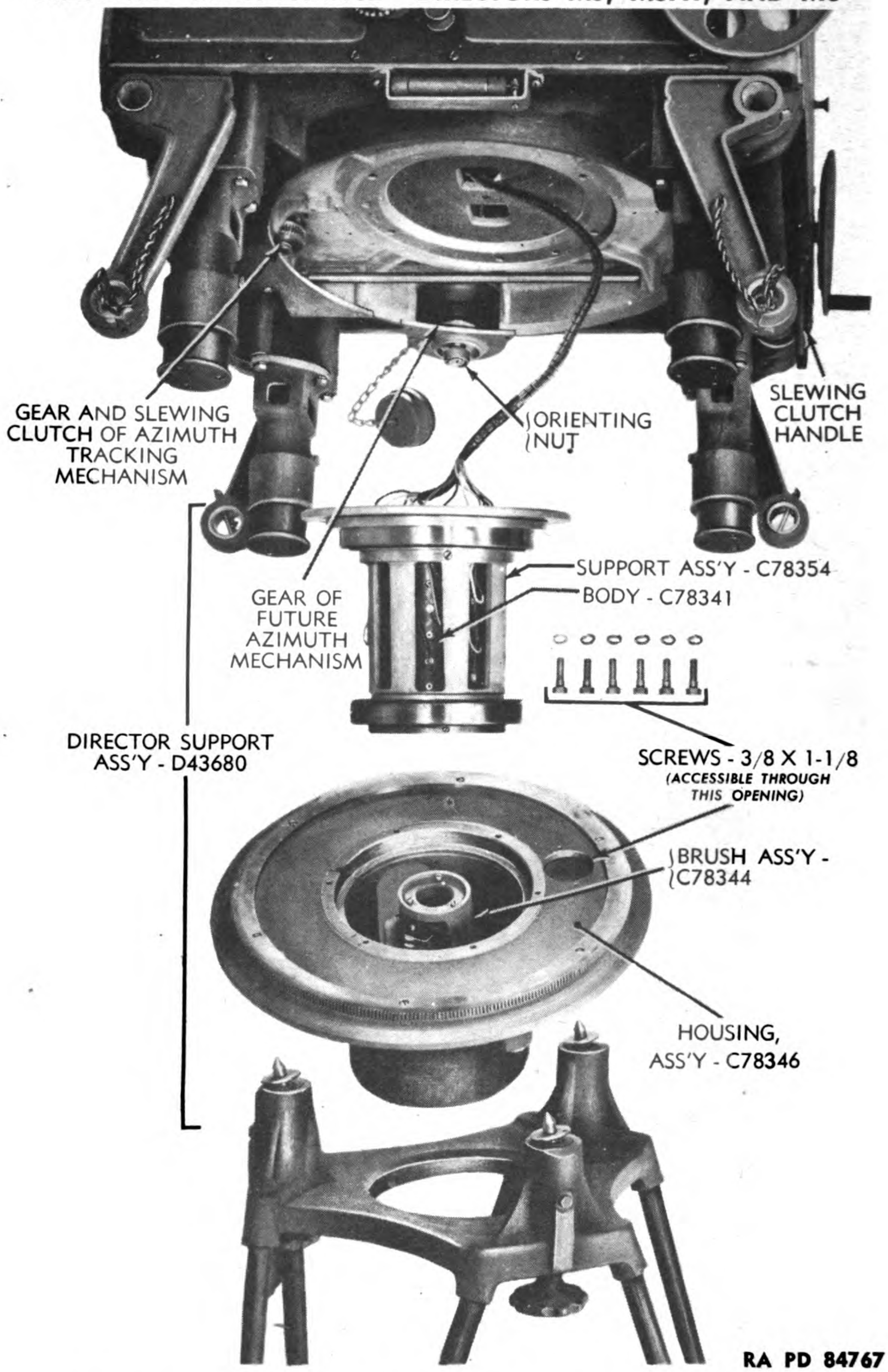

Figure 9 — Support Assembly Exploded, Showing How Director Base Is Supported

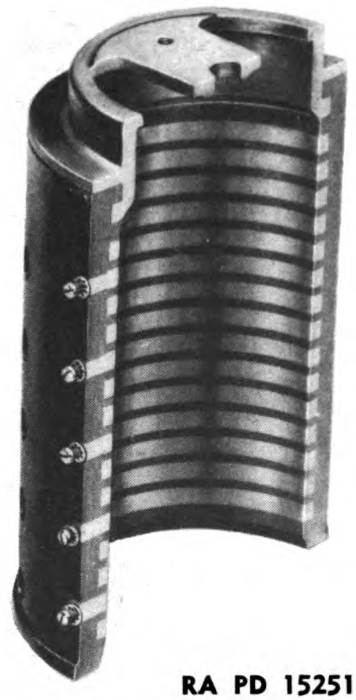

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Figure 10 — Contact Body Cut Away, Showing Rings and Terminals

contact body (figs. 9 and 11). It accommodates the D-shaped plug of the transmission cable, and has a molded plug assembly B172663 which seals the opening when the cable plug is not in place. A pad is used in some assemblies to wipe dust or metal particles from the contact rings.

11. AZIMUTH MECHANISM.

a. The azimuth mechanism is made up of several separate units. Each unit, except the transmitter assembly, is mounted independently on the base casting, and generally on the right side as viewed from the range setter's position. The shafts of the various units are connected by couplings where gears are not required. The floating member of each coupling is held by a retaining screw when not coupled. The units are: the azimuth differential drive shaft group assembly, the azimuth tracking mechanism, the rate setting clutch, the constant-speed motor assembly, the worm drive assembly (Director M5 or M6) or the spiral drive assembly (Director M5A1), the deflection mechanism, the torque amplifier (Director M5 or M6) or the gear reduction unit (Director M5A1), the future azimuth mechanism, and the transmitter assembly.

b. Azimuth Differential Drive Shaft Group Assembly D43778 (figs. 12 and 13). This includes the azimuth handwheel shaft which

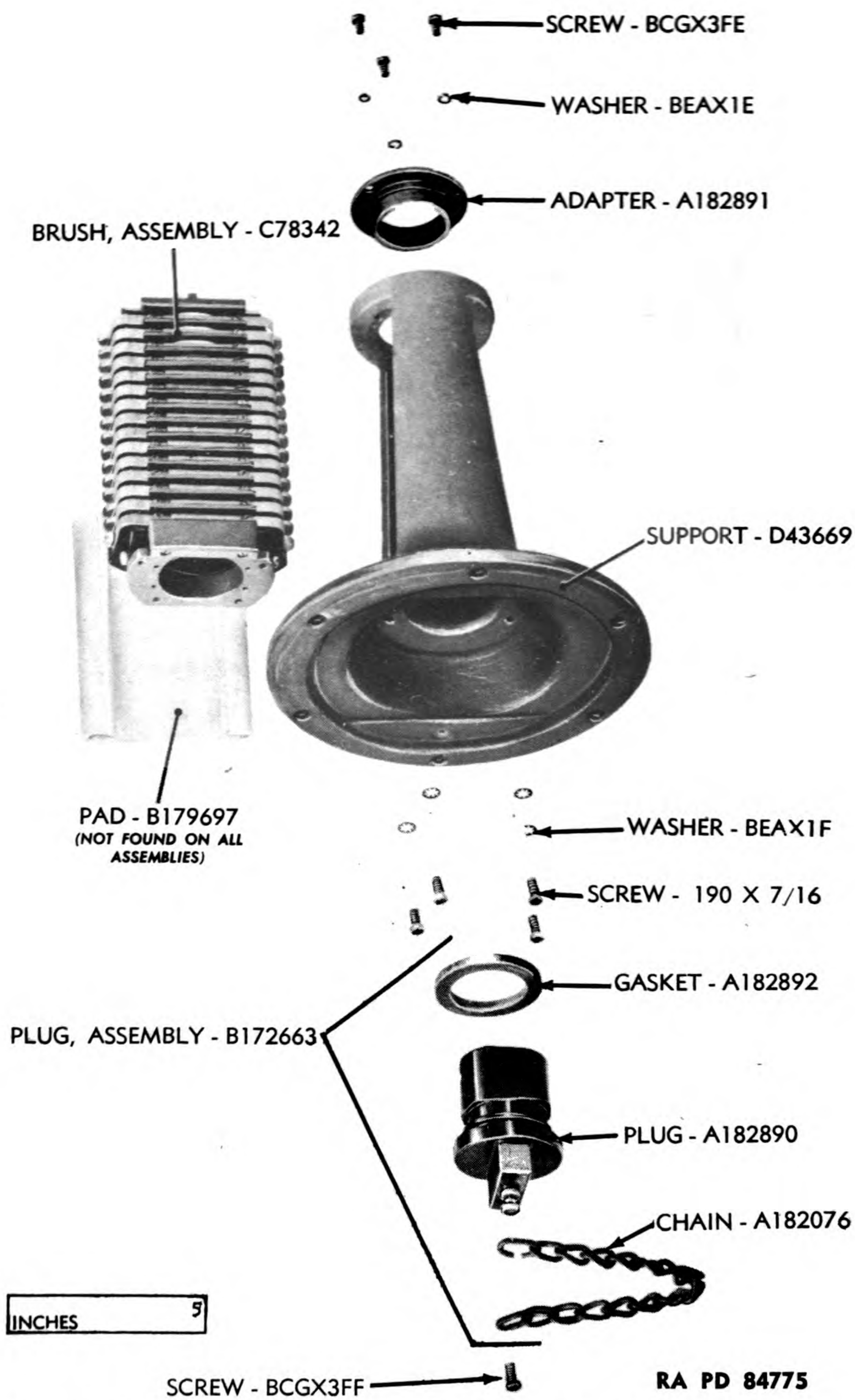

Figure 11 — Brush Support Assembly C78344 — Exploded View

DESCRIPTION

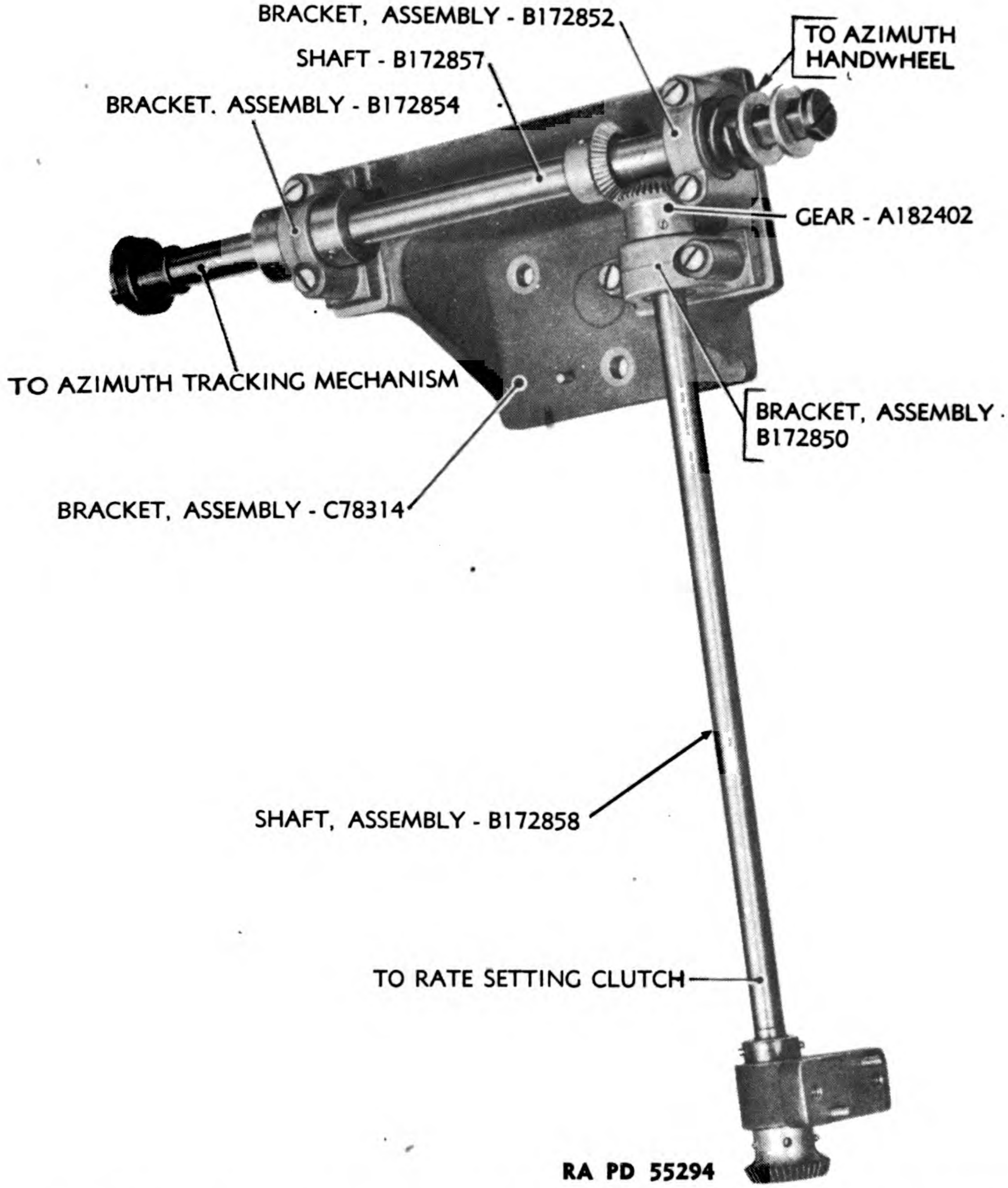

Figure 12 — Azimuth Differential Drive Shaft Group Assembly D43778

connects to the azimuth tracking differential, a geared shaft to the rate setting clutch, coupling, bevel gears, and the brackets which hold them. The main bracket is mounted on the base, and the auxiliary bracket B172859 attaches to the rate setting clutch.

c. Azimuth Tracking Mechanism (figs. 13 and 14).

(1) This mechanism consists primarily of the tracking differential which adds the manual tracking motion received from the azimuth handwheel to the mechanical tracking motion received from the torque amplifier or gear reduction unit. The differential transmits

DESCRIPTION

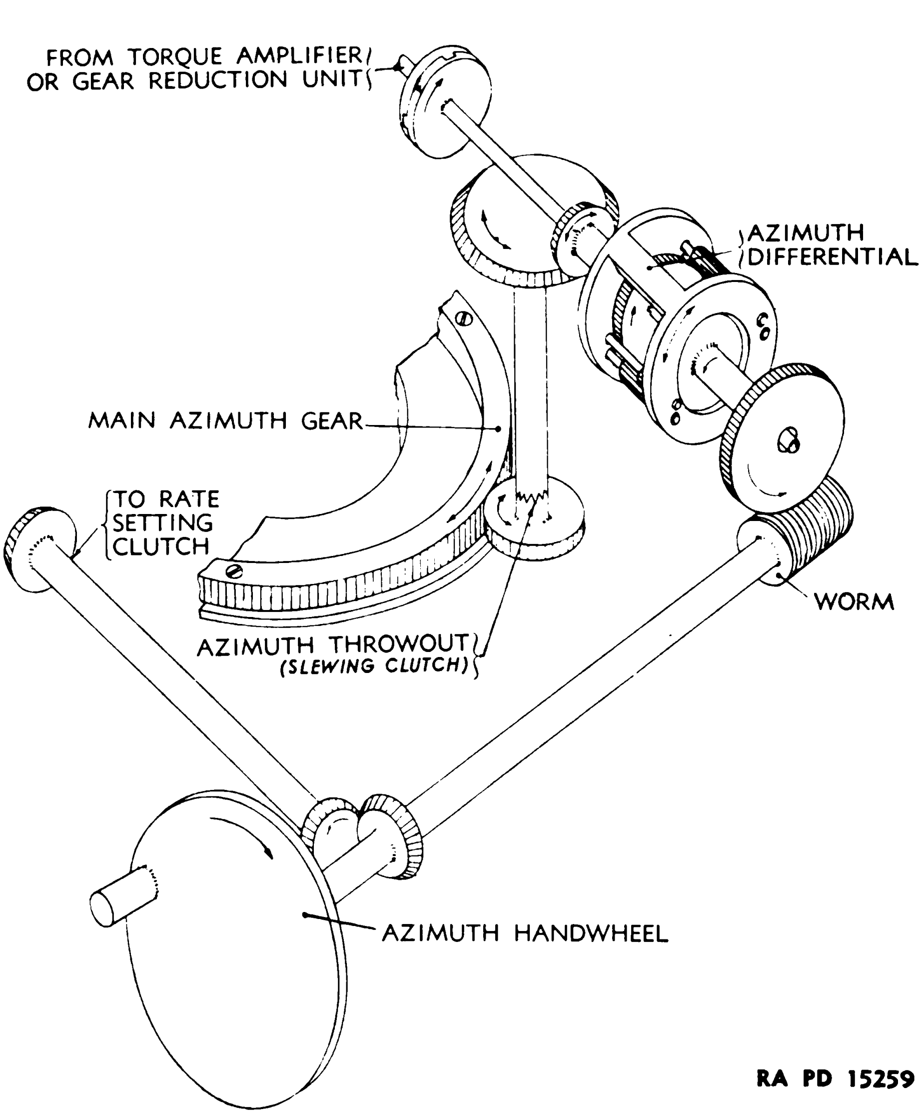

Figure 13 — Azimuth Differential Drive Shaft and Azimuth Tracking Mechanism — Schematic Gearing Diagram

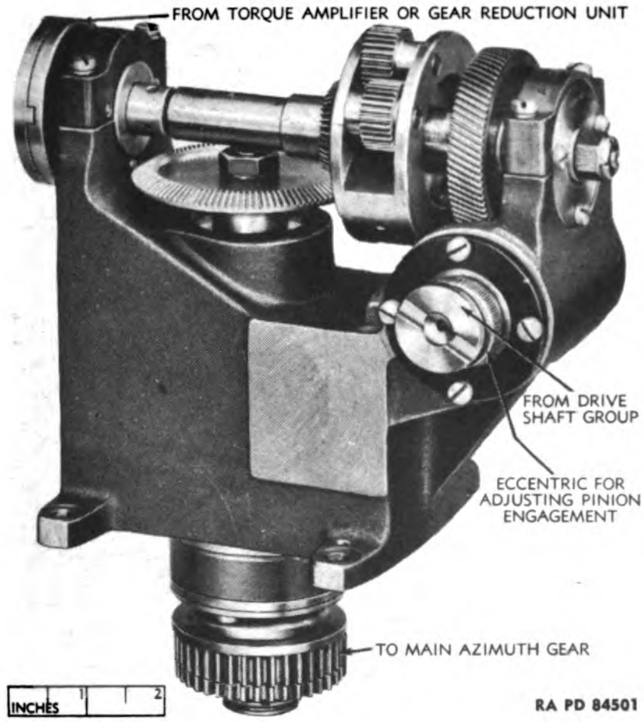

Figure 14 — Azimuth Tracking Mechanism Assembly D43772

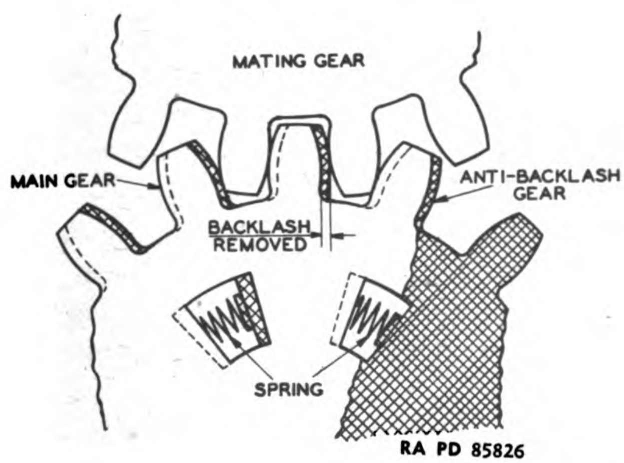

Figure 15 — Schematic Drawing, Showing Principle of Antibacklash Device

the sum (or difference) of the two motions to the pinion which rotates around the main azimuth gear, thus driving the entire mechanism, and the director, in azimuth (fig. 9). The tracking mechanism includes couplings, gears, a bracket, and a slewing clutch.

(2) The pinion assembly which engages the main azimuth gear has an antibacklash device which is used also in several other units.

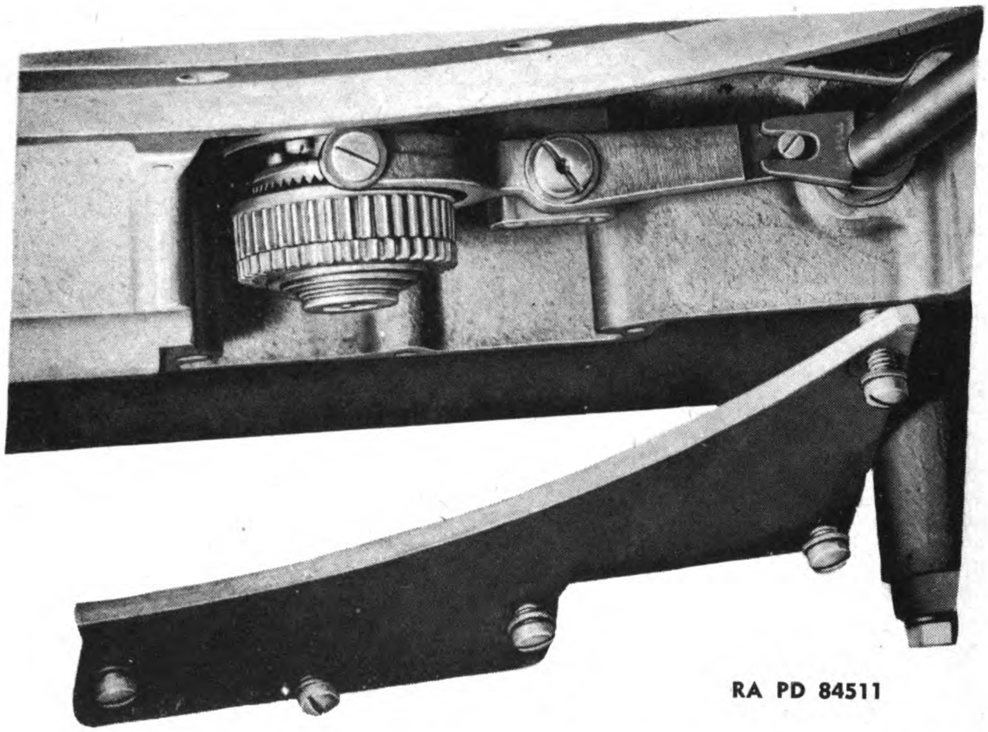

Figure 16 — Underneath Base, Showing Slewing Clutch on Azimuth Tracking Mechanism — Close-up View

It is really a pair of gears connected through a spring which exerts a constant torque between them (greater than the normal operating torque), thus taking up any backlash with the mating gear (fig. 15).

(3) AZIMUTH THROW-OUT LEVER (SLEWING CLUTCH). The pinion assembly is not pinned to its shaft but is driven by a notched collar against which it is held by spring pressure (fig. 16). It may be released through a fork actuated by the slewing clutch handle, to permit the director to be turned rapidly independent of the tracking mechanism.

d. **Rate Setting Clutch Assembly** (figs. 17 and 18). This clutch normally connects the handwheel drive shaft assembly to the movable rack of the deflection mechanism. When the clutch knob is pulled out, the rate setting shaft is locked and is disconnected from the handwheel drive shaft to permit manual tracking. If the mechanism is set near zero deflection before the clutch handle is pulled out, the teeth of the clutch and the fixed collar will move the deflection to exact zero if the fixed collar has been correctly set. This assembly also includes a mechanical stop actuated by a coarse screw thread on the rate setting shaft, which limits the maximum rate set into the deflection mechanism. The azimuth power switch is also mounted

DESCRIPTION

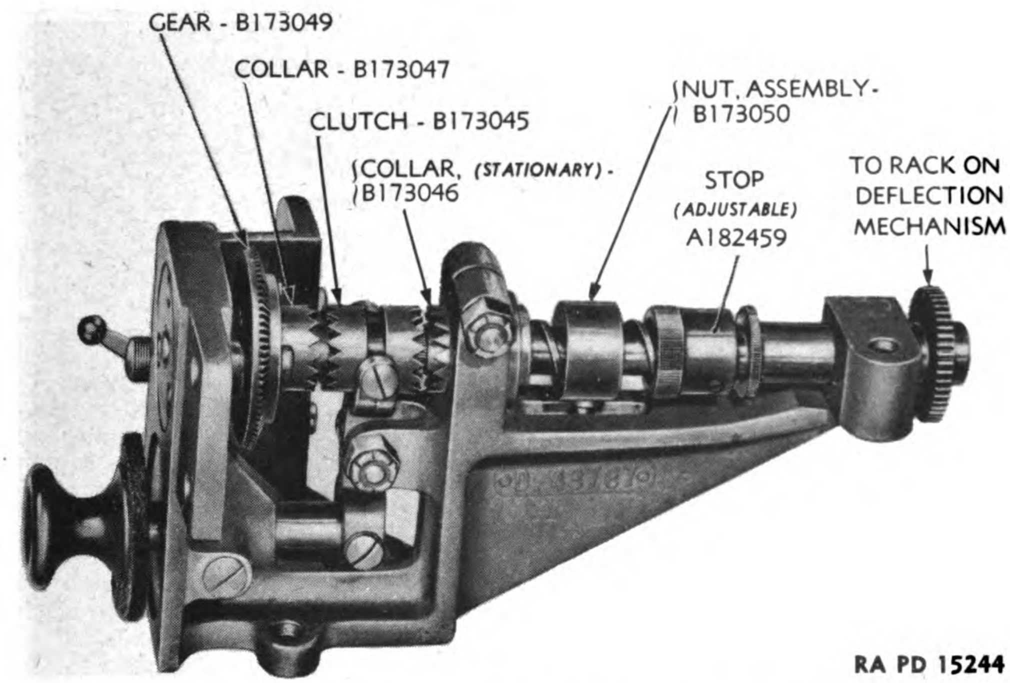

Figure 17 — Rate Setting Clutch Assembly D43785

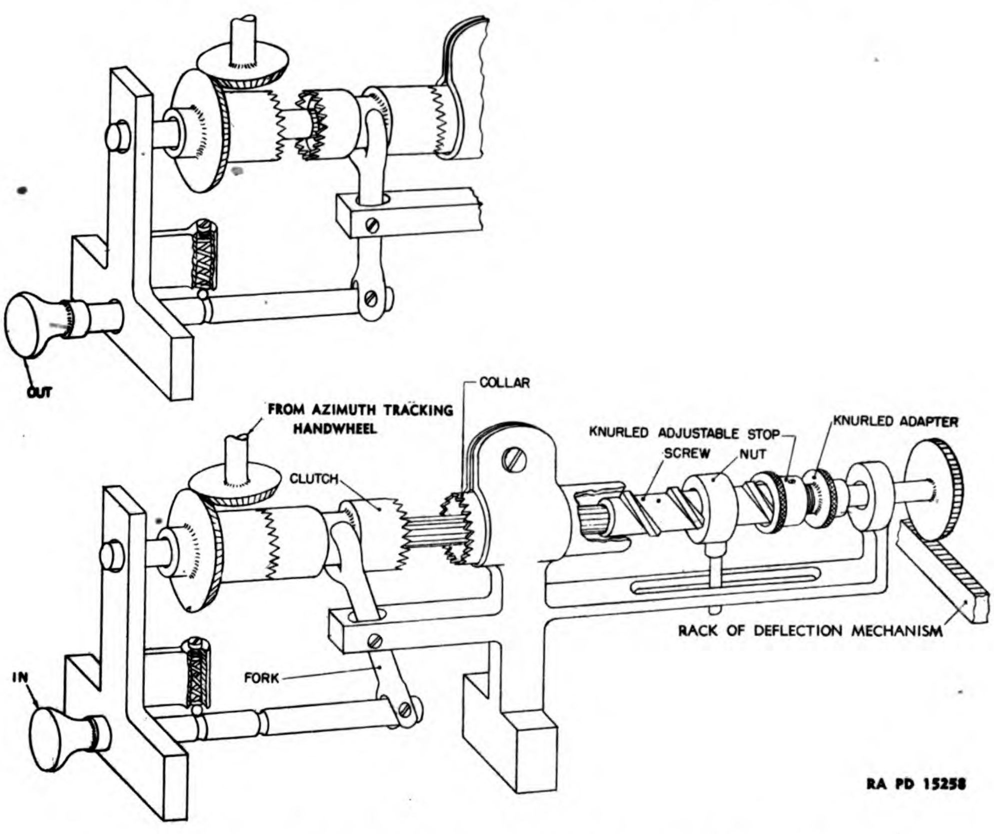

Figure 18 — Rate Setting Clutch — Schematic Diagram

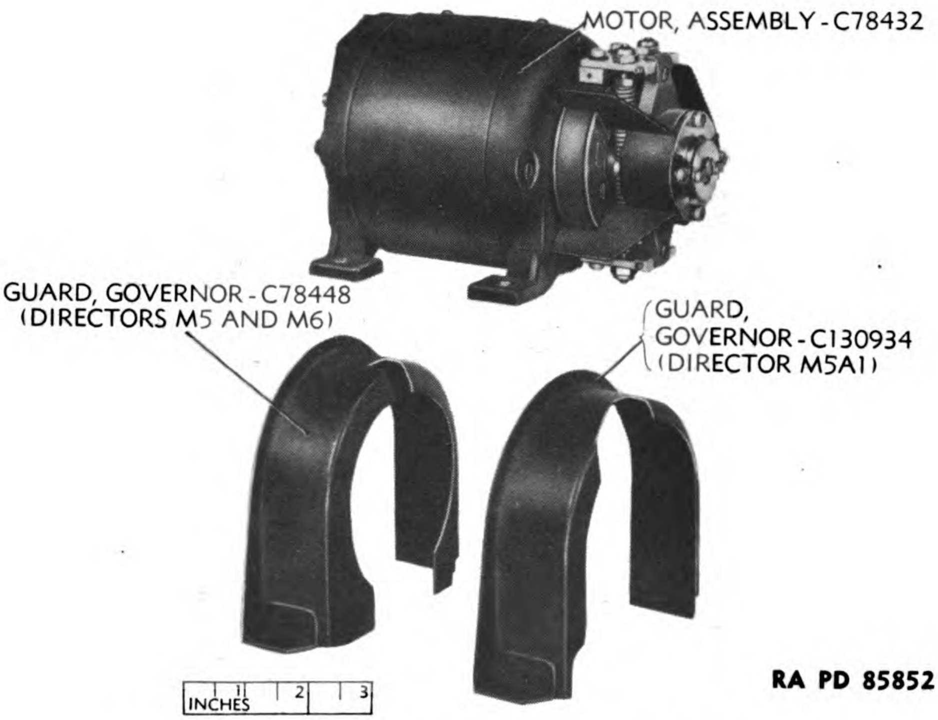

Figure 19 — Constant-speed Motor Assembly and Guards

on this assembly for convenience. Different assemblies may provide different methods of attaching this switch, however.

e. **Constant-speed Motor Assembly.** This is an electric motor with a constant-speed governor, which drives the variable-speed mechanism. The motor drives a carbon ring and normally runs at a higher speed than the desired output speed; the governor is driven by a pair of friction shoes which fly outward from the carbon ring at the governed speed so that the output remains constant. The spring tension on the shoes is adjustable. The governor assembly is carried on a ball bearing on the motor shaft. With light loads, friction or heavy lubricant in this ball bearing would tend to overspeed the governor. Therefore, later governors have fan blades which exert a restraining torque. The motors in Director M5A1 turn in the reverse direction from those in Directors M5 and M6, and the governor speed is slightly higher, but the parts are identical except for the guard.

f. **Worm Drive Assembly (Directors M5 and M6)** (figs. 20 and 21). The worm drive assembly C78253 consists of a short shaft coupled to the constant-speed motor and carrying a worm which drives the variable-speed mechanism. It is mounted in ball bearings in a suitable bracket fastened to the base. The speed reduction is 125 to 1.

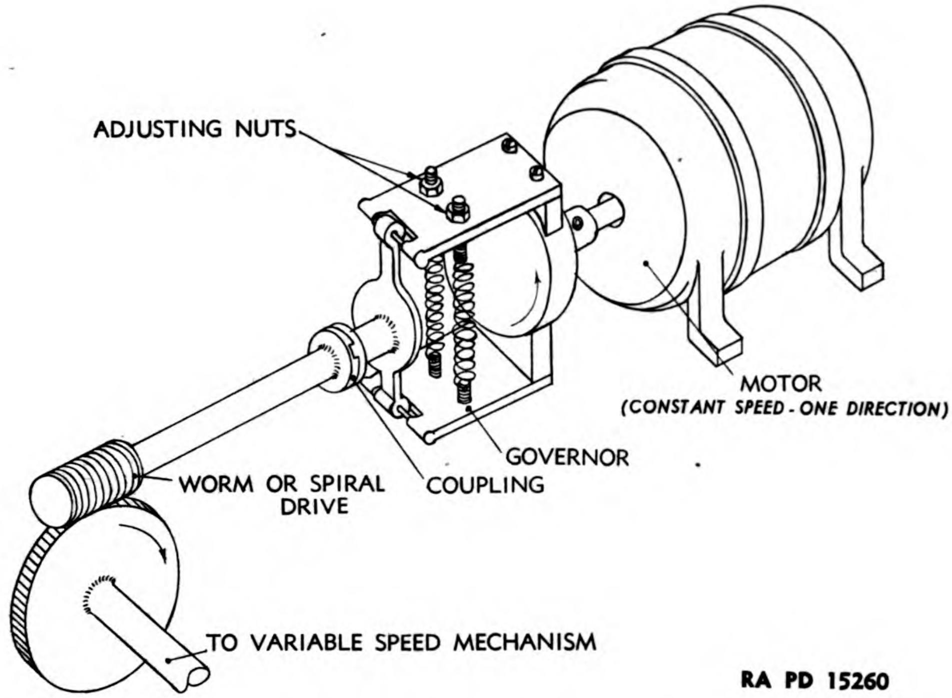

Figure 20 — Constant-speed Motor and Worm Drive — Schematic Diagram

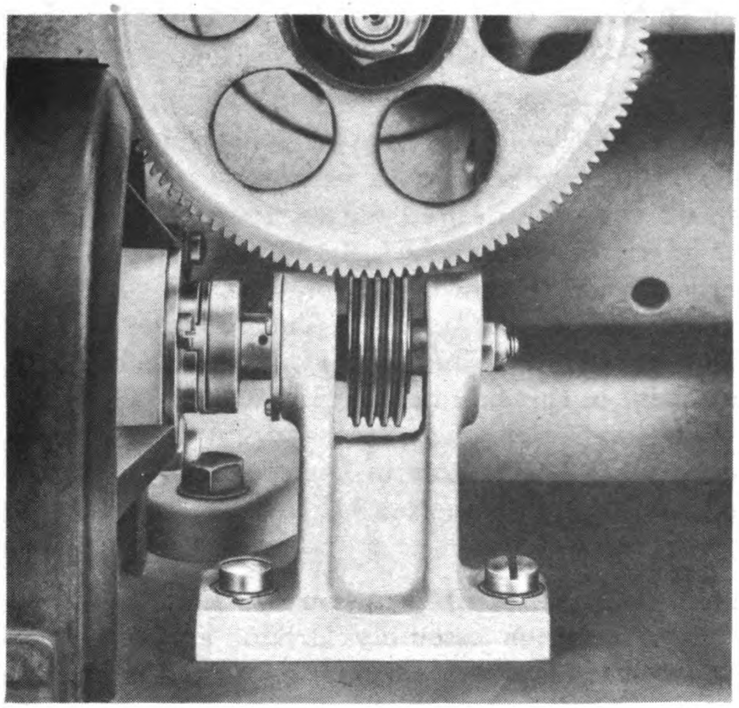

Figure 21 — Worm Drive Assembly C78253 in Director M5 or M6

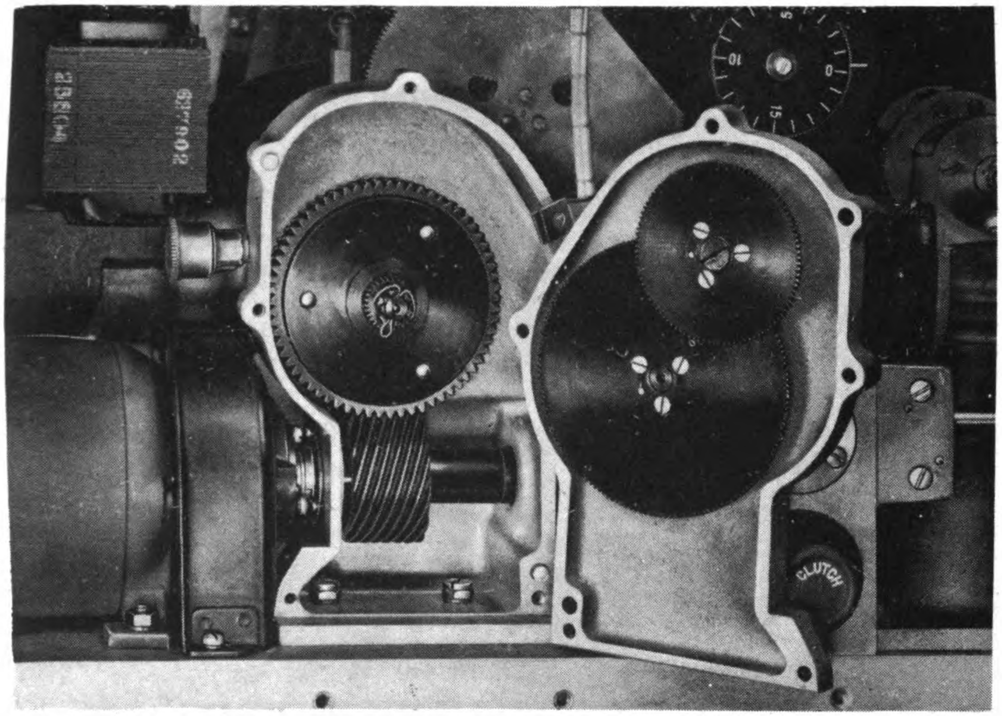

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Figure 22 — Spiral Drive Assembly With Cover Removed, Showing Gear of Variable-speed Mechanism (Director M5A1)

g. Spiral Drive Assembly (Director M5A1). This assembly includes a short shaft with a spiral pinion which drives the variable-speed mechanism, and a housing which surrounds the spiral gear of the latter mechanism (figs. 4 and 22). The speed reduction is six to one. Since the speed of the spiral gear is too great for convenient observation when timing the constant-speed governor, a dial driven by a set of spur gears in the cover of the housing is driven at the same speed as that of the constant-speed gear in Directors M5 and M6 (20 rpm).

h. Lateral Deflection Mechanism.

(1) This is the heart of the azimuth mechanism. It is made up of the variable-speed mechanism, the multiplying mechanism D43760, the bar assembly and bracket which connect the two, and the rail on which the bar slides (figs. 23, 24, and 25).

(2) The variable-speed mechanism is mounted directly back of the worm drive or spiral drive assembly (fig. 3 or 4), and consists essentially of a highly polished disk driving a polished roller through a pair of smooth balls. The balls can be moved by the bar assembly to either side of the center of the disk to drive the roller in either direction, and the speed of the roller depends on the displacement of the balls from the center of the disk. In Director M5A1, the

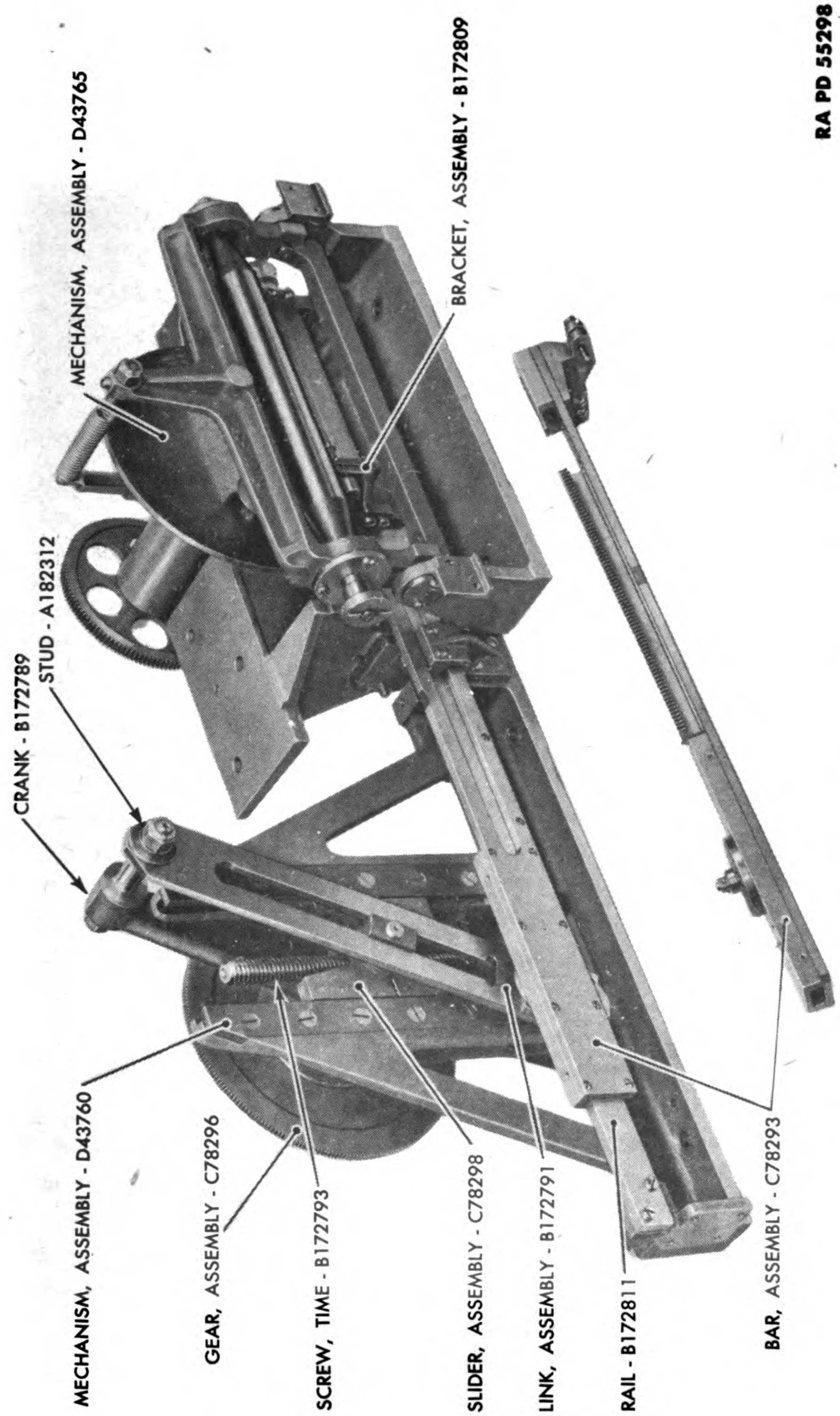

Figure 23 — Lateral Deflection Mechanism (Director M5 or M6)

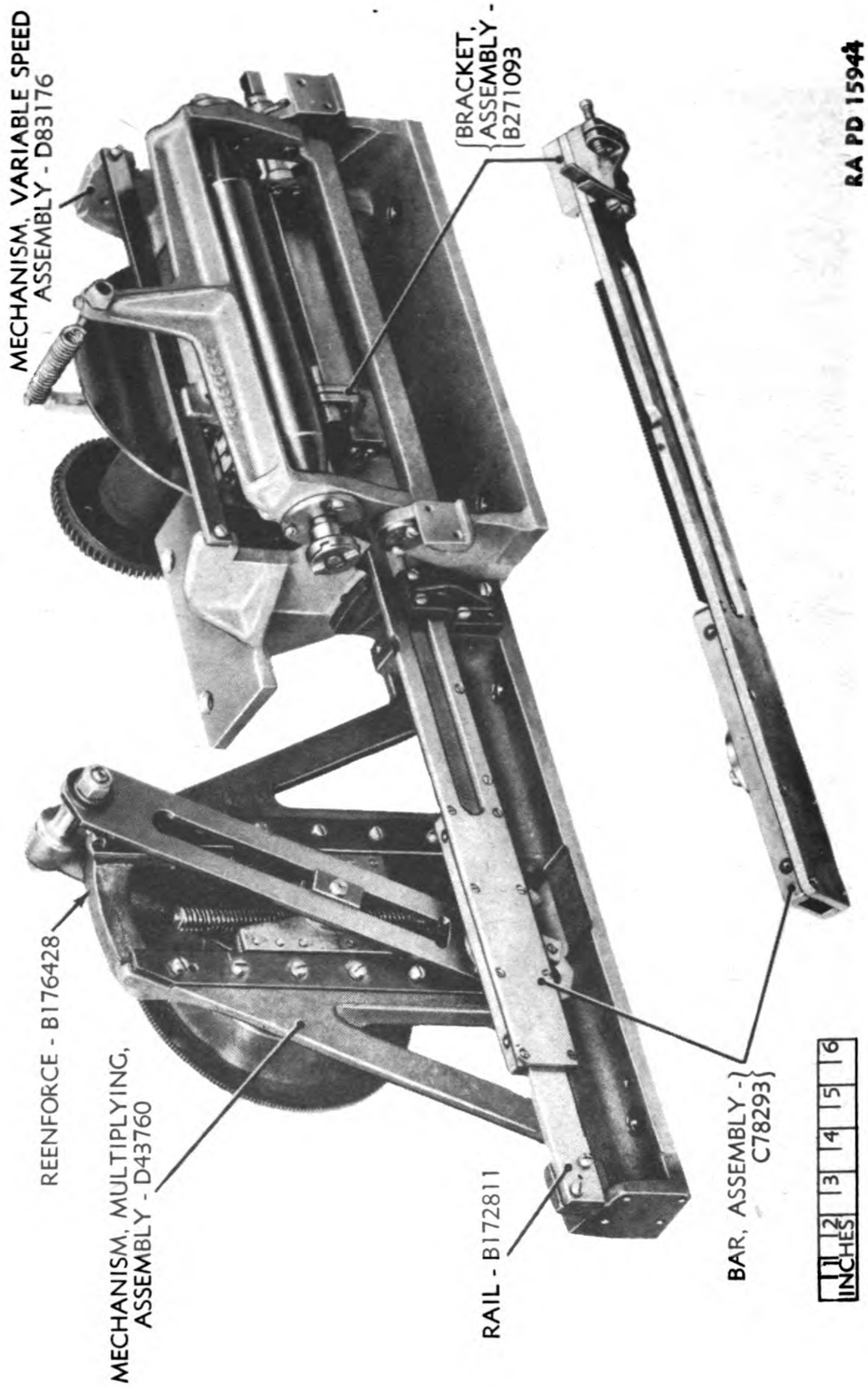

Figure 24 — Lateral Deflection Mechanism (Director M5A1)

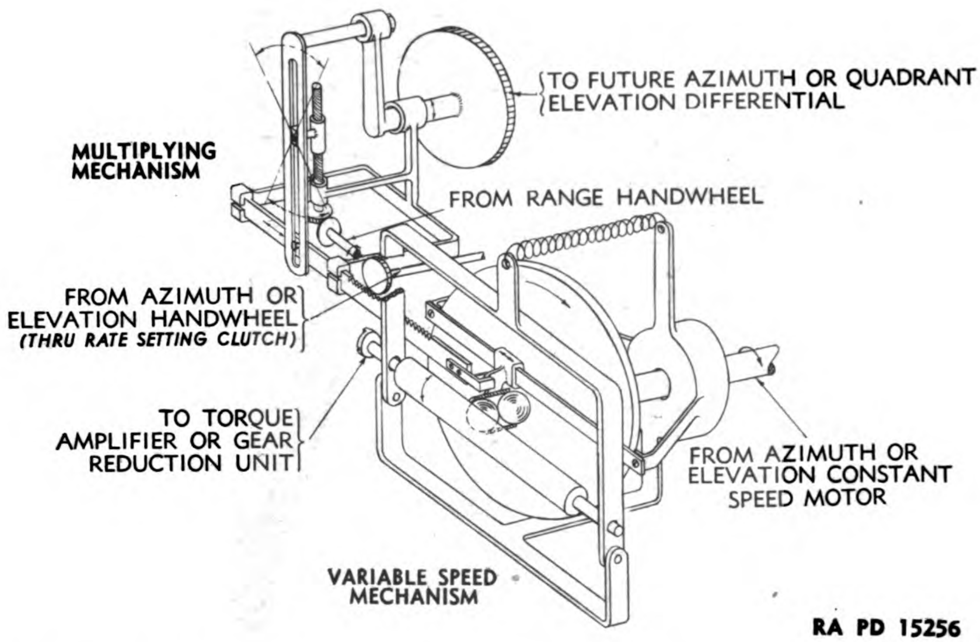

Figure 25 — Lateral Deflection Mechanism — Schematic Diagram

speed of the parts is considerably higher than in Directors M5 and M6 and the spring pressure between roller and disk is greater to transmit more torque. To reduce friction loss, the two balls are supported by small ball bearings in Director M5A1. Compare figures 26 and 27.

(3) The multiplying mechanism is connected to the variable-speed mechanism. The rate setting of the bar assembly moves the bottom of a slotted link, and the resulting deflection of the top of the link actuates a crank which is geared to the future azimuth mechanism (fig. 25). The fulcrum of the link may be moved up or down on a screw driven by the range handwheel, so that the displacement of the bar is multiplied by the range (time) setting to produce the deflection. The reenforce B176428 shown in figure 24 is also found in later models of Director M5 or M6. It strengthens the bracket to insure parallelism of the slideways.

i. Torque Amplifier (Directors M5 and M6) (figs. 28 and 29).

(1) Since the torque output of the variable-speed mechanisms used in these directors is not great enough to drive the director, the torque amplifier provides an independent source of power which is merely controlled by the variable-speed mechanism output.

(2) An electric motor similar to the rate motor drives two smooth carbon drums in opposite directions, through a double worm drive and spur gears. Each drum has a thin friction band wrapped 3½ times around it, with one end connected to a cross arm on the

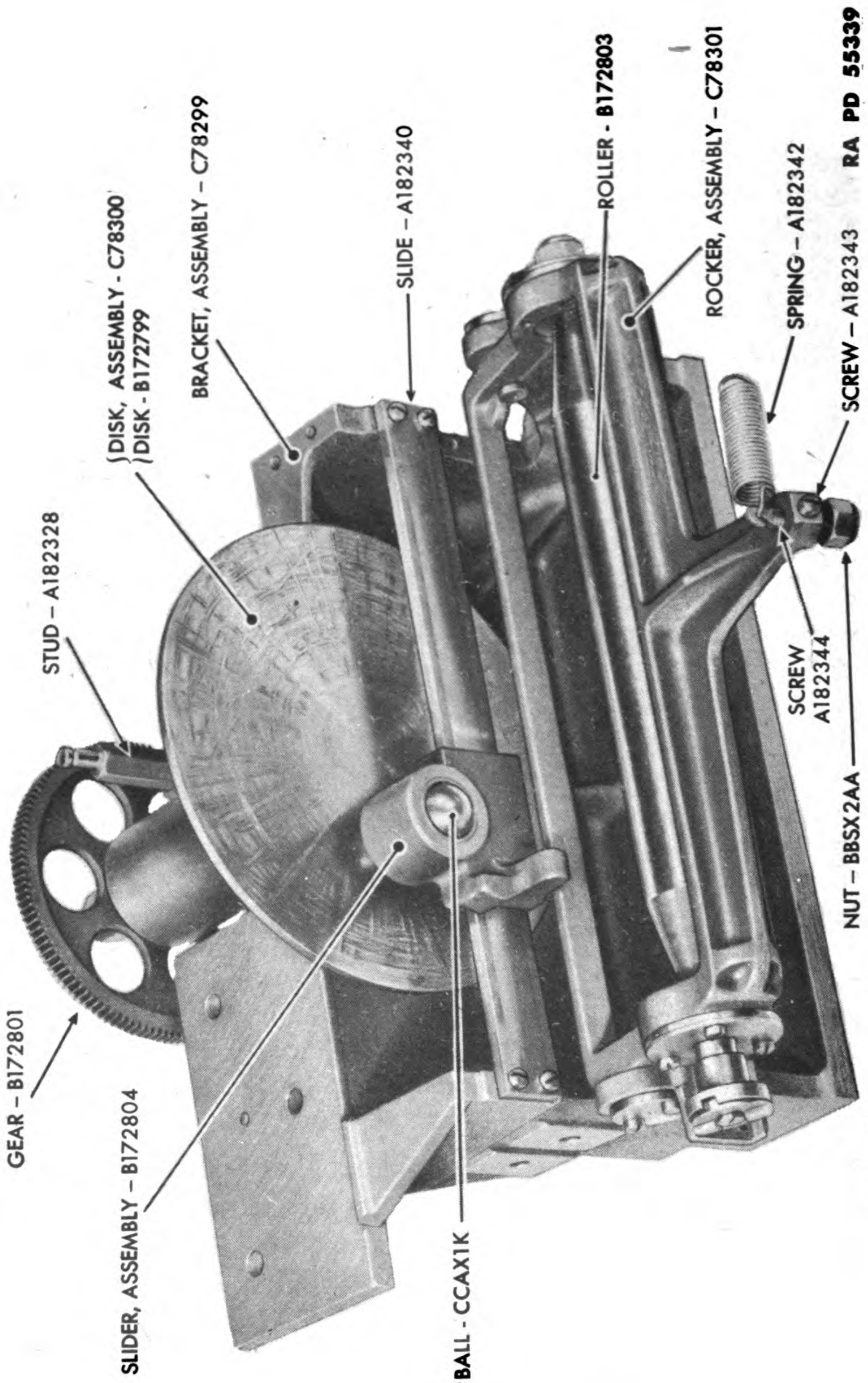

Figure 26 — Variable-speed Mechanism D43765 Opened To Show Ball Slider Assembly B172804 (Director M5 or M6)

DESCRIPTION

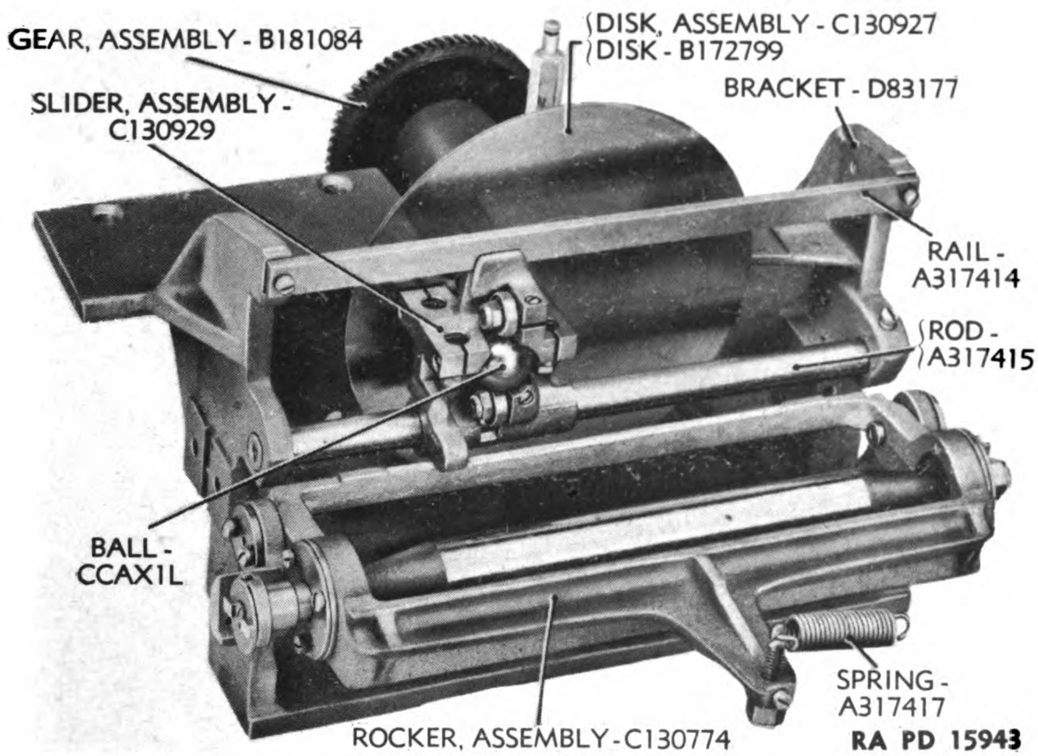

Figure 27 — Variable-speed Mechanism D83176 Opened To Show Ball Slider Assembly C130929 (Director M5A1)

input shaft and the other to an arm on the output shaft. Any movement of the input shaft causes one of the bands to tighten and grip a rotating drum, and hence it receives by friction most of the torque supplied to the output shaft. Movement in the opposite direction causes the other band to grip the drum rotating in the opposite direction.

(3) The input shaft is connected through a pair of spur gears, so that the input and output couplings are not in line and always turn in opposite directions.

j. **Gear Reduction Unit (Director M5A1)** (figs. 7 and 30). This unit simply reduces the variable-speed mechanism output of Director M5A1 by a ratio of 65 to 3, through two pairs of spur gears. It occupies the same position as torque amplifier in Directors M5 and M6.

k. **Future Azimuth Mechanism** (figs. 31 and 33).

(1) This unit consists of a bracket holding the future azimuth differential with its connecting gears, and a shaft which extends through the base and is geared to the main azimuth gear. The rotation of the director is picked up from the azimuth gear and the differential adds to this the deflection received from the azimuth multiplying mechanism. The result is the future azimuth which goes to

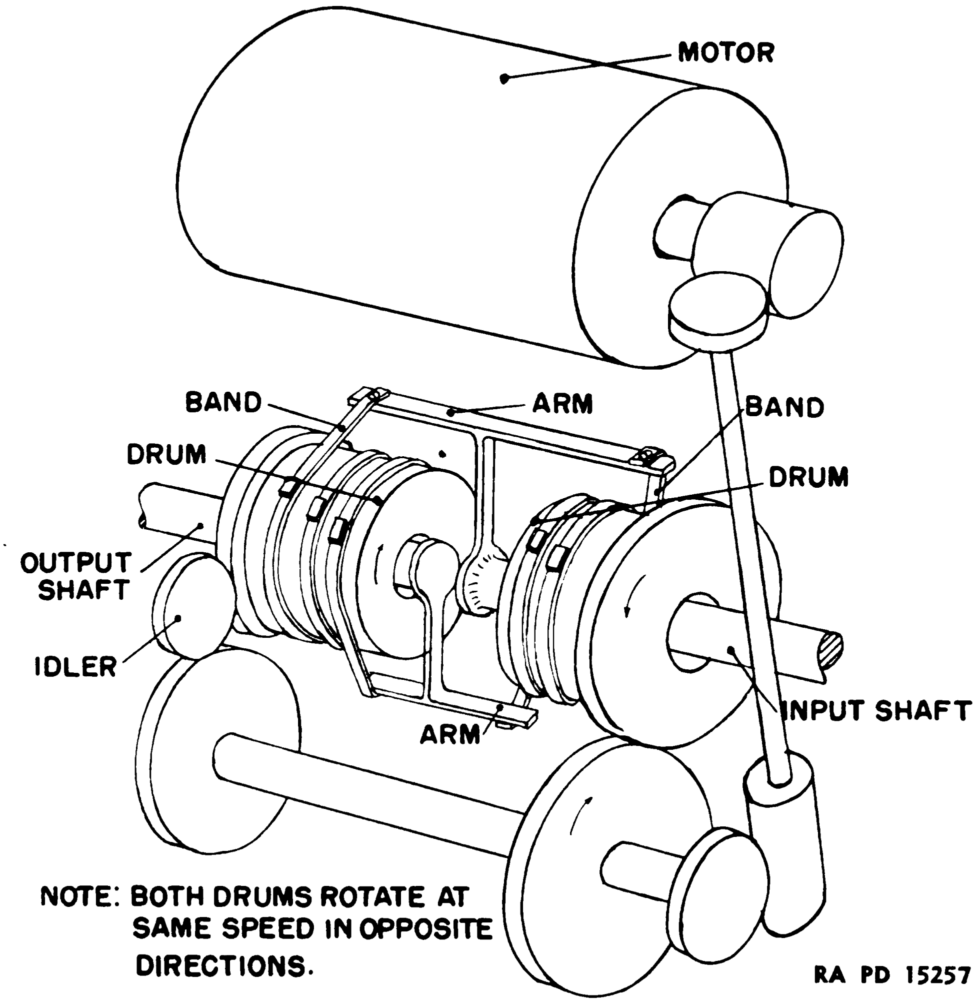

Figure 28 — Torque Amplifier — Schematic Diagram

the transmitters. Two of the gears are of antibacklash type consisting of a pair of gears connected through a spring which exerts a constant torque between them (fig. 15). Unscrewing orienting nut at the bottom of vertical shaft releases the pressure of a retainer A182414 against the gears, and allows them to turn on their hub. This permits director to turn independently of transmitters and gun.

(2) The future azimuth mechanism cover assembly (fig. 31) attaches to the under side of the base and protects the orienting nut, but is not a part of the future azimuth mechanism. It includes a clamp operated by a small thumb nut A182562 which prevents rotation of the shaft when orienting. Turning the director in azimuth while both orienting and clamping nuts are tightened would cause damage to the mechanism; therefore, one of them should always be

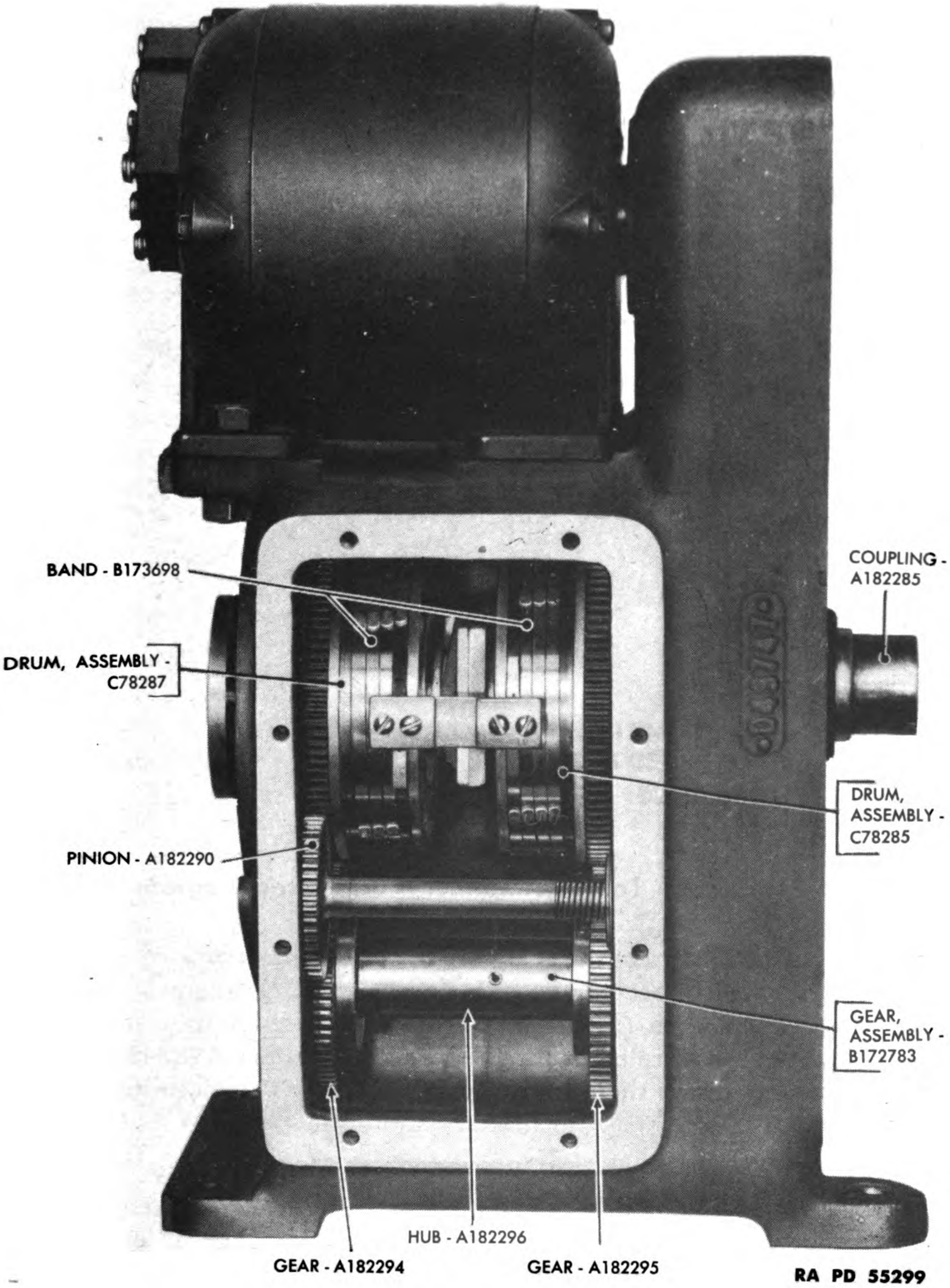

Figure 29 — Torque Amplifier D43745 — Side View (Directors M5 and M6)

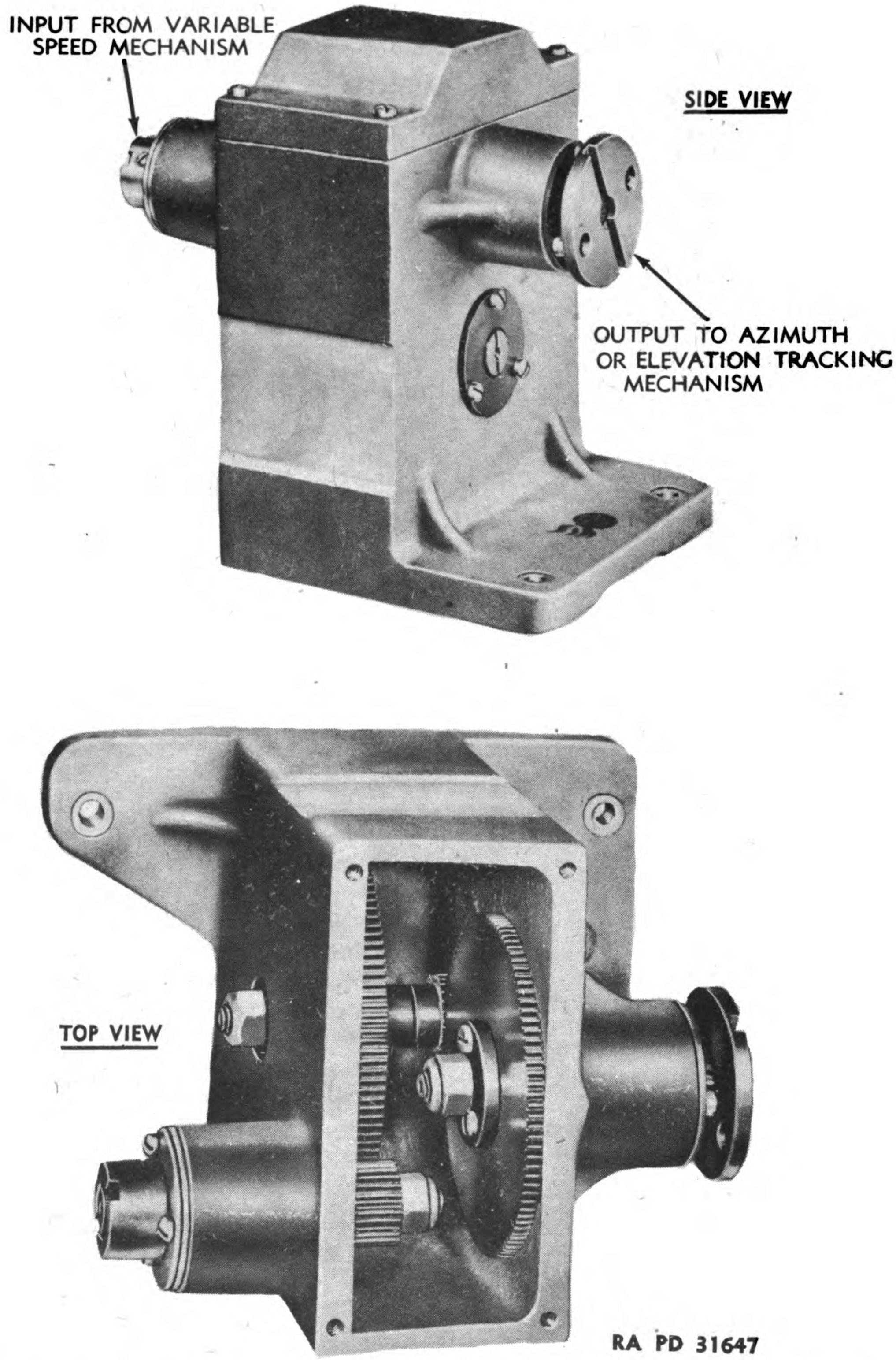

Figure 30 — Gear Reduction Unit — Side and Top Views (Director M5A1)

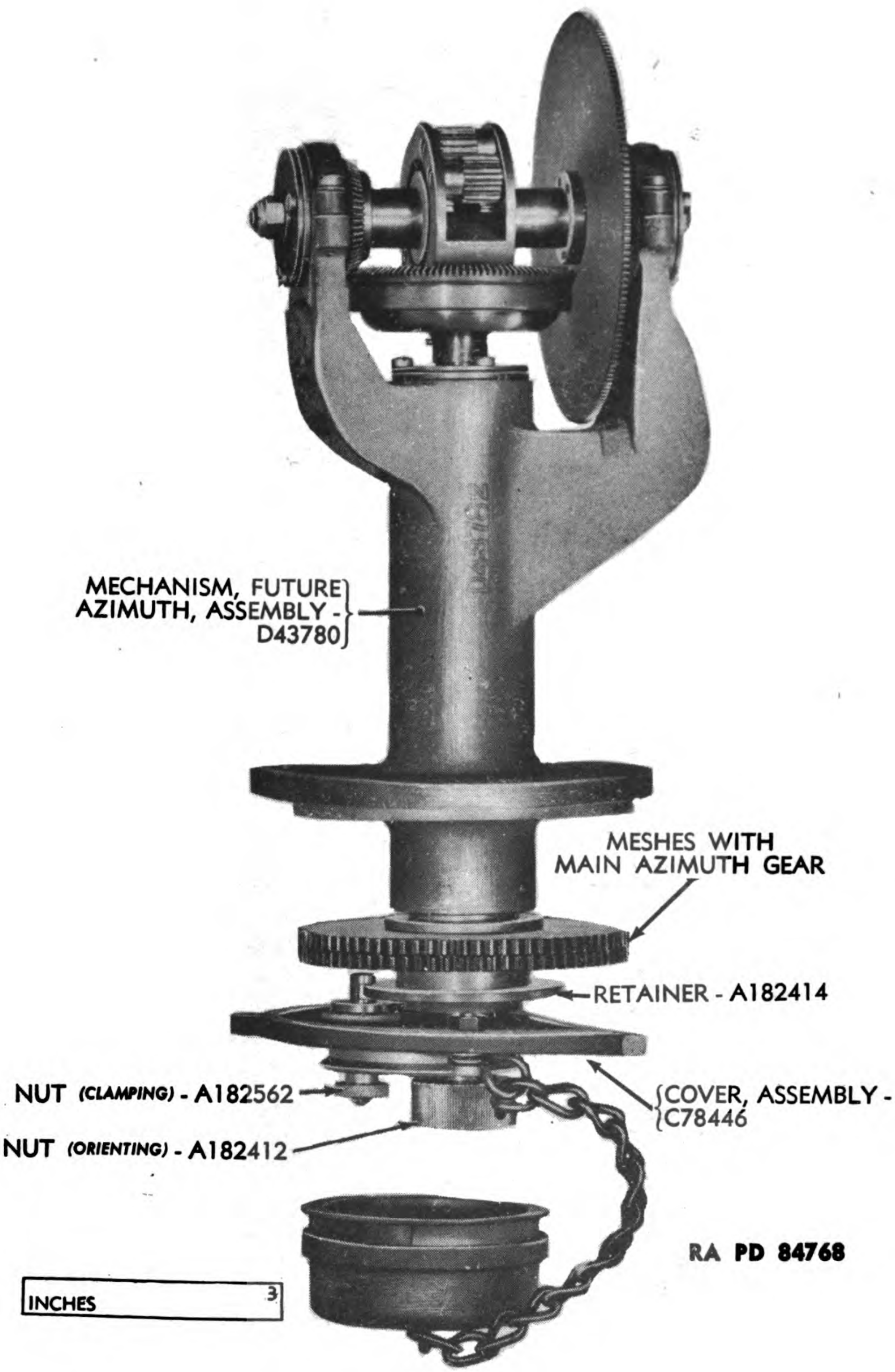

Figure 31 — Future Azimuth Mechanism D43780 With Cover Assembly C78446

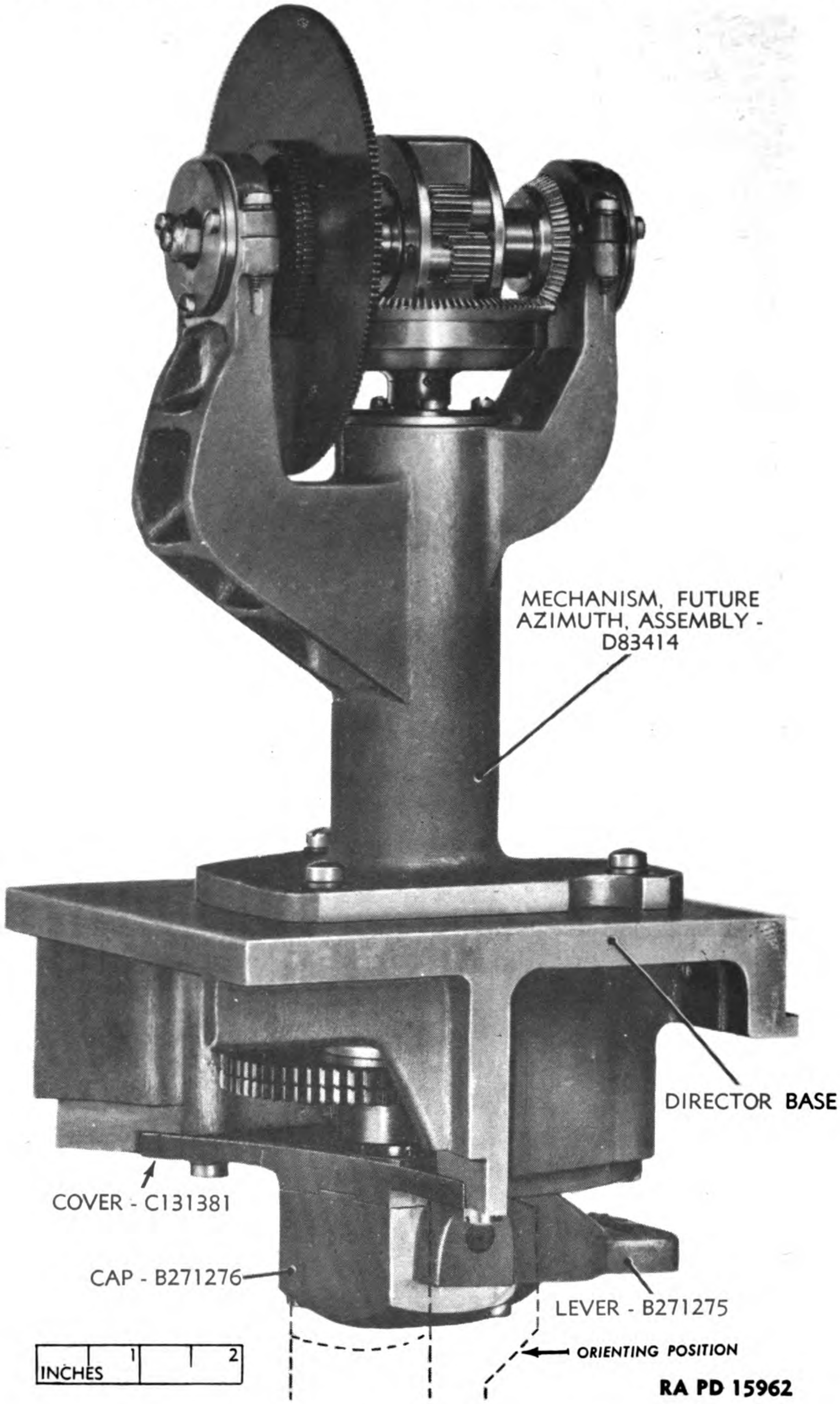

Figure 32 — Future Azimuth Mechanism With New Orienting Clutch (Found on Latest Directors M5A1)

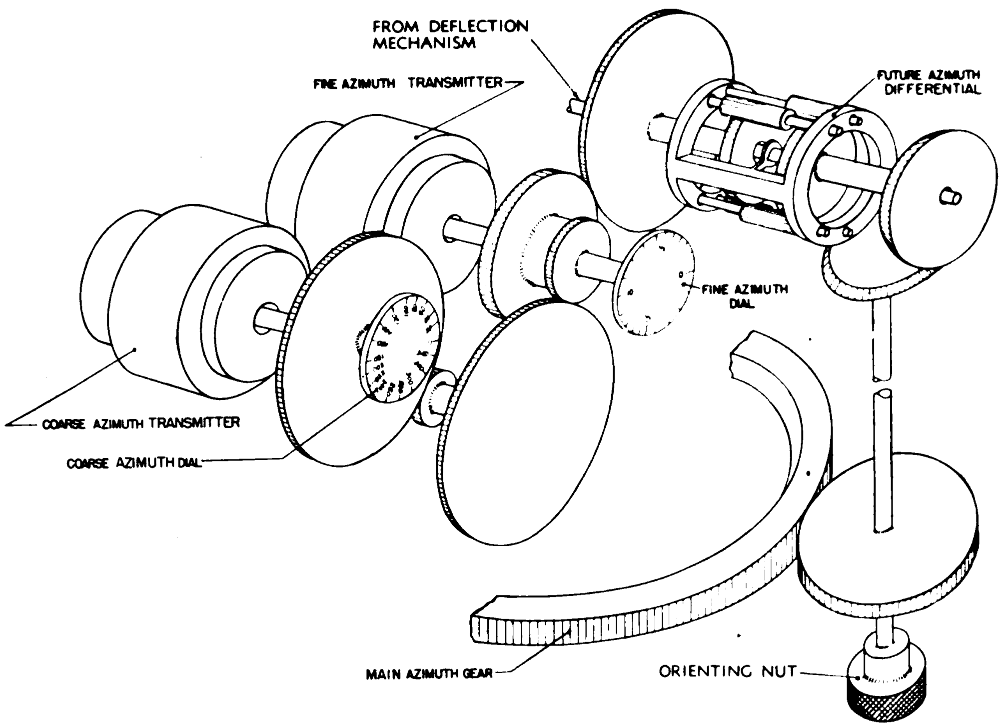

Figure 33 — Future Azimuth Mechanism and Transmitters — Schematic Diagram

backed off unless locked for some particular adjustment.

(3) Later models of the Director M5A1 will be fitted with the type of orienting clutch shown in figure 32, quickly operated by a forked lever. In normal operation a coil spring holds the gear against its hub, but, when the lever is moved to a vertical position, this pressure is released and at the same time a friction shoe is pressed against a collar pinned to the shaft, locking it in a fixed position.

l. **Azimuth Transmitter Assembly** (figs. 33 and 34). The transmitter assembly includes two synchronous electrical transmitters which transmit the firing azimuth to the gun, a gear train, and a dial for each transmitter. The assembly is bolted to the bracket of the variable-speed mechanism. The gear train is driven from the future azimuth mechanism. It is designed to turn the coarse azimuth transmitter and dial once for each revolution of the director, and the fine transmitter and dial once for each 20 degrees of director rotation (provided deflection remains constant). The bracket provides a mounting for a third transmitter which could be used for operating a second gun, but which is not used in present design. Director M6 has 50-volt, 50-cycle transmitters; otherwise assemblies are identical.

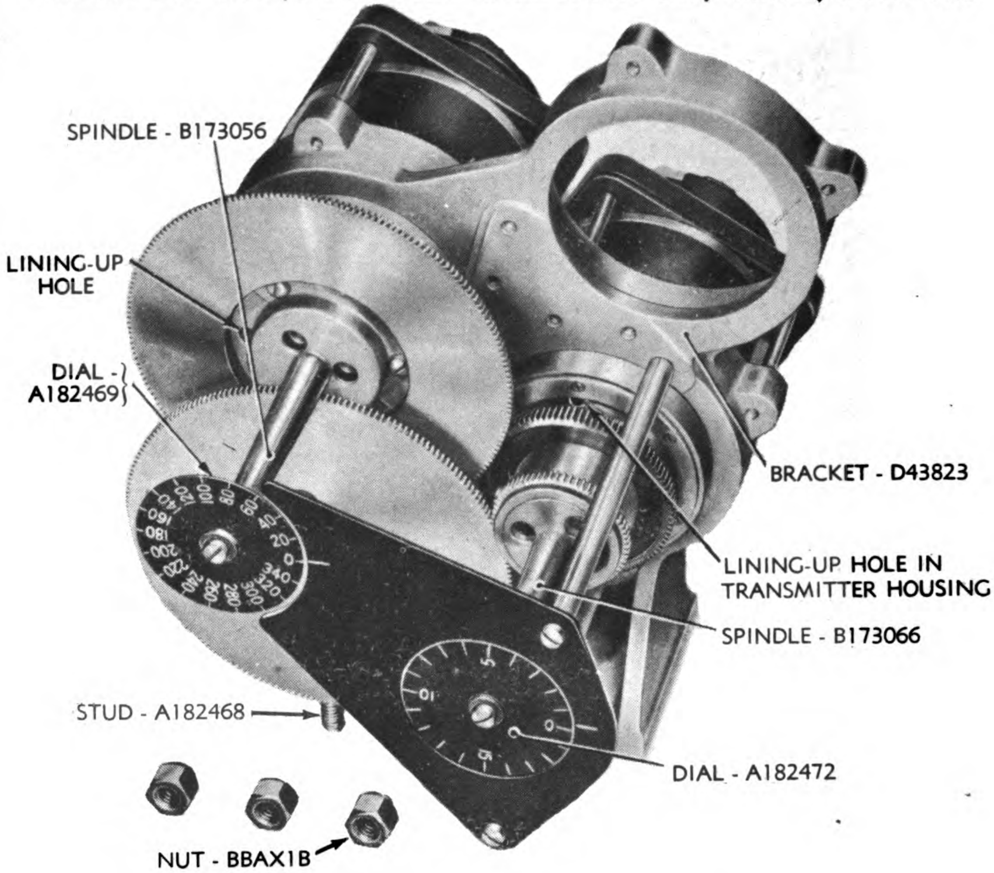

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Figure 34 — Azimuth Transmitter Assembly D43821 (Directors M5 or M5A1) or D43832 (Director M6)

12. ELEVATION MECHANISM.

a. The elevation mechanism is made up of several separate units, most of them similar to or identical with the units of the azimuth mechanism. They are located usually to the left of the frame as viewed from the range setter's position. The units are: the elevation differential drive shaft group assembly, the elevation tracking mechanism, the rate setting clutch assembly, the constant-speed motor assembly, the worm drive assembly (Director M5 or M6), or the spiral drive assembly (Director M5A1), the vertical deflection mechanism, the torque amplifier (Director M5 or M6) or the gear reduction unit (Director M5A1), the quadrant elevation mechanism, the transmitter assembly, and the telescope shaft assembly and open sight. Only units which differ from those in the azimuth mechanism will be described.

b. Elevation Differential Drive Shaft Group Assembly D43779. This assembly includes the elevation handwheel shaft and a geared shaft to the rate setting clutch (fig. 35). It differs from the azimuth

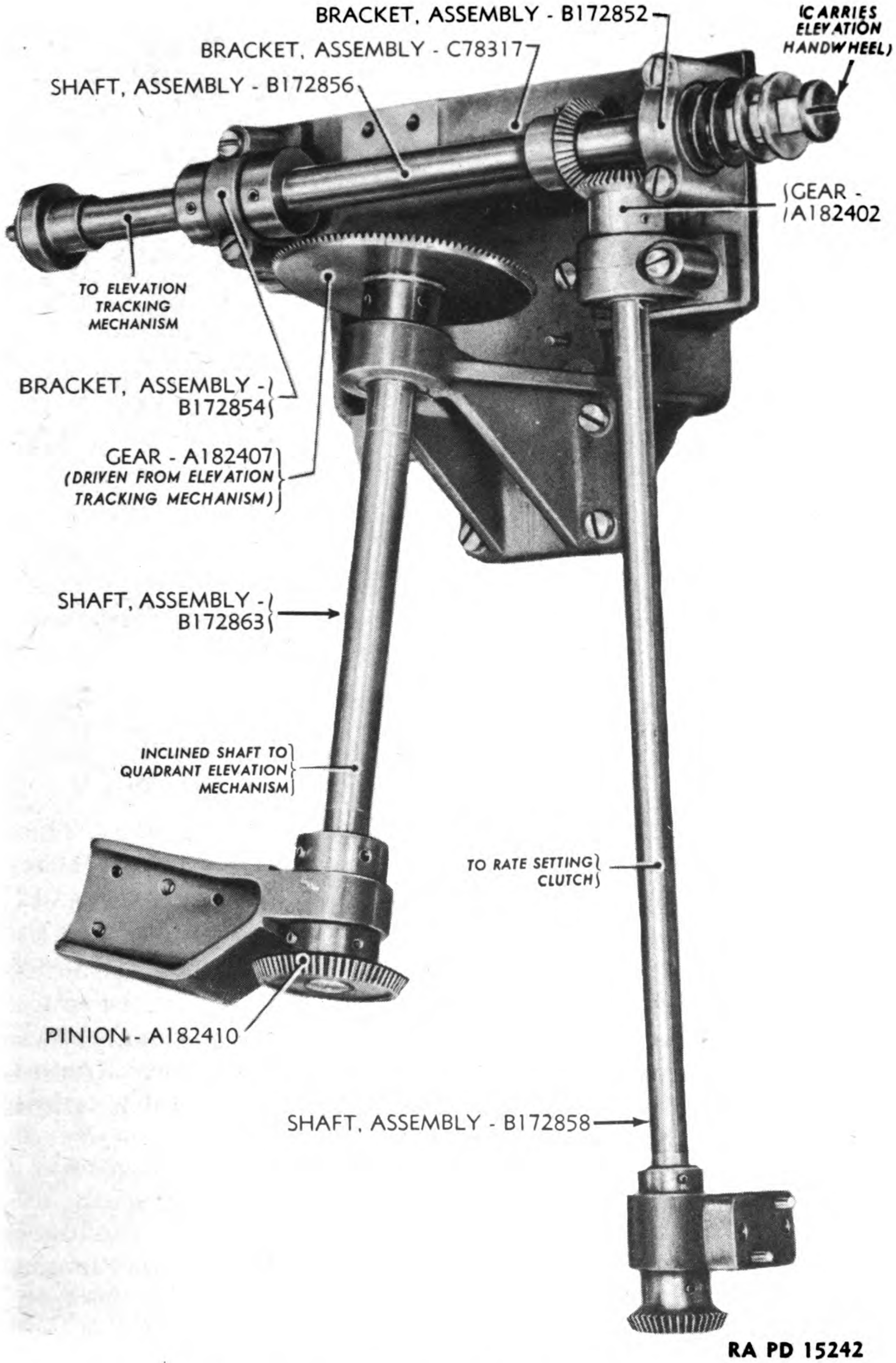


Figure 35 — Elevation Differential Drive Shaft Group Assembly D43779

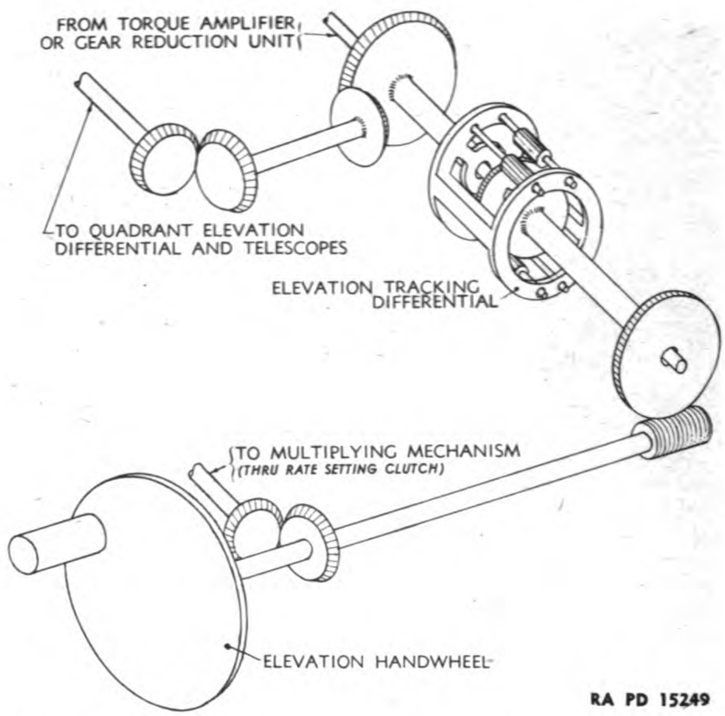


Figure 36 — Elevation Drive Shaft and Elevation Tracking Mechanism — Schematic Diagram

drive shaft group by having an extra bracket holding an independent shaft assembly which gears the output of the elevation tracking mechanism to the quadrant elevation mechanism (fig. 36).

c. **Elevation Tracking Mechanism** (figs. 36 and 37). This is essentially the tracking differential which adds mechanical elevation tracking motion and hand tracking motion. The output is sent to the quadrant elevation mechanism and the telescope shaft through a shaft and gears which are bracketed to the drive shaft group. The bracket and pinion are not a part of either unit, however.

d. **Rate Setting Clutch, Constant-speed Motor Assembly, Worm Drive Assembly (Director M5 or M6) and Spiral Drive Assembly (Director M5A1).** These are the same as corresponding azimuth units (par. 11 **d**, **e**, **f**, and **g**).

e. **Vertical Deflection Mechanism** (fig. 38 or 39). This mechanism is similar to the lateral deflection mechanism (par. 11 **h**), with the following exceptions:

(1) The elevation variable-speed mechanism is the same as in the azimuth mechanism, but is fitted with an additional eccentric shaft. On the bar assembly is a superelevation mechanism. The eccentric shaft is linked to the telescope shaft and actuates the super-

DESCRIPTION

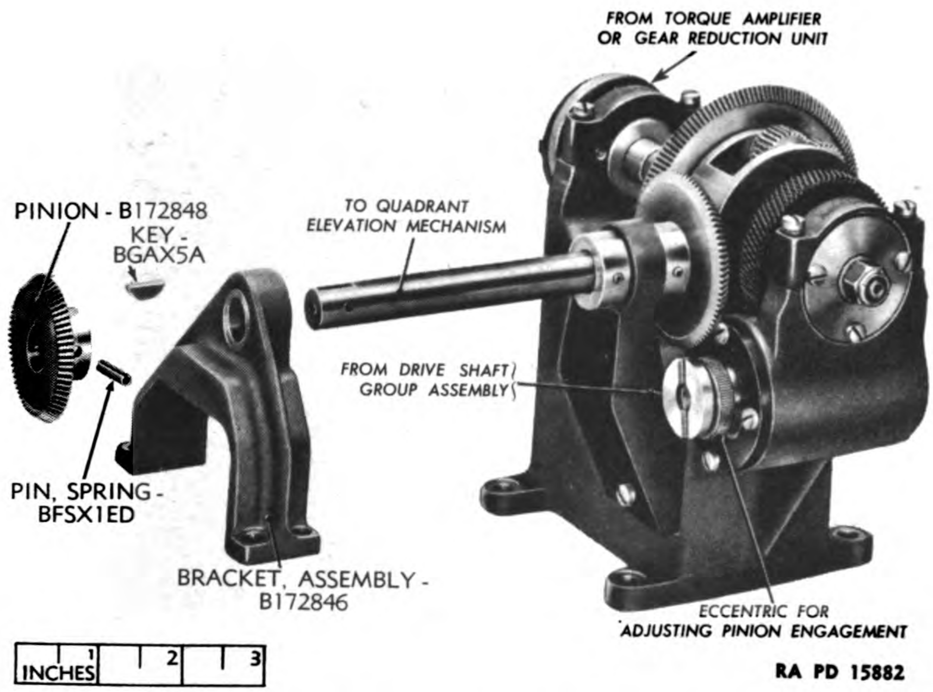


Figure 37 — Elevation Tracking Mechanism D43775 and Associated Parts

elevation mechanism, producing a displacement of the ball carriage with respect to the rack on the bar assembly, as illustrated in figure 40. This displacement is proportional to the cosine of the elevation angle. It may also be adjusted to correspond to different muzzle velocities by adjusting the position of the small roller assembly, a micrometer scale being provided. The spring shown in schematic figure 40 is actually a flat spring.

(2) The vertical deflection mechanism in Director M5A1 has a slightly different superelevation mechanism than the M5 to suit the different ball carriage, as seen by comparing figures 38 and 39. However, the superelevation mechanism in Director M5A1 could be used in older directors. Attached to the mechanism but not part of it, is a friction brake which presses against the back of the constant-speed disk. It is released by an electric solenoid whenever the power to the rate motor is on, but stops the mechanism immediately when the elevation limit switch is actuated. This prevents "coasting" into the mechanical stops and perhaps disengaging the telescope shaft gear segment. The brake should be adjusted occasionally.

(3) The elevation multiplying mechanism is similar to the azimuth multiplying mechanism described in paragraph 11 h, but it has a pair of bevel gears for coupling with the range mechanism in a different direction, as may be seen by comparing figures 23 and 38.

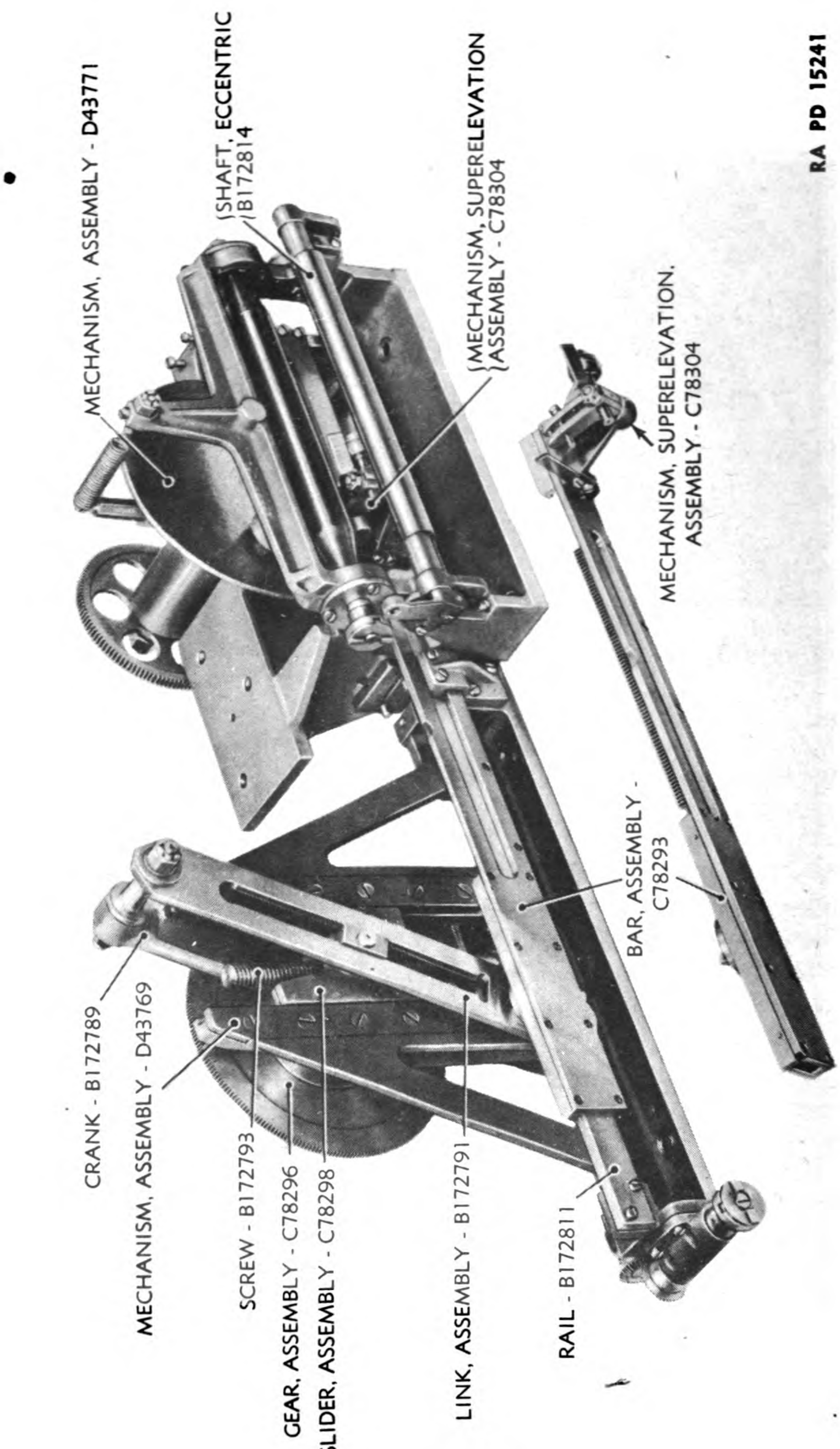


Figure 38 — Vertical Deflection Mechanism (Director M5 or M6)

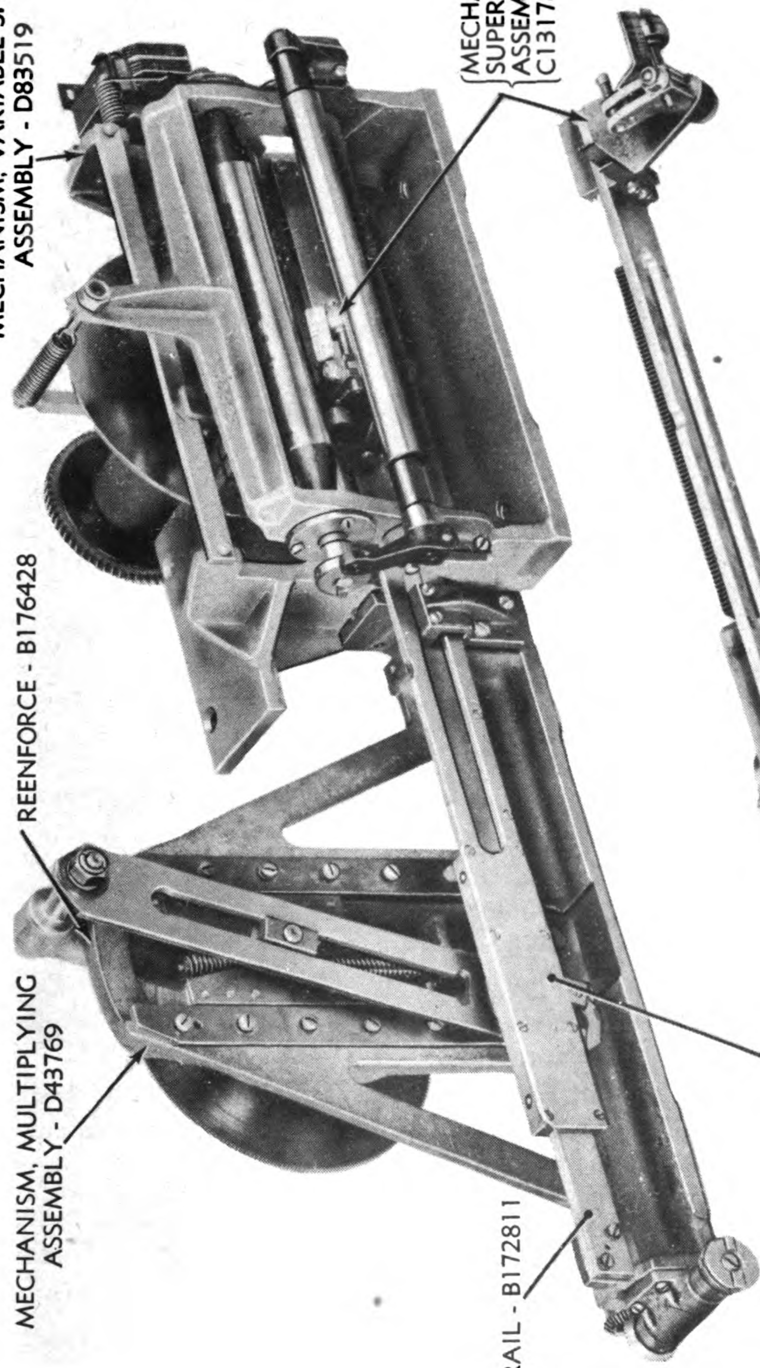


Figure 39 — Vertical Deflection Mechanism (Director M5A1)

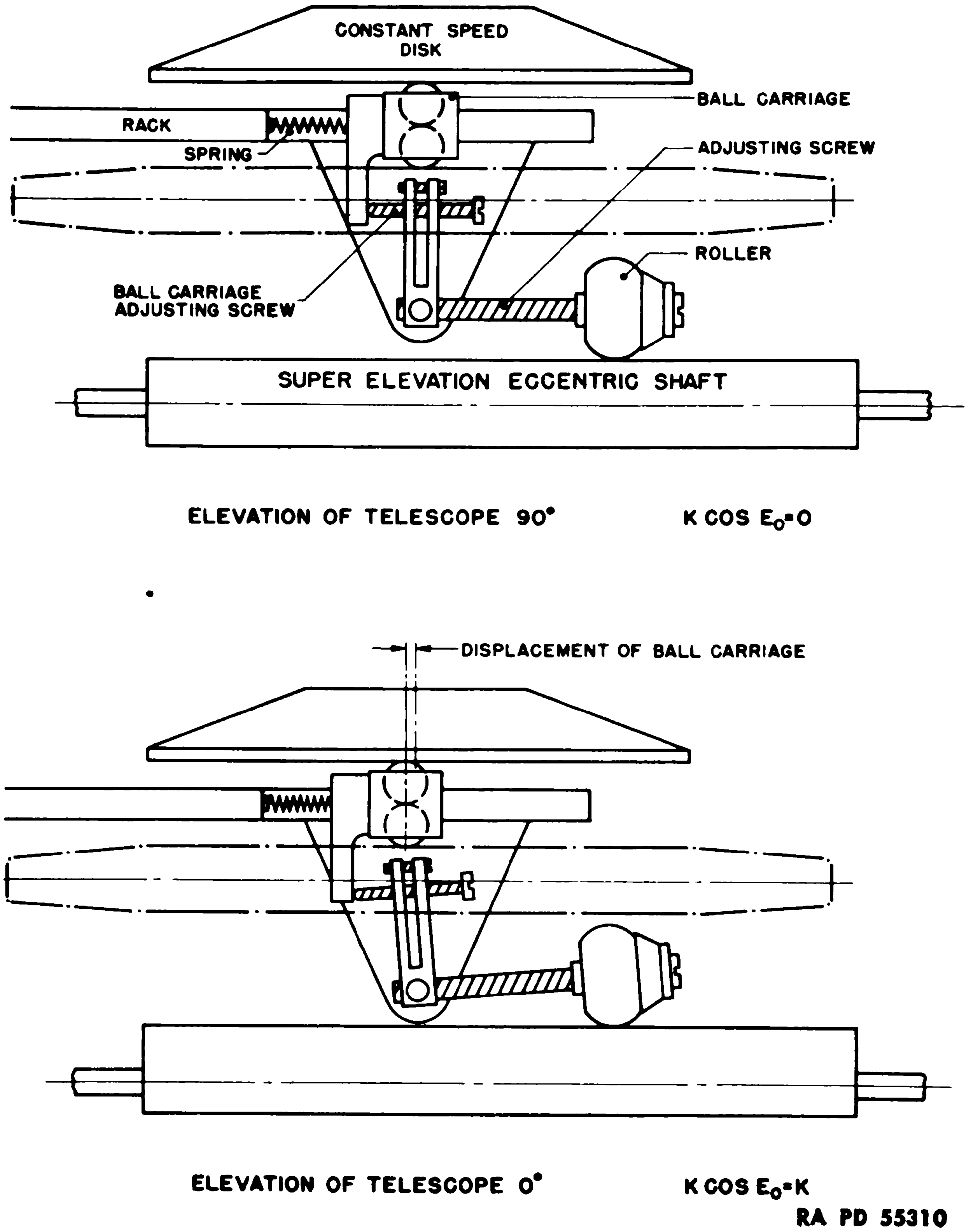


Figure 40 — Superelevation Mechanism — Schematic Diagram

f. **The Torque Amplifier (Director M5 or M6) and the Gear Reduction Unit (Director M5A1).** These are the same as the azimuth units described in paragraphs 11 i and j.

g. **Quadrant Elevation Mechanism** (fig. 41). The quadrant elevation differential is equipped with suitable bracket and gears. An adjustable idler on this mechanism transmits target elevation to the telescope shaft. The differential adds the target elevation (from the elevation tracking mechanism) and the deflection and superelevation data received from the multiplying mechanism. Both input gears have the antibacklash feature described in paragraph 11 k. The out-

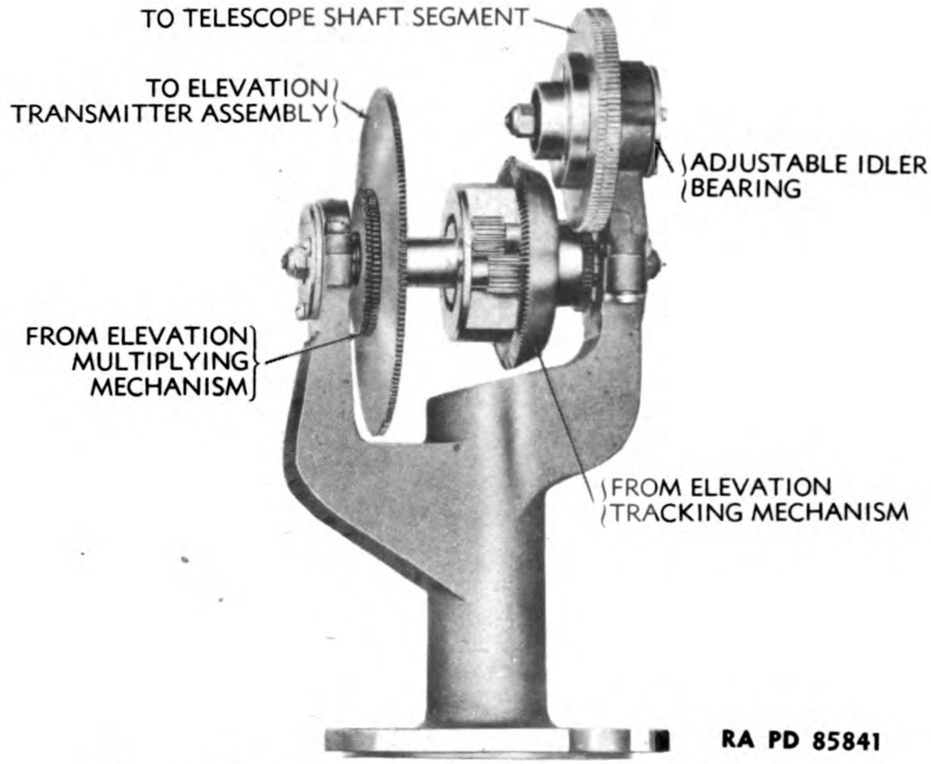


Figure 41 — Quadrant Elevation Mechanism D43783

put, known as the quadrant (firing) elevation, goes to the elevation transmitter assembly. Figure 42 shows the schematic relation of this unit to the others.

h. Elevation Transmitter Assembly.

(1) The transmitter assembly includes the synchronous transmitter or transmitters which send the quadrant elevation to the gun, a gear train, and two elevation dials.

(2) Director M5 employs only one (fine) elevation transmitter in elevation transmitter assembly D43824; however, a coarse elevation dial is provided which is geared and graduated to show approximately 100 degrees elevation in one revolution.

(3) Director M6 uses elevation transmitter assembly D43834 which is identical with assembly D43824 except for the transmitter voltage and frequency.

(4) Director M5A1. Elevation transmitter assembly D83539 employs a coarse and a fine transmitter, with a dial for each. It is identical with the azimuth transmitter assembly except for the coarse dial, which is graduated only in the 110-degree sector normally used. On older models of the Director M5A1, the coarse elevation transmitter dial is identical with the coarse azimuth dial.

i. The Telescope Shaft Assembly and Open Sight (figs. 42 and 45). The telescope shaft assembly includes the flanges on which the

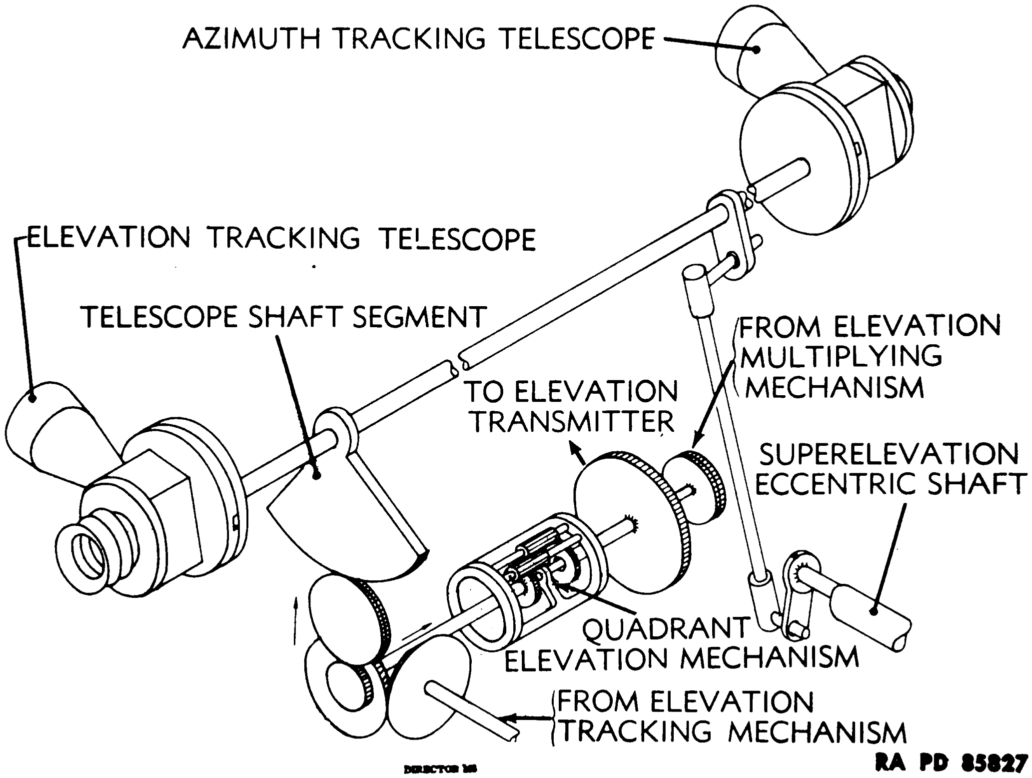


Figure 42 – Quadrant Elevation Mechanism, Telescope Shaft, and Superelevation Eccentric Connection – Schematic Diagram

telescopes are mounted, two bearings, the segment gear (which is driven from the idler on the quadrant elevation mechanism), and a lever which actuates the superelevation eccentric shaft. The azimuth telescope flange has an adapter assembly which permits the two telescopes to be alined in elevation. The open sight, which is located at the rear corner of the case for rough sighting by the range setter, is moved in synchronism with the telescopes by a link from the segment gear. A thumbscrew on the open sight permits its adjustment in elevation.

13. RANGE MECHANISM.

a. The range mechanism consists of the shafts and gears which transmit the range data from the handwheel to the azimuth and elevation and multiplying mechanisms, and an index and scale which show what range in yards is being inserted (figs. 46 and 47).

b. The range setting of the multiplying mechanisms depends on the time of flight of the projectile to its target, and consequently on the muzzle velocity. Therefore, separate scales are provided for the 37- and the 40-mm guns, calibrated in yards range to agree with the different muzzle velocity of each gun. The extra scale is carried in the accessory chest.

DESCRIPTION

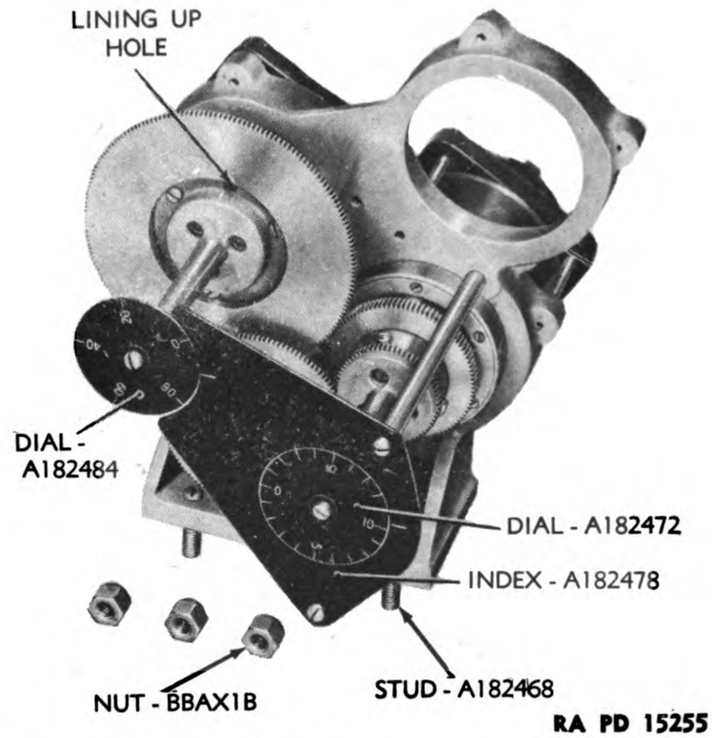


Figure 43 — Elevation Transmitter Assembly D43824 (Director M5) or D43834 (Director M6)

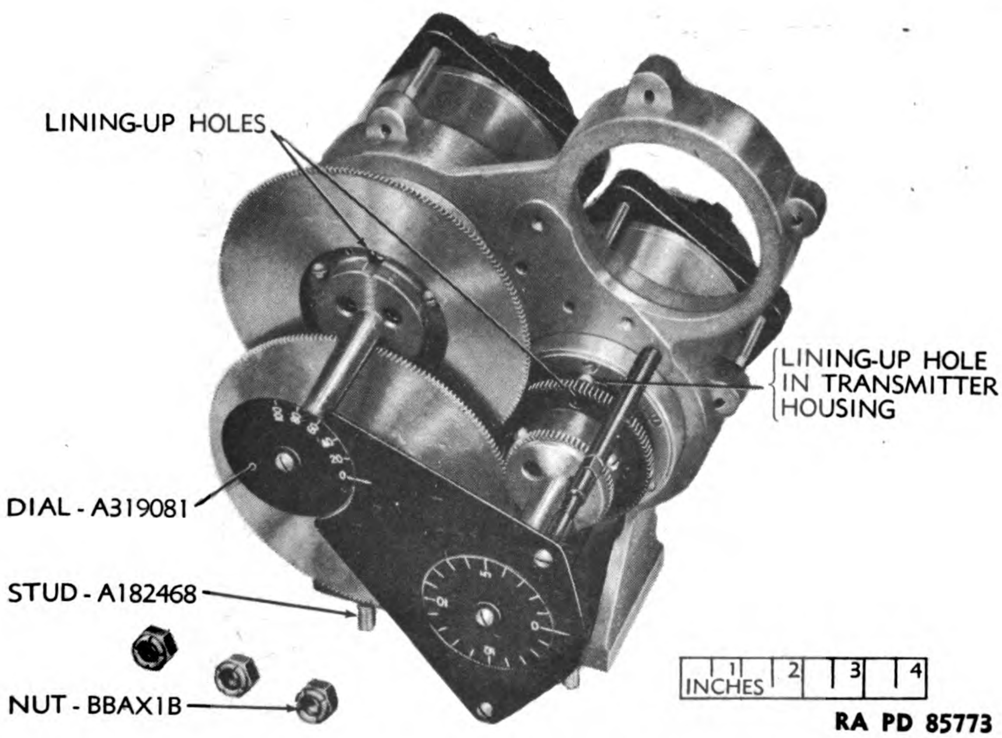


Figure 44 — Elevation Transmitter Assembly D83539 (Director M5A1)

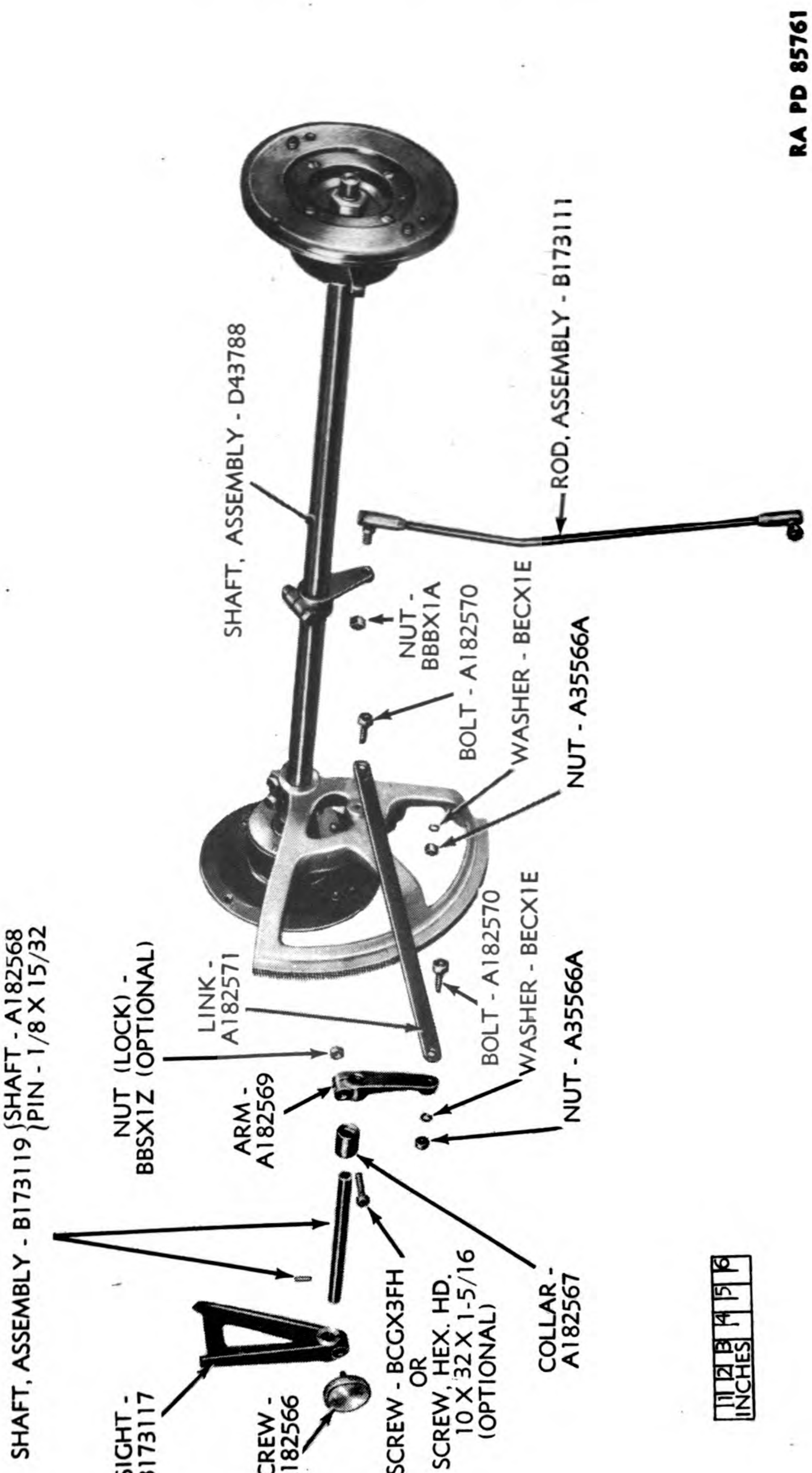


Figure 45 — Telescope Shaft Assembly and Open Sight

DESCRIPTION

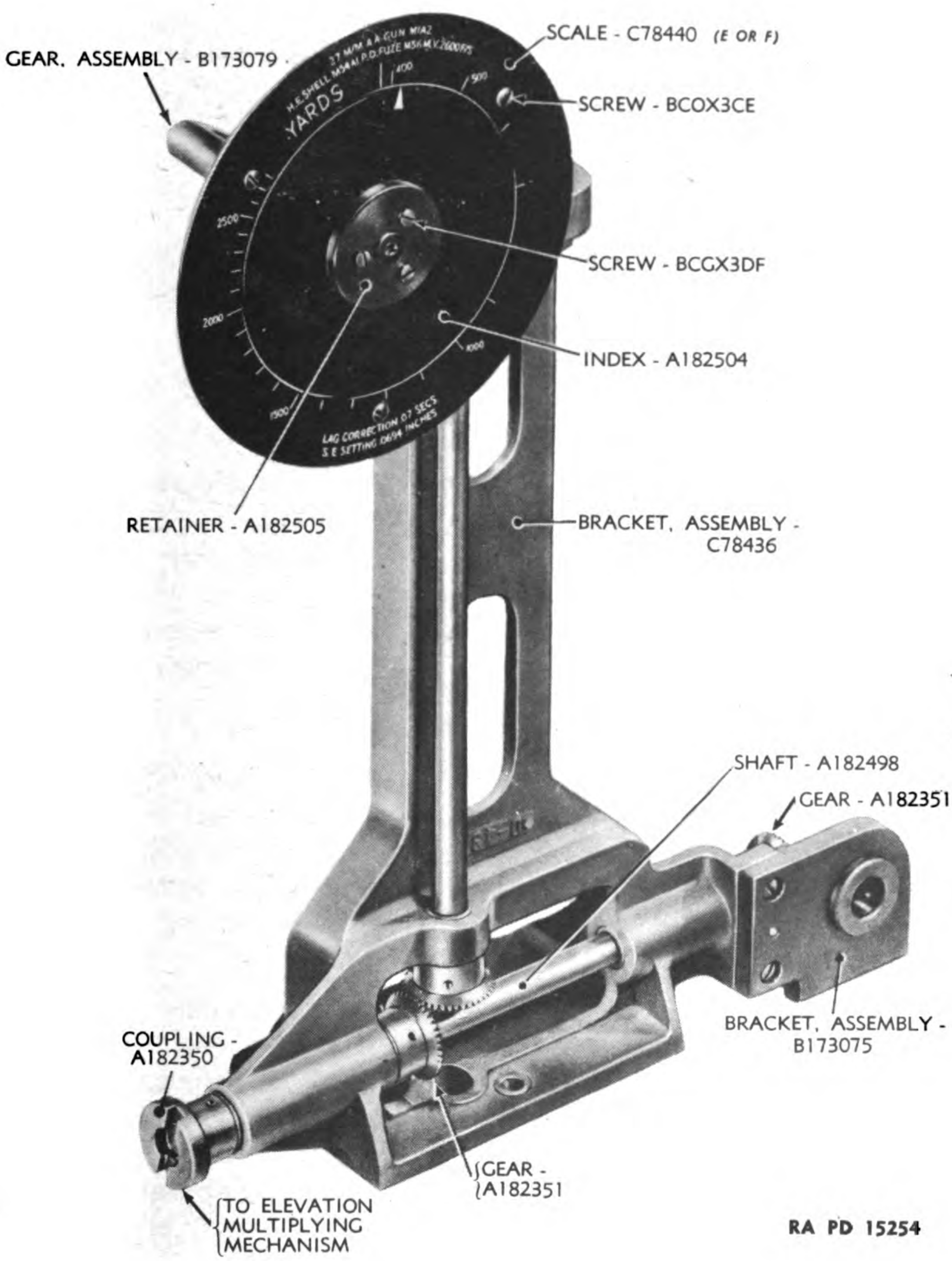


Figure 46 — Range Mechanism Assembly D43789

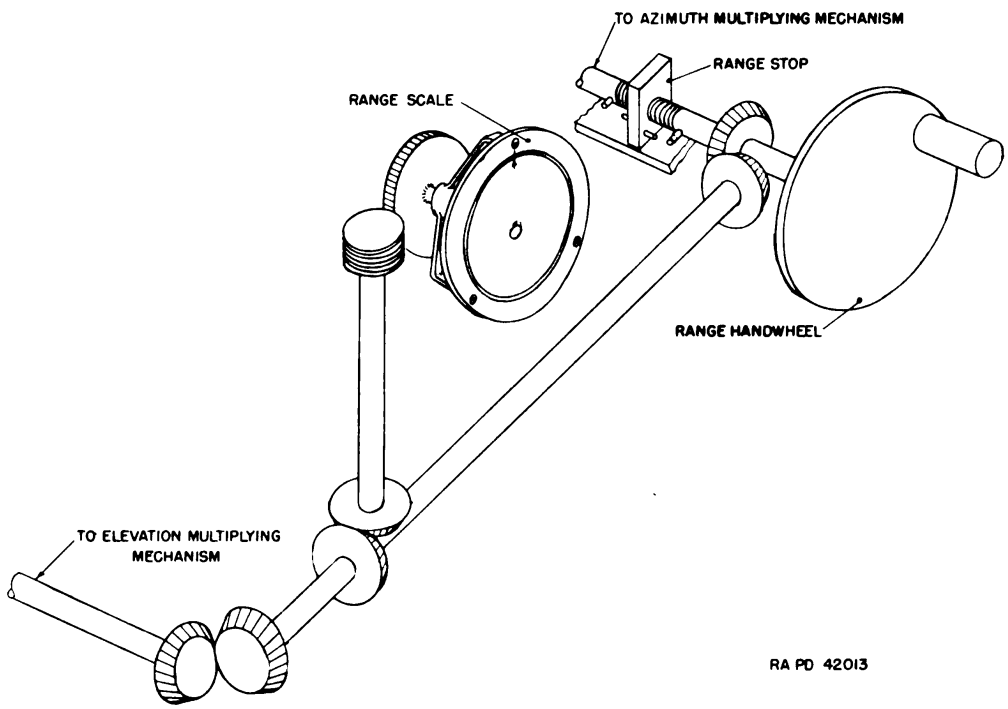


Figure 47 — Range Mechanism — Schematic Diagram

c. Older Directors M5 and M6 were furnished with four additional scales calibrated for lower muzzle velocities of worn 37-mm guns. The differences between scales, however, were less than the possible errors in estimating range, and they are no longer furnished.

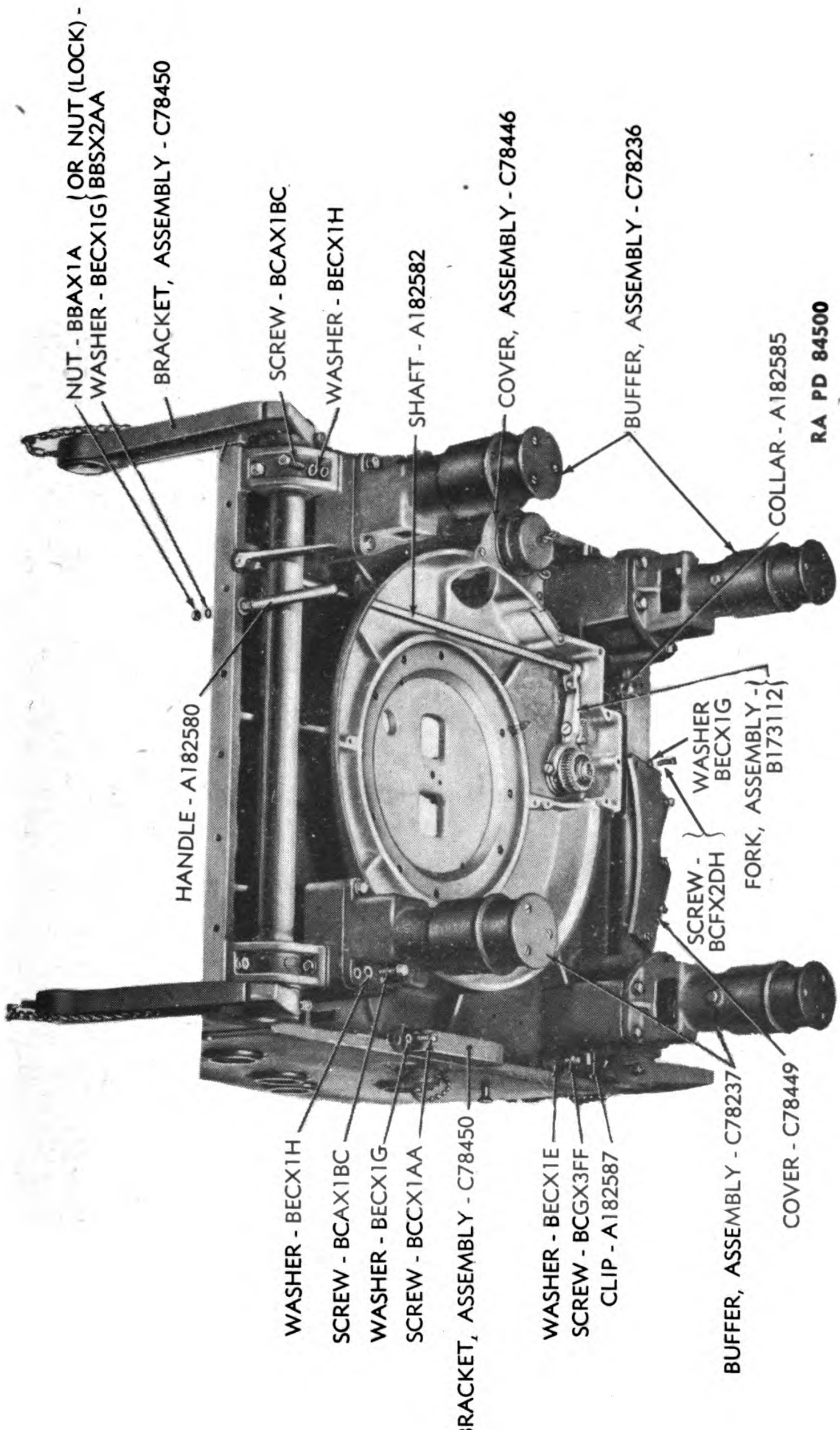
14. BUFFERS AND CARRYING BRACKETS.

a. Four buffer assemblies, two each C78236 and C78237, are bolted to the under side of the director base to support the director when it is not mounted on the tripod (figs. 48 and 49). The assemblies are identical except that the body castings of the right- and left-hand buffers are reversed. Each buffer contains a spring to cushion and distribute the weight of the director evenly.

b. Carrying Bar Brackets. Two carrying bar bracket assemblies C78250 (figs. 48 and 50) are fastened to the base casting for convenience in lifting the director. They accommodate the same carrying bars which are used to carry the packing chest. Pins, chained to the arms, may be inserted to prevent slipping on the bars. The arms swing downward and are held out of the way during operation of the director by means of two clips A182587.

15. ELECTRICAL COMPONENTS.

a. The electrical parts of the director are the motors, the transmitters, the lighting transformer and lamps, the switches, and the



RA PD 84500

Figure 48 — Under Side of Base, Showing Assemblies Attached to It

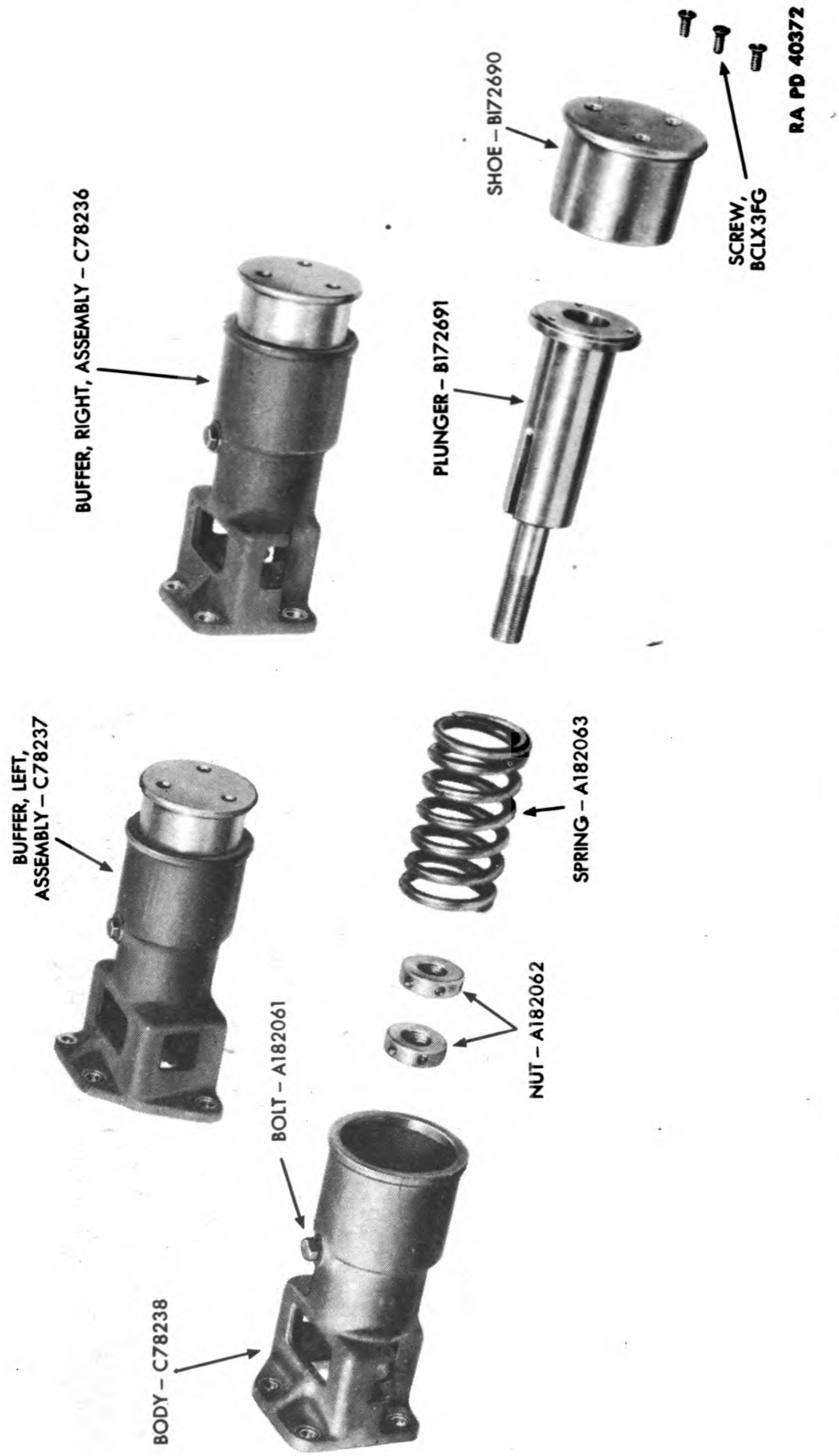


Figure 49 — Buffer Assemblies — Assembled and Exploded Views

DESCRIPTION

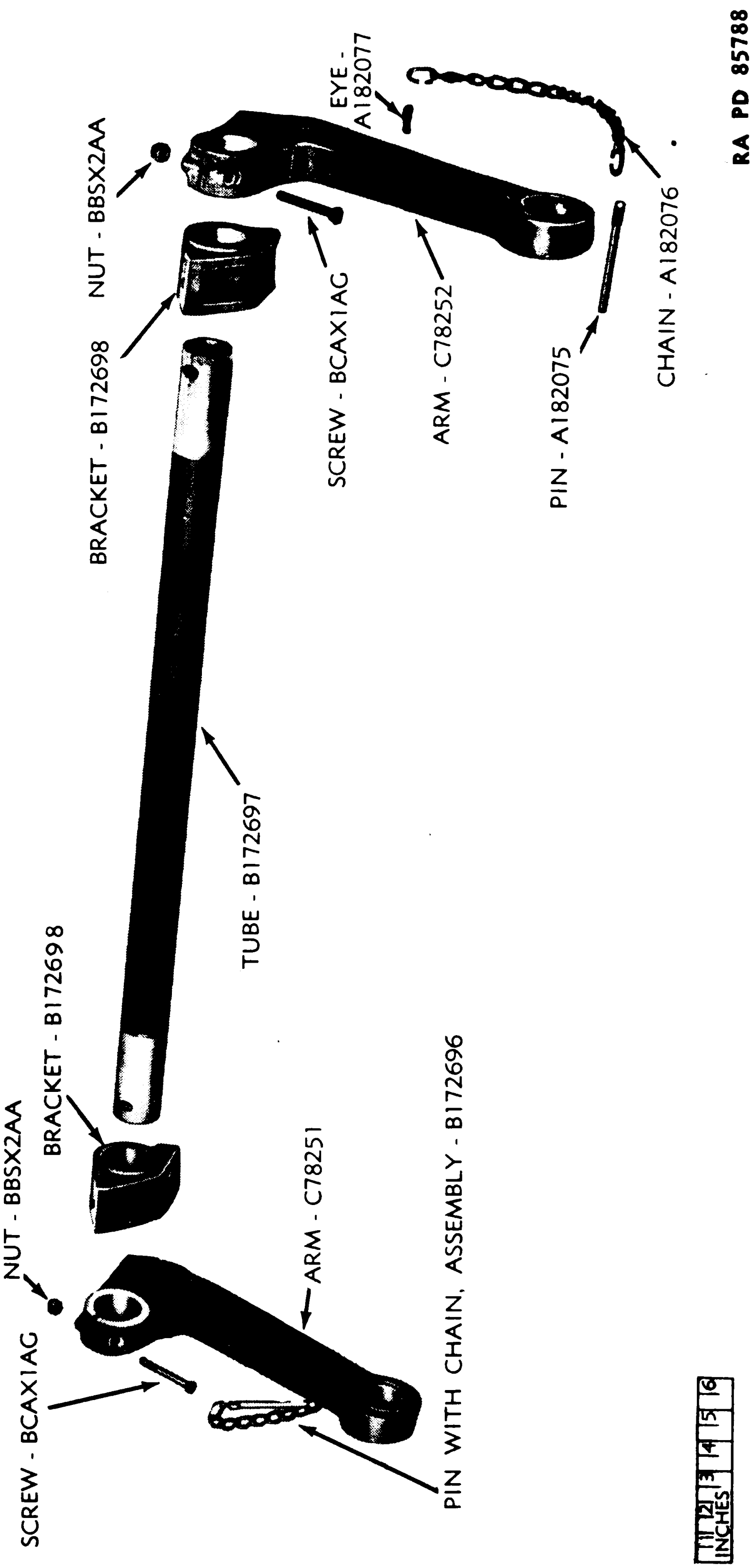


Figure 50 — Carrying Bar Bracket, Assembled C78250

wiring. Earlier Directors M5 and M6 also had a fuse block which was mounted on the bracket of the elevation variable-speed mechanism. The wiring diagrams in figures 51, 52, and 53 will identify which type of wiring is used in a particular director.

b. Directors M5 and M5A1 operate on 115-volt, 60-cycle power. Director M6 operates on 50-volt, 50-cycle power. The same type of motor is used in each by making adjustments, but the transmitters, lighting transformer, and fuses (where used) are different in Director M6 than in other models.

c. Each director receives power from Generating Unit M5. The generator voltage and frequency adjustment must agree with that of the director being used, except that the generator may be adjusted for a slightly higher voltage to compensate for voltage drop in the cable under load. For Director M6, 130 volts at the generator is reduced to 50 volts at the director by a transformer in a junction box. Generating Unit M6 can also be used in place of Unit M5 with certain modifications to obtain 3-phase, 60-cycle supply.

d. **Motors.**

(1) The two motors in the constant-speed drive and the two motors on the torque amplifier (used in Directors M5 and M6 only) are the same except for minor mechanical details. They are 3-phase Y-connected, totally enclosed motors rated at 1/40 horsepower in a temperature range of minus 40° F to plus 125° F. The rated speed at 115 volts, 60 cycles is 3,450 rpm and at 50 volts, 50 cycles is 2,850 rpm. The motors may be converted from one voltage range to the other by shifting a set of links on the terminal block.

(2) The wiring diagram for Director M5A1 (fig. 53) shows that the Z-terminals of the constant-speed motors are connected to terminal block No. 15, which supplies the Y-phase to the transmitters. Terminal block No. 8, the Z-power phase, supplies the Y-motor terminals. This connection permits the same motors to be used in all directors but reverses their direction of rotation in Director M5A1.

e. **Transmitters.**

(1) Director M5 has three type VII synchronous transmitters and Director M6 has three type VIII synchronous transmitters; two are mounted on the azimuth side, one each for coarse and fine control, and one for fine control only, on the elevation side.

(2) Director M5A1 has four type VII synchronous transmitters, for coarse and fine control of both azimuth and elevation, providing self-synchronous control when used with Remote Control System M9 or M10.

(3) A transmitter is a device which transmits electrically the angular position of its rotor. The rotor is supplied with single-phase

DESCRIPTION

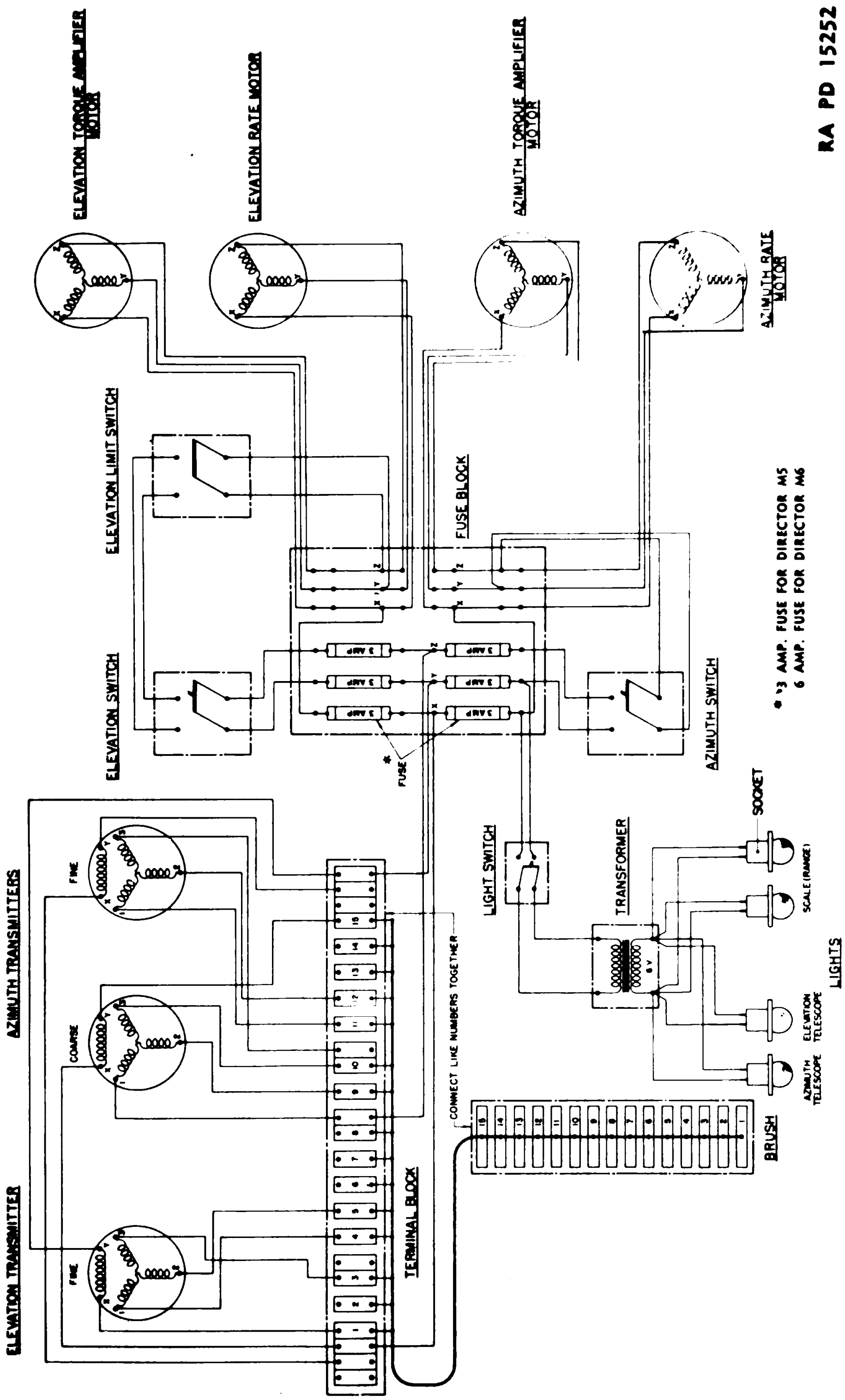


Figure 51 — Wiring Diagram for Directors M5 and M6, Old Type

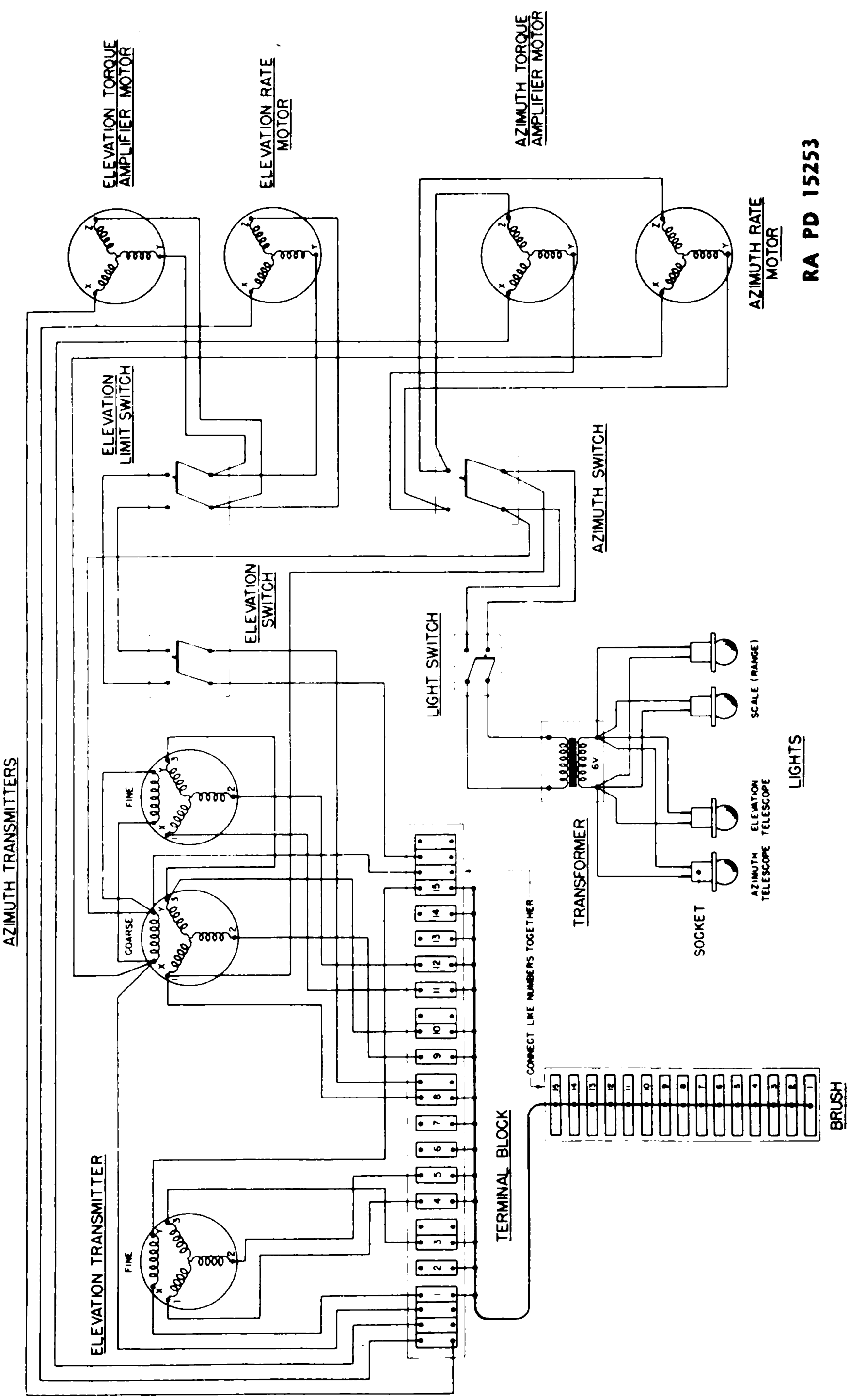


Figure 52 — Wiring Diagram for Directors M5 and M6, New Type

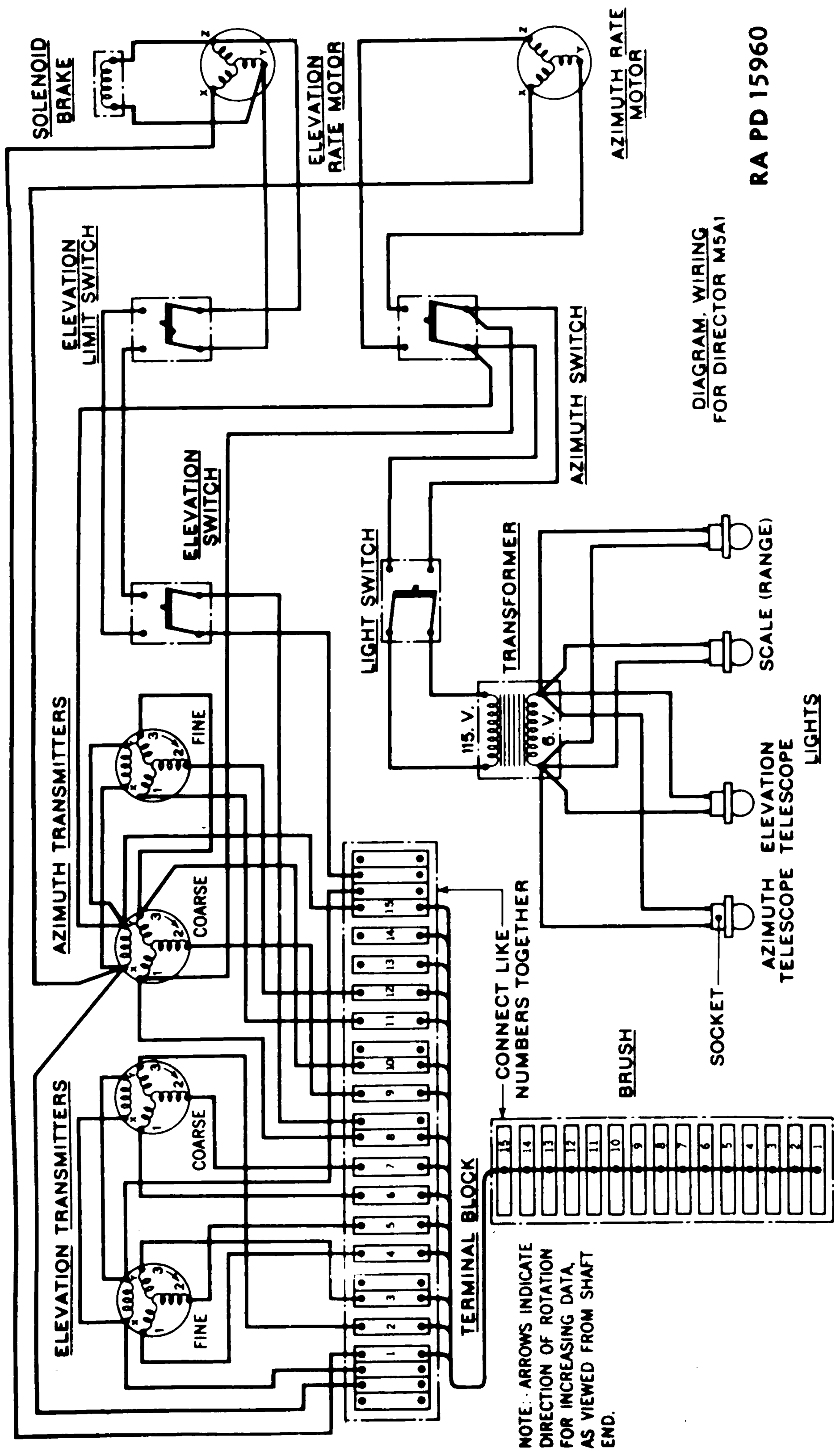


Figure 53 — Wiring Diagram for Director M5A1

alternating current which induces a set of voltages in the stator, and these are transmitted to a device known as a synchronous differential. The differential compares the angular position of the transmitter with the angular position of the gun, and actuates hydraulic controls on the gun mechanism to bring them into synchronism. The transmitters are designed to operate through a temperature range of minus 45° F to plus 125° F.

f. The wiring consists of a 15-conductor cable connecting the contact rings in the support body with the main terminal block, and a wiring assembly connecting all electrical units to the terminal block. A wiring diagram is attached to the inside of the rear cover plate of later Directors M5A1.

g. Fuses in the earlier directors protect all three phases of both azimuth and elevation power supply, as shown in wiring diagram figure 51. The lighting transformer is also supplied through the fuses for phases X and Y on the azimuth side. Later directors do not have a fuse block. When no fuses are available for older directors, they may safely be shorted out in emergency, preferably retaining the good fuses in phases X and Y on the azimuth side because of the additional protection to the lighting transformer.

16. TRIPOD.

a. Tripod M7 (fig. 54) is of welded tubular steel construction. It has three adjustable plunger assemblies, shown in figure 56, which permit the director to be levelled.

b. Tripod M19 (fig. 55) is of similar construction but is made with threaded joints so that it can be disassembled and packed in a smaller space. This tripod has been furnished only with later Directors M5A1, but is interchangeable with Tripod M7.

17. TELESCOPES.

a. Two elbow telescopes, one mounted for azimuth tracking and one for elevation tracking, are used on each director. They are fine optical instruments and should be treated as such.

b. Elbow Telescope M17 is an 8-power erect-image instrument having a field of view of 6 degrees and a diopter scale graduated from minus 4 to plus 2 diopters. The reticle pattern consists of a vertical and a horizontal cross line (fig. 58). Four internal filters, clear, neutral, amber, and red, may be brought into position as required for various lighting conditions. A rubber eye shield protects the observer's eye and blocks out stray light. The lamp bracket which illuminates the cross lines may be reversed so that its opening will be downward for either azimuth or elevation mounting.

DESCRIPTION

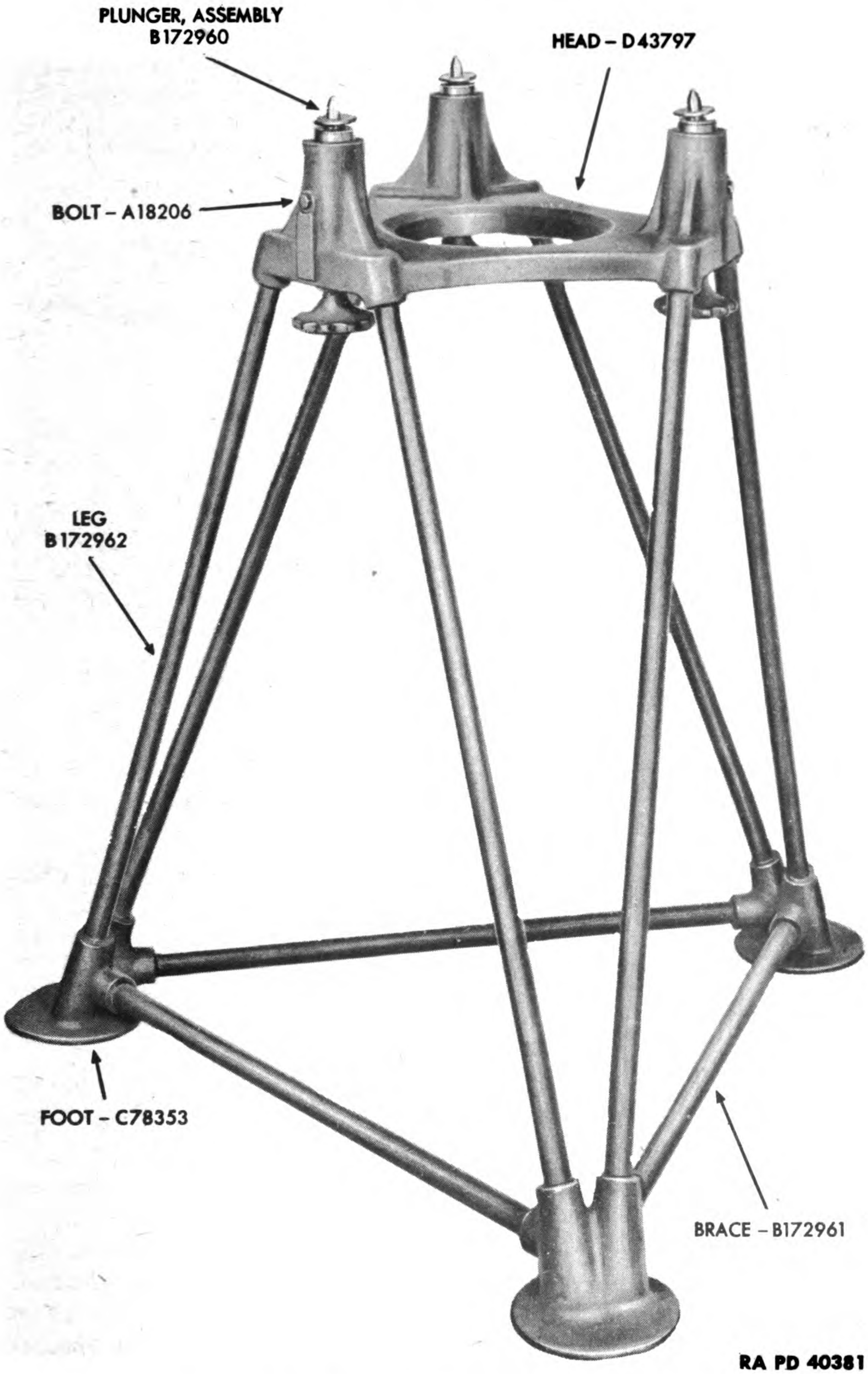


Figure 54 — Tripod M7 (Welded Assembly)

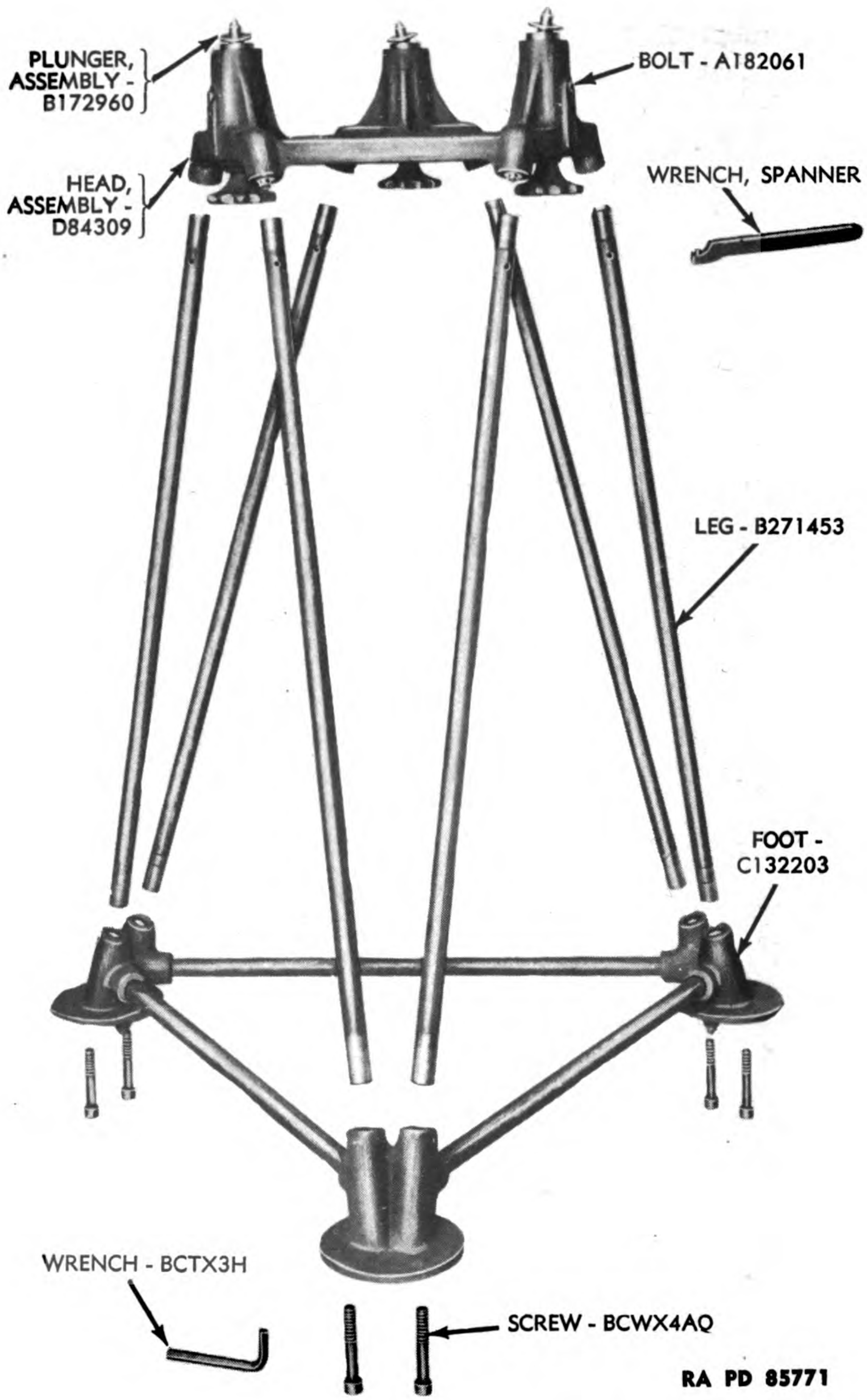


Figure 55 — Tripod M19 — Exploded View

DESCRIPTION

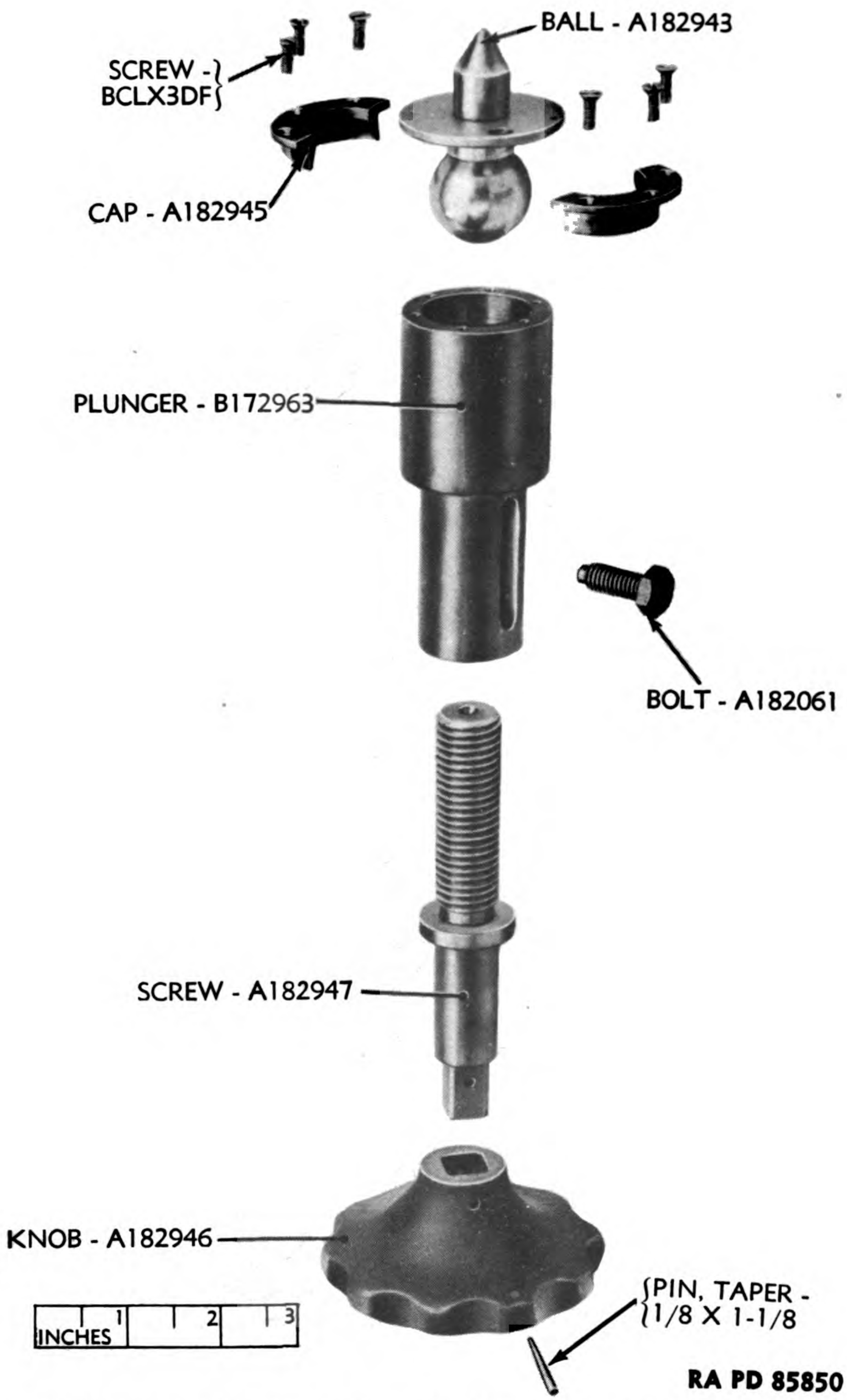
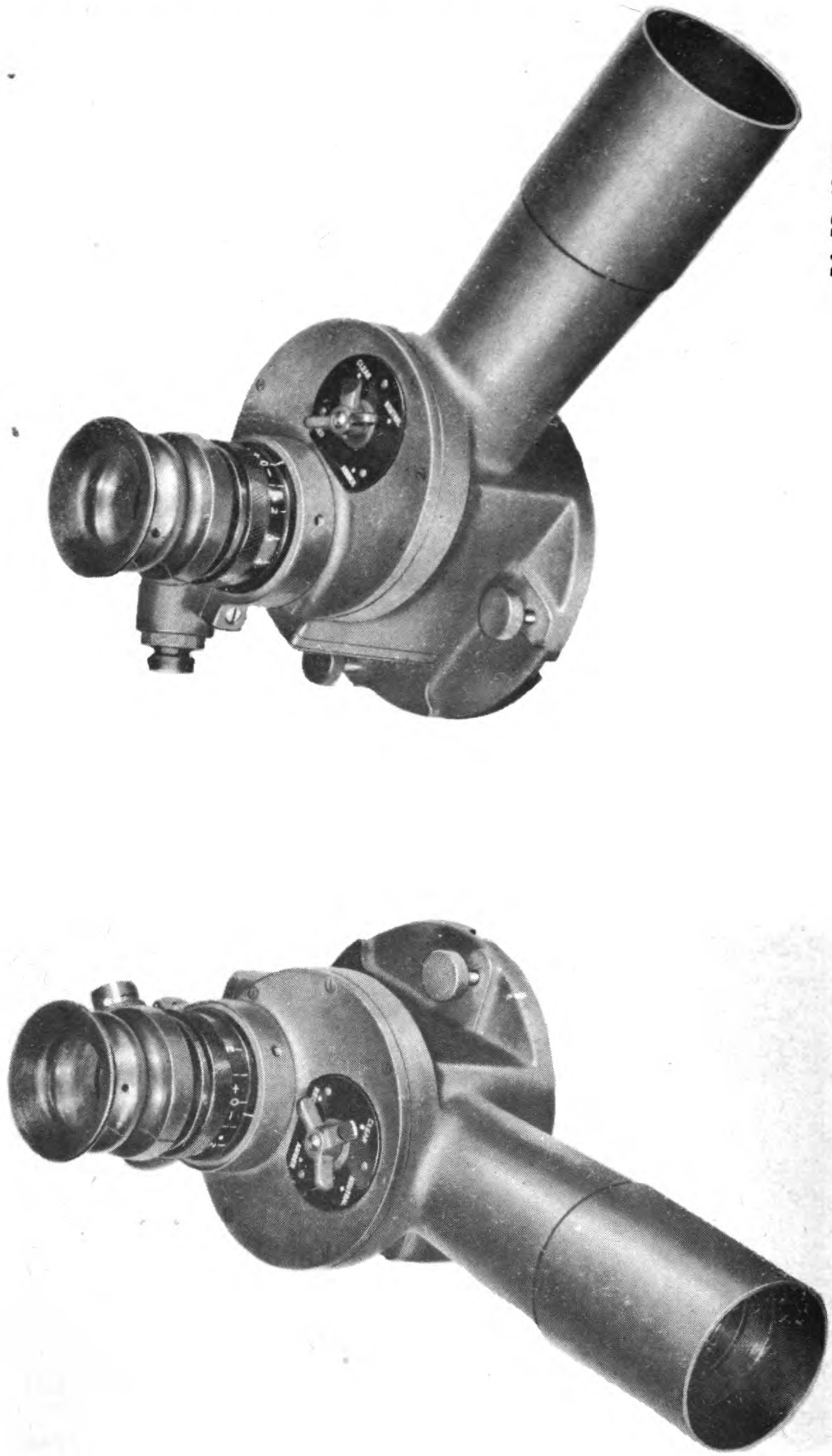


Figure 56 — Tripod Plunger Assembly B172960 and Associated Parts



RA PD 40457

Figure 57 — Elbow Telescope M17

DESCRIPTION

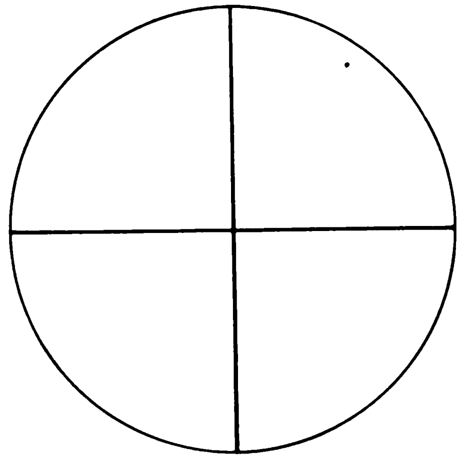


Figure 58 — Cross Line Reticle of Elbow Telescope M17

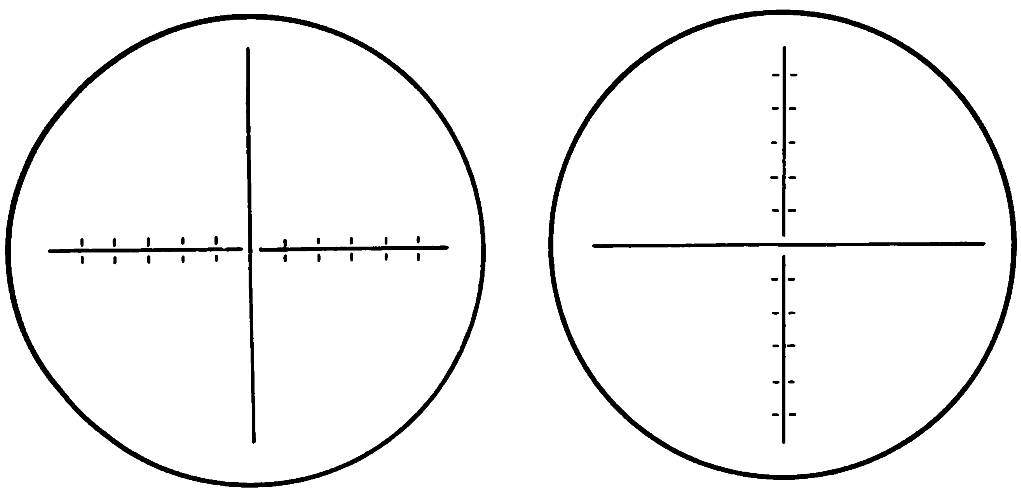


Figure 59 — Reticle Pattern in Elbow Telescopes M75C and D

c. Elbow Telescopes M75C (Azimuth) and M75D (elevation), to be supplied with later Directors M5A1, have a reticle pattern consisting of one unbroken cross line for tracking, and an interrupted or broken cross line for reference (fig. 59). The broken line of each reticle is graduated at 10-mil intervals. This pattern eliminates confusion between elevation and azimuth lines at high elevations. These telescopes also have improved sealing against internal fogging, and a special nonreflecting coating on the optics.

Section III

ACCESSORIES

18. ACCESSORIES FOR DIRECTORS M5 AND M6.

a. The additional equipment supplied with Directors M5 and M6 consists of the packing chest, the canvas cover, the accessory chest, and the tool chest.

b. The packing chest (fig. 60) is a large wooden box used for storing and transporting the director. It is constructed in two parts which are held together by draw bolts or by screws inserted through metal strips. Matching arrows painted on the lid and body indicate the proper alinement. Padded blocks in the inside of the chest prevent the director from moving. In later chests these blocks are felt-cushioned. In earlier chests, two supports on the floor of the body were provided for mounting the telescopes. Later chests have the telescope box shown in figure 60. Brackets are provided for the insertion of carrying bars, and a pin chained to each bracket may be inserted to lock the bar to the bracket.

c. The canvas cover is used to protect the director for short periods when it is mounted on the tripod.

d. The accessory chest may be of either steel or wood construction, shown in figure 61 or 62. One chest is issued with each 4 directors and contains 1 torque amplifier assembly, 1 constant-speed motor assembly, 1 synchronous transmitter assembly, 10 electric lamps, 2 sets of auxiliary range scales, and 2 level vial bracket assemblies (SNL F-209).

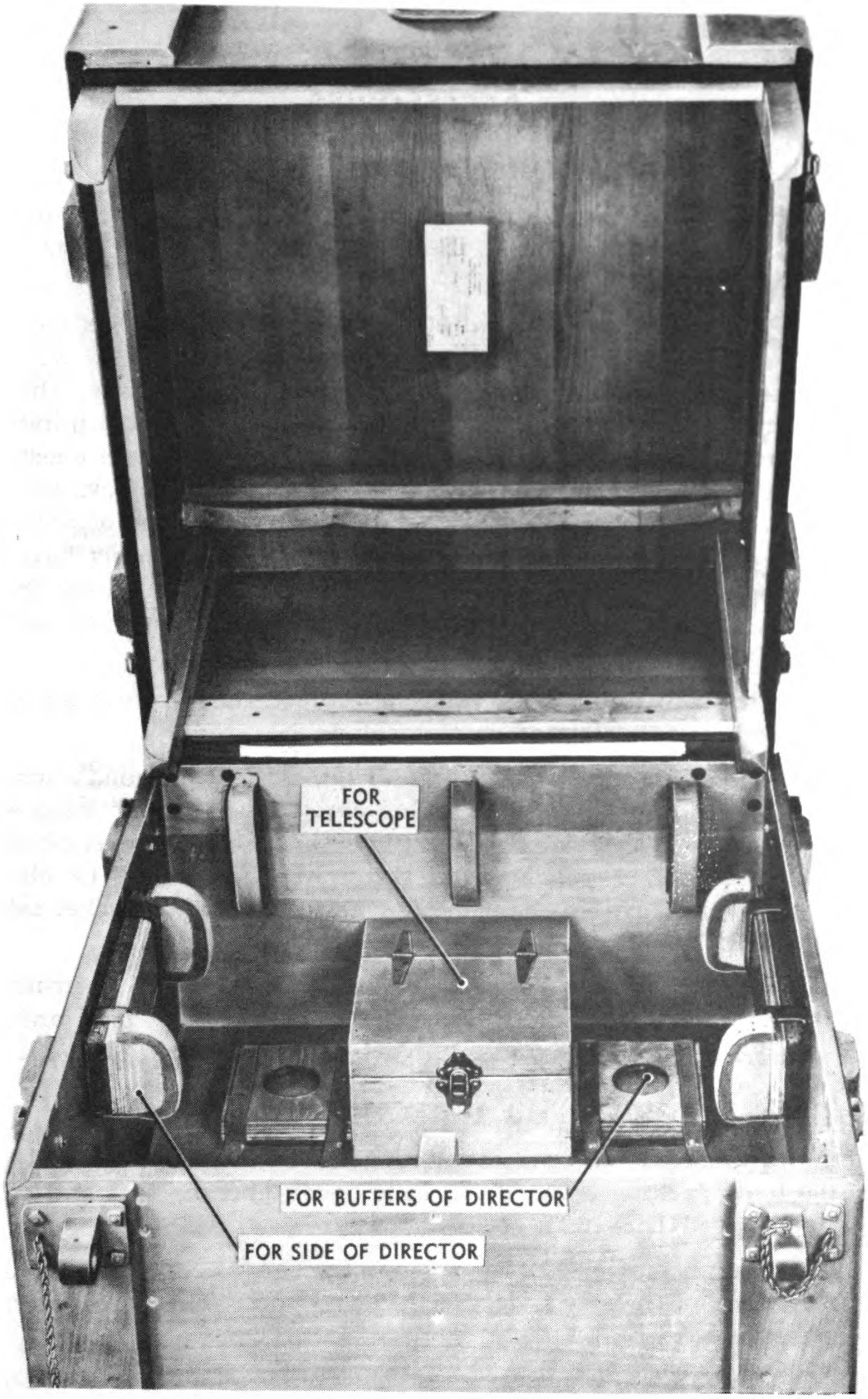
e. The tool chest (fig. 63) carries the tools and instruments shown in figures 64 and 65, also certain spare screws, pins, and terminals. One chest is issued with each four directors (SNL F-209).

19. ACCESSORIES FOR DIRECTOR M5A1.

a. The additional equipment supplied with Director M5A1 consists of the packing chest, the canvas cover, and the tool and accessory chest (SNL F-209).

b. The packing chest (fig. 60) and the canvas cover are the same as furnished with later Directors M5 and M6. They are described in paragraph 18 **b** and **c**.

c. The tool and accessory chest, shown in figure 66, is issued with each four Directors M5A1. It carries both the tools shown in figure 67 and the following spare parts: 1 constant-speed motor assembly C78432, 1 transmitter assembly B175809, 1 Elbow Telescope M17, 2 cable and plug assemblies, 1 power switch, 1 light switch, 1 level



RA PD 15599

Figure 60 — Packing Chest

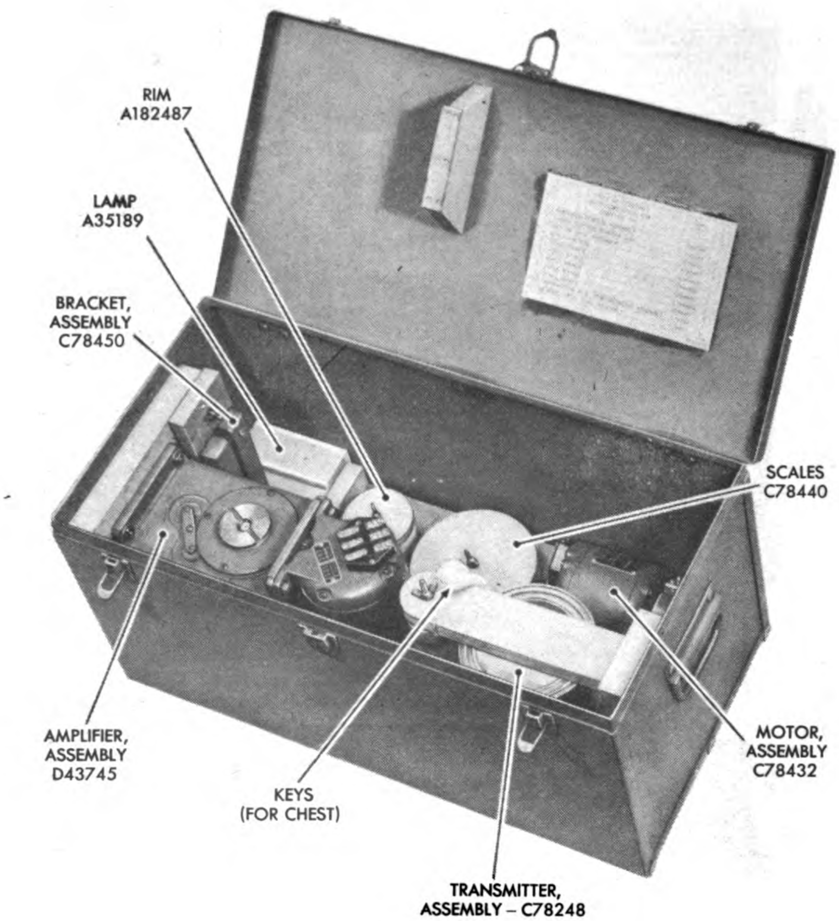
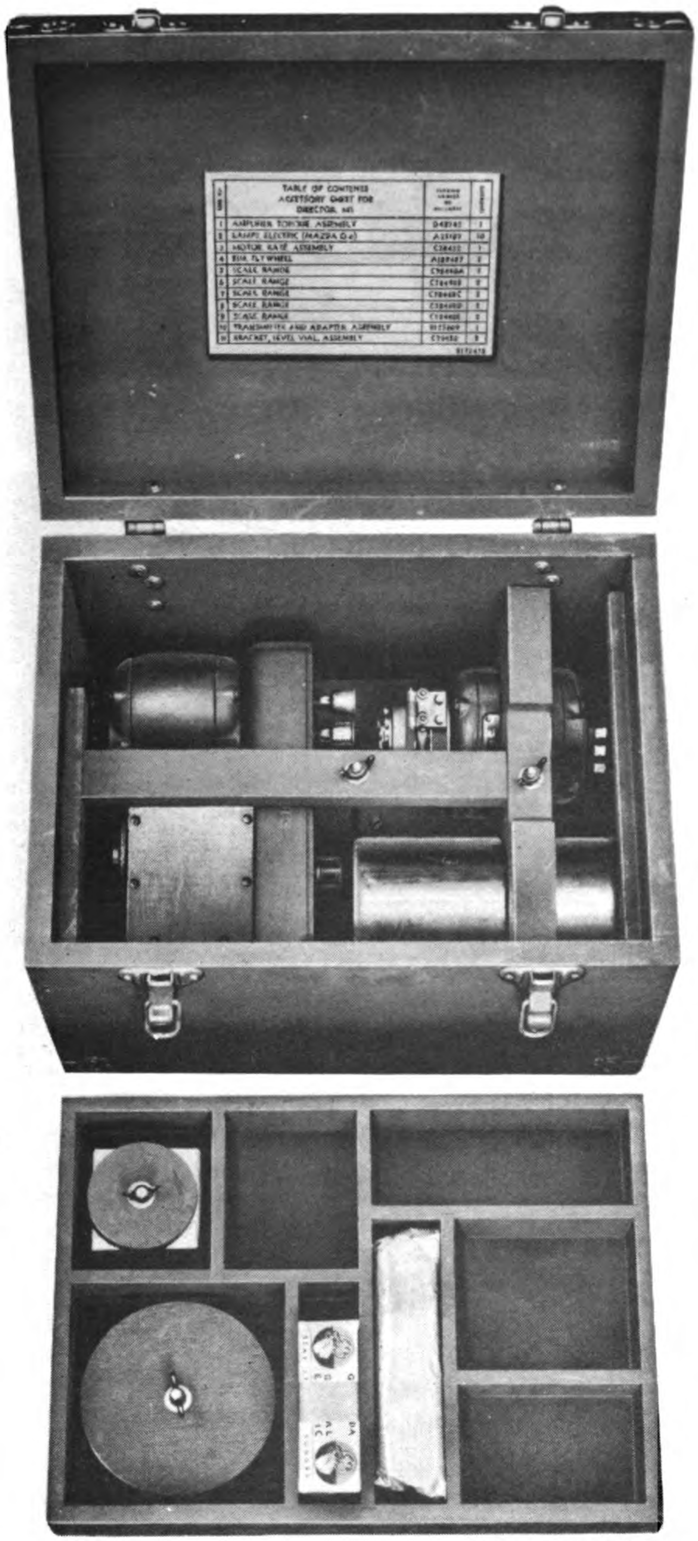


Figure 61 — Steel Accessory Chest (Directors M5 and M6)

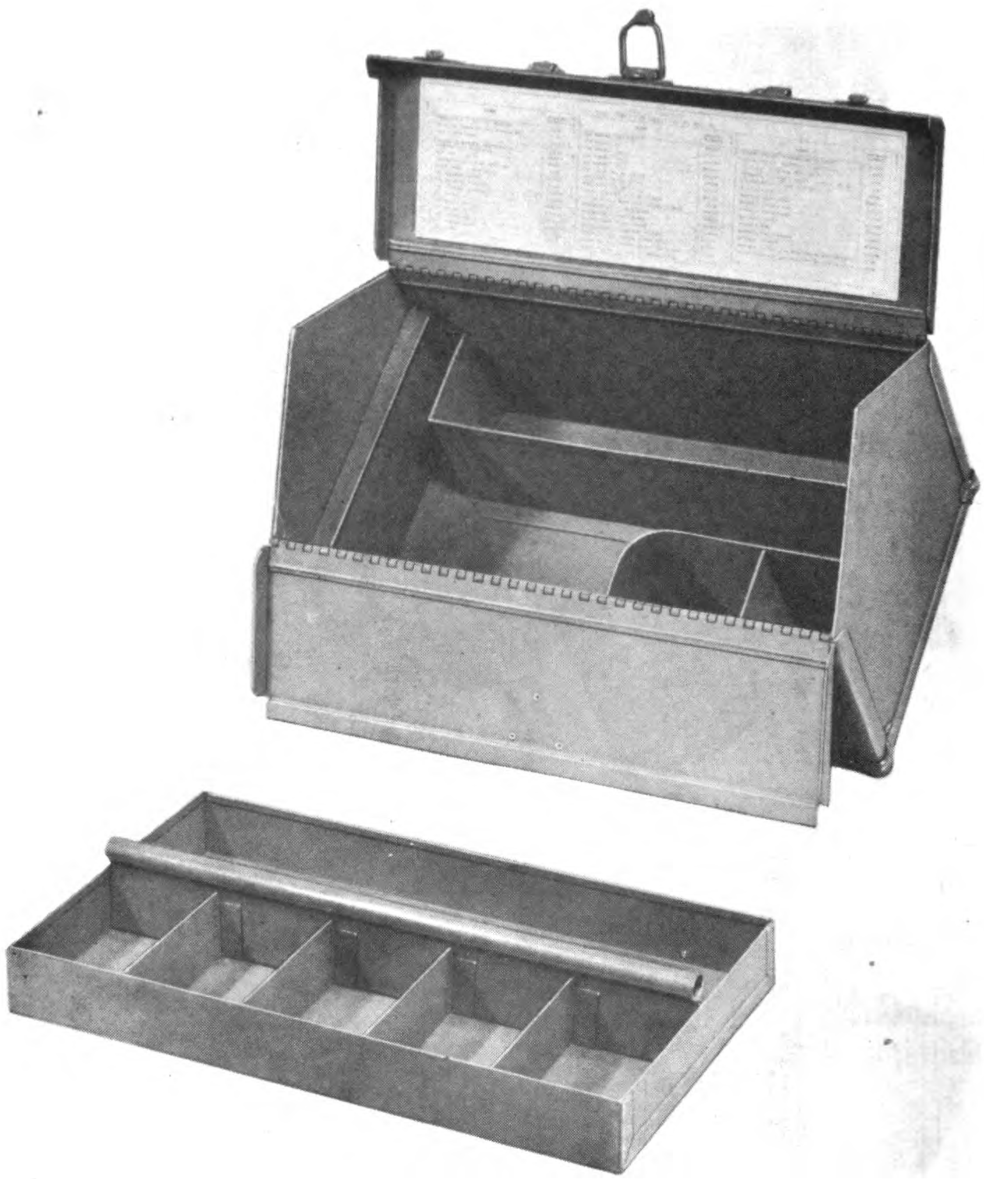
vial, 4 range scales C78440E, 4 range stop pins, 25 feet of insulated wire, and assorted screws and small hardware. A bag is supplied for the tools.

ACCESSORIES



RA PD 84399

Figure 62 — Wooden Accessory Chest (Directors M5 and M6)



RA PD 40385

Figure 63 — Tool Chest — Opened

ACCESSORIES

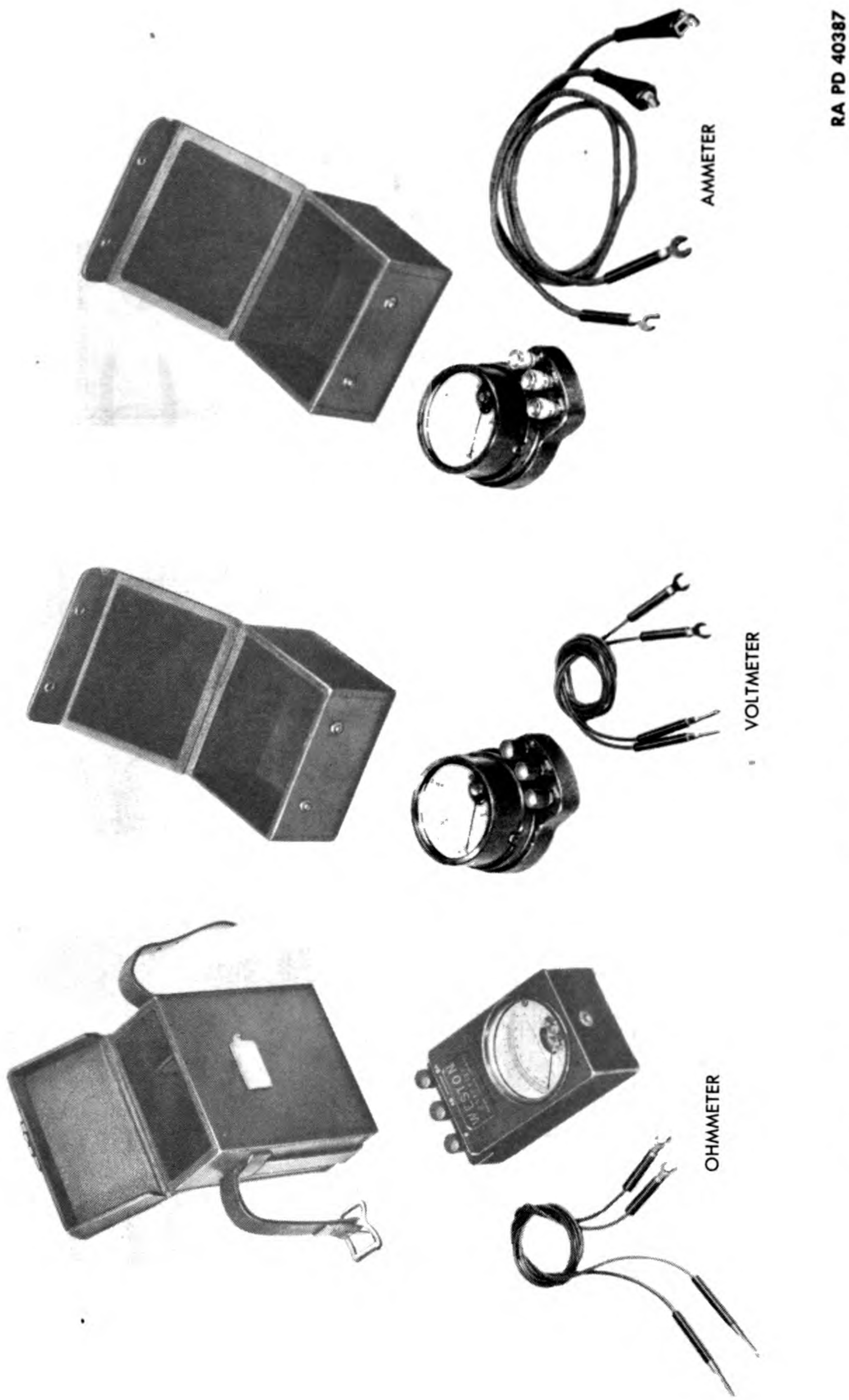


Figure 64 — Instruments Supplied in Tool Chest (Directors M5 and M6)

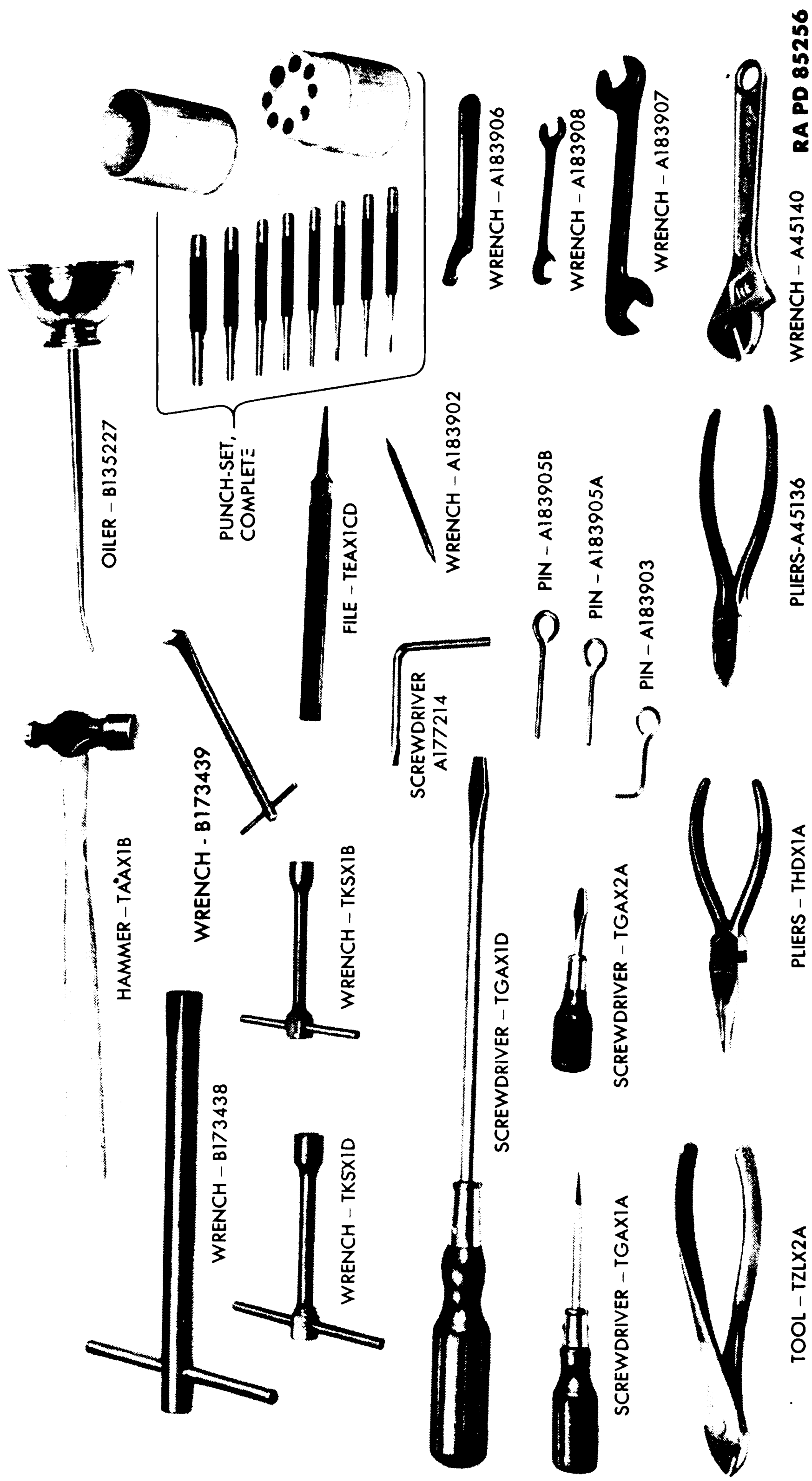


Figure 65 — Tools Carried in Tool Chest (Directors M5 and M6)

ACCESSORIES

RA PD 84400

Figure 66 — Tool and Accessory Chest (Director M5A1)

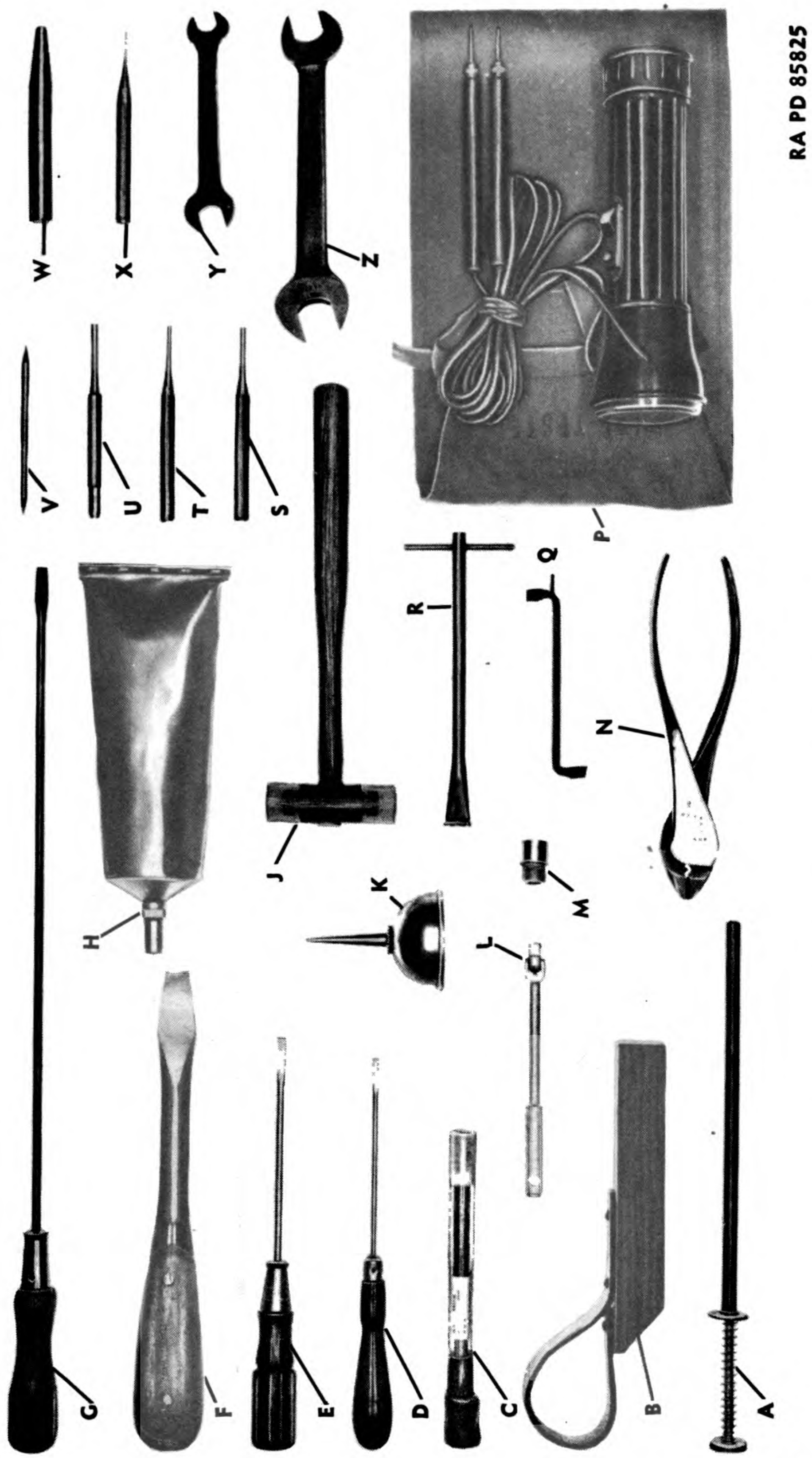


Figure 67 — Tools Carried in Tool and Accessory Chest (Director M5A1)

A — TOOL, HANDY HOLDING - BONNEY K48
B — WRENCH, STRAP - A39123 *(FOR ORIENTING NUT)*
C — BRUSH, CAMEL HAIR - SBAX3E *(IN SEALED CONTAINER)*
D — SCREWDRIVER - TGCX1E
E — SCREWDRIVER - 4-1/2" X 3/16"
F — SCREWDRIVER - TGBX1A
G — SCREWDRIVER, SQ. SHANK - 13-3/4" X 7/32"
H — GREASE, LUBRICATING, SPEC.
J — HAMMER, PLASTIC HD., 8 OZ.
K — CAN, OIL 1-1/2" SPOUT
L — HANDLE, FLEX., SOCKET
M — WRENCH, SOCKET 7/16"
N — STA-KON TERMINAL TOOL - TZLX2A
P — BUZZER, CIRCUIT TESTING - D83468
Q — SCREWDRIVER, OFFSET - TGEX1A
R — WRENCH, OFFSET - B173439
S — PUNCH, PIN - TCFX1CC
T — PUNCH, PIN - TCFX1BB
U — PUNCH, PIN - TCFX1DD
V — WRENCH, PIN - A183902
W — DRIFT, BRASS - TCGX2A
X — PUNCH, PIN - TCFX2D
Y — WRENCH - TKKX1D
Z — WRENCH - TKKX13F

RA PD 85825A

Legend for Figure 67 — Tools Carried in Tool and Accessory Chest (Director M5A1)

Section IV

INSPECTION

20. PURPOSE OF INSPECTION.

a. Inspection is for the purpose of determining by critical examination the condition of the materiel, whether repairs or adjustments are required, and to insure serviceability and proper functioning. Its immediate aim is trouble prevention, which includes the following:

(1) Detecting faulty or careless operation and care.

(2) Determining when replacement of parts is necessary because of ordinary wear, breakage, or defective parts.

(3) Determining that all modifications authorized by Modification Work Orders have been completed.

b. Inspection should always be accompanied by corrective measures to remedy any deficiencies or defects found. When properly carried out, inspection and necessary corrective maintenance will insure the maximum rehabilitation and performance of the materiel.

c. Suggestions for improvement in design, maintenance, safety, and efficiency of operation, prompted by chronic failure or malufunction of the materiel, spare parts, or equipment should be forwarded to the Office, Chief of Ordnance, Field Service Division, Maintenance Branch, with all pertinent information necessary to initiate corrective action. Such suggestions are encouraged in order that other organizations may benefit.

d. Upon receipt of a director, it should be inspected to determine its over-all condition. A record should be made of missing parts, defects, and malfunctions, and action should be taken to correct these conditions as soon as possible.

e. Upon reissuance of the director to using troops, it is the responsibility of the officer in charge to determine that the materiel is complete and in sound operating condition.

21. BASIC INSPECTION.

a. Examine the director for completeness (sec. III), appearance, condition of paint, and for broken or damaged parts. Check the name plate data to identify the model and the correct power input. See that the correct range scale is installed for the gun to be used. Check seal of windows and cover plates for signs of entrance of water or dust. See that locating and mating surfaces of director, tripod, and telescopes are smooth and clean. Remove switch covers and old style orienting clutch cap.

b. Buffer Assemblies. Measure the over-all height of each buffer assembly when director is on tripod. It should be $8^{11}/_{16}$ inches. For adjustment, see paragraph 46. When director is off the tripod, try the action of the buffers by placing your weight on each corner of the director in succession.

c. Telescope Light Cables. Examine for signs of breaking at plugs. Tape securely or replace to prevent short circuits which might burn out transformer and wiring.

d. Inspection With Power Off. Try orienting clutch action. With old style orienting clutch, be sure small locking nut is released before slewing director. Try slewing clutch action, slewing director through 360 degrees to note any roughness or friction. Level director and see that levels are properly adjusted. Look through telescopes, noting whether optics are clean, reticles clear, and focusing good. Sight on a distant object to see whether both telescopes and the open sight are in line. See that elevation dials agree with telescope scale at zero deflection.

e. Handwheel Rotation.

(1) Try both handwheels with clutch knob out and with clutch knob pushed in. The azimuth handwheel should allow unlimited rotation clockwise or counterclockwise when the rate setting clutch is disengaged, and approximately 3 turns clockwise or counterclockwise when the rate setting clutch is engaged. The elevation handwheel should allow sufficient rotation to elevate or depress the telescopes from minus 10 to plus 92 degrees when the rate setting clutch is disengaged, and approximately 3 turns clockwise or counterclockwise when the rate setting clutch is engaged. See that both azimuth and elevation deflection marks aline when clutch knobs are pulled out.

(2) The range handwheel should allow 10 full turns but no more unless the stop pins are sheared off.

(3) Do not force any controls which are jammed, but attach a warning tag or proceed to find the cause.

f. Inspection With Power On. Try range scale and telescope lights. Turn on motor switches and turn off immediately if motors do not start. Set in varying deflection rates in both directions and note whether tracking is smooth or jerky. Note whether telescopes accelerate and decelerate smoothly when handwheel is turned quickly. Try action of elevation limit switch by setting zero deflection and turning in elevation by hand. On Director M5A1, see that solenoid brake stops telescopes in less than 5 degrees when elevation switch is turned off at full deflection. Time both motors for 1 minute.

g. Test Problems. If performance has not been satisfactory but there is not time for a detailed inspection, try running the test problems in paragraph 35. Then refer to section VI.

22. DETAILED INSPECTION.

a. The detailed inspection should be performed in a clean, dust-free room where the cover plates may be removed without danger to the mechanism. A large room with a fairly high ceiling is preferable for testing the telescope alinement.

b. In the following tests, certain tolerances are given as an indication of the accuracy required for proper functioning. Due to wear, an older instrument may approach or exceed certain limits without being entirely unusable, depending on the availability of parts or adequate service. The instrument repair man when making adjustments should not be satisfied merely to keep within the tolerances but should always attempt to reduce the errors to lowest possible limits if time and conditions permit.

c. The following tools and equipment are required for detailed inspection of a director (SNL F-209 and SNL F-272):

(1) Three-phase power source: for Director M5 or M5A1, one of the devices shown in figure 68, 69, or 70 will permit using generator without going through gun junction box. Also see subparagraph **d**, below.

(2) Ohmmeter or test buzzer set for electrical tests.

(3) A-c voltmeter, 0- to 150-volt and 0- to 15-volt scales preferably, for checking transmitter setting.

(4) Gunner's quadrant and special fixture B315845 (fig. 81) for testing telescopes.

(5) Testing target (fig. 74), for testing telescopes.

(6) Peep sight A400153 (fig. 81), for testing telescopes.

(7) Plumb line, for testing telescopes.

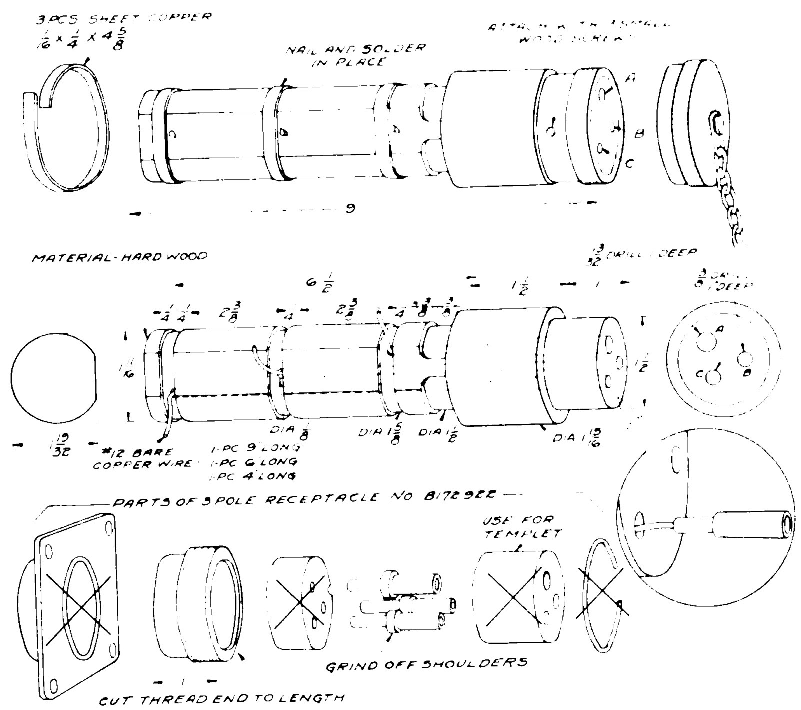
(8) Spring scale (0- to 25-lb for Director M5A1, or 0- to 12-lb for Directors M5 and M6 only), for checking variable-speed mechanism.

(9) Stop watch, to time constant-speed motors and test problems.

(10) Two-ounce weight A400158, torque arm B315848, and spring scale (fig. 81), for testing torque amplifier in Director M5 or M6. Or use the simpler tools in item (11), below.

(11) One-ounce and 14-ounce weights (fig. 78), and torque arm B315849 (fig. 80 or 81), for field test of torque amplifier.

d. Testing With Single-phase Current. If 3-phase power is not available, it is possible to use single-phase power from 115-volt, 60-cycle lighting circuits, for testing Director M5 or M5A1 (or single-phase 50-volt, 50-cycle power for Director M6).



RA PD 85828

Figure 68 — Dummy Power Plug Which Permits Operating Director M5 or M5A1 Direct From Generator Cable

(1) Connect to terminal blocks Nos. 8 and 15 to run the motors. If the motors do not start immediately when the switch is turned on, twist the governor body in the right direction, and as soon as it has come up to speed, the torque amplifier motor should start (on Director M5 or M6). When testing the transmitters, connect to terminal blocks Nos. 1 and 15; with these connections, the motors will not start without aid. Do not leave switches on without starting motors, and do not run for long periods as the motors may overheat.

(2) The torque amplifier may be tested separately by connecting to any two motor terminals and twisting the input coupling to start it.

(3) The remote control system will not operate on single-phase power.

e. Order of Testing. Whenever possible, tests should be made and errors corrected in the order given. Correction of errors in some of the earlier tests would affect later tests and adjustments; therefore, all subsequent tests should be repeated after an adjustment.

23. RANGE HANDWHEEL SHAFT STOPS.

a. Turn the range handwheel as far as it will go in both directions, but avoid forcing in case the stop pins have been sheared off.

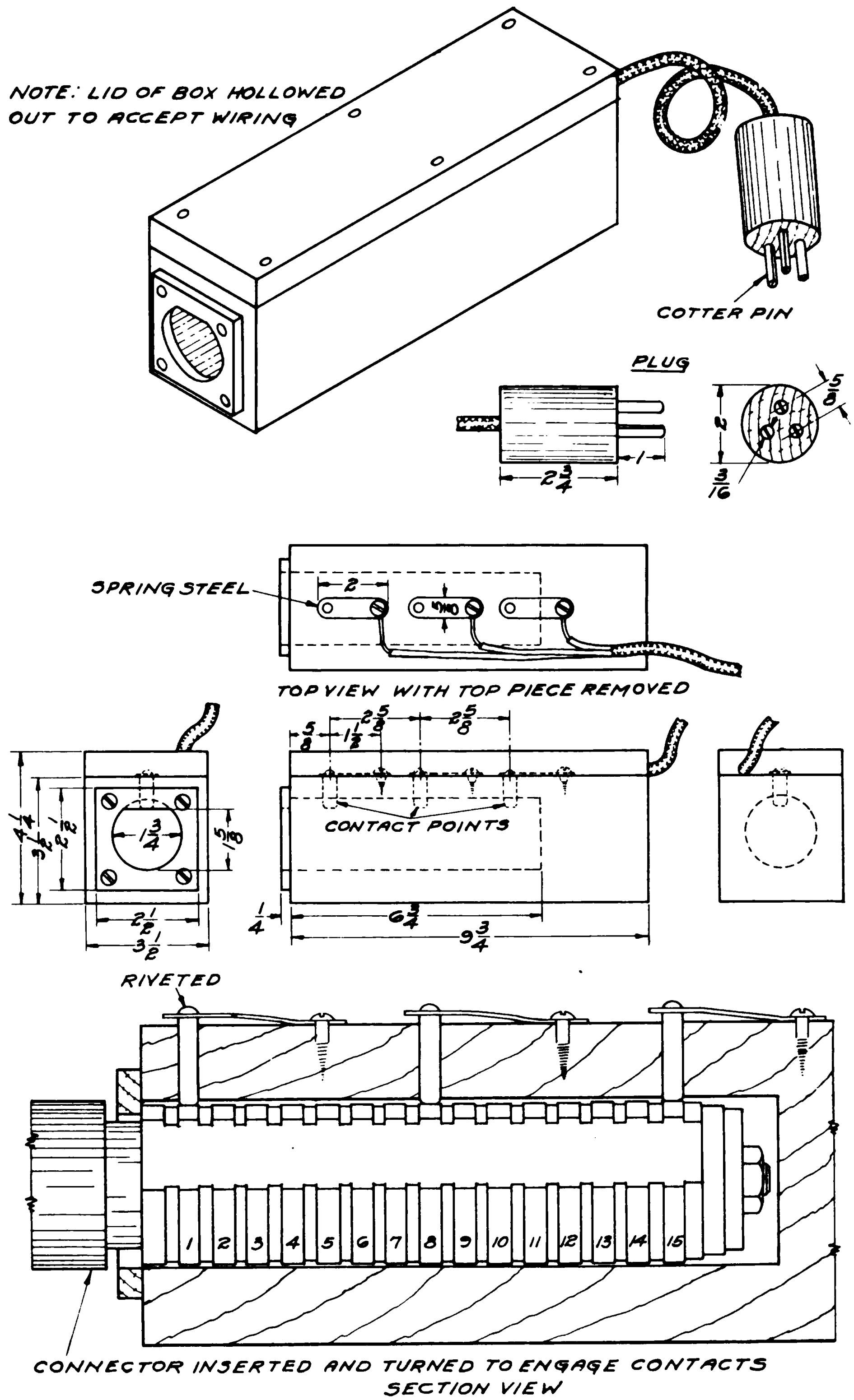


Figure 69 — Generator Junction Box for Connecting 15-conductor Cable to Generator

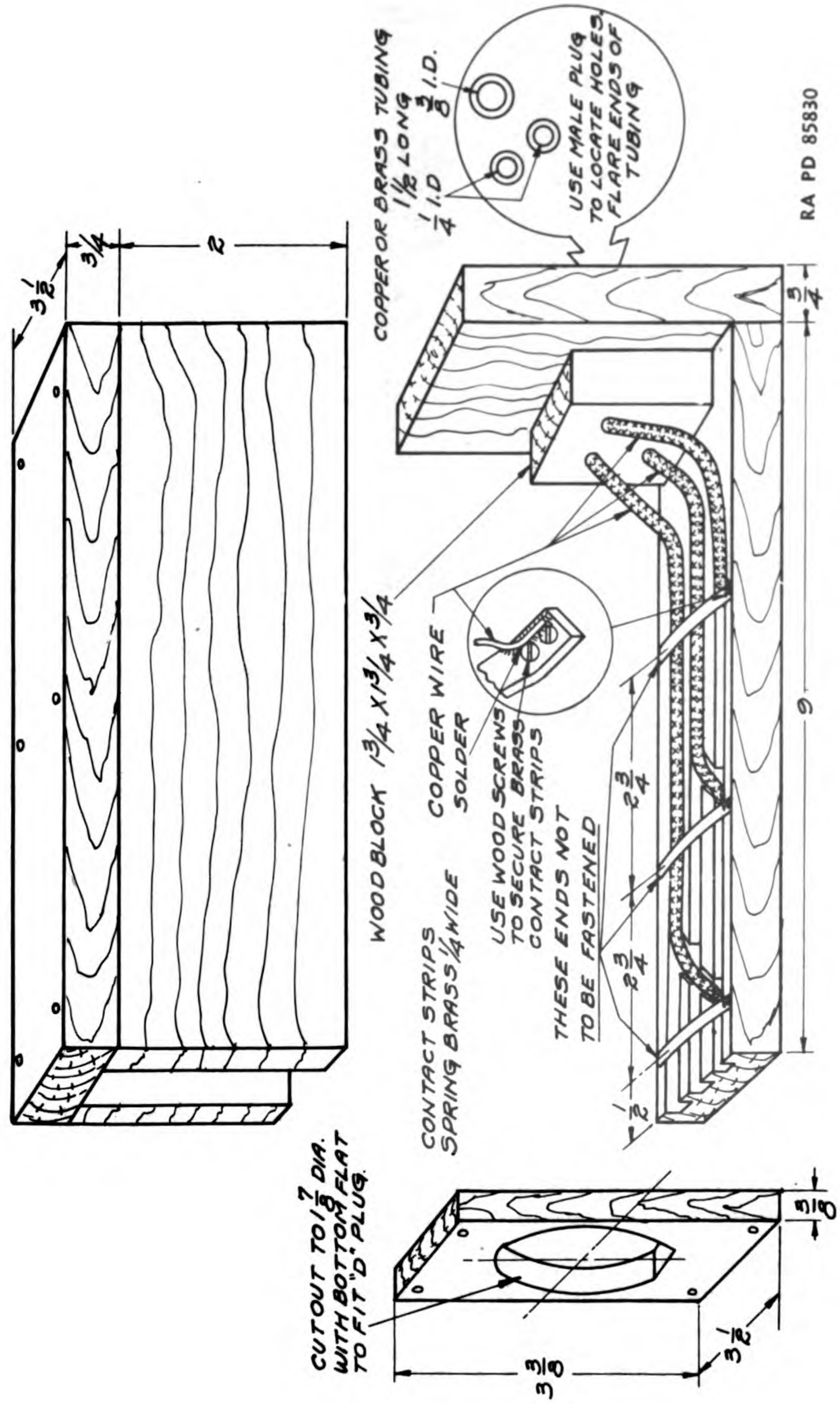
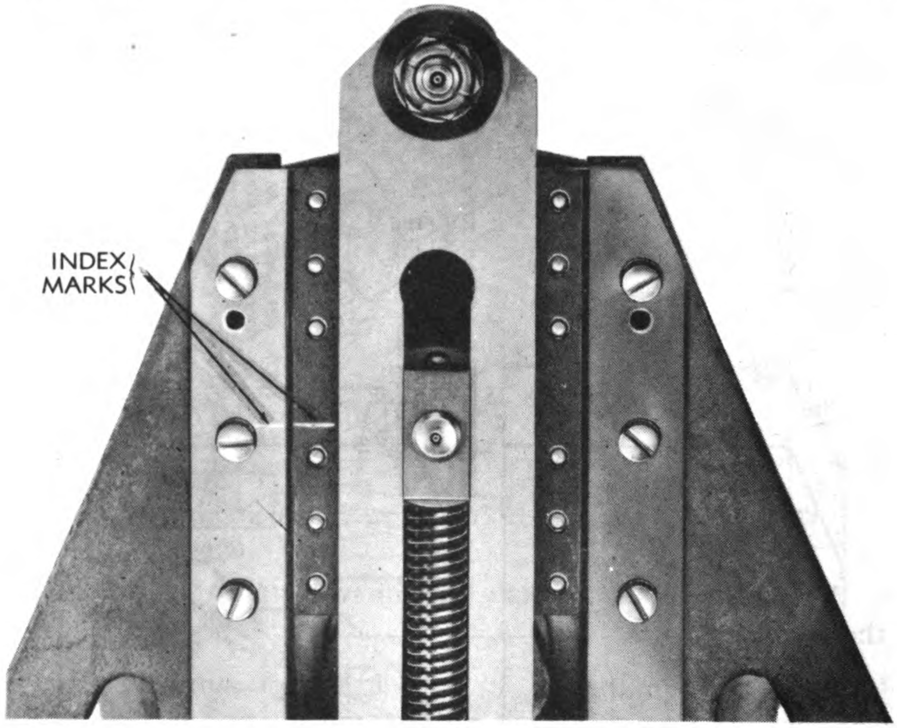


Figure 70 — Junction Box for Connecting 15-conductor Cable to Generator Cable



RA PD 15895

Figure 71 — Multiplying Mechanism Showing Scribed Marks Alined at Minimum Range Position

The stop should allow 10 full turns of the handwheel but no more (to 2,600-yd mark on 37-mm scale or 2,800-yd mark on 40-mm scale). When the range handwheel is turned counterclockwise as far as it will go, the range index should be opposite the datum line, or half the width of the line to the left of it, and the scribed lines on both the azimuth and elevation multiplying mechanisms should be alined within $\frac{1}{64}$ inch (fig. 71).

b. For correction see paragraph 49.

24. ZERO AND MAXIMUM DEFLECTION SETTINGS.

a. Turn the azimuth handwheel until the zero deflection marks on the multiplying mechanism line up (fig. 72); then pull out the rate setting clutch. The rate setting clutch should pull them into line (as determined in subpar. **b**, below) even if they are set slightly to one side or the other.

b. With the rate setting clutch pulled out, turn the range handwheel from one end of its travel to the other and see if there is any movement of the fine azimuth dial. There should be none. This test is more critical than visual alinement of deflection marks. For correction, see paragraph 50 **e**.

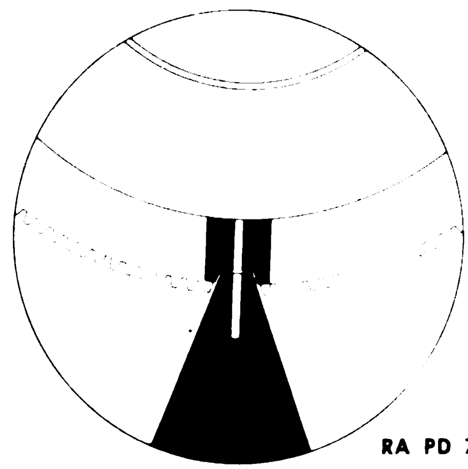


Figure 72 — Zero Deflection Lines in Matching Position

c. Repeat operations performed in subparagraphs **a** and **b**, above, on the elevation side.

d. Place a narrow ruler or rod 8 inches or more long against the end of the bar assembly and make a mark opposite the end of the rail at the zero deflection position and at both ends of its travel (fig. 73). The rate setting clutch stops should allow it to travel between 3 and $3\frac{1}{16}$ inches from zero in either direction, without hitting either shaft or pinion on the rate setting clutch.

e. Repeat for both azimuth and elevation mechanisms. For correction, see paragraph 50.

25. ELECTRICAL WIRING TEST.

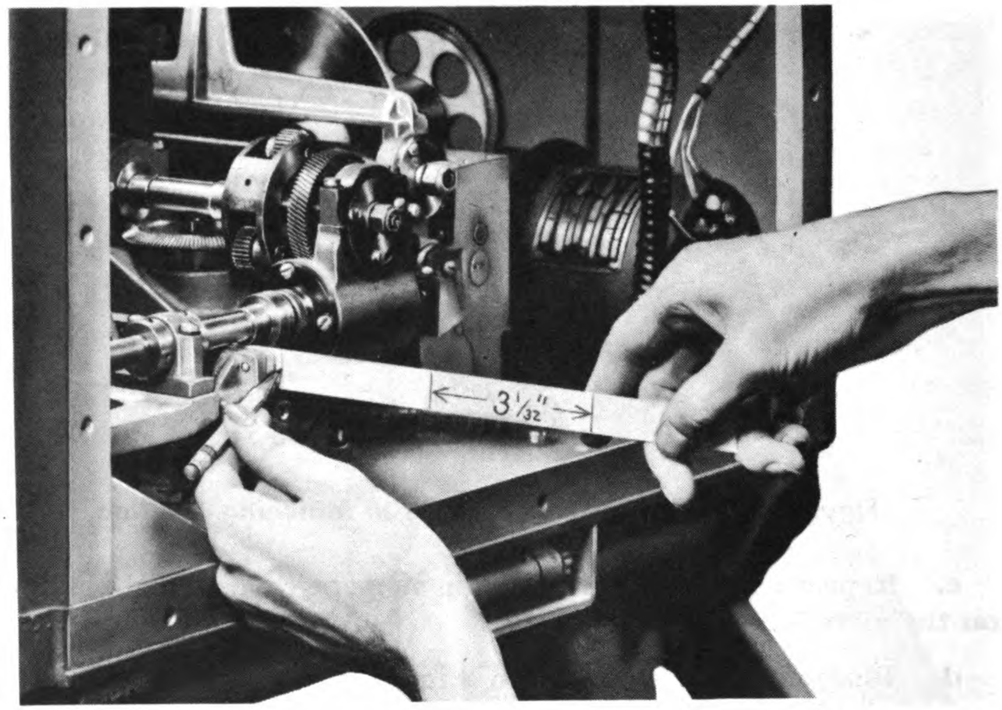
a. Take off the side cover plates. Examine insulation for cracks and cuts. Turn telescopes to between 0- and 80-degree elevation. With an ohmmeter or test buzzer set, make a continuity test from terminals on contact body (or other end of 15-conductor cable) to corresponding numbers on terminal block.

b. Director M5 or M6. Remove cable plug from director. Disconnect all wires from terminal block No. 15, and make the following continuity tests. See wiring diagram (fig. 51 or 52).

(1) All switches off. Terminal block No. 1 to X-wire on all motors (disconnect wire from motor when testing).

(2) All switches off. Disconnect Y-wire from azimuth fine (lower) transmitter. Test terminal block No. 1 to X-terminal on all transmitters. Reconnect Y-wire to transmitter.

(3) Old type wiring only. Light switch on, power switches off. Terminal block No. 1 to transformer.



RA PD 85783

Figure 73 – Measuring Travel of Rack on Deflection Mechanism

c. Reconnect all wires to terminal block No. 15. Disconnect all wires from terminal block No. 1.

(1) All switches off. Terminal block No. 15 to Y on all transmitters. (On new type wiring, disconnect X-wire from azimuth fine (lower) transmitter while testing.)

(2) All switches on. Disconnect Y-wires from all four motors, and test each wire to terminal block No. 15. Reconnect motor wires.

(3) Light switch on. Power switches off. Terminal block No. 15 to transformer.

(4) New type wiring only. Light switch on. Power switches off. Terminal block No. 8 to transformer.

(5) Azimuth switch on. Other switches off. Terminal block No. 8 to Z-wire on azimuth motors (disconnect wire from motor while testing).

(6) Elevation switch on. Other switches off. Terminal block No. 8 to Z-wire on elevation motors (disconnect wire from motor while testing).

(7) All switches off. Terminal block No. 8 to No. 1 on azimuth coarse (upper) transmitter.

(8) All switches off. Terminal block No. 3 to No. 3 on elevation fine transmitter.

(9) All switches off. Terminal block No. 4 to No. 1 on elevation fine transmitter.

(10) All switches off. Terminal block No. 5 to No. 2 on elevation fine transmitter.

(11) All switches off. Terminal block No. 9 to No. 2 on azimuth coarse transmitter.

(12) All switches off. Terminal block No. 10 to No. 3 on azimuth transmitters.

(13) All switches off. Terminal block No. 11 to No. 1 on azimuth fine transmitter.

(14) All switches off. Terminal block No. 12 to No. 2 on azimuth fine (lower) transmitter.

d. Reconnect wires to terminal block No. 1. All switches on. Test all terminal blocks for short circuit to frame (subpar. **h**, below).

e. Director M5A1. Remove cable plug from director. Disconnect all wires from terminal block No. 15, and make the following continuity tests. See wiring diagram (fig. 53).

(1) All switches off. Terminal block No. 1 to **X** on both constant-speed motors.

(2) All switches off. Terminal block No. 1 to **X** on elevation transmitters (disconnect **Y**-wire from coarse (upper) transmitter while testing).

(3) All switches off. Terminal block No. 1 to **X** on azimuth transmitters (disconnect **Y**-wire from fine (lower) transmitter while testing).

f. Reconnect all wires to terminal block No. 15. Disconnect all wires from terminal block No. 1. All switches off for operations performed in steps (1) and (2), below.

(1) Terminal block No. 15 to **Y** on elevation transmitters (disconnect **X**-wire from coarse (upper) transmitter while testing).

(2) Terminal block No. 15 to **Y** on azimuth transmitters (disconnect **X**-wire from fine transmitter while testing).

(3) Azimuth switch on. Other switches off. Terminal block No. 15 to **Z**-wire on azimuth constant-speed motor (disconnect wire from motor while testing).

(4) Elevation switch on. Other switches off. Terminal block No. 15 to **Z** on elevation constant-speed motor.

(5) Light switch on. Power switches off. Terminal block No. 15 to transformer.

(6) Light switch on. Power switches off. Terminal block No. 8 to transformer.

(7) Azimuth switch on. Other switches off. Terminal block No. 8 to Y on azimuth constant-speed motor.

(8) Elevation switch on. Other switches off. Terminal block No. 8 to Y on elevation constant-speed motor.

(9) All switches off. Terminal block No. 8 to No. 1 on azimuth coarse (upper) transmitter.

(10) All switches off. Terminal block No. 2 to No. 3 on elevation coarse (upper) transmitter.

(11) All switches off. Terminal block No. 3 to No. 3 on elevation fine (lower) transmitter.

(12) All switches off. Terminal block No. 4 to No. 1 on elevation fine (lower) transmitter.

(13) All switches off. Terminal block No. 5 to No. 2 on elevation fine (lower) transmitter.

(14) All switches off. Terminal block No. 6 to No. 1 on elevation coarse (upper) transmitter.

(15) All switches off. Terminal block No. 7 to No. 2 on elevation coarse (upper) transmitter.

(16) All switches off. Terminal block No. 9 to No. 2 on azimuth coarse (upper) transmitter.

(17) All switches off. Terminal block No. 10 to No. 3 on azimuth transmitters.

(18) All switches off. Terminal block No. 11 to No. 1 on azimuth fine (lower) transmitter.

(19) All switches off. Terminal block No. 12 to No. 2 on azimuth fine (lower) transmitter.

(20) All switches off. Disconnect one wire from brake solenoid. Test one solenoid wire to Y on elevation constant-speed motor, other wire to Z on elevation constant-speed motor. Reconnect wire.

g. Reconnect wires to terminal block No. 1. All switches on. Test all terminal blocks for short circuit to frame.

h. Any particular unit suspected to be faulty should be tested individually after referring to the wiring diagram and disconnecting all wires from the unit.

26. ELECTRICAL ZERO OF TRANSMITTERS, AND DIAL SETTING.

a. The transmitters are accurately set at electrical zero at the factory. The following tests will indicate whether the transmitters have been disturbed from their original setting.

b. Before testing each transmitter, turn the handwheel until the dials read "ZERO" and check to see that the lining-up hole (fig. 44) is directly opposite the hole in the transmitter housing (usually at a 12-o'clock position). Supply power to the director through usual connections, or by connecting single-phase power to terminal blocks Nos. 1 and 15. Leave director switches off. Disconnect the wire from terminals Nos. 1, 2, and 3 on the transmitter while testing. Place a jumper between terminals X and No. 2 on the transmitter, and measure the voltage between terminals Y and No. 1. The voltage should be between 20 and 30. *CAUTION: If the transmitter is 180 degrees from electrical zero position, the voltage may be about 200; so merely touch the terminals until certain the needle does not go off scale (with a 0- to 150-volt meter). Then remove the jumper and measure voltage between terminals 1 and 3 on the transmitter. It should be zero (or less than 1 volt) when the holes are alined and should increase as the handwheel is moved in either direction. Check with a low-range meter if available. Refer to paragraph 51 for zeroing method if necessary.*

c. When the holes are exactly alined in the coarse azimuth transmitter, the holes in the fine transmitter should also be alined, and both dials should be at zero.

d. Director M5A1 Only. When the holes are exactly alined in the coarse elevation transmitter, the holes in the fine transmitter should also be alined, and both dials should be at zero.

e. Directors M5 and M6. When the holes in the fine elevation transmitter are alined, the fine dial should be at zero and the coarse dial at any one of its graduations, corresponding to the elevation scale near the telescope.

f. If any transmitter appears to zero at any other point than with the holes alined, it will be necessary to reset it at electrical zero. If each transmitter zeros properly but dials are not at zero, or coarse and fine transmitters do not zero at same position, follow the procedure for adjustment given in paragraph 52 or 53 before proceeding with inspection.

g. If there are any indications of a burned-out transmitter, see the test described in paragraph 44 **b.**

27. TELESCOPE SHAFT SEGMENT ENGAGEMENT AND ELEVATION STOPS.

a. Set vertical deflection to zero and pull out clutch knob. Turn the elevation dials to minus 5 degrees (15 deg on fine dial). At this position, the fourth or fifth tooth of the segment should be engaged with the idler gear on the quadrant elevation mechanism. If the segment is more than one tooth away from this position, the limit switch will probably be found out of adjustment and it will be necessary to reengage the gear segment. In any case, the segment should never come within two teeth of the end at minus 10 or plus 92 degrees on the dials.

b. **Limit Switch.** The elevation limit switch should be adjusted to shut off the power at minus 5 and at plus 85 degrees on the dials. Set zero deflection, pull out clutch knob, turn on elevation switch, and turn handwheel until motor stops. With the limit switch off, slowly back the telescopes off with the handwheel and note whether there is a space in which the motor hums before picking up. This space should not exceed one-half degree on the fine dial. For correction, see paragraph 54.

c. **Mechanical Stops.** The telescope shaft segment should strike the mechanical stops at minus 10 and plus 92 degrees to prevent the segment teeth from being disengaged at either end. The stops may be bent slightly to the correct position if they have not been badly bent or fatigued. If the segment has been disengaged, check to see that the antiblacklash gear is properly wound. For correction, see TM 9-659.

d. **Solenoid Brake, Director M5A1 Only.** Turn on elevation power switch. The brake should release immediately. Turn telescopes to about 75-degree elevation; then set in maximum rate downward and shut off the switch. The telescopes should stop within 5 degrees on the elevation scale, so that if they should open the limit switch at minus 5 degrees, they would stop before the segment strikes the mechanical stop. For adjustment of brake, see paragraph 57.

28. TELESCOPES AND OPEN SIGHT.

a. Look through each end of each telescope and examine the optical elements for signs of breakage, dirt, grease, moisture, or deterioration of adhesive balsam in the compound lenses. Also check filters and the focus and illumination of the reticles. The movement of the diopter ring should be free from approximately minus 4 diopters to plus 2 diopters. When observing a *distant* object, there should be no relative movement (parallax) between the object and the reticle when the eye is moved slightly from side to side or up and down. The telescope may be removed from the director for this test. Repair of faulty telescopes should be handled by an instrument repair man.

b. Level the director carefully, as described in paragraph 45, before proceeding with the tests.

c. **Vertical Plumb Travel.** Suspend a thin plumb line from the highest point available, so that the telescope can follow it up to a

45-degree elevation. It should not be closer to the director than 15 feet, however. With the director levelled, the vertical reticle line of the *azimuth* telescope should follow the plumb line from 0 to 45 degrees within one mil. To avoid parallax at close range, use a peep sight. For this test only, a crude peep sight could be used in which the location of the hole is not held to close limits. For alinement tests, the hole must be accurately located. If the line is still not clear, place a single lens, such as a jeweler's magnifying glass, in front of the peep sight.

d. Turn the telescope shaft to 90 degrees. Remove the elevation telescope and attach the special fixture B315845 shown in figure 81, being sure that the straightedge rests against the locating studs in the telescope flange. Use the regular telescope thumbscrews. Place a gunner's quadrant or a good level on the fixture, and turn the handwheel to level it. Move off from level a degree or two and slowly approach level position from either direction without overrunning, to take up blacklash. The average reading of the elevation dials should be 90 degrees within the width of the index line on the fine elevation dial. For correction, see paragraph 58.

e. If no level or fixture is available, the elevation dials may be checked at zero elevation on the distant horizon in flat country, or with a test mark at the exact height of the telescope shaft center. In any case, approach level position from both directions and average the dial readings to cancel out the backlash.

f. **Parallelism Between Telescopes.**

(1) Set up a testing target like that shown in figure 74, at 100 to 200 yards if testing is done outdoors, or at as great a distance as possible indoors. It should be approximately the same height as the telescope shaft. Mark the 1-mil tolerance lines on the target after measuring the distance. Check the distance between vertical lines carefully when used at close range, remembering the possibility of shrinkage of paper or wood. With the director levelled, aline the elevation telescope on the left end of the horizontal target line. Then slew the director until the same telescope is aimed at the right end of the line. The horizontal line should still be on the crosshair if the target is level. If not, adjust the target and recheck. With the director and target level, make the following tests. The use of a peep sight (A400153 in fig. 81) over the telescope is necessary for accuracy at short ranges.

(2) ALINEMENT IN ELEVATION. Aline the *horizontal* reticle line in the *elevation* telescope on the left end of the target line. Block handwheel lightly. The horizontal reticle line of the azimuth telescope should be parallel within 1 mil, or inside the small tolerance marks on the target.

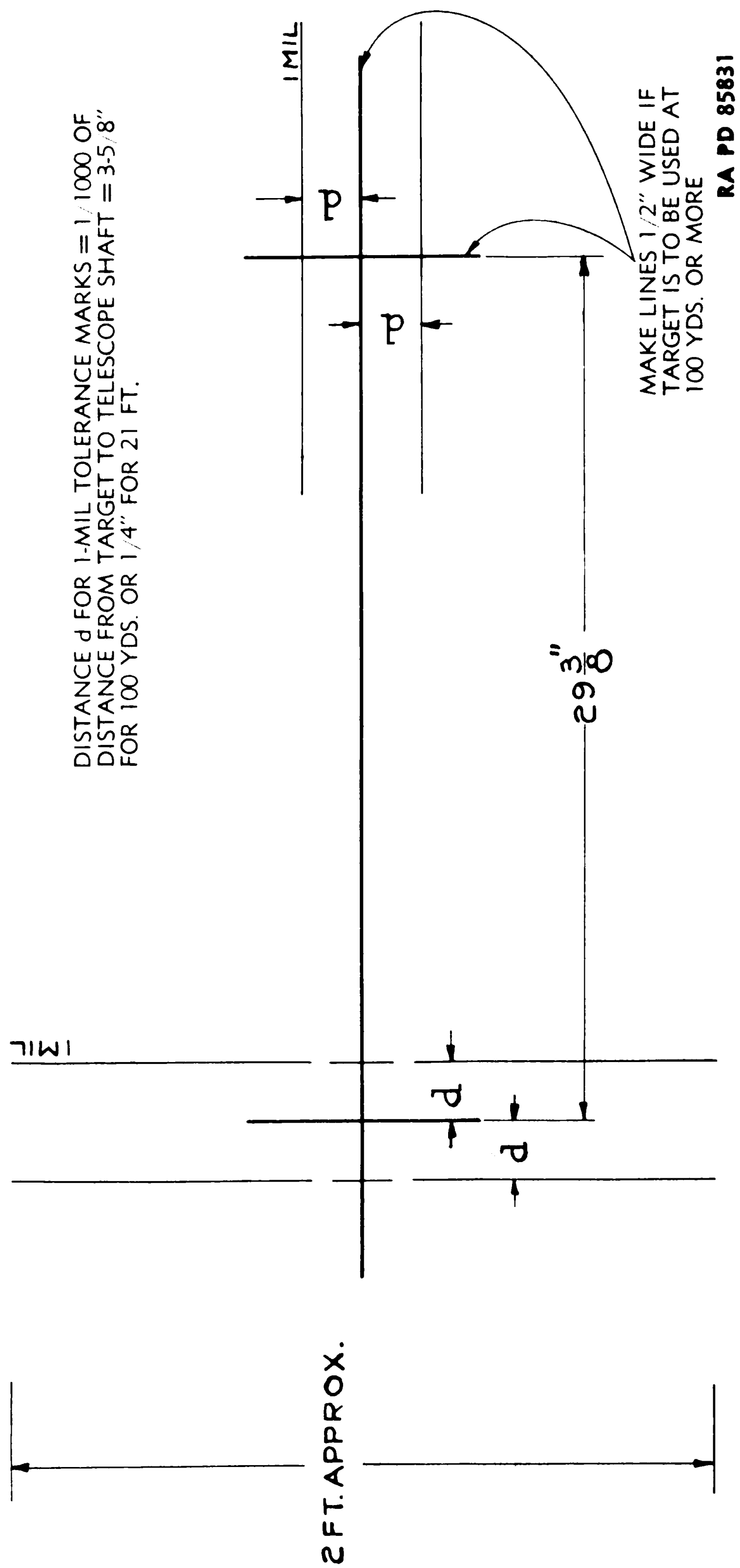


Figure 74 — Testing Target

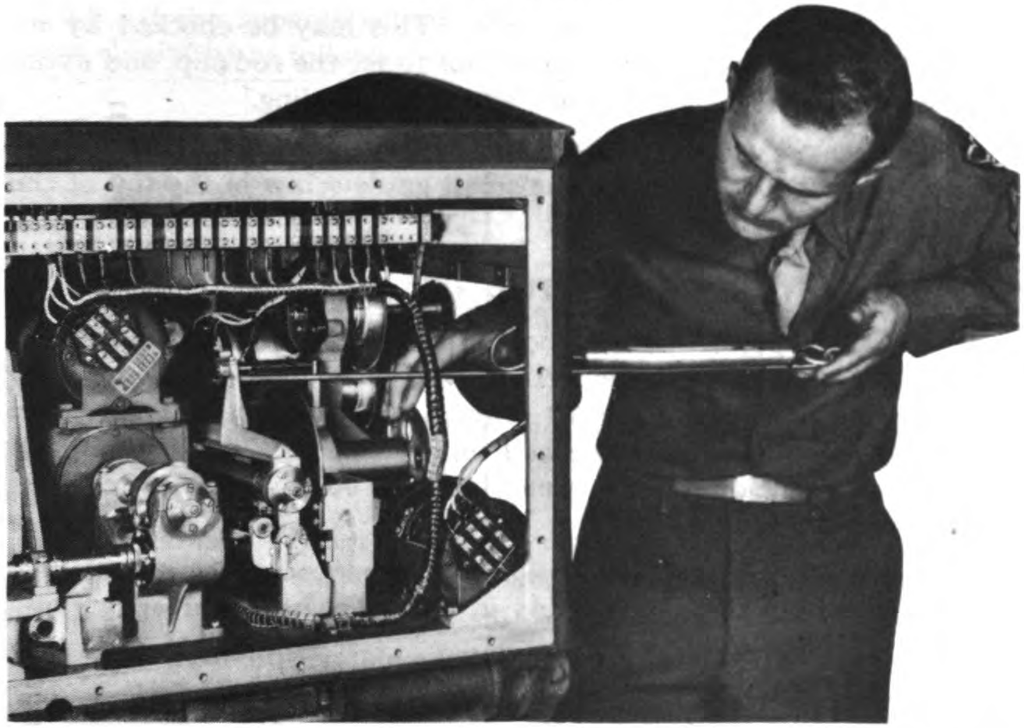


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Figure 75 — Measuring Spring Tension on Variable-speed Mechanism

(3) ALINEMENT IN AZIMUTH. Aline the vertical reticle line of the *azimuth* telescope on the right target line. Block handwheel lightly. The verticle reticle line of the elevation telescope should be inside the 1-mil tolerance lines.

g. For correction of telescopes, see paragraph 58.

h. **Open Sight.** With the director level, check the open sight for parallelism with the elevation telescope in azimuth, using the target and the plumb line. For correction, see paragraph 59.

29. TENSION SPRINGS OF VARIABLE-SPEED MECHANISMS.

a. **Directors M5 and M6.** The tension springs of both the azimuth and elevation variable-speed mechanisms should exert a pull of from 7 to 8 pounds.

b. **Director M5A1.** The tension springs of both the azimuth and elevation variable-speed mechanisms should exert a pull of 20 pounds.

c. The spring tension may be measured while the unit is in the director by placing a stiff rod about ⅜ inch by 2 feet long against the rocker casting, near the spring, as shown in figure 75. A spring scale hooked onto the end of the rod and pulled toward the director will indicate the spring tension when the polished roller in the rocker assembly just barely leaves the balls. This may be checked by inserting a piece of paper. Be careful not to let the rod slip, and avoid pushing on the rod, which would affect the reading.

d. If necessary, turn the adjusting nut until the tension is correct. It may be necessary to loosen the small guide screw in the top of the rocker.

30. CONSTANT-SPEED MOTOR GOVERNORS.

a. Connect power cable and turn on azimuth and elevation switches. Set in a small deflection, which should be upward from 0 degree or downward from 90 degrees in elevation. Observe and time each wormwheel or index as it makes exactly 20 revolutions in the direction of the arrow. The time should be 60 seconds plus or minus one-half second.

b. Note any noise or other signs of overspeeding at zero deflection which would indicate friction in governor ball bearings.

c. For adjustment of governors, see paragraph 60.

31. AZIMUTH ZERO CREEP.

a. Make this test only when the zero deflection is set correctly as indicated in paragraph 24 **b**.

b. Set azimuth mechanism for zero deflection and pull out rate setting clutch firmly. Turn handwheel to bring any division of the fine azimuth dial opposite its index. Turn on azimuth switch and see that the fine azimuth dial does not creep more than 1 degree in 1 minute.

c. For adjustment of ball carriage, see paragraph 61.

32. ELEVATION ZERO CREEP AND SUPERELEVATION CREEP.

a. Make this test only when the zero deflection is set correctly as indicated in paragraph 24 **b** and **c**.

b. Set elevation mechanism for zero deflection and pull out rate setting clutch. Turn telescope to 90 degrees on the elevation dials. Place jumpers around limit switch so elevation motor will operate, and turn elevation switch on. The fine elevation dial should not creep more than 1 degree in 1 minute.

c. Remove limit switch jumpers.

d. **Superelevation Setting.** With the deflection still at zero, turn the telescopes down to about 67 degrees by hand, and time the creep of the dials from 65 degrees down to 60 degrees. Likewise turn down to about 10 degrees and time creep from 5 degrees to 0.

(1) If the superelevation mechanism is correctly adjusted, the times should be as follows:

Range Scale	Value of K	65 to 60 (deg)	5 to 0 (deg)
E (37-mm)	0.0694	25 ± 2.5 sec	10.8 ± ½ sec
F (40-mm)	0.0580	25 ± 2.5 sec	12.9 ± ½ sec

e. For adjustment, see paragraph 62.

33. BACKLASH.

a. In both azimuth and elevation, the backlash of the gear train should not be more than 6 minutes or twice the width of lines on the fine dials.

b. Backlash readings should be made at several points, perhaps 30 degrees apart in elevation and 60 degrees apart in azimuth. Select suitable target points and approach each point slowly from both directions, being careful not to reverse the tracking direction. Note the dial reading when the telescope is on the target. The difference in the two dial readings is total backlash.

34. SMOOTHNESS OF OPERATION.

a. In both azimuth and elevation, the director should track smoothly at all rates without jerk or chatter of the dials.

b. Aline deflection marks and pull out the rate setting clutch knob. Check that the torque required to turn the handwheel is not excessive. The motion should be smooth, without jerk or chatter. If these conditions are not met, the load imposed by the gearing is too great and should be corrected. The gear train may be dirty, in which event it should be properly cleaned and lubricated.

c. Set range to datum line. Push in rate setting clutch knob. Turn on power. Set in increasing and decreasing deflection rates from minimum to maximum rates. This should be done smoothly. The director should traverse or the telescopes should elevate or depress in a like manner without hesitation. Dials should register all movements without chatter or jerk. It is advisable to check that the orienting clutch is properly tightened should this condition exist. Smoothness of travel in azimuth may be checked by noting the reaction of the bubbles on the level vials while the director is traversing. Check action in both directions. Smoothness of travel in elevation may be checked by observing an object through the telescope, also by noting the smoothness of the elevation fine dial. Any tendency to jerk or chatter will be especially noticeable at very low deflection rates.

d. If these conditions are not satisfactorily met, the torque amplifier (in Director M5 or M6) should be checked as indicated in paragraph 36. The gear train of the director, and the worm drive should also be checked for proper functioning.

35. TEST PROBLEMS.

a. Test problems are a final check upon the operation of the director. By the accuracy of the results of the time problems, it is possible to determine the exact condition of the mechanical components of the director. The problems determine the given time in seconds required for a certain predetermined travel of the director or telescopes under known conditions of range and deflection. The observed time should agree with the given time within the specified tolerances. Consult whichever table corresponds to the range scale in the director.

b. **Elevation Problems.** See table I or II.

(1) Aline the deflection marks and pull out the elevation rate setting clutch knob.

(2) Set in the required range on the range dial.

(3) Set the elevation dials to 80 degrees for a decreasing deflection or to 0 degree for an increasing deflection.

(4) Push in the rate setting clutch knob, and set in the required deflection. This may be set directly on the dials for increasing elevation, or must be subtracted from 80 degrees to get dial reading for decreasing elevation.

TABLE I — ELEVATION TEST PROBLEMS
RANGE SCALE FOR 37-MM GUN
M.V. 2600 F/S — Superelevation Setting 0.0694

Degrees Deflection	RANGE — YARDS 500	1,000	1,500	2,000
	TIME IN SECONDS FOR TELESCOPES TO DEPRESS FROM 75 TO 15 DEGREES			
–5	9.6 ± 0.8	17.4 ± 1.2	26.0 ± 1.6	35.5 ± 2.1
–10	4.8 ± 0.5	9.0 ± 0.7	13.7 ± 1.0	19.3 ± 1.3
–15	3.1 ± 0.5	5.9 ± 0.6	9.2 ± 0.8	13.0 ± 0.9
–20		4.3 ± 0.5	6.7 ± 0.6	9.7 ± 0.8
–30				6.0 ± 0.6
	TIME IN SECONDS FOR TELESCOPES TO ELEVATE FROM 15 TO 75 DEGREES			
+5	10.6 ± 0.8	21.1 ± 1.4	35.3 ± 2.1	55.6 ± 3.1
+10	5.1 ± 0.6	9.8 ± 0.8	16.0 ± 1.1	23.9 ± 1.5
+15	3.2 ± 0.4	6.3 ± 0.6	10.1 ± 0.8	15.0 ± 1.0
+20		4.5 ± 0.5	7.2 ± 0.7	10.7 ± 0.8
+30				6.4 ± 0.6

INSPECTION

(5) Turn on power. Using a stop watch, check the time required for the telescopes to travel from either 75 to 15 degrees or from 15 to 75 degrees, on the elevation scale near the telescope.

(6) Aline the deflection marks and turn the power off immediately after the required position has been reached.

TABLE II — ELEVATION TEST PROBLEMS
RANGE SCALE FOR 40-MM GUN
M.V. 2750 F/S — Superelevation Setting 0.0580

Degrees Deflection	RANGE — YARDS 500	1,000	1,500	2,000
	TIME IN SECONDS FOR TELESCOPES TO DEPRESS FROM 75 TO 15 DEGREES			
−5	9.4 ± 0.8	16.9 ± 1.1	25.1 ± 1.6	33.8 ± 2.0
−10	4.7 ± 0.5	8.7 ± 0.7	13.1 ± 1.0	18.0 ± 1.2
−15		5.7 ± 0.6	8.7 ± 0.7	
−20				8.9 ± 0.7
−30				5.5 ± 0.6
	TIME IN SECONDS FOR TELESCOPES TO ELEVATE FROM 15 TO 75 DEGREES			
+5	10.2 ± 0.8	19.9 ± 1.3	32.0 ± 1.9	47.6 ± 2.7
+10	4.9 ± 0.5	9.4 ± 0.8	14.7 ± 1.0	21.3 ± 1.4
+15		6.0 ± 0.6	9.4 ± 0.8	
+20				9.7 ± 0.8
+30				5.8 ± 0.6

c. **Azimuth Problems.** See table III or IV.

(1) With the deflection marks alined and the rate setting clutch disengaged, set the firing azimuth dials to zero for reference. Disengage and clamp the orienting clutch by loosening the large thumb nut and tightening the small nut (fig. 31). With new type orienting clutch, move lever to vertical position. Incorrect settings will be made if the clutch is not properly clamped.

(2) Provide an index on the base of the director and a mark on the housing or tripod as a fixed reference for timing one revolution of the director.

(3) Set in the required range on the range dial.

(4) Turn on power. The power should be turned on before the deflection is set in to prevent damage to the torque amplifier or the gear train.

(5) Turn the azimuth handwheel until the dial indicates the required deflection in either direction from zero. Time the director for one complete revolution, and compare with correct time in chart.

(6) Set deflection for opposite direction of rotation and repeat.

TABLE III — AZIMUTH TEST PROBLEMS
RANGE SCALE FOR 37-MM GUN
M.V. 2600 F/S — Superelevation Setting 0.0694

TIME IN SECONDS REQUIRED FOR THE DIRECTOR TO TURN ONE COMPLETE REVOLUTION IN AZIMUTH — CLOCKWISE OR COUNTERCLOCKWISE

Degrees Deflection	RANGE — YARDS 500	1,000	1,500	2,000
5	50.0 ± 1.8	103.9 ± 3.4	169.0 ± 5.4	248.3 ± 7.7
10	24.2 ± 1.0	50.9 ± 1.8	83.2 ± 2.8	122.6 ± 4.0
15		32.7 ± 1.3	54.0 ± 1.9	79.9 ± 2.7
20		23.3 ± 1.0	38.9 ± 1.5	58.0 ± 2.0
30				34.8 ± 1.3

TABLE IV — AZIMUTH TEST PROBLEMS
RANGE SCALE FOR 40-MM GUN
M.V. 2750 F/S — Superelevation Setting 0.0580

TIME IN SECONDS REQUIRED FOR THE DIRECTOR TO TURN ONE COMPLETE REVOLUTION IN AZIMUTH — CLOCKWISE OR COUNTERCLOCKWISE

Degrees Deflection	RANGE — YARDS 500	1,000	1,500	2,000
5	48.9 ± 1.8	99.2 ± 3.3	158.1 ± 5.0	226.0 ± 7.1
10	23.6 ± 1.0	48.6 ± 1.8	77.8 ± 2.7	111.5 ± 3.6
15		31.2 ± 1.2	50.4 ± 1.8	
20				52.6 ± 1.9
30				31.5 ± 1.2

36. TORQUE AMPLIFIER (DIRECTORS M5 AND M6).

a. The torque amplifier is a frequent source of trouble, and it is desirable to test this unit independently after removal from the director.

b. With motor not running, input and output shafts should rotate easily when turned in opposite directions.

c. When motor is switched on, it should come up to speed quickly without noticeable noise or vibration. If motor is running backward, the output and input will be reversed, and the output coupling will

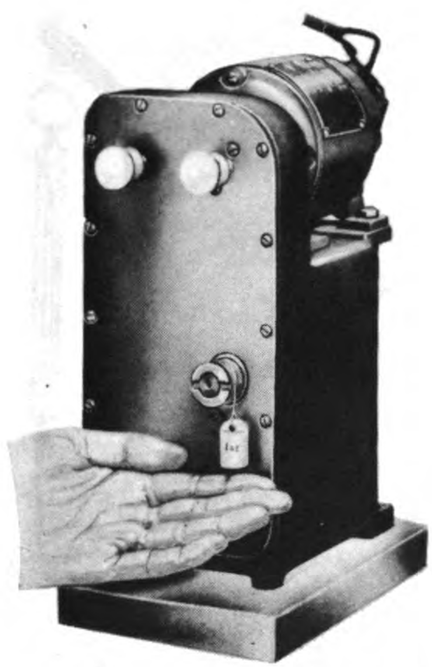

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Figure 76 — Method of Applying Torque to Torque Amplifier Input Coupling

turn very easily. If there is any difficulty, try starting motor when it is removed from torque amplifier.

d. Sensitivity. With motor running and output shaft *free,* a 1-ounce weight suspended by a thread from the input coupling, as shown in figure 76, should start smooth rotation. Allow the weight to unwind from the coupling for at least one turn, in both directions. A 1-ounce weight may be made of any material which will not rust or absorb moisture, and may usually be checked on a postal scale. A suggested design is shown in figure 78.

e. Amplification. With the motor running, a ½- or 1-ounce-inch torque applied to the input coupling in either direction must produce a reasonably smooth output torque 50 to 220 times as great.

(1) A 1-ounce-inch torque may be applied by suspending a 2-ounce weight A400158 from the input coupling, and the 50- to 220-ounce-inch output torque may be measured as shown in figure 77, using torque arm B315848. The torque is obtained by multiplying the length of the arm in inches by the scale reading in ounces.

(2) When the above tools are not available, the simple weights and arm shown in figures 78, 79, and 80 may be made and used. Suspend the 14-ounce weight from the arm between the inner and outer marks. When it is at the $1\frac{13}{16}$-inch mark, it should be lifted to a

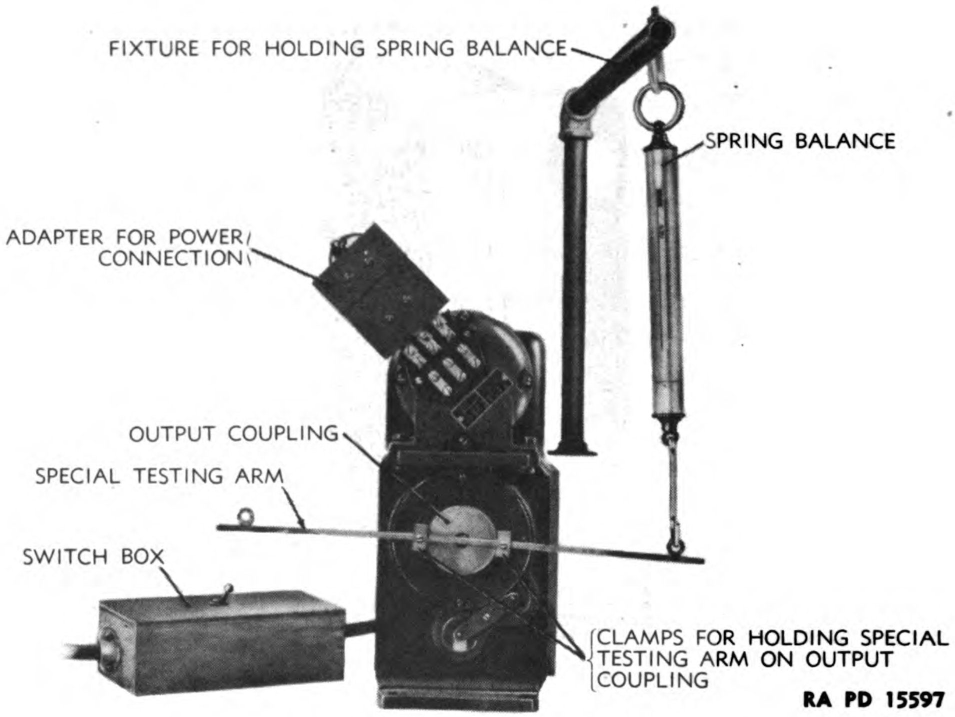

Figure 77 — Shop Test of Torque Amplifier

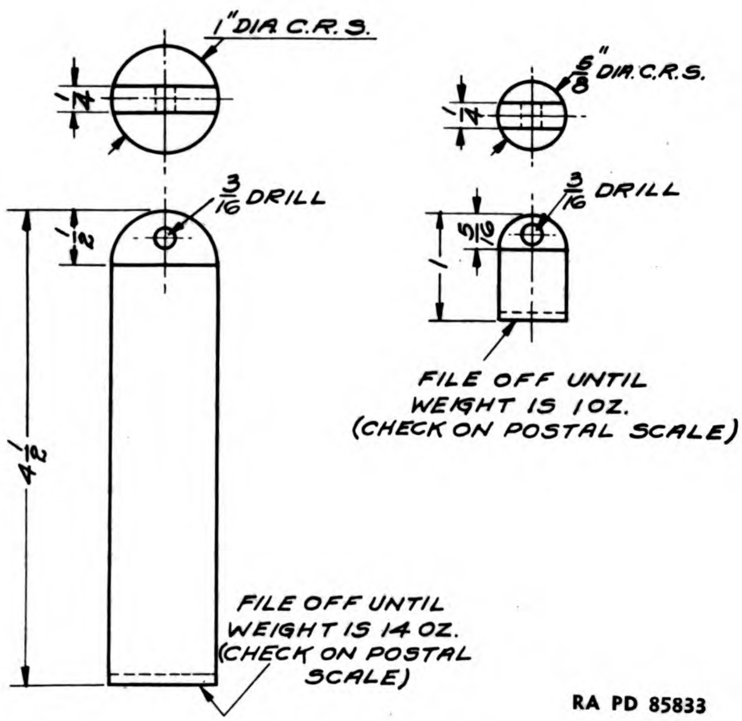

Figure 78 — Suggested Dimensions for Torque Amplifier Testing Weights

INSPECTION

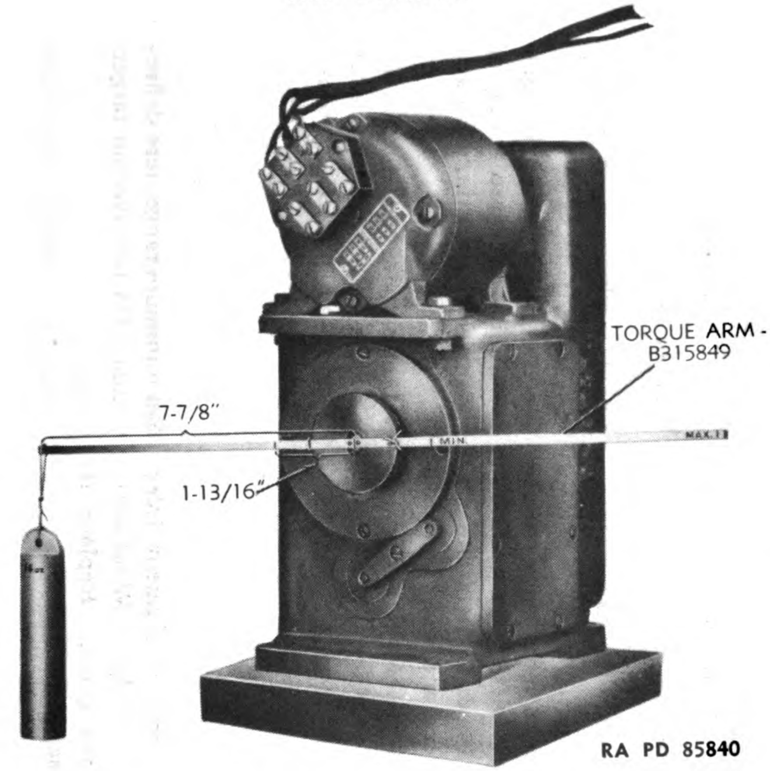

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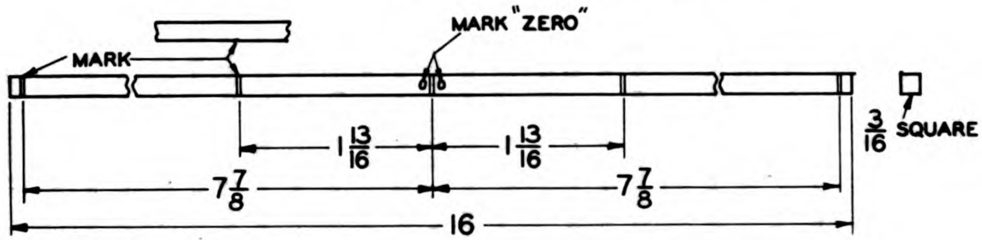
Figure 79 — Field Test of Torque Amplifier



ARM-T.A. OUTPUT COUPLING (FIELD TEST) B315849

MATERIAL-STEEL. FILE AT CENTER IF NECESSARY TO FIT SLOT IN OUTPUT COUPLING. BALANCE ABOUT CENTER MARK. FASTEN TO COUPLING WITH WIRE.

RA PD 85834

Figure 80 — Details for Making Torque Arm B315849

horizontal position when the 1-ounce weight on the input coupling is carefully released; when it is at the outer (7⅞ in.) mark, it should *not* be lifted to the horizontal.

(3) Old style aluminum handwheel assembly B173120 weighs approximately 14 ounces and may be used in emergency, but later handwheels do not weigh the same and special weight is preferable.

f. Examine input coupling for burs or rough spots which might bind at certain positions. When torque amplifier is installed in director, see that it is properly alined so that couplings can turn without binding.

37. TEST AND ADJUSTMENT CHECK LIST.

a. When a repair man is thoroughly familiar with the procedure for inspection and adjustment of a director, the following check list will be found a convenient working guide:

Test or Adjustment	Inspection Data	Adjustment	Precautions
1. Buffer assemblies	Over-all height $8\frac{11}{16}$ inches.	Adjust nuts on plungers.	Tighten lock nuts.
2. Gear train friction	Test friction of mechanism with power off.	Disassemble and clean.	Avoid working in dusty air. Plug all holes in case.
3. Smoothness of operation	Power on, try different rates. Watch level bubbles and fine dials. Sight telescopes at low rates.	Remove and test torque amplifier (Director M5 or M6). Clean brush contacts. Observe governors and worm drive.	See that orienting nut is tight, clamping nut loose. Look for damage to orienting clutch.
4. Backlash in azimuth	Sight 5 or 6 objects in different directions, observe difference in dial readings when approached from opposite directions. Difference should not be more than twice width of line.	Check mesh of gears between units. Replace if necessary.	Set minimum range, zero deflection. Have orienting clutch tight, not locked. Do not overrun target.
5. Backlash in elevation	Sight 3 or 4 targets 0 to 90 degrees. Approach from above and below. Difference in dial readings, not over twice width of line.	Check mesh of segment idler gear and others. Wind anti-backlash gears. Replace if necessary.	Set minimum range, zero deflection. Do not overrun target.
6. Range stop and range dial	Range handwheel should turn 10 full revolutions.	Replace stop pins.	Do not break pins by forcing handwheel.
	When against stop at minimum range, both multiplier sliders	If sliders out of position, re-engage range shaft gears. Re-	

	should be at reference marks, and dial should be at datum line or half-line width to left.	set dials.	
7. Rate setting clutch	Deflection marks alined, clutch knob out; fine dial should not move over width of one line when range wheel is turned through entire range.	Turn fixed clutch collar.	Block handwheel lightly for final adjustment. *Do not break casting* by tightening nut too much.
	Bar assembly should move 3 to 3$\frac{1}{16}$ inches either side of zero. (Travel of stop nut — $\frac{23}{32}$ in.)	Turn up against fixed stop; if not 3 to 3$\frac{1}{16}$ inches from zero, lift pinion and remesh with rail. Recheck preceding step. Reset adjustable stop for travel other way.	Have nut against fixed stop when reengaging pinion. See that bar does not strike at either end.
8. Electrical zero of transmitters	Voltage across transmitter terminals 1 and 3 should be zero when lining-up holes are alined.	Loosen 3 adapter screws. Connect X and 2; connect Y, 1, and 3. Turn spindle until holes line up. If slot in adapter does not line up with hole in housing, loosen six screws and rotate ring.	Leave director switches off.
9. Azimuth transmitter and dial setting	Pins should go into both transmitters at same time. Dials should be at zero.	Loosen clamping ring and remesh fine transmitter gear. Set dials at zero.	Remove pins before turning handwheel. Do not damage small pin in dial washer.
10. Quadrant elevation transmitter and dial setting	Director M5A1 — same as azimuth transmitter. Director M5 or M6 — with pin inserted, fine dial should be zero, coarse dial any division.	Set dials.	Remove pins before turning handwheel. Do not damage small pin in dial washer.

Test or Adjustment	Inspection Data	Adjustment	Precautions
11. Segment engagement and limit switch	At 80-degree elevation, 21st tooth of segment (within 1 or 2 teeth) should engage.	Reengage segment at 100 degrees.	Do not bend stops excessively. Last 3 or 4 teeth of segment should not be used.
	Limit switch should cut out at 85 degrees and −5 degrees, within 1 degree. Both phases within ½ degree.	Move limit switch or reengage segment.	Zero deflection. Have power off when using ohmmeter.
12. Elevation stops	91 degrees to 93 degrees and −9 degrees to −11 degrees.	Swing stops or bend slightly.	Do not bend excessively. Replace.
13. Level director	Both bubbles within 1½ divisions anywhere in 360 degrees.	Adjust levels if necessary.	Be sure screw and lock nuts are tight.
14. Alining telescopes	Azimuth telescope should follow plumb line from 0 to 45 degrees within 1 mil.	Try elevation telescope. Place shim under right or left telescope shaft housing.	Director must be level. All screws tight. Use peep sight.
	Elevation telescope exactly horizontal or vertical when dials are 0 or 90 degrees.	Use distant horizon or gunner's quadrant. Turn shaft in segment.	Average out backlash. Have director level.
	Azimuth telescope agrees with elevation within 1 mil.	Rotate azimuth clamping ring.	Be sure testing target is level. Use peep sight.
	Elevation telescope agrees in azimuth within 1 mil.	Look for dirt or burs on telescope mountings, bent shaft, or flange. Adjust reticle if telescope has been tampered with.	Measure testing target occasionally. Unauthorized personnel should not open telescopes.

15. Open sight	Parallel with telescope.	File off side of tongue for small azimuth correction, or replace bent shaft or sight.	Remove shaft before trying to straighten. Do not bend sight.
16. Variable-speed mechanisms	Spring tension should be 7 to 8 pounds on Director M5 or M6, 20 pounds on Director M5A1.	Adjust by turning locking nut.	Straight pull on scale. Measure tension just as roller leaves ball.
17. Governors	20 revolutions of wormwheel or index in 60 seconds (59½ to 60½).	If very fast or erratic, check and clean ball bearing. Adjust governor springs equally. ⅙ turn both ends—½ second.	Do not run segment gear off. Hold screw while turning nuts.
18. Azimuth zero creep	Not over 1 degree per minute.	Adjust ball carriage on azimuth bar assembly.	Check zero deflection first. Check flat spring.
19. Elevation zero creep	Short limit switch. Not over 1 degree per minute at 90 degrees.	Check that largest radius of superelevation eccentric shaft is downward. Adjust elevation ball carriage.	Check zero deflection and flat spring. Do not push against spring when adjusting screws.
20. Superelevation creep	See table, paragraph 32.	Check micrometer setting with range dial. Readjust ball carriage, then reset eccentric shaft for zero creep and recheck.	Zero deflection, leave clutch out during test. Check flat spring tension.
21. Test problems	See paragraph 35.	See section VI, trouble shooting charts.	

Section V

GENERAL MAINTENANCE

38. GENERAL CARE.

a. Care in Handling.

(1) The director is built to withstand all normal service conditions, but rough handling should be avoided as it may result in serious damage to the delicate mechanisms and accurately adjusted parts. When the director is set up into position, be sure that the tripod will not shift, allowing the director to fall and be damaged. When placing the director on the tripod, lower it carefully into position. The bushings on the director housing may be lined up with the plungers by disengaging the slewing clutch and rotating the director housing until the bushings are lined up in proper position. Do not drop director onto the tripod.

(2) Be sure the power is off at the generator when inserting or removing the D-plug.

(3) Do not slew the director by pushing on the case; use the azimuth throw-out lever. Grip the lever tightly so as to disengage the clutch teeth fully.

(4) Whenever using the orienting clutch, do not attempt to turn the director while both the orienting clutch and lock nut are tightened, as it will result in serious damage to the clutch.

(5) Whenever replacing cover plates, seal with grease.

b. Care of Cables.

(1) Cables will not withstand repeated kinking or twisting, so avoid excessive twisting or bending the cables on a short radius. Do not allow vehicles to run over unprotected cables, especially in very cold weather, and protect cables from heat or sunlight when not in use. Do not allow dirt of any kind to accumulate on the cable plugs as it will impair connections and may lead to short circuits.

(2) Oil and grease are detrimental to rubber; therefore, keep the cables free from these materials. If oil or grease gets on the rubber, wipe it off or, better, wash with soapy water.

(3) The reticle light cables are frequently broken at the plugs by twisting, and cause shorts which may burn out the transformer and wiring. Broken cables should be replaced or firmly taped to prevent further damage.

c. Cold Weather Operation. Cold tends to freeze moving parts by congealing the lubricants. This will be evidenced by stiffness of operation. To avoid this, lubricate the director very lightly using oil, only, and do not use grease.

d. Desert Operation. To keep sand and dust away from it, keep the director covered at all times when not in use. Keep the orienting clutch and switch covers on at all times when the director is not in use. Never remove cover plates in dusty air if it can be avoided. The lubrication for the director is the same as for normal conditions except that it may have to be done more often. Sand wears gears and bearings rapidly. Disassemble and clean as soon as possible.

39. CLEANING.

a. Cleaning Materials.

BRUSH, artist, camel's-hair, rd.

PAPER, lens, tissue

SOAP, liquid, lens cleaning

b. Metal Parts. Dust off the metal surfaces with a soft, dry cloth. Do not use cleaning polishes of any kind. Clean telescope flanges and seats, and brush out electrical receptacles with a soft, dry cloth.

c. Cleaning Lenses and Windows.

(1) Never touch the surface of a lens with the fingers. Never use a cloth of any kind on an optical glass surface.

(2) Remove dust from lenses and windows with a clean camel's-hair brush. Tap brush against a hard surface to remove clinging dust particles, and repeat until lens is clean.

(3) To remove grease from windows or lenses of M17 Telescopes, apply liquid lens cleaning soap with a tuft of lens tissue paper, and wipe off with a clean tuft of lens tissue.

CAUTION: Due to the special coating on the lenses of M75 Telescopes, the use of lens soap is forbidden. Clean only by breathing on lens and wiping gently with a tuft of clean lens tissue paper. Excessive rubbing must be avoided.

(4) Internal fogging may be cleared up by taking the telescope to a warm room. Do not apply local heat. Complaints of persistent internal fogging should be referred to an instrument repair man.

40. LUBRICATION.

a. These instructions apply to all three directors. They are in addition to lubrication instructions for the using arms, as given in TM 9-659.

b. The following lubricants and cleaning materials are prescribed for use in the directors:

GREASE, lubricating, special (for all lubrication where grease is specified)

OIL, lubricating, for aircraft instruments and machine guns (for all lubrication where oil is specified)

SOLVENT, dry-cleaning (for cleaning parts, wherever solvent is specified)

c. Any time that a director is taken in for maintenance, and it is necessary to remove the cover plates, the director should be inspected for necessary lubrication. All bearings and points of sliding friction that are accessible should be checked. Ball bearings are coated with grease at the time of assembly, and ordinarily require no attention until the time of general overhaul. However, if the grease shows signs of hardening or other deterioration, the bearing should be removed, thoroughly cleaned with solvent, dried, and immediately relubricated.

(1) BALL BEARINGS. After thoroughly cleaning and drying, apply a light coat of oil and work well into bearings. Then apply a seal of grease, but do not work the grease down around the balls. The grease is applied only to keep the oil from running off and also to keep dirt and foreign material out.

(2) MACHINED SURFACES. A light coating of grease should be applied to all steel machined surfaces even though they are not working surfaces.

(3) DIFFERENTIAL GEARS, GEAR DRIVES, BALL BEARINGS, ETC. These may be lubricated, if necessary, with a drop or two of oil, but do not oil excessively. This is to be done only when it is not possible to remove, clean, and lubricate these parts properly, due to lack of time or dusty conditions.

(4) TORQUE AMPLIFIER (DIRECTOR M5 OR M6). Take a half-turn on each grease cup. Every 6 months, clean and refill as in subparagraph d (8), below.

(5) SPIRAL DRIVE (DIRECTOR M5A1). Take a half-turn on the grease cup.

(6) GEAR REDUCTION UNIT (DIRECTOR M5A1). Remove cover and coat gears with grease.

d. Whenever the director is given a general overhaul, all bearings should be removed, cleaned, and properly lubricated as per subparagraph c (1), above. All other parts requiring lubrication should be cleaned and properly lubricated at the same time. Specific points to be lubricated are as follows:

(1) GOVERNOR BEARINGS. Cover with a light film of oil; do not apply grease. If these bearings become dirty or gummed up it will cause the governor shoes to fly out and strike the base of the director. Any time that gouges are observed in the base immediately under the governor, the bearings should be removed and thoroughly cleaned and lubricated.

GENERAL MAINTENANCE

(2) VARIABLE-SPEED MECHANISM, DISK, ROLLER AND ECCENTRIC SHAFT. After cleaning, cover with a thin film of oil, then grease, in order to prevent corrosion.

(3) MULTIPLYING MECHANISM. Oil slider rails and time screw lightly upon reassembly.

(4) BAR AND RAIL. Put one drop of oil in each of the marked oilholes when necessary. Clean and oil at each overhaul.

(5) TRACKING MECHANISMS. Clean and oil lightly whenever differential becomes dirty or sticky.

(6) GEARS. Apply a light film of oil throughout the gear train. (Do not oil excessively.)

(7) LARGE BEARINGS IN HOUSING. These usually require lubrication only at time of overhaul. Pressure gun fitting can be reached through hole in base near torque amplifier or gear reduction unit.

(8) TORQUE AMPLIFIER (DIRECTOR M5 OR M6). The gear train on torque amplifiers of Directors M5 and M6 will be lubricated every 6 months and at such other times as the director is in a base shop for maintenance. Lubrication will be performed by authorized ordnance personnel only, in accordance with the following instructions:

(a) Remove cover C78284 from input shaft end of torque amplifier. Remove gear guard A182268. Using a cloth wet with dry-cleaning solvent, wipe grease from all gears. When the gears are dry, apply a coating of special lubricating grease.

(b) Fill housing around upper gears until the teeth of gear A182282 dip into grease.

(c) Clean and refill grease cups.

(d) When the foregoing procedure has been followed, grease cups can be given a partial turn whenever side covers are removed.

(e) Cold Weather Operation.

1. Maintenance. During cold weather operation, that is for temperatures below plus 32° F, whenever sluggish operation indicates, the director should be carefully relubricated. Directors which have been in storage for a considerable length of time must be completely disassembled and relubricated. The importance of removing all old lubricant by cleaning with dry-cleaning solvent and relubricating sparingly cannot be overemphasized. NOTE: All residue left by the dry-cleaning solvent must be carefully removed before relubrication.

2. Lubrication. When lubricating those mechanisms for which special lubricating grease is prescribed apply *very* sparingly. When oiling those parts for which lubricating oil for aircraft instruments and machine guns is prescribed, apply only the lightest possible film.

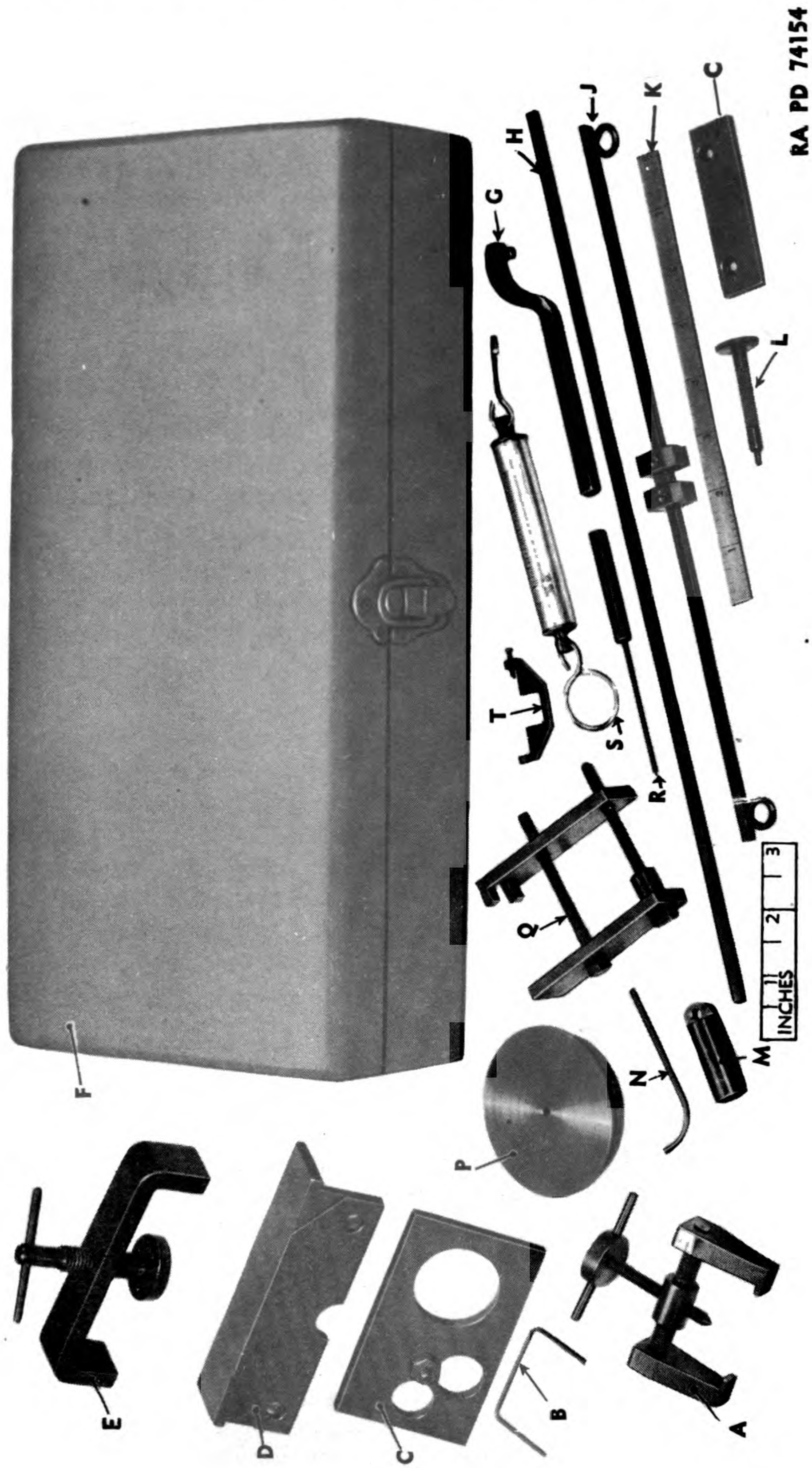


Figure 81 — Special Tools for Director Maintenance

A — PULLER, ADJUSTABLE GEAR - B315852
B — PIN, DOGGING *(FOR AZIMUTH TRACKING MECHANISM)* - A400157
C — TOOL, FACING, FOR CARBON RINGS OF TORQUE AMPLIFIER - B315850
D — FIXTURE *(FOR SETTING TELESCOPES)* - B315845
E — PULLER, SHAFT *(FOR TORQUE AMPLIFIER MAIN GEAR GROUP ASSEMBLY)* - B315847
F — CHEST, WOOD *(FOR TOOLS)*
G — WRENCH, SPANNER *(FOR ADJUSTING BUFFERS)* - B315851
H — ARM *(FOR TORQUE AMPLIFIER FIELD TEST* - SEE FIG. 80) - B315849
J — ARM *(FOR TORQUE AMPLIFIER SHOP TEST)* - B315848
K — RULE, 8 IN. *(FOR MEASURING BAR TRAVEL)* - A400160
L — PIN, ALINING *(FOR TRANSMITTERS)* - A400156
M — WEIGHT, 2 OZ. *(FOR TORQUE AMPLIFIER SHOP TEST)* - A400158
N — PIN, DOGGING *(1/8" DIA. APPROX., FOR ANTI-BACKLASH GEARS)* - A400161
P — SIGHT, PEEP *(FOR SETTING TELESCOPES)* - A400153
Q — PULLER, BEARING *(TORQUE AMPLIFIER INTERMEDIATE GEAR GROUP)* - B315846
R — PIN, DRIFT *(FOR REMOVING TORQUE AMPLIFIER SPRING PINS)* - A400154
S — SCALE, 6 LB. SPRING *(FOR TORQUE AMPLIFIER SHOP TEST)* - A400159
T — TOOL, TORQUE ARM HOLDING *(FOR TORQUE AMPLIFIER)* - A400155

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Legend for Figure 81 — Special Tools for Director Maintenance

(9) SPIRAL DRIVE (DIRECTOR M5A1). Remove cover and wipe out old grease; coat gears with grease and refill grease cup.

(10) GEAR REDUCTION UNIT (DIRECTOR M5A1). Remove cover and wipe off old grease; coat gears with new grease. See subparagraph c (1), above, for ball bearings.

(11) SEALING. Use grease on the contact surfaces on all cover plates as a seal.

(12) TRIPOD. The leveling screws should be oiled occasionally. Do not pack the ball of the plunger assemblies with grease.

41. SPECIAL TOOLS.

a. There are some special tools, shown in figure 81, that will aid materially in the maintenance of the directors. Some of these are tools for the torque amplifier in Directors M5 and M6. See also the special testing devices shown in figures 68, 69, 70, 74, 78, and 80, and the emergency tool in figure 278.

Section VI

MALFUNCTIONS AND CORRECTIONS

42. TROUBLE SHOOTING.

a. Trouble shooting on the directors is a process of orderly analysis of the symptoms indicating faulty operation, when there is not time for a thorough inspection and overhaul. Troubles can be quickly located if a regular procedure is followed. If the gun does not follow the director properly, determine first whether the trouble lies in the mechanical part of the director or in the electrical signalling system. With the gun and director in operating position perform the following steps:

(1) Watch the dials on the director; the gun should follow the dials exactly. If the dials behave in the normal fashion, and the gun is erratic, the trouble is in either the hydraulic part of the oil gear or in the electrical signalling system. If the dials are erratic, the trouble is in the mechanical part of the director.

(2) Operate the oil gear pilot valve manually; if the gun responds normally, the trouble is in the electrical signalling system. If it does not, the trouble is in the hydraulic part of the oil gear.

(3) As a rough check, move gun or director manually and watch the deflections of the electrical differential torque arm. If the torque arm deflects normally, the trouble is in the hydraulic part of the oil gear. If it does not, the trouble is in the electrical signalling system.

(4) If the trouble is determined to lie in the mechanical parts of the director, the following charts will serve as a guide in locating the trouble (after running test problems in section IV).

43. MECHANICAL TROUBLE SHOOTING CHARTS.

a. Azimuth Errors.

CHECK AZIMUTH PROBLEMS ACCORDING TO PARAGRAPH 35 c. IF SATISFACTORY, GO NO FURTHER IN THIS GROUP

TIME ERRORS ARE EITHER ALL PLUS OR ALL MINUS. If not, go no further in this group.

- Time constant-speed motor worm gear or index — 20 rpm. If much too fast, check governor bearings.
- Check variable-speed mechanism spring if all errors are plus.
- Check range dial setting.
- Check scribed marks on multiplier when range is minimum.
- Check torque amplifier, subpar. e, below (Director M5 or M6 only).
- Friction due to chips in orienting mechanism.
- If errors are inconsistent, check spring on ball slider.

TIME ERRORS PLUS ONE WAY, MINUS THE OTHER. If not, go no further in this group.

- Check zero deflection.
- Check zero creep.
- Check method used to set problems (range value first).

MAXIMUM DEFLECTION CANNOT BE OBTAINED. If satisfactory, go no further in this group.

- Check travel of bar assembly.
- Check range stop.
- Check gearing for dirt or damage.

DIRECTOR WILL NOT ROTATE. If satisfactory, go no further in this group.

- Torque amplifier motor not running or running in wrong direction (Director M5 or M6).
- Check fuses, wiring, voltage, azimuth motor.
- Check spring on variable-speed mechanism.
- Check torque amplifier, subpar. e, below (Director M5 or M6 only).
- Check gearing for dirt and damage.

b. Elevation Errors.

CHECK ELEVATION PROBLEMS ACCORDING TO PARAGRAPH 35 b. IF SATISFACTORY, GO NO FURTHER IN THIS GROUP

TIME ERRORS ARE EITHER ALL PLUS OR ALL MINUS. If not, go no further in this group.

- Time constant - speed motor worm gear or index — 20 rpm. If much too fast, check governor bearings.
- Check variable-speed mechanism spring if all errors are plus.
- Check range dial setting.
- Check scribed marks on multiplier at minimum range.
- Check torque amplifier (Director M5 or M6) (subpar. e, below).
- If errors are inconsistent, check spring on superelevation mechanism.

TIME ERRORS PLUS ONE WAY, MINUS THE OTHER. If not, go no further in this group.

- Check zero deflection.
- Check zero rate.
- Check superelevation setting.
- Check method used to set problems. (Range value first.)

MAXIMUM DEFLECTION CANNOT BE OBTAINED. If satisfactory, go no further in this group.

- Check travel of bar assembly.
- Check range stop.
- Check gearing for dirt and damage.

TELESCOPES WILL NOT ELEVATE. If satisfactory, go no further in this group.

- Torque amplifier motor not running or running in wrong direction (Director M5 or M6).
- Check fuses, wiring, voltage, elevation motor.
- Check spring on variable - speed mechanism.
- Check gearing for dirt or damage.
- Check torque amplifier (Director M5 or M6) (subpar. e, below).

MALFUNCTIONS AND CORRECTIONS

c. Elevation Dials Disagree With Telescopes.

ELEVATION ZERO INCORRECT. IF NOT, GO NO FURTHER IN THIS GROUP

ZERO OFF ABOUT ONE DEGREE, or more. Limit switch may be off by same amount. Mechanical stops bent.

Telescope shaft segment has probably been reengaged incorrectly.

Reengage segment. Check limit switch, stops. Check zero elevation.

Reset zero elevation. Be sure horizon is true or target at right height. If using level or quadrant, try reversing it.

Dials may have shifted. Insert pin in transmitter and see that dial reads zero.

Approach zero from each direction to average backlash.

Backlash excessive. Antibacklash gears may be improperly wound.

Idler gear which engages segment may not be properly meshed. If off, loosen four bearing screws and shift.

d. Tracking Errors.

TELESCOPES TRACK JERKILY. IF NOT, GO NO FURTHER IN THIS GROUP

AZIMUTH JERKY. If not, go no further in this group.

See that orienting clutch is tight and clamping nut loose. Look for burs on orienting clutch parts from rotating director with clamping nut tightened.

ELEVATION JERKY.

Superelevation connecting rod or open sight link interfering with other parts.

BOTH AZIMUTH AND ELEVATION JERKY.

Check power cables for loose connections or shorts.

Connect power direct to terminal blocks 1, 15, 8. If condition is corrected, check and clean brushes and contact rings.

Check gearing for backlash, tight mesh, or dirt.

Director M5 or M6. With Director M5A1 go no further in this group.

Burs or misalinement of torque amplifier input coupling.

Tracking irregular, usually more in one direction than other. Check torque amplifier (subpar. e, below).

Flutter of worm drive; check for end play, replace cork washer if necessary. See that worm drive assemblies have not been interchanged.

Telescopes jump every 1½ seconds on average, particularly at low tracking rates. Check balance of wormwheel and disk.

e. **Torque Amplifier.**

TORQUE AMPLIFIER WILL NOT FUNCTION PROPERLY. IF SATISFACTORY, GO NO FURTHER IN THIS GROUP

NO OUTPUT
- Check input
- Check motor rotation
  - See that bands are clamped on arms
  - Bands wound improperly
- Motor will not run
- Check motor alone
- Check gear train
- Check tightness of bands

DIFFICULTY IN TURNING BOTH COUPLINGS IN OPPOSITE DIRECTIONS WHEN MOTOR IS STOPPED.
- Check tightness of bands
- Check gear train
- Check for frozen bearings
- Check bands overriding

JERKY OPERATION
- Check alinement of bands
- Check carbon rings for ridges or scored areas
- Check for oil, grease, or moisture on bands or carbon rings
- Check for kinks in bands.
- Check eccentricity of carbon rings

BACKLASH
- Check for looseness of bands
- Check backlash between input coupling and input torque arm

NOISY OPERATION
- Check gear train
- Check for ridges on carbon rings
- Check for loose carbon rings
- Check for carbon deposit on bands
- Check alinement of bands

UNSATISFACTORY OUTPUT
- Low amplification
  - Poor polish on carbon rings
  - Worn out carbon rings
- High amplification
  - Too high polish on carbon rings
  - See that bands are clean
- Check for oil, grease, or moisture on bands or carbon rings
- Unloaded shafts turn when motor is running (bias)
- Change position of torque arms
- Lower amplification on pertinent carbon ring
- Check alinement of bands

MALFUNCTIONS AND CORRECTIONS

44. ELECTRICAL TROUBLE SHOOTING.

a. If the primary checks indicate the trouble is in the electrical signalling system, test director with a second gun if possible. If the second gun acts in the same erratic manner as the first, the trouble is probably in the director and can be found by testing the signal voltages of each transmitter by the following method:

(1) Connect the power from the generator to the director without going through the gun junction box in order to prevent the feedback from the transmitters in the oil gears giving incorrect data. (See special connectors in figs. 68, 69, and 70, or connect a single-phase supply to terminal blocks Nos. 1 and 15. Leave motor switches off.) Check voltages between terminal blocks Nos. 1 and 15. Connect a voltmeter across each pair of stator terminals (1, 2, and 3) on each transmitter, and turn the transmitter through one complete revolution. The voltage between *each pair* of terminals should build up smoothly from 0 to approximately 105 volts (with 115-volt supply) and back to zero, twice in one full turn of the transmitter dial. In Director M6, the voltage should vary from 0 to about 45 volts. The easiest way to check the transmitters is to remove the front cover plate and measure at the terminal block.

(a) Azimuth Coarse Transmitter. Measure between terminal blocks 8-9, 8-10, 9-10. Slew director 360 degrees each time.

(b) Azimuth Fine Transmitter. Measure between terminal blocks 10-11, 10-12, 11-12. Turn azimuth handwheel. Voltage should build up every 10 degrees on fine dial.

(c) Elevation Fine Transmitter. Measure between terminal blocks 3-4, 3-5, 4-5. Turn elevation handwheel. Voltage should build up every 10 degrees on fine dial.

(d) Elevation Coarse Transmitter (Director M5A1). As the telescopes are turned from 0 to 90 degrees, the voltage should go from 0 to 105 between terminal blocks 2-6, from about 90 through zero, and up to 50 between blocks 2-7, and from 90 through 105 and down to 50 between blocks 6-7.

(e) If no voltage is found on any of the above terminals, the transmitter may be burned out. Give it a continuity test. Also check the wiring for a short which may be the cause of the failure, before installing a new transmitter.

(f) Check to see that coarse and fine transmitters zero at the same time (both pins can be inserted). This is particularly important with Director M5A1.

(g) Look for signs of arcing between brushes and contact body or cable plug. Clean off all dust and grease, and lightly stone the contact rings. With an ohmmeter if available, check resistance from

gun end of 15-conductor cable to terminal blocks in director. Try slewing the director while testing.

b. Power Supply.

(1) If one of the power leads is open, the motors may run, either forward or backward, and the director may track. The lamps may light normally (step (2), below). The usual cause is a blown fuse at the generator. Also, one of the pins in the 3-conductor cable may not make contact. Check cables and junction box.

(2) If the A- or No. 1 circuit is open, the motors will usually start up slowly in the right direction, and the director will track normally. If the B- or No. 8 circuit is open, the motors will not start. If the C- or No. 15 circuit is open, the motors will usually start in the wrong direction, and Director M5 or M6 will not track. Do not operate the director with this condition. If an individual motor lead is open, the motor will not start alone but will run in either direction if started.

(3) If some of the motors run properly and some do not, the trouble is in the director (look for blown fuse in older directors).

c. Director M5 or M6. If the director or telescopes do not traverse when a deflection is set in but move easily when touched, the torque amplifier motor is running the wrong way. Stop the motors immediately to prevent damage to the variable-speed mechanism. Check rotation of other motors, and connections to torque amplifier motors (par. 25).

Section VII

ADJUSTMENT AND REPAIR

45. ADJUSTMENT OF LEVEL VIALS.

a. Check. To check the level vials, the director must first be levelled as follows:

(1) Slew the director until one of the levels is parallel to two of the levelling screws on the tripod, and adjust the two screws until the bubble is centered.

(2) Adjust the third tripod screw to center the bubble in the other level vial.

(3) Slew the director 90 degrees and check levels, readjusting tripod screws if necessary.

(4) If director cannot be levelled by this method so that bubbles do not move more than one division from center in a complete revolution of the director, adjustment of the levels is necessary.

b. Adjustment.

(1) Slew the director until one of the levels is parallel to two of the levelling screws, and center the bubble as in subparagraph **a** (1), above.

(2) Slew director exactly 180 degrees. Note bubble error and correct one half of this error by adjusting the same levelling screws.

(3) Then loosen the two adjusting nuts at the right end of the vial (fig. 306) with a pin wrench and bring the bubble to center. Make sure that the screw and the two nuts are tight. Slew 180 degrees again and recheck. Level bubbles should remain centered.

(4) Slew 90 degrees and center the bubble by adjusting the third levelling screw on the tripod. The director should now be level, so that this bubble will be centered at all director positions.

(5) If necessary, the bubble in the other level vial should now be centered by means of the adjusting nuts.

46. ADJUSTMENT OF BUFFER ASSEMBLIES.

a. The two round nuts in the buffer assemblies (fig. 49) should compress the buffer spring until the over-all length of the buffer assembly from bottom of shoe to top of body is $8\frac{11}{16}$ inches. This setting gives more protection to the director than the original setting of $8\frac{7}{16}$ inches.

b. These two nuts may be easily adjusted with spanner wrench B315851 (G, fig. 81). The top nut is a lock nut which should be loosened before adjustment and tightened afterward.

47. AZIMUTH THROW-OUT (SLEWING) CLUTCH.

a. If slewing clutch does not disengage fully, see whether the slewing clutch lever or the gripping handle A182580 is bent (fig. 48). If the handle is bent, loosen and turn it so it is bent away from the lever rather than toward it. A shim may also be placed under the block A182555 (fig. 168). See that the fork is properly alined when replacing.

b. Blow out any chips which may have been formed by the slewing clutch. Also check for dirt or interference between housing and base (or covers) which might be noticed when slewing.

48. ORIENTING CLUTCH (FUTURE AZIMUTH MECHANISM).

a. Attempting to turn the director while the clamping nut A182562 is tightened may cause burs and chips around the clamp and the retainer (fig. 31). These parts should be cleaned and examined for looseness. The parts at the lower end of the shaft of the future azimuth mechanism may be removed after driving out the taper pin at the end of the shaft (par. 79 **b**).

b. Play between the retainer A182414 and the shaft or between gear hub and shaft, may be caused by enlargement of the keyway. The simplest way to correct this is to fit an oversize key by filing. It will be necessary to remove the future azimuth mechanism as instructed in paragraph 79. Remember that the retainer must slide vertically on the shaft for proper operation of the orienting clutch.

c. **New Orienting Clutch** (figs. 195 to 200). Note shaft assembly C78321 and antibacklash gears are same as old design. See paragraph 79 **c** for removal. Disassemble only if required. Before pinning retainer A319222, be sure clutch can be entirely released without compressing spring A319223 solid.

49. ADJUSTMENT OF RANGE STOPS AND RANGE DIAL.

a. The range stop should allow 10 full turns of the handwheel. If the handwheel turns more, one of the stop pins may be sheared off. The range stop is on the long shaft of the azimuth multiplying mechanism (fig. 257). The spring pins BFSX1ED found in M5 and M6 Directors and accessory chests may be replaced with the newer square type solid pins A317358 if available. If one of the pins is inserted from the wrong side of the shaft, only 9½ turns will be permitted. If both pins are inserted from the wrong side, only 9 turns will be permitted.

b. When the stop is against the pin furthest from the handwheel (minimum range position), the scribed marks on the strip and slider of each multiplier should be alined as in figure 71. If the azimuth slider does not aline, drive out the stop pins and turn the screw on the shaft until the stop operates correctly; then replace the pins as in subparagraph **a**, above. If only the elevation slider does not line up, remove the bolts which hold the range mechanism and move it outward until the bevel gears disengage. Turn the coupling at the left of the range mechanism until both sliders are in time; then reengage the gears and fasten the range mechanism.

c. **Range Dial.** If the dial index is not opposite the datum line at the top of the range scale when at the minimum position, loosen the three screws which clamp it and shift it to the proper position.

50. RATE SETTING CLUTCH ADJUSTMENTS.

a. The adjustment of the rate setting clutch is the same for both azimuth and elevation mechanisms.

b. If the clutch has been disassembled, see that the adjustable stop A182459 (fig. 17) is set to permit $^{23}\!/_{32}$-inch travel of the stop nut.

c. If the clutch has been removed or if the bar travel is not correct (par. 24 **d**), lift the clutch mechanism to disengage the pinion from the rack. Move the bar assembly by hand until it is 7⅛ inches from the end of the rail (measured as in fig. 73). Turn the clutch shaft until the stop nut is against the fixed stop, nearest the clutch knob. Drop the pinion into engagement with the nearest tooth of the rack, and fasten the clutch to the base. Check to see that the bar assembly does not strike the pinion or the handwheel shaft at either end of its travel (test for clearance with a piece of paper). Reengage pinion one tooth one way or the other if necessary.

d. The adjustable stop A182459 should now permit the bar assembly 6 to 6⅛ inches total movement, or between 3 and 3$^1/_{16}$ inches either side of zero deflection position. Shift the adjustable stop if necessary, after loosening its set screw and cleaning the threads, damaged by the set screw, with a sharp instrument.

e. Zero Deflection. Push in clutch knob and turn handwheel until the deflection marks are alined (fig. 72). Pull out clutch knob firmly. Turn range handwheel throughout its range and note whether the fine dial moves. If it does, loosen the clamping nut BBSX2AA to free the stationary collar B173046. Set in maximum range and tap the arm at the top of the multiplying mechanism with the hand until it is vertical and the fine dial does not move when the range wheel is turned. Then tighten the clamping nut *but not tight enough to break the casting.* A special washer shown in figure 138 may be inserted in the slit of the casting to prevent overtightening. See that the stationary collar will bring the deflection to zero from either side of this position, and recheck for dial movement.

f. If the deflection marks (fig. 72) are now out of line, loosen the screws which hold the index and shift it as required. Also check bar movement either side of zero, as in subparagraph **d**, above.

51. ELECTRICAL ZERO OF TRANSMITTERS.

a. New transmitters are accurately set at the factory so they are at electrical zero when an alining pin (A400156, fig. 81) is inserted through the slot in the adapter A182171 (fig. 123). When installing a new transmitter, skip to subparagraph **c**, below. If an adapter has been removed or if the voltage tests in paragraph 26 **b** indicate that the transmitter has been disturbed, it may be reset as follows:

b. Transmitters with adapter A182171 may be set before they are installed in the transmitter assembly. Older transmitters having adapter A182479 without the slot (see fig. 129) can be set only after assembly, as described in (1), (2), and (4).

(1) If assembled, see that the **X** terminal of the transmitter is at the 12 o'clock position. Loosen the bakelite clamping ring and rotate the transmitter to this position if it is not. Also loosen the

three screws which may be seen through the holes in the spindle, so that the rotor is free to turn.

(2) Connect one side of a 115-volt single-phase source (50 volt for Director M6) to terminals X and 2 of the transmitter. Connect the other side to terminals Y, 1, and 3 of the transmitter. *NOTE: If the transmitter assembly is installed in the director, terminals X and Y are already supplied with single phase current and it will be necessary only to correct terminals 2 and X on the transmitter, and terminals Y, 1, and 3.*

(3) The rotor will immediately assume an electrical zero position with respect to the transmitter body. Try moving the adapter and note that it returns to a definite position. If the slot in the adapter is not in line with the hole in the transmitter housing, loosen the six screws in the ring outside the lining-up hole, and rotate the lug until the hole is exactly in line with the adapter slot. (If this position should be near the bottom, it may be that the adapter has been replaced incorrectly and should be rotated 180° on the shaft.) Insert an alining pin, tighten the six screws in the ring, and recheck by the voltmeter method described in paragraph 26 **b**.

(4) With old style adapters A182479, the lining-up hole in the transmitter should be at 12 o'clock, and the alining hole in the gear is lined up directly with it after making the connections indicated in step (2), above. Insert an alining pin, make sure the rotor has assumed its neutral position, and then tighten the three clamping screws.

c. With electrical zero established, insert an alining pin in the transmitters and assemble the gear and spindle assembly so that the alining hole of the gear is in line with the pin. Then tighten the three clamping screws through the holes in the spindle. See paragraph 52 or 53.

52. SETTING FUTURE AZIMUTH TRANSMITTERS AND DIALS.

a. After each transmitter is assembled (par. 51 **c**) insert an alining pin in the coarse (upper) transmitter. If a pin cannot be inserted in the fine transmitter at the same time, back the fine transmitter and spindle assembly out by removing the bakelite clamping ring. Turn the spindle until the pin can be inserted; then reengage the assembly, with the X-terminal at a 12 o'clock position. Leave both pins in until the clamping ring is tightened.

b. With pins in both transmitters, set both dials to zero by loosening the screw at the center of each dial. *CAUTION: See that the small pin in the end of the spindle is through the hole in the small washer ring before tightening the screw. If the index plate is*

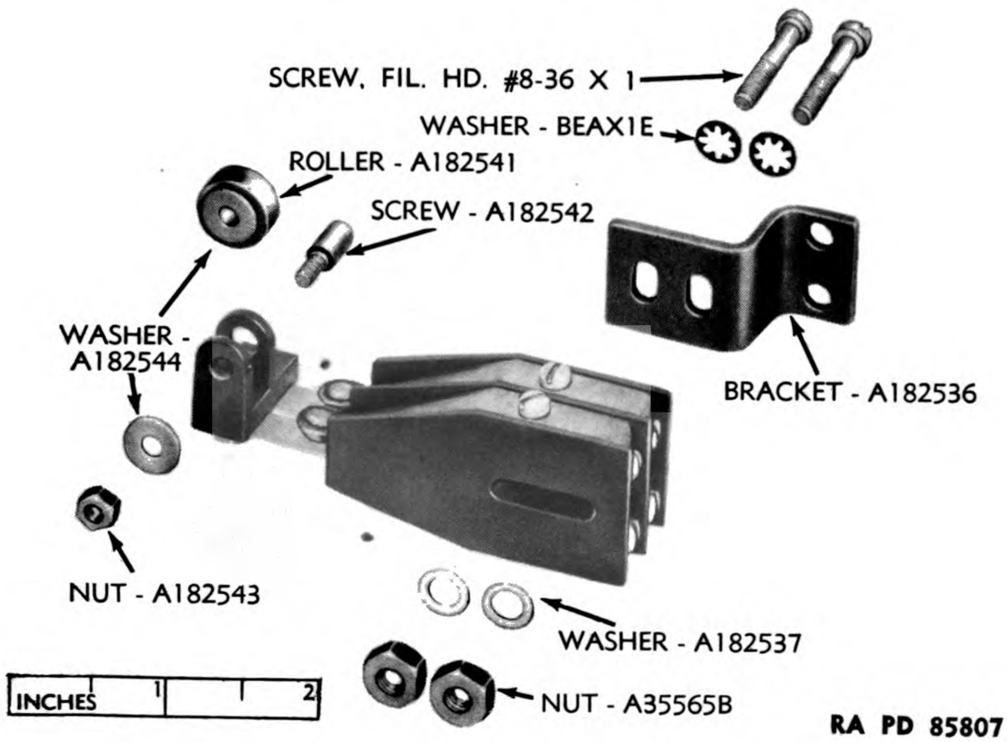

Figure 82 — Elevation Limit Switch Contact Block Assembly C78445

not concentric with the dials, bend the long studs slightly. Remove both alining pins.

53. SETTING QUADRANT ELEVATION TRANSMITTERS AND DIALS.

a. Assemble transmitters as in paragraph 51 c. Turn the telescopes to zero on the elevation scale, or to exact zero if a reference is available. Set in zero vertical deflection.

b. Director M5 or M6. If an alining pin cannot be inserted, remove the bakelite clamping ring and back out the transmitter and spindle assembly; insert a pin, and reengage the transmitter with terminal X at 12 o'clock position. Set both dials to zero. *CAUTION: See that the small pin in the end of the spindle is through the hole in the small washer ring before tightening the screw. If the index plate is not concentric with the dials, bend the long posts A182477. Remove alining pin.*

c. Director M5A1. If both alining pins cannot be inserted, back out the fine (lower) transmitter with the dial assembly attached. Insert a pin in each transmitter, and reengage the fine transmitter assembly with the X-terminal at 12 o'clock position. Set both dials to zero. *CAUTION: See that the small pin in the end of the spindle*

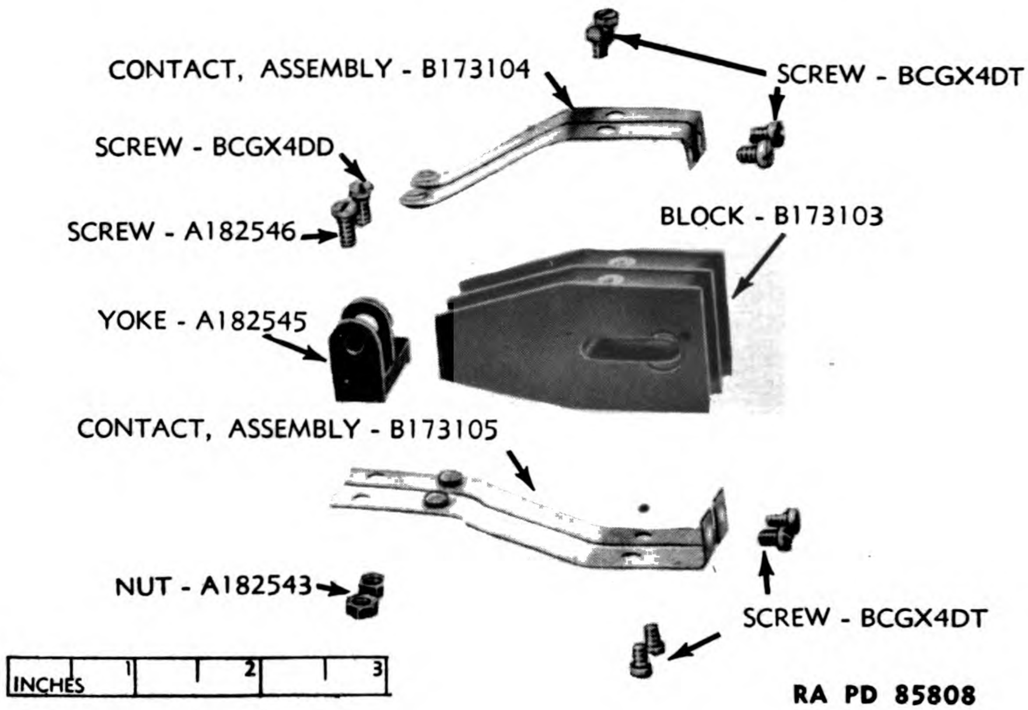

Figure 83 — Elevation Limit Switch — Removal of Contacts

is through the hole in the small washer ring before tightening the screw. If the index plate is not concentric with the dials, bend the long posts A182477. Remove alining pins.

54. ELEVATION LIMIT SWITCH.

a. If inspection (par. 27) shows that the limit switch adjustment is out at both upper and lower limits by 1 degree or more, it may be that the telescope shaft segment has been disengaged and incorrectly reengaged (particularly on Director M5 or M6) (par. 55).

b. Set vertical deflection to zero and pull out clutch knob. Turn handwheel until the elevation dials read 85 degrees. Loosen the two screws which hold the molded block of the switch to the switch bracket (fig. 82) and move it forward or back until the roller touches the lug on the segment and just commences to open the contacts. Tighten the screws.

c. Decrease elevation a few degrees, turn on elevation motor, and slowly increase elevation with the handwheel until the limit switch stops the motor, which should be at 85 degrees within 1 degree. Decrease elevation until motor comes on again, and note whether the motor hums before picking up. If so, it means that the two lines are not being cut in at the same time. Remove the switch

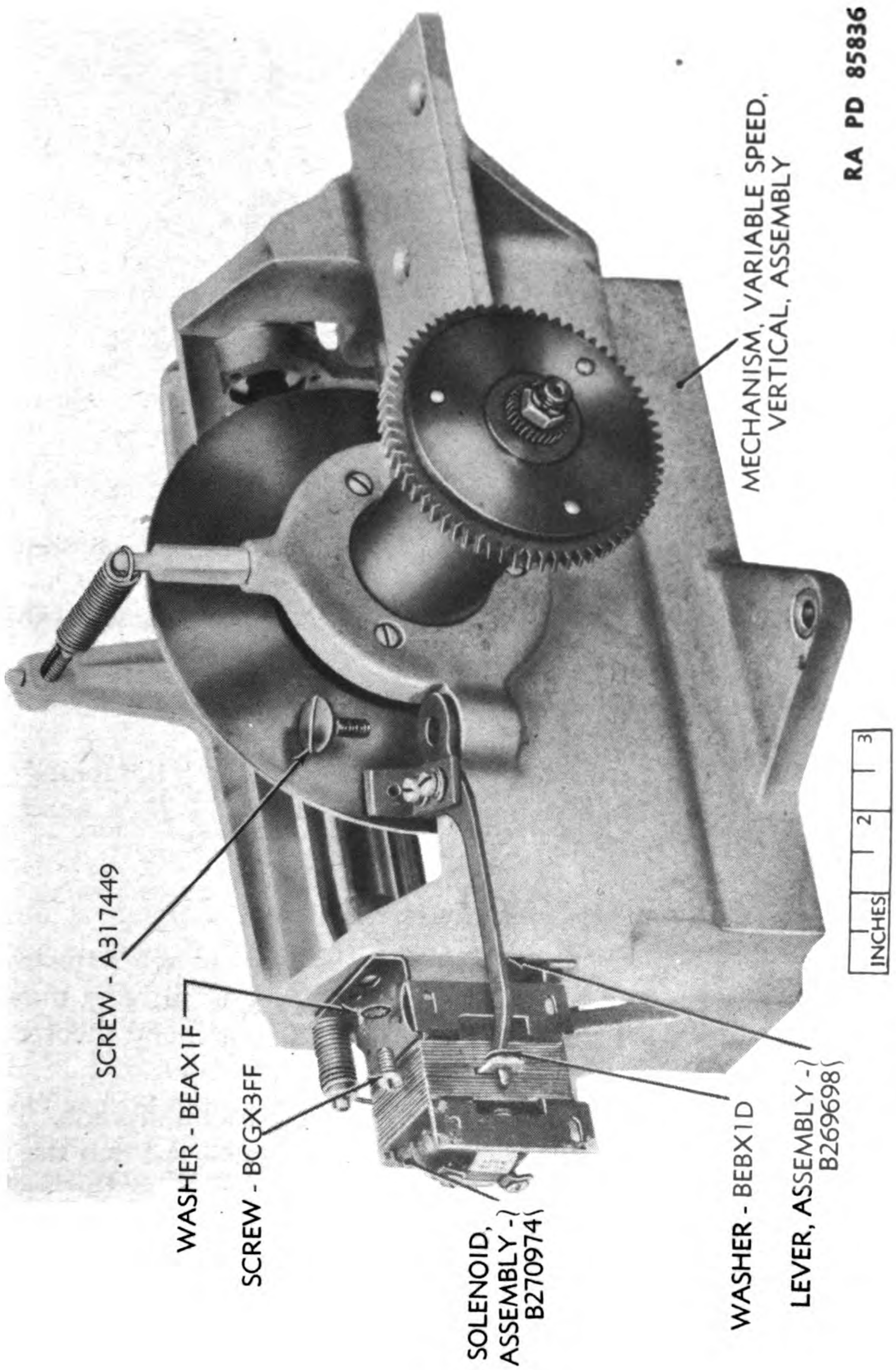

Figure 84 — Installing Solenoid Brake (Director M5A1)

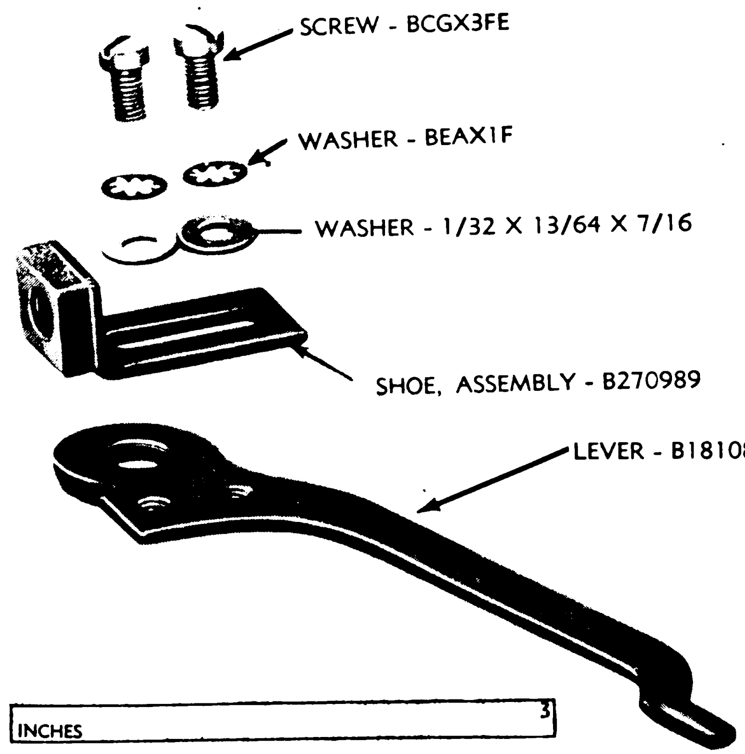

Figure 85 — Lever Assembly B269698 — Exploded View

and bend the contacts slightly until both lines open or close within one-half degree. This may be checked more accurately with an ohmmeter or test buzzer, but when using this method be sure to disconnect the power to the director.

d. In the same manner, see that the limit switch opens at minus 5 degrees on the dials, within 1 degree. If any adjustment is necessary at the lower limit, the upper limit must be rechecked or vice versa. If the switch operating points are not 90 degrees apart, the switch may be tilted slightly.

e. If the maximum adjustment of the limit switch is insufficient to meet these requirements, it may be necessary to reengage the segment one or two teeth in either direction. Another method is to turn the segment until the switch is just opening at minimum elevation; then elevate exactly 5 degrees and reset the transmitter assembly to zero as described in paragraph 53. In either case, the telescopes must be reset as instructed in paragraph 58 **a**.

55. REENGAGING TELESCOPE SHAFT SEGMENT.

a. Set vertical deflection to zero. Swing aside or remove the forward (straight) mechanical stop, and elevate the telescopes until the segment disengages. *CAUTION: Hold the antibacklash gear*

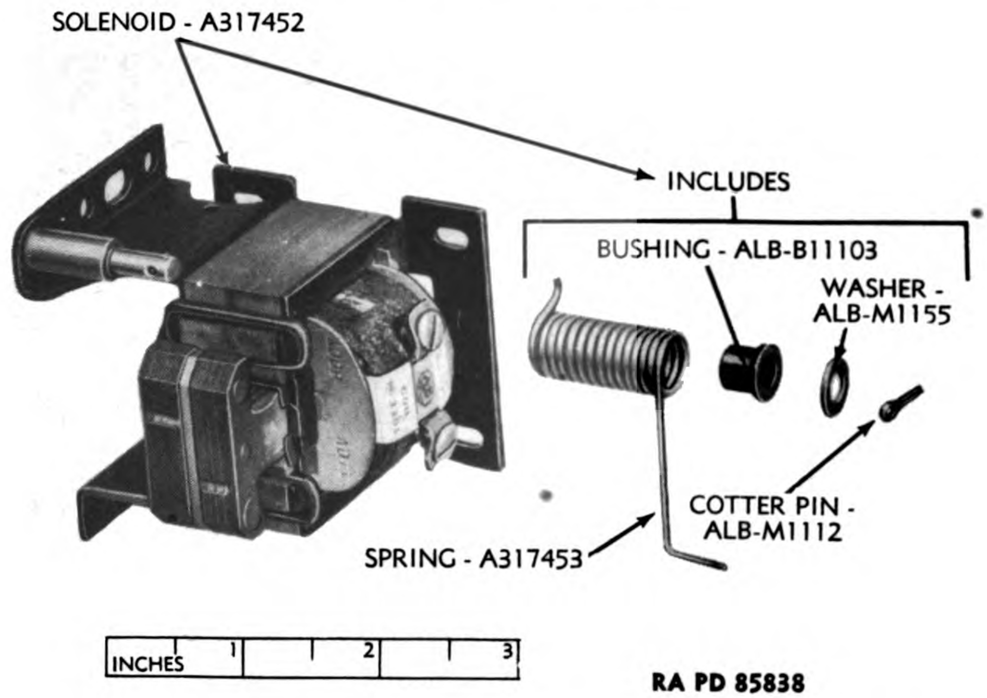

Figure 86 — Solenoid Assembly B270974 — Component Parts

with the fingers as the segment disengages to prevent the spring from whipping.

b. Hold the segment out of engagement with the idler and turn the handwheel until the dials read 100 degrees. Wind the antibacklash gear (counterclockwise from elevation tracker's position) until the spring is tight; then back off two teeth. Allow the segment to drop into engagement; lower the telescopes and replace the forward stop.

c. Check the limit switch and reset the mechanical stops. Reset the telescopes as described in paragraph 58 **a**.

56. ELEVATION MECHANICAL STOPS.

a. Maintenance of these stops is described in TM 9-659.

57. SOLENOID BRAKE ADJUSTMENT (DIRECTOR M5A1).

a. Test the action of the brake as described in paragraph 27 **d**, whenever cover plates are removed.

b. If the brake does not stop the disk soon enough, loosen the two screws which hold the brake shoe to the arm (fig. 85) and move the shoe closer to the disk. It should not, of course, be set so close that it rubs on the disk when the current is on.

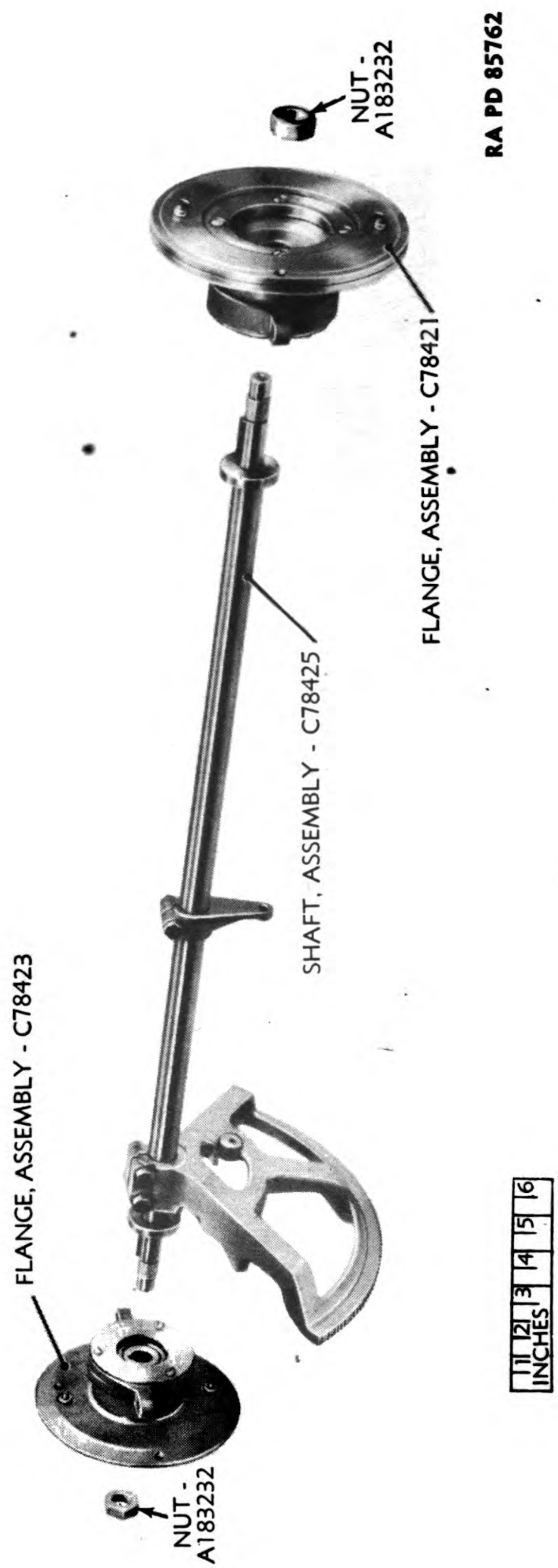

Figure 87 — Telescope Shaft Assembly D43788 — Major Components

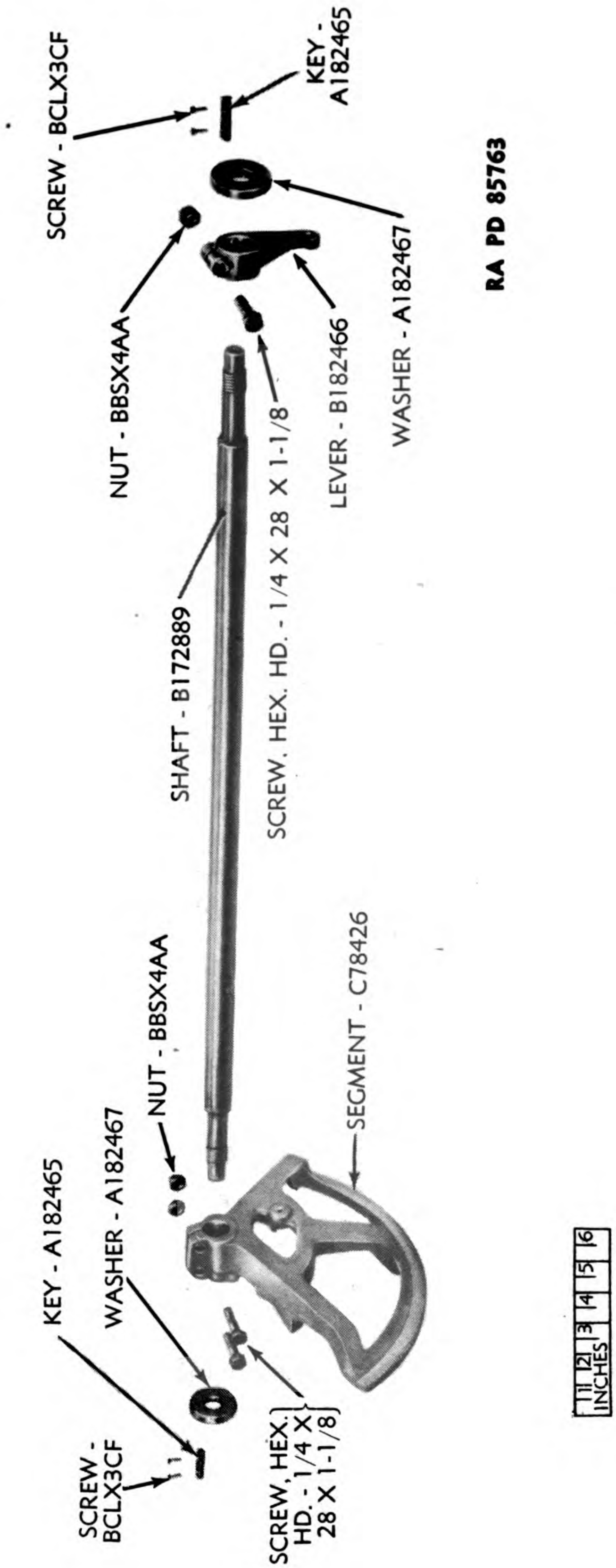

Figure 88 — Shaft Assembly C78425 — Exploded View

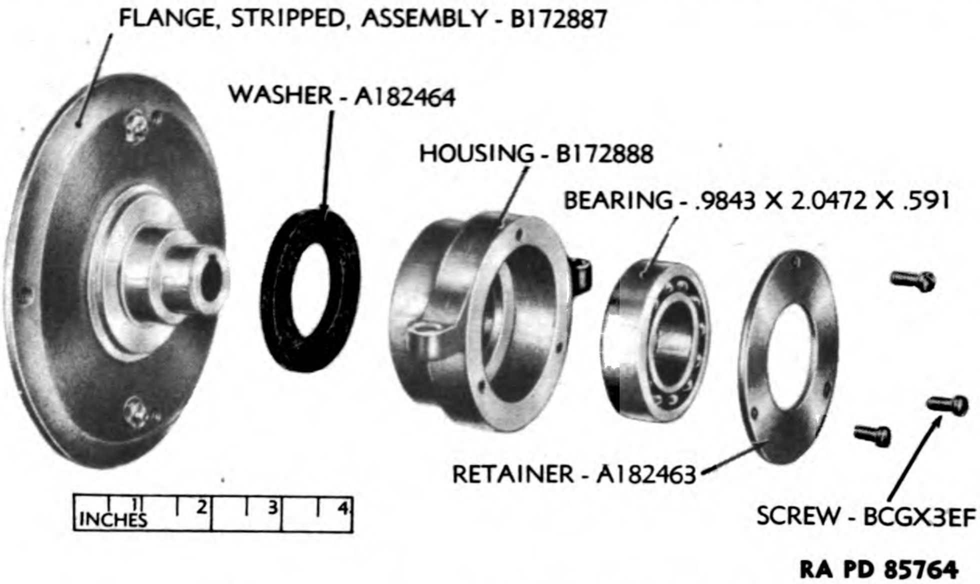

Figure 89 — Flange Assembly C78423 — Exploded View

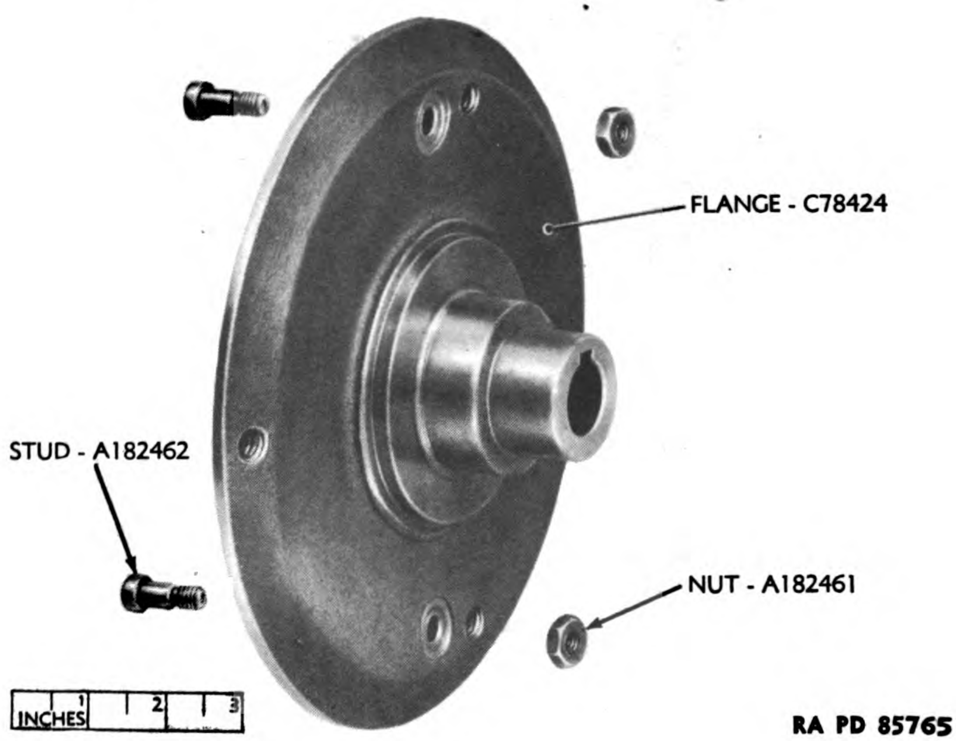

Figure 90 — Stripped Flange Assembly B172887 — Component Parts

c. If the brake fails to release when the switch is on and the limit switch is not cut out, the solenoid may be defective and should be replaced. Be sure the spacing washer BEBX1D is on the end of the lever as shown in figure 84, otherwise the solenoid may not release

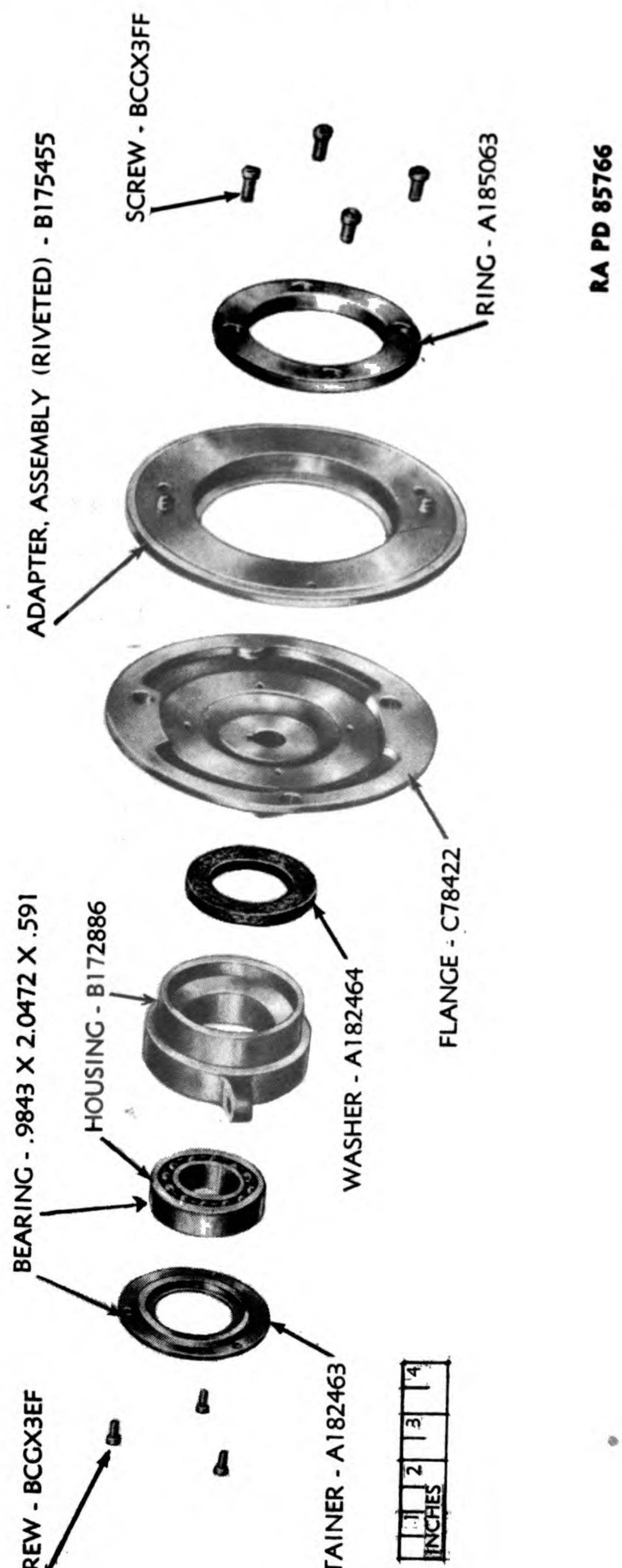

Figure 91 — Azimuth Flange Assembly C78421 — Exploded View

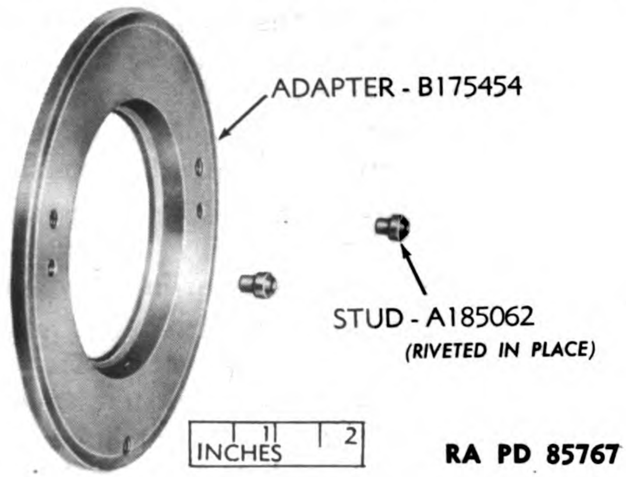

Figure 92 — Parts of Riveted Adapter Assembly B175455

properly. Also check to see that one phase of the power supply is not open.

58. ALINEMENT OF TELESCOPES.

a. Setting Elevation Telescope. Follow the procedure given in paragraph 28 b and d. If the dials do not read 90 degrees when the quadrant is level (or 0 degree if sighting a horizontal target), turn the handwheel until the dials do read correctly and lightly block the handwheel. Loosen the two bolts which clamp the segment to the telescope shaft, and turn the telescope shaft until it agrees with the dials. Tighten the two bolts and recheck, remembering to average out the backlash as explained in paragraph 28 d. Reset superelevation mechanism as in paragraph 62.

b. Alinement in Elevation. If the test described in paragraph 28 e indicates that the azimuth telescope is not alined with the horizontal target line, remove the azimuth telescope and loosen the four screws which hold the clamping ring A185063 (fig. 91). Leave the screws just loose enough so the adapter assembly B175455 can be turned by hand. Attach the telescope, turn it by hand until it agrees with the elevation telescope, then carefully remove it, and tighten the four clamping screws. Attach the telescope and recheck the alinement. Be sure the target is level as mentioned in paragraph 28 e.

(1) If not enough adjustment can be obtained for correction, it may be that the reticle has been set incorrectly during repair of the telescope. If so, loosen the two screws bearing against the top of the reticle cell and tighten the two bottom screws the same amount, or vice versa.

c. Alinement in Azimuth. If the telescopes are not parallel in azimuth, make sure the seats of the telescopes and flanges are clean. See that there is no dirt under the azimuth adapter assembly and that the four clamping screws are tight. Try using only one telescope and shifting it from azimuth to elevation positions.

(1) If both telescopes give the same variation, the telescope shaft or flange may be bent. An emergency correction may be made by placing a shim under one side of the azimuth adapter.

(2) If only one telescope shows an error, the reticle may have been shifted during repair of the telescope. If the error is appreciable and no instrument repair man is available, locate the four adjusting screws which control the lateral movement of the reticle cell; loosen those on one side and tighten those on the other side the same amount.

59. ALINEMENT OF OPEN SIGHT.

a. The open sight may be alined with the elevation telescope by loosening its thumbscrew and turning it on the shaft.

b. If it is not in line laterally with the elevation telescope, the sight or the shaft may be bent. Remove the shaft before attempting to straighten it. A small correction may be made by filing off one side of the tongue of the sight, or filing out the groove so as to move the "V" sideways.

60. ADJUSTMENT OF CONSTANT-SPEED GOVERNORS.

a. Remove the two holding screws and lift the governor guard up and out with a slight twisting motion. See that the motor assembly is in line with the worm or spiral drive coupling to eliminate noise. Also see that each spring is all the way on its studs and properly centered between the two arms.

b. To change the governed speed, hold each adjusting screw in turn with needlenose pliers and turn each adjusting nut the same amount, clockwise for more speed or counterclockwise for less speed. One flat (one-sixteenth turn) on each nut will change the time for 20 revolutions of the index by about one-half second.

c. If the governor has been overspeeding, especially in cold weather or at small deflections, or if the base or guard show gouges where the governor weights have flown out, the governor should be disassembled as instructed in paragraph 69, and the ball bearing thoroughly cleaned in solvent and oiled. *Keep the carbon ring clean.*

d. After replacing and alining the motor, it may be necessary to file the holes in the guard in order to have it clear the governor properly.

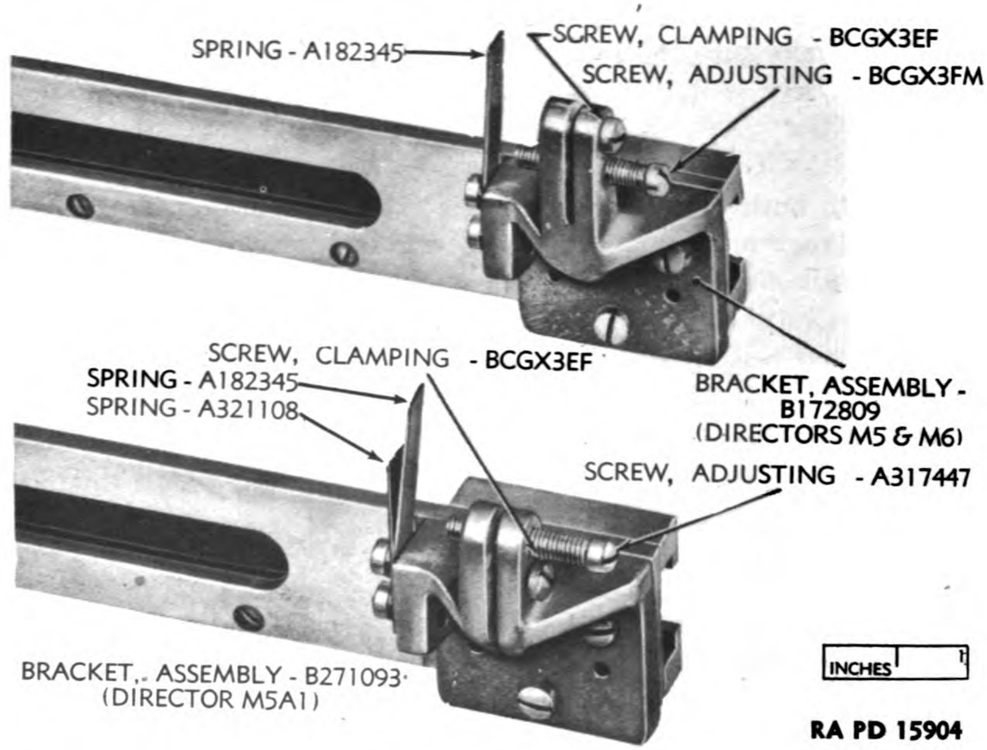

Figure 93 — Location of Screws for Adjusting Azimuth Creep

61. ADJUSTING FOR AZIMUTH ZERO CREEP.

a. Aline zero deflection marks and pull out clutch knob. Any creep of the fine azimuth dial is eliminated by moving the ball carriage in the variable-speed drive to exact center of the disk. The bar assembly should already be set according to paragraph 50.

b. Loosen the clamping screw in the top of the bracket assembly (fig. 93), and turn the adjusting screw until the fine dial does not move more than 1 degree in 1 minute. See that the flat spring on the bracket assembly holds the ball carriage against the adjusting screw, and will return it if displaced slightly. Tighten the clamping screw.

62. ADJUSTING FOR ELEVATION ZERO CREEP AND SETTING SUPERELEVATION MECHANISM.

a. Check the speed of the elevation constant-speed motor.

b. Set in zero vertical deflection and pull out clutch knob. Turn the telescopes to 90 degrees, and lightly block the handwheel.

c. Loosen the superelevation connecting rod lever on the telescope shaft and turn it until the maximum radius of the superelevation eccentric shaft is downward, toward the director base. Tighten the lever and remove handwheel block.

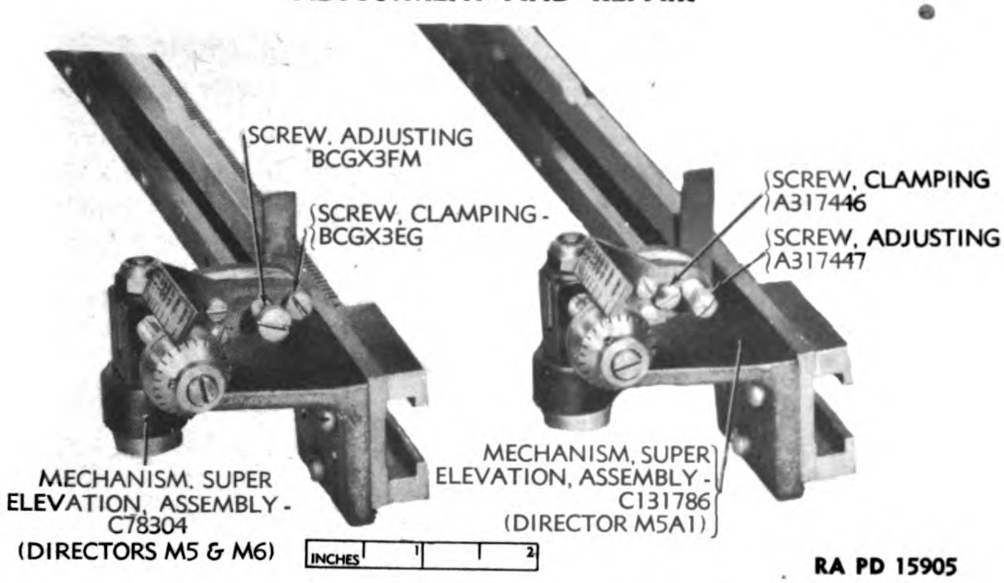

Figure 94 — Location of Adjusting Screws in Superelevation Mechanism

d. See that the flat spring A182345 (fig. 94) is pressing the ball carriage against the adjusting screw on the superelevation mechanism, and will return it if the ball carriage is displaced momentarily.

e. Check to see that the superelevation micrometer is set according to the range scale which is to be used. This is done as follows: Loosen the lock nut BBSX1Z (fig. 94) and turn the micrometer until the center line on the roller is opposite the ".05" mark on the scale, and "0" mark on the micrometer is opposite the edge of the scale.

(1) RANGE SCALE FOR 37-MM GUN. M.V. 2600 f/s, superelevation setting 0.0694. Turn the micrometer in (clockwise) 13 full turns plus 9 micrometer divisions. Tighten the lock nut.

(2) RANGE SCALE FOR 40-MM GUN. M.V. 2750 f/s, superelevation setting 0.0580. Turn the micrometer in (clockwise) 6 full turns plus 13 micrometer divisions. Tighten the lock nut.

f. Place jumpers around the elevation limit switch. Turn telescopes to upper stop, then back to 90 degrees. Turn on the elevation motor and observe fine elevation dial. If it creeps more than 1 degree in 1 minute loosen the clamping screw (fig. 94) in the superelevation mechanism. *CAUTION: To protect the spring A182345, hold the mechanism when loosening the screw.* Turn the adjusting screw until the fine dial does not move; then shut off power and tighten the clamping screw.

g. The action of the superelevation shaft should displace the ball carriage and cause the telescopes to depress at any position other than 90 degrees (fig. 40). Check the creep from 5 to 0 degrees as explained in paragraph 32 d. If the time is not within tolerance, adjust the screw in the superelevation mechanism as in subparagraph f, above, until the time is correct.

h. The creep at 90 degrees will then be affected, and this should be corrected by loosening the lever on the telescope shaft and turning the eccentric shaft until the creep is zero again at 90 degrees.

i. Repeat subparagraphs **g** and **h**, above, until both are satisfactory. Then check the creep from 65 to 60 degrees. In case times are slow at both 65 to 60 degrees and 5 to 0 degrees, it may be necessary to turn the micrometer in one turn or more. If superelevation creep is erratic, check tension of flat spring A182345. Look for looseness of bar assembly on rail or loose or bent connecting rod.

j. Remove jumpers around limit switch.

63. REMOVING BACKLASH.

a. Check for backlash as described in paragraph 33. Backlash is usually caused by wear, especially under dusty conditions.

b. Excessive backlash must be located by a systematic check of the entire azimuth or elevation gear train. Examine particularly all antibacklash gears for broken or improperly wound springs, adjustable bearings for proper setting, and all differentials for wear. Replace any units found faulty.

64. TORQUE AMPLIFIERS (DIRECTORS M5 AND M6).

a. Removal and adjustment of torque amplifiers is described in section VIII, and is the same for both azimuth and elevation units.

Section VIII

DISASSEMBLY AND ASSEMBLY

65. PRECAUTIONS.

a. The Director M5 is an instrument containing many small, close fitting parts which are expensive and difficult to replace. Supply of these parts is critical and this makes it imperative that extreme care be observed when any disassembly or adjustment is being performed.

b. The exploded views of various subassemblies are inserted to show the construction details but do not necessarily authorize such complete disassembly. In many cases, parts must be specially selected or lapped, fitted, or machined after assembly. Therefore, they should be replaced by complete assemblies and the old assemblies returned to base shops.

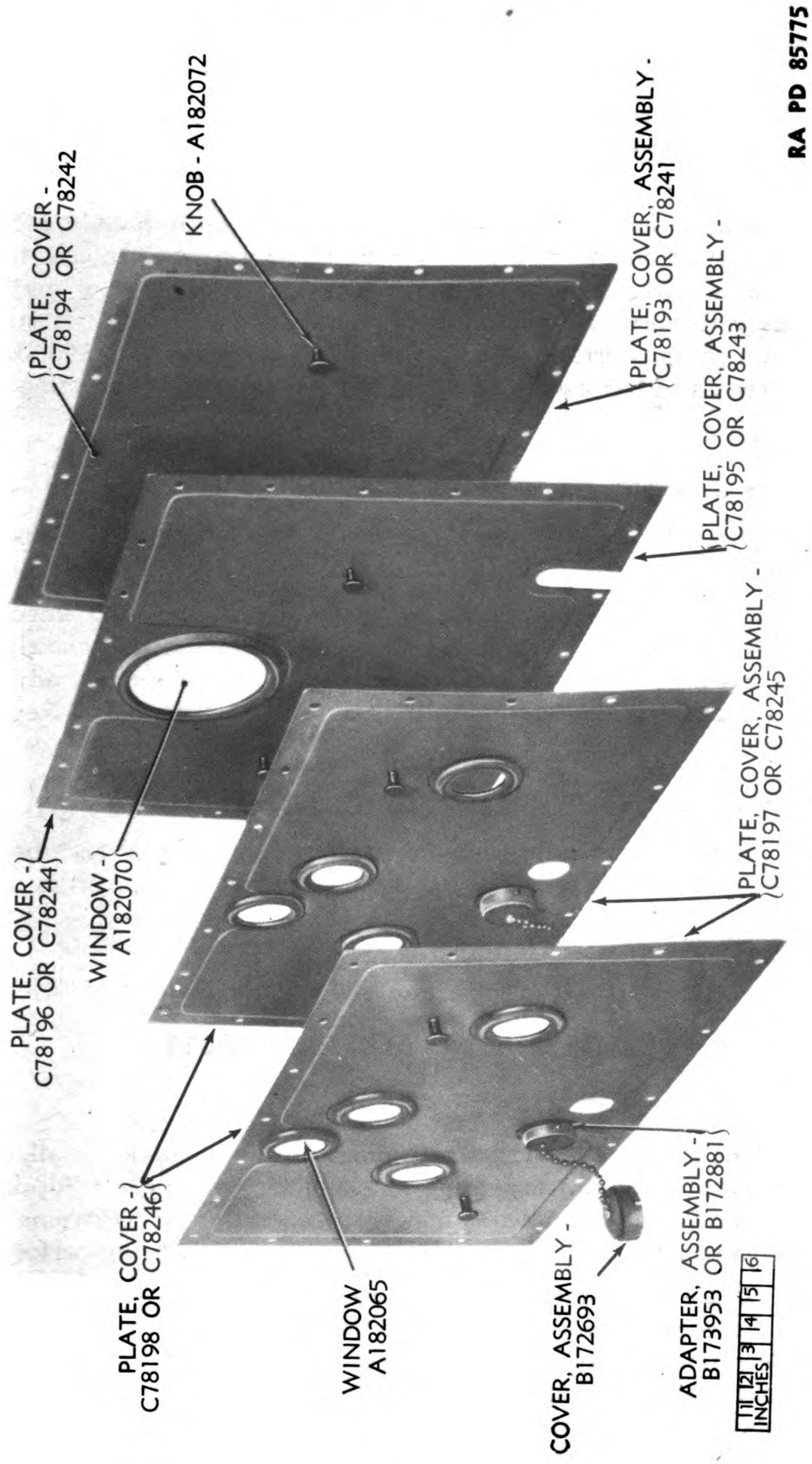

Figure 95 — Cover Plate Assemblies

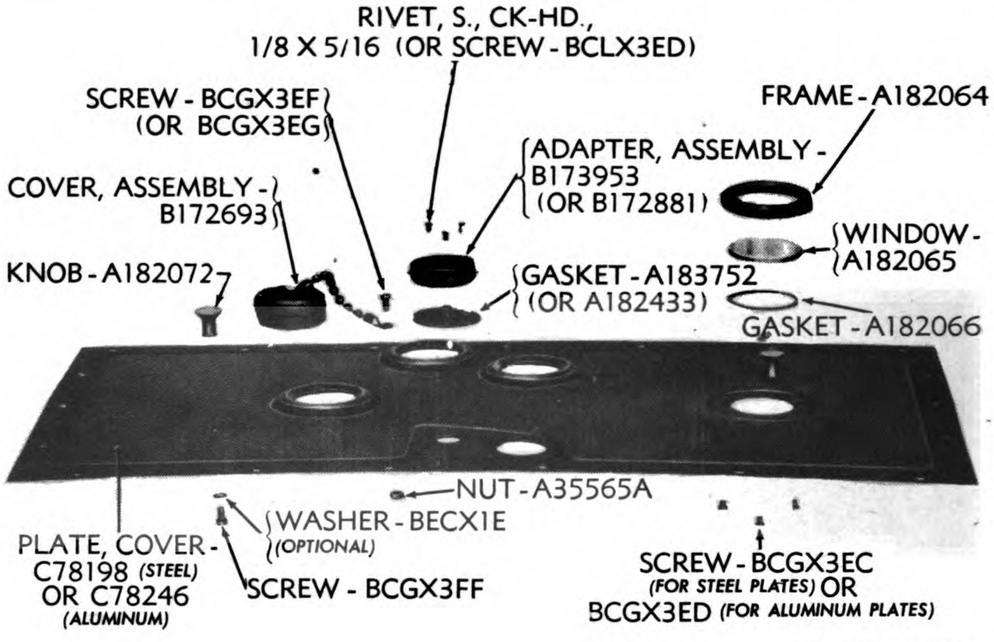

Figure 96 — Side Cover Plate Assembly C78197 (Steel) or C78245 (Aluminum)

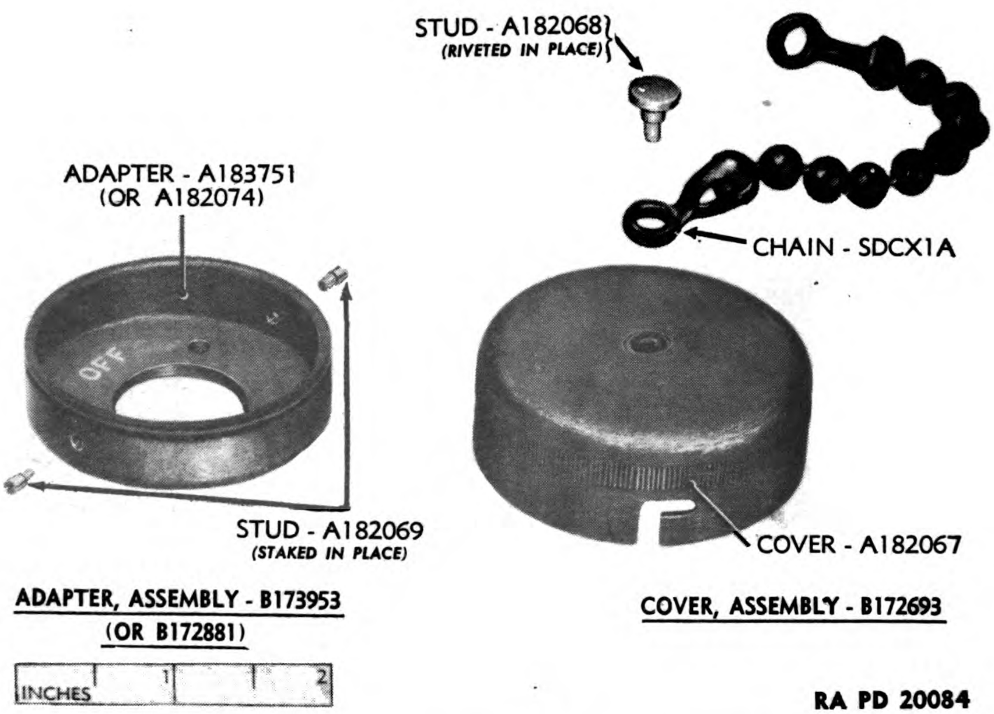

Figure 97 — Adapter and Cover Assemblies

DISASSEMBLY AND ASSEMBLY

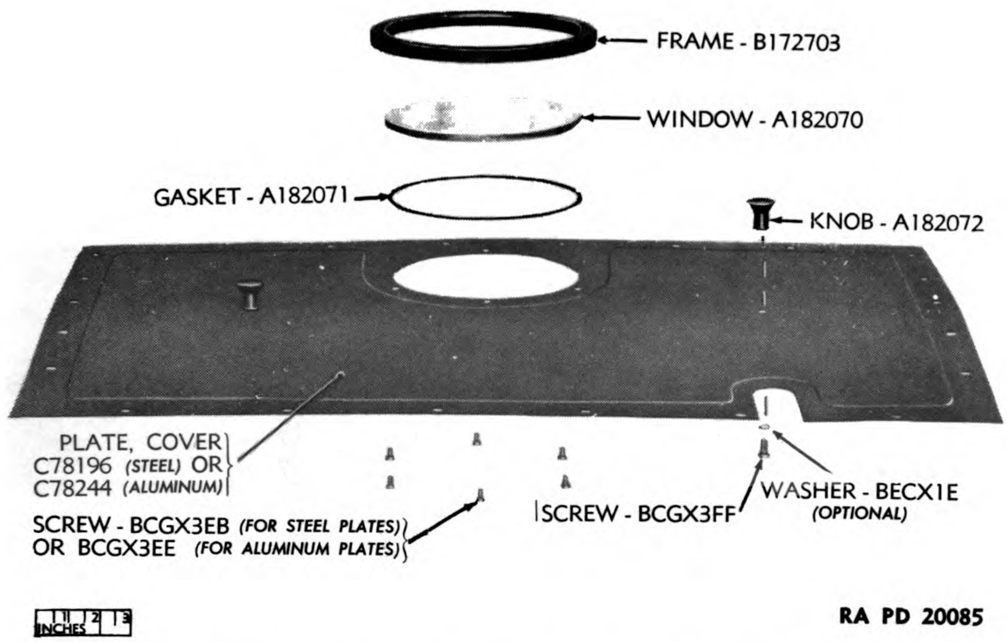

Figure 98 — Rear Cover Plate Assembly C78195 (Steel) or C78243 (Aluminum)

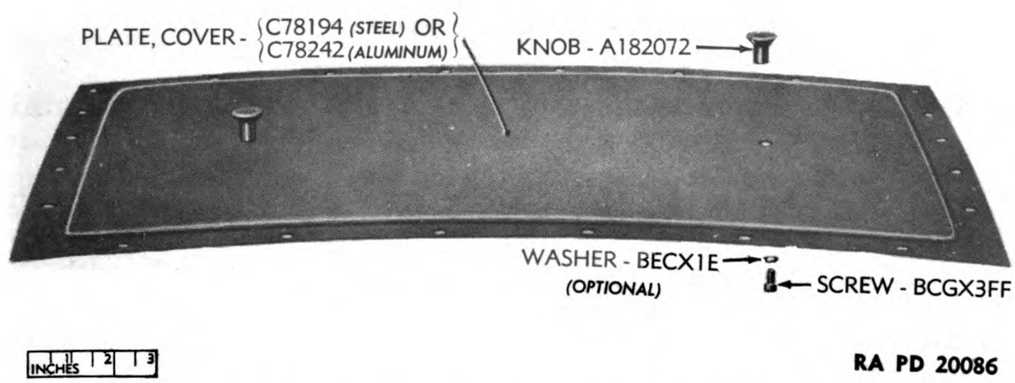

Figure 99 — Front Cover Plate Assembly C78193 (Steel) or C78241 (Aluminum)

c. Select and use the proper size tool for each operation. *Do not, however, leave these tools lying in the director.*

d. Do not touch polished surfaces with the fingers. Body acids will cause these parts to rust. Protect steel surfaces by a film of grease or oil.

e. Do not force any part or assembly, either when taking it apart or putting it together. All parts can be removed without the use of damaging force.

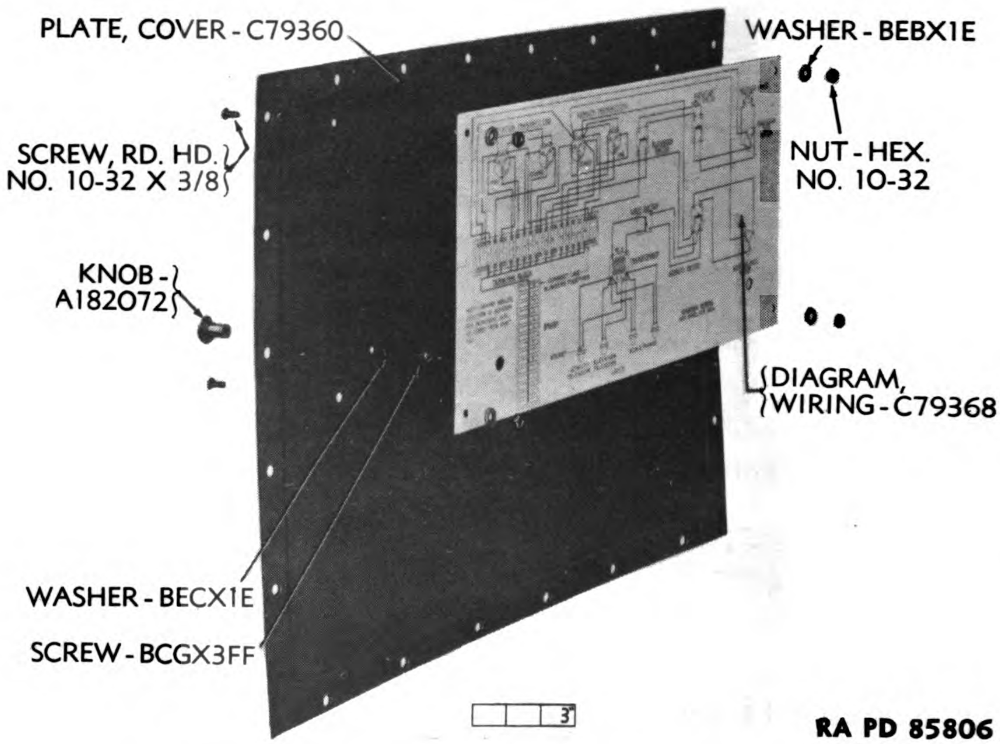

Figure 100 — New Front Cover Plate With Wiring Diagram Assembly C79359

f. Do not turn handwheels or turn on power until you are certain that no damage will result.

g. Before attempting to drive out any dowel pin, make sure the hole extends through the casting. If it does not, remove the screws or bolts and loosen the unit by tapping from side to side with the hand. It is good practice to drive out pins from the bottom upward.

h. Before replacing pins in a shaft, check the alinement of both ends of the pinhole. The hole may have been drilled off center and the part can be replaced only one way on the shaft.

i. Mark all assemblies so that they can be replaced in the same position. Do not interchange parts or units from azimuth to elevation sides or between different directors. Even identical parts should not be interchanged after they have been fitted and pinned in place. Mark all screws and pins or replace them in the holes, since screws which appear the same may have a different thread or length. Keep lock washers with screws and make sure in reassembly to replace all washers.

j. Apply grease to frame surfaces before replacing main cover plates, to act as a seal.

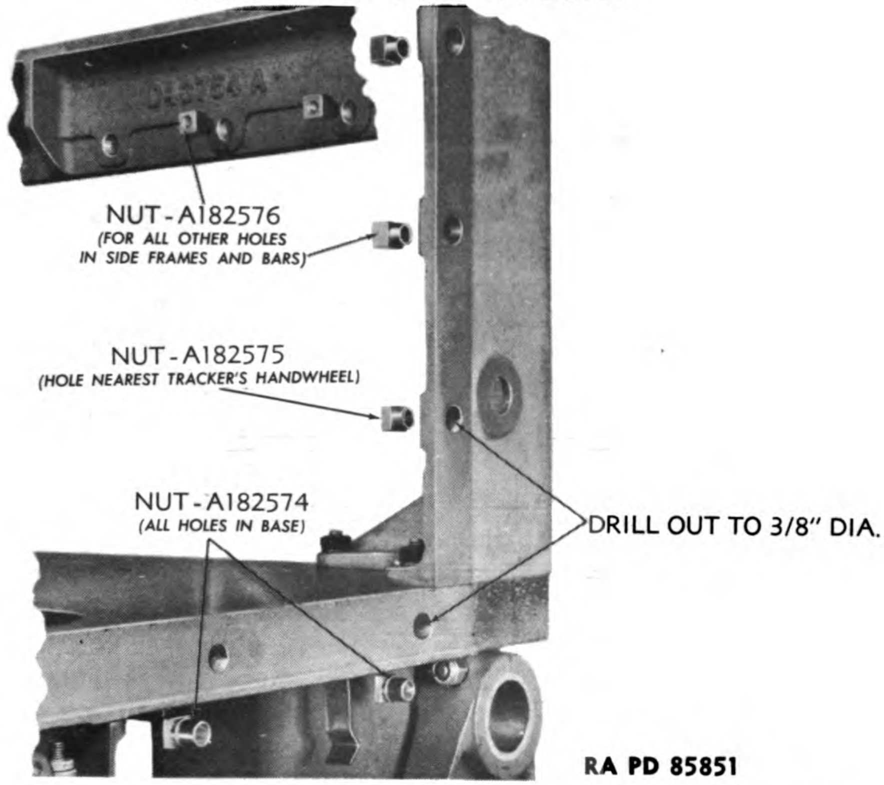

Figure 101 — Old Style Nuts for Cover Plate Screws Can Be Used To Repair Stripped Holes

k. Do not omit any screws or pins in the base or cover plates which might leave an opening for dust or moisture to enter the director. If a cover plate screw hole is stripped, drill out with a ⅜-inch drill and insert one of the old-style nuts shown in figure 101. When new dowel pin holes are drilled through the base, the old ones should be plugged. Any chips from drilling or filing must be prevented from getting into the mechanism.

66. ANTIBACKLASH GEARS.

a. There are five pairs of antibacklash gears as described in paragraph 11 **c** (2). Their effectiveness depends upon being wound to a greater tension than the normal torque they transmit.

b. Where alining holes are provided near the rim of the gears, these should be lined up and a pin may be inserted until the gears are engaged. Do not attempt to line up the holes in which the ends of the spring are inserted (fig. 190).

c. Where no alining holes are provided, the following rule will be useful: Wind the gears until considerable resistance is felt, just as when winding a clockspring; then back off two teeth from this position and engage the gears.

67. PREPARATION.

a. Aline the zero deflection marks and pull out the rate setting clutch knobs. On the elevation side, turn the telescopes to a 90-degree elevation.

b. Remove all of the handwheels, cover plates, and the two telescopes.

c. Where a complete disassembly is necessary, as for cleaning or complete overhaul, it is recommended that the units be removed in the order given. Most units can be removed independently, however, and where only one or two units are to be removed the appropriate paragraphs should be consulted.

d. *Assembly* procedure is the reverse of disassembly unless specific instructions are given. Particular attention should be paid to alinement and mesh of gears between units. Gears should have a small but perceptible backlash. If the same assemblies are replaced, the dowel pin holes should be used to determine the exact position before mounting screws are tightened. However, *if a different assembly is installed, the old dowel pin holes should be disregarded.* After the correct position is determined, and the screws tightened, either drill out the old holes for a larger size pin, or drill entirely new holes. If new holes are drilled through the director base, be sure to plug the old ones.

e. Always test shafts for binding as each bracket or assembly is tightened, because any tightness will be difficult to trace after complete assembly. Be sure base and mounting surfaces are clean, as any dirt might prevent proper alinement.

68. TO REMOVE TORQUE AMPLIFIERS (DIRECTOR M5 OR M6).

a. Both torque amplifiers are removed in the same manner. It is frequently necessary to test or replace them and they may be removed without disturbing other units.

b. Precaution. Do not loosen the set screw on the input coupling more than one-half turn. More than this will permit the coupling to slide forward and allow the screw to be tightened down on the splines of the shaft, thus damaging the spline and preventing proper motion of the coupling. Elevate telescope to 90 degrees to avoid interference with superelevation connecting rod when torque amplifier is removed.

c. Disconnect and tag the motor leads (X, Y, and Z) for identification. Loosen the screw on the input coupling (nearest center of director) and slide the coupling back on its splined shaft. Turn the output shaft of the torque amplifier so that its slot is vertical. Remove the three screws holding the torque amplifier to the base. Lift the

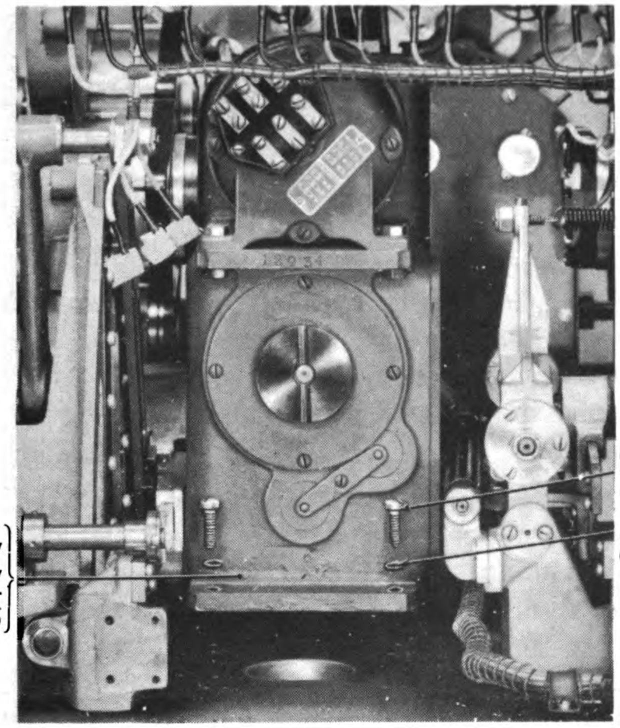

Figure 102 — Removing Torque Amplifier From Director M5 or M6

torque amplifier out of the director, being careful to free the foot of the casting from the 15-conductor cable on the base.

d. For disassembly of torque amplifier, see paragraph 85.

e. *When replacing,* see that the superelevation connecting rod passes freely between the two torque amplifiers, and that the couplings are perfectly alined before tightening the mounting screws.

69. CONSTANT-SPEED MOTOR ASSEMBLIES.

a. On some Directors M5 or M6, it may be necessary to remove the worm drive before removing the motor. Before removing the elevation motor on older directors having a fuse block, detach the fuse block and tie it to the front tie bar out of the way.

b. Take out the two screws which hold the guard and lift it up and out with a slight twisting motion. For clearance in early directors, it may be necessary to turn the governor arms to a 2 o'clock position (fig. 103). Disconnect and tag the X-, Y-, and Z-motor leads for identification. Remove the four screws holding the motor to the base; slide and lift the motor to the rear and out. If the bolt nearest the corner will not come out, replace the nut to prevent the bolt from being bent by the carrying bracket.

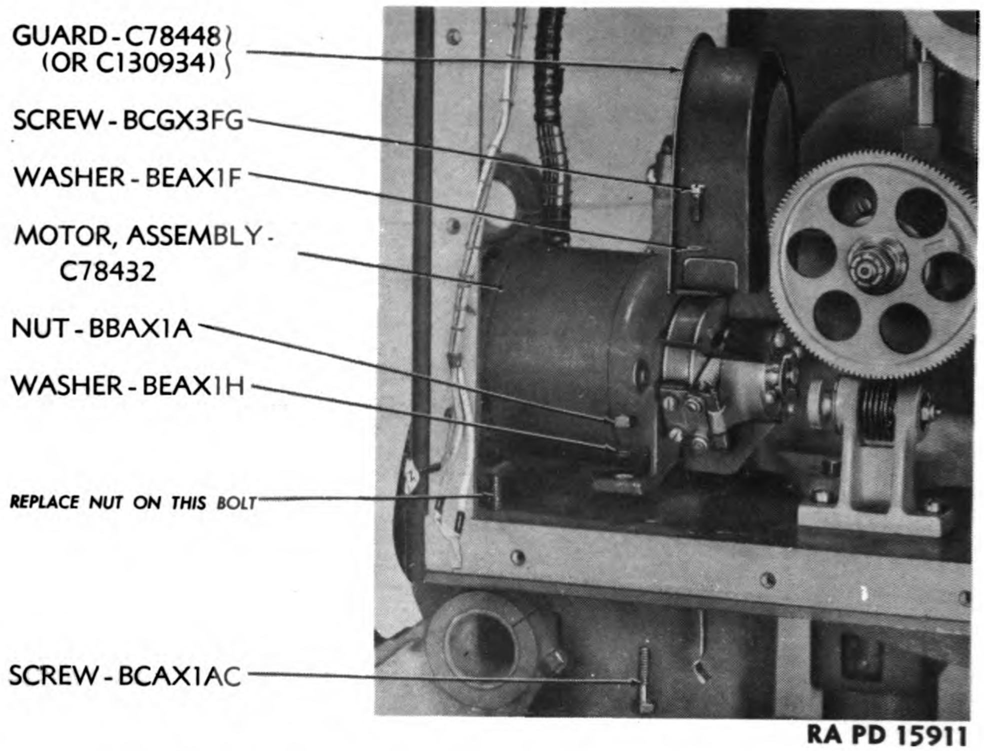

Figure 103 — Removing Constant-speed Motor Assembly C78432 From Director

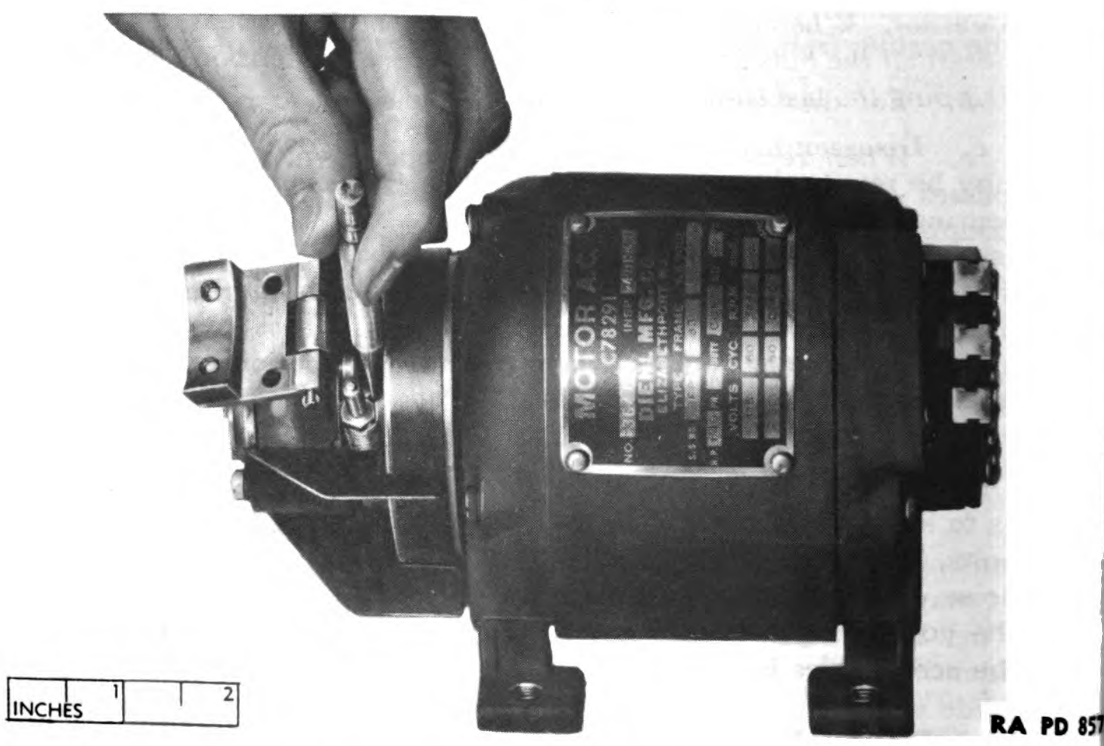

Figure 104 — Drive Out Pin To Remove Complete Governor Assembly

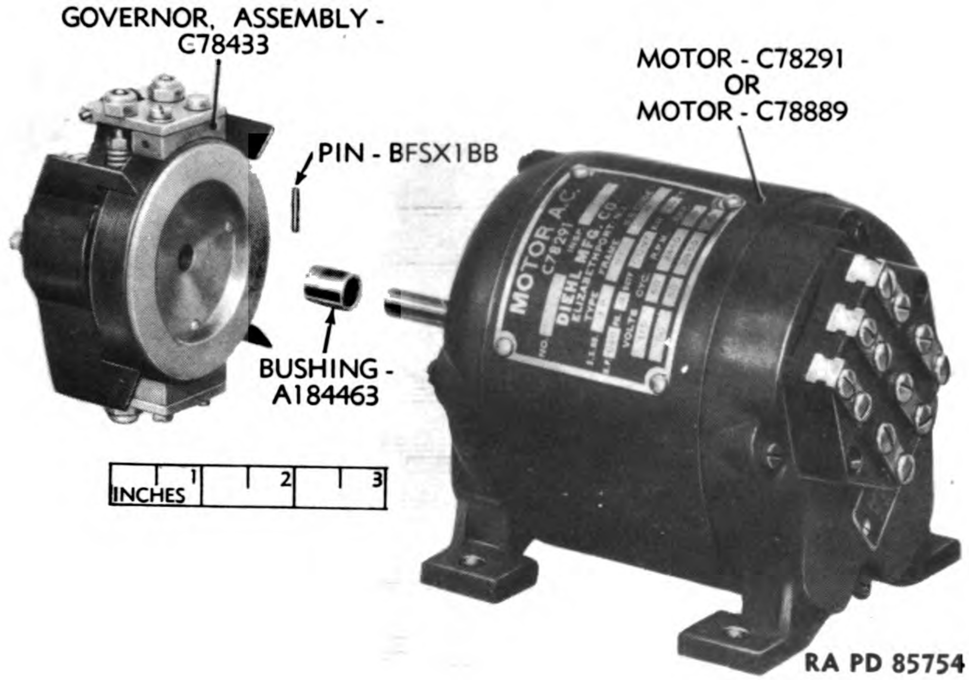

Figure 105 — Governor Assembly Removed From Motor

CAUTION: Do not allow grease to get on the carbon ring of the governor. When disconnecting the governor springs, it is desirable to loosen all the nuts at the same time to release the tension and prevent stripping the last thread of the nut.

c. Disassembly. When replacing a new governor assembly, it may be removed as shown in figure 104. However, to reach the ball bearing, it is necessary only to remove the fan blades, coupling assembly, and spring ring as shown in figures 106 and 107. Note that an offset screwdriver is necessary to loosen the screws nearest the motor when removing the fan blades. These blades may be installed on older motors when trouble is experienced with over-speeding.

d. Assembly. When replacing governor springs, see that they are all the way on the screws, and tighten both nuts the same amount so as to keep the spring in balance. Before finally tightening the motor bolts, line the motor up perfectly with the worm drive to eliminate noise or vibration. See paragraph 60 for governor adjustment. If the governor guard does not clear the governor when replaced, file the screw holes larger to allow shifting it slightly.

70. WORM DRIVE ASSEMBLY (DIRECTORS M5 AND M6).

a. If the motor has not been removed, take off the guard. It

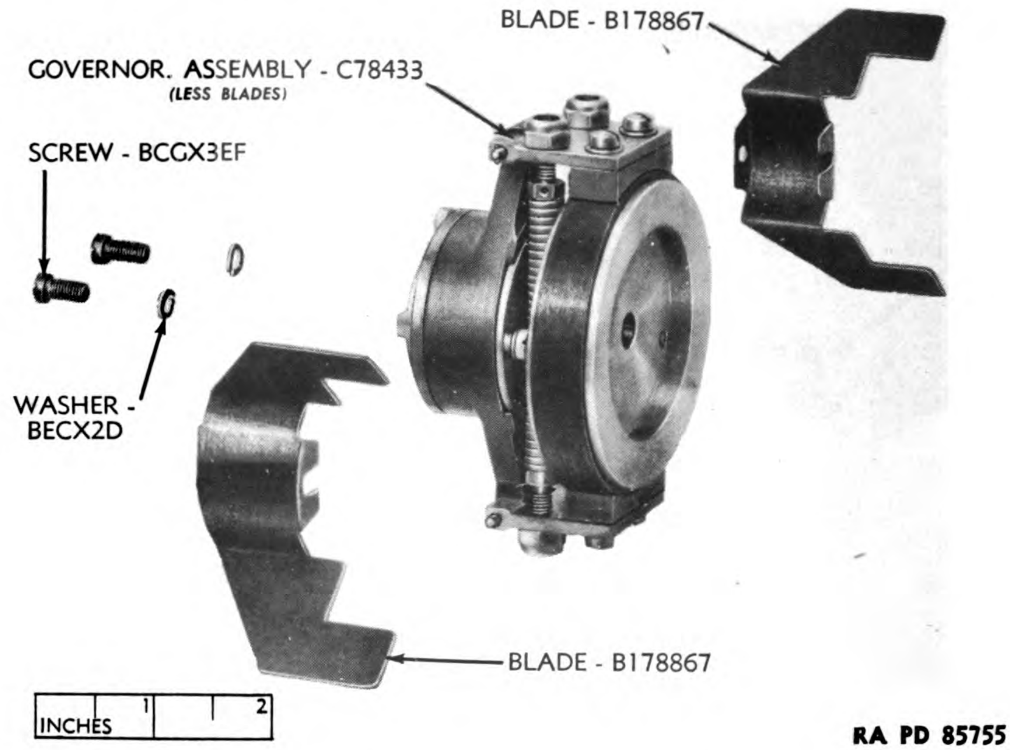

Figure 106 — Removing or Installing Fan Blades

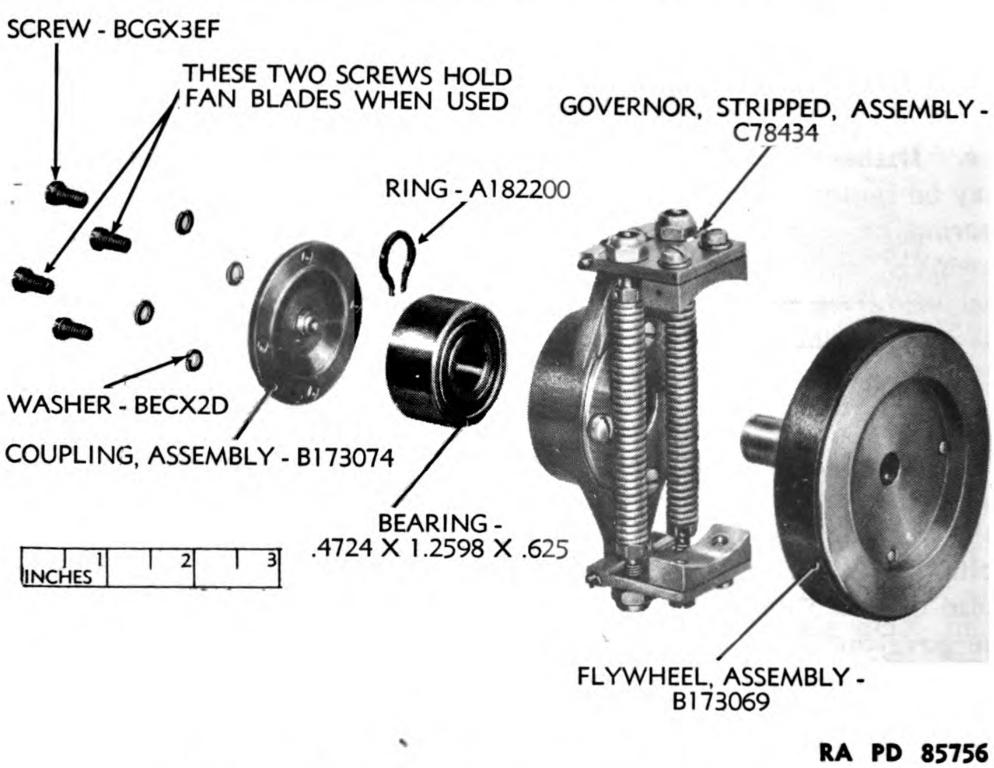

Figure 107 — Removing Governor From Flywheel

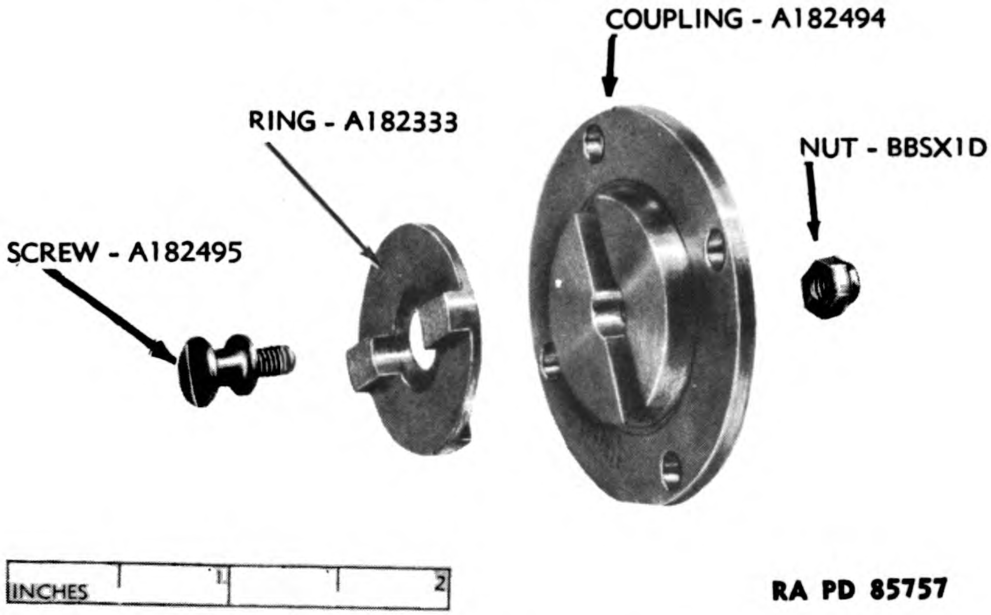

Figure 108 — Coupling Assembly B173074

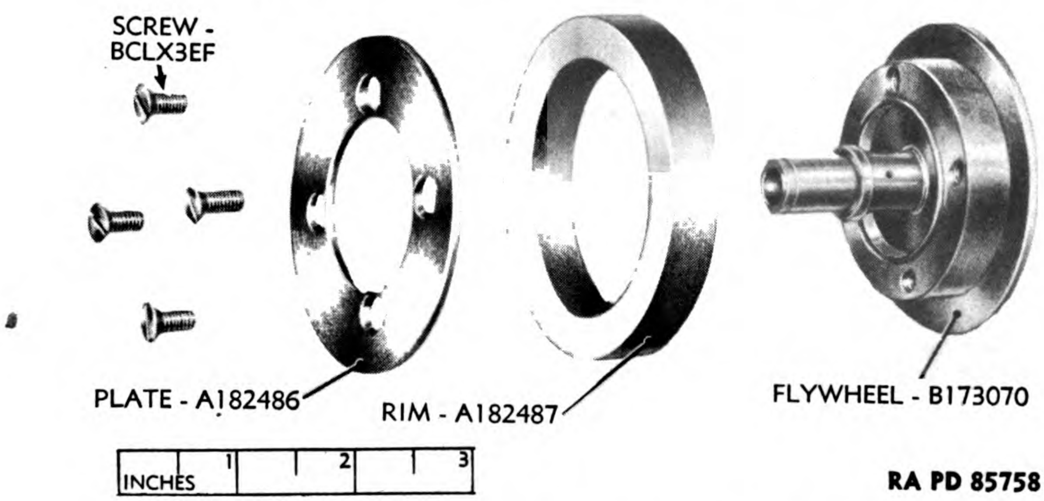

Figure 109 — Parts of Flywheel Assembly B173069

may also be necessary to move the motor slightly endwise to disengage the coupling.

b. Remove the nut and washer holding the large helical gea. on the variable-speed mechanism, and pull the gear off straight to the front. Do not lose Woodruff key located in variable-speed drive shaft. Remove the two screws in the base and lift the assembly off the dowel pins (fig. 111).

c. Figures 112 and 113 show the method of disassembly It may be advisable to replace cork washer A182083 to prevent endwise flutter of the worm.

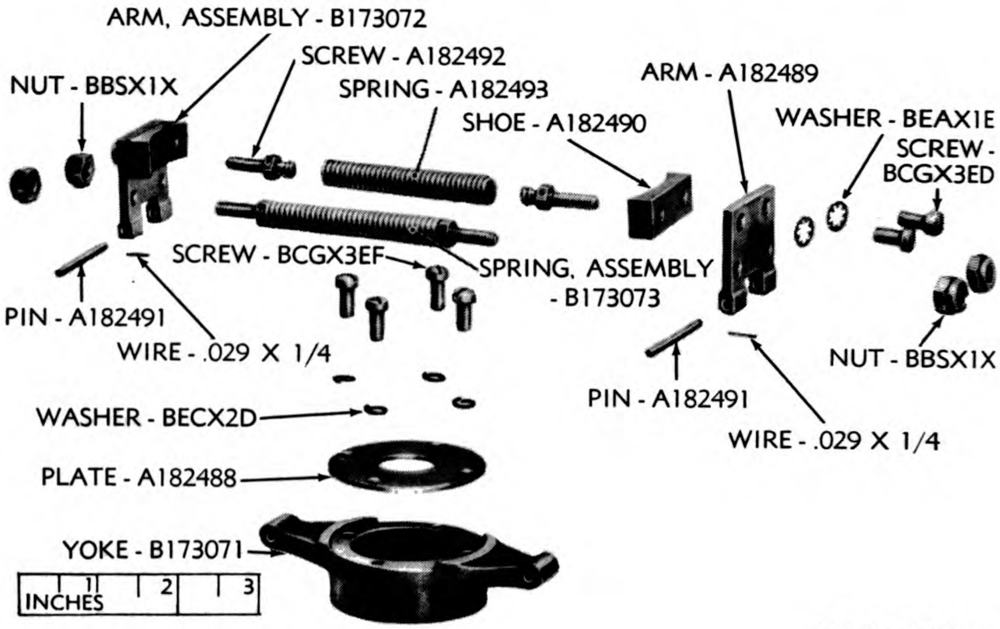

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Figure 110 — Stripped Governor Assembly — Exploded View

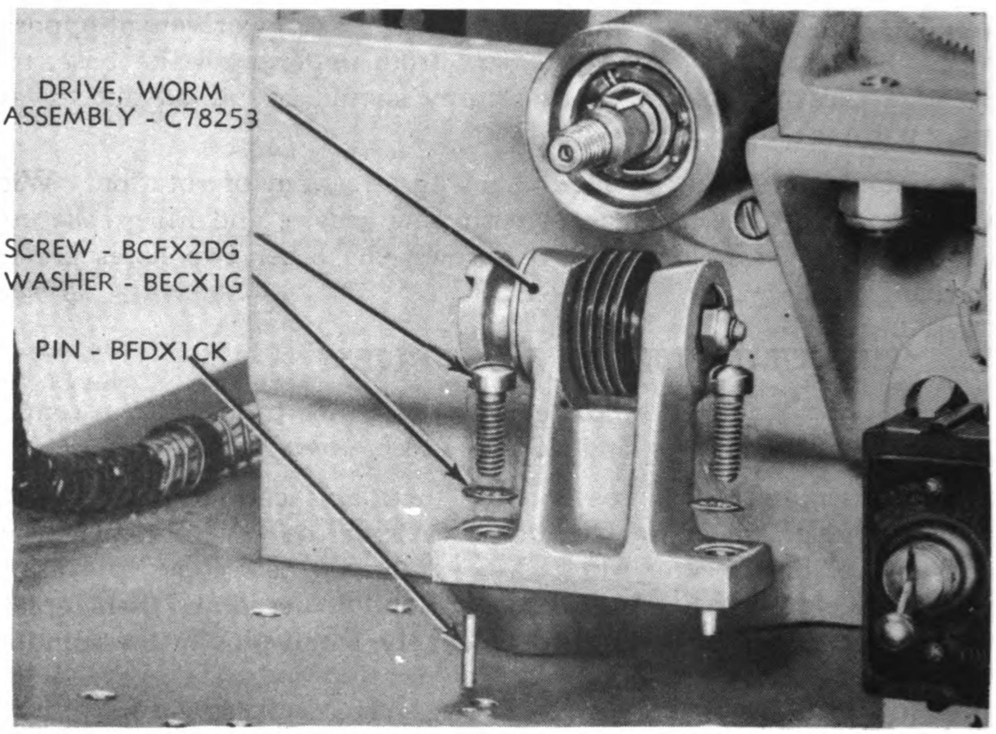

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Figure 111 — Removing Worm Drive Assembly From Director M5 or M6

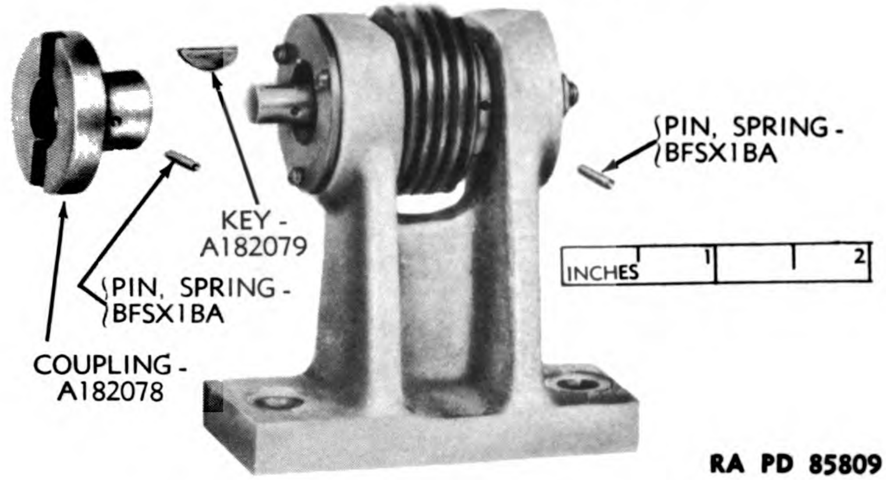


Figure 112 — Disassembling the Worm Drive

71. SPIRAL DRIVE ASSEMBLY (DIRECTOR M5A1).

a. Remove the constant-speed motor or slide it back far enough to disengage the coupling. Remove the five screws and take off the cover assembly of the spiral drive assembly.

b. Remove the nut from the shaft of the variable-speed mechanism, and pull off the spiral gear with the small pinion. If it sticks, it may be pried *carefully* with two small offset screwdrivers at opposite sides. Drive out the two dowel pins from underneath the base, and remove the two bolts. The assembly should be pulled out toward the operator.

c. Before replacing cover, check for freedom of rotation. Wipe out any old grease, coat gears with new grease, and fill grease cup. Note that cover is held by five screws; the other two holes are for locating pins.

72. THE TRANSMITTER ASSEMBLIES.

a. It is not necessary to remove the entire transmitter assembly to replace a transmitter (fig. 122 or 128).

b. Disconnect all wires and tag for identification. Remove the spiral drive assembly on Director M5A1, or the governor guard and wormwheel on Director M5 or M6. Turn the telescopes to a minus 10-degree elevation. Remove the fine and coarse dials; then replace the washer rings and screws to protect the small pins in the spindles. Remove the index plate.

c. Drive out the dowel pin in the base of the transmitter bracket if convenient. Remove the three nuts underneath the assembly and lift the assembly out of the director, being careful not to strike any of the gear teeth.

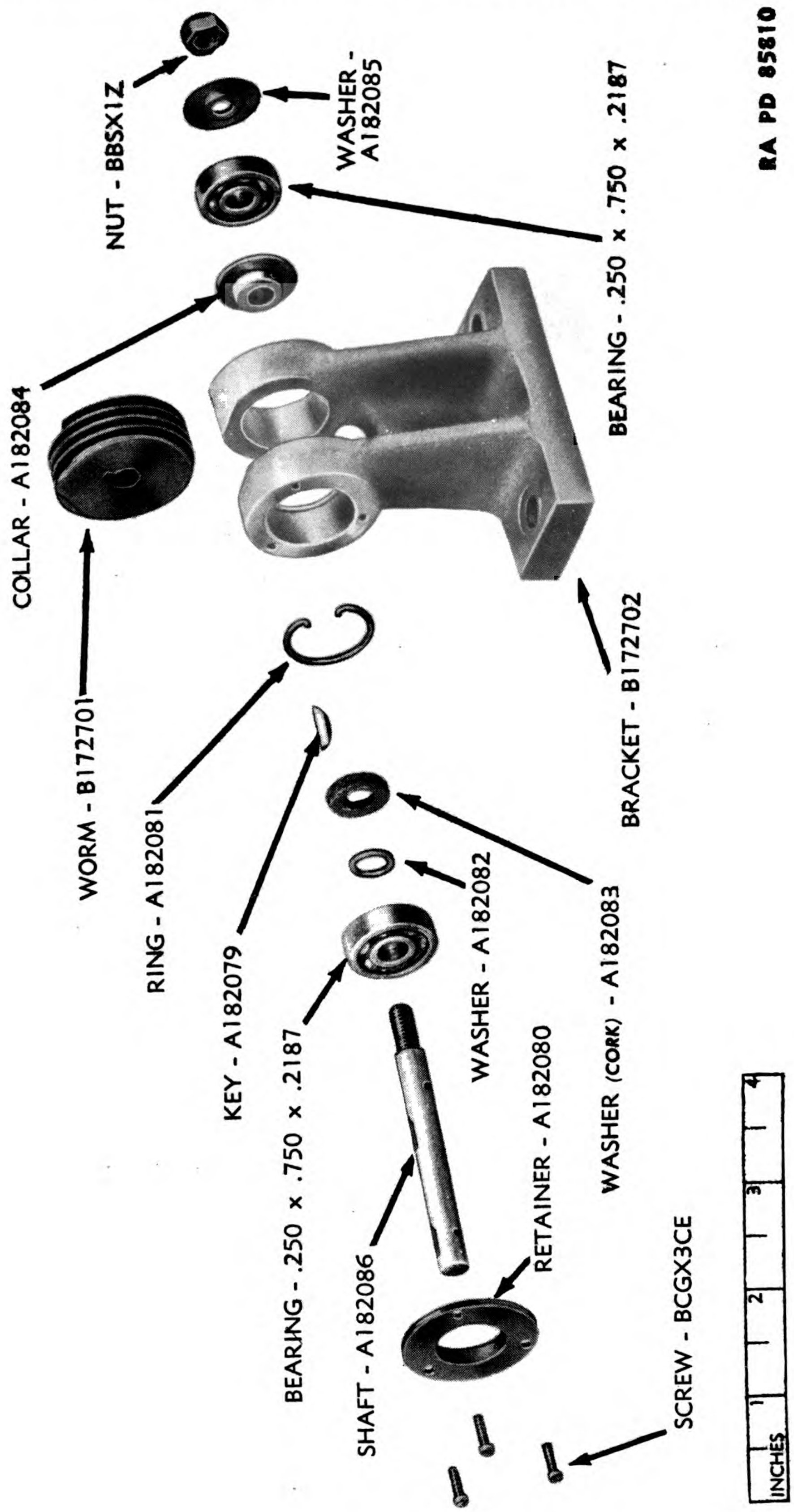


Figure 113 — Disassembling the Worm Drive

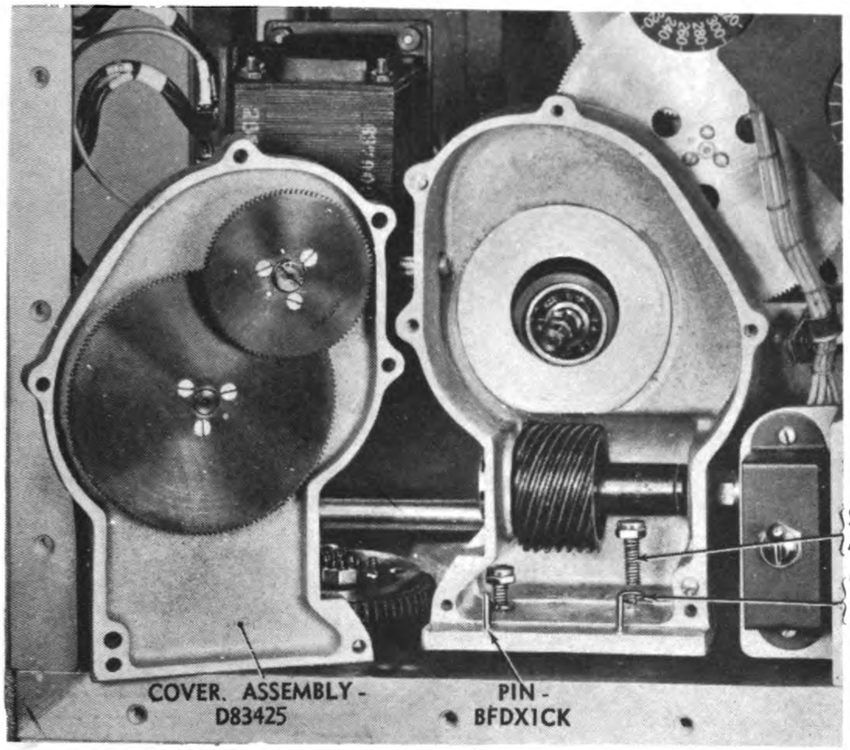


Figure 114 — Removing Spiral Drive Assembly From Director M5A1

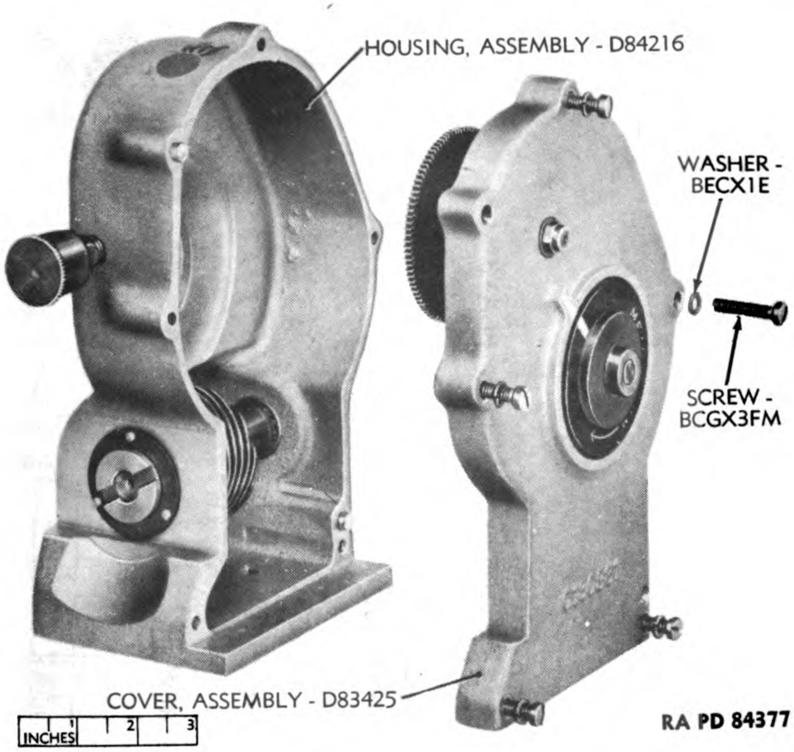


Figure 115 — Disassembly of Spiral Drive D83180

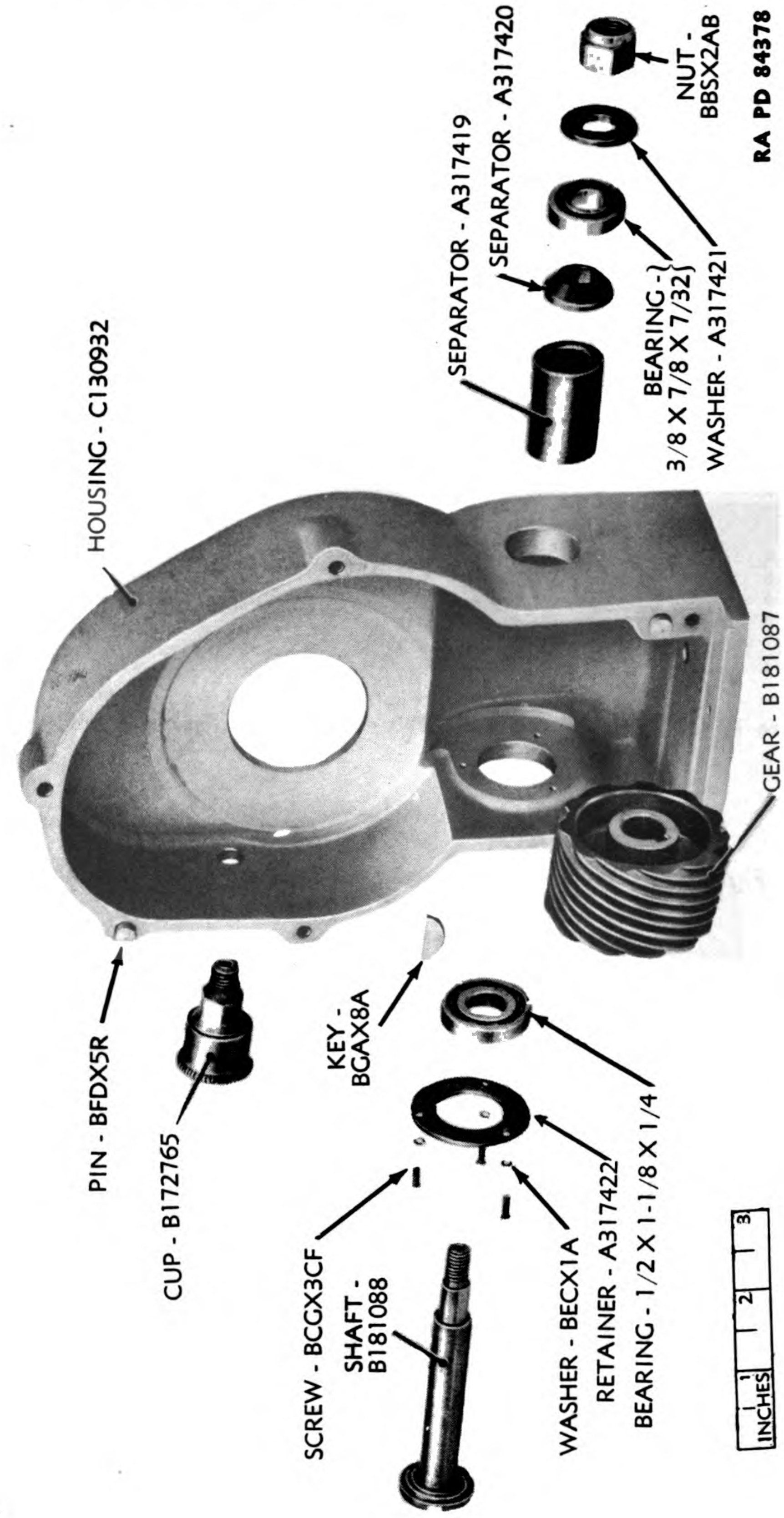


Figure 116 — Disassembly of Spiral Drive D83180

DISASSEMBLY AND ASSEMBLY

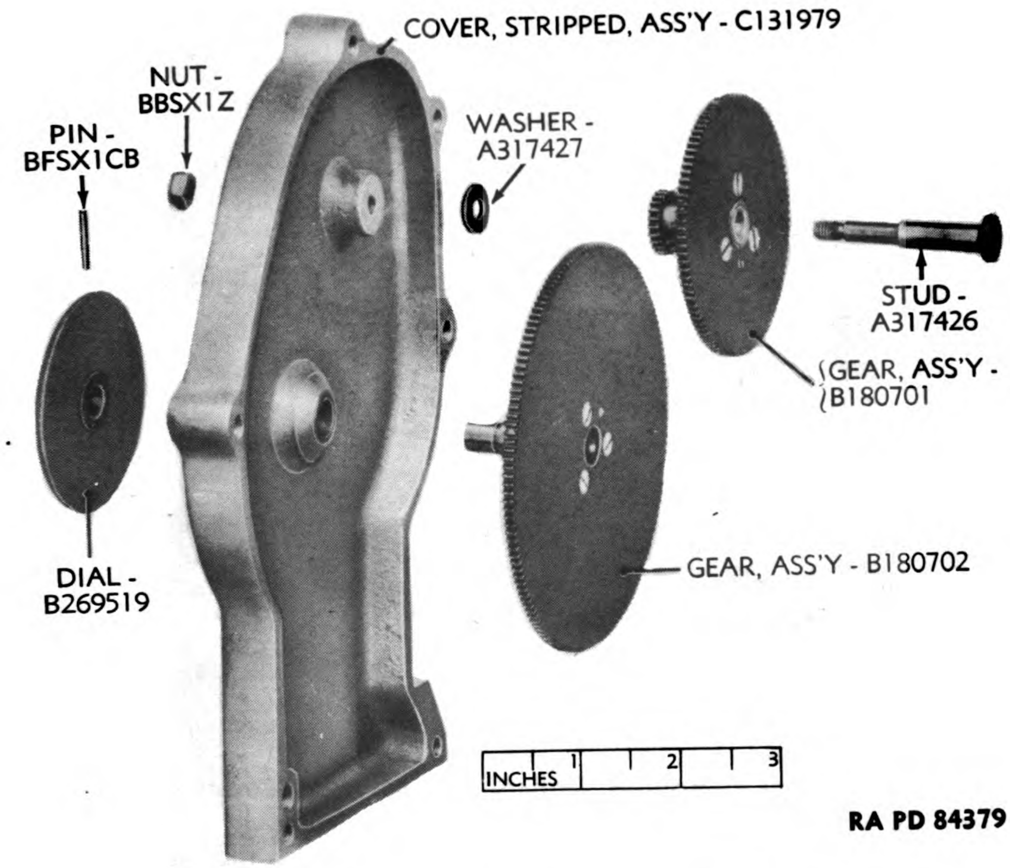


Figure 117 — Cover Assembly D83425 — Showing Gears Which Drive Dial

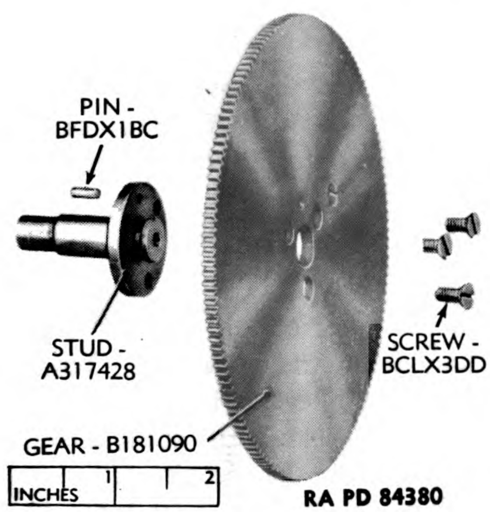


Figure 118 — Gear Assembly B180702 — Exploded View

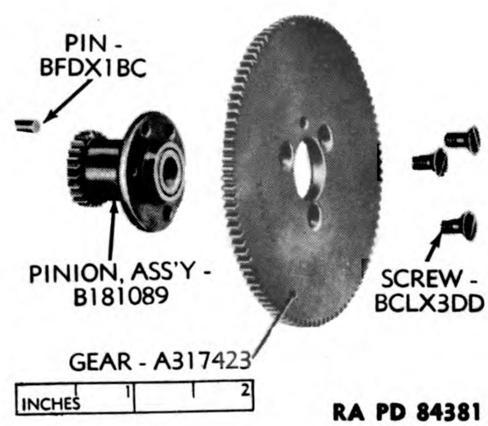
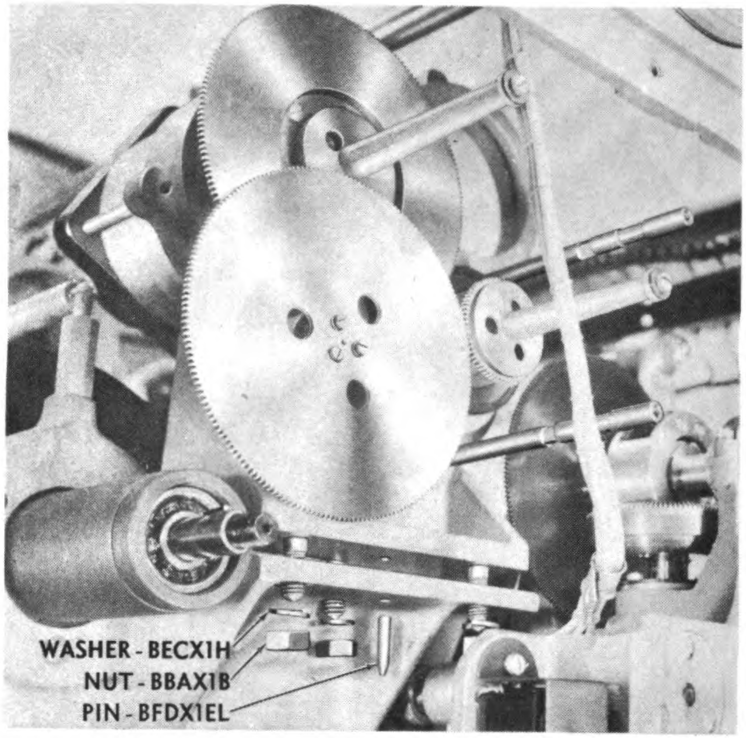


Figure 119 — Gear Assembly B180701 — Exploded View



RA PD 15913

Figure 120 — Removing Transmitter Assembly From Director

d. Before replacing elevation transmitter assembly, remember to turn the segment to a minus 10-degree position. Locate the assembly with the dowel pin before tightening nuts. See paragraph 52 or 53 for setting of transmitters and dials.

73. RATE SETTING CLUTCHES.

CAUTION: When the clutch is removed, it is possible to move the ball carriage in the variable speed drive beyond the edge of the disk. If the clutch is not to be replaced immediately, the spring tension on the variable-speed drive should be released to prevent damage, first noting the exact position of the tension nut on the screw if a spring scale is not available for resetting tension.

a. With the clutch knob in, the handwheel should be turned to the left until the stop nut is all the way from the operator. This is not necessary if the transmitter assembly has been removed. Loosen the small bracket B172850 which holds the horizontal shaft assembly B172858 (fig. 134) to the drive shaft assembly in the corner of the director, and slide the bracket toward the clutch. Remove the two screws which fasten the clutch to the base, and one screw in the multiplier casting.

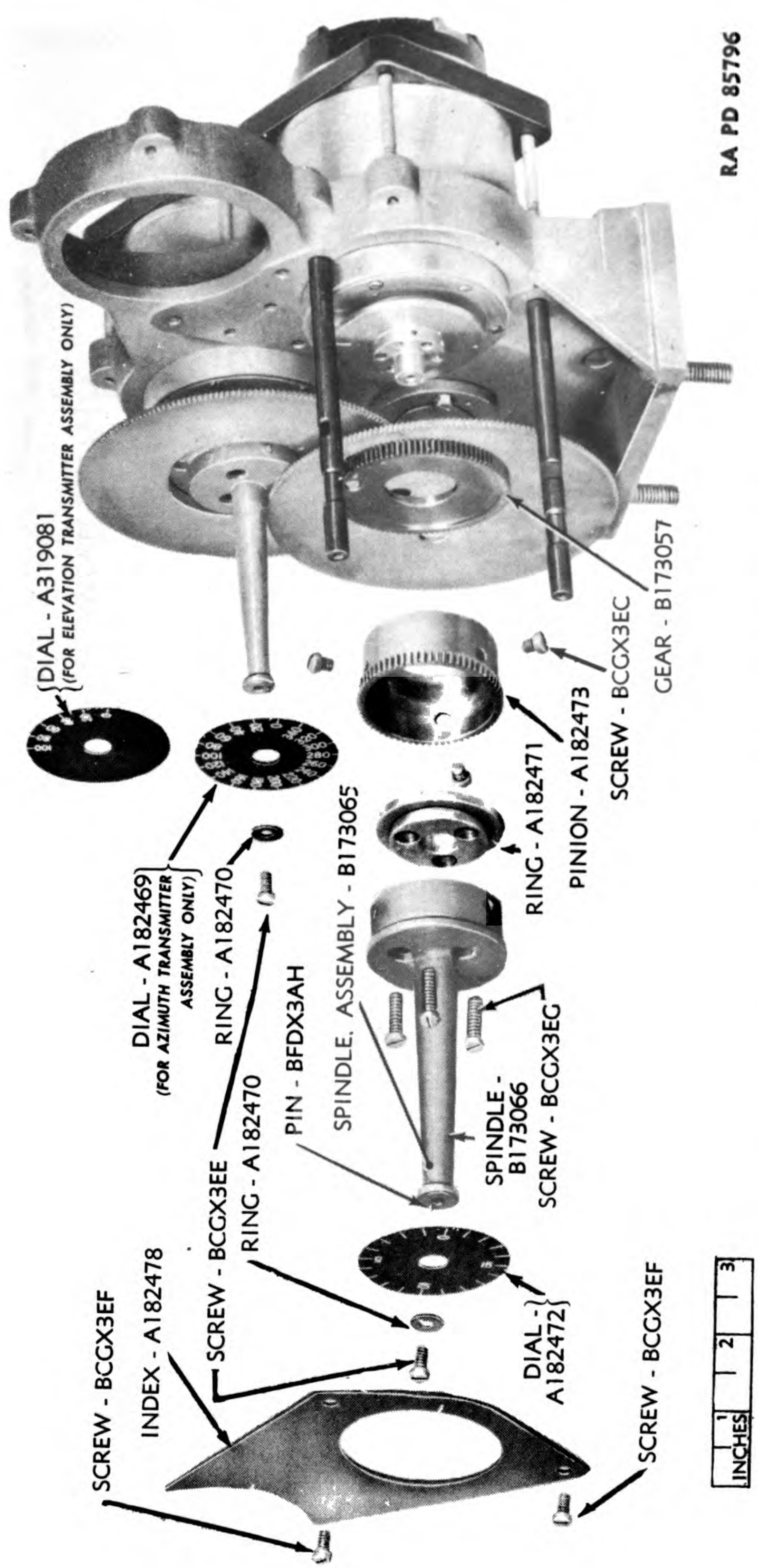


Figure 121 — Disassembling Azimuth Transmitter Assembly (or Elevation Transmitter on Director M5A1)

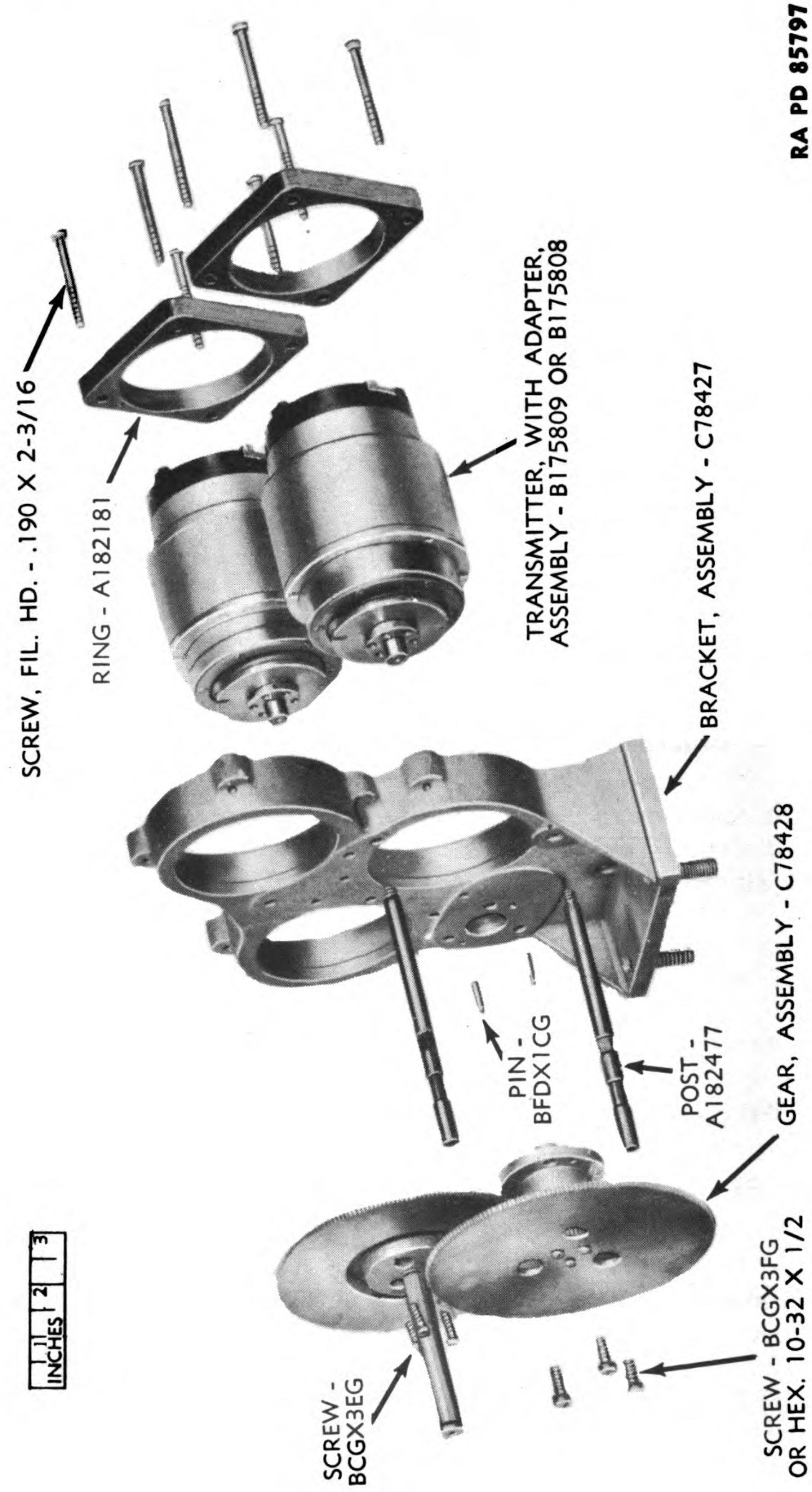


Figure 122 — Further Disassembly — (Note That Coarse Dial Spindle and Intermediate Gear Assembly Are Removed Together)

DISASSEMBLY AND ASSEMBLY

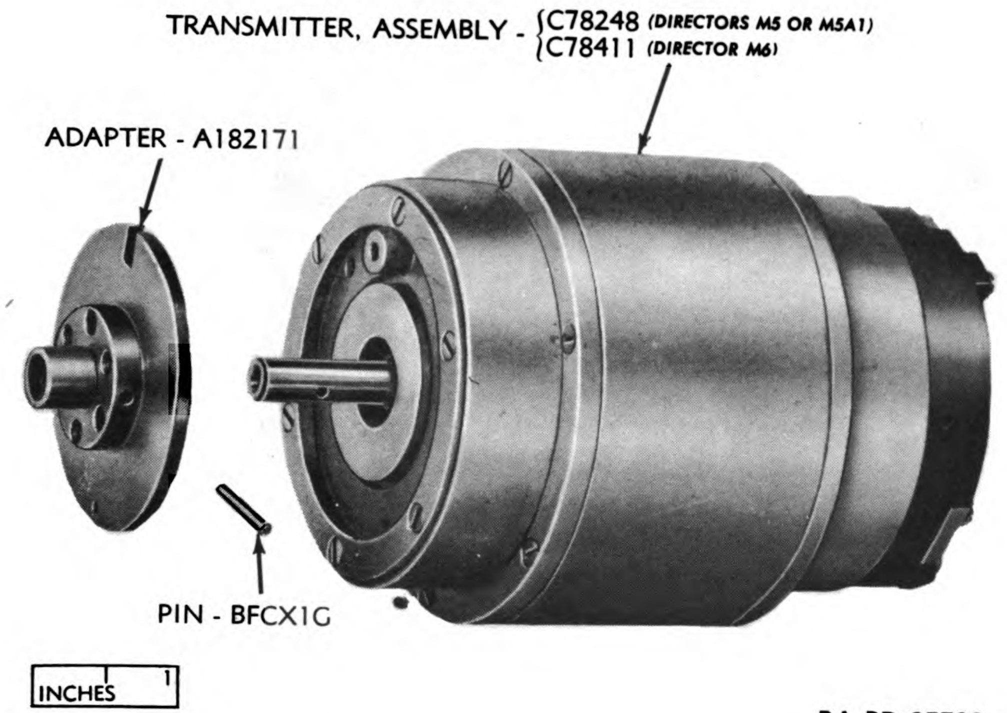


Figure 123 — Transmitter With Adapter (New Style) Assembly B175809 or B175808 (Also See Figure 129)

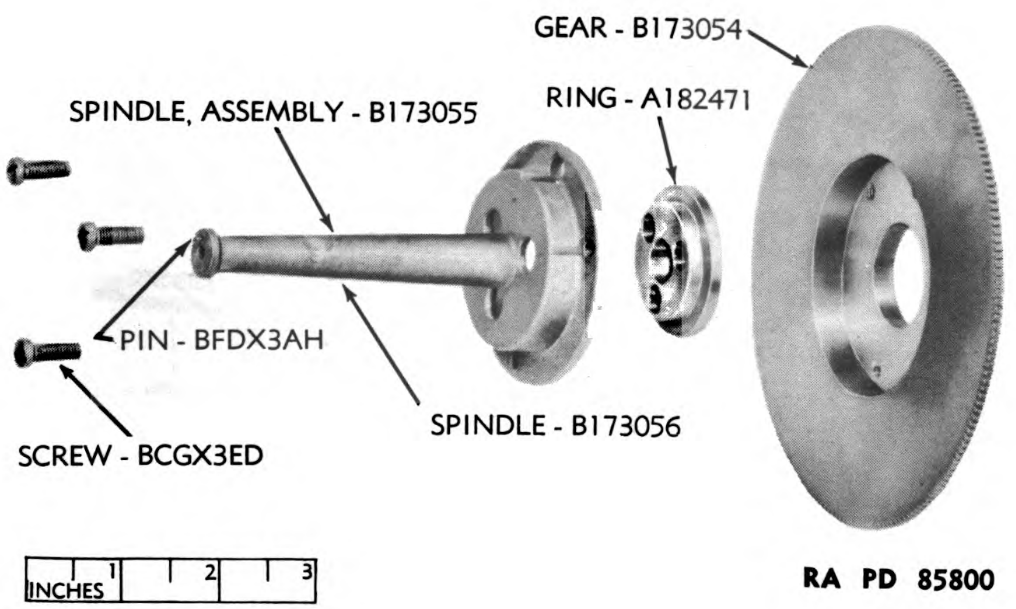


Figure 124 — Coarse Dial Spindle and Related Parts

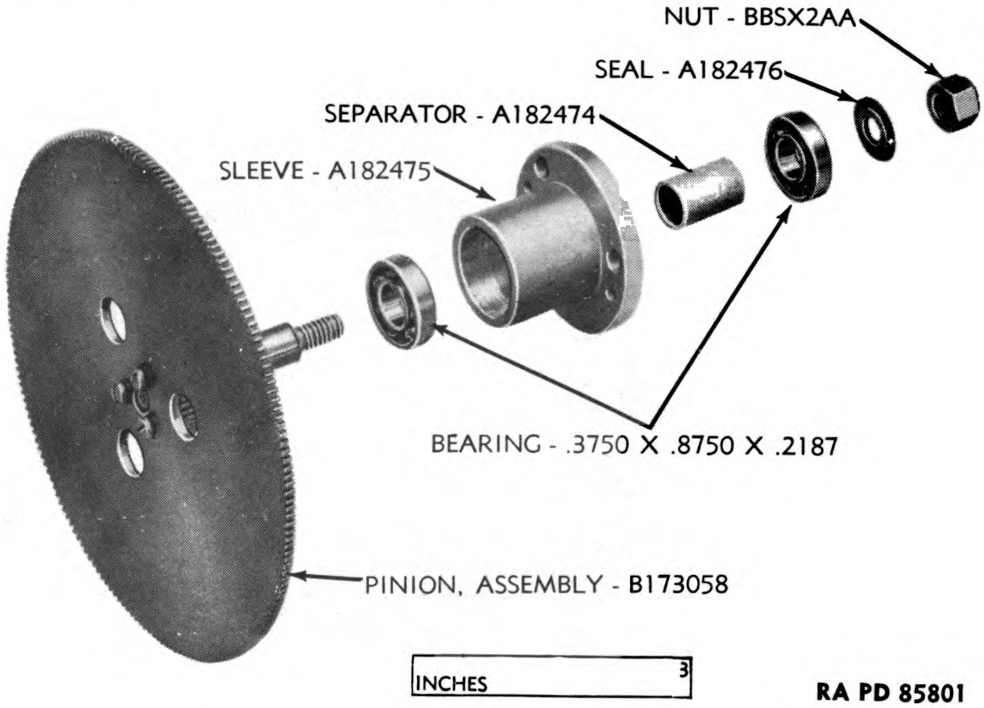


Figure 125 — Gear Assembly C78428 — Exploded View

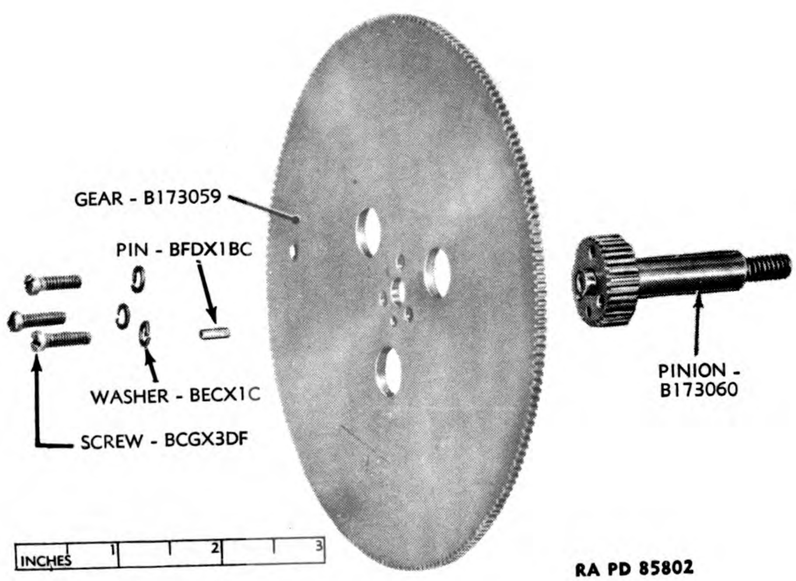


Figure 126 — Pinion Assembly B173058 — Exploded View

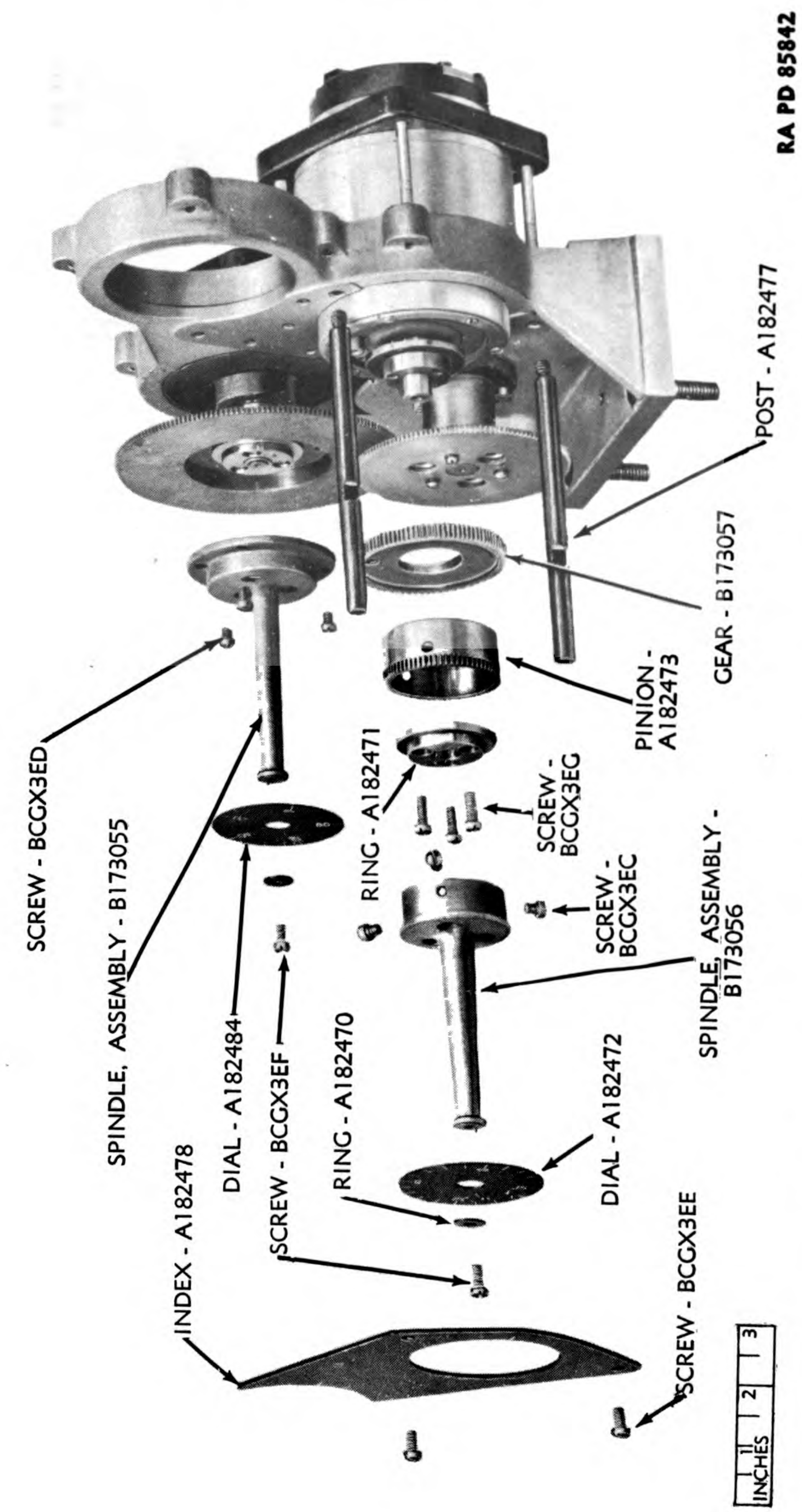


Figure 127 — Disassembling Elevation Transmitter Assembly (Director M5 or M6)

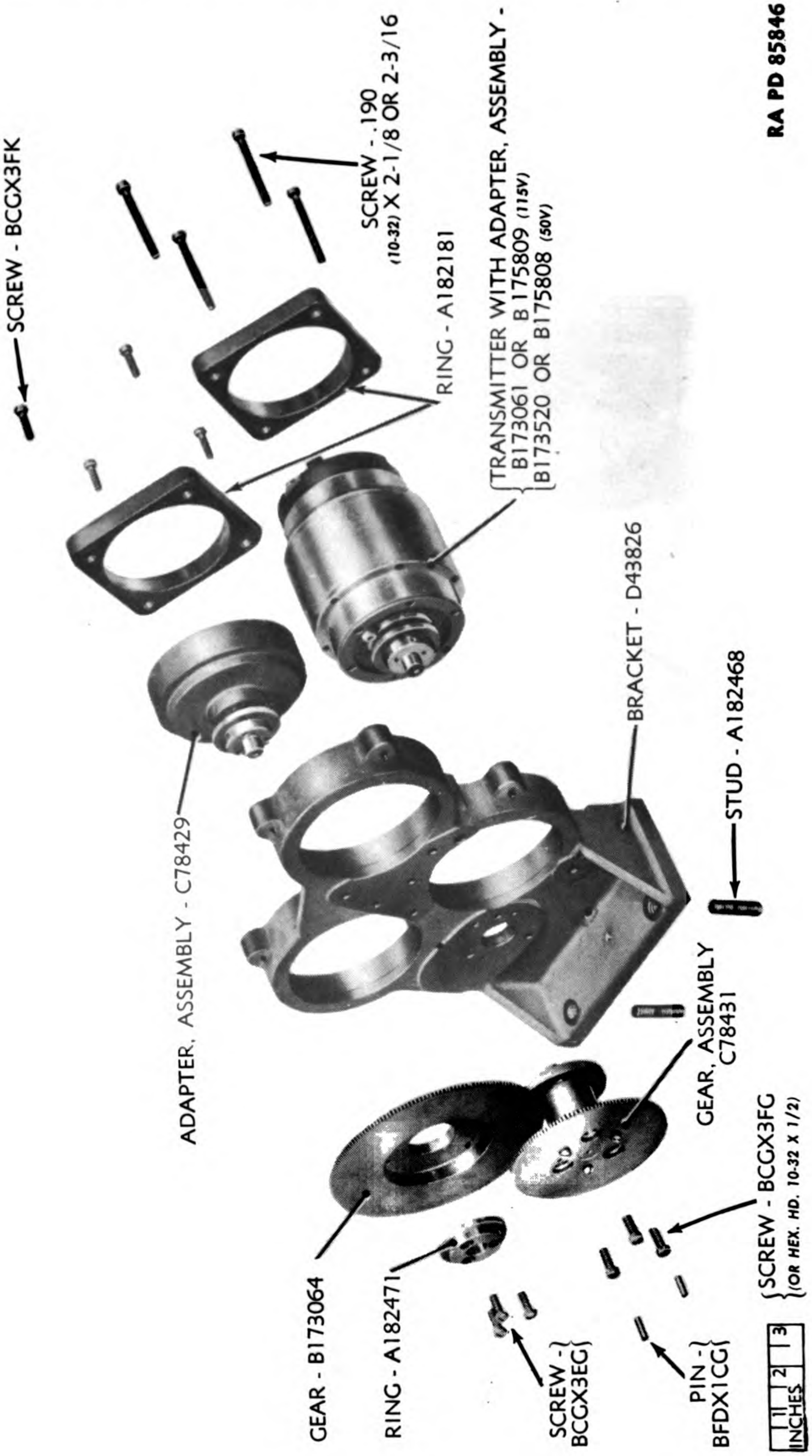


Figure 128 — Further Disassembly of Elevation Transmitter Assembly (Director M5 or M6)

DISASSEMBLY AND ASSEMBLY

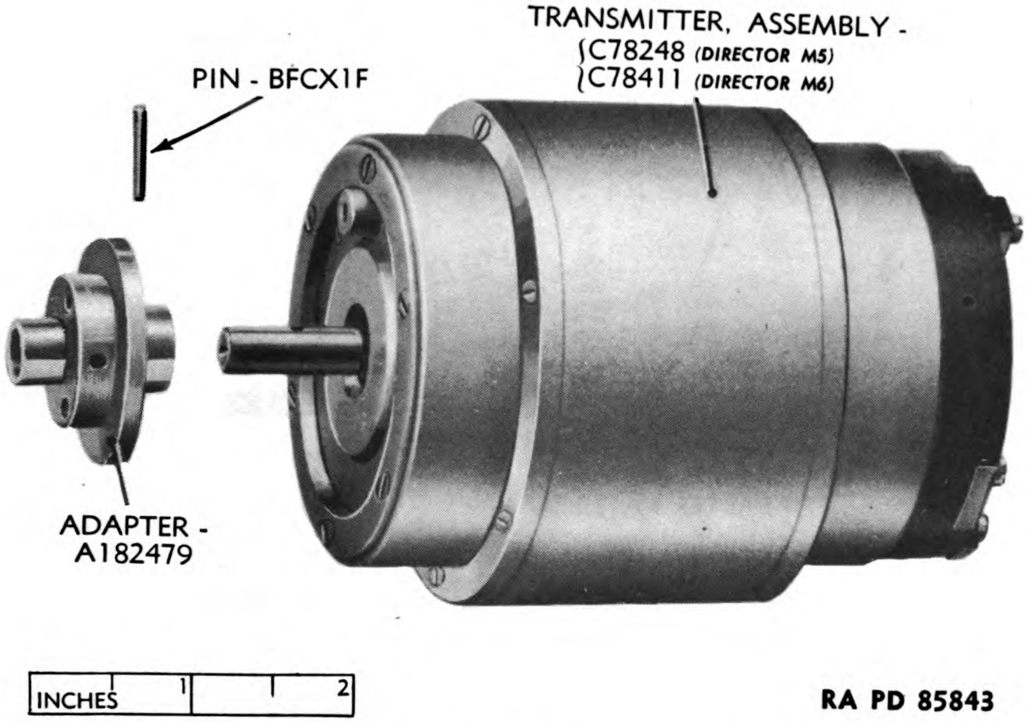


Figure 129 — Transmitter With Adapter (Obsolete) Assembly B173061 or B173520 (Also See Figure 123)

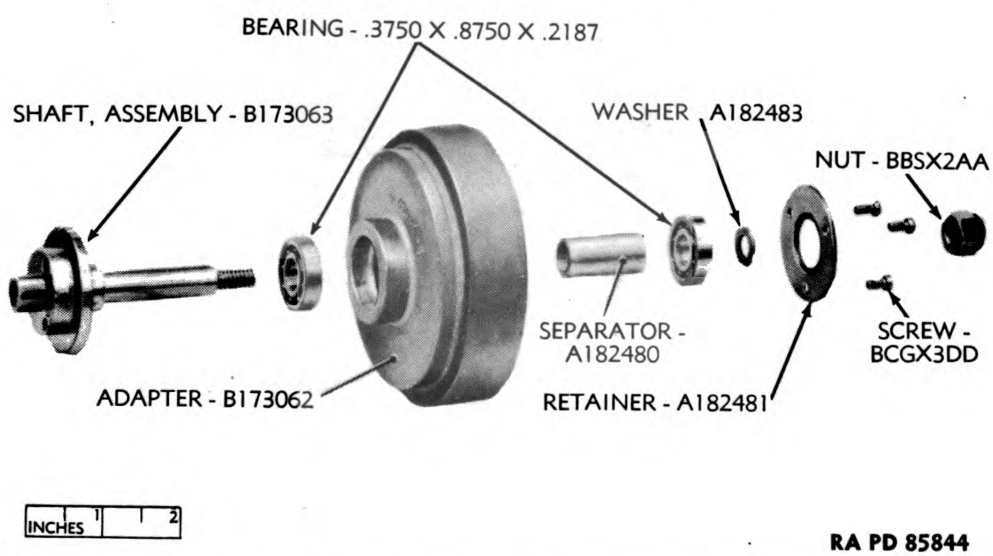


Figure 130 — Adapter Assembly C78429 — Exploded View

b. On Director M5A1, if the spiral drive has not been removed, remove the spiral drive cover, also the nearest screw in the base of the future azimuth or quadrant elevation mechanism.

c. Withdraw the clutch with the horizontal shaft until the wires from the switch can be removed. *NOTE: With the transmitter as-*

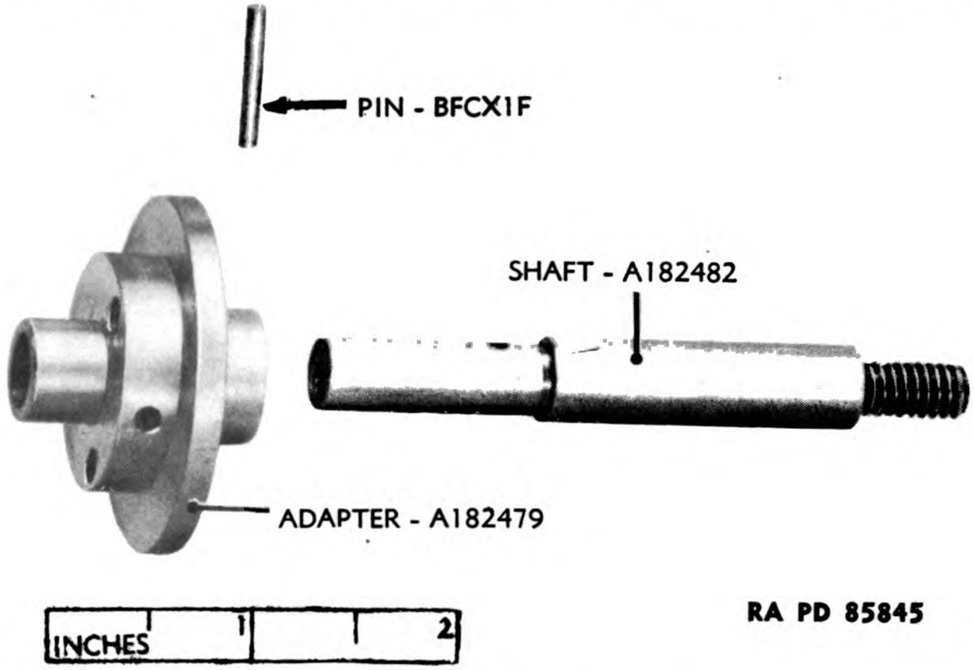


Figure 131 — Parts of Shaft Assembly B173063

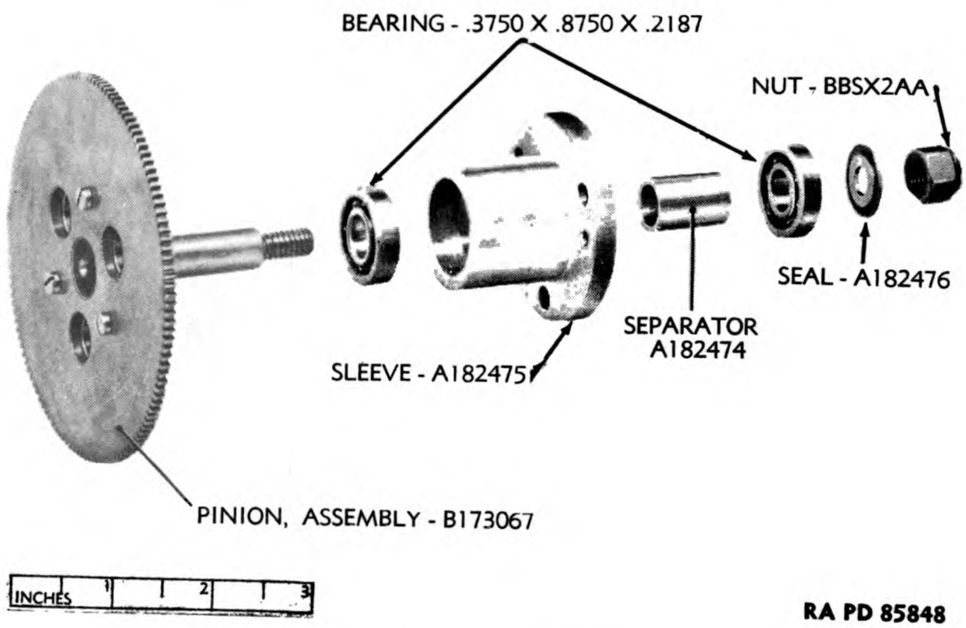


Figure 132 — Gear Assembly C78431 — Exploded View

sembly in place, the clutch will not come out unless the stop nut is against the adjustable stop.

d. If the clutch is disassembled for cleaning (figs. 136 to 142), the stop nut and its screw must be replaced in the same relative posi-

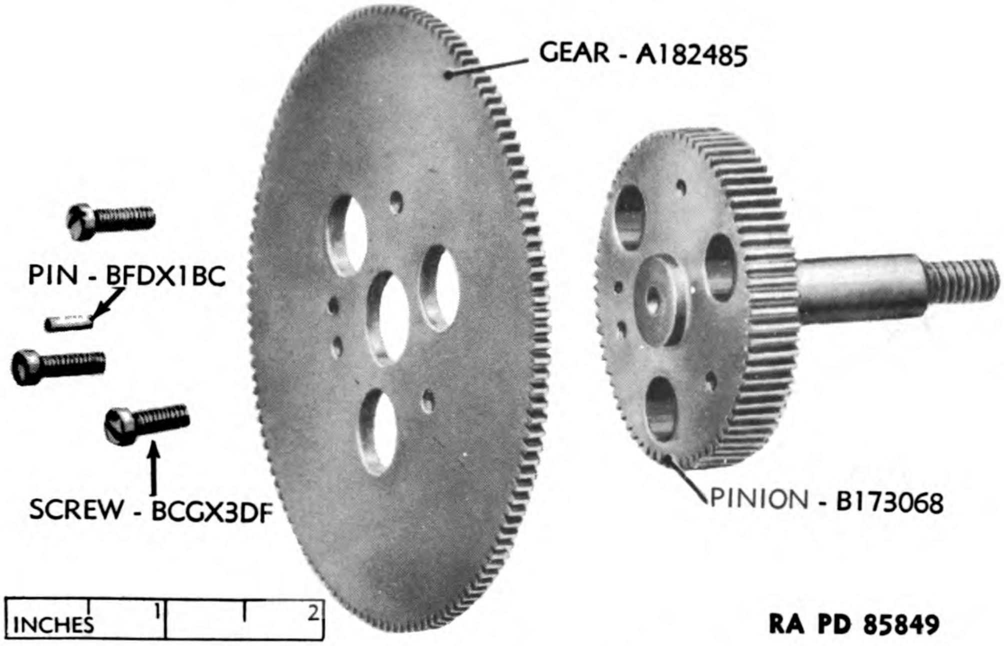


Figure 133 — Pinion Assembly B173067 — Exploded View

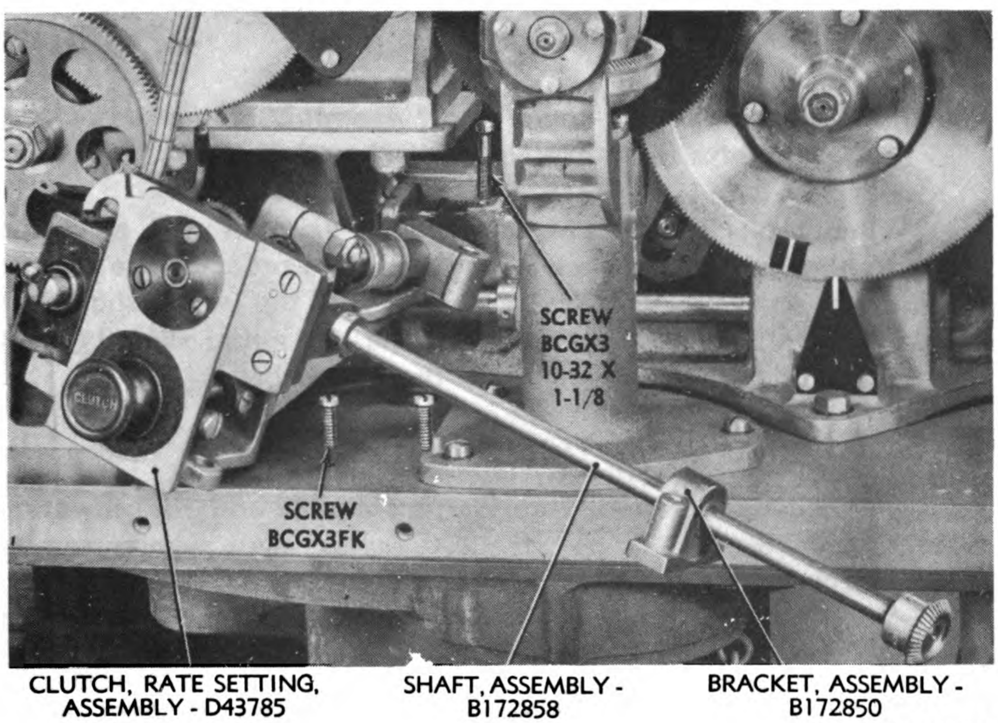


Figure 134 — Removing Rate Setting Clutch From Director

tion, since these parts may not be interchangeable. Also, the pinholes in the shaft and the screw must be lined up before the splines are engaged if the same pinhole is to be used.

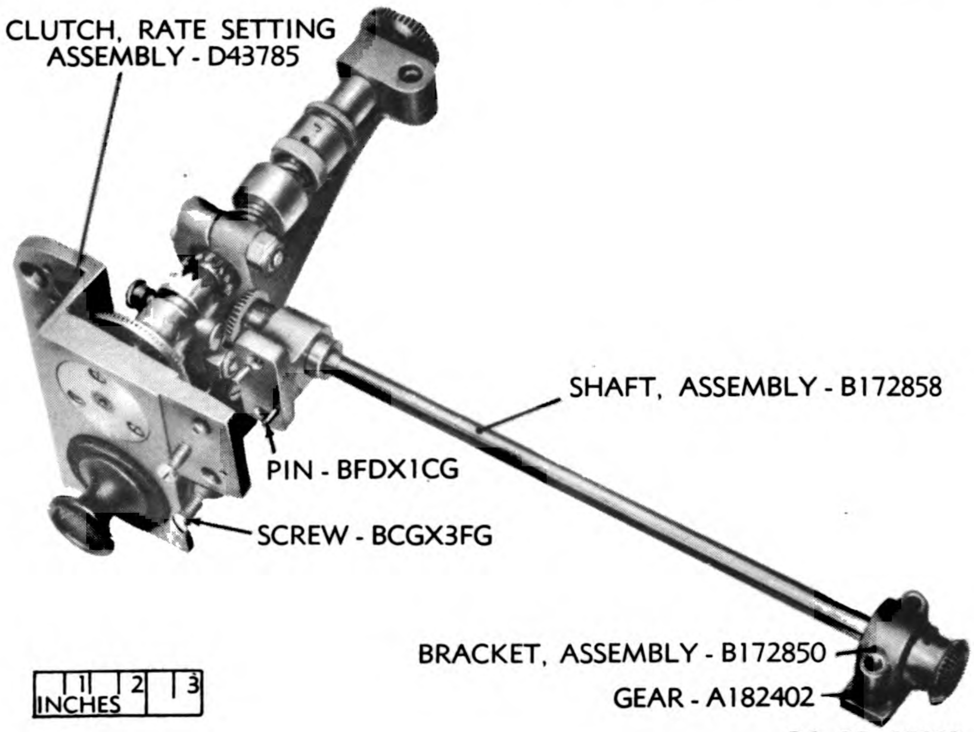


Figure 135 — Removing Horizontal Shaft Assembly From Rate Setting Clutch (Also See Figures 203 and 209)

e. When replacing, do not interchange azimuth and elevation units. Replace wires to switch in their original order or the motors may turn the wrong way. The "on" position of the switch should be downward. Tighten the two screws in the horizontal shaft bracket before tightening the three screws in the clutch body.

74. QUADRANT ELEVATION MECHANISM.

a. Remove the elevation rate setting clutch and the elevation transmitter assembly. Disengage the telescope shaft segment as instructed in paragraph 55 a, and hold or tie it out of engagement.

CAUTION: When disengaging the antibacklash gears, hold them to prevent sudden unwinding.

b. Remove the four screws which hold the lower bracket of the inclined shaft assembly to the drive shaft assembly (fig. 143). Drive the dowel pin up and remove the three screws which hold the quadrant elevation mechanism in the base; lift up the mechanism, with the inclined shaft, and tilt it forward to clear the gears. If any prying is necessary, be careful not to damage the bottom surface of the casting.

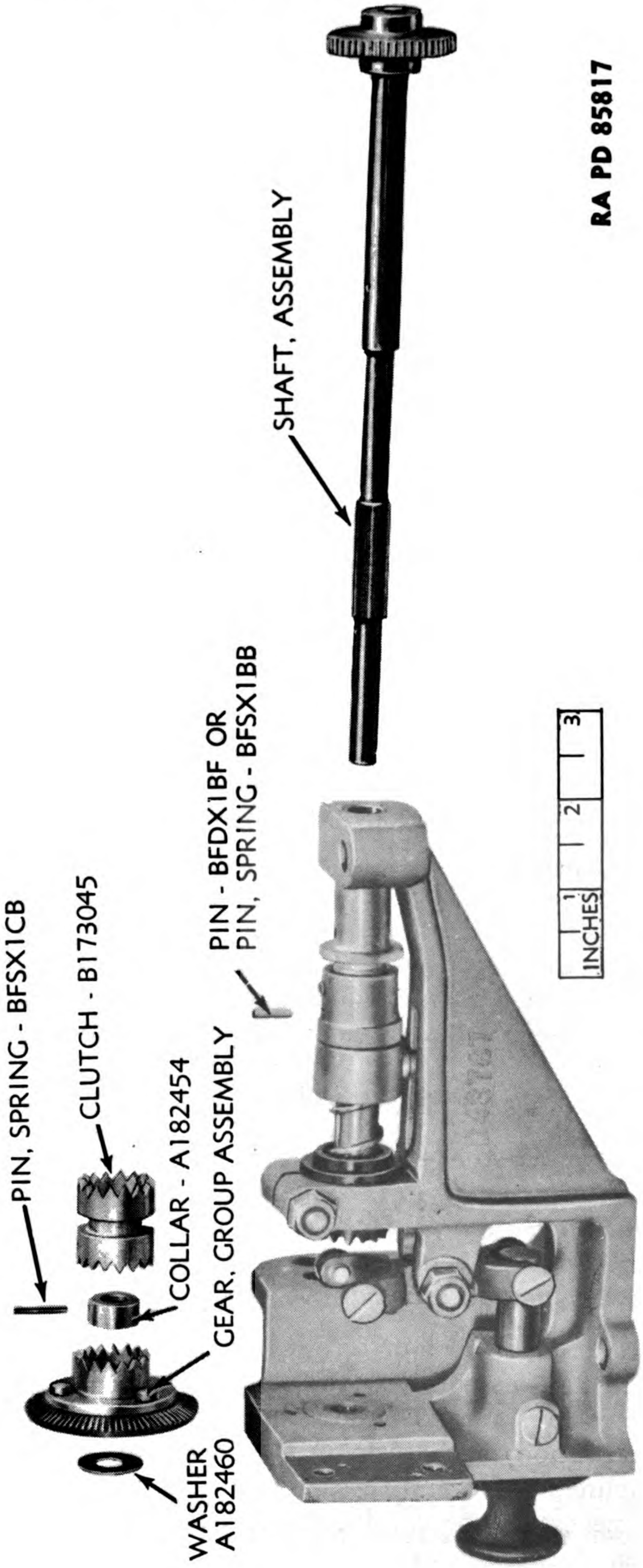


Figure 136 — Disassembly of Rate Setting Clutch

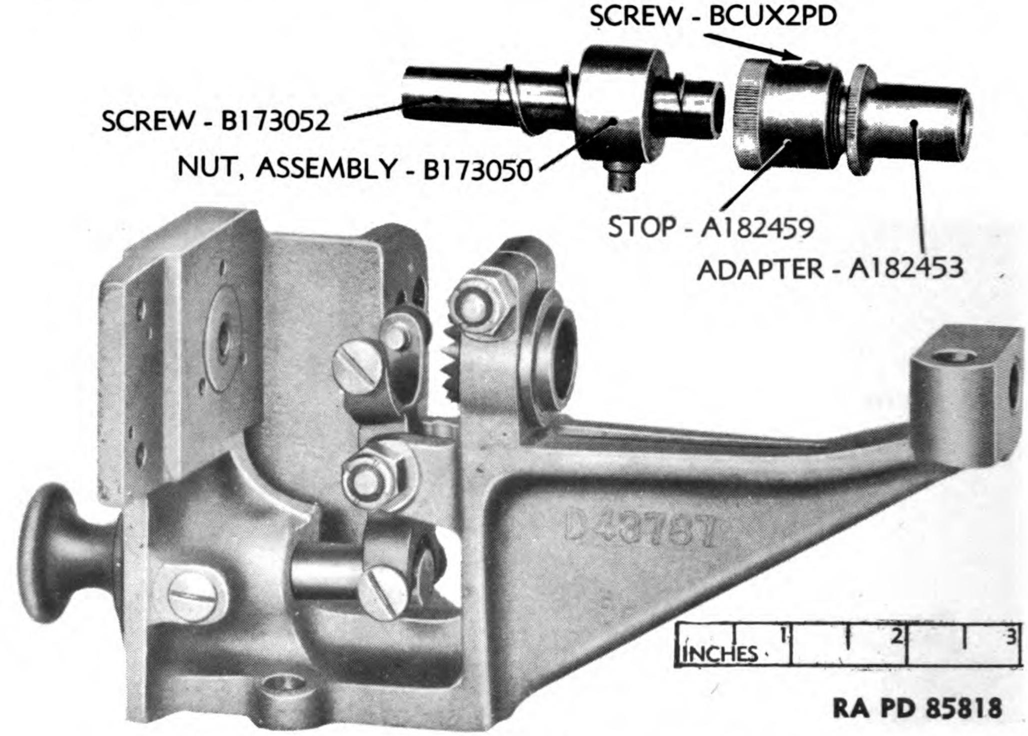


Figure 137 — Disassembly of Rate Setting Clutch

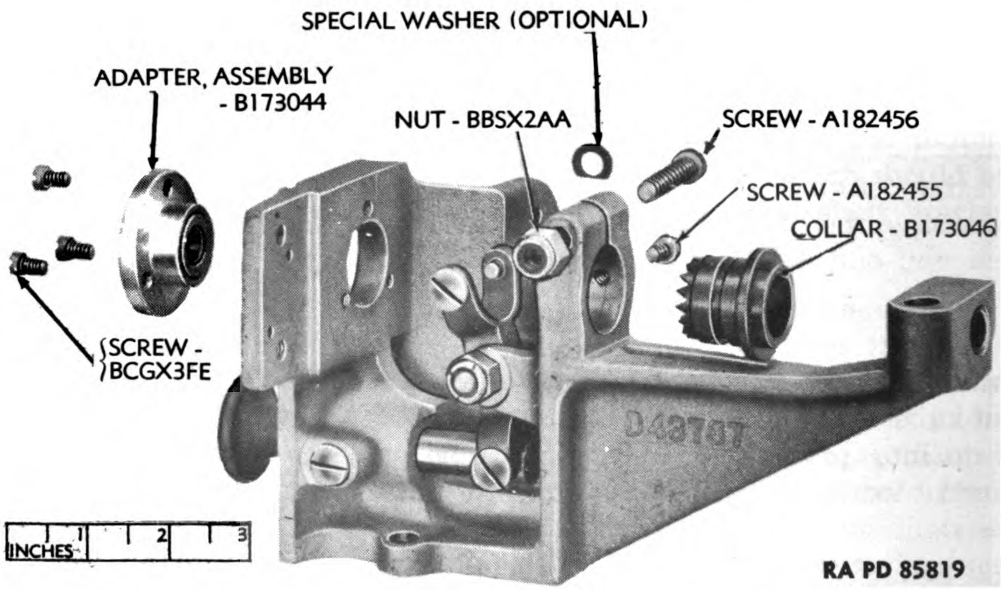


Figure 138 — Further Disassembly of Rate Setting Clutch

c. **Replacing.** See paragraph 55 for reengagement of segment. If the idler gear bracket has been disassembled, it will be necessary to loosen the four screws in cover A182436 and position the idler for proper mesh (fig. 146).

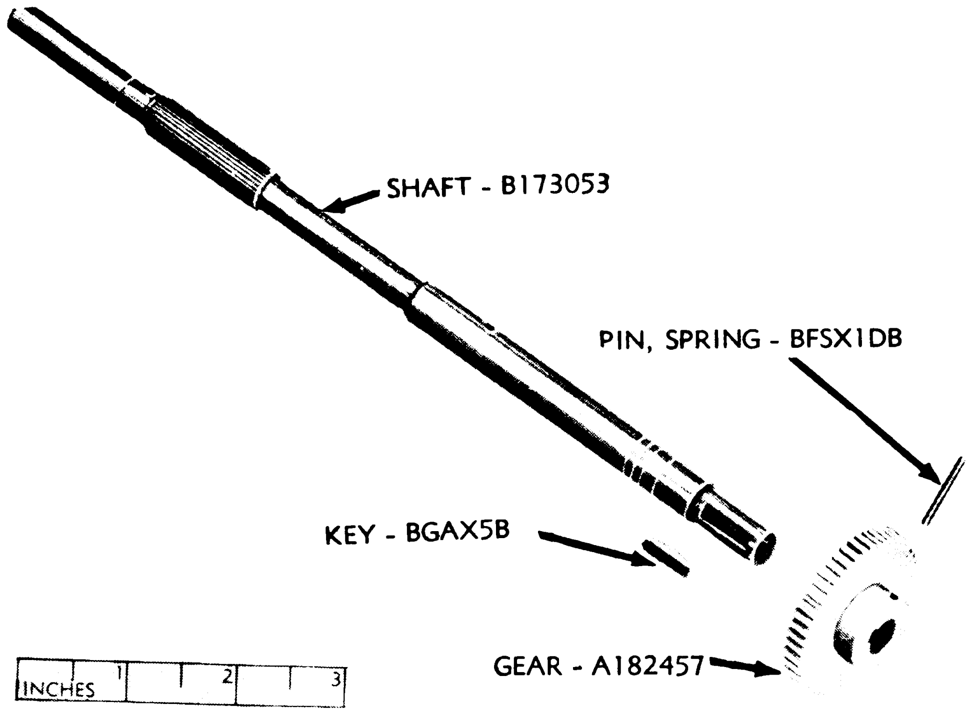


Figure 139 — Rate Setting Clutch Shaft Assembly

75. THE RANGE MECHANISM.

a. Remove the range handwheel. Remove the three screws holding the range mechanism to the base, also the one screw holding the range handwheel bracket assembly B173075 to the base (fig. 151). Set the slot on the right-hand coupling A182350 to a horizontal position; slide the range mechanism slightly to the right and then to the rear and out.

b. Assembly. Set both multiplier sliders so the scribed marks are alined. If the range stop on the azimuth multiplier shaft is not against the pin furthest from the operator, lift the end of the shaft until the nut can be turned on the screw. Slide the range mechanism into place with its coupling positioned correctly, pressing slightly to the right until the coupling will engage. The bracket at the right should be flush with the base so that the cover plate will seal against it. See paragraph 49 for setting of dial index.

76. THE ELEVATION TRACKING MECHANISM.

a. Remove the range mechanism (par. 75). If the dowel pin in the base of the tracking mechanism cannot be driven out, the torque amplifier or gear reduction unit should also be removed (par. 68 or 81).

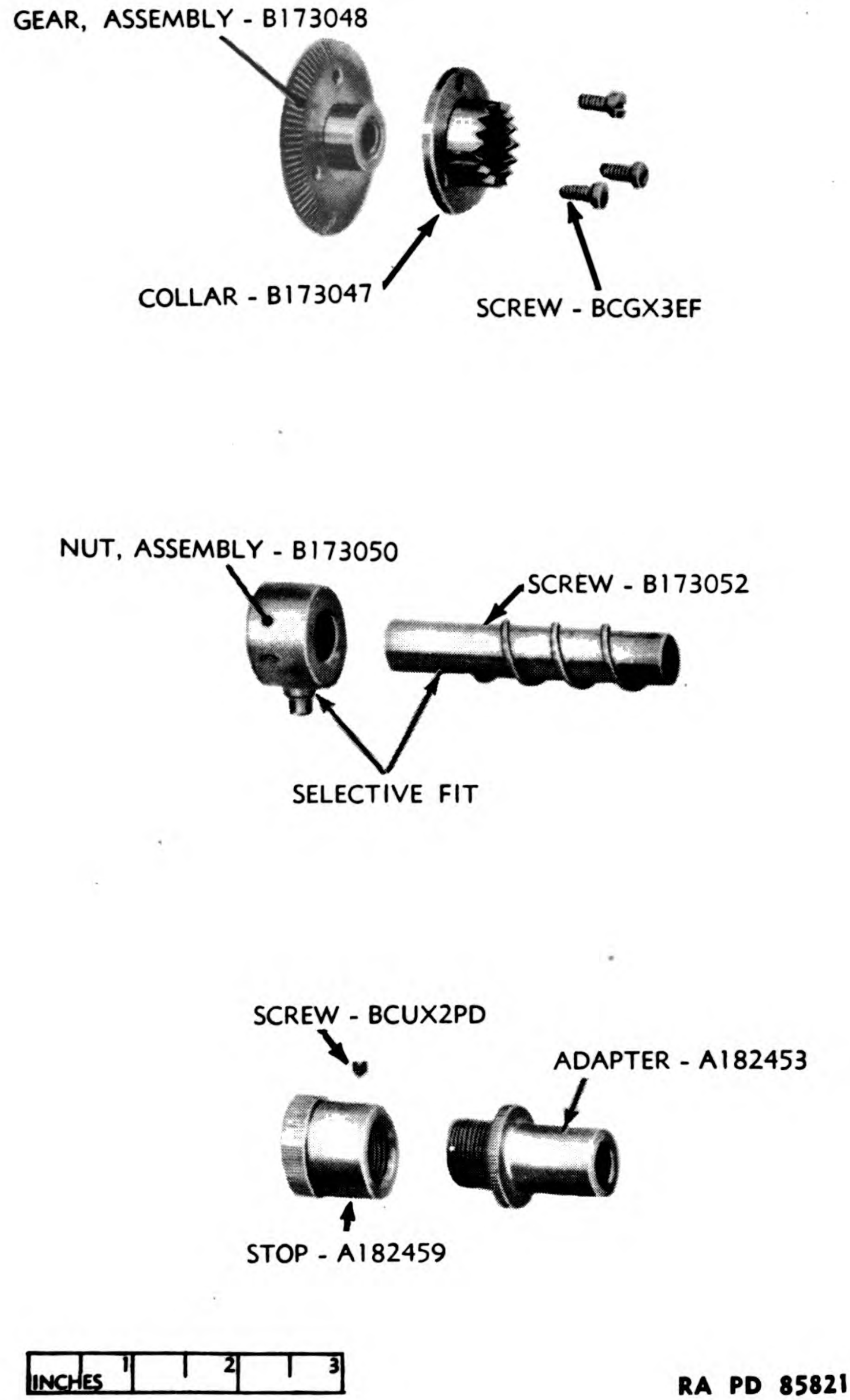


Figure 140 — Further Disassembly of Rate Setting Clutch Parts

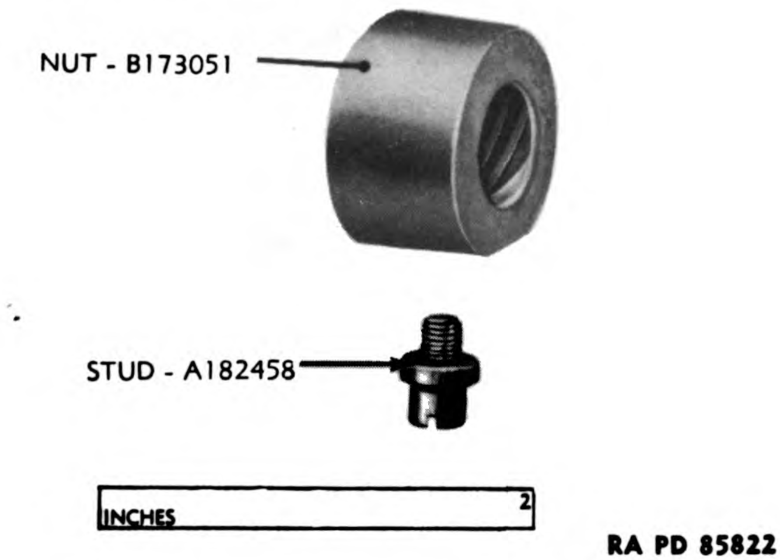


Figure 141 — Stop Nut Assembly B173050

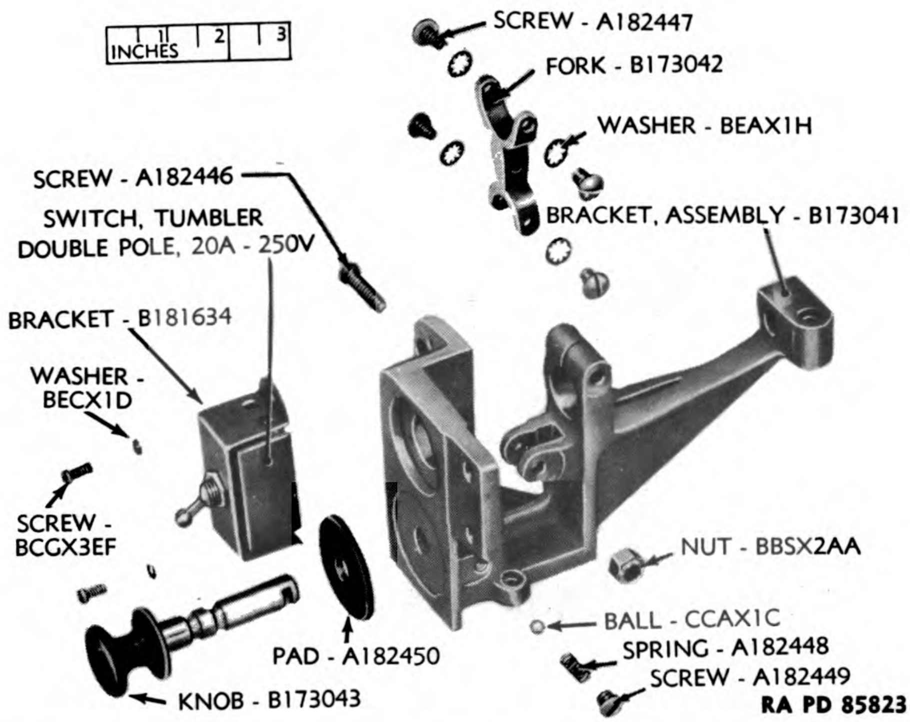


Figure 142 — Additional Parts of Rate Setting Clutch D43785

b. Remove the four screws holding the intermediate drive shaft bracket B172846 (fig. 160). Remove the screws in the nearest bracket which holds the horizontal handwheel shaft assembly B172856 and slide it back to disengage the coupling. If the rate

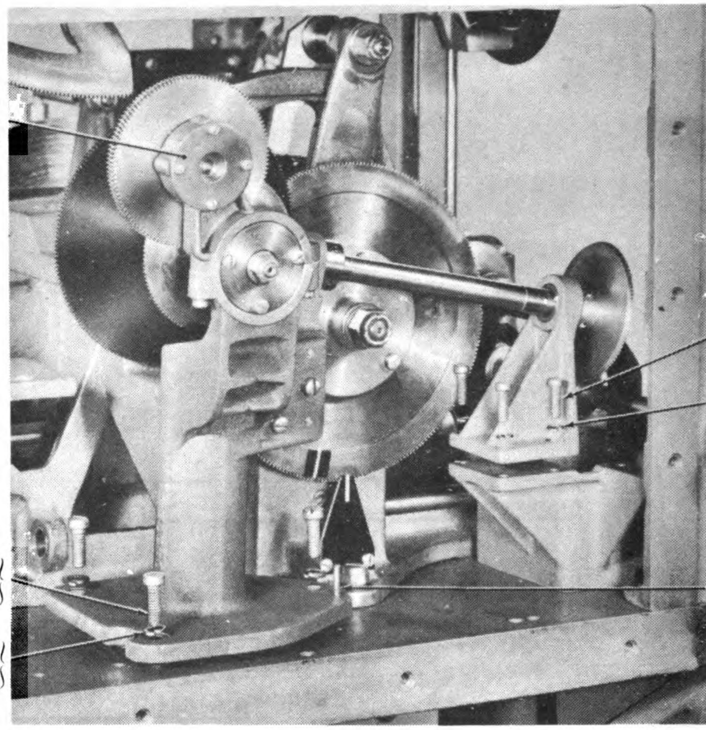


Figure 143 — Removing Quadrant Elevation Mechanism, With Inclined Shaft Attached

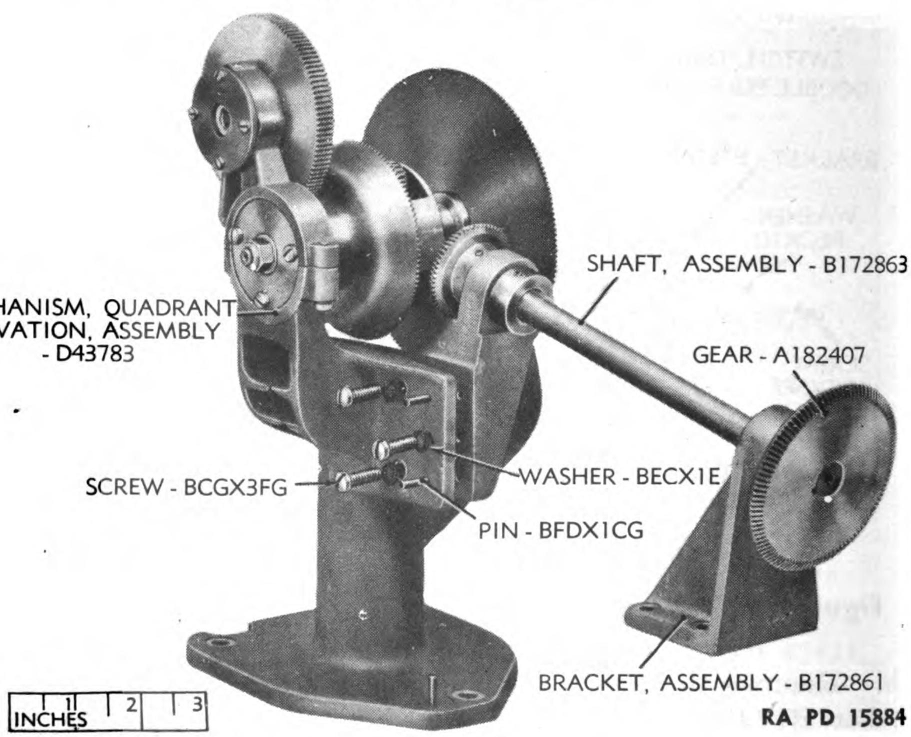


Figure 144 — Removing Inclined Shaft From Quadrant Elevation Mechanism (Also See Figure 202)

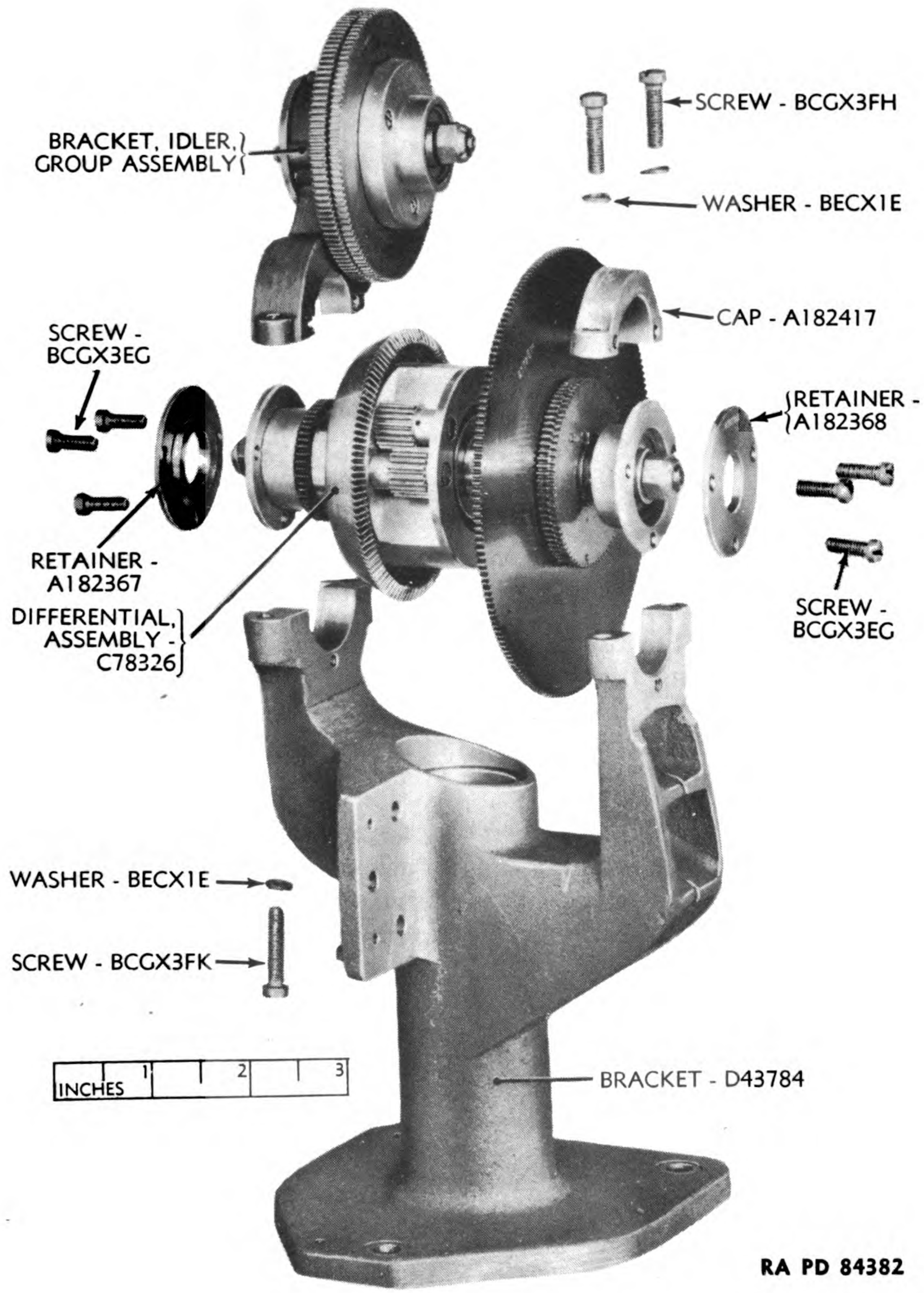


Figure 145 — Quadrant Elevation Mechanism — Major Disassembly

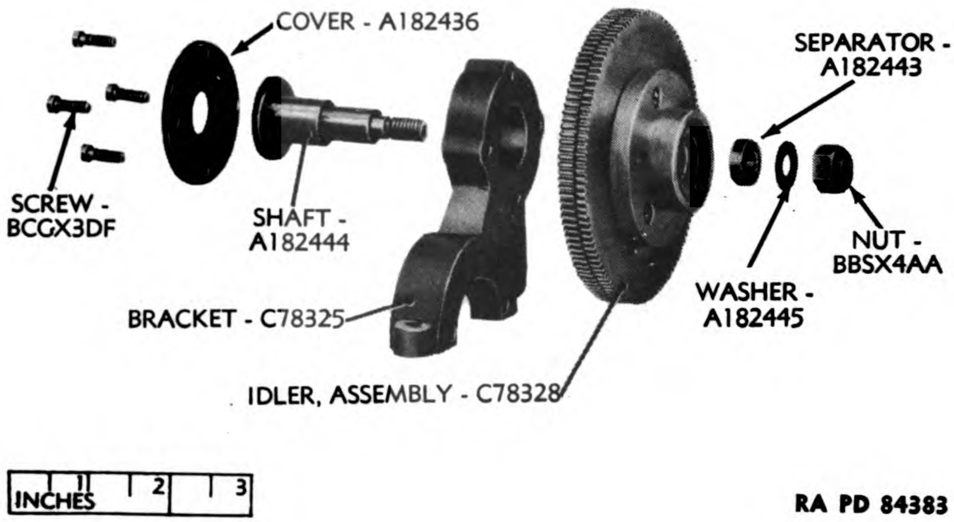


Figure 146 — Idler Bracket Group Assembly, Showing Adjustable Idler Shaft — Exploded View

setting clutch has not been removed, it will be necessary to remove both brackets and lift this shaft out to disengage the coupling.

c. Drive out the dowel pin from underneath, and remove the four screws holding the elevation tracking mechanism to the base. Turn the coupling of the torque amplifier or the gear reduction unit to a vertical position, and lift out the mechanism *with the intermediate shaft attached.*

d. When replacing the assembly, do not tighten the inaccessible screw under the intermediate shaft bracket unnecessarily tight. Use a screw with a good slot in this position for ease in removing the next time. Check alinement of coupling and tighten screws in the torque amplifier or gear reduction unit.

77. THE AZIMUTH THROW-OUT LEVER (SLEWING CLUTCH) ASSEMBLY.

a. Remove the cover plate underneath the right front of the base (fig. 48). Remove the collar A182585 from the end of the slewing clutch shaft, and pull the shaft back. Take out the two screws in the block, and remove the fork assembly B173112.

b. For disassembly, see figure 168.

c. See paragraph 47 for adjustment if slewing clutch does not disengage properly.

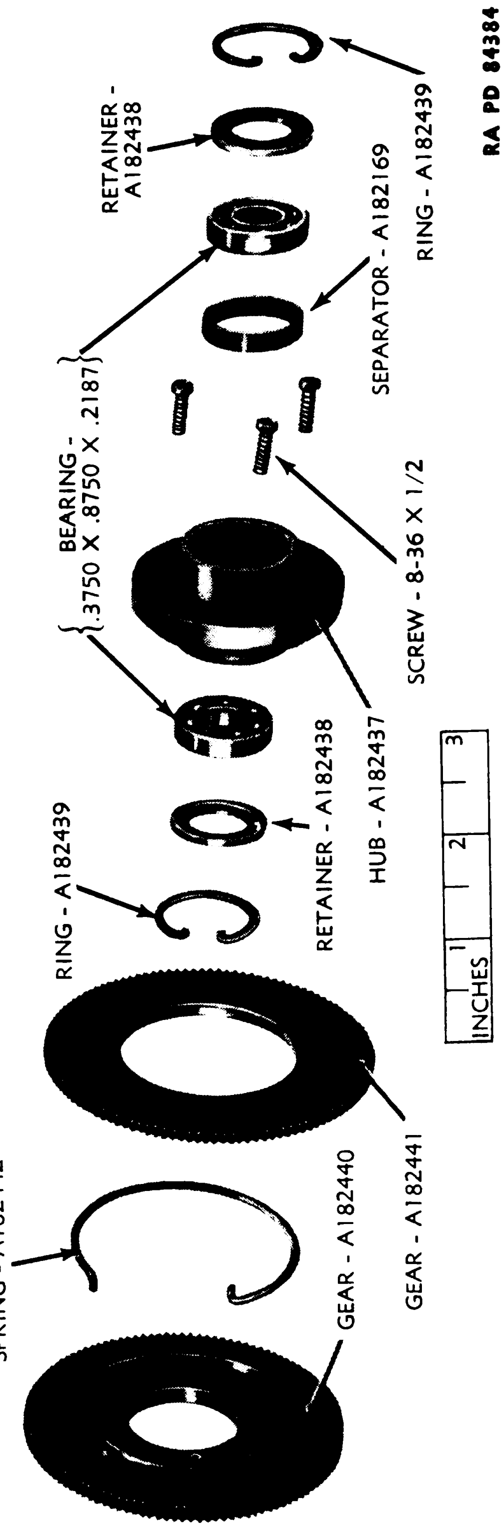


Figure 147 — Idler Assembly C78328 — Exploded View

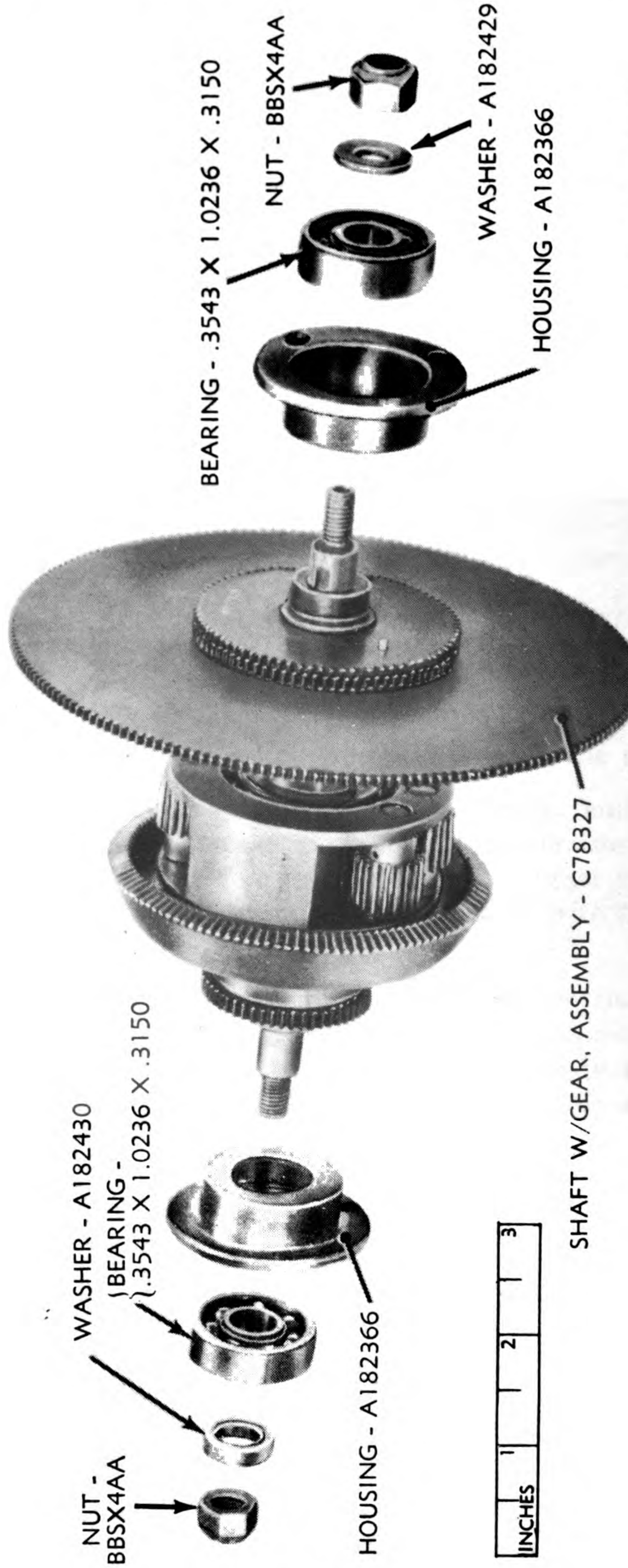


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Figure 148 — Parts of Quadrant Elevation Mechanism Main Shaft

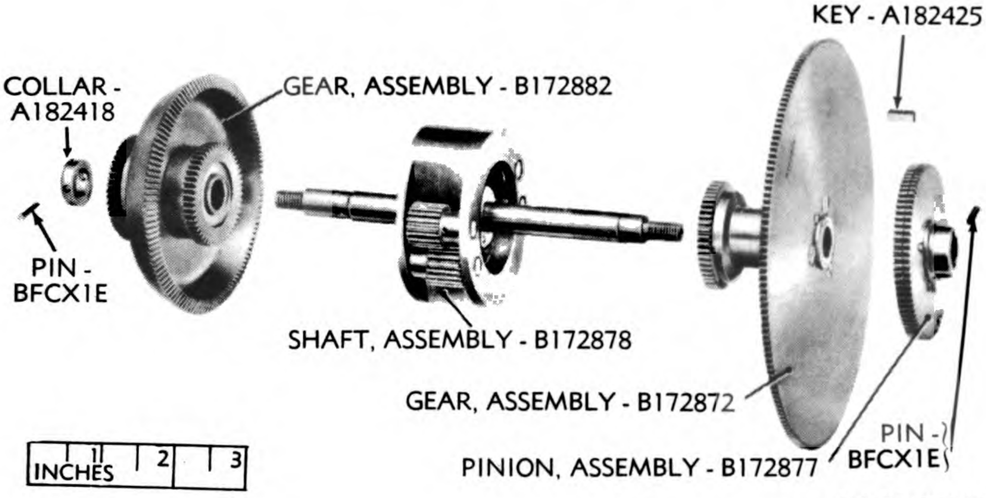

Figure 149 — Components of Quadrant Elevation Shaft With Gear Assembly C78327 (See Figures 150, and 188 to 191)

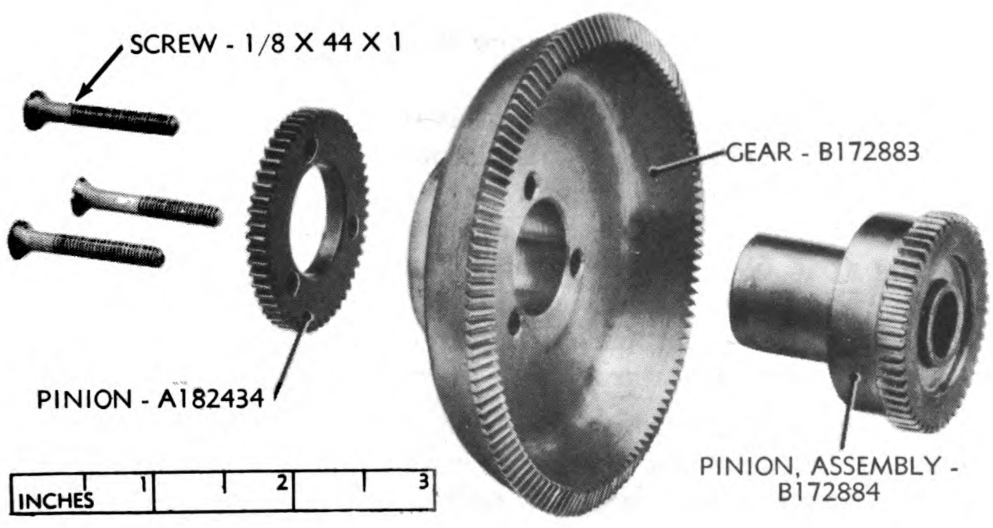

Figure 150 — Gear Assembly B172882 — Exploded View

78. THE AZIMUTH TRACKING MECHANISM.

a. Remove the azimuth throw-out fork assembly as instructed in the previous paragraph.

b. Remove the screws in one or both of the brackets which hold the handwheel shaft assembly B172856 (fig. 169) and slide it back

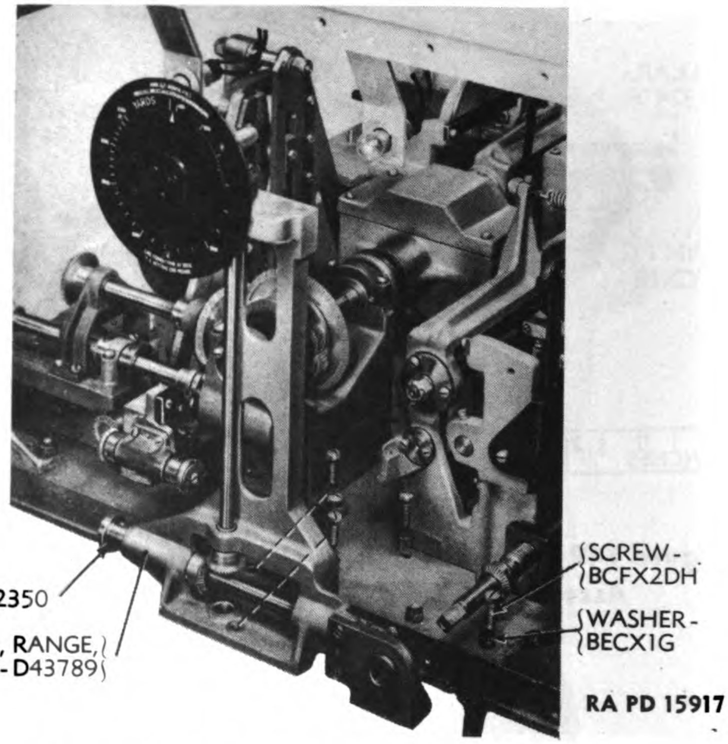

Figure 151 — Removing Range Mechanism From Director

or lift it to disengage the coupling. If the dowel pin hole is drilled all the way through the base, drive it out. Turn the coupling of the torque amplifier or gear reduction unit to a vertical position, or if the dowel pin cannot be driven out, it is better to remove this mechanism first (par. 68 or 81). Remove the four screws which hold the tracking mechanism to the base and lift the mechanism straight up and out, holding the antibacklash gear underneath the base as it is disengaged from the main azimuth gear.

c. When replacing the mechanism, tool A400157 shown in figure 81 will be found useful for winding the antibacklash gear before engaging with the main azimuth gear.

d. If the torque amplifier or gear reduction unit has been removed, check the alinement of the coupling and see that the mounting screws of this unit are tightened.

79. FUTURE AZIMUTH MECHANISM.

a. Remove the rate setting clutch and preferably the azimuth transmitter assembly.

b. Pull off the orienting clutch cap, loosen the small locking nut, and turn the large orienting nut until the taper pin in the shaft can be driven out (fig. 181). *Be sure to drive from the small end of the*

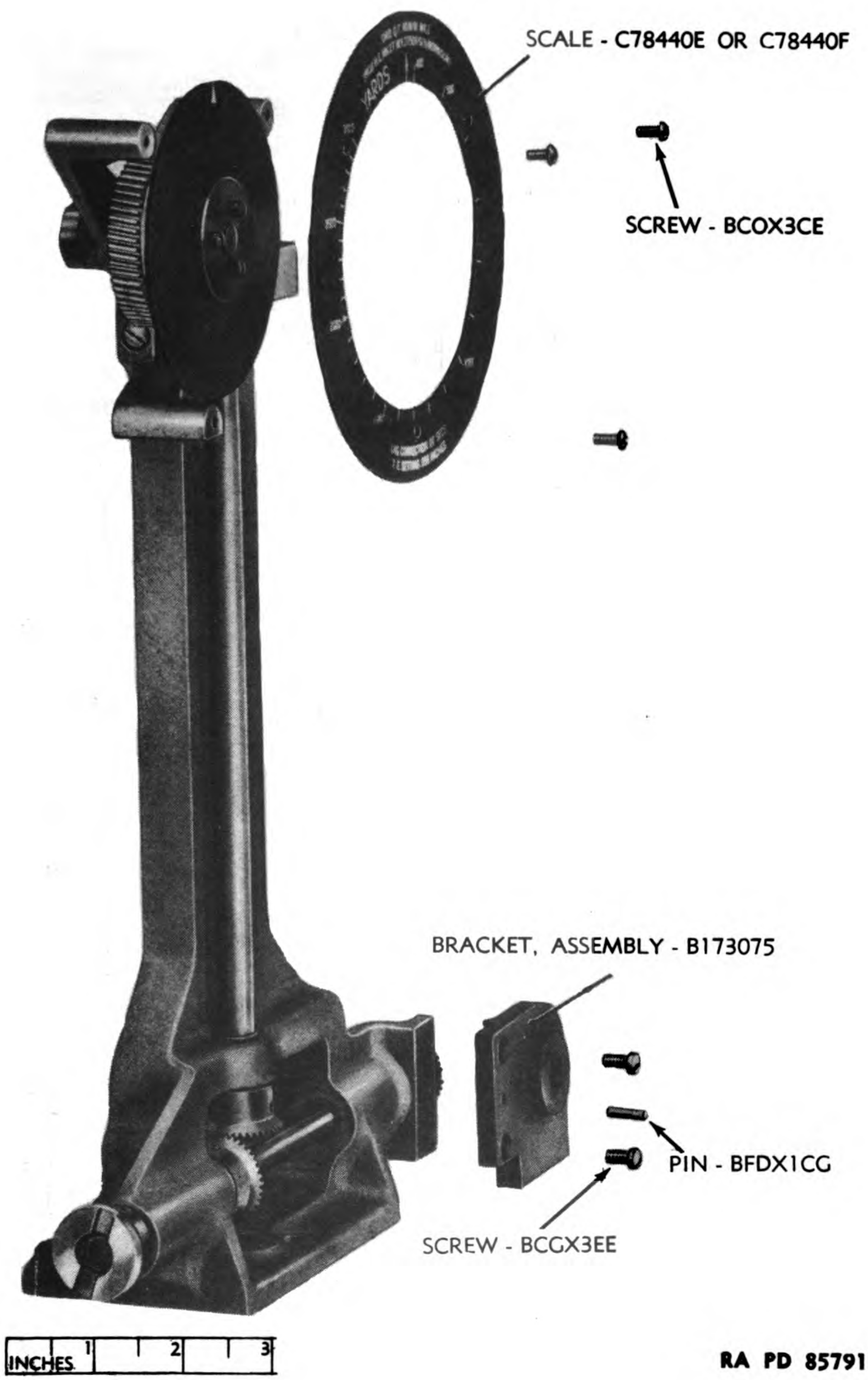

Figure 152 — Range Mechanism Assembly C43789 — Removing Scale and Bracket Assembly

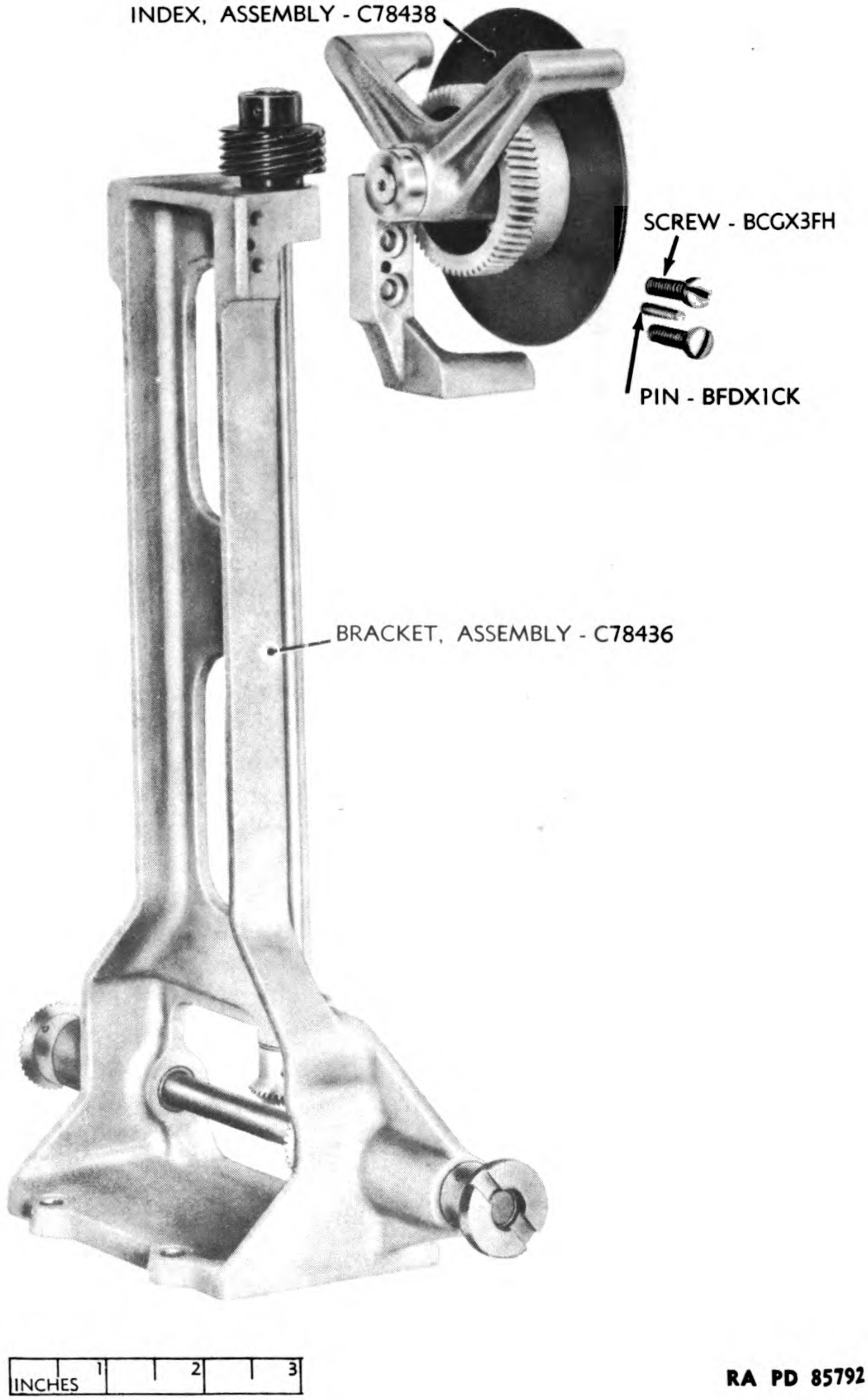

Figure 153 — Range Mechanism — Removal of Index Assembly

DISASSEMBLY AND ASSEMBLY

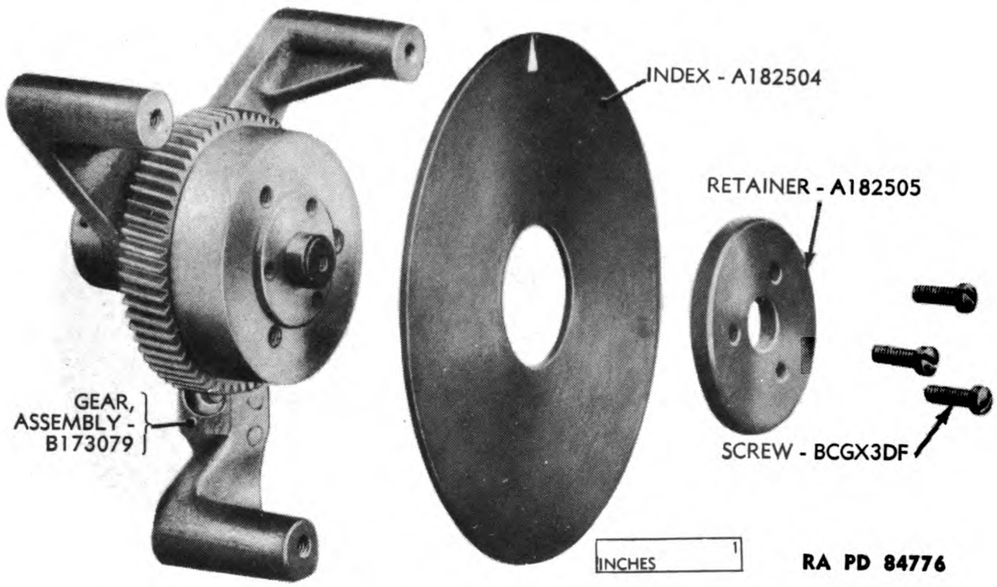

Figure 154 — Index Assembly C78438 — Exploded View

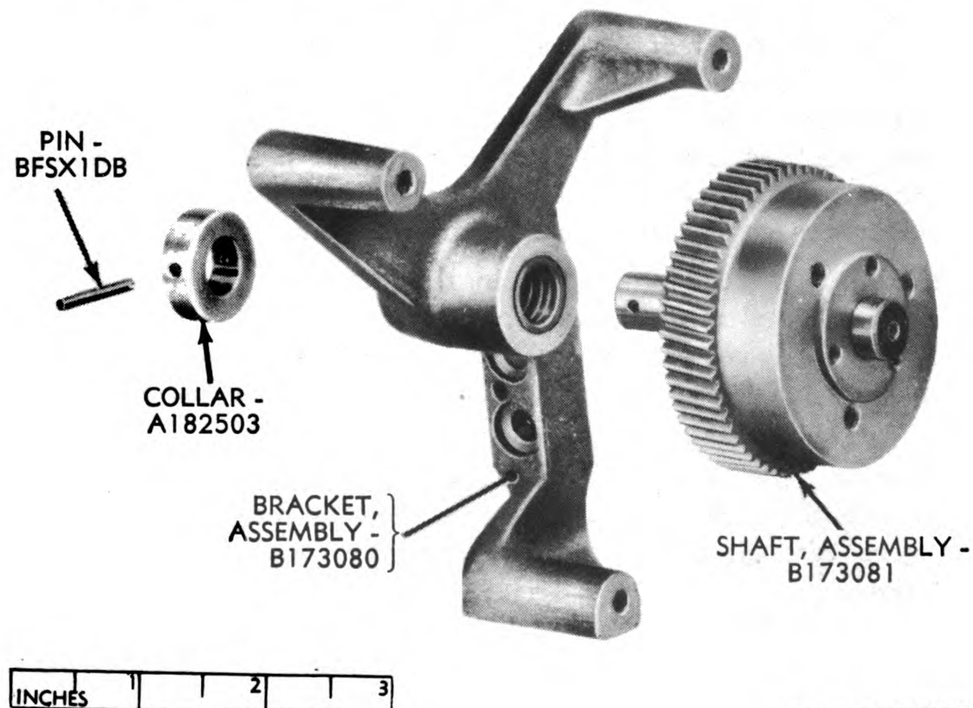

Figure 155 — Gear Assembly B173079 — Exploded View

pin and back up with a lead weight to prevent bending the shaft. Remove the inner nut A182413 and the large orienting nut; then remove the three screws which hold the cover assembly to the base, tilt the cover and remove it. *Replace the orienting nut* to hold the gears when the unit is removed.

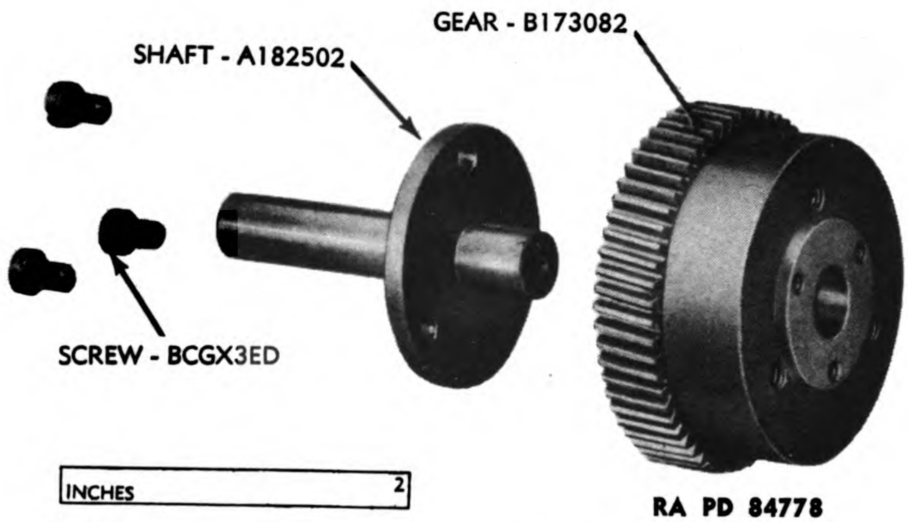

Figure 156 – Shaft Assembly B173081 – Exploded View

c. On latest Director M5A1 with the new type orienting clutch (fig. 195), remove the lever retaining clip, and the small cap B271276; then slide the lever assembly out sidewise with the two bearing blocks A319227. The cover C131381 need not be removed, but the circular shoes must be turned so their lugs are in line with the clearance cuts in the cover before the unit is lifted out.

d. Drive up the dowel pin in the base of the future azimuth mechanism and remove the three screws. Tilt the mechanism slightly to disengage the gears (hold the antibacklash gears as they disengage) and carefully lift it out of the director.

e. When replacing, wind antibacklash gear before placing unit in director. See figure 31 for correct position of the clamp in the cover assembly. When replacing the orienting nut, be sure the taper pin goes through both the shaft and the inner nut in the right direction.

80. DIFFERENTIAL DRIVE SHAFT GROUP ASSEMBLIES.

a. Remove the rate setting clutches, and on the elevation side remove the quadrant elevation mechanism and the elevation tracking mechanism.

b. Remove the washer from the outer end of the handwheel shaft and remove the shaft. Note the spring and washer on the shaft (fig. 201) which tend to push the nearest bracket away from the side frame; the bracket should be held while the screws are being removed or replaced.

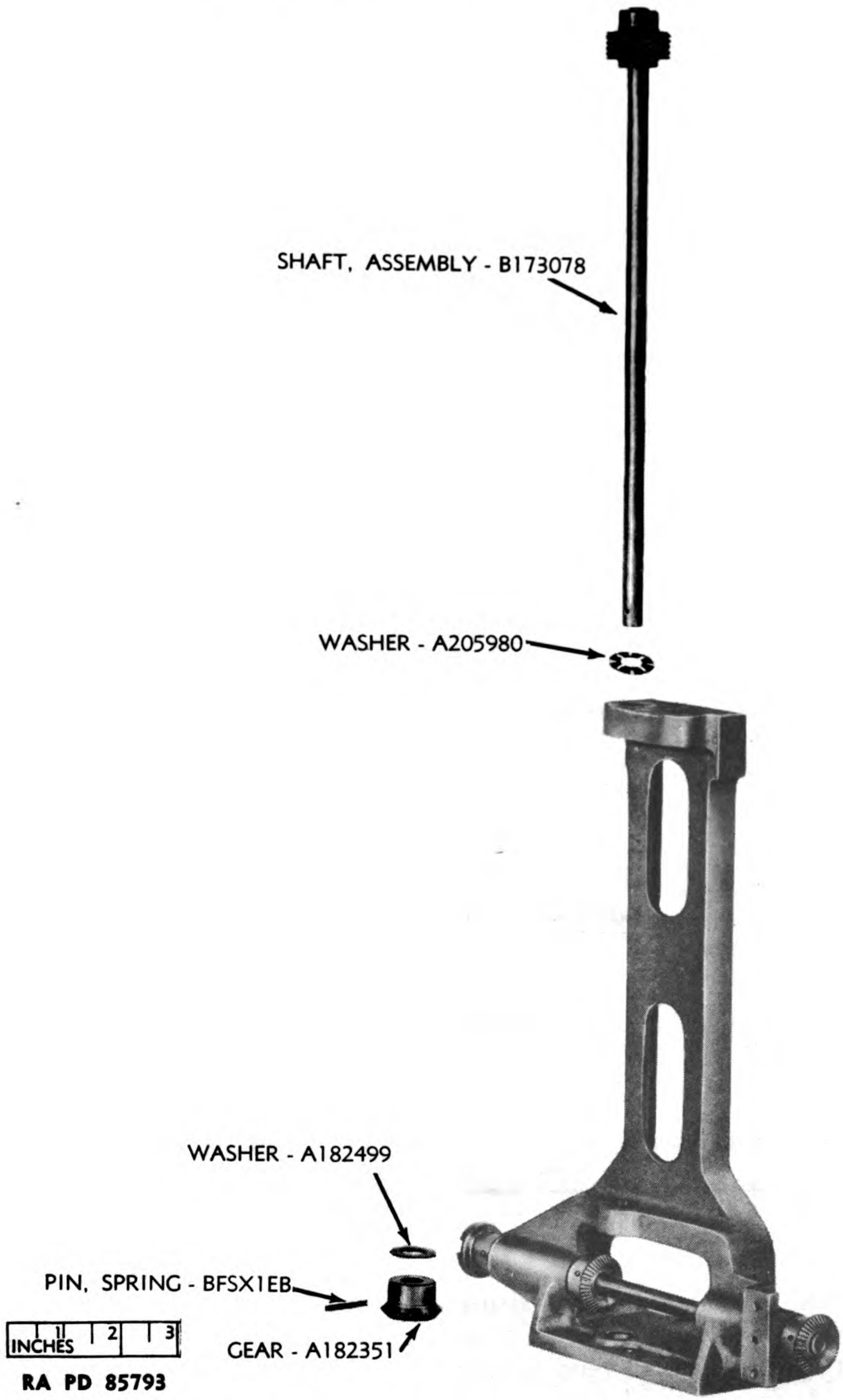

Figure 157 — Range Mechanism — Removal of Vertical Shaft

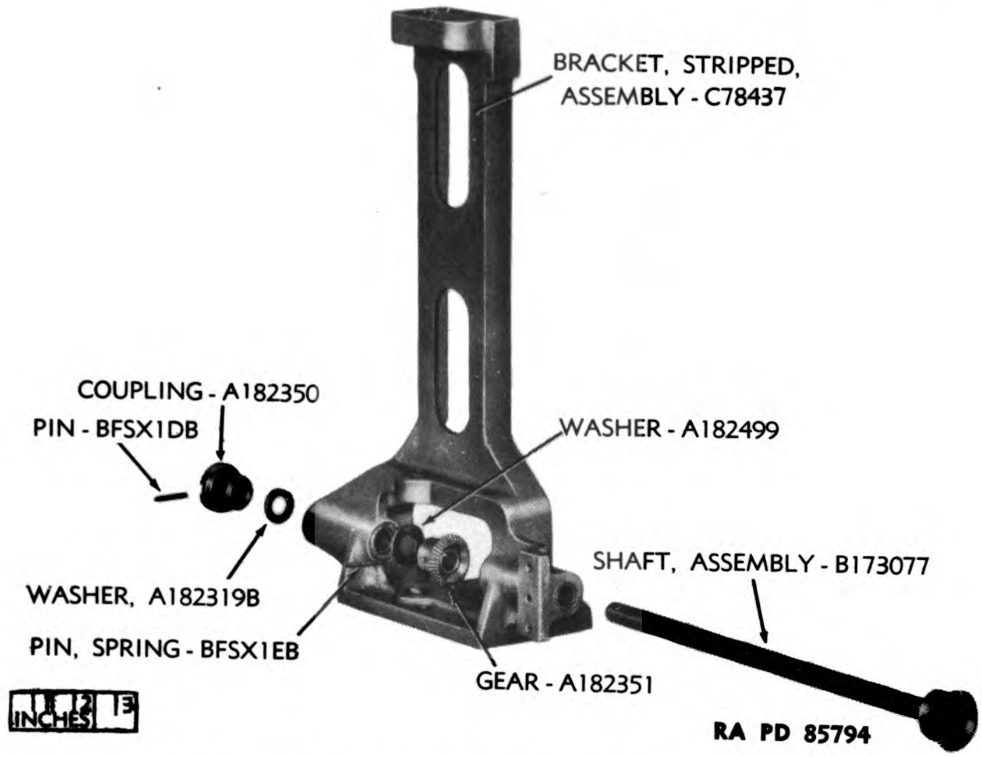

Figure 158 — Range Mechanism — Removal of Horizontal Shaft

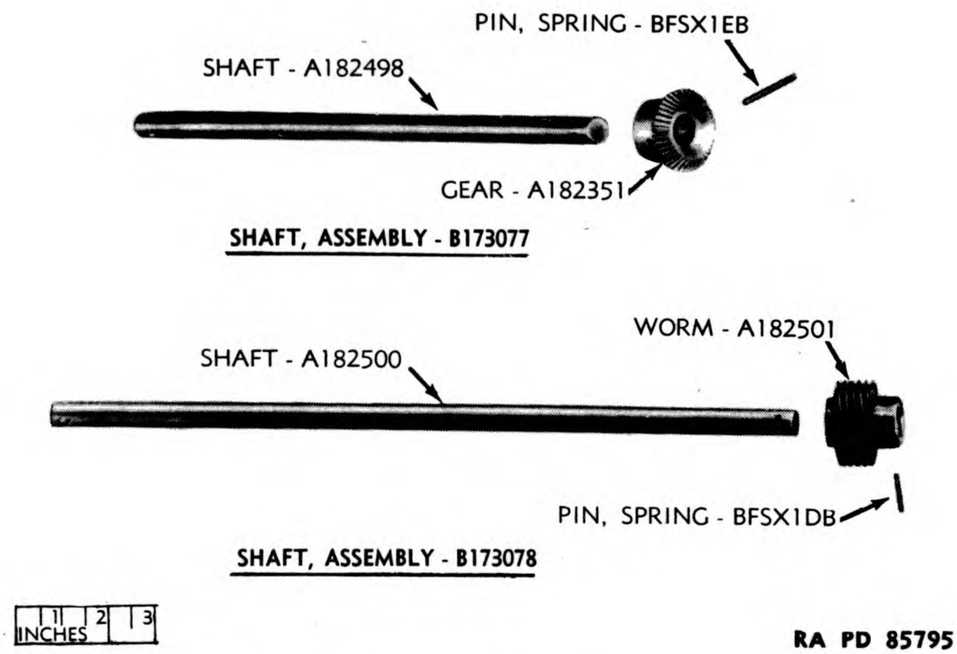

Figure 159 — Shaft Assemblies — Range Mechanism

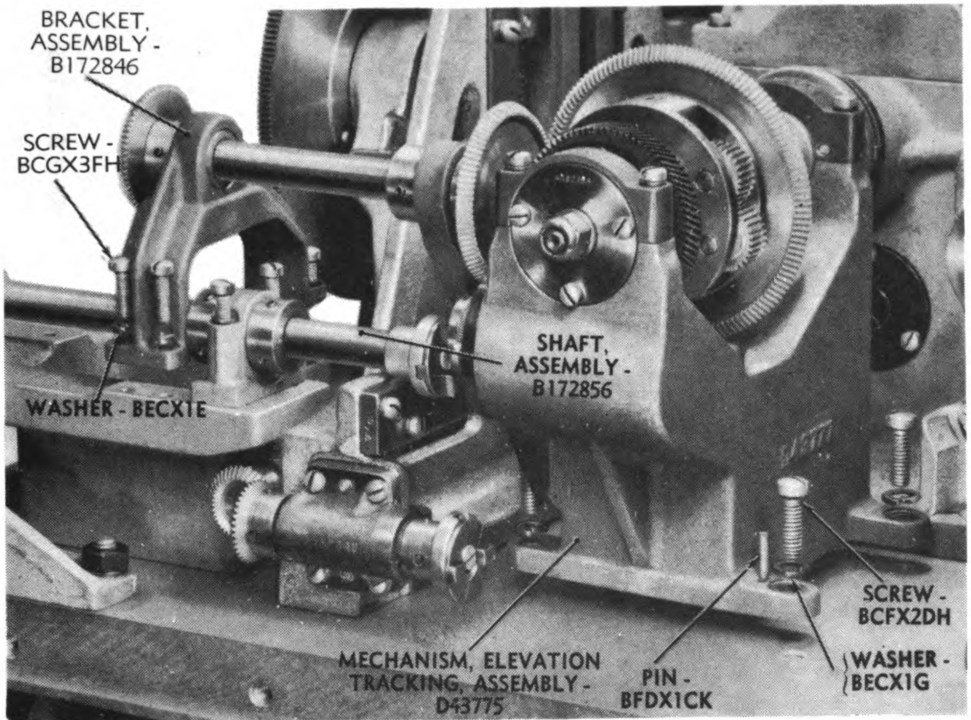

Figure 160 — Removing Elevation Tracking Mechanism (Also See Figure 37)

c. Remove the three screws in the base and lift the casting up off the dowel pins.

81. THE GEAR REDUCTION UNITS (DIRECTOR M5A1).

a. These units can be removed without disturbing any other unit.

b. Loosen the set screw in the input coupling one-half turn and slide the coupling back out of engagement. Turn the output coupling of the gear reduction unit to a vertical position if the tracking mechanism has not been removed. Remove the three screws in the base and lift the unit out.

c. Before replacing, wipe off old or dirty grease and apply new grease to the gears. For ball bearing lubrication, see paragraph 40.

d. Aline the couplings carefully before tightening the screws in the base, particularly the input coupling.

82. TO REMOVE THE DEFLECTION MECHANISMS.

a. The variable-speed or multiplying mechanisms should not be removed independently, but the variable-speed mechanism can be disassembled without removal from the director (par. 83). Extreme care must be used in handling the complete deflection mechanisms to

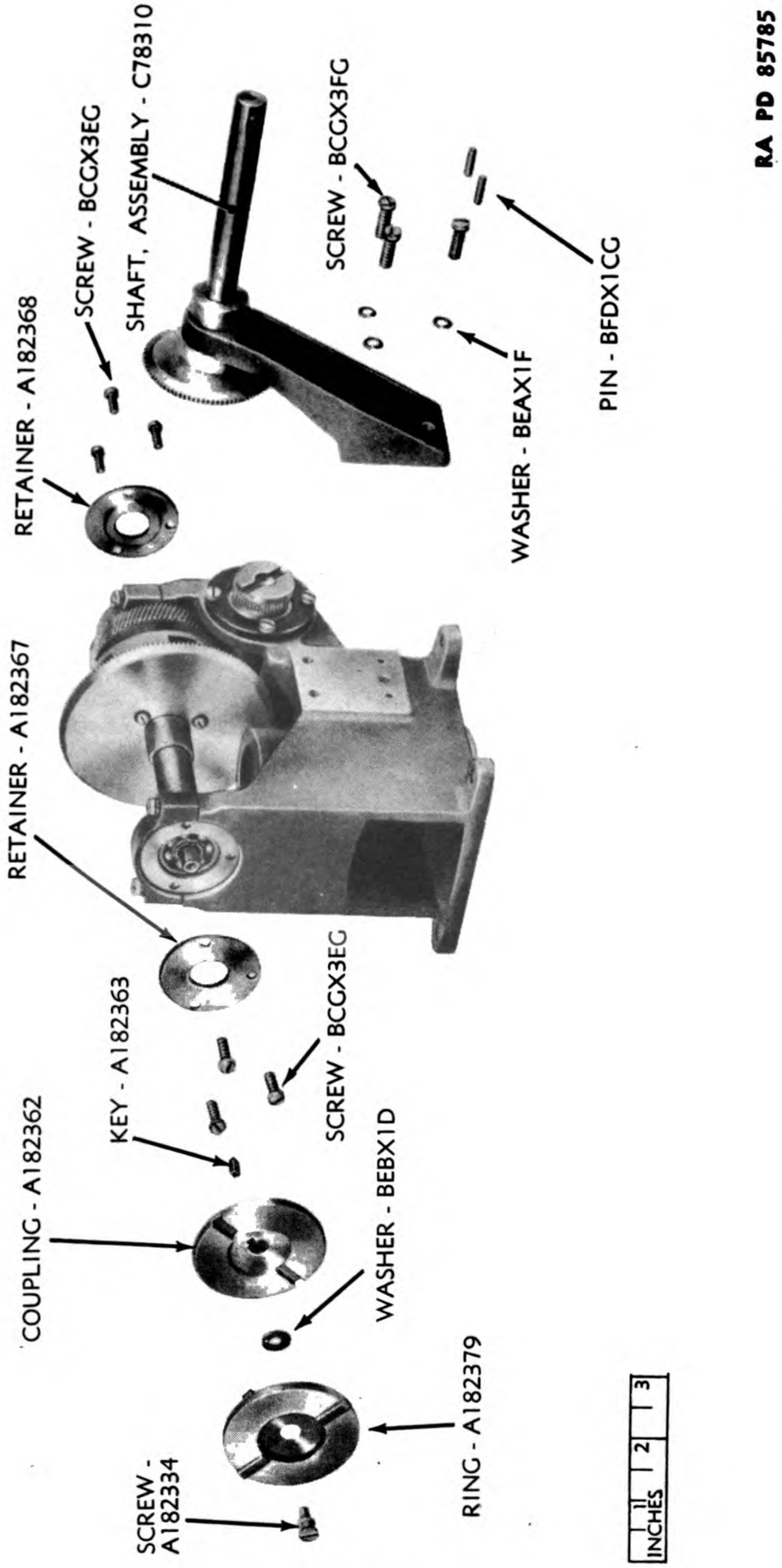

Figure 161 — Elevation Tracking Mechanism D43775 — Partial Disassembly

DISASSEMBLY AND ASSEMBLY

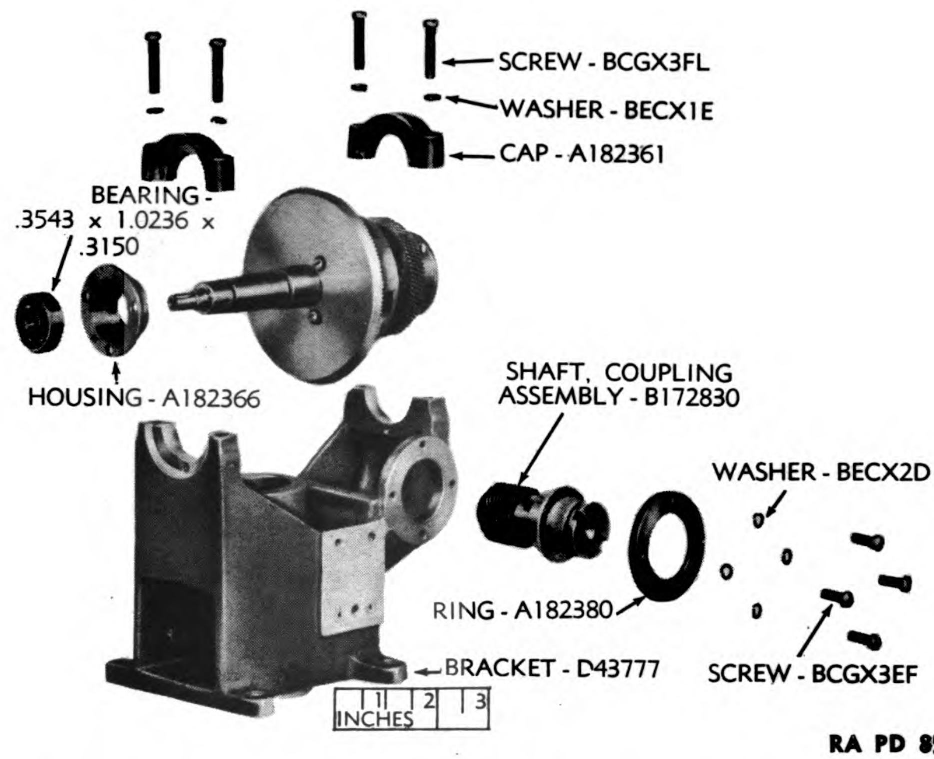

Figure 162 — Elevation Tracking Mechanism — Removal of Shafts

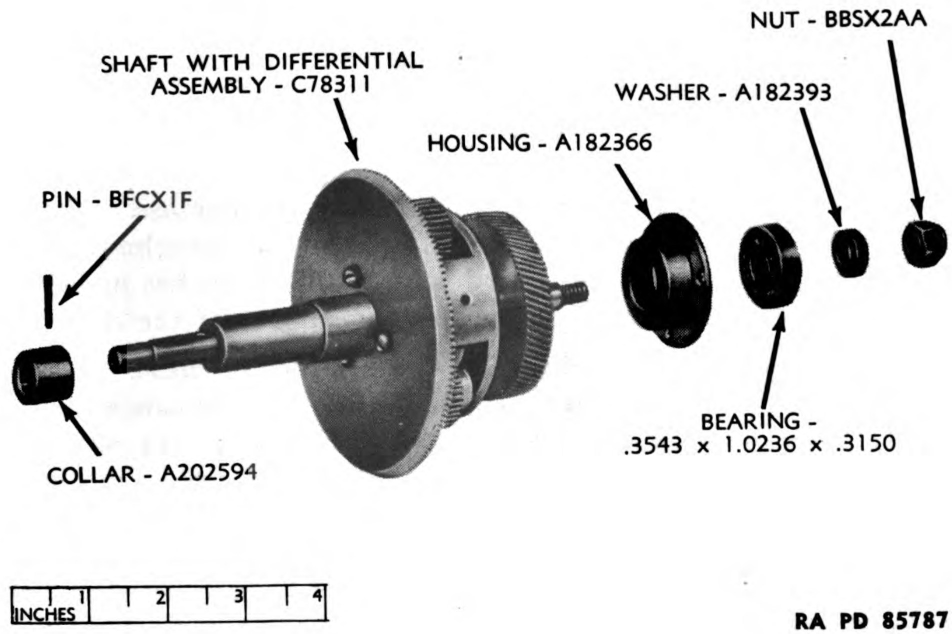

Figure 163 — Elevation Tracking Differential Shaft, Group Assembly

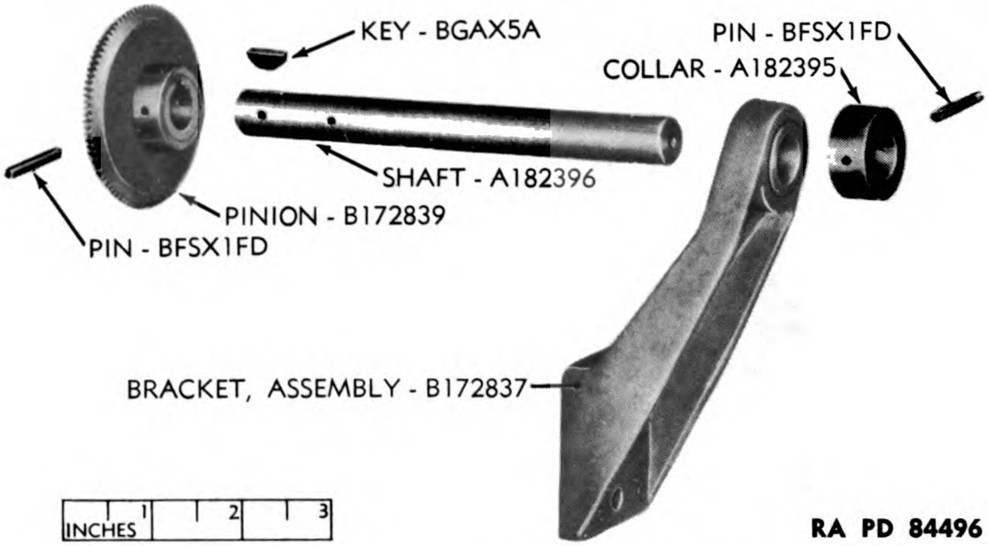

Figure 164 — Shaft Assembly C78310 — Exploded View

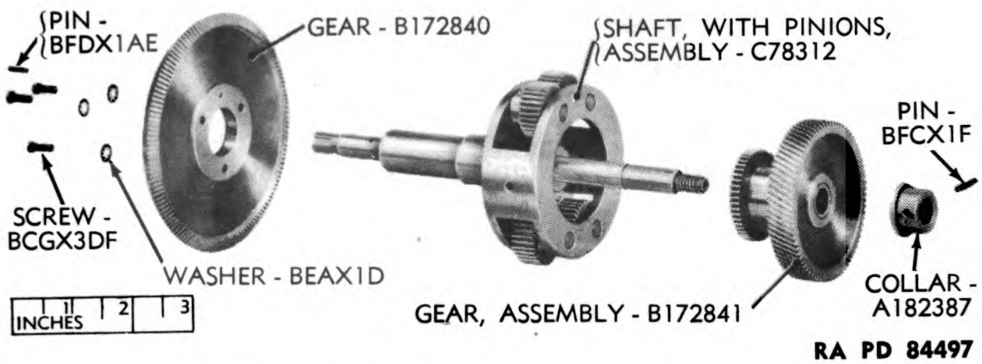

Figure 165 — Shaft With Differential Assembly C78311

avoid bending or distortion which would cause the bar assembly to seize on the long rail, due to the small area of the attachment between the two castings. A flat board 1 by 12 by 30 inches or larger should be provided for handling the mechanism out of the director.

b. Remove all the mechanisms on the azimuth or elevation side of the director (depending on which deflection mechanism is to be removed) with the exception of the constant-speed motor and the worm drive (on Director M5 or M6). If the two bolts in the base of the variable-speed mechanism cannot be loosened with a screwdriver, it will also be necessary to remove the other tracking mechanism. See preceding paragraphs. Remove the transformer bracket from the azimuth side, or the fuse block or brake solenoid from the elevation side. Also on the elevation side, disconnect the superelevation connecting rod at the bottom.

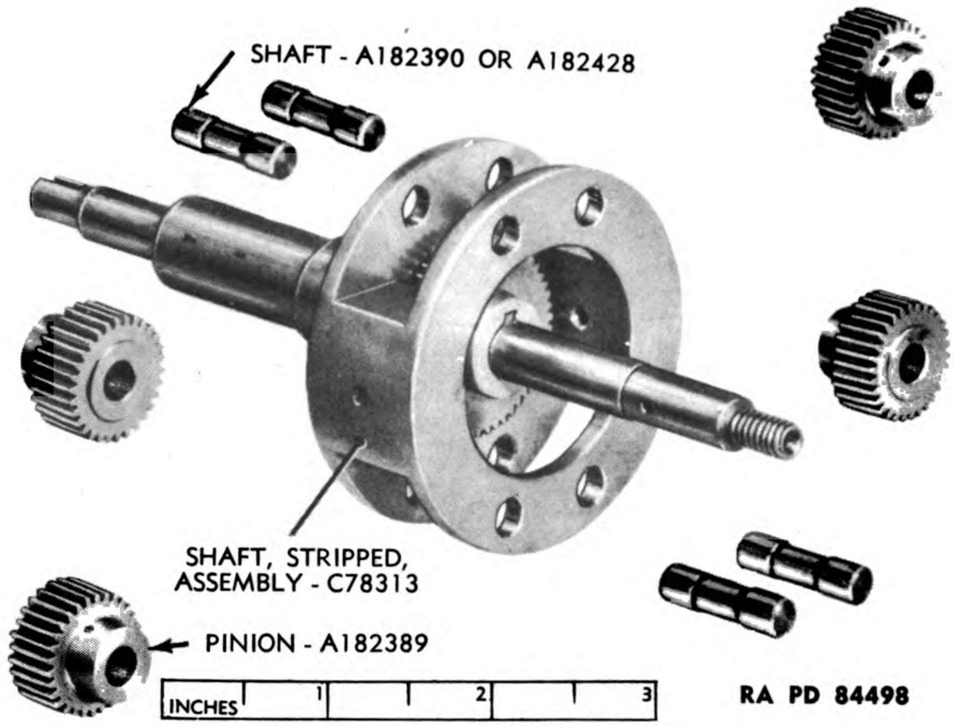

Figure 166 — Differential Shaft With Pinions Assembly C78312 (Pinion Shafts Are Staked in Place)

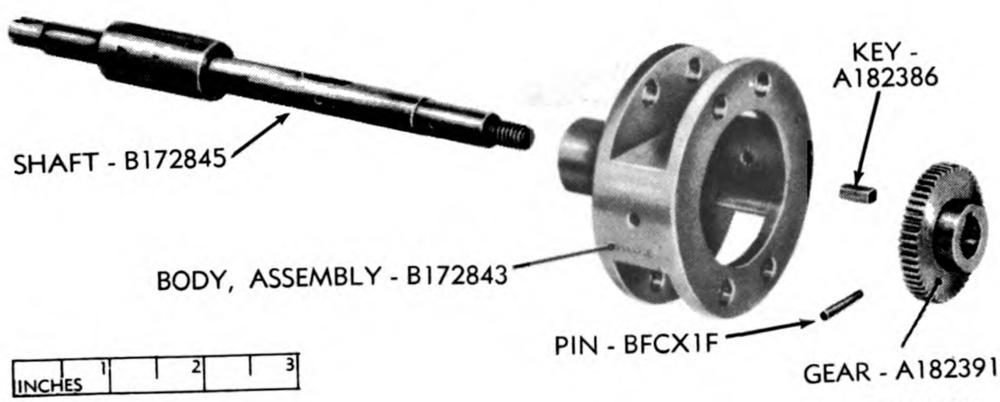

Figure 167 — Differential Shaft, Stripped Assembly C78313

c. Drive out from the bottom the two dowel pins, one in the multiplier base and one in the variable-speed bracket near the motor. Remove the five screws holding the castings to the base. Loosen the six screws that secure the rail. Slide the complete mechanism carefully off the director base onto a flat board held flush with the base, as shown in figure 220. Remove to a flat table. Never lift the mechanism by the ends, but if necessary, lift it by the centers of the

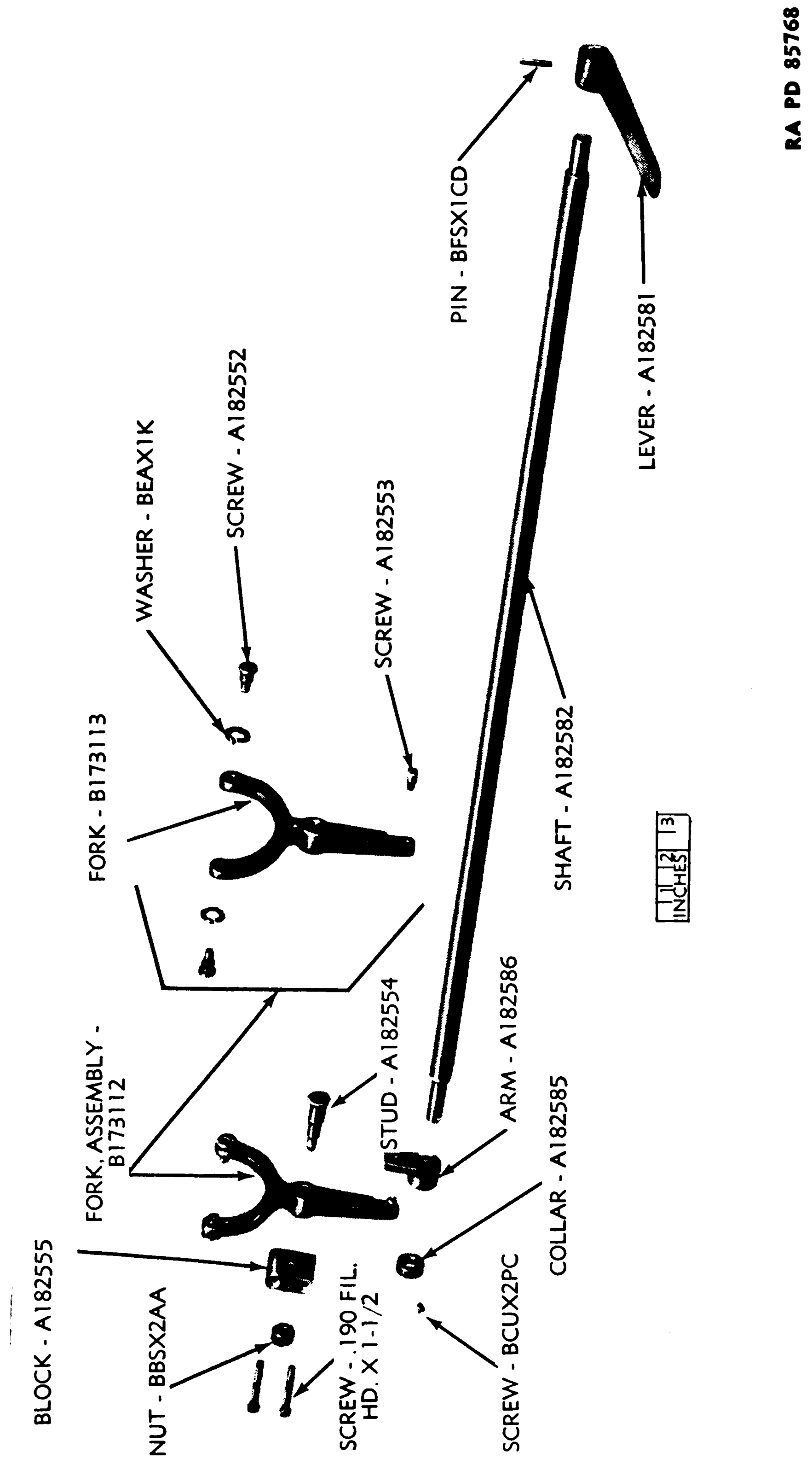

Figure 168 — Azimuth Throw-out Lever (Slewing Clutch) Parts

DISASSEMBLY AND ASSEMBLY

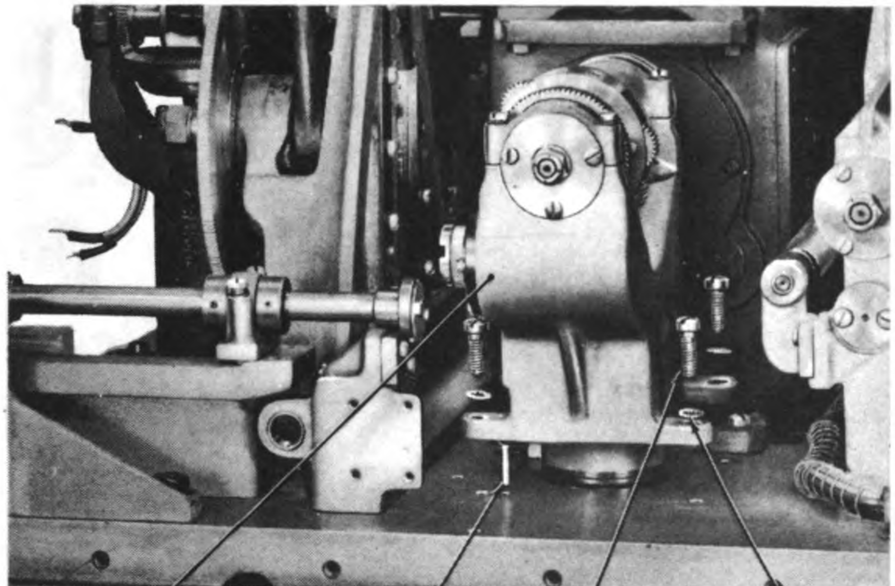

Figure 169 — Removing Azimuth Tracking Mechanism From the Director

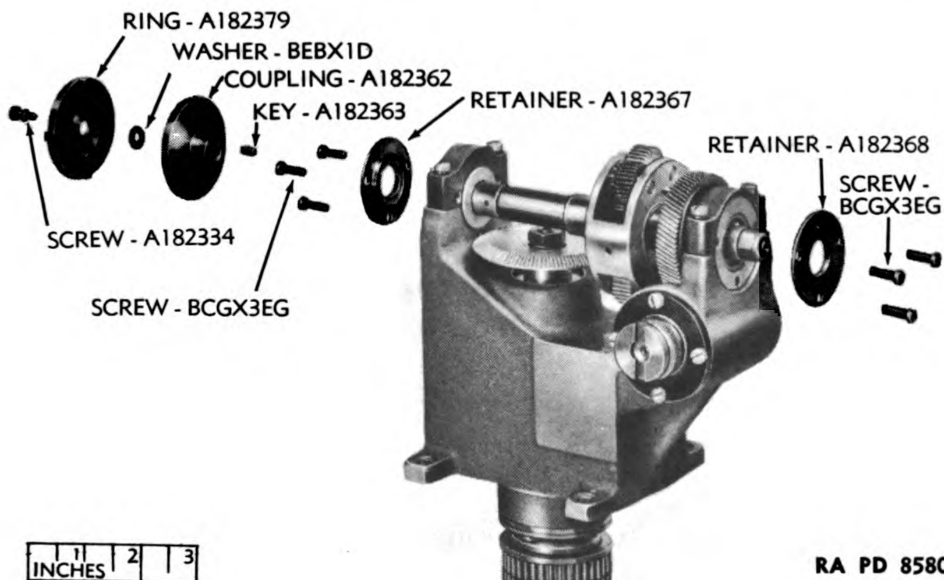

Figure 170 — Azimuth Tracking Mechanism Assembly D43772

two castings. Avoid striking the superelevation eccentric shaft on the vertical deflection mechanism.

d. Replacing. Observe same precautions in handling. Locate on base with dowel pins; then insert five screws. Test bar assembly for free movement.

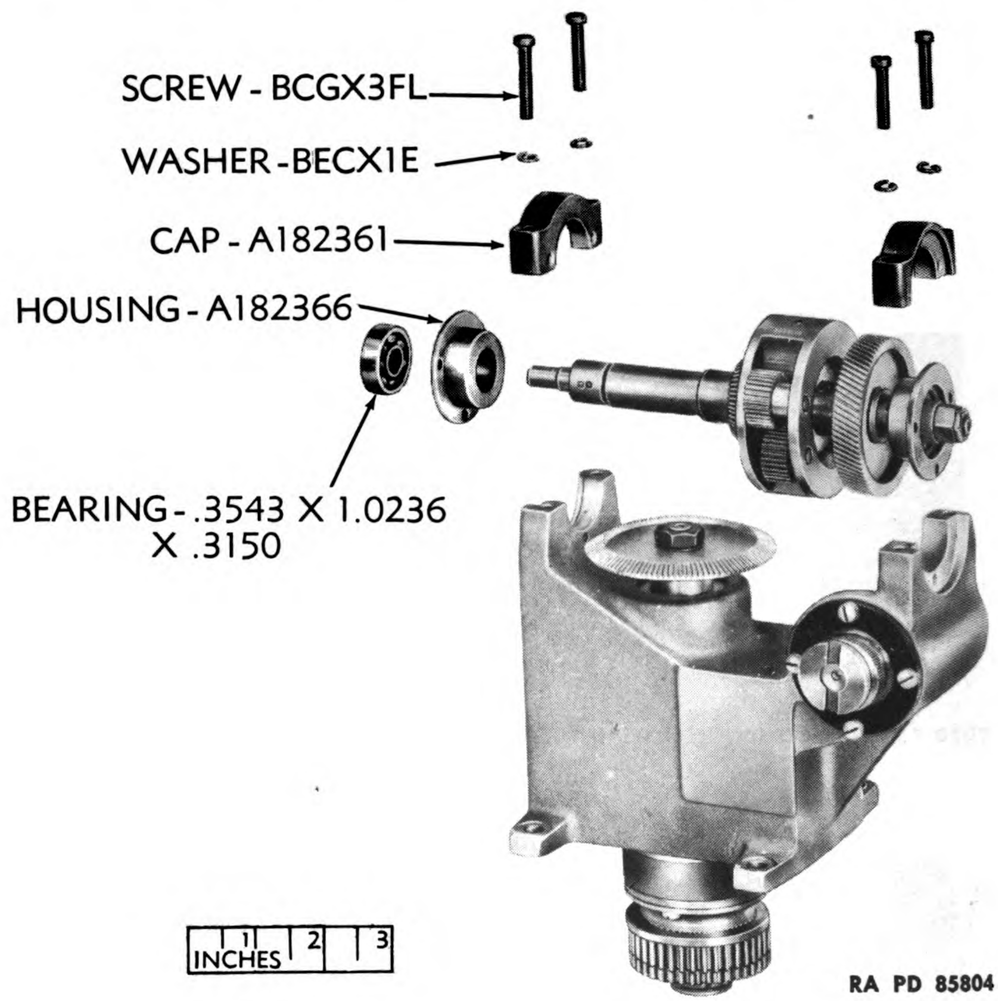

Figure 171 — Azimuth Tracking Mechanism — Removal of Horizontal Shaft Group

83. DISASSEMBLY OF DEFLECTION MECHANISM.

a. It is possible to disassemble the variable-speed mechanism without removing it from the director, after removing the torque amplifiers or the gear reduction units.

b. On the vertical (elevation) deflection mechanism, remove the eccentric shaft assembly (fig. 221 or 222). Note location of any shims.

c. Release the spring at the top of the variable-speed mechanism, first noting the exact position of the tension nut on the screw if a spring scale is not available for resetting tension. ***CAUTION: Be ready to catch the balls which float between the polished roller and disk.***

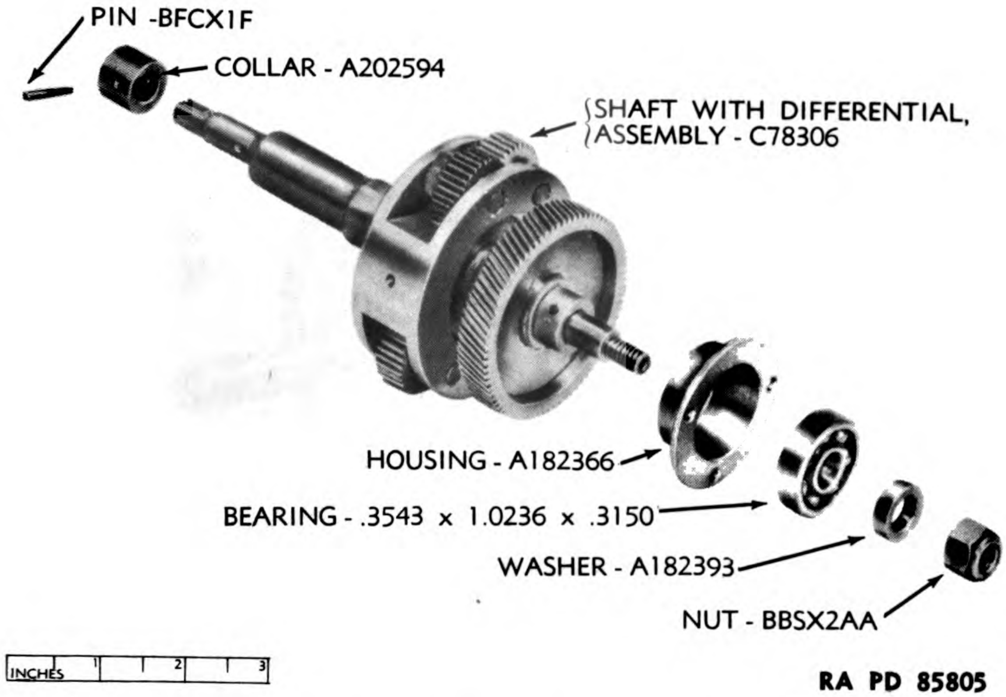

Figure 172 — Removal of Parts From Azimuth Tracking Differential Shaft

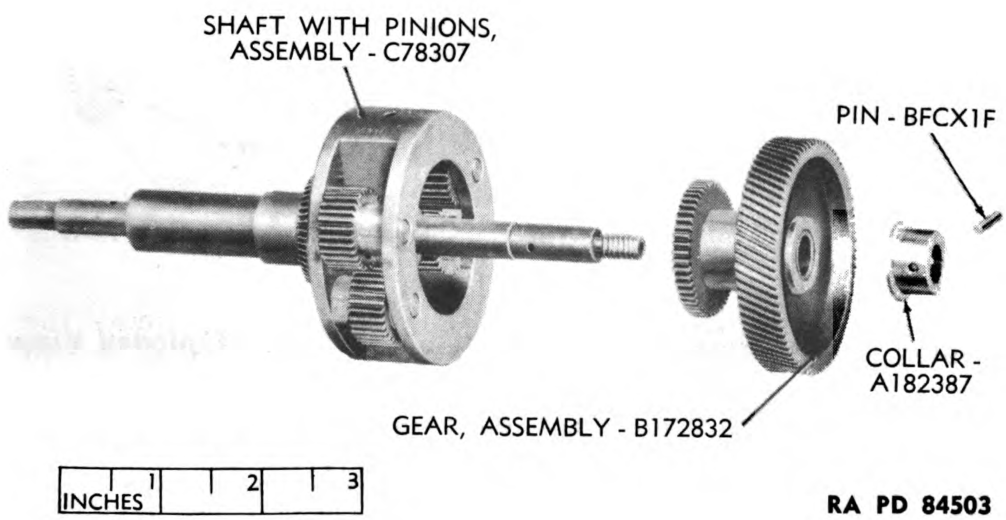

Figure 173 — Shaft With Differential Assembly C78306

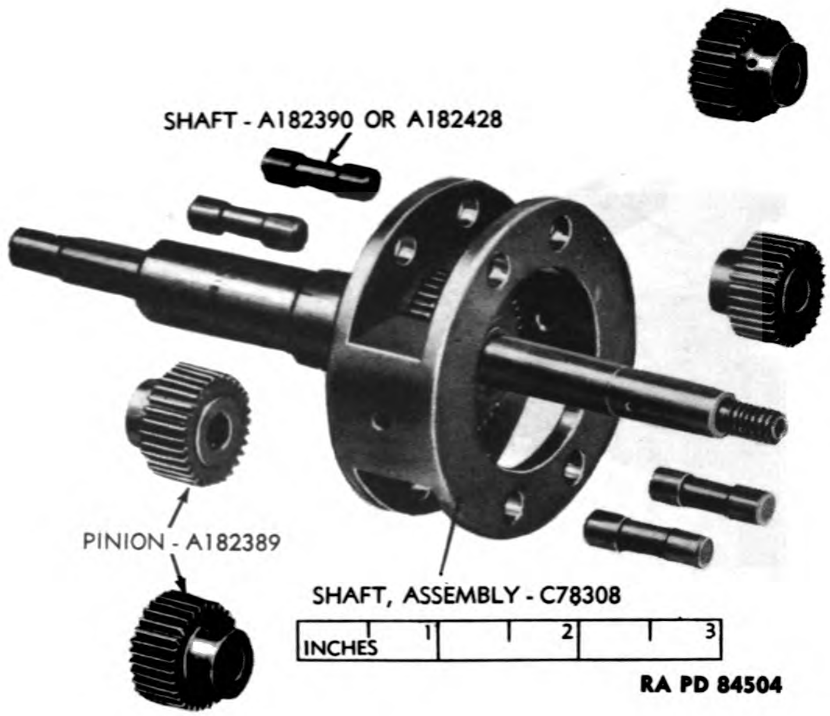

Figure 174 — Shaft With Pinions Assembly C78307 (Pinion Shafts Are Staked in Place)

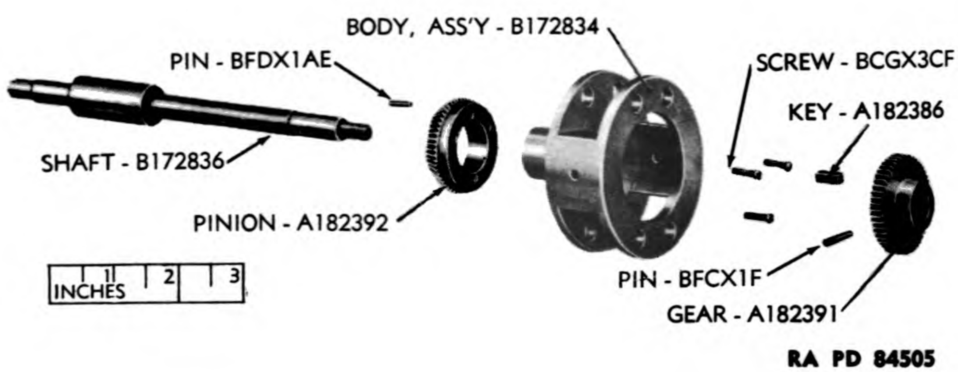

Figure 175 — Differential Shaft Assembly C78308 — Exploded View

d. Remove the trunnions A182339 and take out the rocker assembly (figs. 224 or 225). Remove the flat spring from the azimuth mechanism slider bracket (fig. 226 or 227). Drive out the two center dowel pins and remove the six screws which hold the long rail, and remove the rail with the bar assembly; bring it straight out until the third dowel pin is disengaged; then tilt and lift the assembly

DISASSEMBLY AND ASSEMBLY

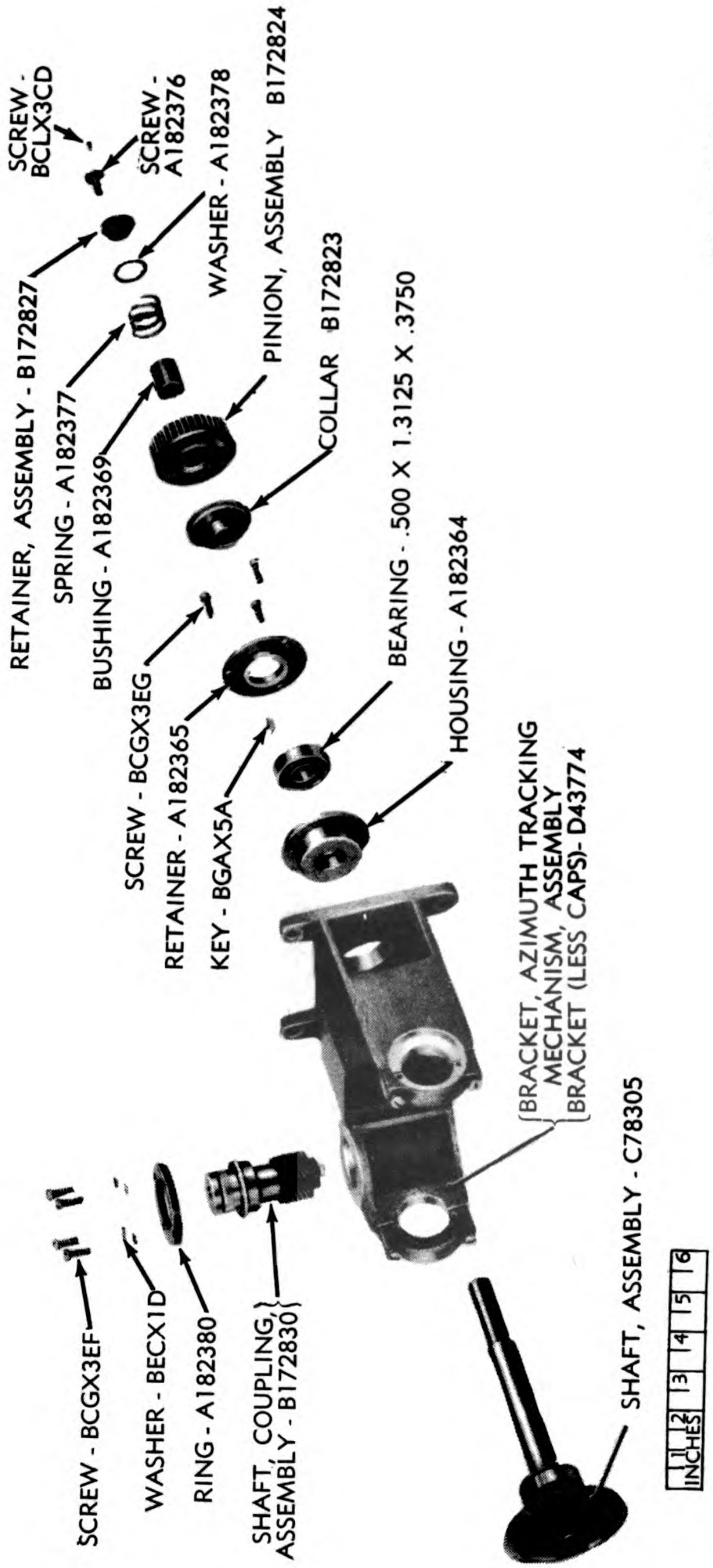

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Figure 176 — Azimuth Tracking Mechanism — Removal of Vertical Shaft and Eccentric Coupling Shaft

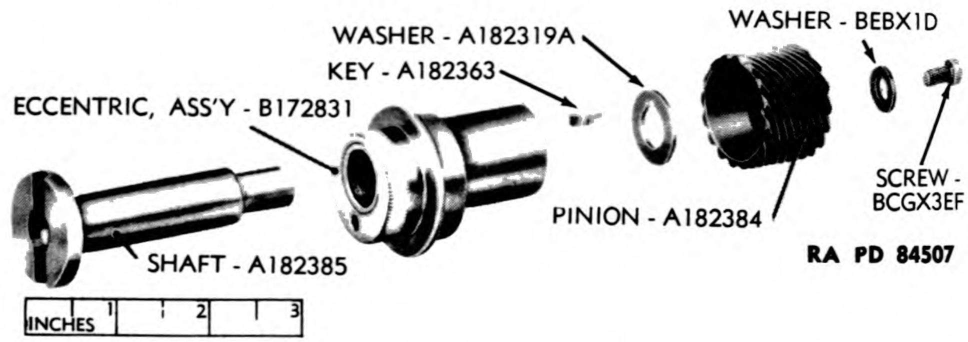


Figure 177 — Coupling Shaft Assembly B172830 — Exploded View

Figure 178 — Retainer Assembly B172827 — Enlarged View

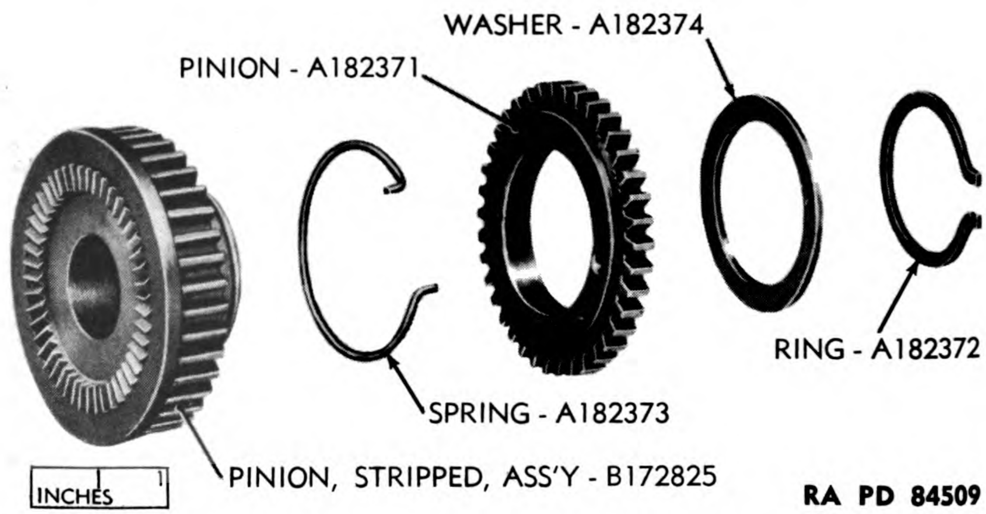


Figure 179 — Antibacklash Pinion Assembly B172824 — Exploded View

(figs. 226 to 229). Handle carefully, laying it on a flat surface. Remove the center bracket and the bar assembly may be slid off the rail (fig. 230). The variable-speed mechanism casting may now be separated from the multiplier by removing the two screws with a long screwdriver (fig. 235 or 236). However, these screws are more accessible after the slider and disk assemblies are removed.

e. Further disassembly is illustrated by figures 237 to 269. Disassembly of bar assembly C78293 for cleaning is not advised, nor complete disassembly of the multiplying mechanism.

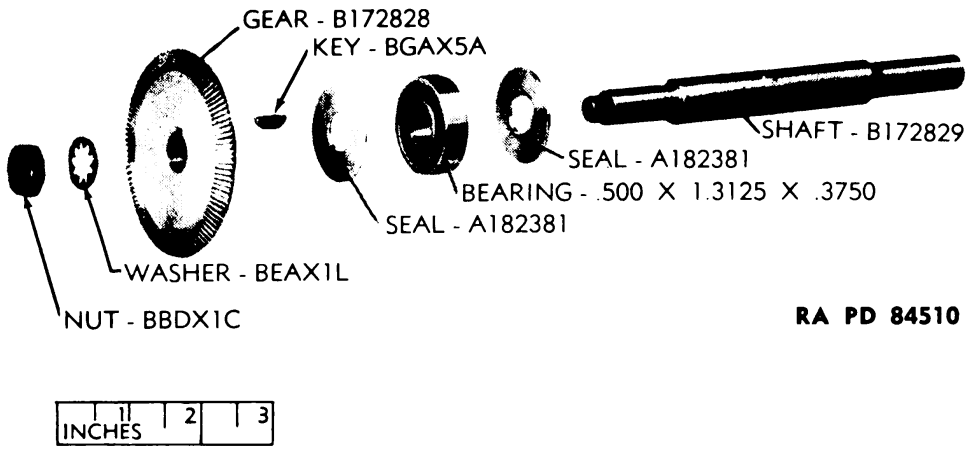


Figure 180 — Vertical Shaft Assembly C78305 — Exploded View

f. Adjustment of Ball Slider (Director M5A1) (fig. 244). Note that the two upper ball bearings and the two on one side are mounted on eccentric studs so that they can be brought closer to or further from the large balls. If these studs are removed or if the balls should be replaced, adjust each eccentric bearing as follows:

(1) First fasten the bearings which do not have eccentric studs.

(2) Turn each eccentric stud until the ball is just tight between the two opposite bearings.

(3) Then back off the eccentric stud about one-eighth turn or until the ball has about 0.0005-inch clearance between the bearings. Tighten the clamping screw on the eccentric stud.

g. Assembly. Do not interchange azimuth and elevation units. Carefully clean and oil the rail and bar assembly. See that the bar assembly slides freely on the rail after attaching to the mechanism. Leave the two screws at the center of the rail loose until after the center bracket A182305 has been pinned. Check spring tension on variable-speed mechanism as instructed in paragraph 29, or turn tension nut to its original position.

84. THE TELESCOPE SHAFT ASSEMBLY (figs. 45, 87 to 92, and 293).

a. If the quadrant elevation mechanism is not to be removed, mark one of the teeth of the segment and both mating gears for reengagement.

b. Disconnect superelevation connecting rod (fig. 270) and open sight link. Remove tops of side frames and screws holding the housings of the azimuth and elevation flange assemblies. Note position of any

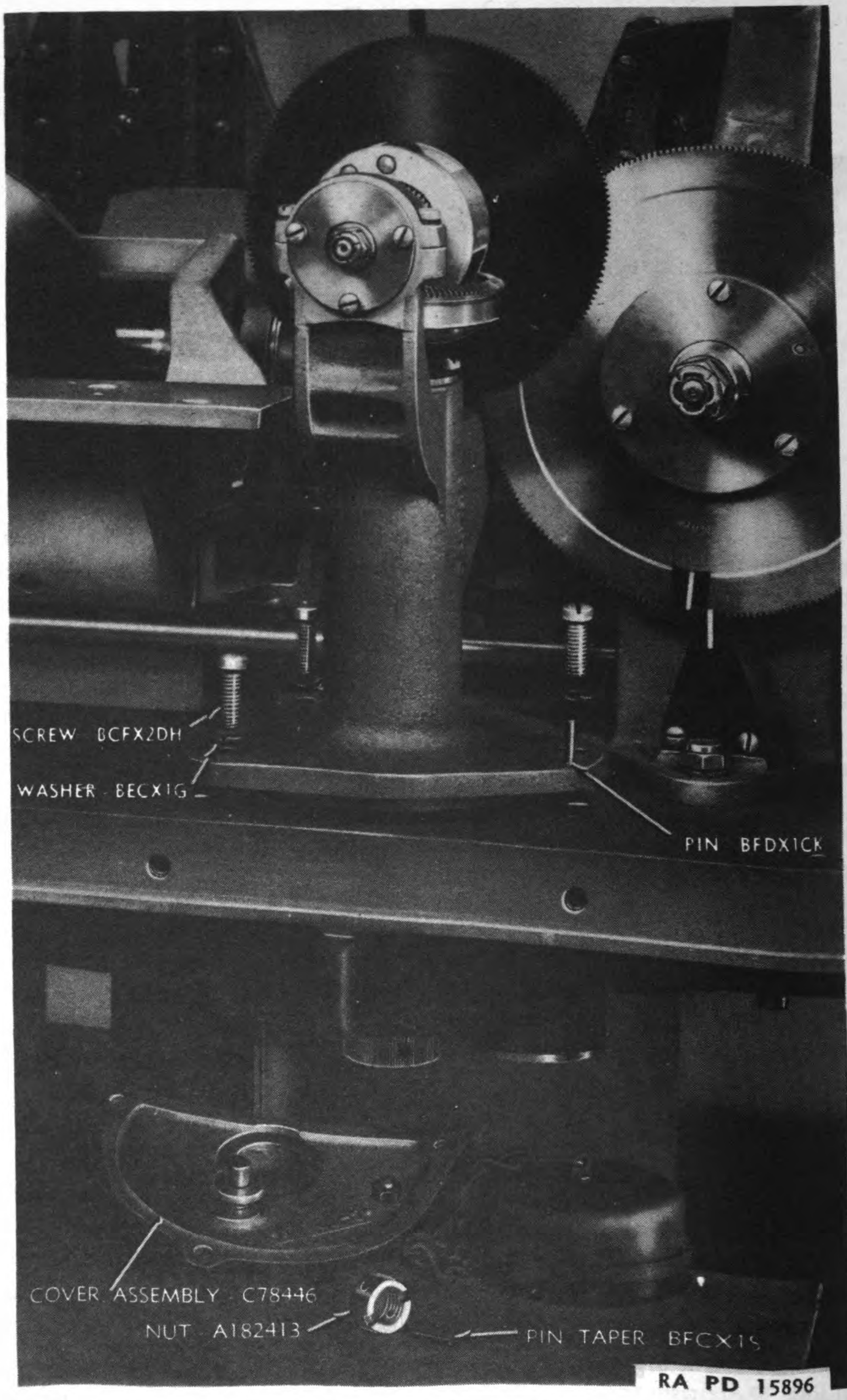


Figure 181 — Removing Future Azimuth Mechanism From Director

DISASSEMBLY AND ASSEMBLY

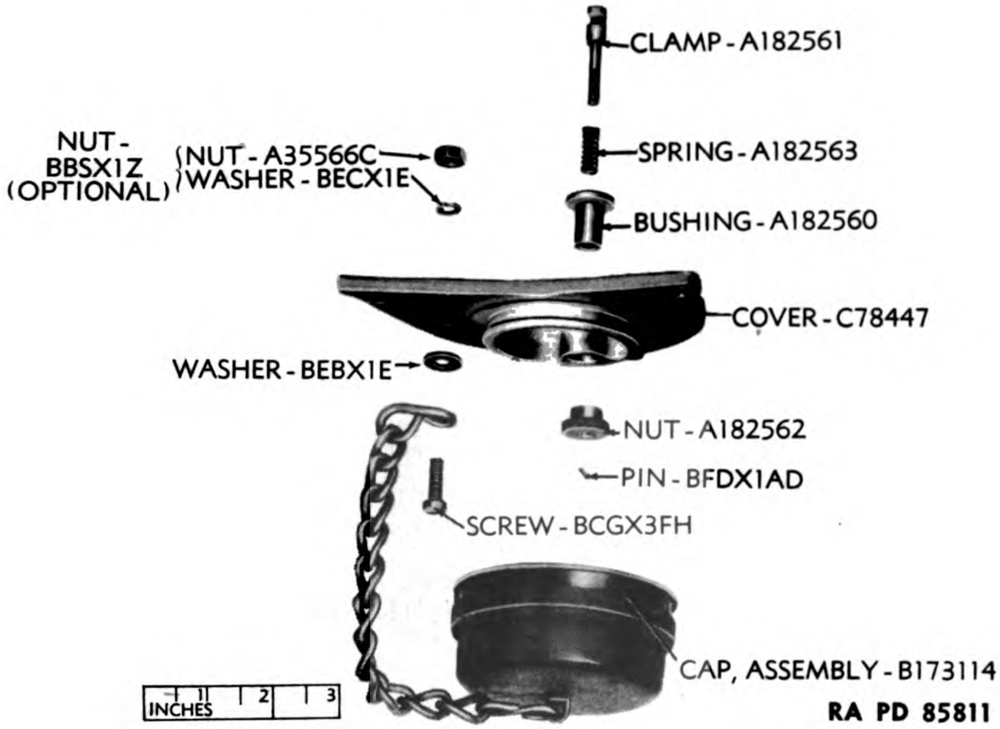


Figure 182 — Future Azimuth Mechanism Assembly C78446

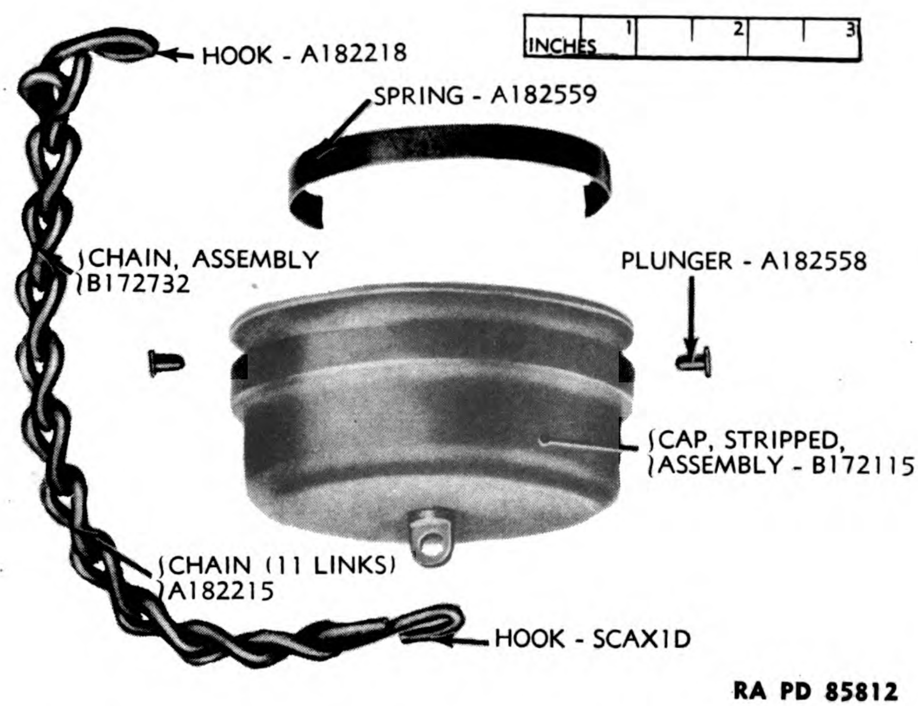


Figure 183 — Cap Assembly B173114 — Exploded View

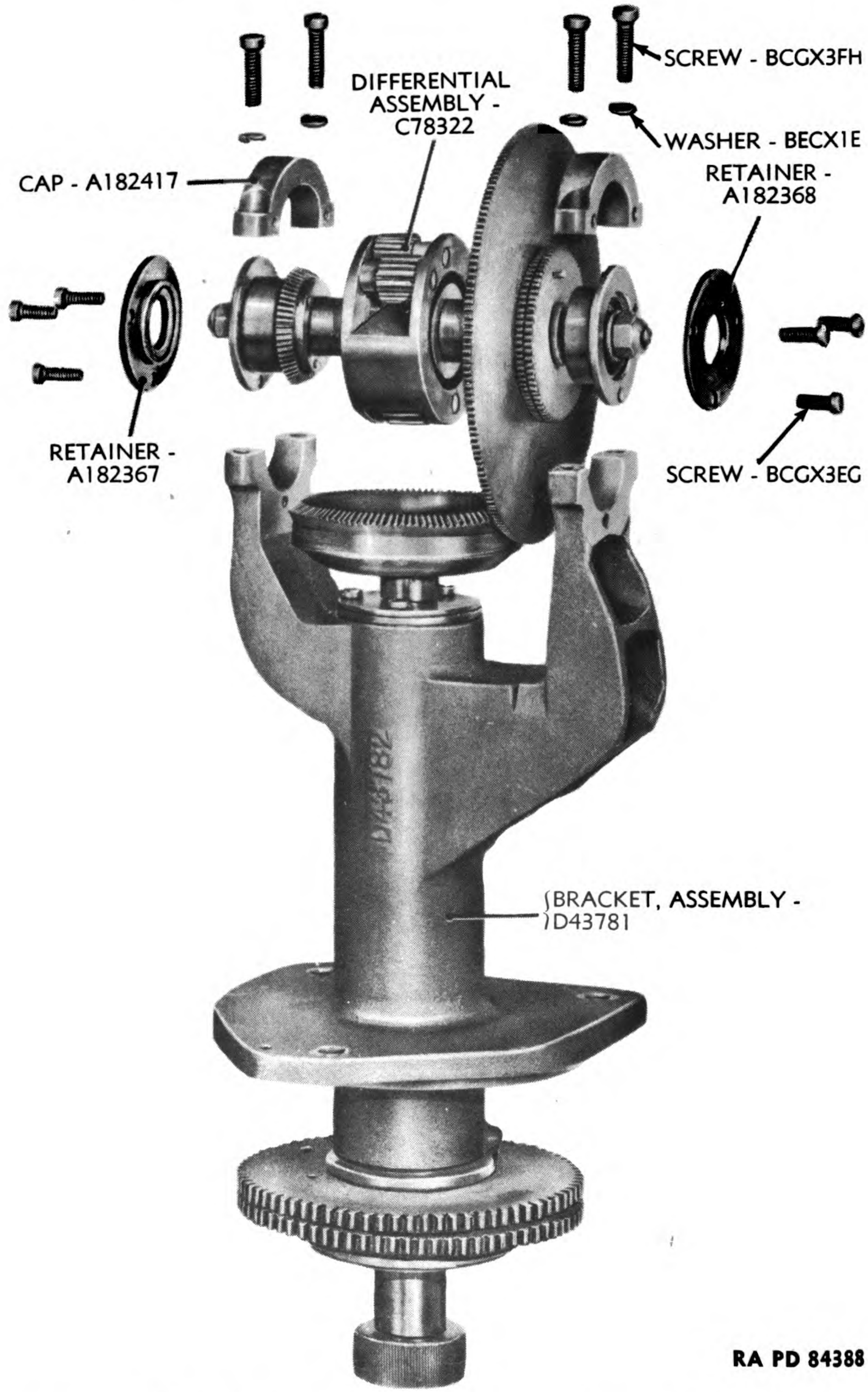


Figure 184 — Future Azimuth Mechanism Assembly D43780

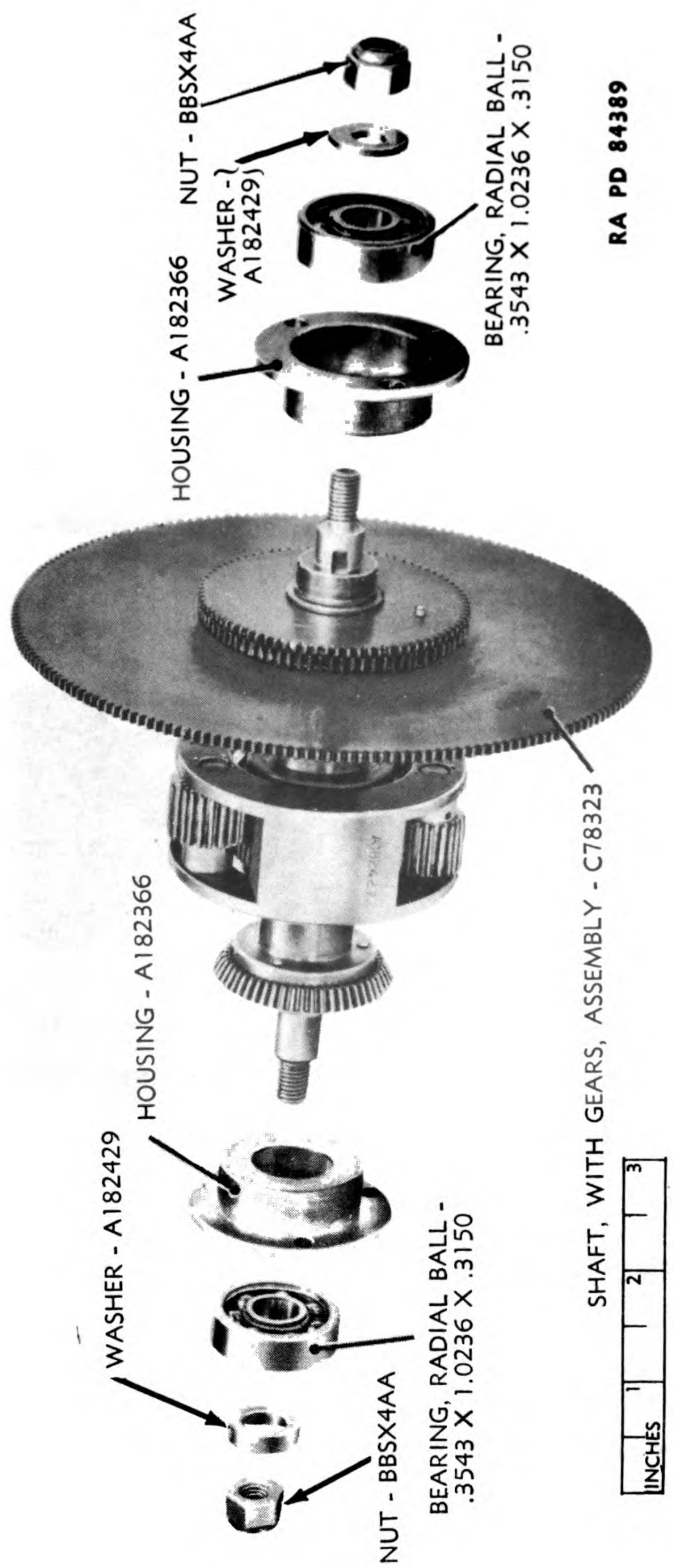


Figure 185 — Removing Parts From Future Azimuth Differential Shaft

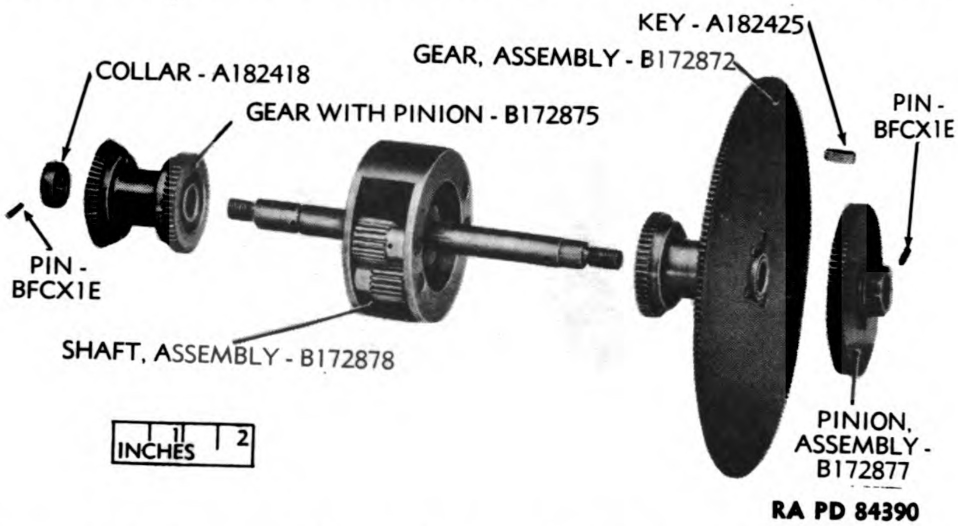


Figure 186 — Future Azimuth Mechanism Differential — Shaft With Gears Assembly C78323 — Exploded View

Figure 187 — Gear With Pinion B172875 — Component Parts

shims. Hold antibacklash gears on quadrant elevation mechanism when segment is disengaged.

c. **Assembly.** Coat frame parts with grease to provide a seal before replacing. See paragraph 55 for engagement of segment. Engage marked teeth. Check telescope setting as in paragraph 28.

85. DISASSEMBLY OF TORQUE AMPLIFIER (DIRECTORS M5 AND M6).

a. For inspection or minor adjustments of bands, start with subparagraph j, below.

b. **Large Cover Plate Assembly.** Remove the screws holding the cover plate assembly to the casting. One of these screws may have a

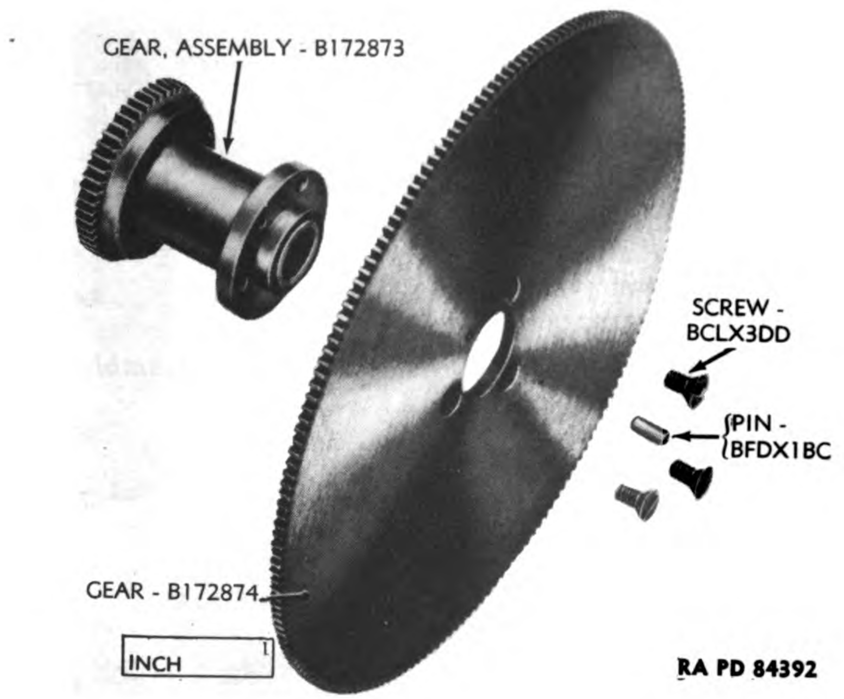


Figure 188 — Gear Assembly B172872 — Component Parts

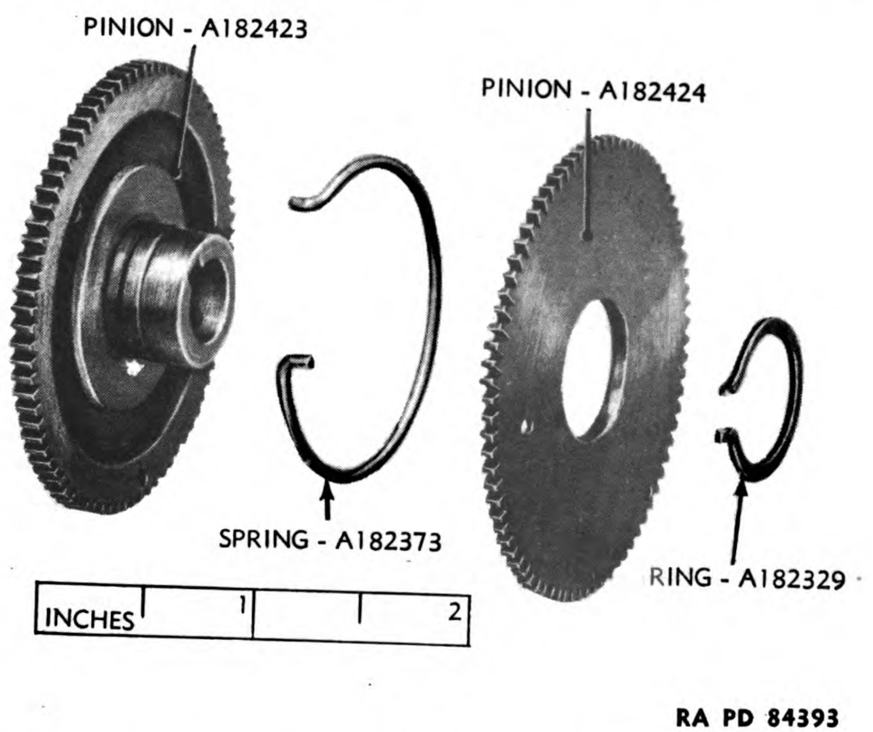


Figure 189 — Antibacklash Pinion Assembly B172877 — Exploded View

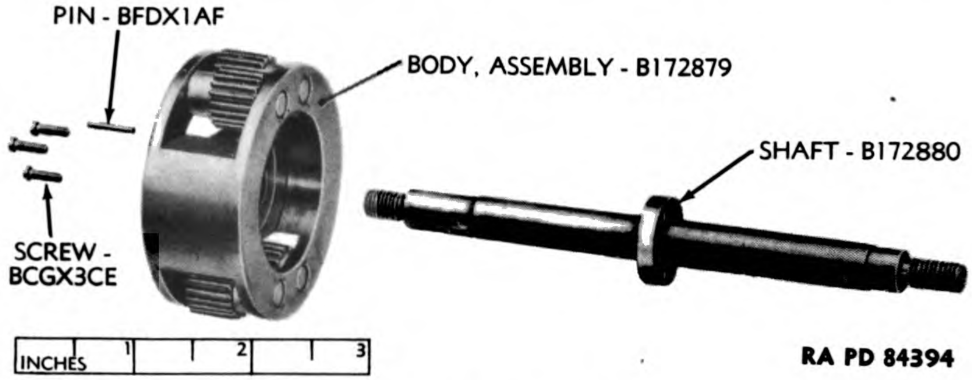


Figure 190 — Components of Differential Shaft Assembly B172878

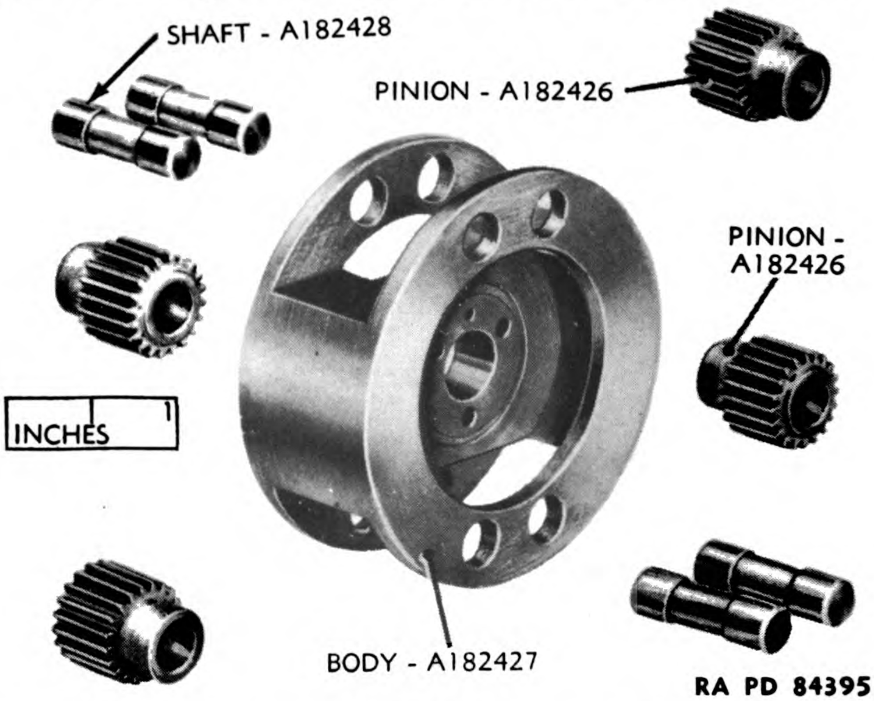


Figure 191 — Body Assembly B172879 (Pinion Shafts Are Staked in Place) — Exploded View

lead seal over it and this should be removed first. Three screws, two in the upper right-hand corner and one in the lower left-hand corner of the cover plate, hold the grease channel to the cover plate and need not be removed (fig. 272). When removing the cover plate assembly, do not damage the gasket.

c. Motor (fig. 274). Remove the two bolts which hold the torque amplifier motor to the casting. Slide the motor directly to the rear. It may be necessary to turn the vertical shaft of the housing assembly a slight amount as the motor is pulled out, in order to disengage the two spiral gears.

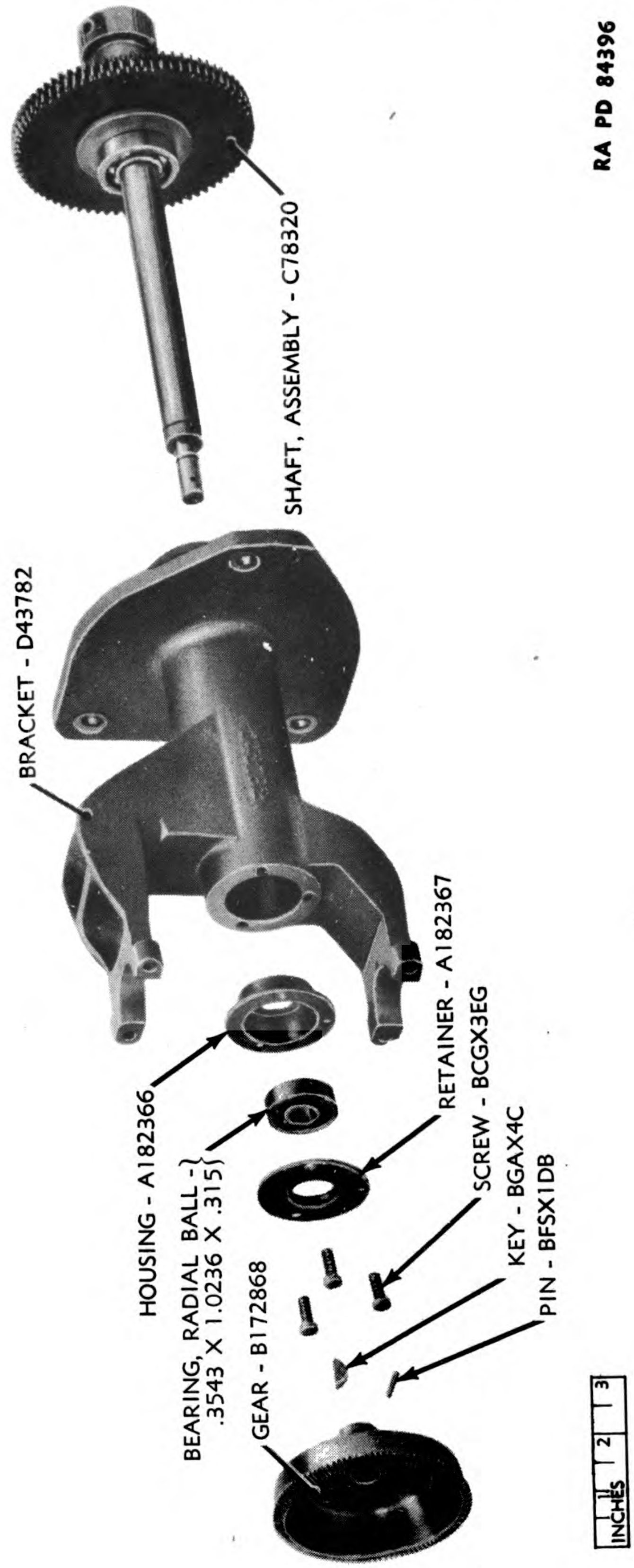


Figure 192 — Future Azimuth Mechanism — Removal of Vertical Shaft

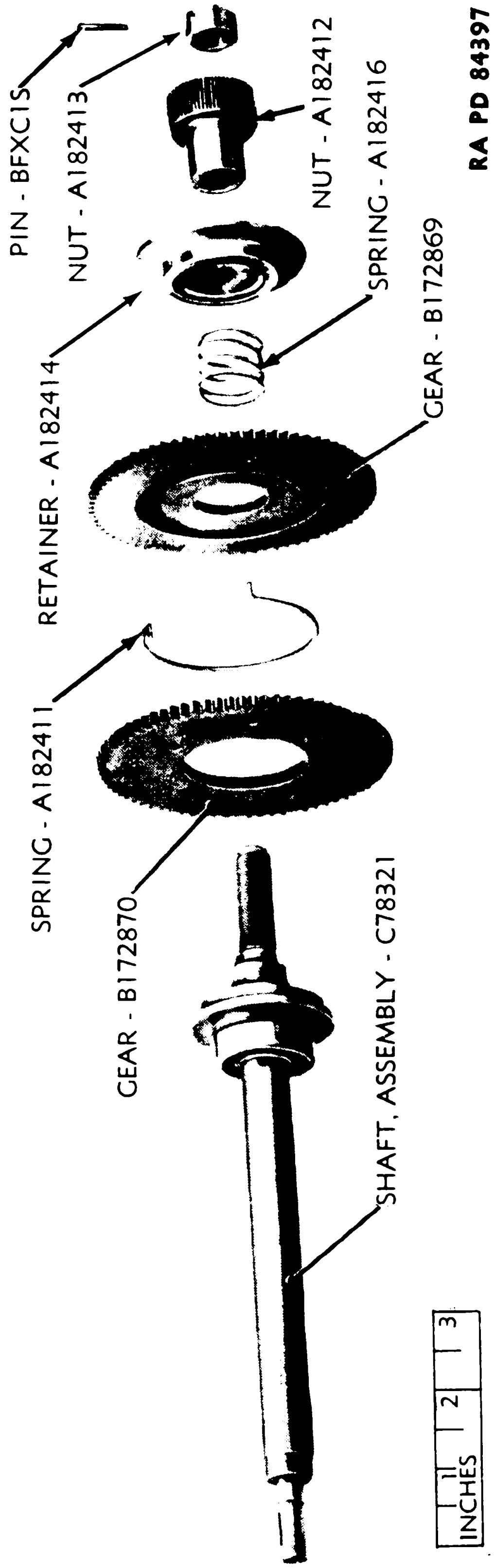


Figure 193 — Future Azimuth Mechanism Shaft Assembly C78320 — Exploded View

Figure 194 — Parts of Shaft Assembly C78321

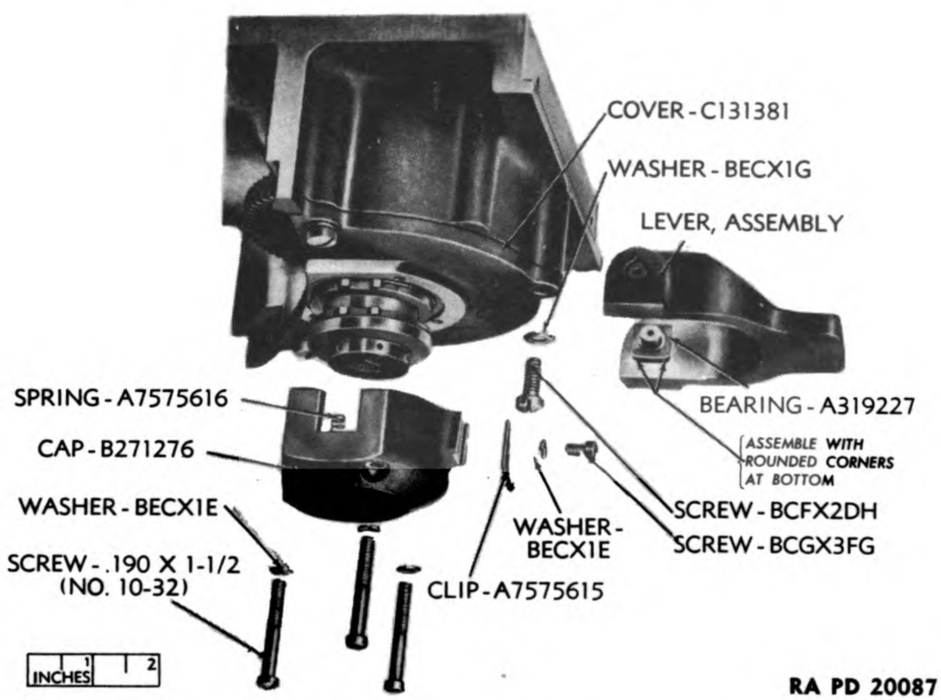


Figure 195 — New Orienting Clutch Parts Removed Preparatory to Removal of Future Azimuth Mechanism

d. **Input Shaft Assembly** (fig. 273). Remove the four screws holding the input shaft assembly in place, being careful not to lose the four separators or the rubber gasket. Remove the input shaft assembly.

e. **Gear Guard** (fig. 273). Remove the two screws holding the guard. Remove guard by rotating it counterclockwise, end for end, and lifting it out. Do not lose the two separators.

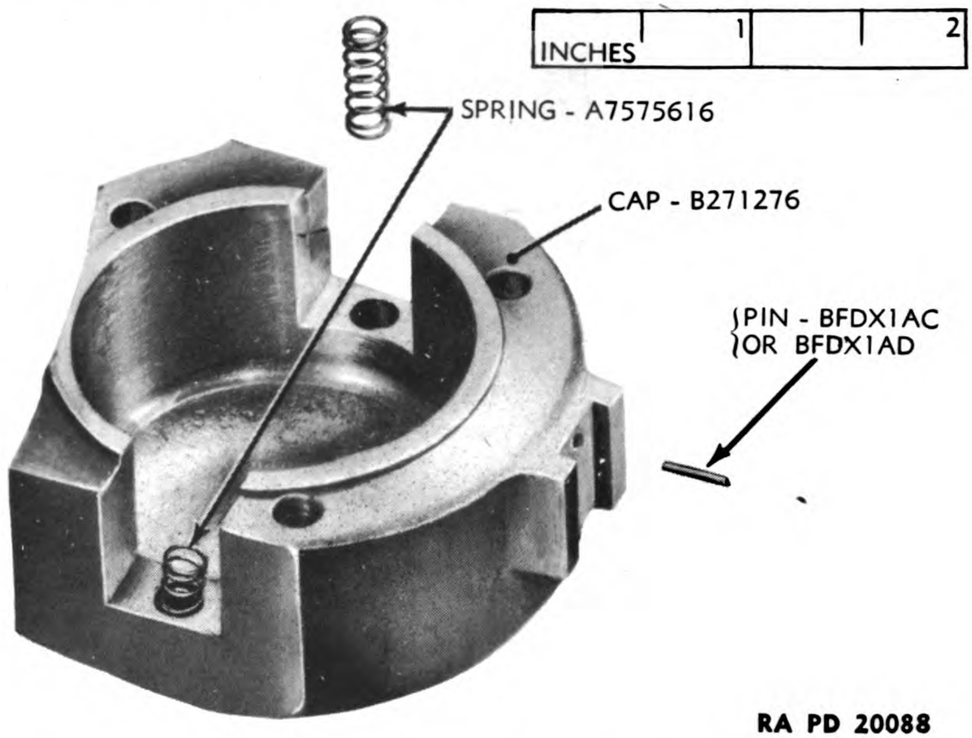


Figure 196 — Showing Cushion Springs on Which Bearings Rest

f. **Spiral Gear** (fig. 274). Remove the three screws holding the spiral gear on the lower shaft. The gear may now be removed by pulling it straight to the front. It may be necessary to use the adjustable gear puller shown in figure 81.

g. **Housing Assembly** (fig. 276). Remove the two short screws and the two long screws which hold the housing assembly to the casting. If the assembly is pinned, drive out the upper tapered dowel pin. Shift the housing assembly from side to side, working it loose and pulling it forward at the same time.

h. **Small Cover Plate.** Remove all screws from the cover plate. One of the screws may have a lead seal over it which should be removed first. Remove cover plate. When removing the cover, do not damage the gasket.

i. **Nomenclature of the Torque Amplifier.** Turn the torque amplifier so that the small cover plate side is toward the operator, and note the following nomenclature: The carbon ring on the right is part of the input drum assembly; and the carbon ring on the left is part of the output drum assembly. The two assemblies are not connected except by the bands which are clamped to the torque arms. The longer arm, having one screw at each end, is the input torque arm and is part of the input drum assembly. The shorter arm, having two

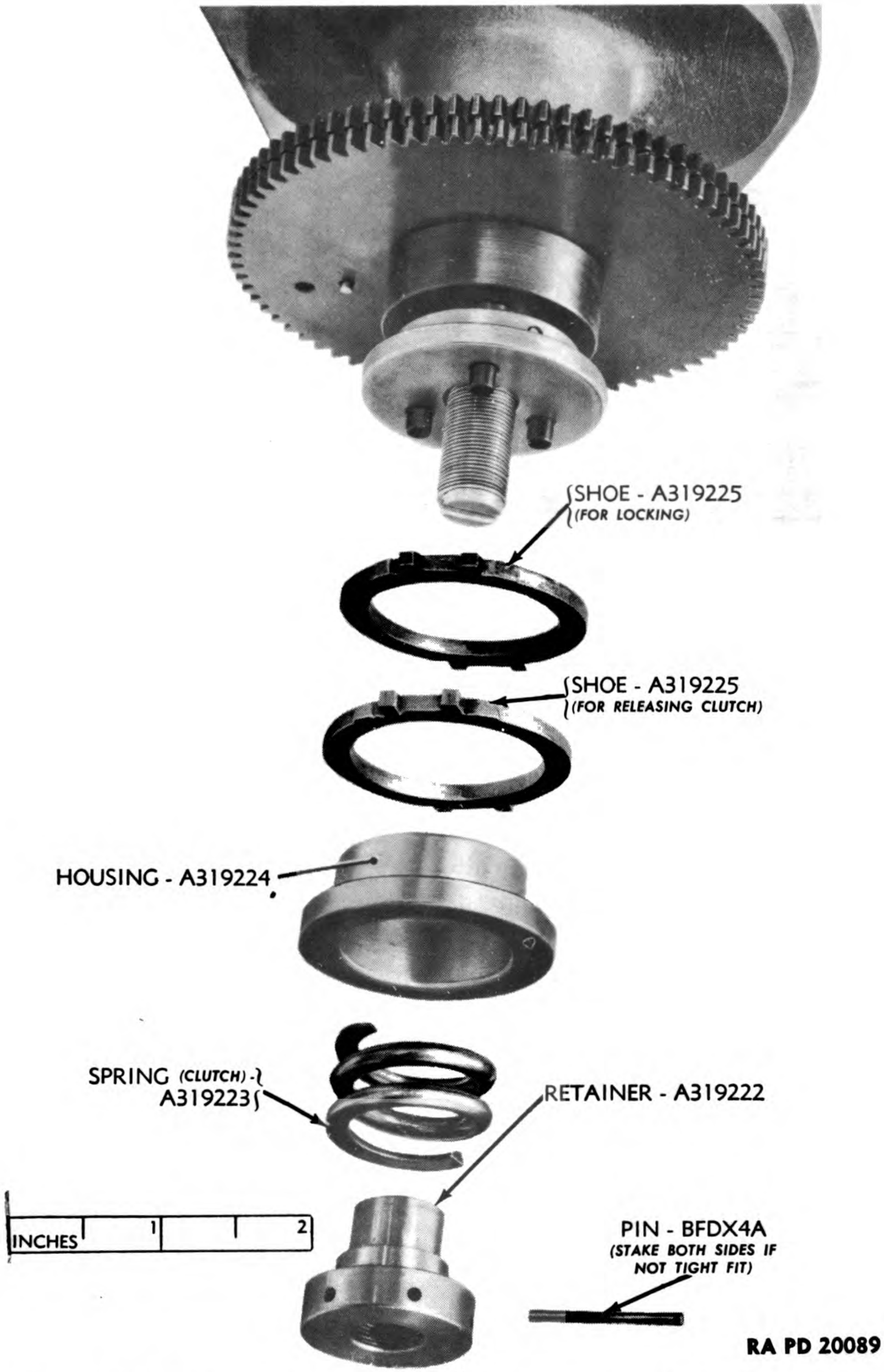


Figure 197 — New Orienting Clutch — Removal of Clutch Spring, and Circular Shoes Which Release Spring Pressure and Lock the Mechanism

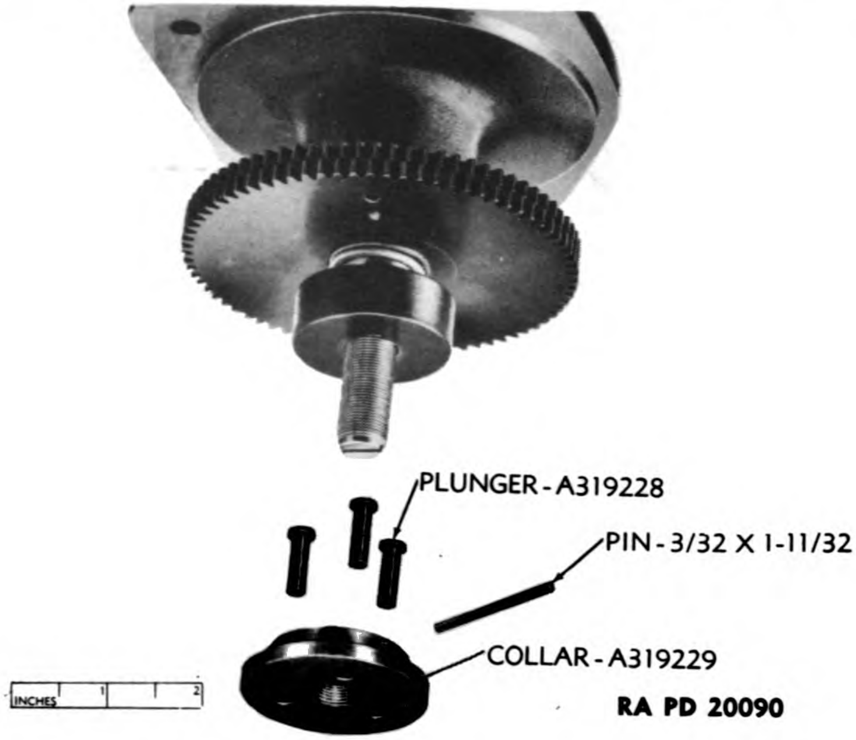


Figure 198 — New Orienting Clutch — Removal of Locking Collar, and Plungers Which Transmit Clutch Spring Pressure to Clamp Gear to Hub

screws at each end, is the output torque arm and is part of the output drum assembly. Although the two carbon rings are part of the so-called input and output drum assemblies, they are independently driven by the motor and both have the same function. One band is wound around each of the carbon rings, and the direction of the input determines which of the bands shall transmit torque to the output arm (par. 11 i). The small solder drops on the bands serve to keep adjacent turns from piling up on each other.

j. **Bands.** Remove all grease and moisture from the hands. Before loosening either band, the two torque arms must be secured in position to keep the bands from unwrapping and tangling. Use the special tool A400155 (fig. 81) or the easily made clip shown in figures 277 and 278. If neither of the special tools is available, wrap a strip of masking tape, about ½ by 12 inches, between the torque arms, to hold them in relative position while removing the bands.

(1) Turn the input (longer) torque arm until it is facing the operator. Place the left index finger on the solder drop furthest to the right, just above the input torque arm. This is to prevent the band from unwinding when the clamp is loosened. Use a screwdriver of the correct size to loosen the screw on the right end of the input torque

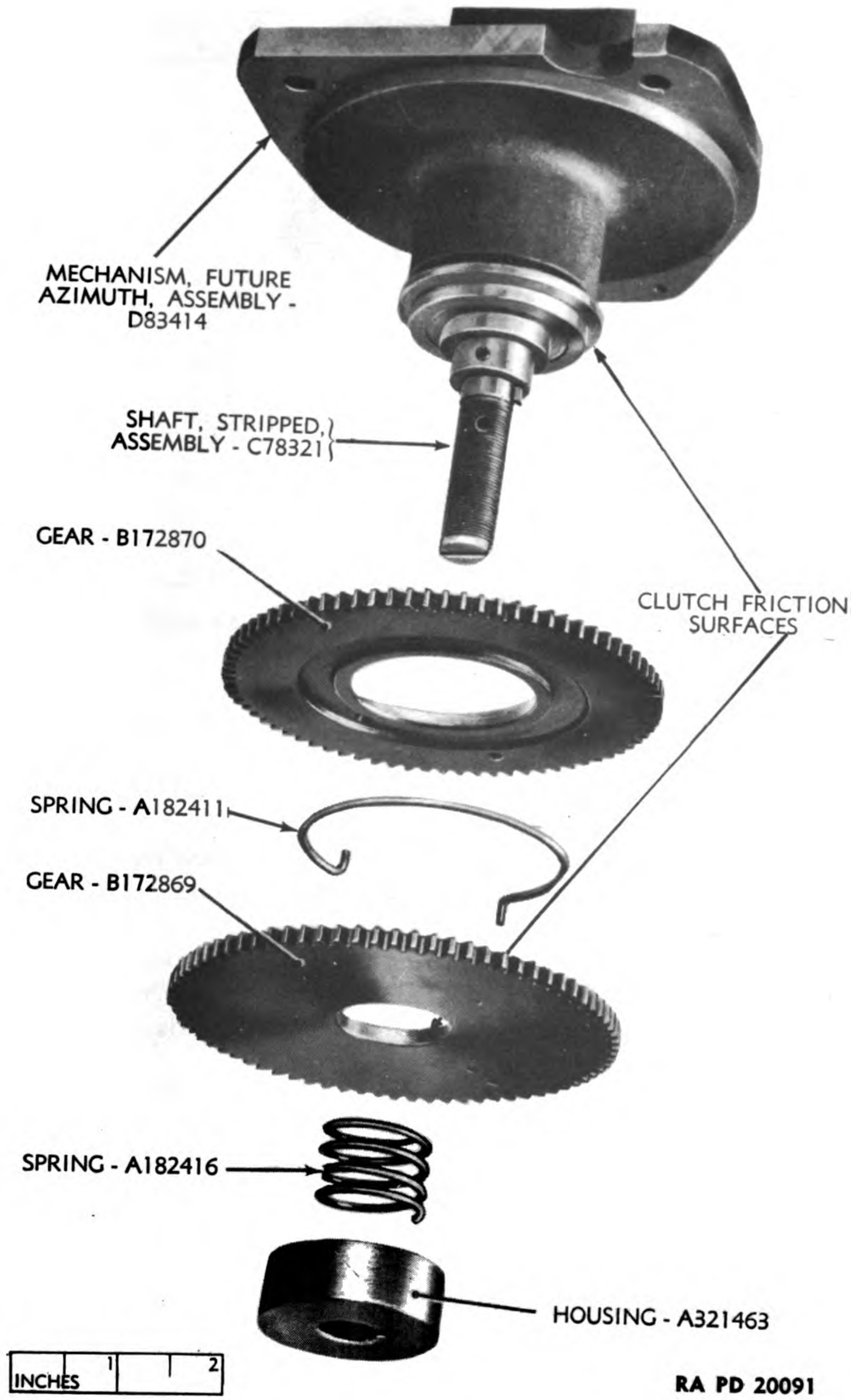


Figure 199 — New Orienting Clutch — Removal of Release Spring, Housing, and Antibacklash Gears

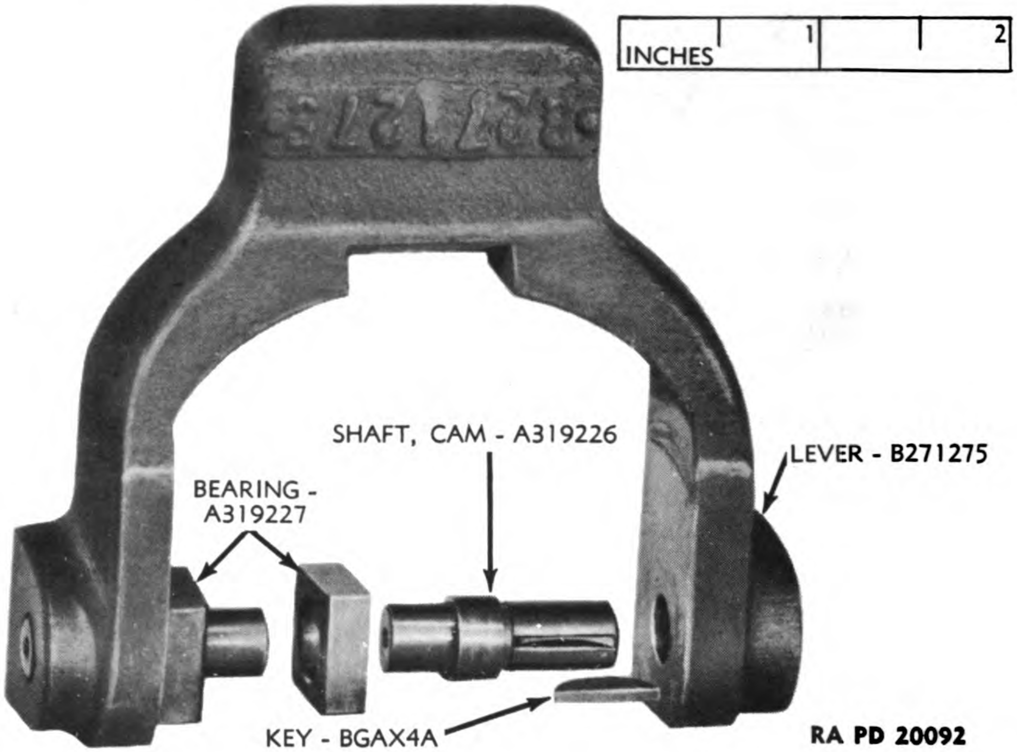


Figure 200 — New Orienting Clutch — Hand Lever Assembly, Showing Cam Shafts Which Actuate Clutch Shoes

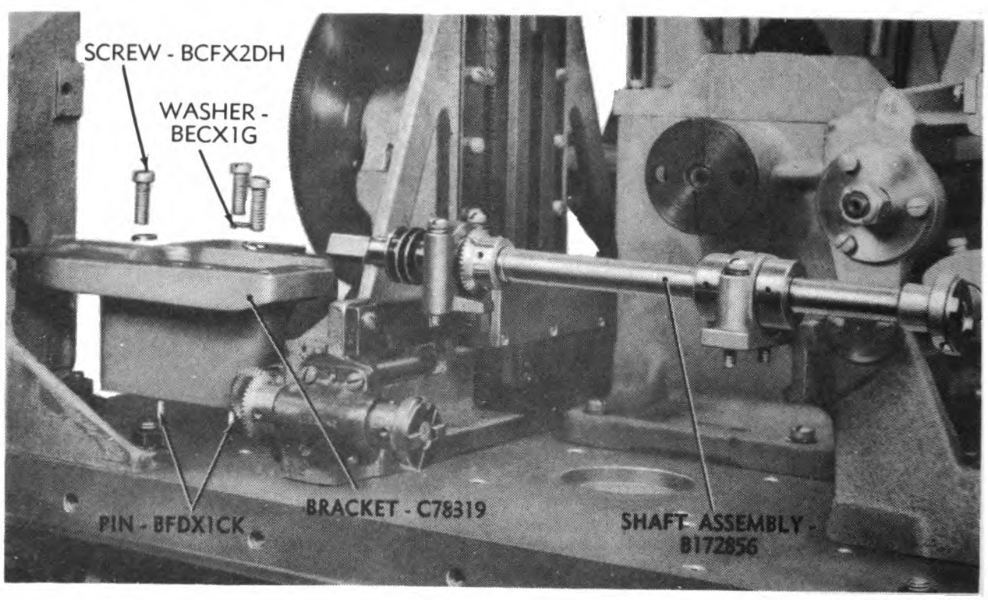


Figure 201 — Removing Shaft and Handwheel Bracket of Differential Drive Shaft Group (See Figures 134 and 143 for Removal of Other Shaft Assemblies)

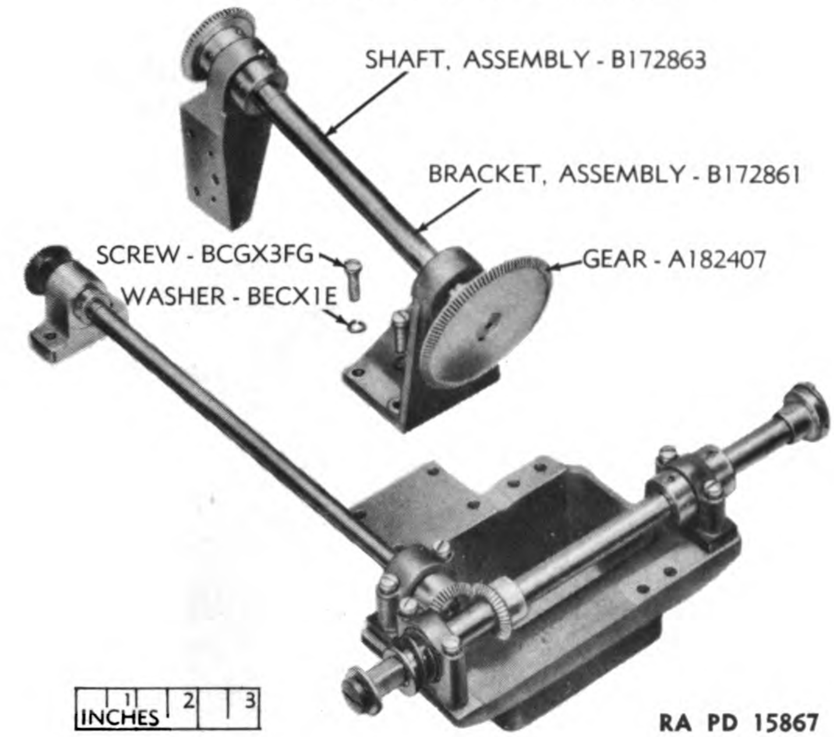
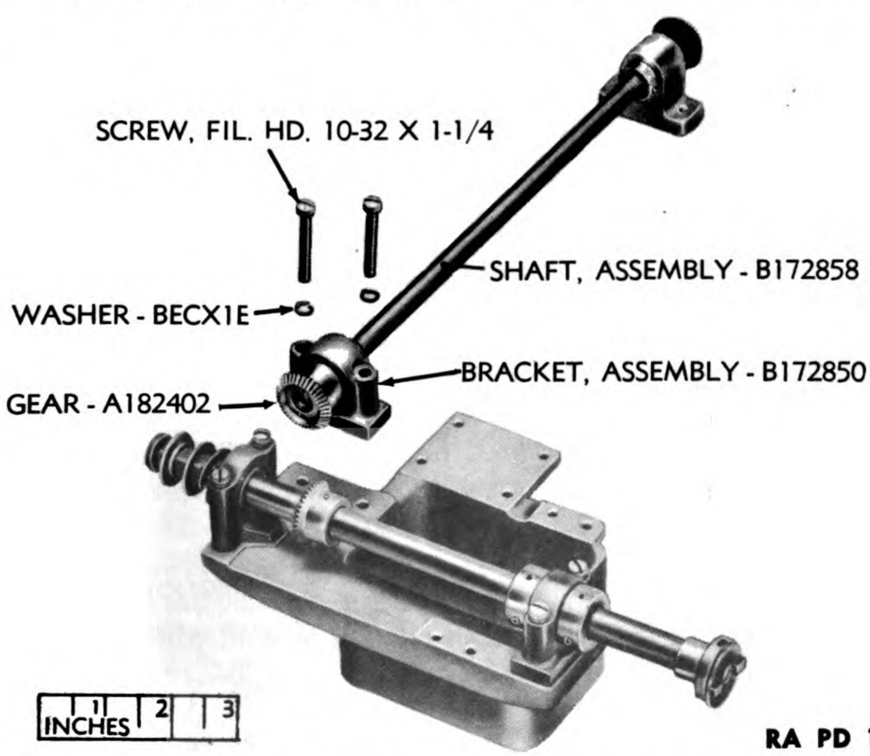


Figure 202 — Attachment of Inclined Shaft to Elevation Differential Drive Shaft Group (See Figures 143 and 144 for Actual Removal)



'igure 203 — Attachment of Clutch Connecting Shaft to Elevation Differential Drive Shaft Group (See Figures 134 and 135 for Actual Removal)

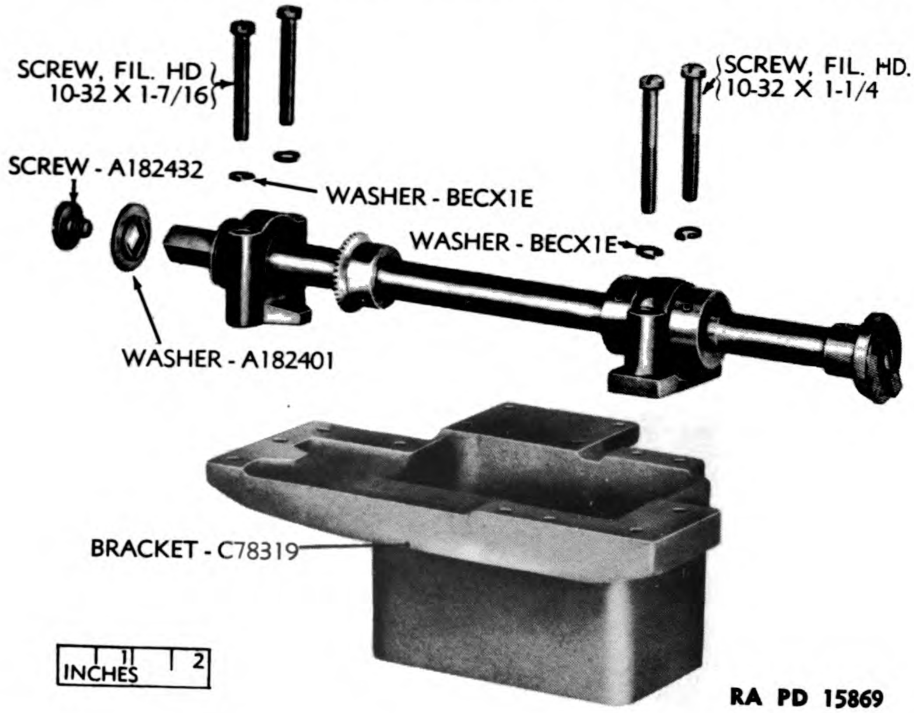


Figure 204 — Removal of Main Shaft From Elevation Handwheel Bracket

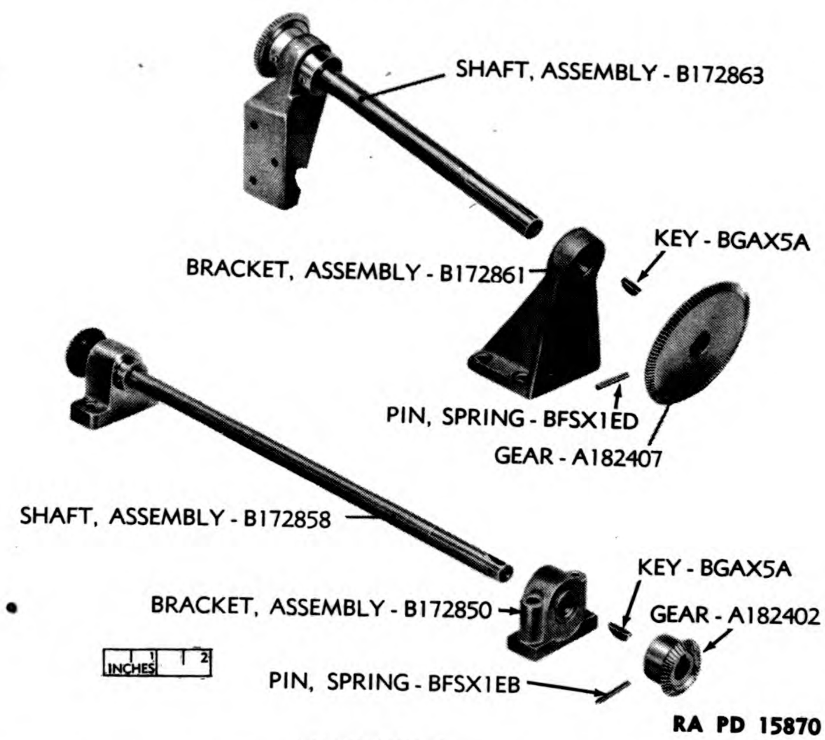


Figure 205 — Parts of Inclined Shaft and Clutch Connecting Shaft Groups

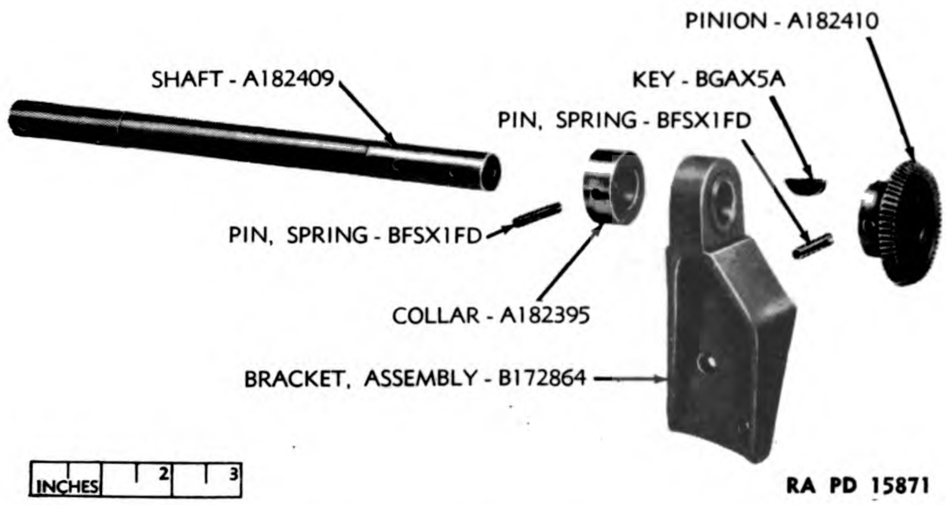


Figure 206 — Inclined Differential Drive Shaft Assembly B172863 — Exploded View

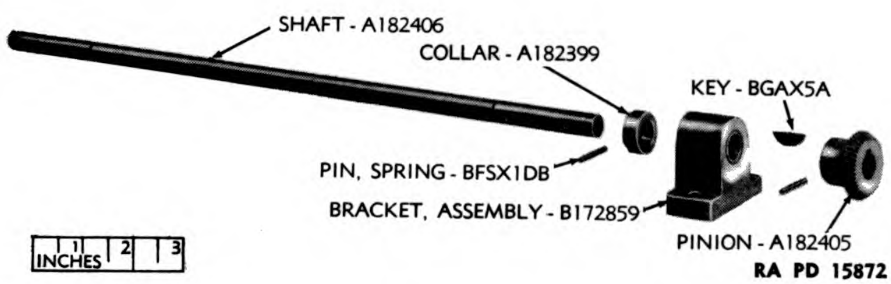
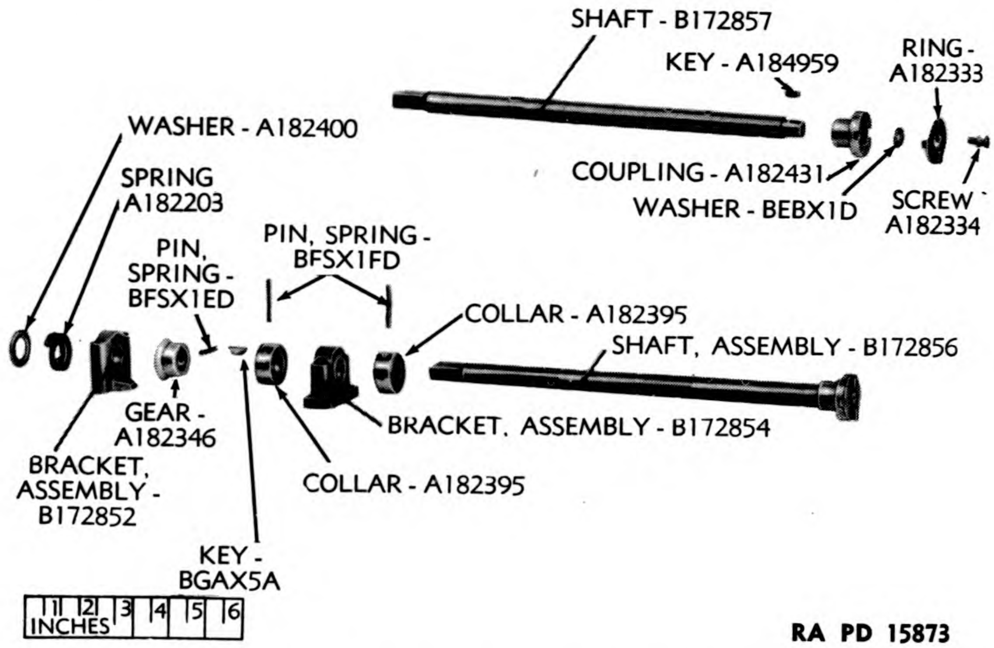


Figure 207 — Assembly B172858 — Exploded View

arm. Do not let the screwdriver slip and damage the friction ring or band. Grasp the band with the fingers of the right hand and pull it slowly toward the front (fig. 278). Use the left hand to hold the output coupling and prevent slack in the band, as excessive slack will cause the band to override and make removal difficult. Slip the band underneath the input torque arm each time it comes around, taking care not to kink or otherwise damage the band. Before loosening the band from the output torque arm, note the direction in which the band leaves the arm, as this information is needed during reassembly of the bands. Loosen the clamp and remove the band. Place the band, with the smooth side down, on a clean, flat surface.

(2) The band is removed from the output drum assembly in a similar manner.

(3) Remove screws and clamps from both torque arms. Remove masking tape or holding tool. Wrap a strip of clean paper ⅝ by 10



RA PD 15873

Figure 208 — Parts of Main Shaft Group Assembly

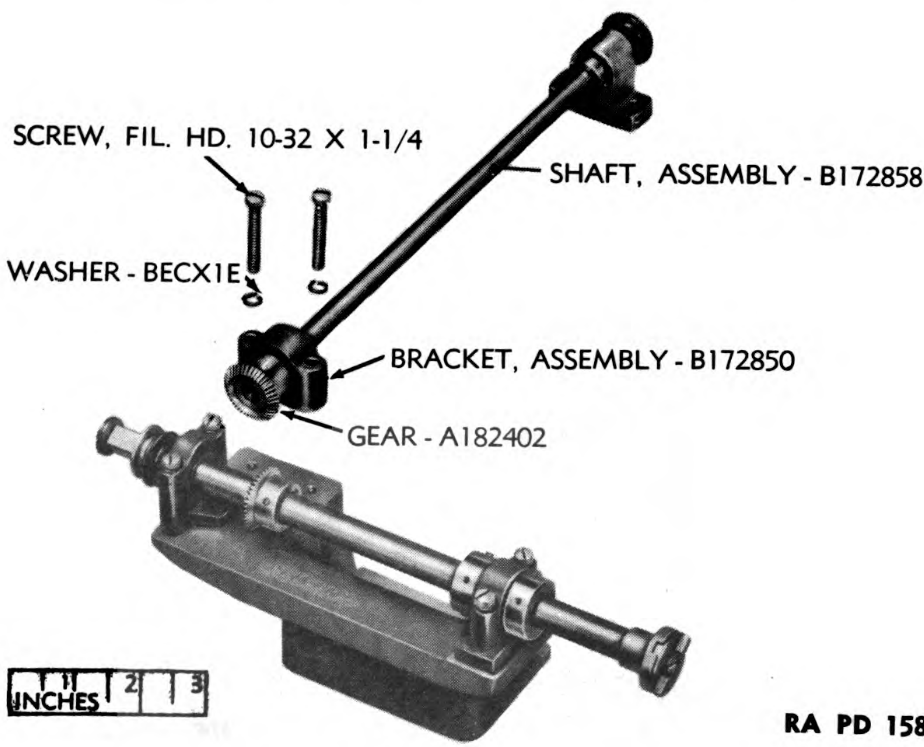


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Figure 209 — Attachment of Clutch Connecting Shaft to Azimuth Differential Drive Shaft Group (See Figures 134 and 135 for Actual Removal)

DISASSEMBLY AND ASSEMBLY

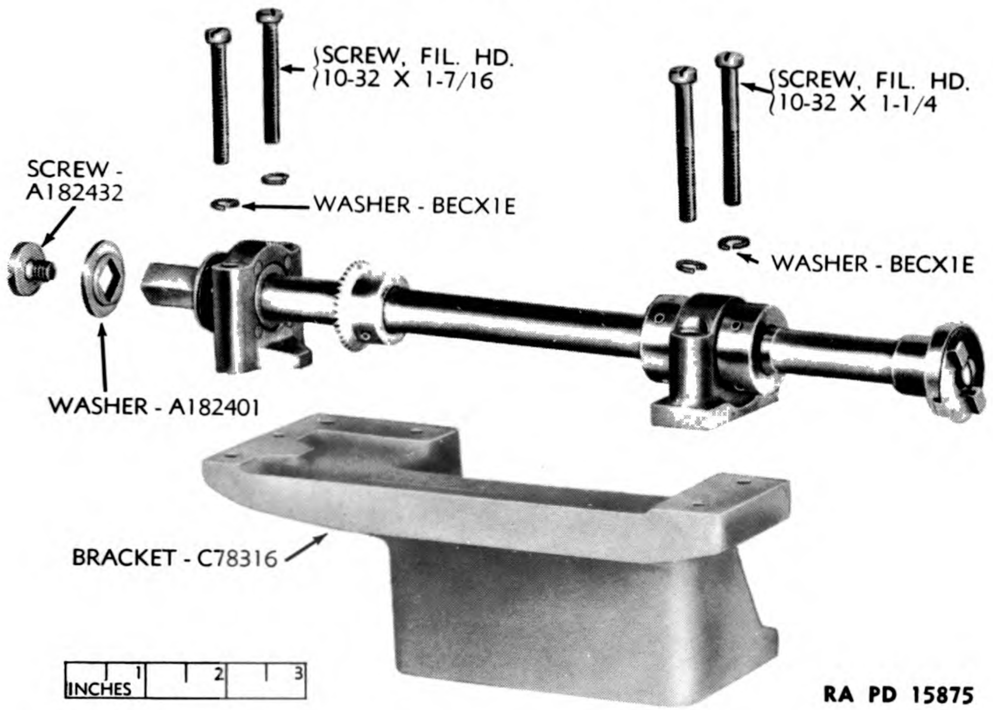
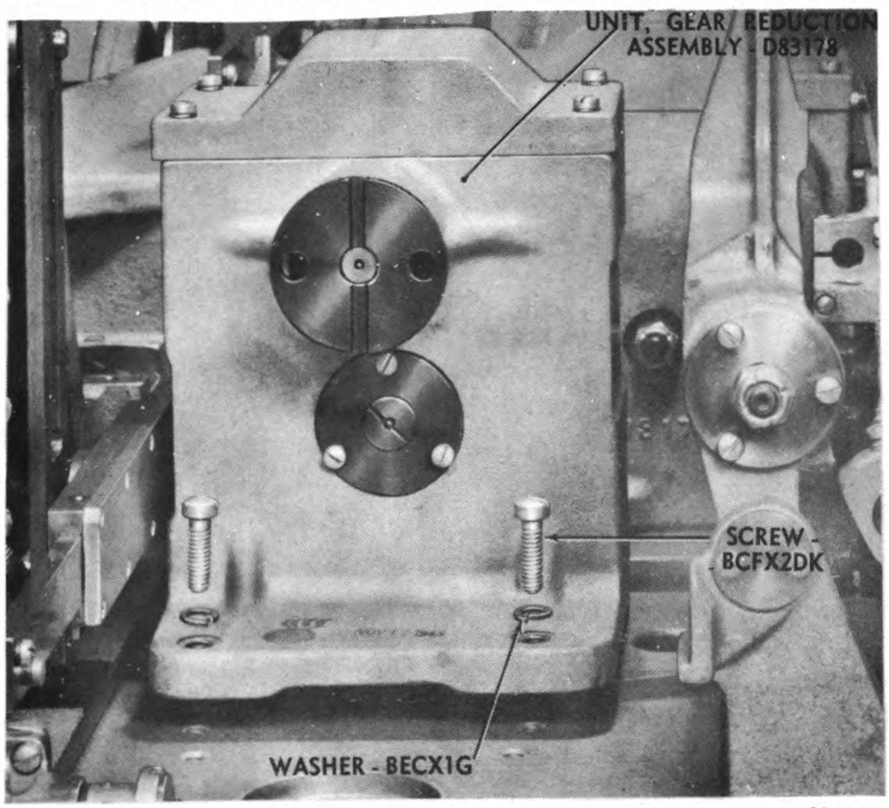


Figure 210 — Removal of Main Shaft From Azimuth Handwheel Bracket



RA PD 15897

Figure 211 — Removing the Gear Reduction Unit From Director M5A1

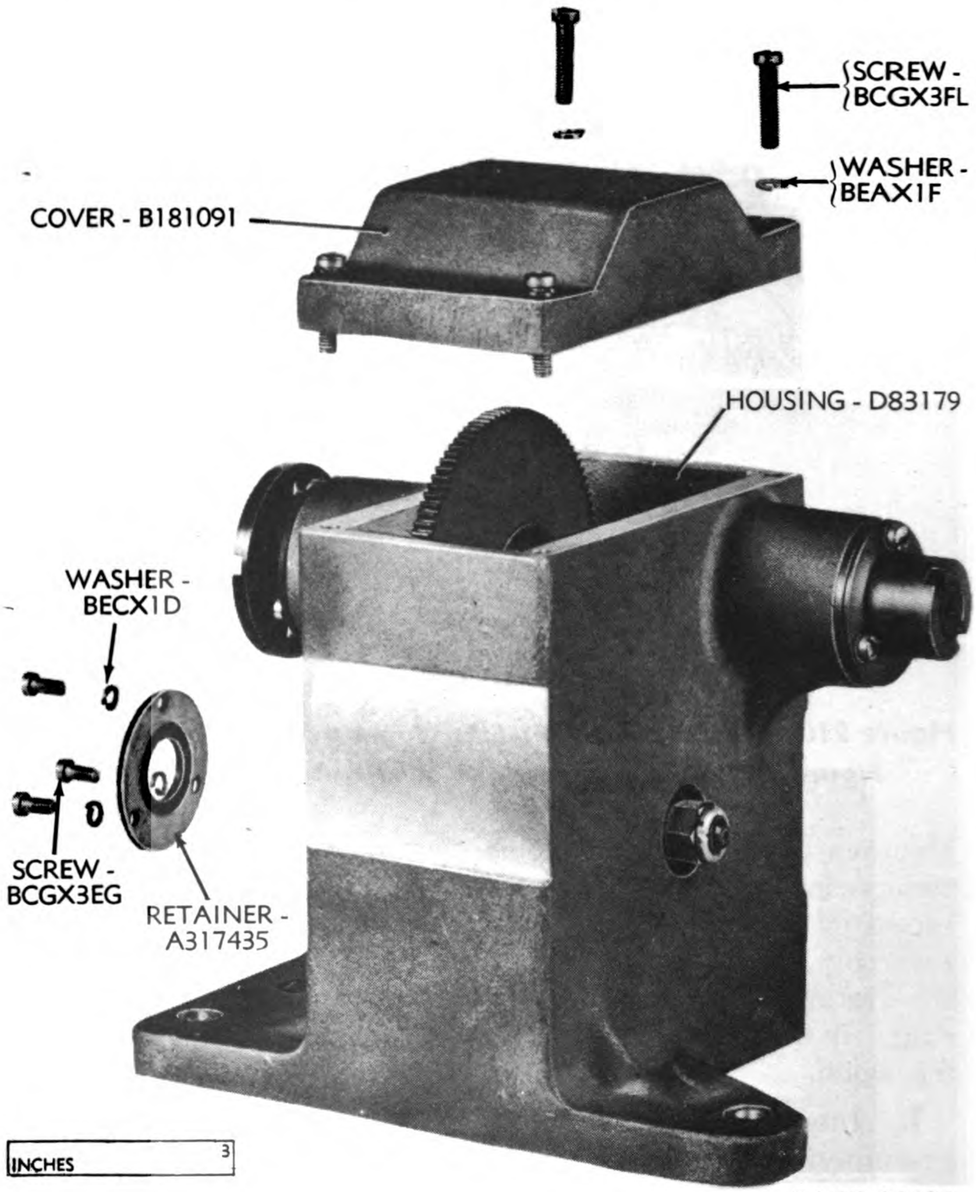


Figure 212 — Gear Reduction Unit — Disassembly

inches around each carbon ring to protect it from handling. **Secure** the paper with a piece of masking tape. *Do not touch the carbon ring with the fingers.*

k. Input Drum Assembly (fig. 279). If not already removed, remove parts as instructed in subparagraphs **b** to **g**, above. **Turn the** torque amplifier until the large cover plate side is towards the operator. Scribe a reference mark on the spindle assembly and the casting, to insure reassembly of the input drum assembly in the same position.

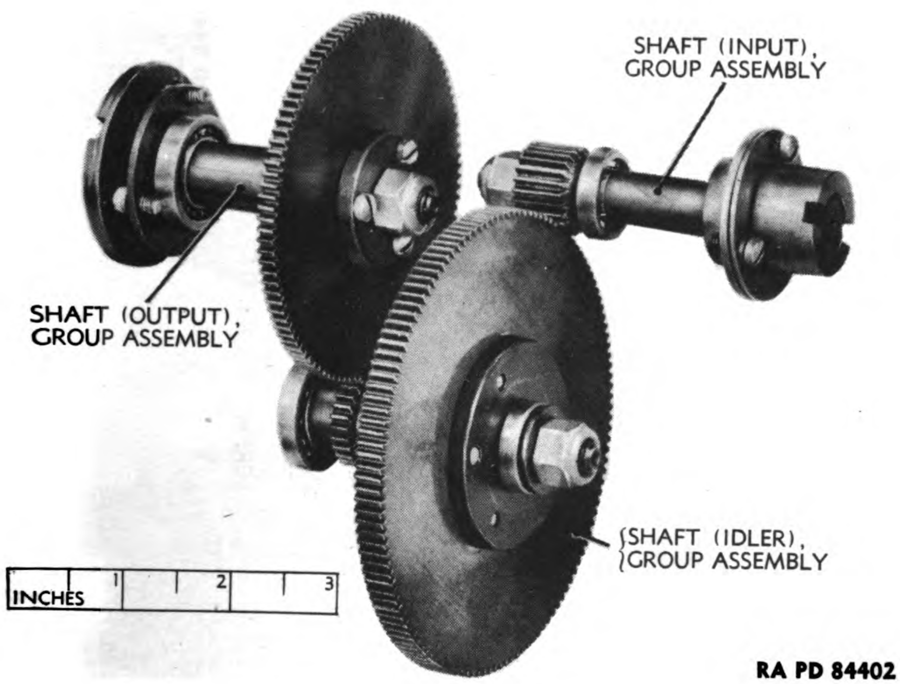


Figure 213 — Arrangement of Shafts in Gear Reduction Unit

Remove the four screws which clamp the input drum assembly to the casting. Turn the input torque arm until it is opposite the small recess in the upper portion of the casting. Remove the input drum assembly by easing it to the right. Do not jam the assembly against the casting during removal, as this can cause damage to the friction ring. If the assembly becomes jammed, tap it back into place and try again.

l. **Intermediate Gear Group Assembly** (fig. 280). The bearing assembly B172778 on the right end of the intermediate gear group assembly (small cover plate side facing the operator) should be forced out to the right. Some of these are very tight and may have to be driven out with the aid of a wood block or a brass drift. Do not damage the bearing, and take care not to bend the shaft. After the bearing has been removed, remove the spring, shaft, and gear by pulling them to the right.

m. **Output Drum Assembly.** Turn the torque amplifier until the side opposite the large cover plate side is facing the operator. Remove the four screws which hold the output drum assembly to the casting. Gently loosen the assembly and start it out to the left. *Do not jam the assembly against the casting.* If there is a recess in the casting similar to that on the input drum side through which the input torque

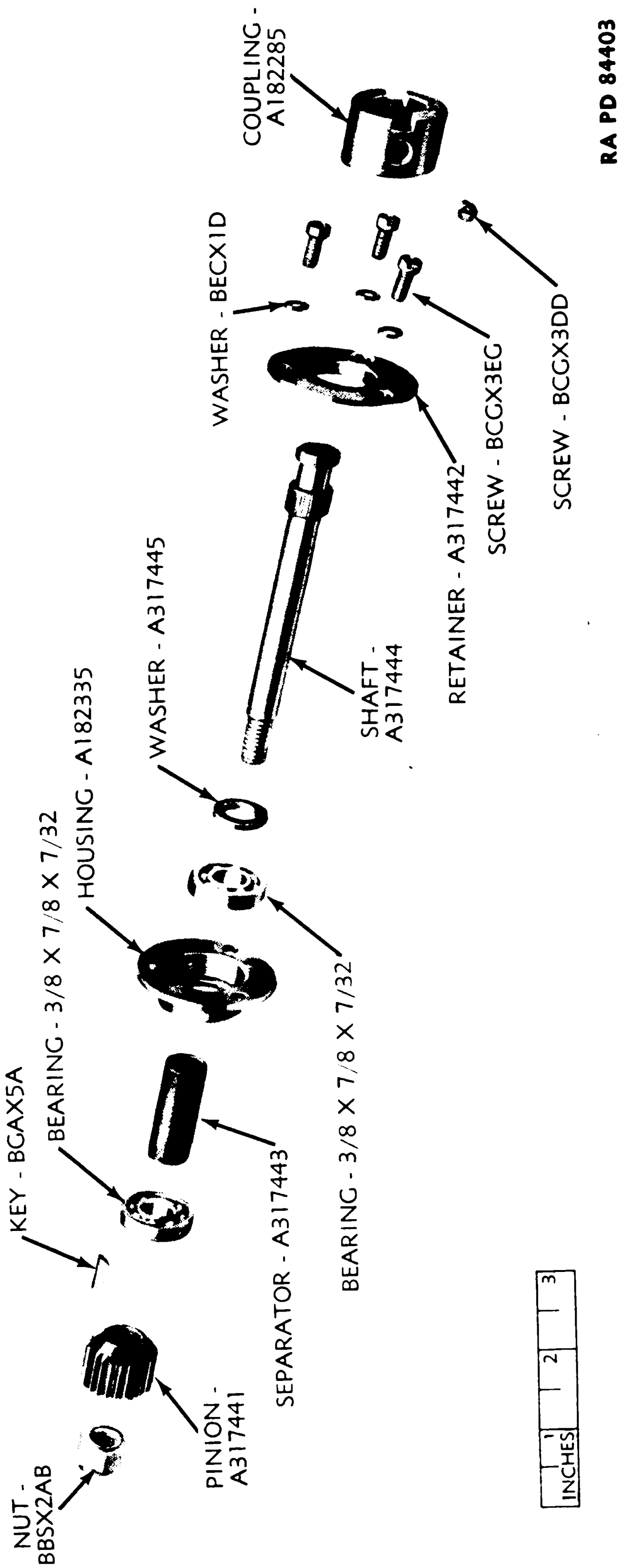


Figure 214 — Input Shaft Group — Exploded View

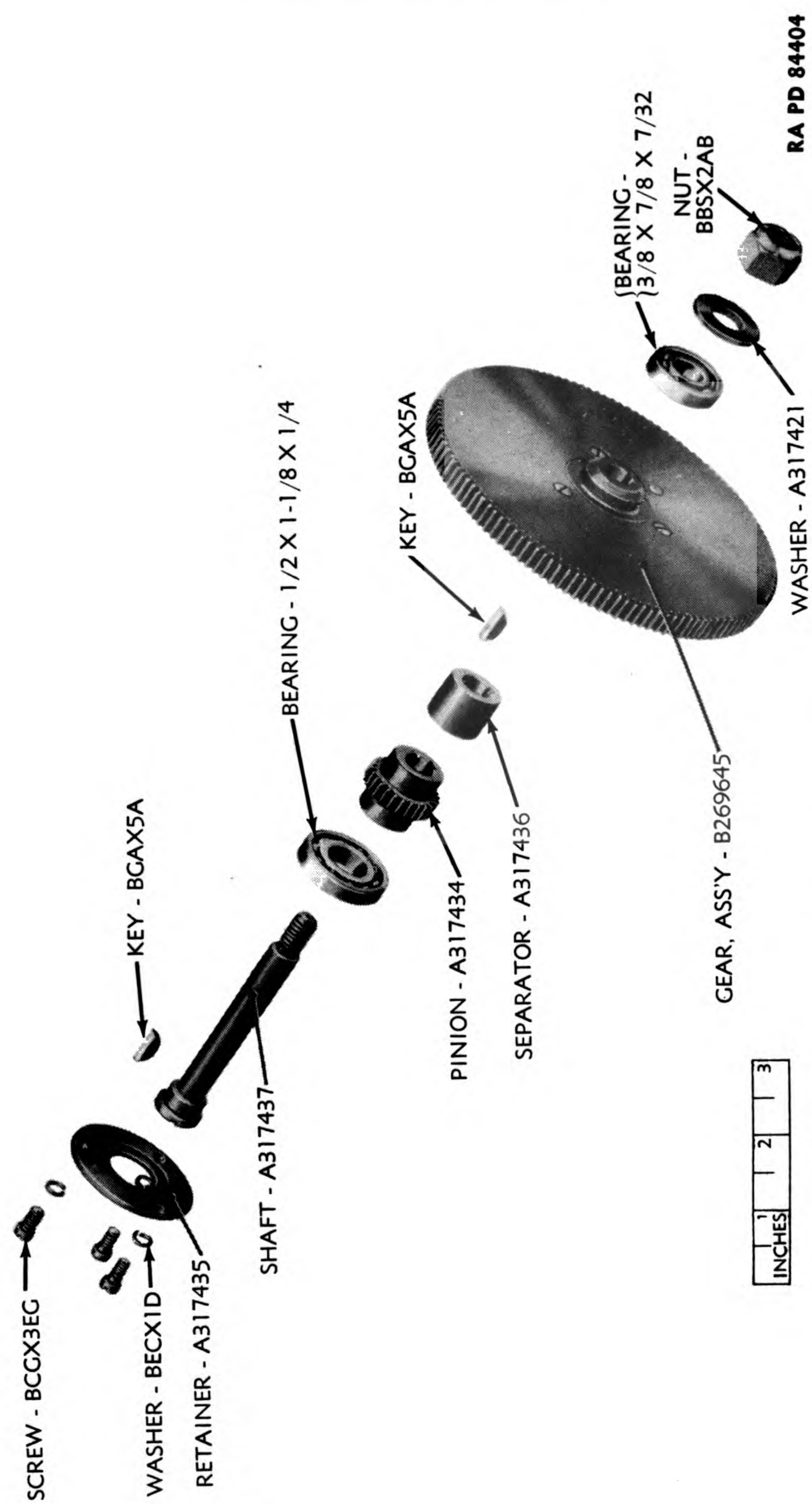


Figure 215 — Idler Shaft Group — Exploded View

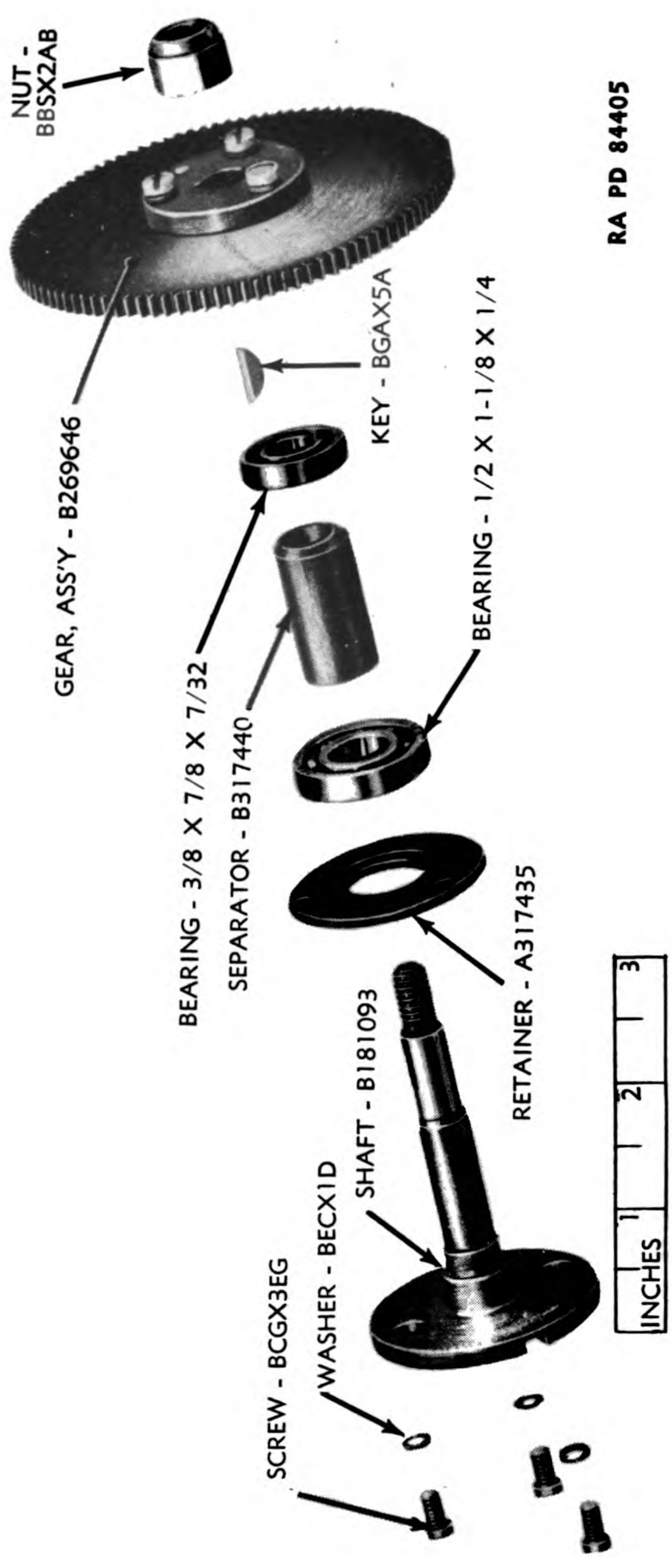


Figure 216 — Output Shaft Group — Exploded View

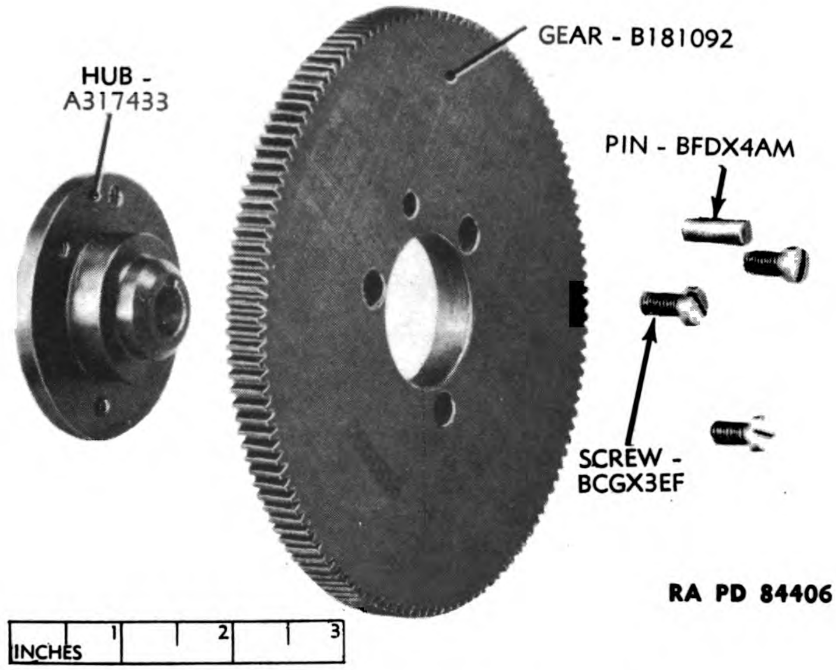


Figure 217 — Idler Gear Assembly B269645

arm was removed, turn the output torque arm opposite the recess and remove the assembly. If not, turn the output torque arm until the end on which the band was clamped is facing the operator. Carefully twist the output drum so that the weighted end of the torque arm starts through the casting first. *Be careful that the friction ring is not damaged.* Ease the assembly out to the left. The clearance for the removal of this assembly is very small. Care and patience are needed to satisfactorily perform this operation.

n. Main Gear Group Assembly (fig. 281). Use the proper size punch (fig. 81) and drive out the spring pin in the center of the main gear group shaft. Do not bur the shaft by improper use of the punch. Pull the shaft out through the large cover plate side of the torque amplifier. This shaft may be very tight; if so, try replacing the spiral gear and pulling by this method, or use the special shaft puller B315847 shown in figure 81.

o. Disassembly of Input Drum Assembly (figs. 286 and 287). In order to replace a friction ring on the input drum assembly, the following disassembly is necessary: Drive out the spring pin which holds the gear to the torque arm of the input drum assembly (use special drift pin A400154, fig. 81). Remove the gear (it may be necessary to use the adjustable gear puller B315852). Push the torque arm through the spindle assembly. Remove external retaining

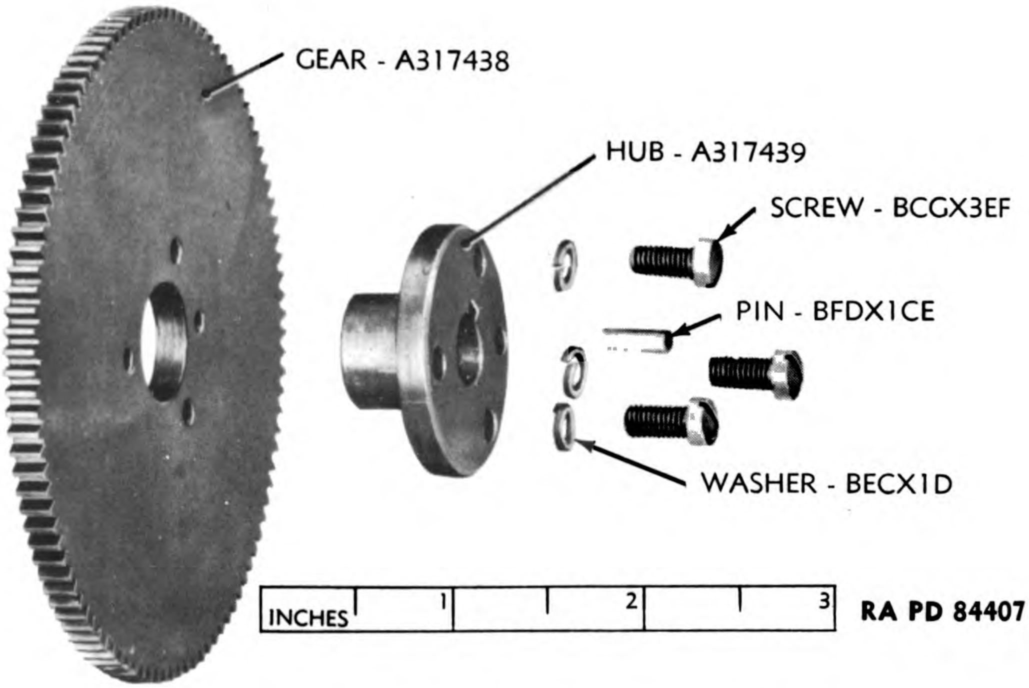


Figure 218 — Output Gear Assembly B269646

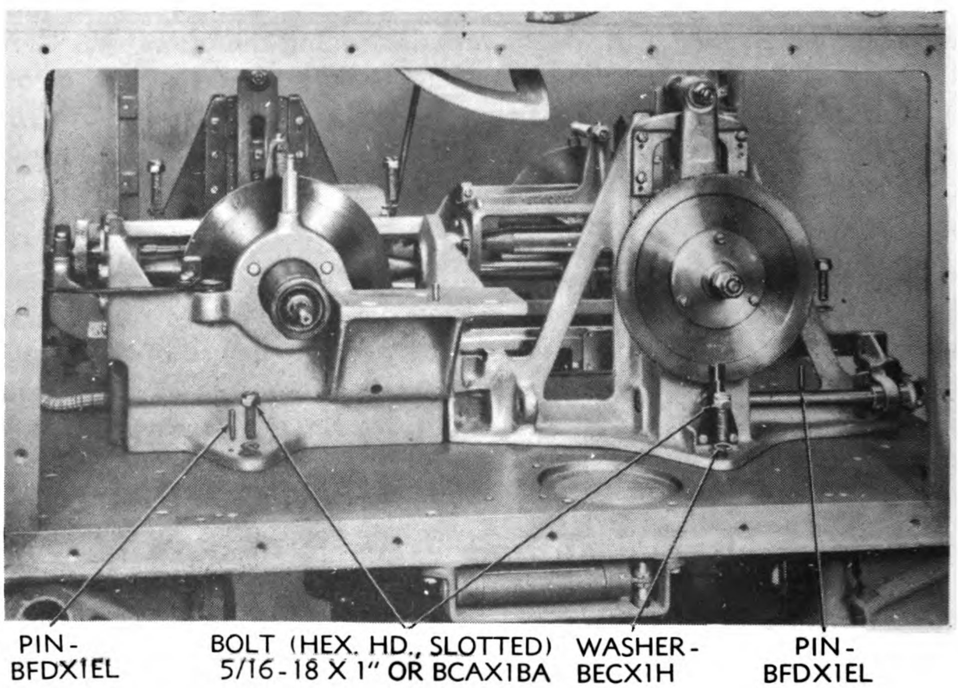


Figure 219 — Screws and Pins Which Hold Deflection Mechanism

DISASSEMBLY AND ASSEMBLY

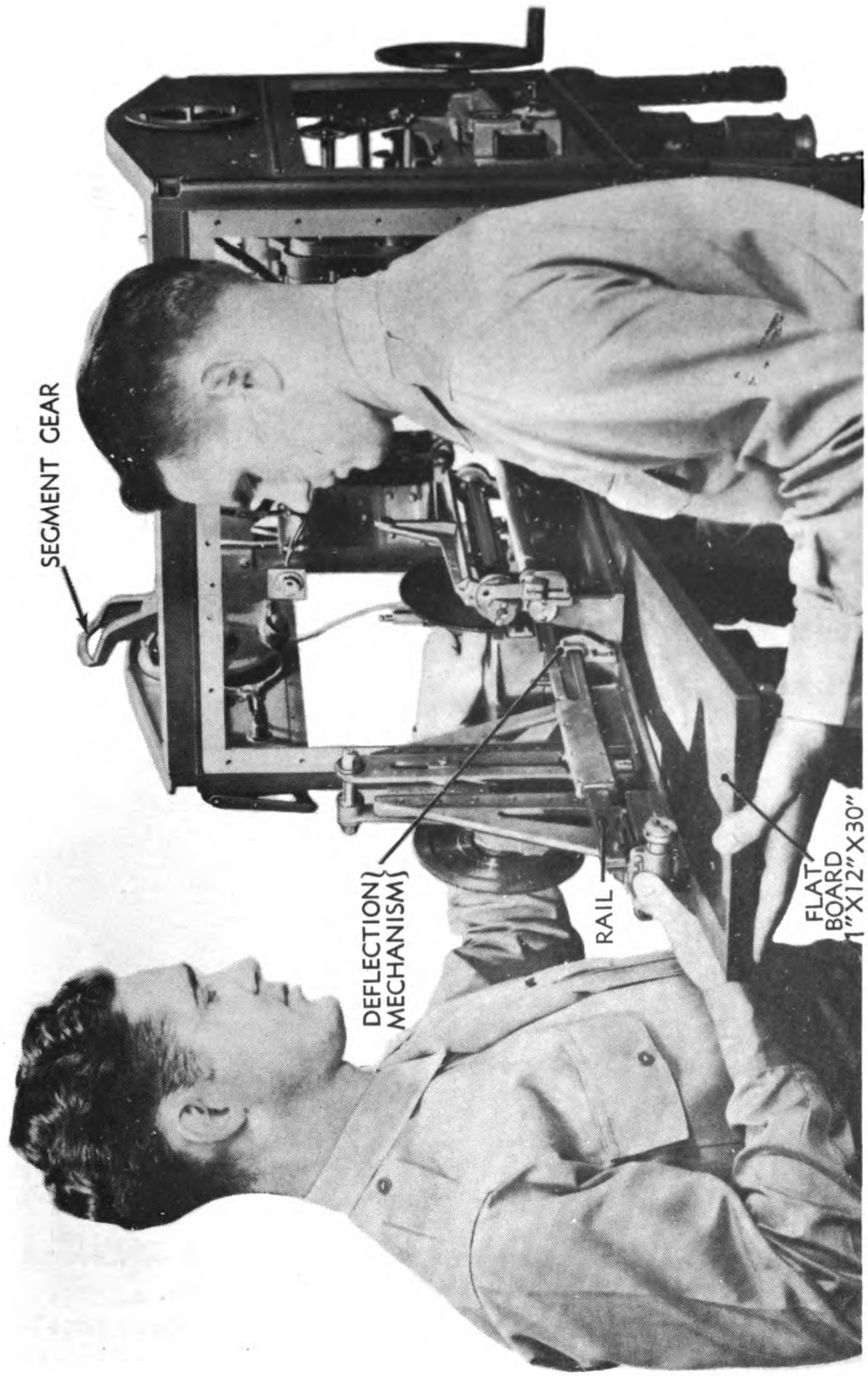


Figure 220 — Removing Deflection Mechanism From Director

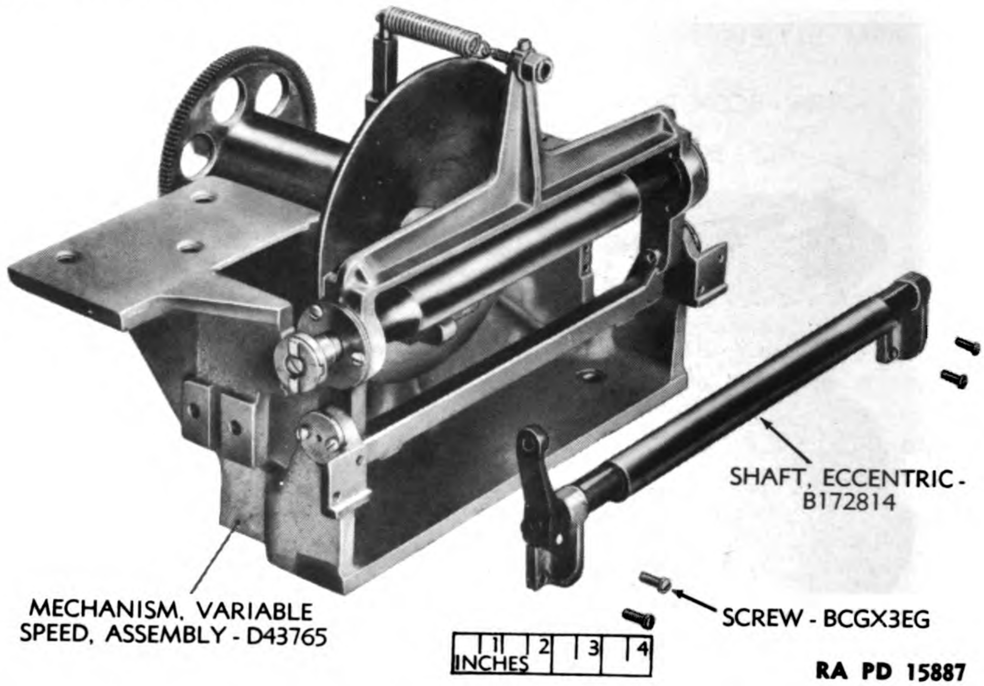


Figure 221 — Vertical Deflection Mechanism (Directors M5 and M6). Variable Speed Mechanism Is Identical With Azimuth Unit After Removal of Eccentric Shaft

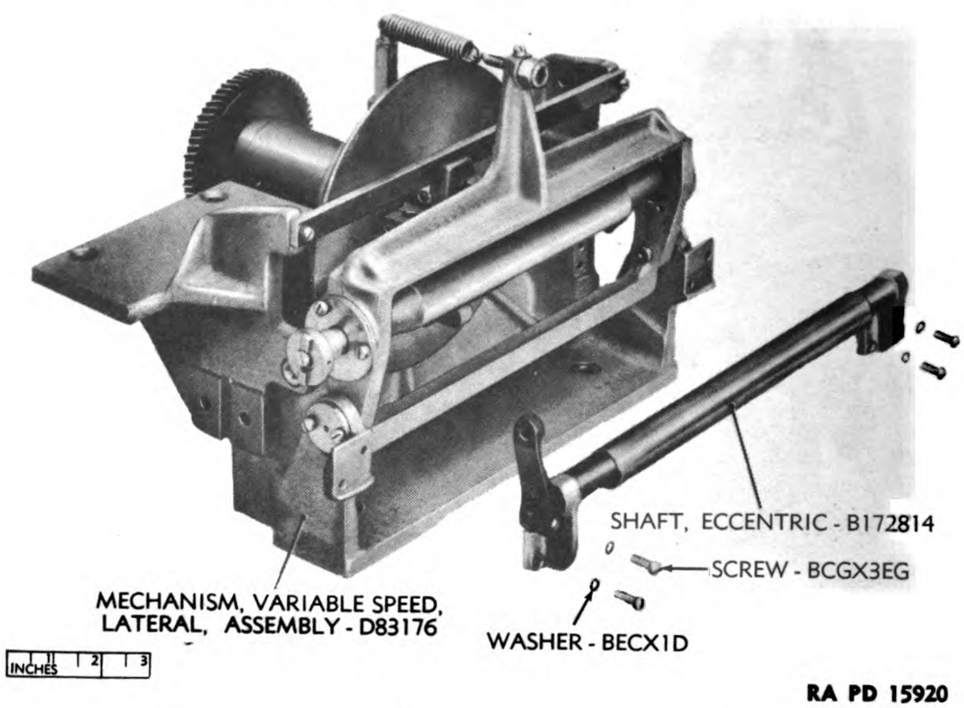
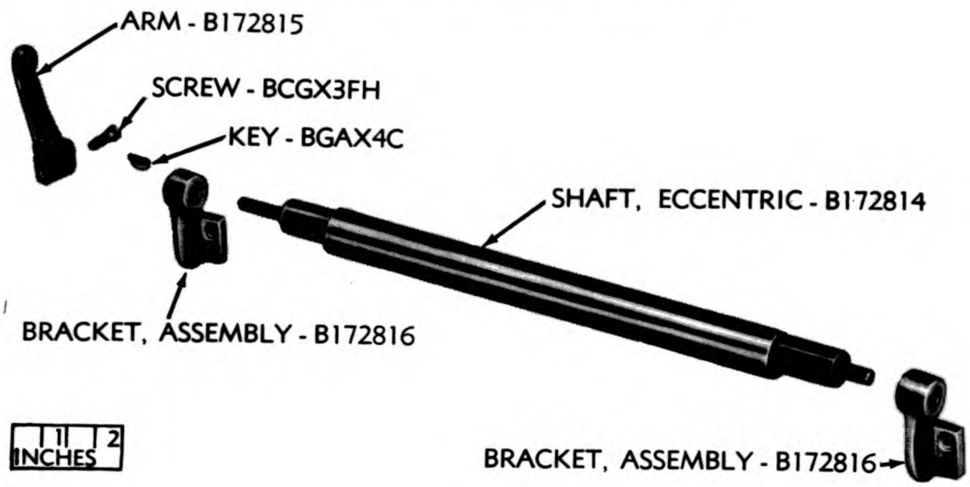


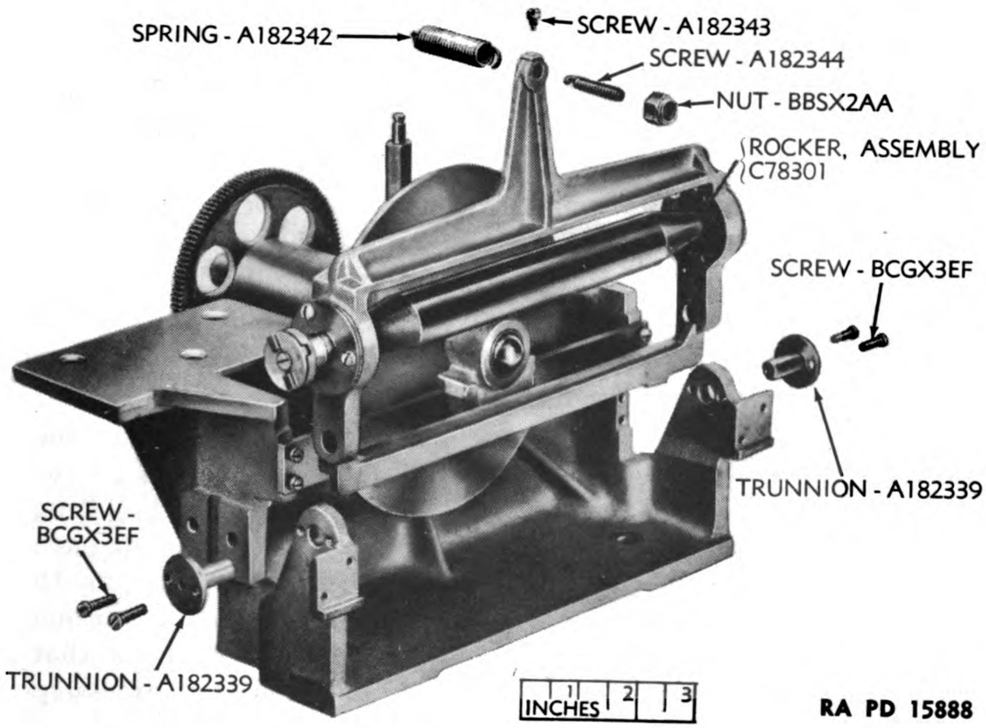
Figure 222 — Vertical Deflection Mechanism (Director M5A1). Variable Speed Mechanism Is Identical With Azimuth Unit After Removal of Eccentric Shaft

DISASSEMBLY AND ASSEMBLY



RA PD 15894

Figure 223 — Eccentric Shaft (Superelevation) and Associated Parts (Directors M5, M6 and M5A1)



RA PD 15888

Figure 224 — Removing Rocker Assembly (Directors M5 and M6)

ring (spring clip). Lift off the seal. Grasp the fiber gear and work the friction ring assembly off the spindle assembly. Remove the three screws which go through the fiber gear and friction ring into the steel ring. Lift the steel ring off. Carefully lift the friction ring from the hub. Assemble in reverse order.

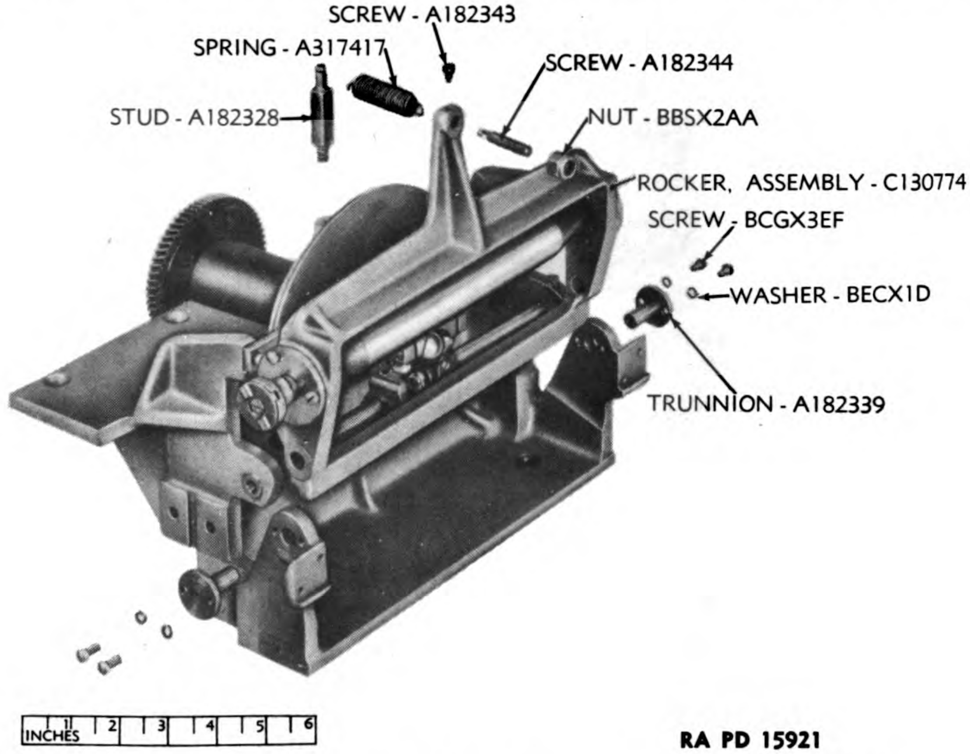


Figure 225 — Removing Rocker Assembly (Director M5A1)

p. Disassembly of Output Drum Assembly. Drive out spring pin which holds the coupling to the torque arm, and slide the coupling off the splined shaft (use special drift pin A400154). Follow the procedure outlined in subparagraph **o**, above.

86. ASSEMBLY AND ADJUSTMENT OF TORQUE AMPLIFIER.

a. Assembly is in reverse order of disassembly, except that the bands should not be replaced until after all other working parts have been reassembled. This is to prevent oil or moisture from getting on the bands or friction rings while they are being handled. As each gear train is assembled, check it for freedom of movement, as smooth functioning of gears is essential to proper operation of the torque amplifier. When the input drive assembly is replaced, check that gearing turns freely without "high" spots and that there is no excessive backlash. To check backlash in the gearing, hold the input torque arm stationary and turn the input coupling each way. If the coupling moves more than one sixty-fourth inch, there is excessive backlash which may be removed by shifting the input drive assembly into closer mesh and then tightening the clamping screws.

b. Before Assembly. Proper operation of the torque amplifier depends to a very large extent upon the surface condition of the friction rings and the steel bands.

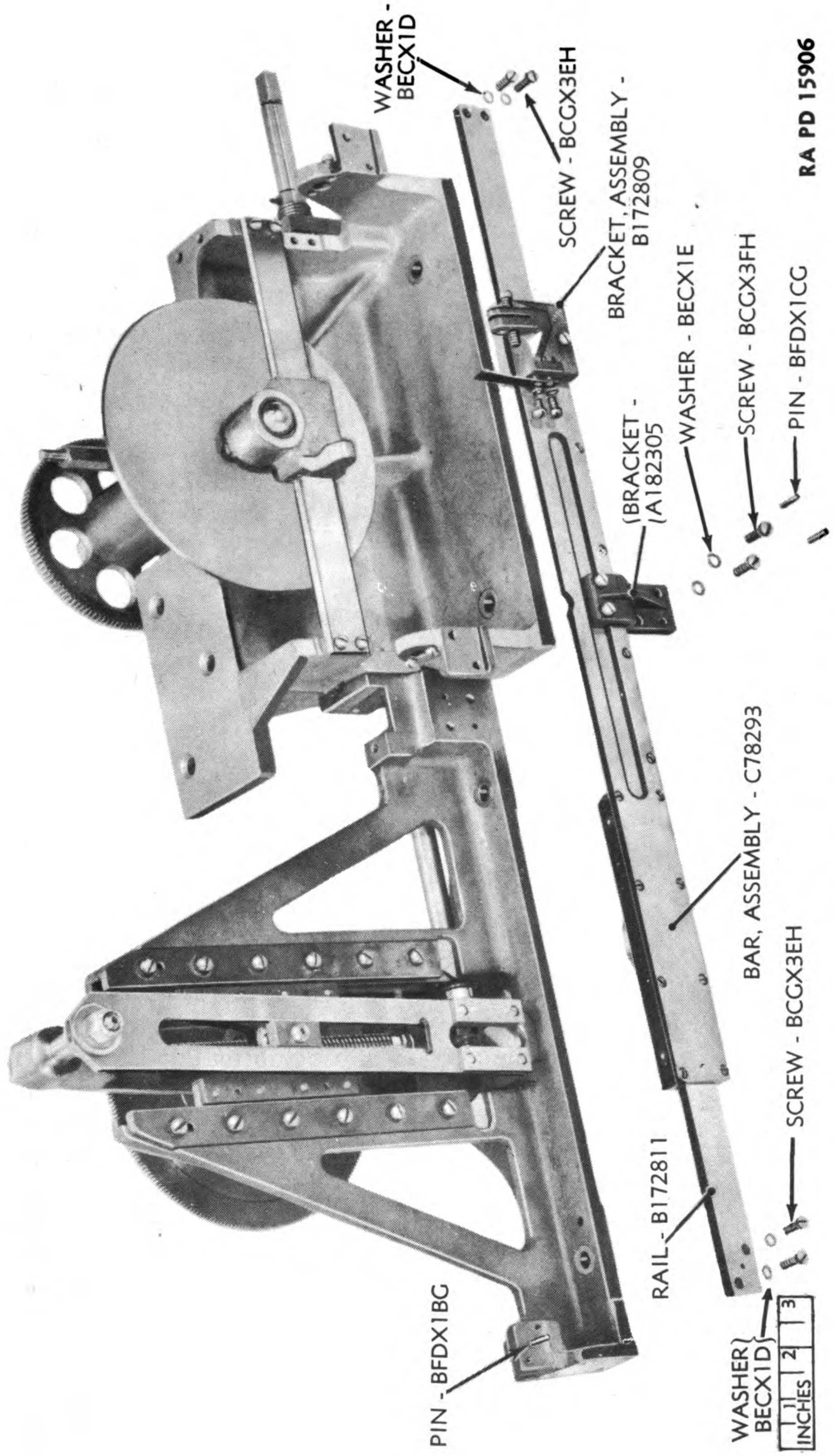


Figure 226 — Disassembling Lateral Deflection Mechanism (Directors M5 and M6)

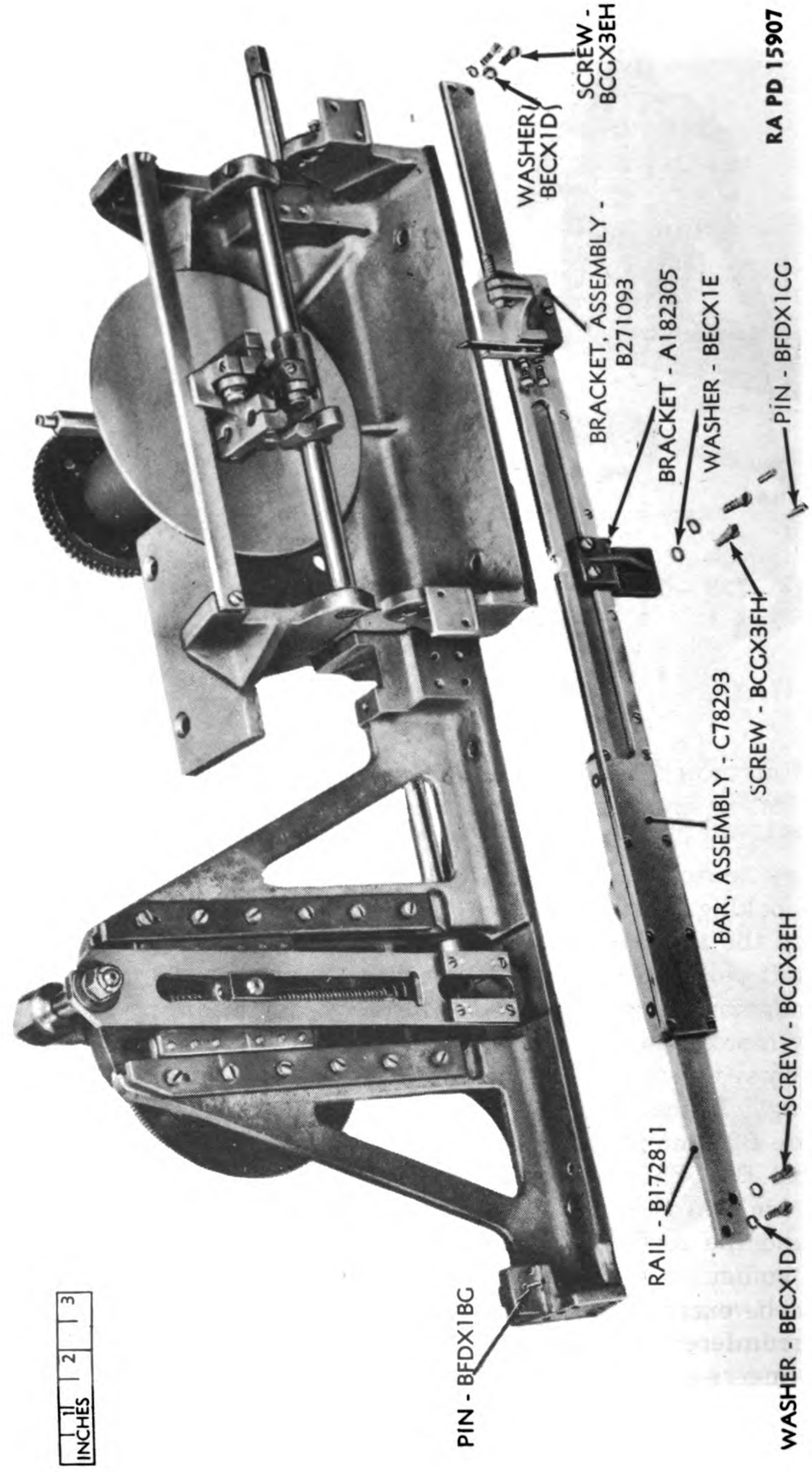


Figure 227 — Disassembling Lateral Deflection Mechanism (Director M5A1)

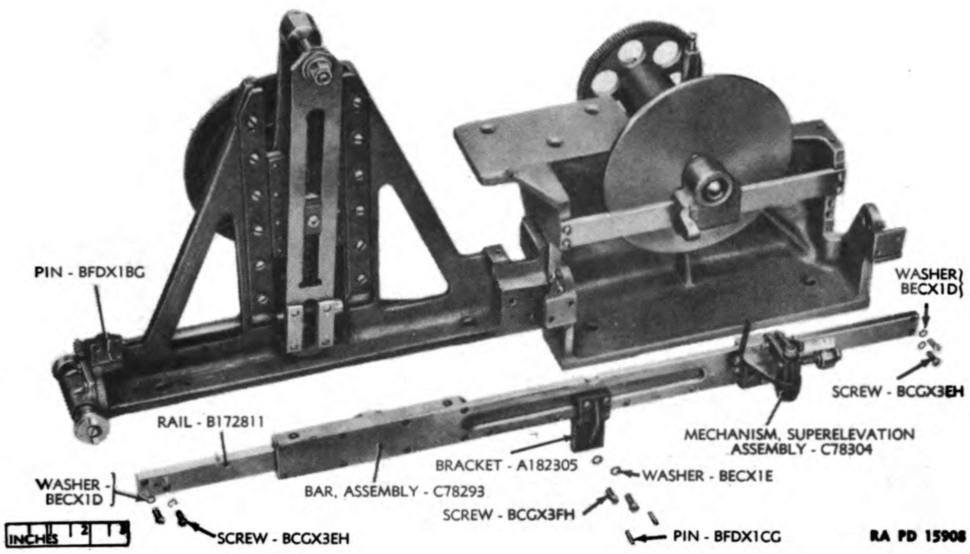


Figure 228 — Disassembling Vertical Deflection Mechanism (Directors M5 and M6)

(1) FRICTION RINGS. At all times care must be taken to keep moisture, oil, or grease from the rings. If oil or grease does get on a ring, it is best to replace the ring with a new one, although sometimes the oil may be removed with cleaning solvent or carbon tetrachloride, and then baking. The most satisfactory method of obtaining a good surface on the ring is to polish it with crocus cloth, and then, with a clean soft cloth, to remove carbon dust. This is done by pressing the cloth against the ring while it is in the torque amplifier and being driven by motor (bands removed). The cloth should be moved constantly across the surface of the ring so as to avoid cutting a groove in the ring. If the ring has too high a polish, it may be removed with grade 00 flint paper. If the ring surface is extremely bad, the facing tool B315850, shown in figure 81, may be used to resurface the ring while in the torque amplifier, or the ring may be set up in a lathe and the surface ground or turned down. Only a very light cut, just sufficient to provide a new surface, should be taken, and care must be exercised that the surface is not chipped and that there are no circumferential scores. The ring surface should not be touched with the fingers as oil or moisture might get on it.

(2) STEEL BANDS. The bands must be perfectly straight and free from kinks, have the surface highly polished and free from rust,

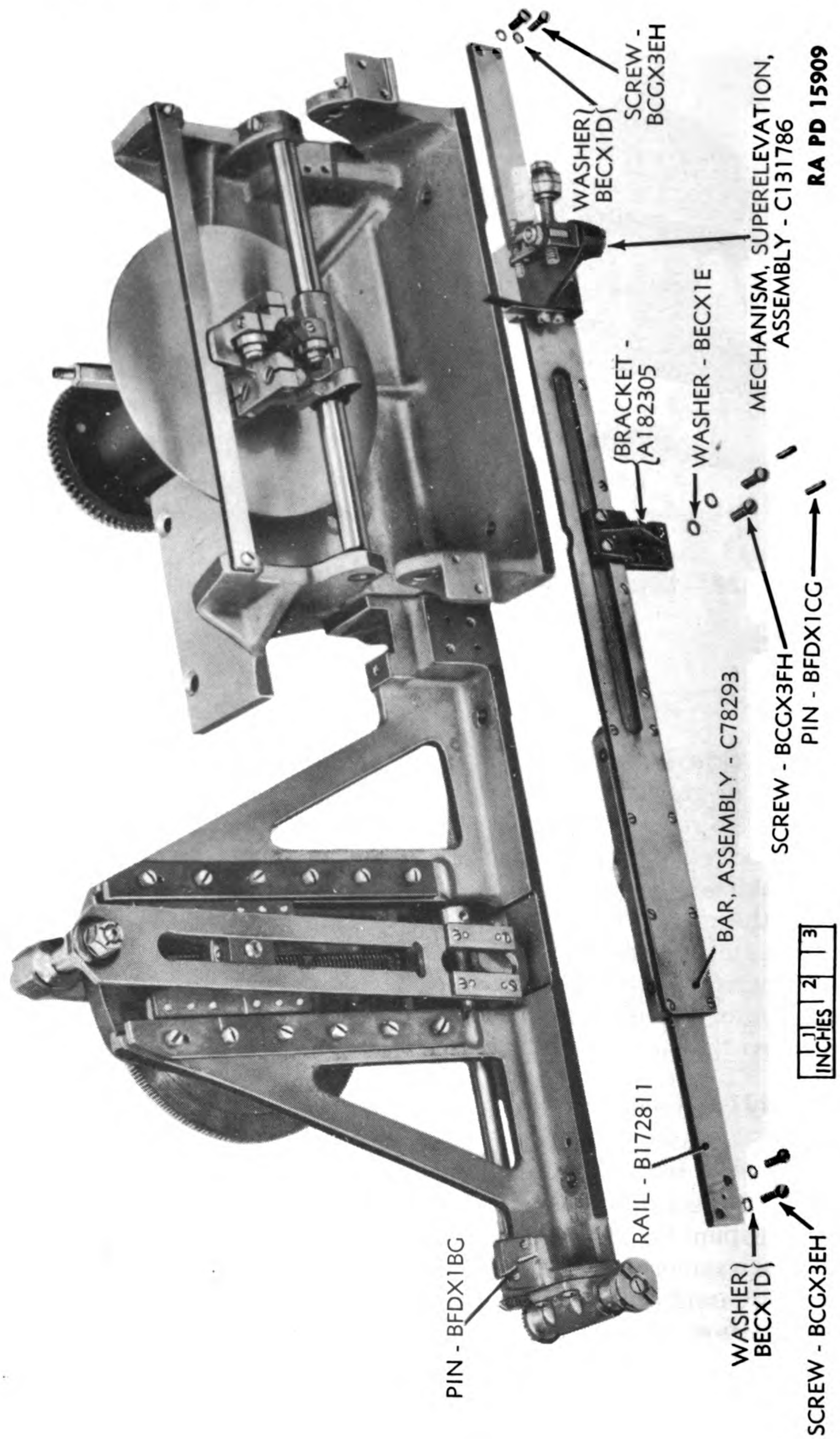


Figure 229 — *Disassembling Vertical Deflection Mechanism (Director M5A1)*

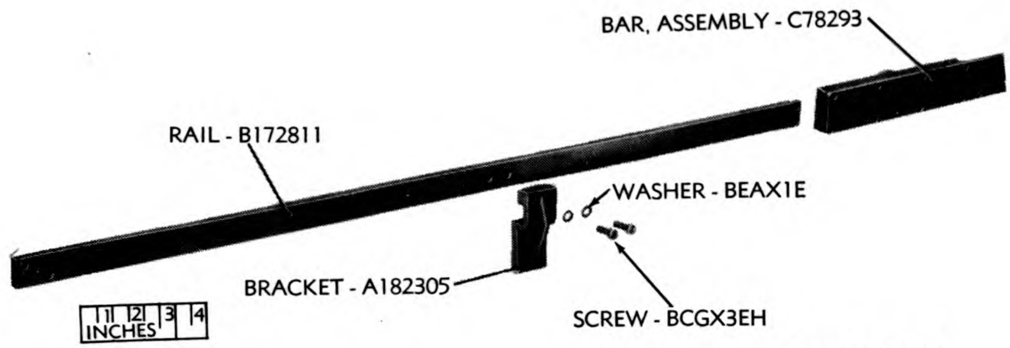


Figure 230 — Removing Rail From Bar Assembly — Lateral or Vertical Deflection Mechanism

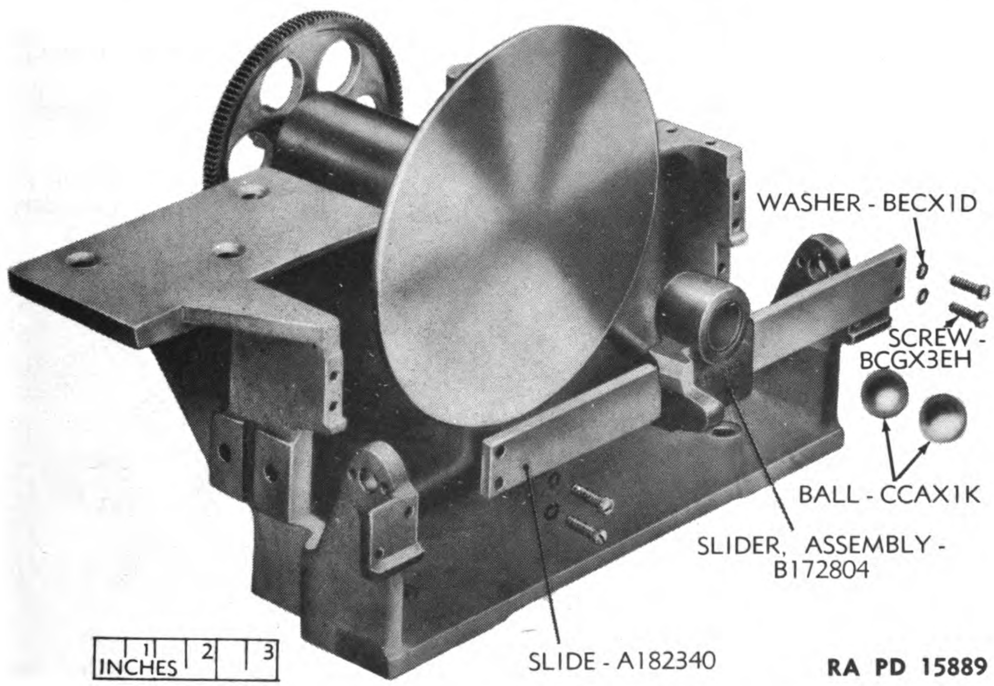


Figure 231 — Removing Slider Assembly (Directors M5 and M6)

dirt, carbon deposits, moisture, oil, grease, and have all the 14 solder drops in place. Oil, grease, dirt, and carbon deposits may be removed by wiping the band with a clean cloth moistened with alcohol or carbon tetrachloride. Tightly adhering dirt and small particles of rust may be removed by polishing with crocus cloth. In extreme cases, a very fine round emery stone may be used or, better, the band may be replaced with a new one. Just prior to assembly of the bands into the torque amplifier, they should be cleaned of all dirt and moisture with a clean cloth moistened with alcohol or carbon tetra-

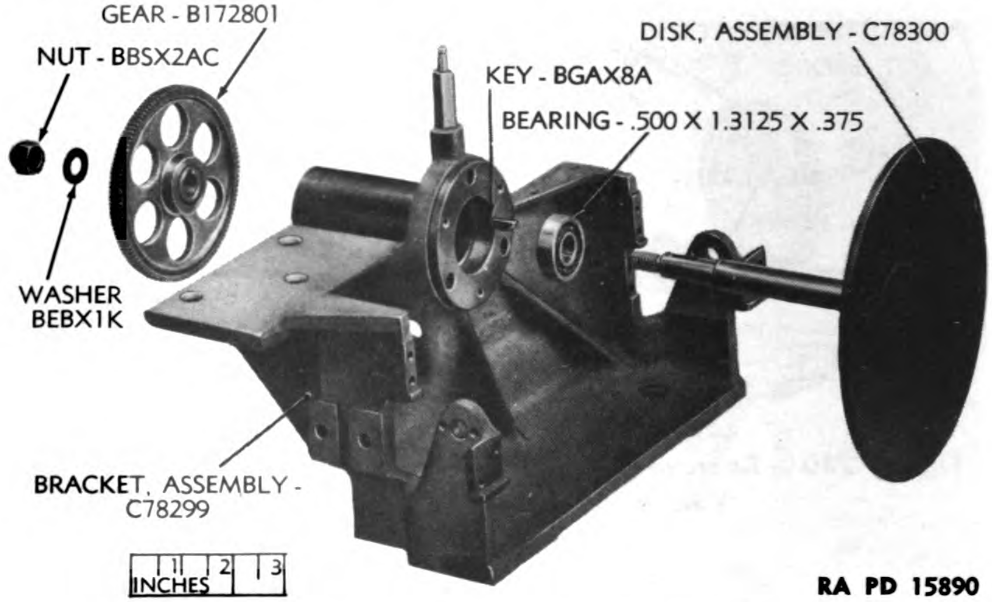


Figure 232 — Removing Disk Assembly (Directors M5 and M6)

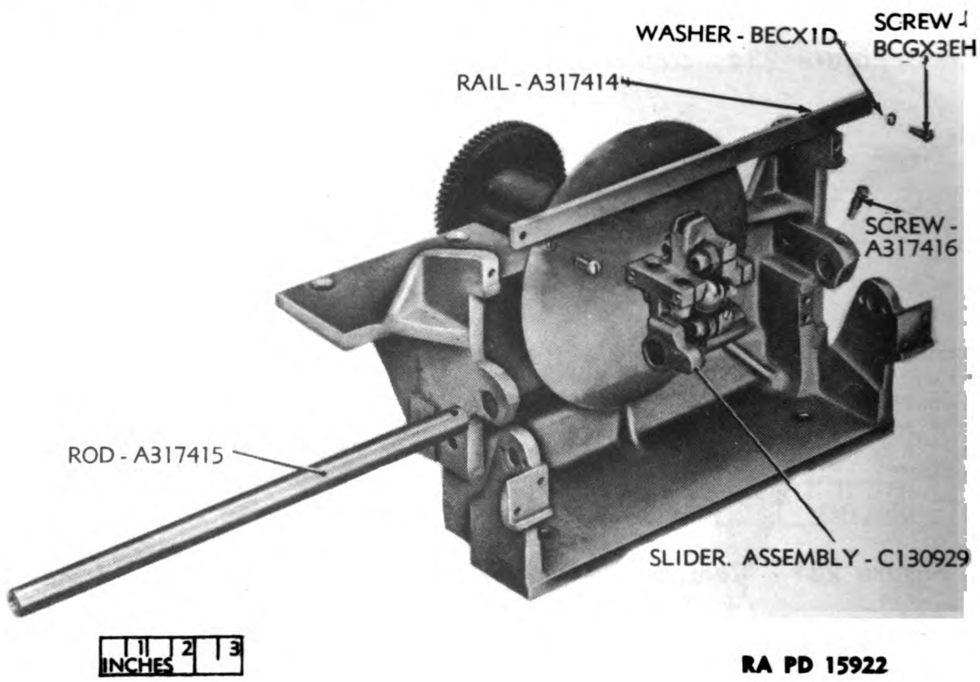


Figure 233 — Removing Slider Assembly (Director M5A1)

chloride and then wiped with a clean dry cloth. Thereafter the polished side should not be touched with the fingers.

c. **Torque Arms.** The clamps and screws should be assembled to the torque arms and each arm tested for balance. Each arm may be balanced by filing lightly on the arm or counterweight.

DISASSEMBLY AND ASSEMBLY

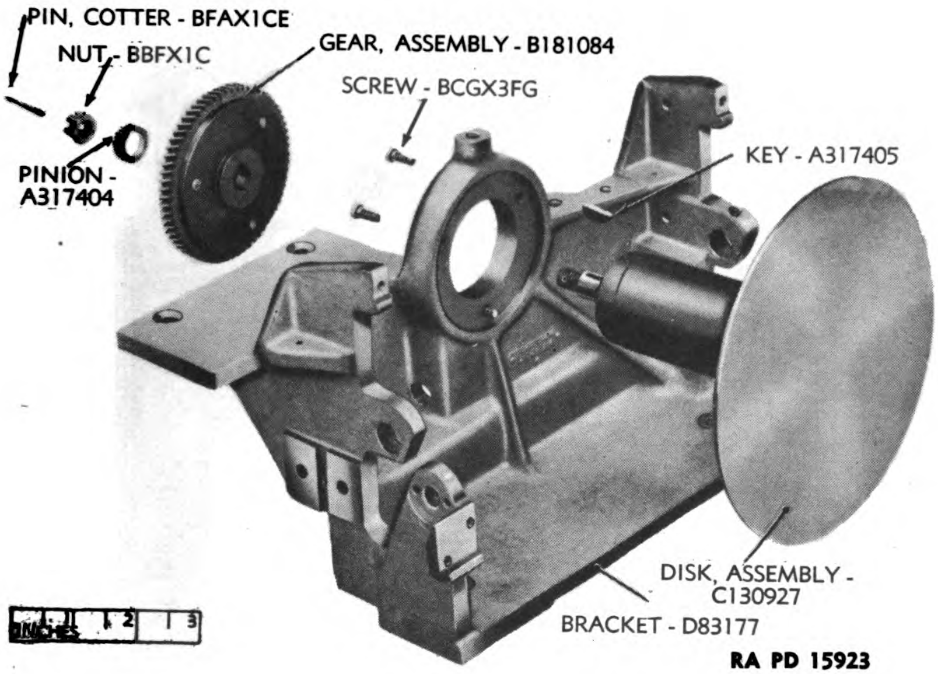


Figure 234 — Removing Disk Assembly (Director M5A1)

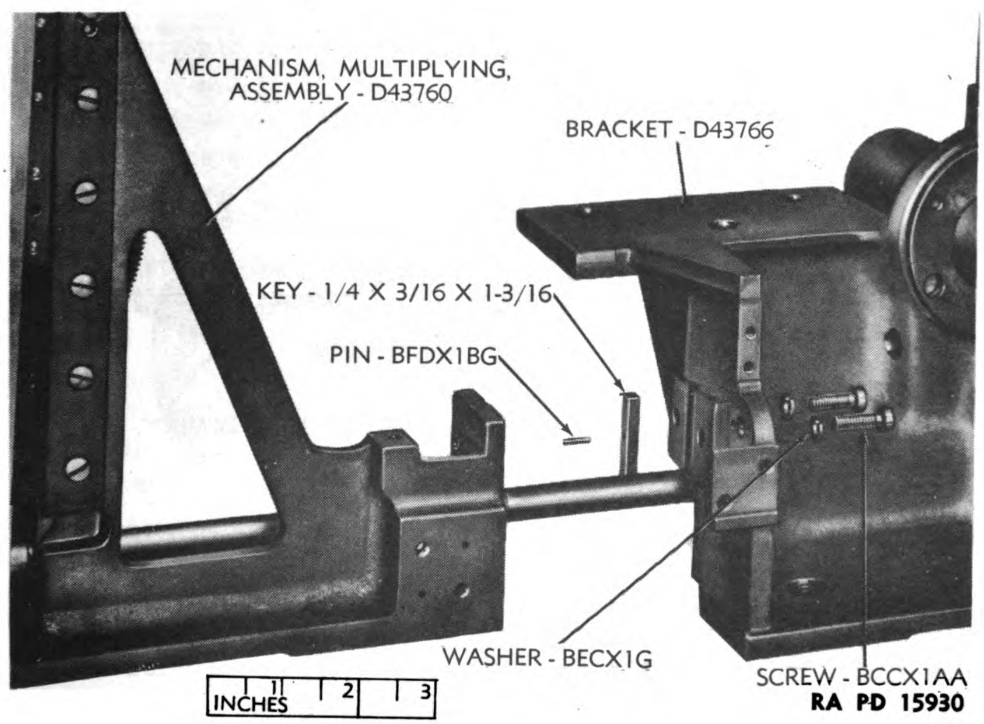


Figure 235 — Separating Variable Speed and Multiplying Mechanisms (Directors M5 and M6)

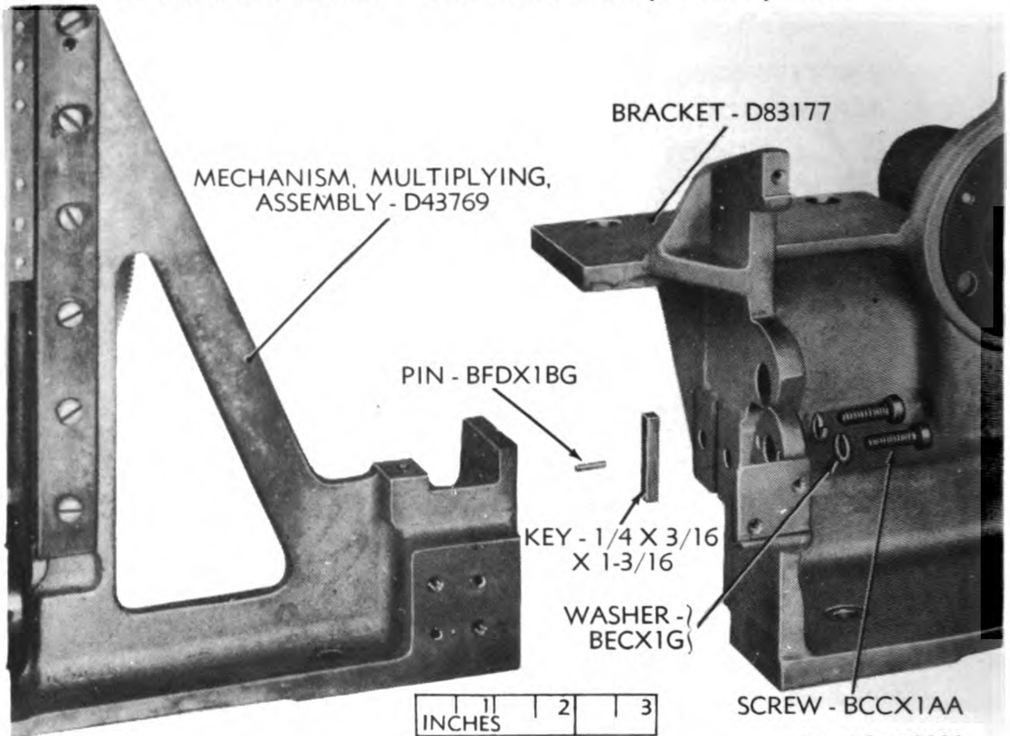


Figure 236 — Separating Variable Speed and Multiplying Mechanisms (Director M5A1)

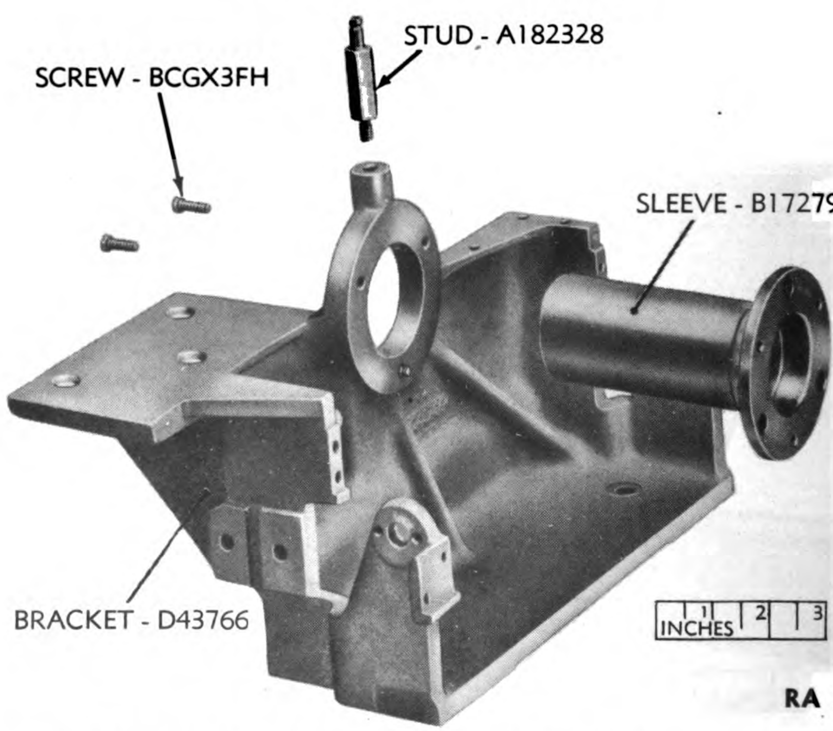


Figure 237 — Further Disassembly of Variable Speed Mechanism (Directors M5 and M6)

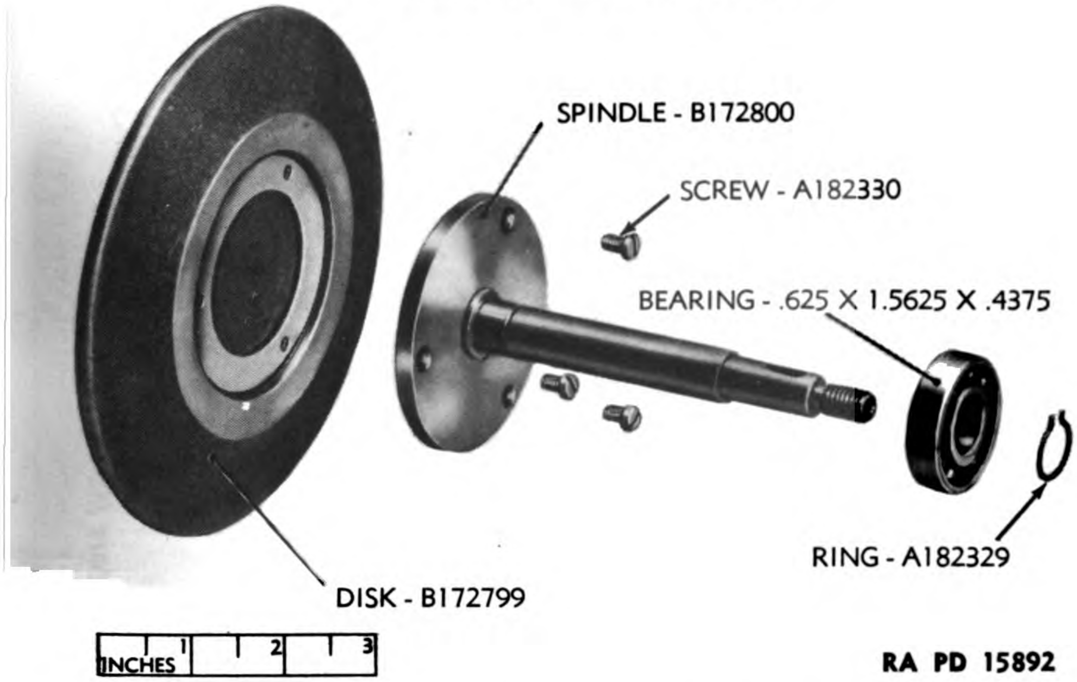


Figure 238 — Exploded View of Disk Assembly (Directors M5 and M6)

d. Replacing the Bands. With the tool shown in figure 81 or 277 or with masking tape, fasten the two torque arms together so that they are 180 degrees apart. Loosen the clamp on the right side of the output torque arm and insert the end of the band between the two screws and under the clamp, until it extends three-eighths inch on the other side. On some bands there is a small hole three-eighths inch from the end of the band, and some are copperplated for three-eighths inch at the end. If you have either type band, place the end marked through the output arm clamp. The short end of the band should extend towards the top of the torque amplifier on the input side. The band on the output side is wound in the opposite direction. Tighten the clamp so that the band leaves at such an angle that, when the band is wound into place, it does not ride on the edge of the friction ring. Wind the band into place, slipping it underneath the input torque arm each time it comes around (fig. 278). Attach the other end of the band to the input torque arm so that very little slack exists. Replace the band on the output drum assembly in a similar manner.

e. Alining Bands. Remove the masking tape or the special holding tool. By loosening the clamp alternately on the input and output torque arm, and shifting the band sideways, adjust it so that it will ride evenly over the center of the friction ring and will not spread when the output coupling is held and the input coupling is rotated slightly. Check for spread at each line of solder drops. Spreading

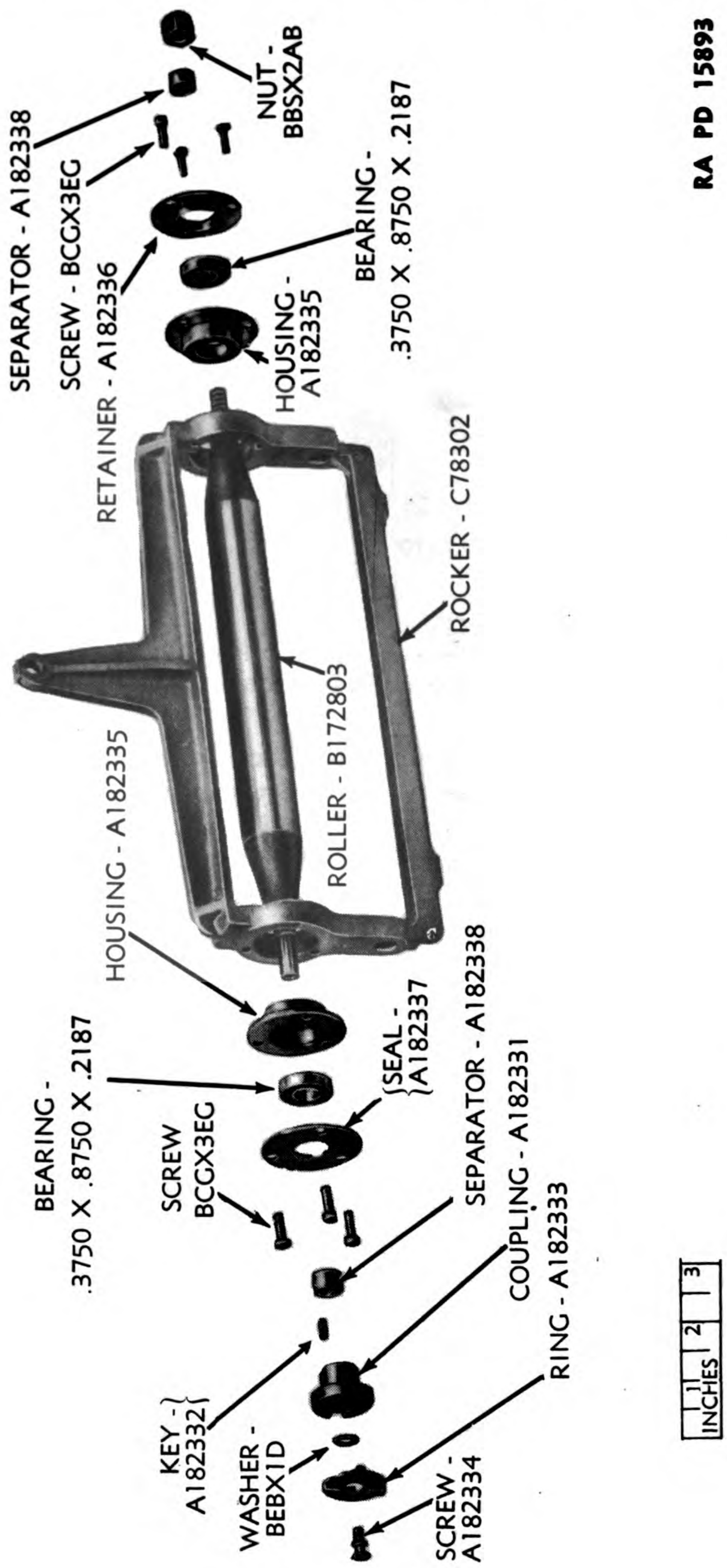


Figure 239 — Parts of Rocker Assembly C78301 (Directors M5 and M6)

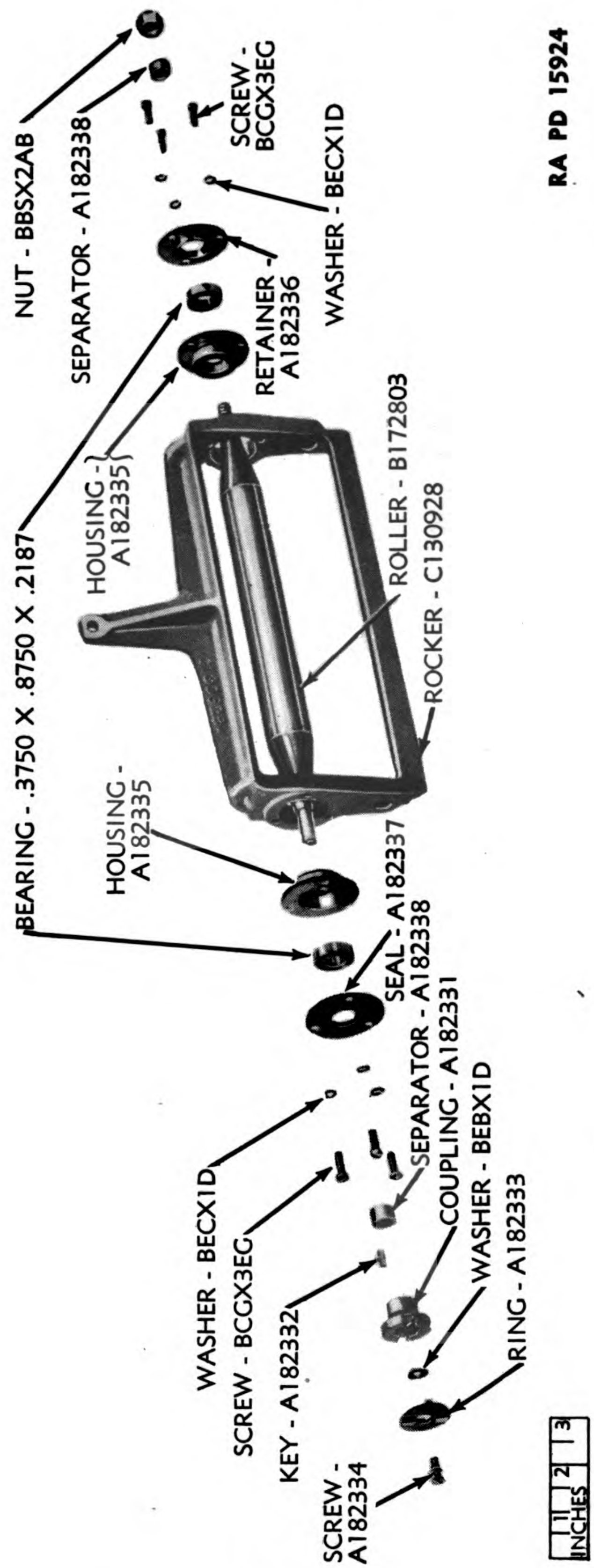


Figure 240 — Parts of Rocker Assembly C130774 (Director M5A1)

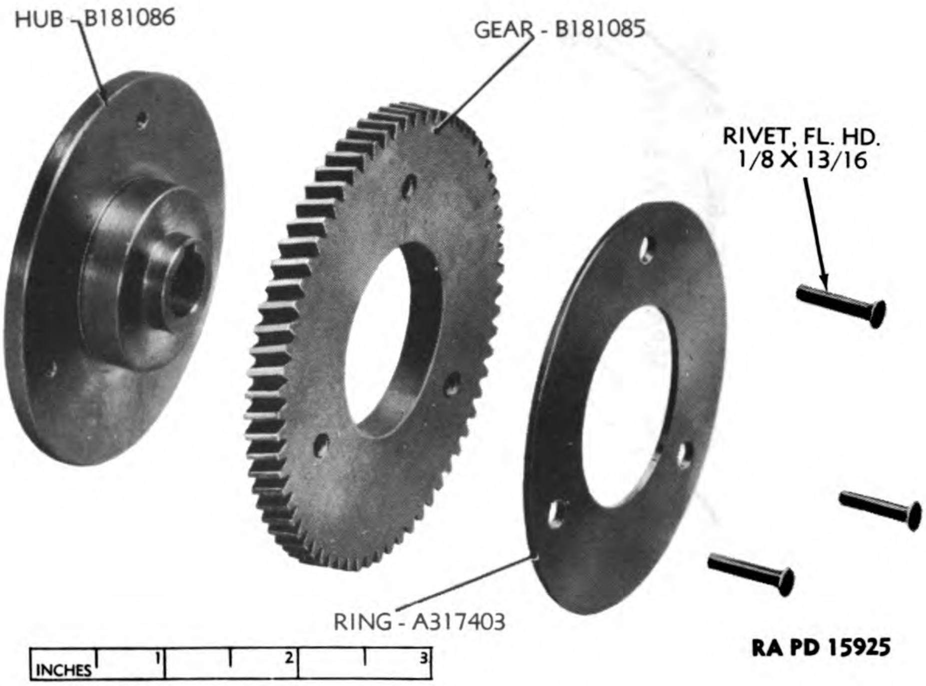


Figure 241 — Exploded View of Riveted Gear Assembly B181084 (Director M5A1)

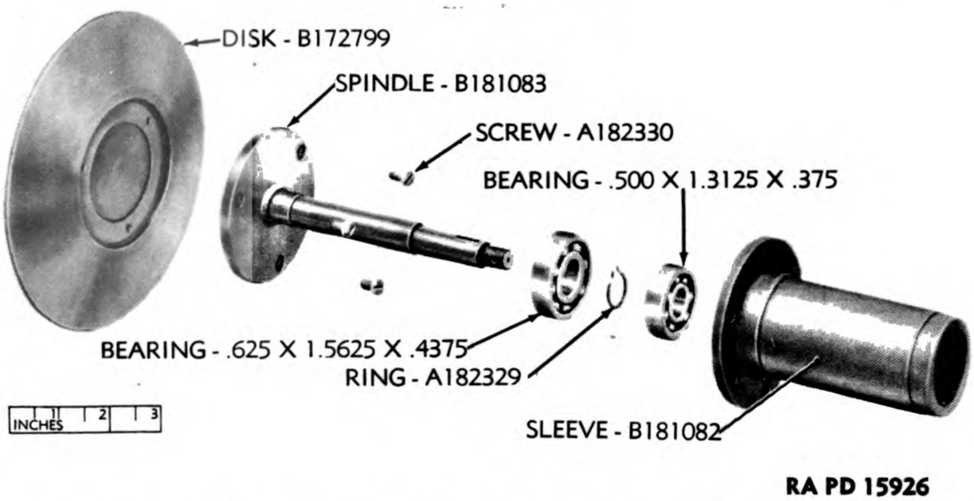


Figure 242 — Exploded View of Disk Assembly C130927 (Director M5A1)

must be kept to a minimum. When this is accomplished, tighten the screws on the output torque arm firmly and do not again touch them. Make further adjustments at the input torque arm only.

f. Adjusting Backlash.

(1) Turn the input coupling while the output coupling is being

DISASSEMBLY AND ASSEMBLY

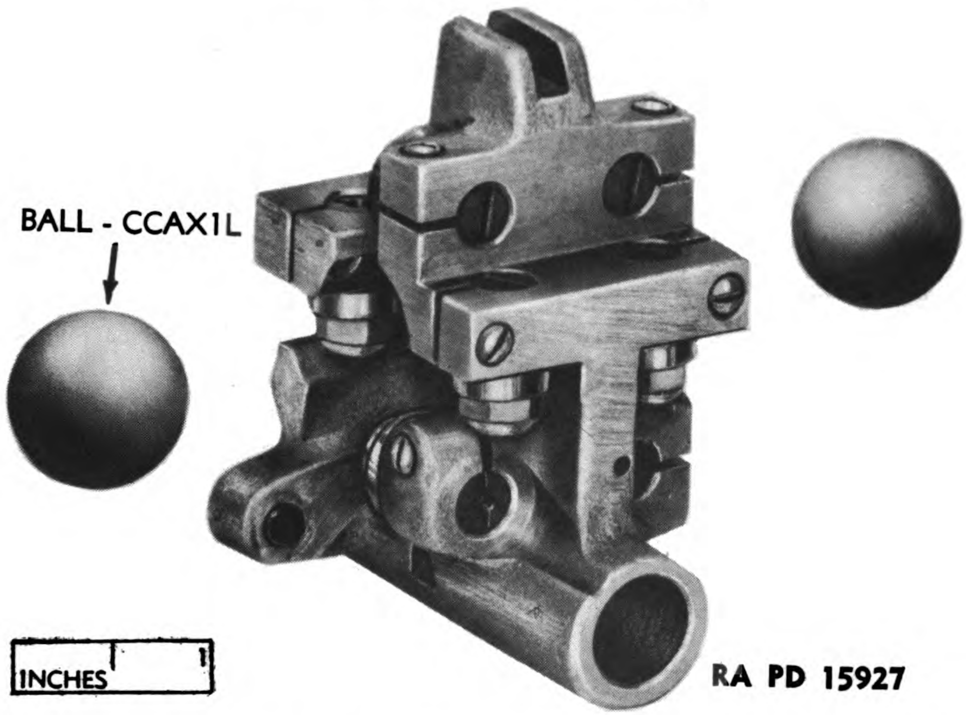


Figure 243 — Ball Bearing Slider Assembly (Ball Carriage) and ⅞-inch Balls Used in Director M5A1

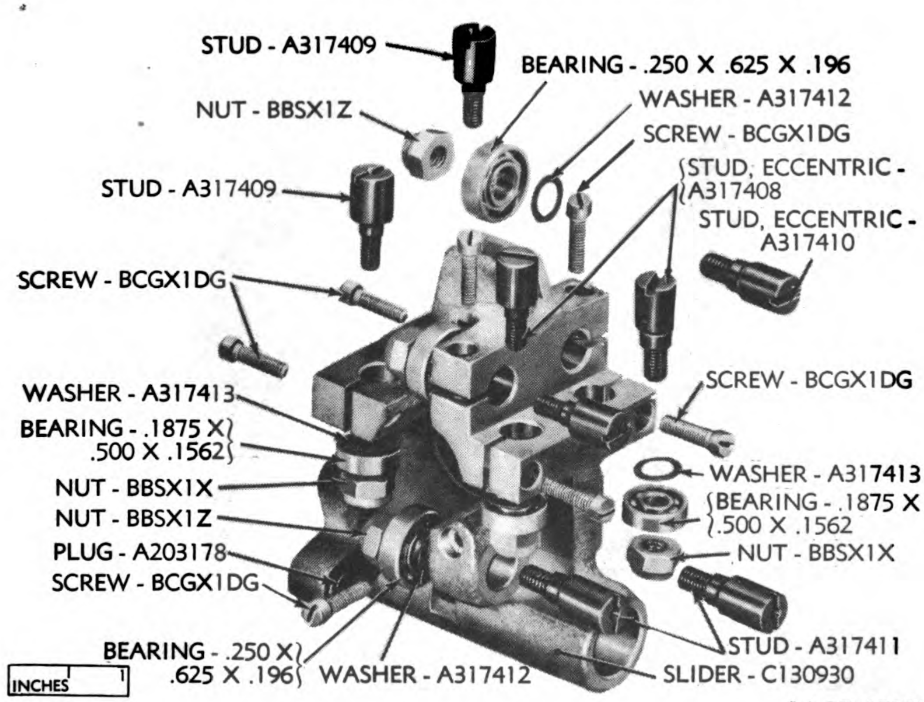


Figure 244 — Exploded View of Ball Slider Assembly C130929 (Director M5A1)

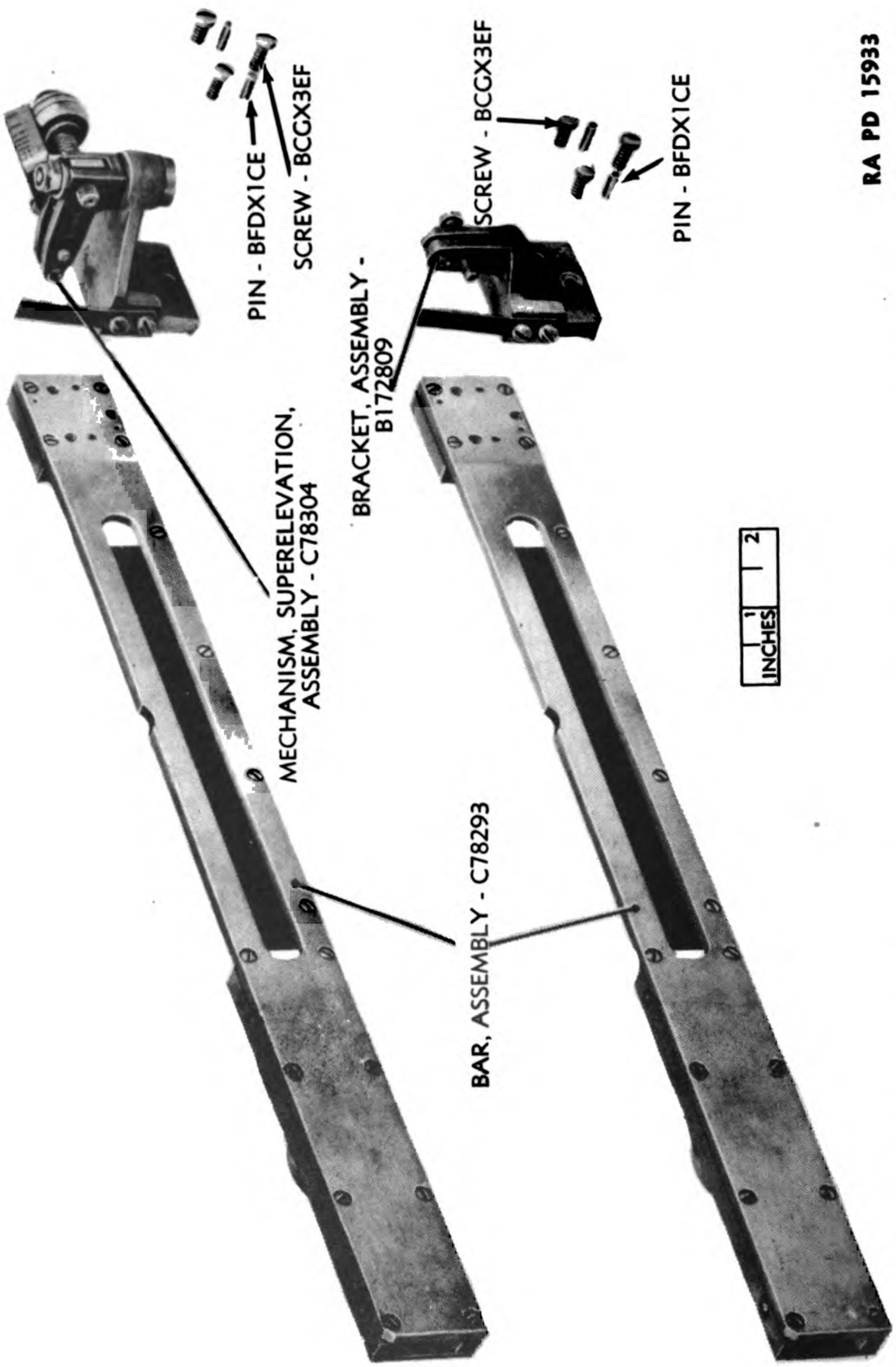


Figure 245 — Removing Superelevation or Bracket Assembly (Directors M5 and M6)

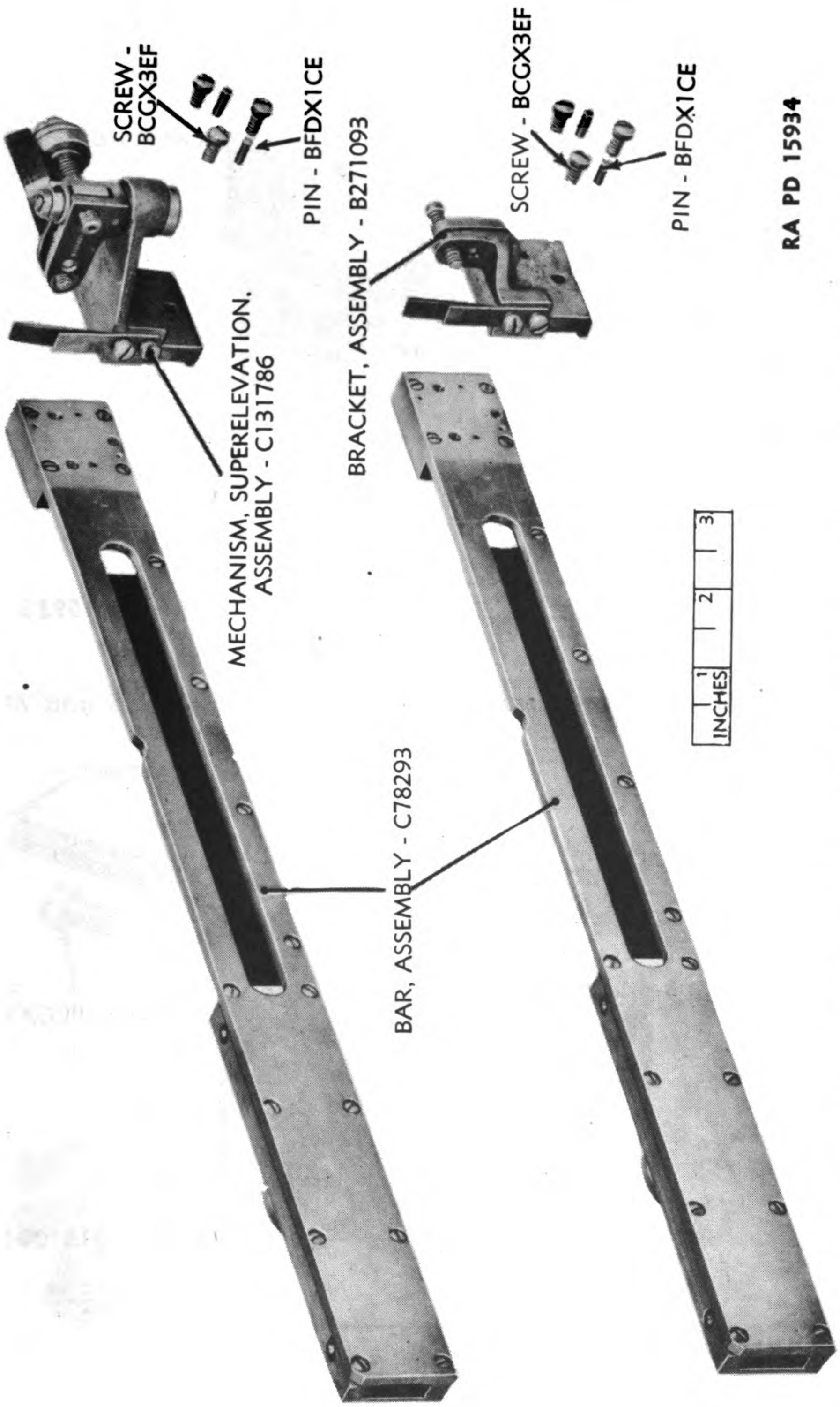
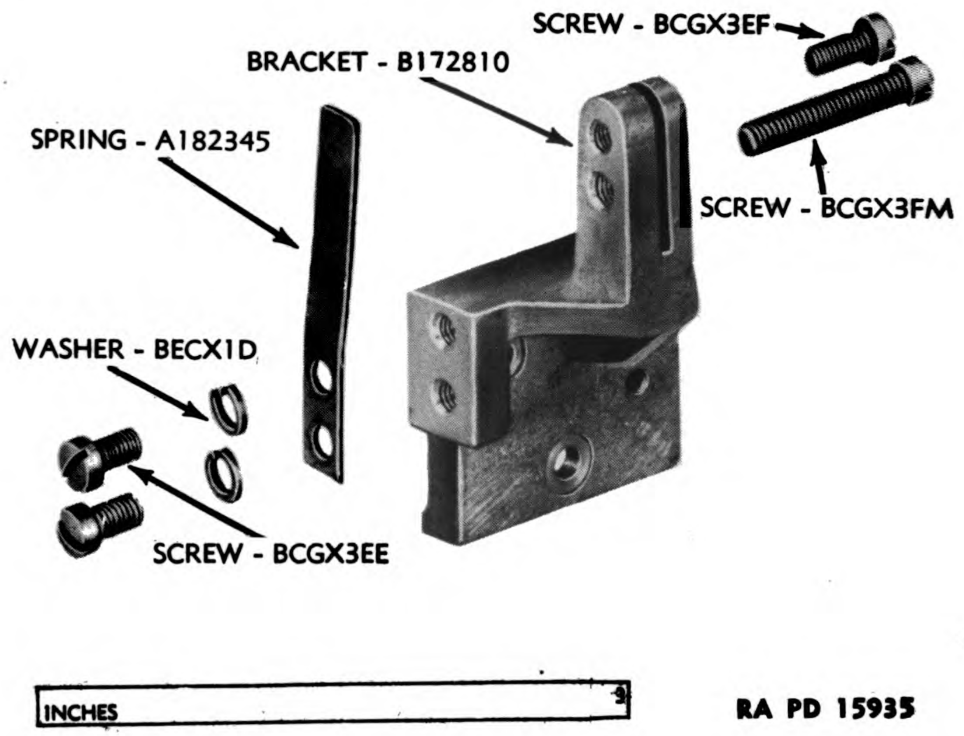
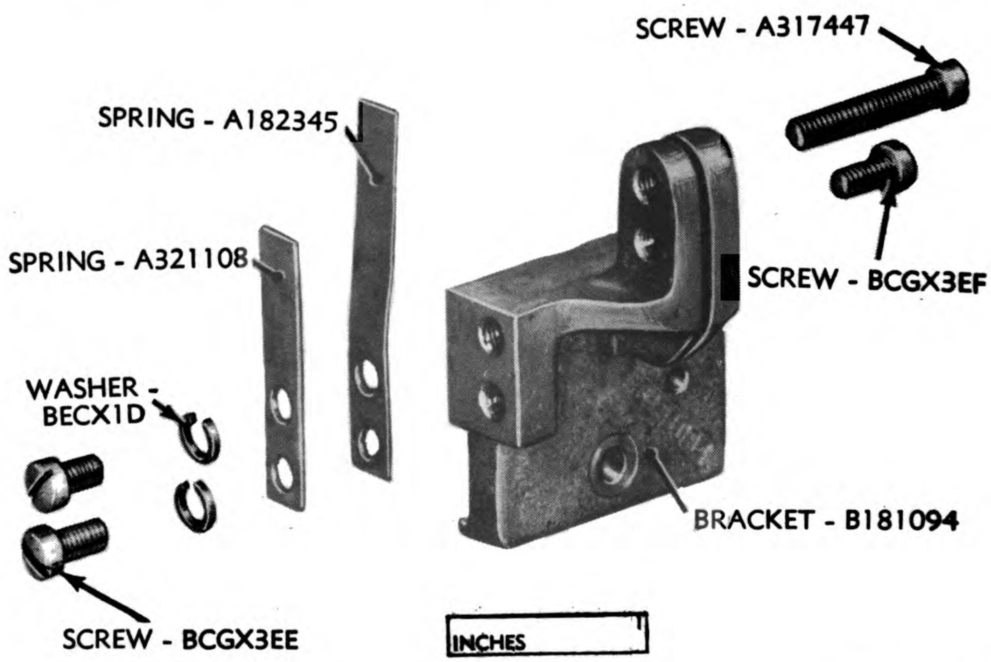


Figure 246 — Removing Superelevation or Bracket Assembly (Director M5A1)



RA PD 15935

Figure 247 — Bracket Assembly B172809 (Directors M5 and M6)



RA PD 15936

Figure 248 — Bracket Assembly B271093 (Director M5A1)

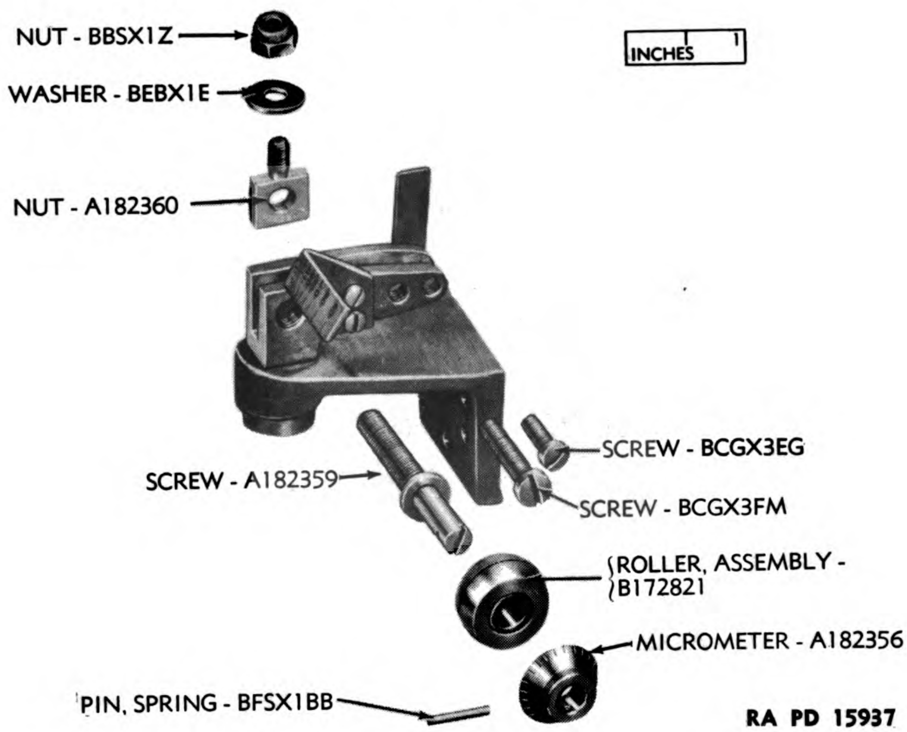


Figure 249 — Disassembly of Superelevation Mechanism C78304 (Directors M5 and M6)

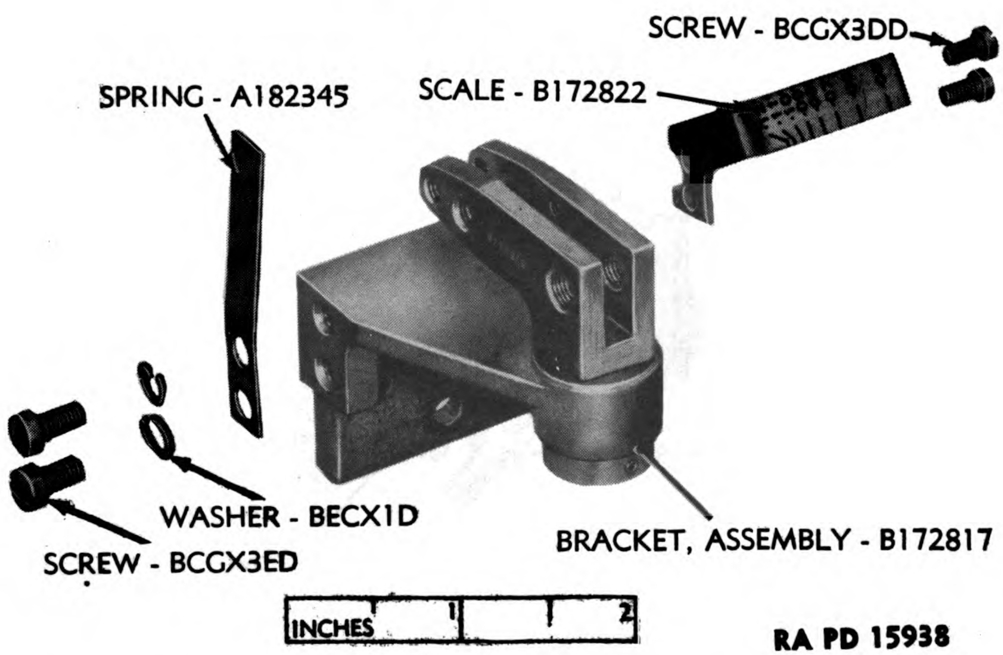


Figure 250 — Further Disassembly of Superelevation Mechanism (Directors M5 and M6)

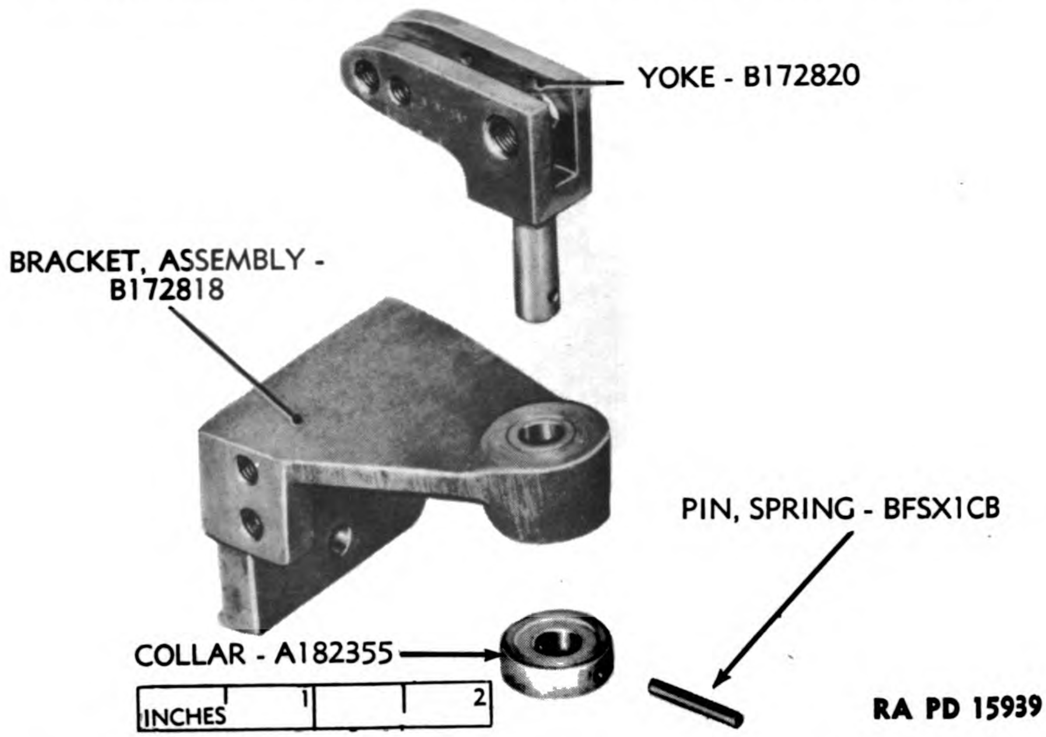


Figure 251 — Parts of Superelevation Bracket Assembly B172817 (Directors M5 and M6)

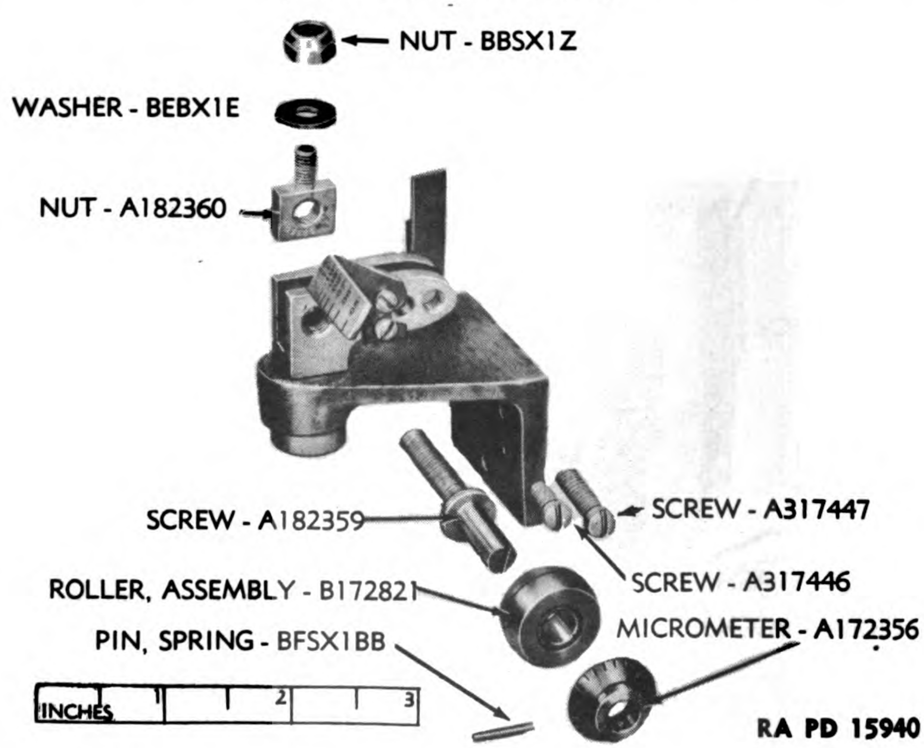


Figure 252 — Disassembly of Superelevation Mechanism C131786 (Director M5A1)

DISASSEMBLY AND ASSEMBLY

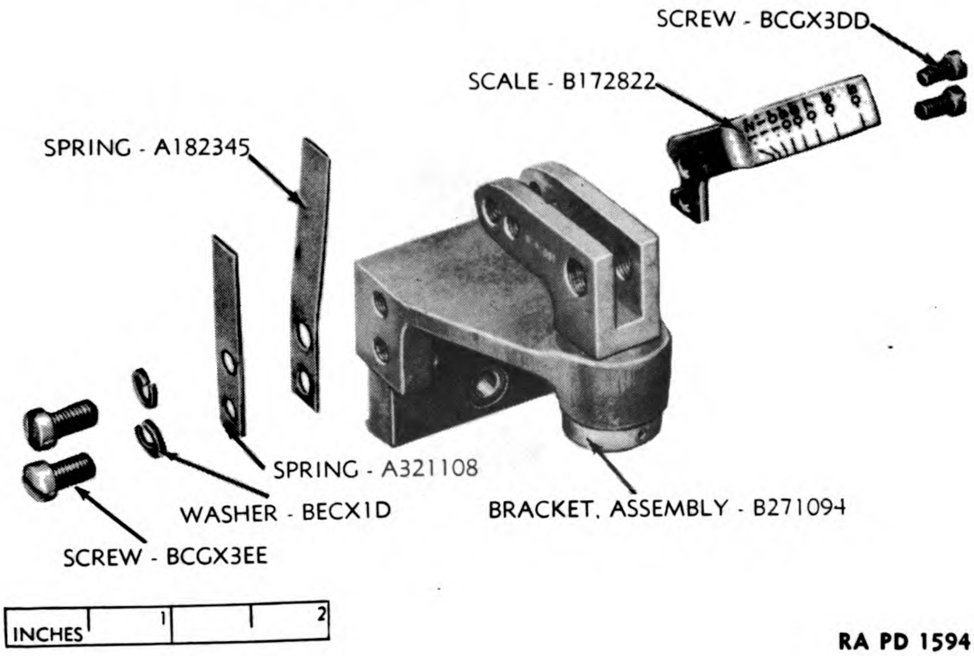


Figure 253 — Further Disassembly of Superelevation Mechanism (Director M5A1)

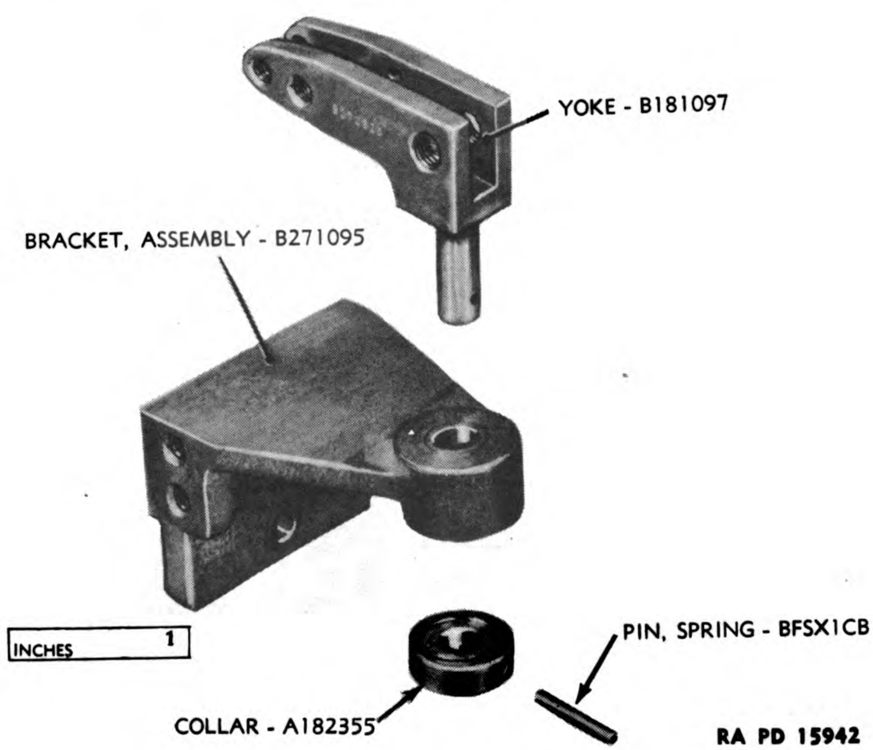


Figure 254 — Parts of Superelevation Bracket Assembly B271094 (Director M5A1)

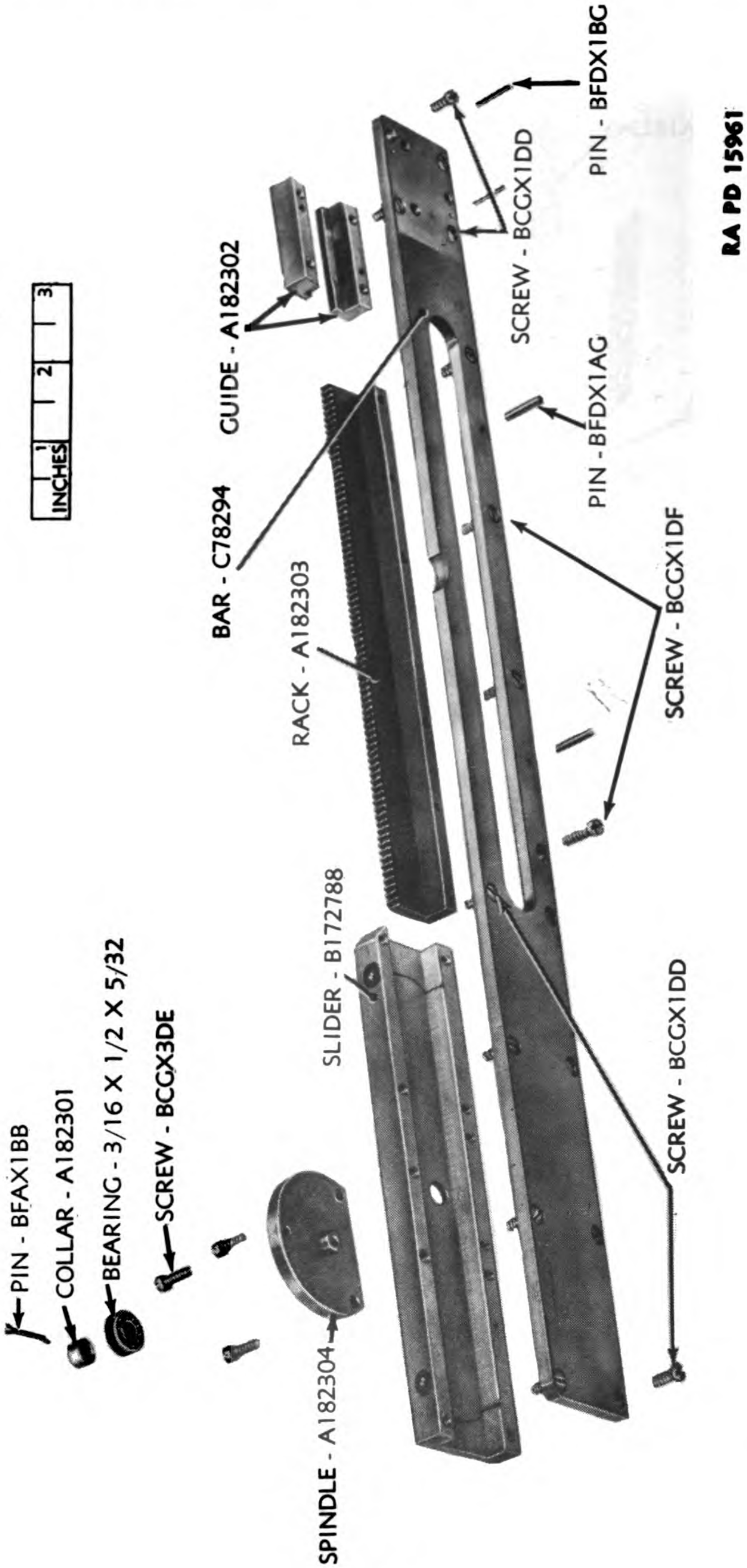


Figure 255 — Parts of Bar Assembly C78293

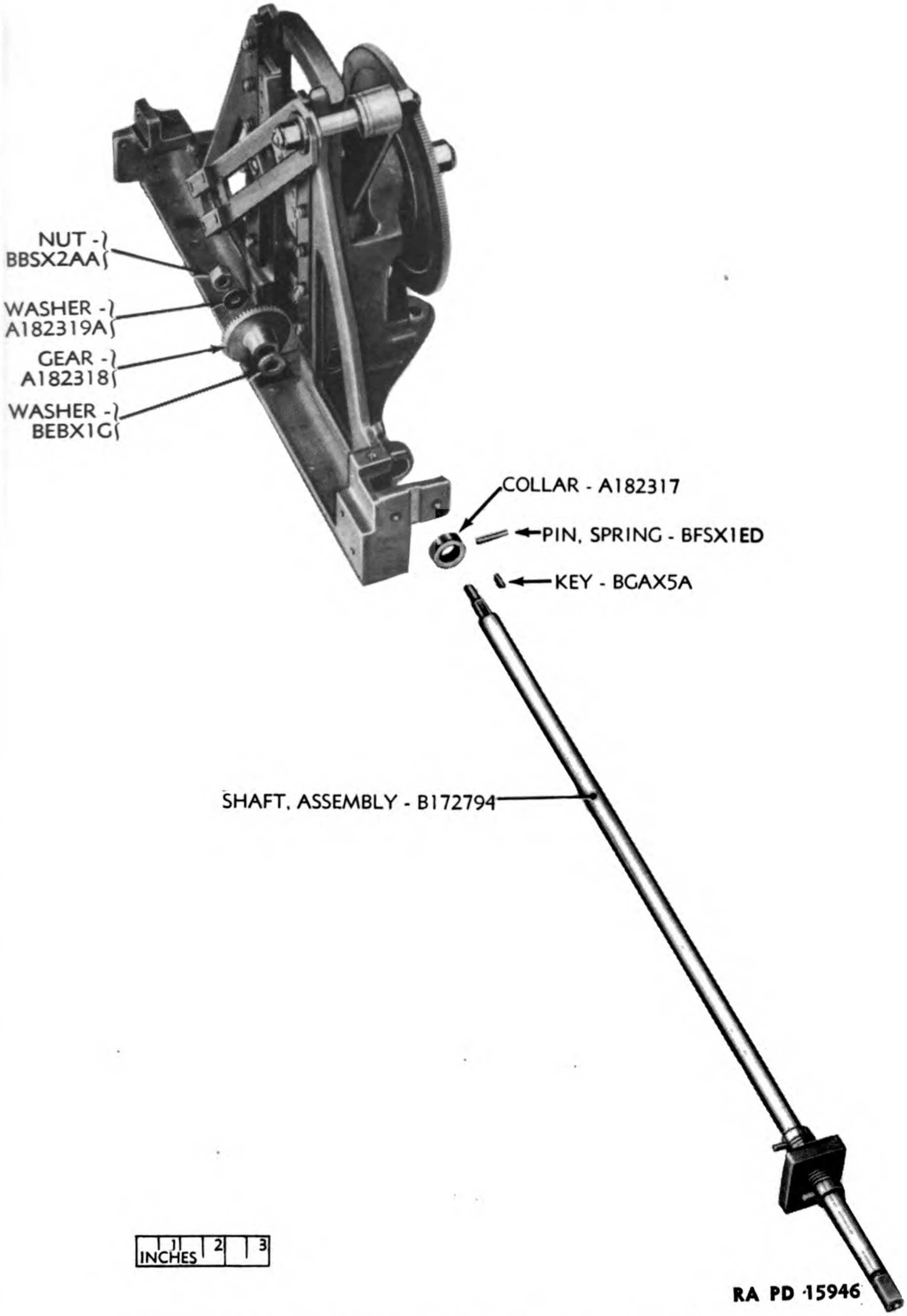


Figure 256 — Disassembly of Lateral Multiplying Mechanism Assembly D43760 (Directors M5, M6 and M5A1)

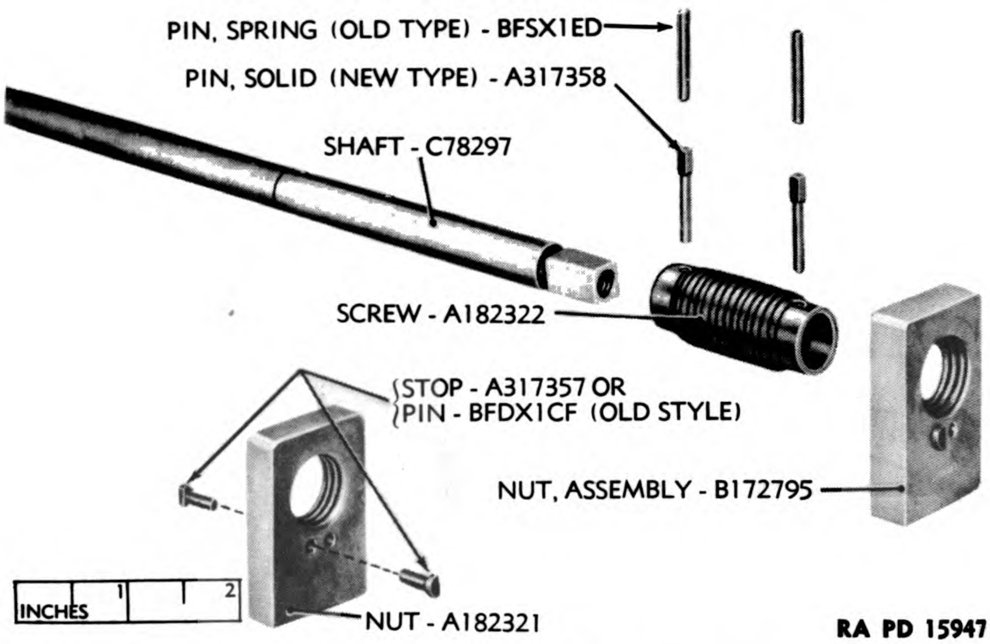


Figure 257 — Range Stop Nut and Associated Parts of Shaft Assembly B172794

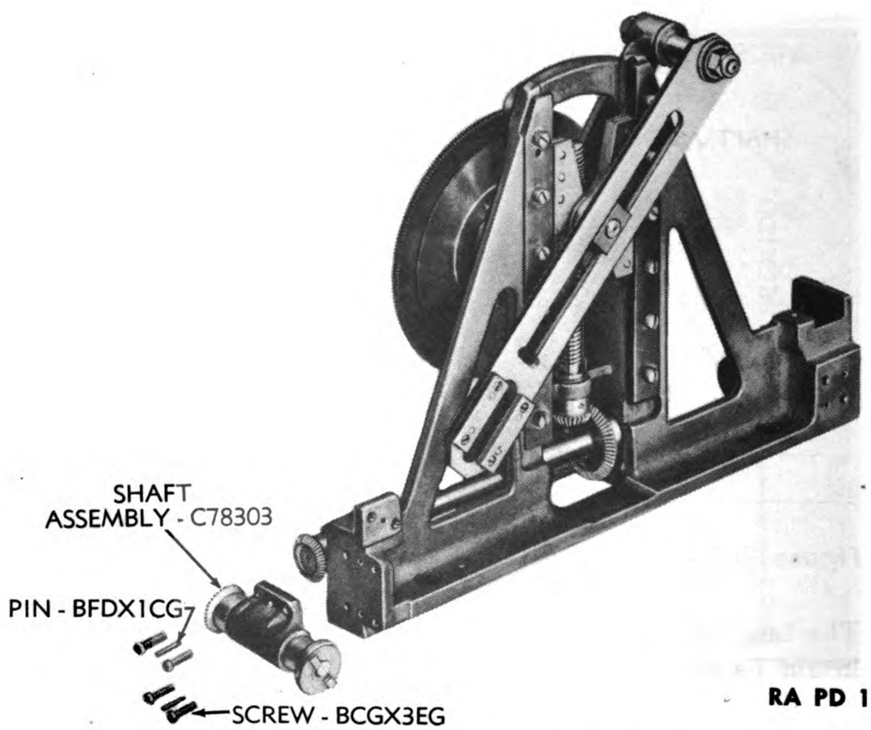


Figure 258 — Disassembly of Vertical Deflection Multiplying Mechanism D43769

DISASSEMBLY AND ASSEMBLY

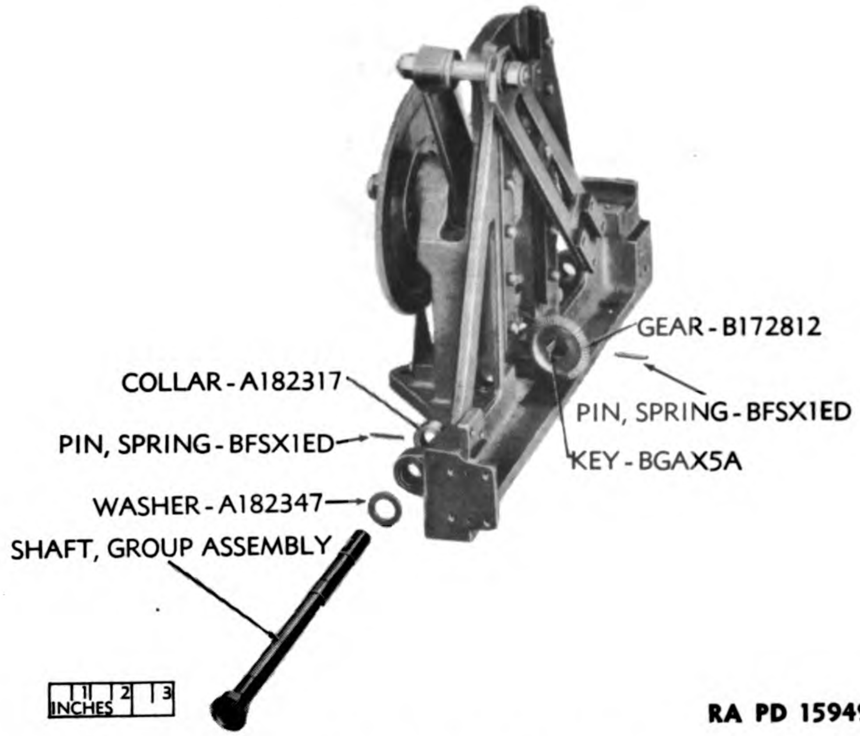


Figure 259 — Disassembly of Vertical Deflection Multiplying Mechanism D43769

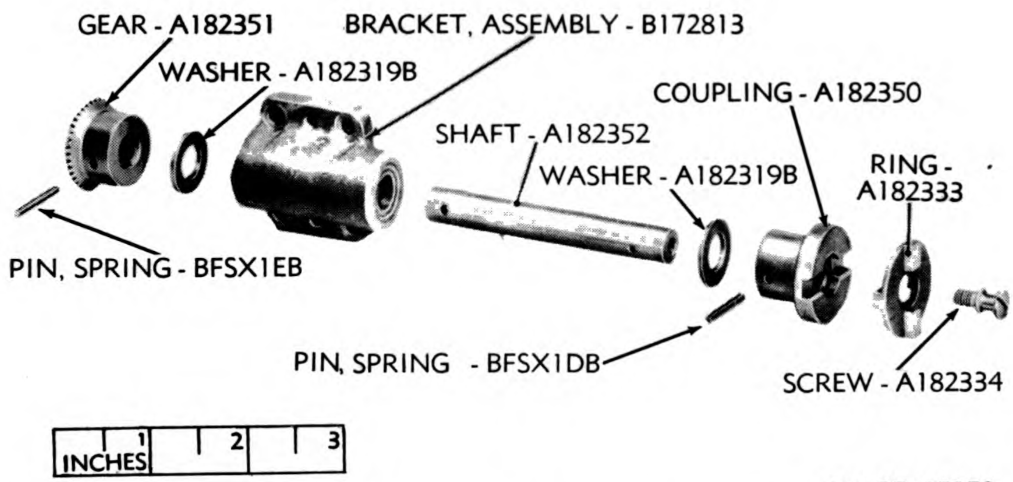


Figure 260 — Exploded View of Shaft Assembly C78303

held. The backlash between the torque arms, measured at the torque arms, should be between $\frac{3}{64}$ and $\frac{1}{16}$ inch. If it is excessive, the end of the band should be drawn in slightly at the input torque arm. Recheck the alinement of the bands.

(2) It should be possible to turn the output and input couplings in opposite directions, simultaneously, without appreciable effort. If

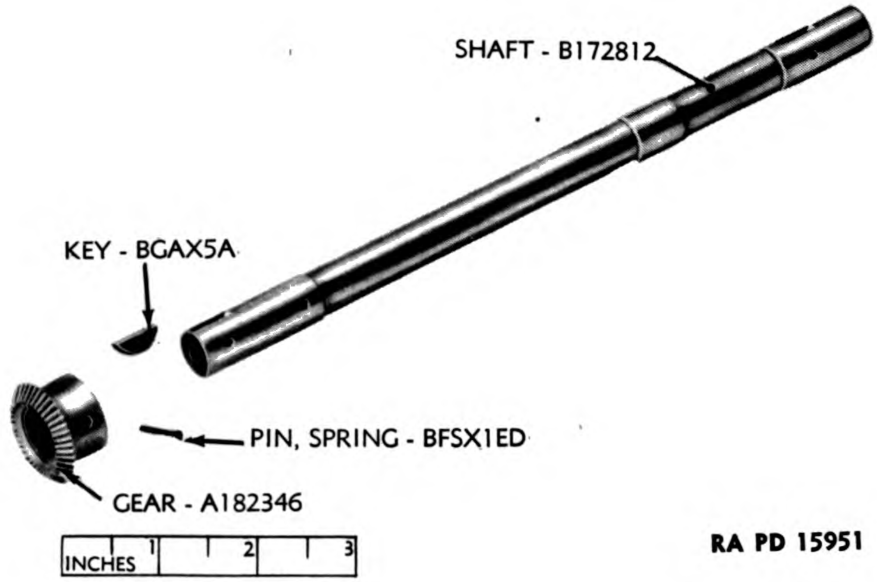


Figure 261 — Shaft Group Assembly of Vertical Multiplying Mechanism

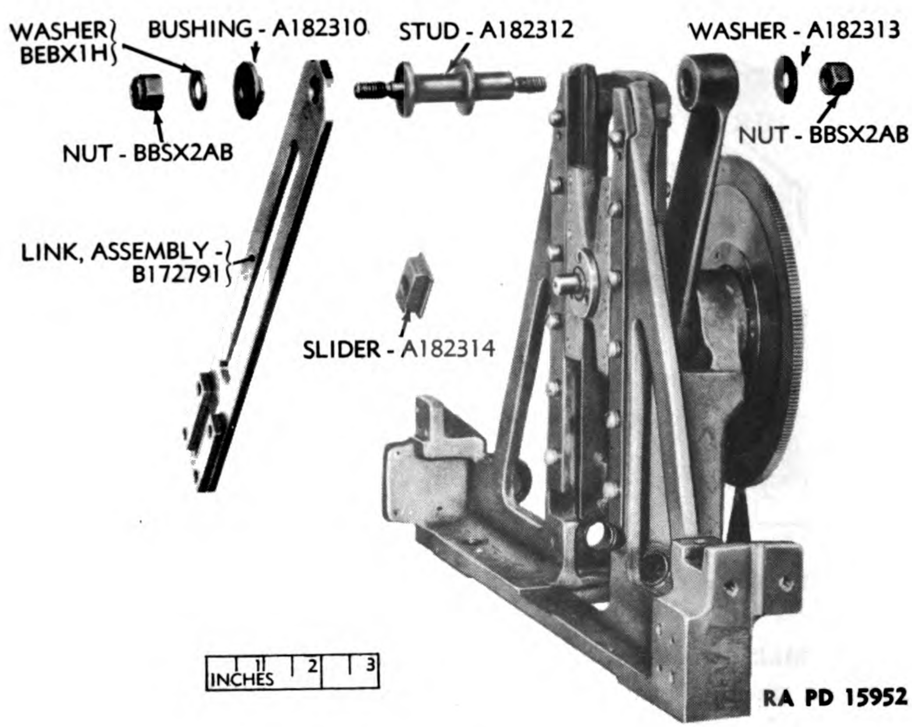


Figure 262 — Further Disassembly of Multiplying Mechanism D43760 or D43769

DISASSEMBLY AND ASSEMBLY

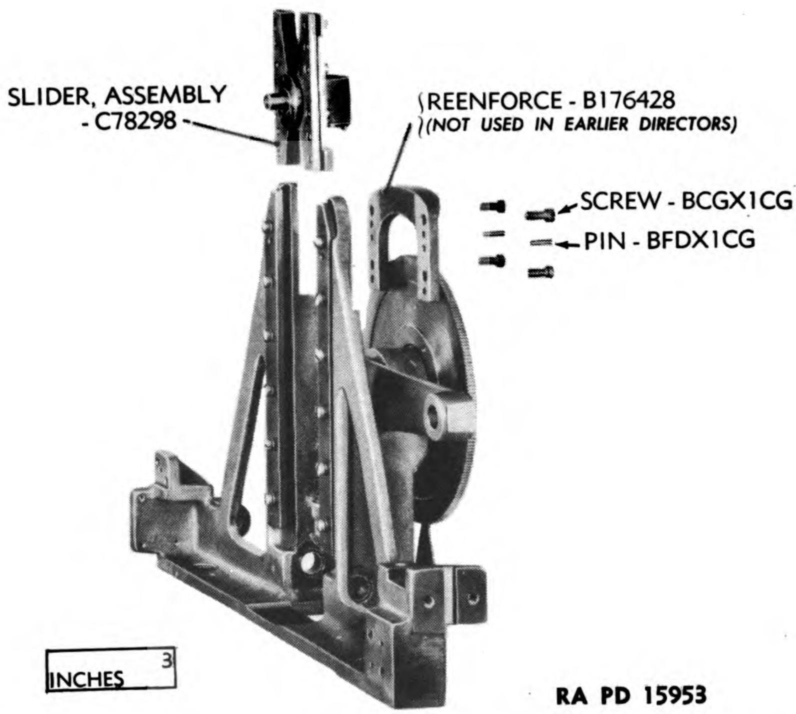


Figure 263 — Further Disassembly of Multiplying Mechanism D43760 or D43769

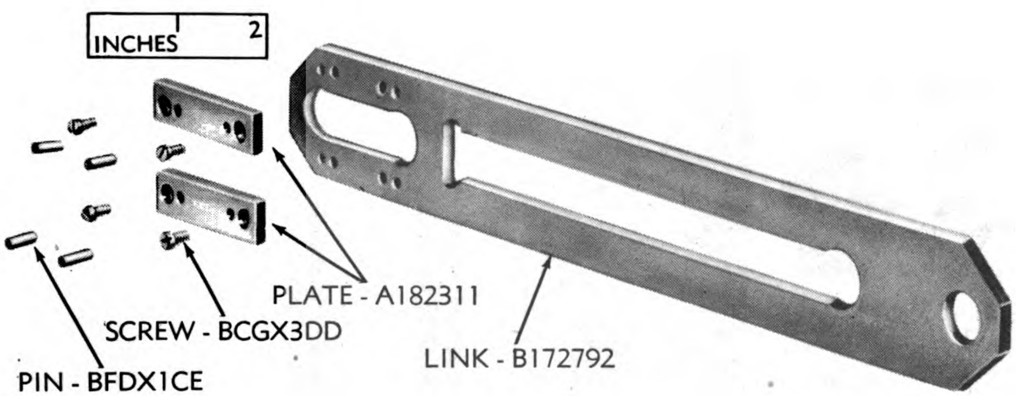


Figure 264 — Exploded View of Link Assembly B172791

the drag is excessive, the bands may be too tight. However, it is possible that oil or moisture has been inadvertently dropped on the friction ring, in which event the ring will probably have to be replaced. The drag should not be sufficient to cause the rings to be turned when the couplings are rotated in opposite directions at the same

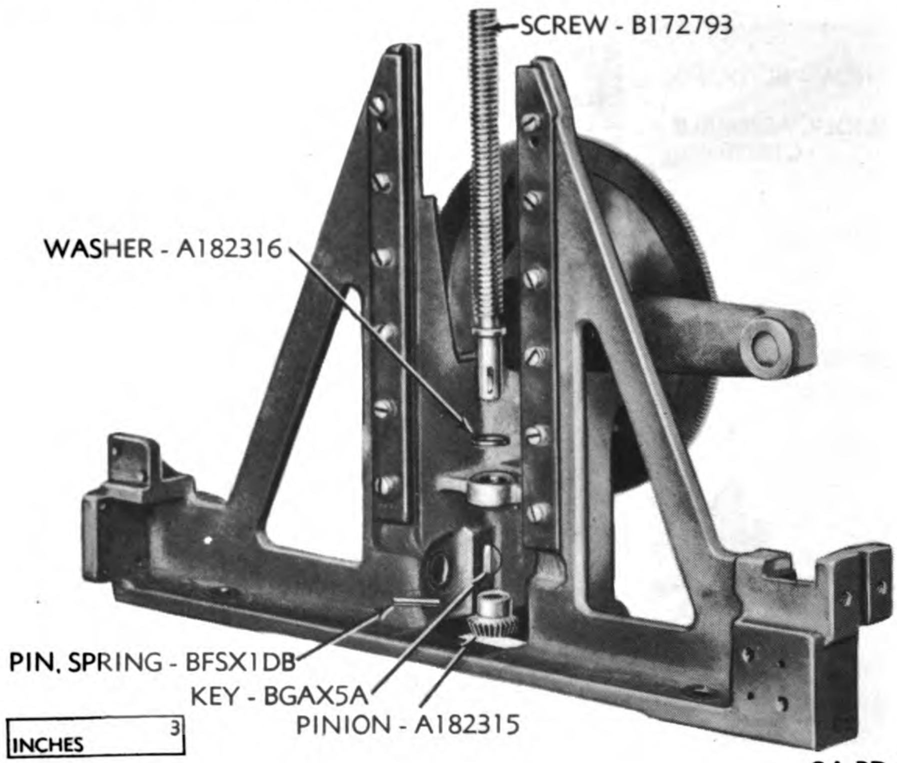


Figure 265 — Removal of Time Screw From Multiplying Mechanism

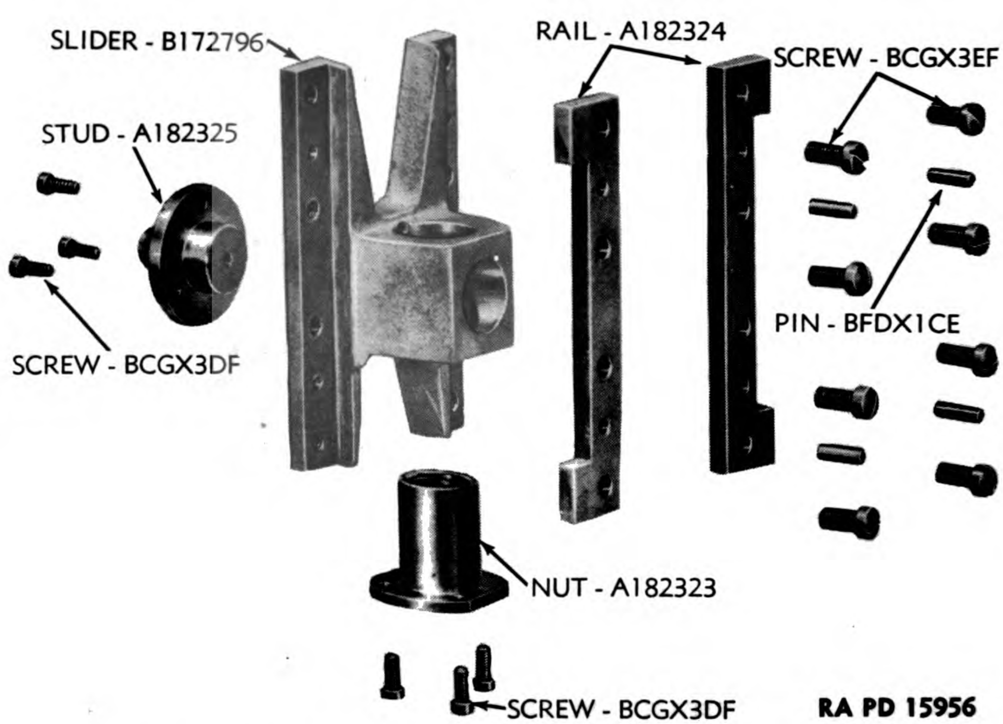


Figure 266 — Exploded View of Slider Assembly C78298

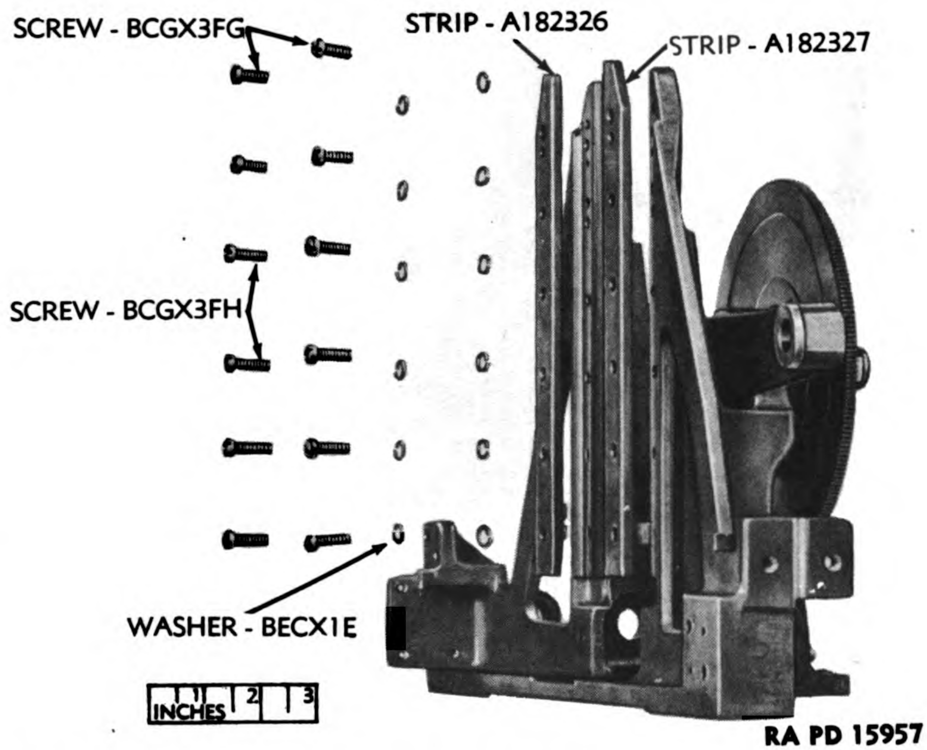


Figure 267 — Removal of Slideway Strips From Multiplying Mechanism

time. Also check to see that the band on either drum is not overriding itself.

g. **Testing for Bias.** Connect power to motor. Note that the phase connections are correct. When phase connections are correct, the input friction ring will turn in a counterclockwise direction (looking at the torque amplifier from the large cover plate side) and the output friction ring will turn in a clockwise direction. When both input and output couplings are not loaded, neither coupling should turn when the motor is running. If they do turn, it is a condition known as "bias." Any bias must be stopped by a ⅛-ounce weight suspended from the input coupling. Bias indicates that the amount of friction between the band and friction ring on one side is greater than that on the other side. Any tendency of the coupling to turn may be corrected by decreasing the amount of band extending through the clamp on one side of the input torque arm, and increasing the amount of band extending through the clamp on the other side of the input torque arm. This adjustment changes the amount of band which is in contact with a friction ring, thus tending to equalize the amount of friction. However, it also changes the relative positions of the arms which must not be adjusted more than 5 degrees from the 180-degree relation.

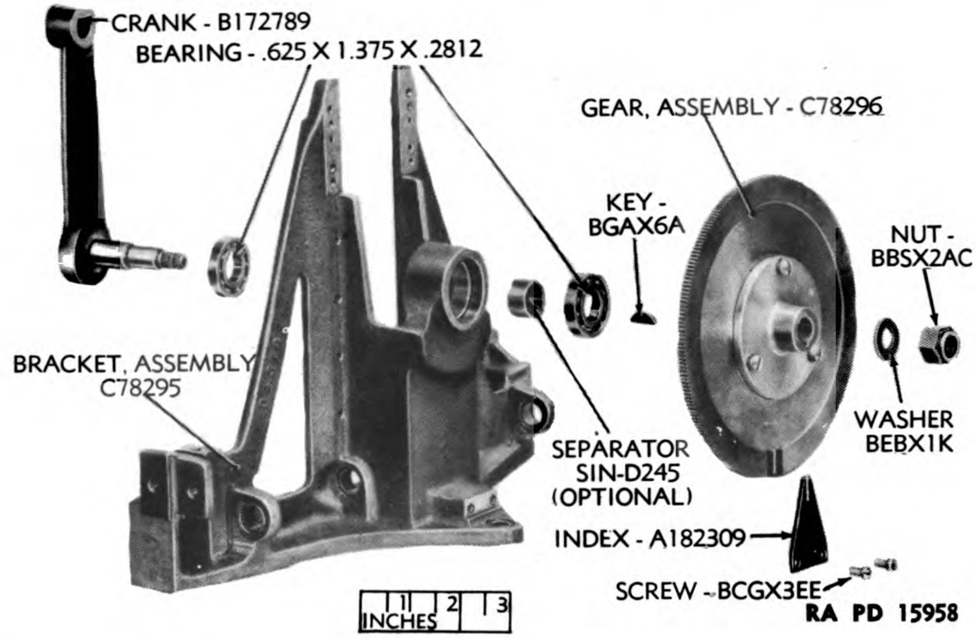


Figure 268 — Crank and Gear Removed From Multiplying Mechanism

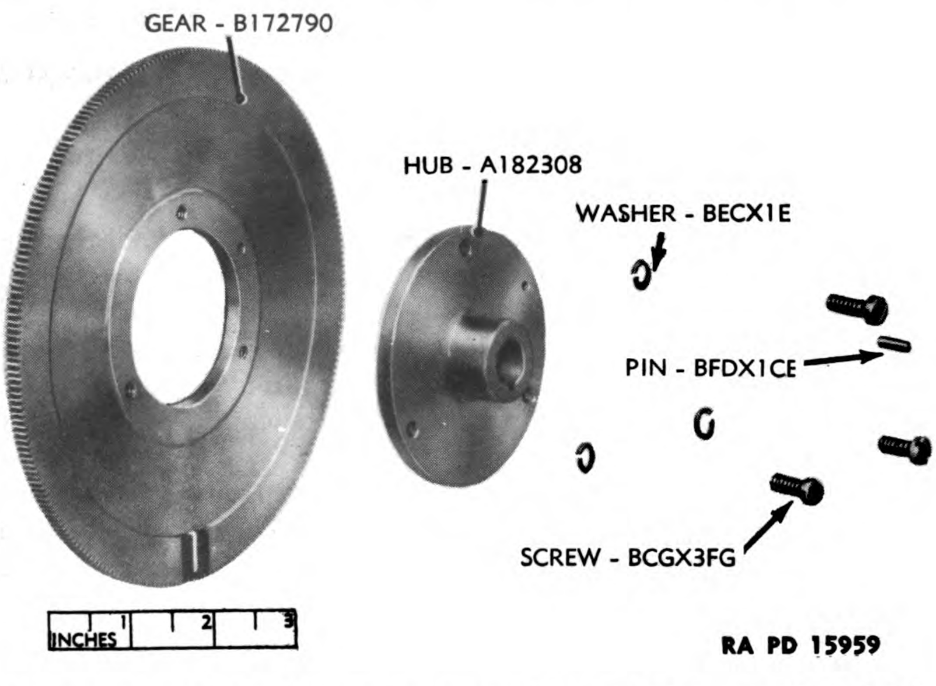


Figure 269 — Deflection Gear Assembly C78296 — Exploded View

h. Sensitivity and Amplification Tests. These tests should now be made as described in paragraph 36. If the sensitivity is poor, look for friction in the ball bearings or too tight a mesh of the input shaft gears. If the output torque is jerky (more than about 2 ounces with

DISASSEMBLY AND ASSEMBLY

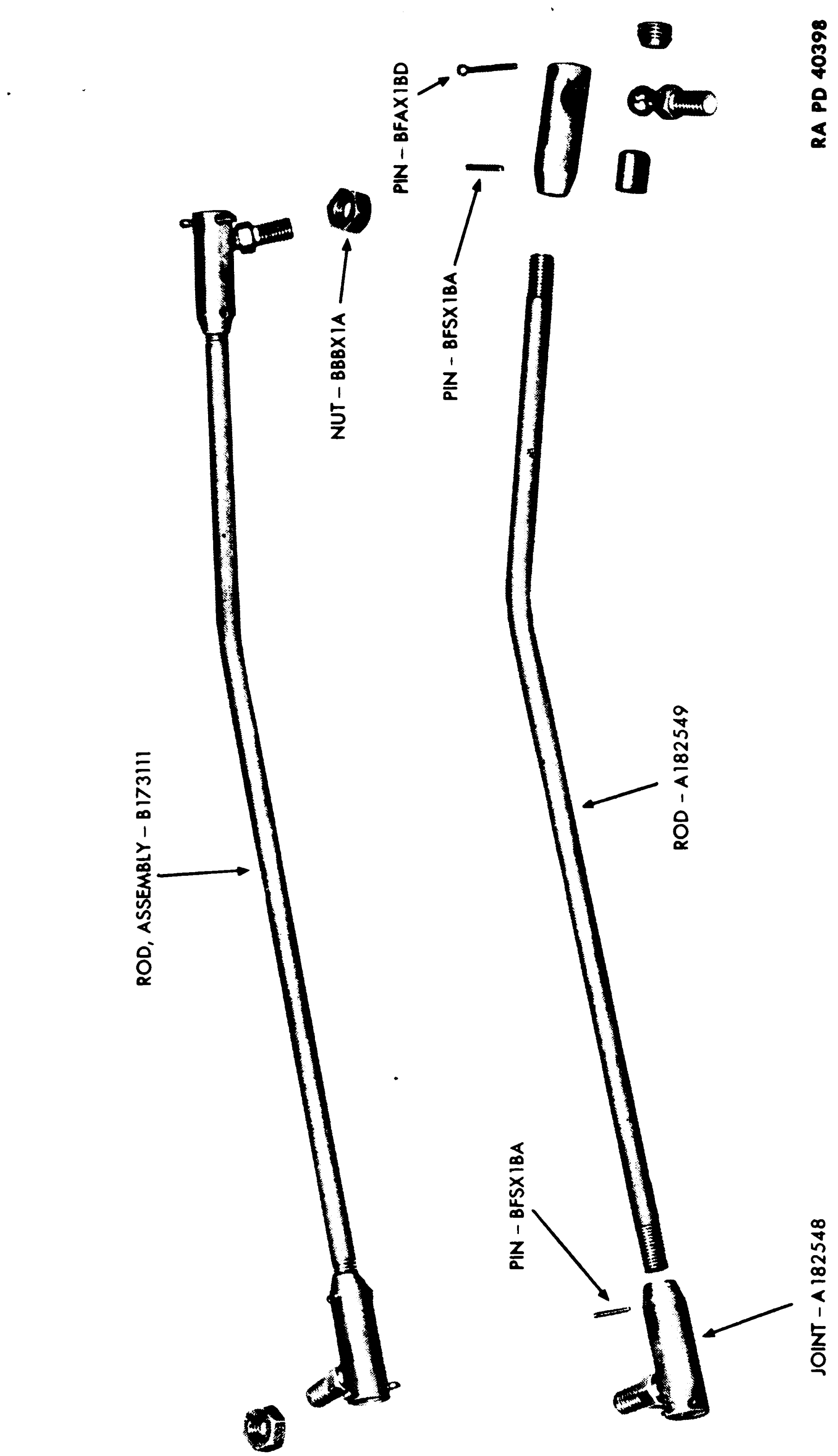


Figure 270 — Superelevation Connecting Rod Assembly B173111 — Assembled and Exploded Views

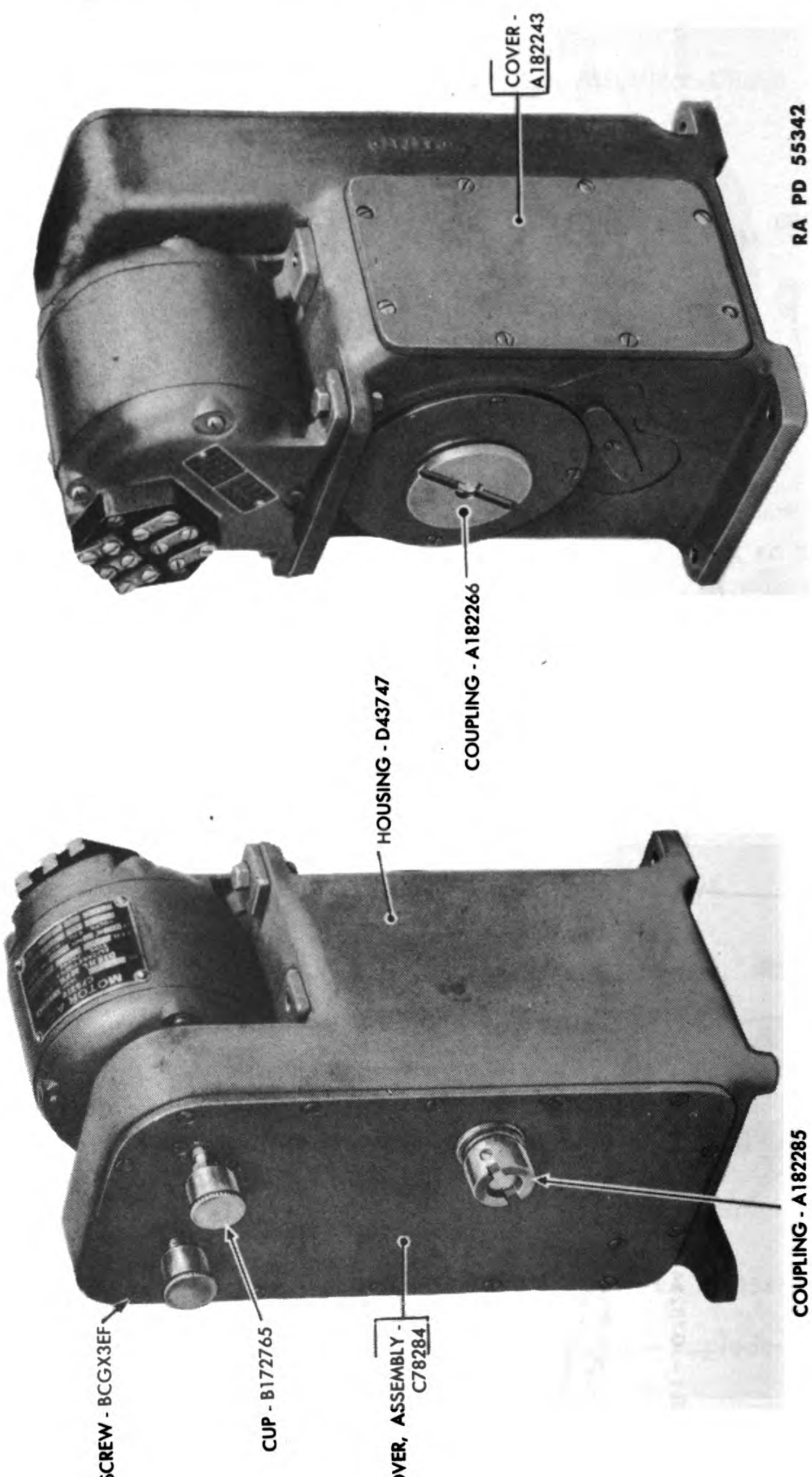


Figure 271 — Torque Amplifier Assembly D43745 (Directors M5 and M6)

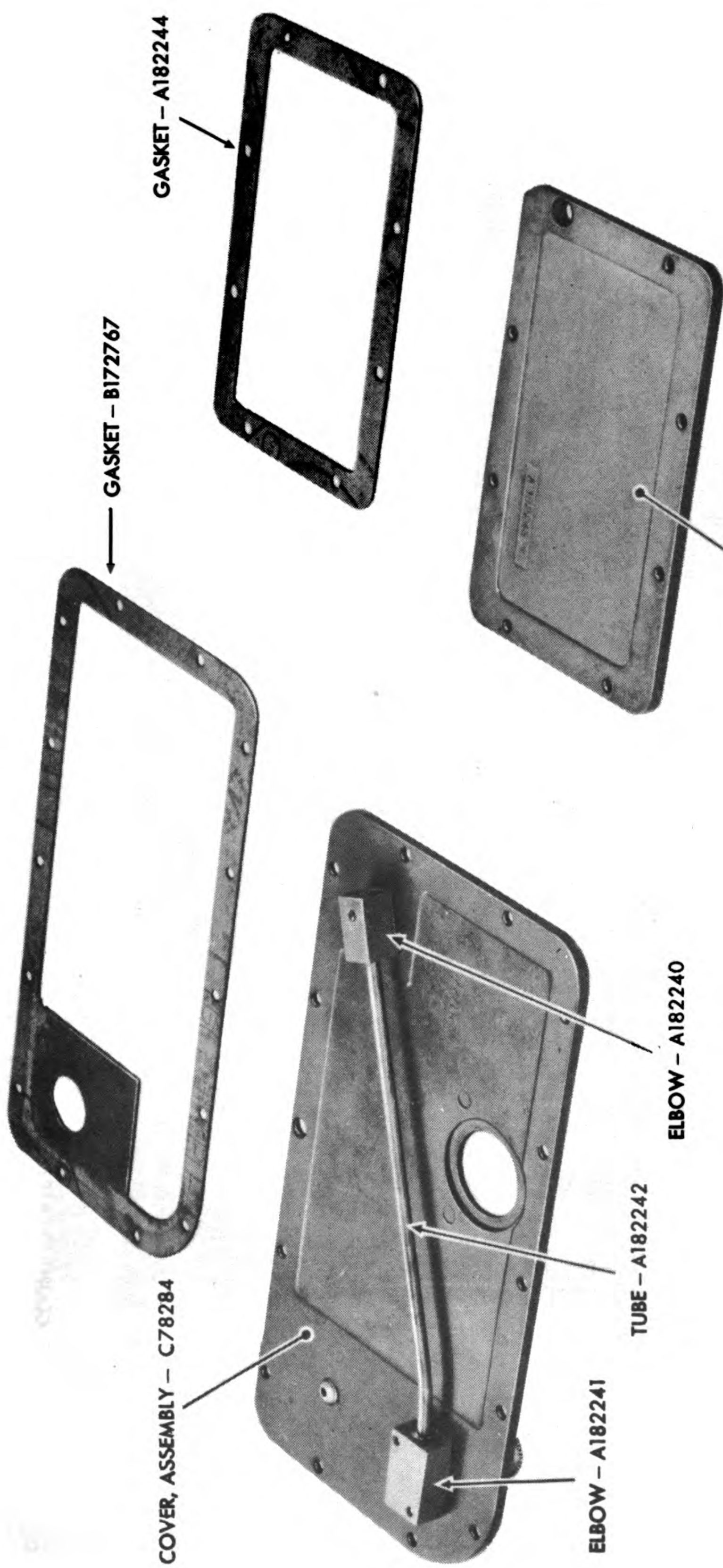


Figure 272 — Torque Amplifier Covers and Gaskets

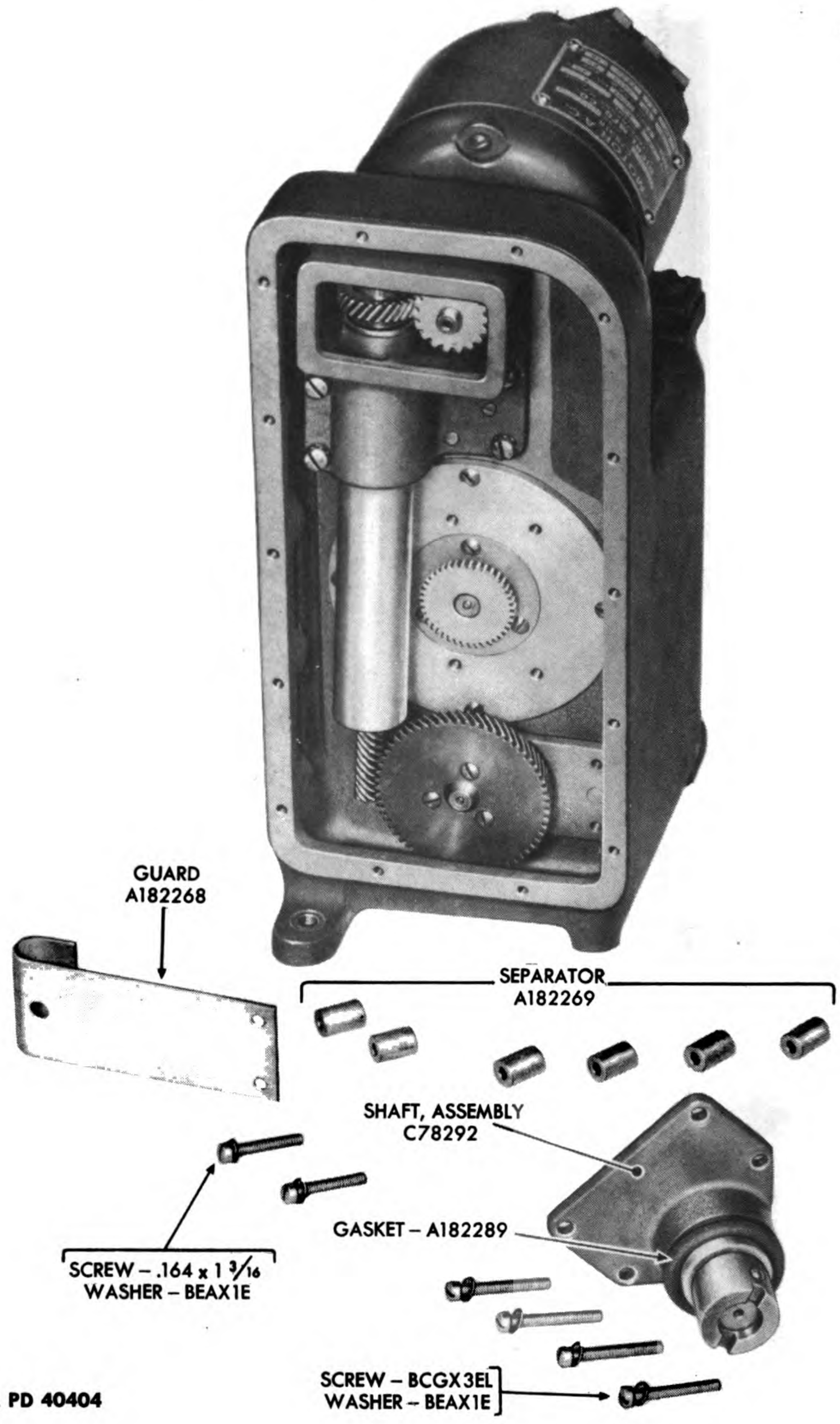


Figure 273 — Torque Amplifier — Removal of Input Shaft and Guard

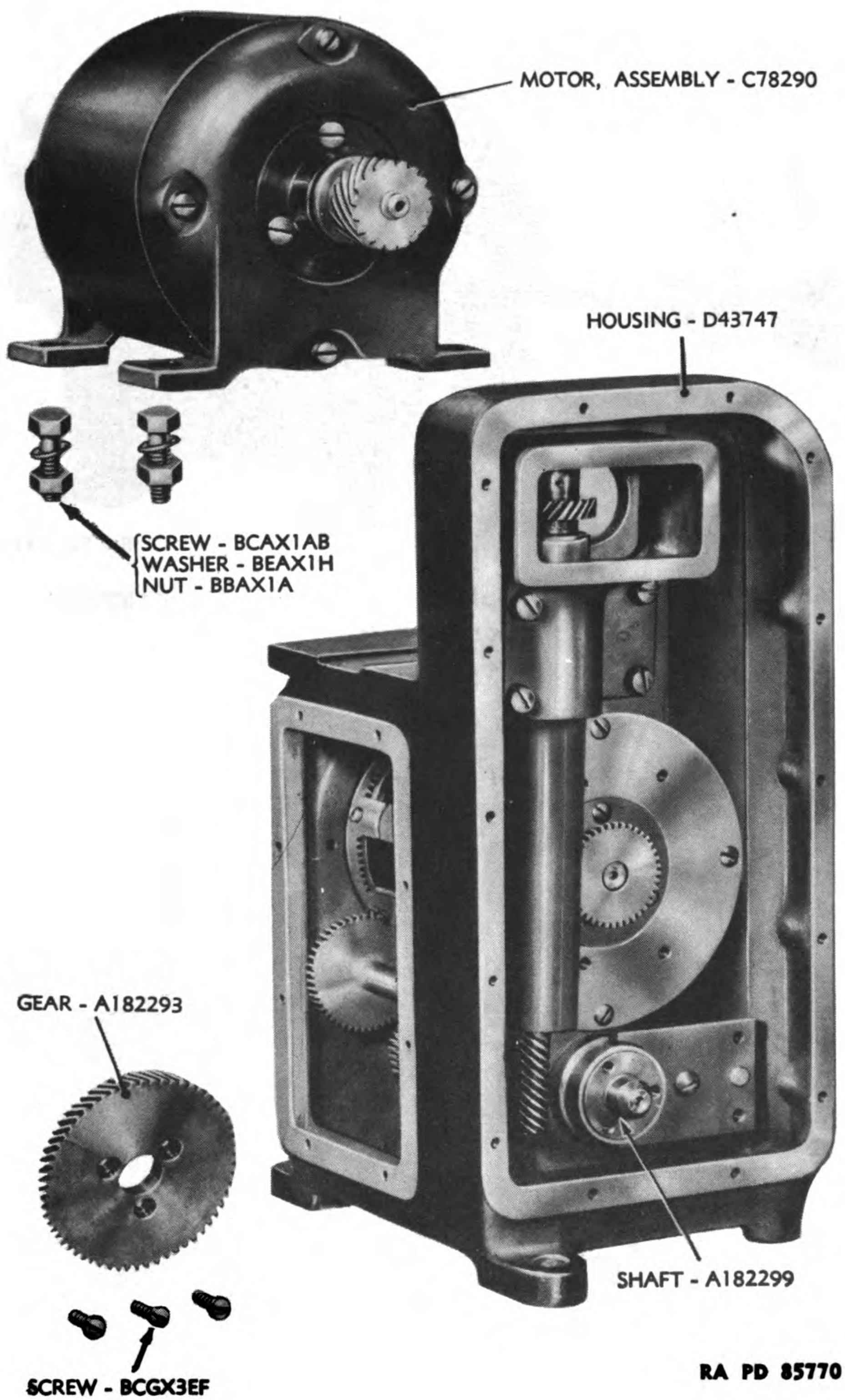


Figure 274 — Torque Amplifier — Motor and Spiral Gear Removed

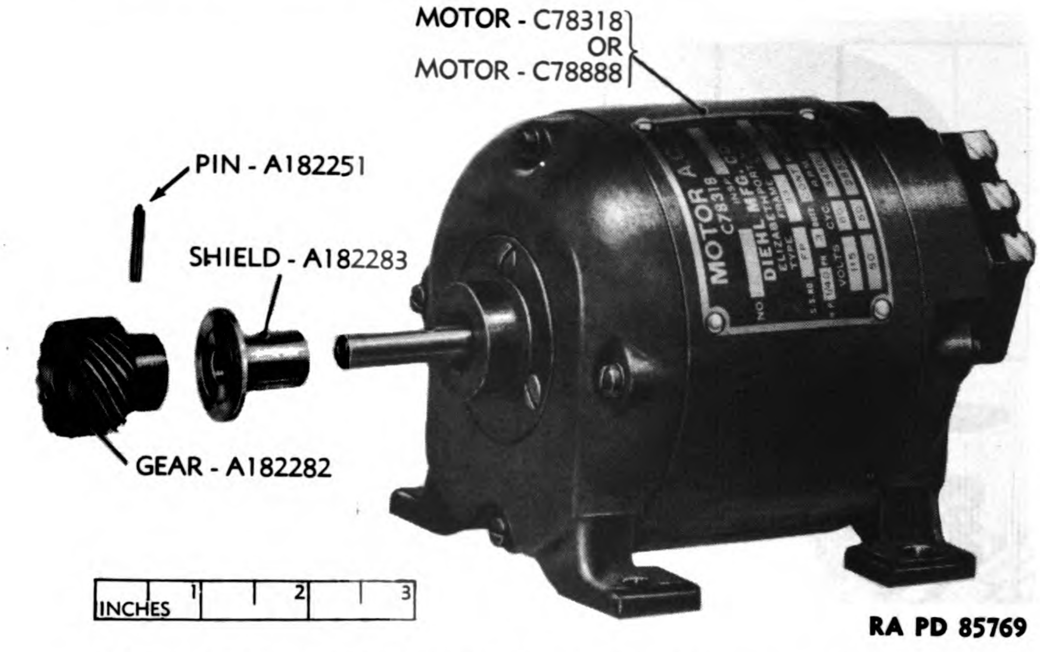


Figure 275 — Torque Amplifier Motor Assembly C78290 — Components

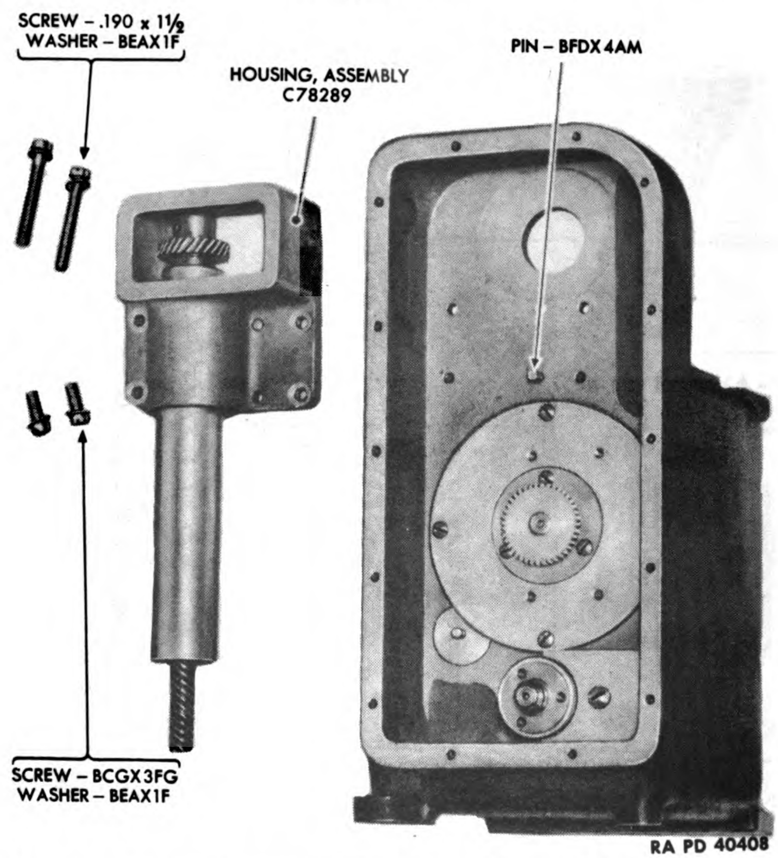


Figure 276 — Torque Amplifier — Removing Housing

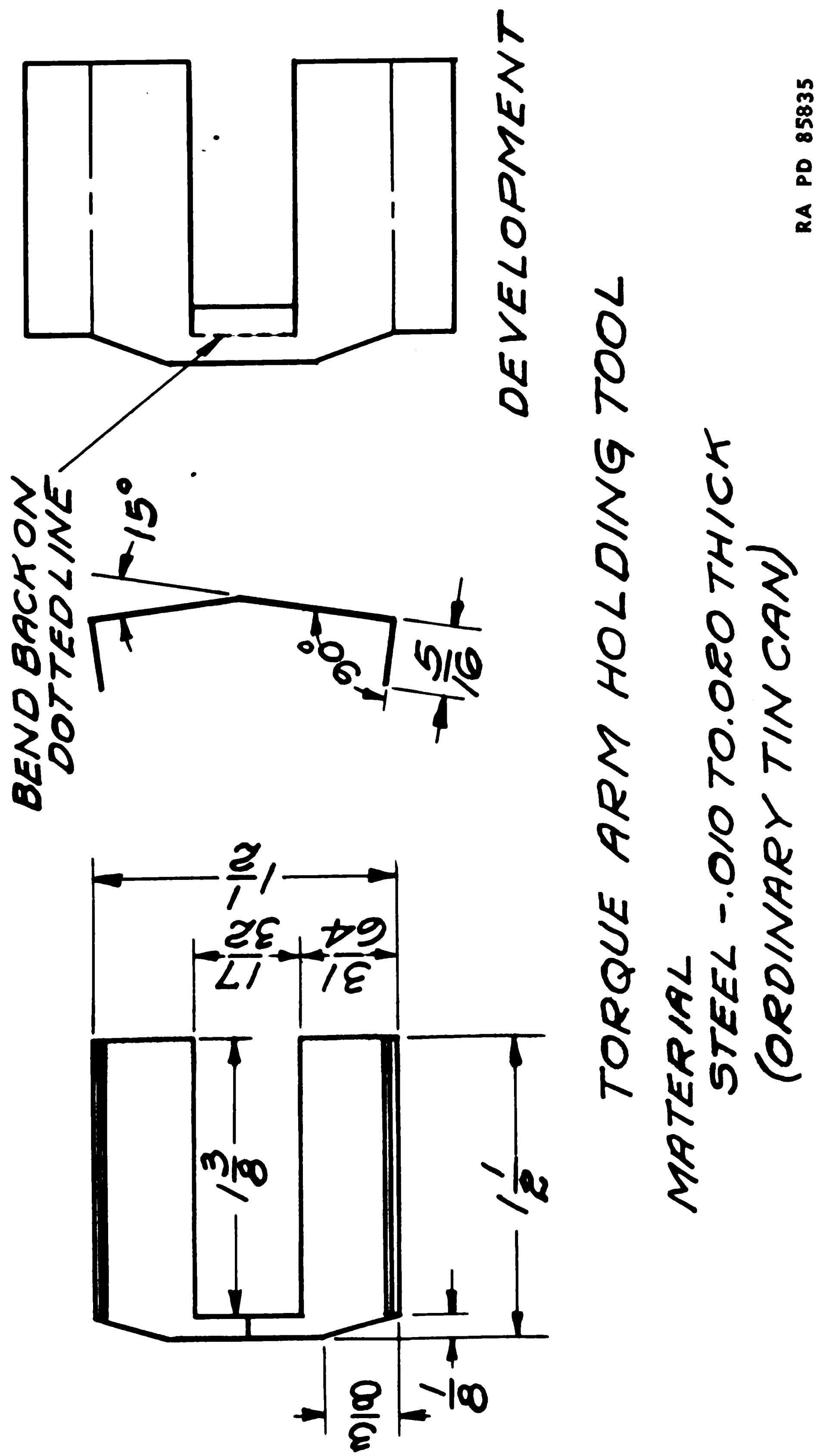
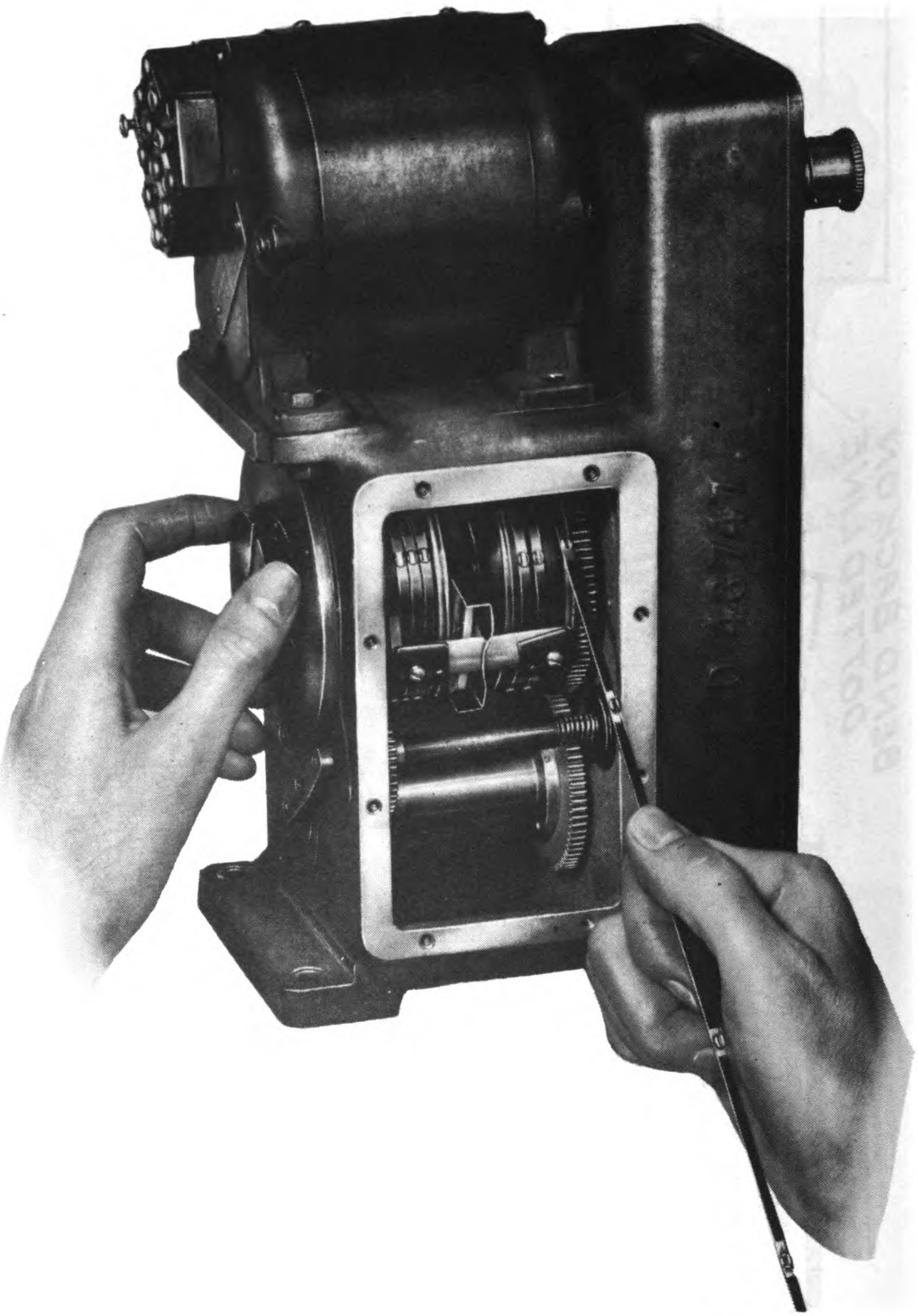


Figure 277 — Improvised Torque Holding Clip for Removing Bands From Torque Amplifier



RA PD 85772

Figure 278 — Removing or Replacing Bands in Torque Amplifier

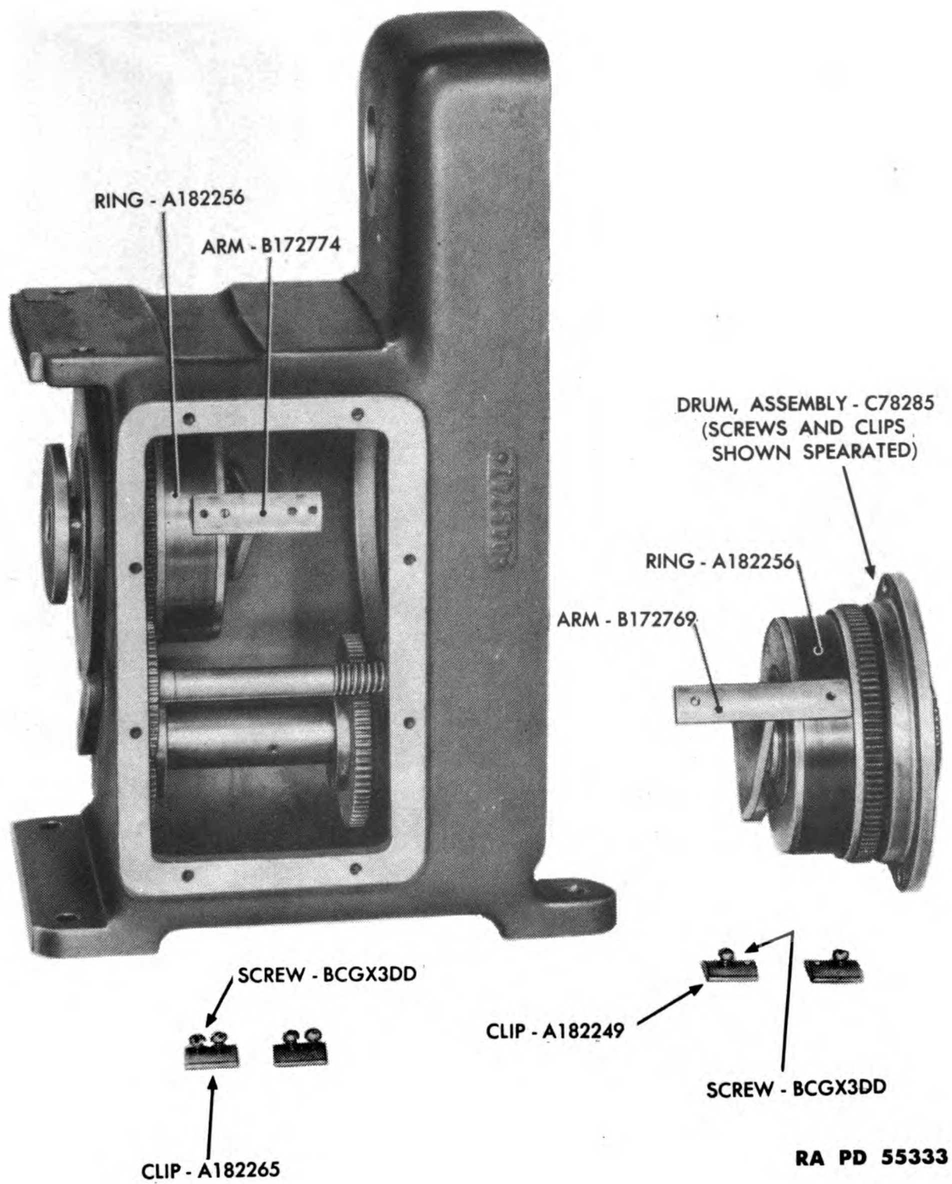


Figure 279 — Torque Amplifier — Removing Input Drum Assembly

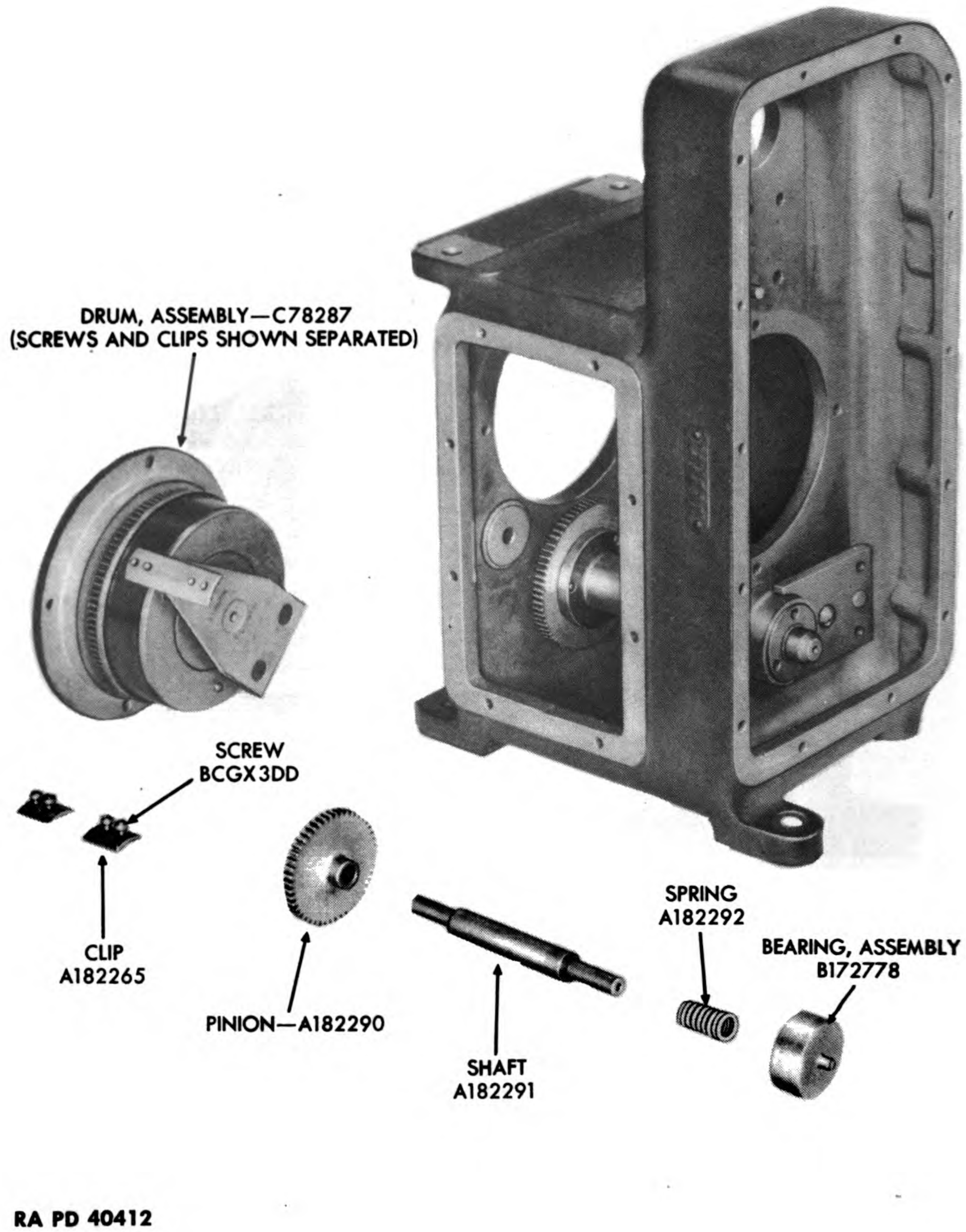


Figure 280 — Torque Amplifier — Removal of Intermediate Gear Group and Output Drum Assemblies

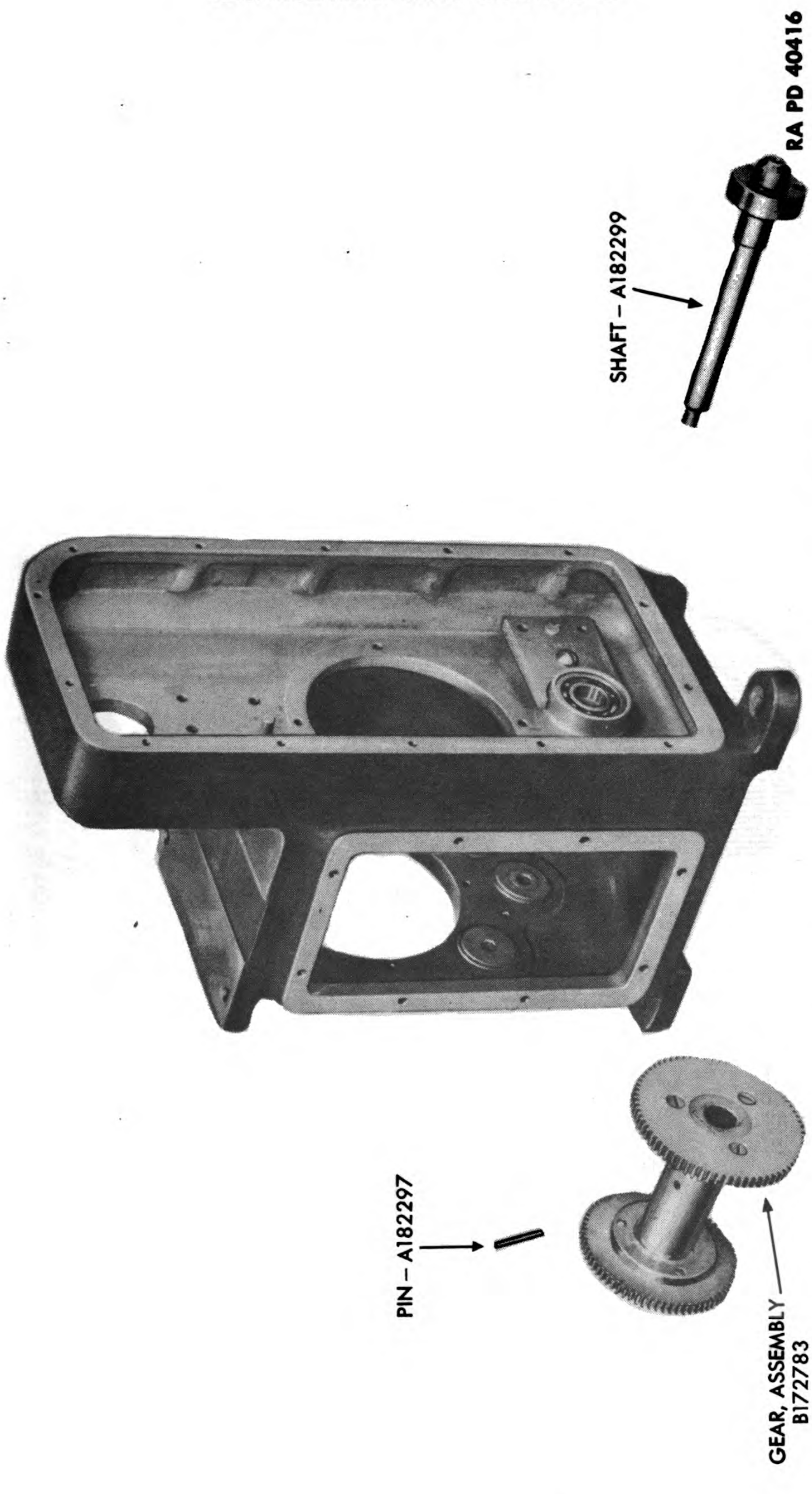


Figure 281 — Torque Amplifier — Removal of Main Gear Group Assembly

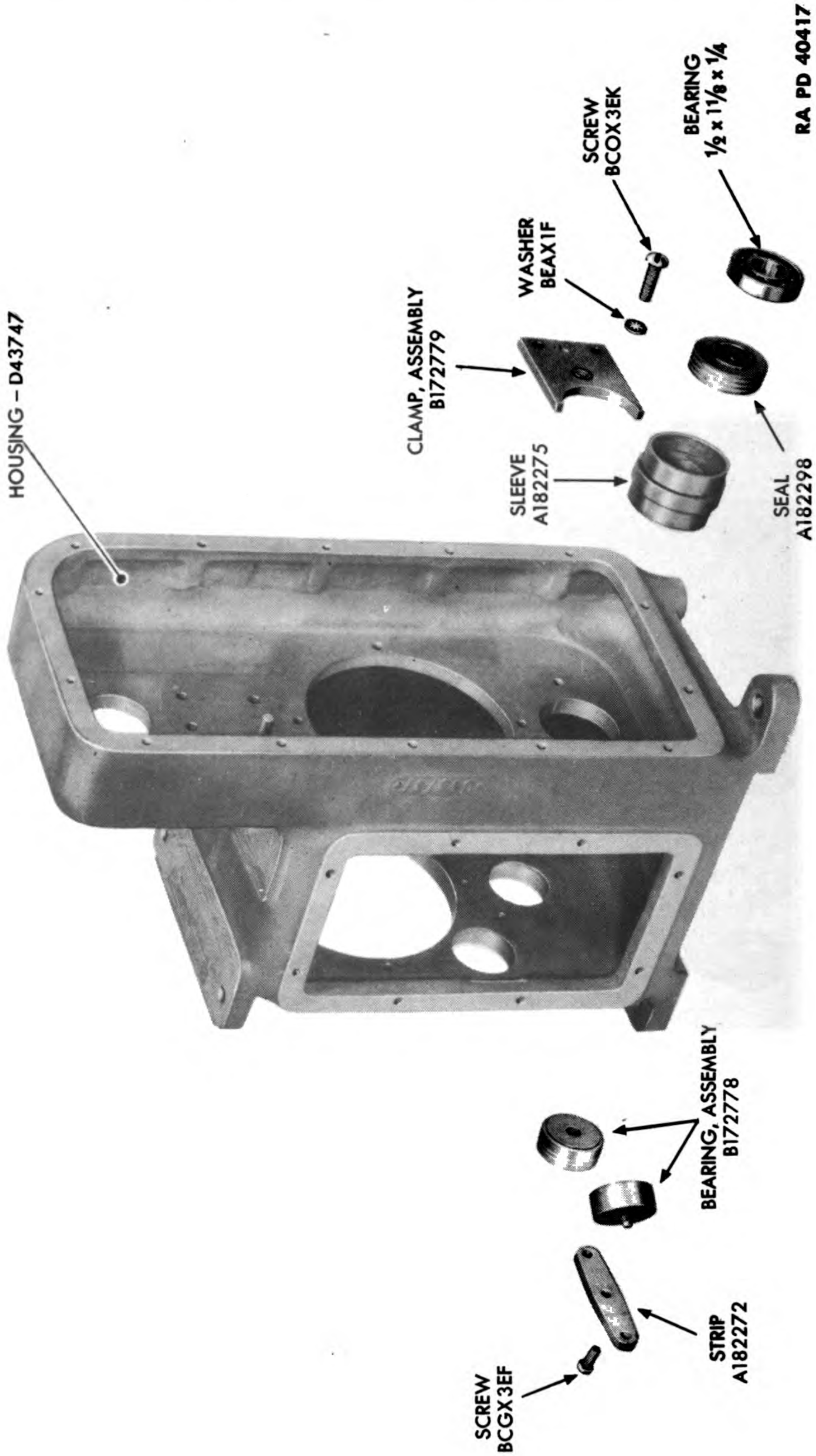


Figure 282 — Torque Amplifier — Final Disassembly

DISASSEMBLY AND ASSEMBLY

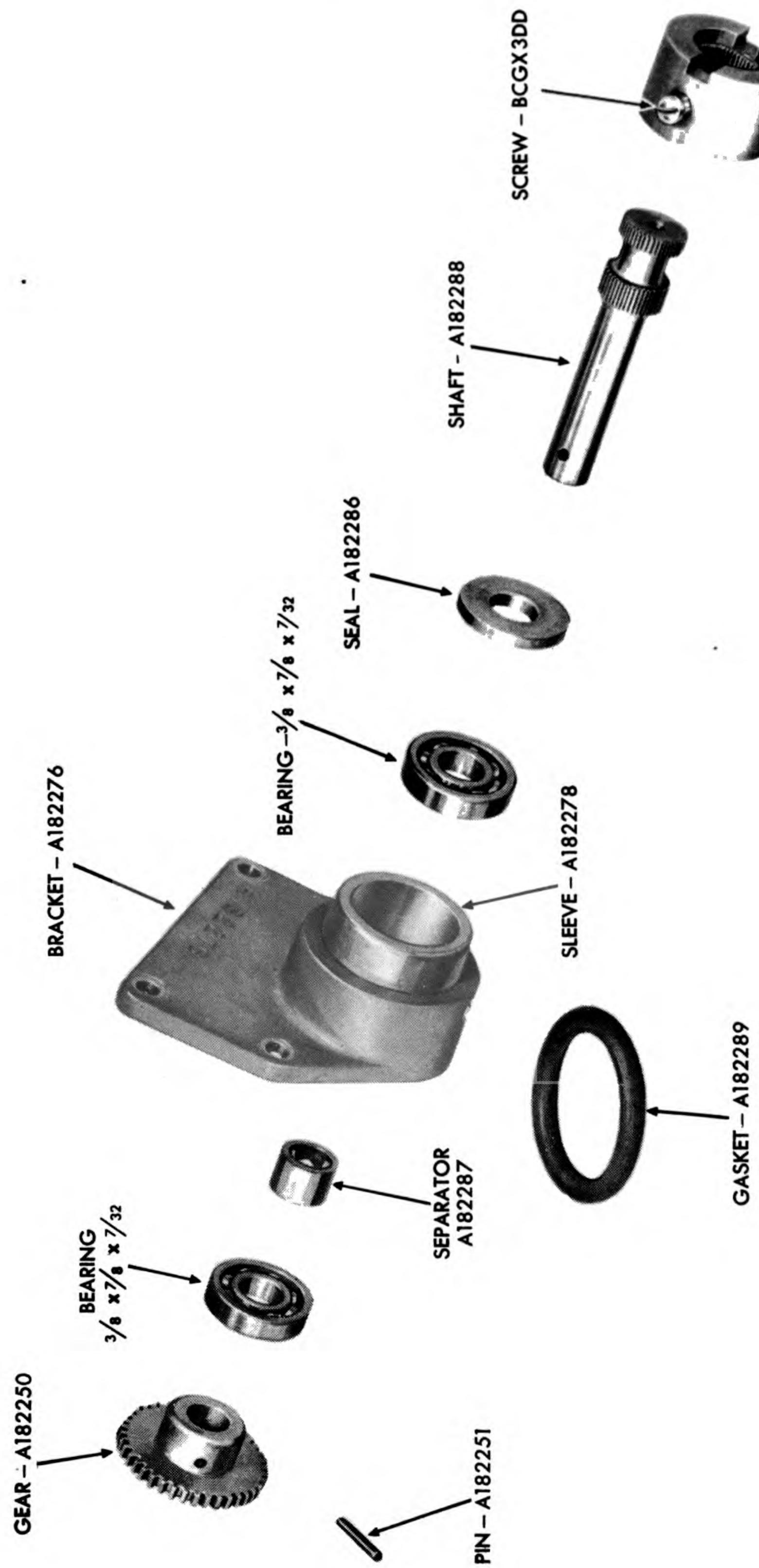
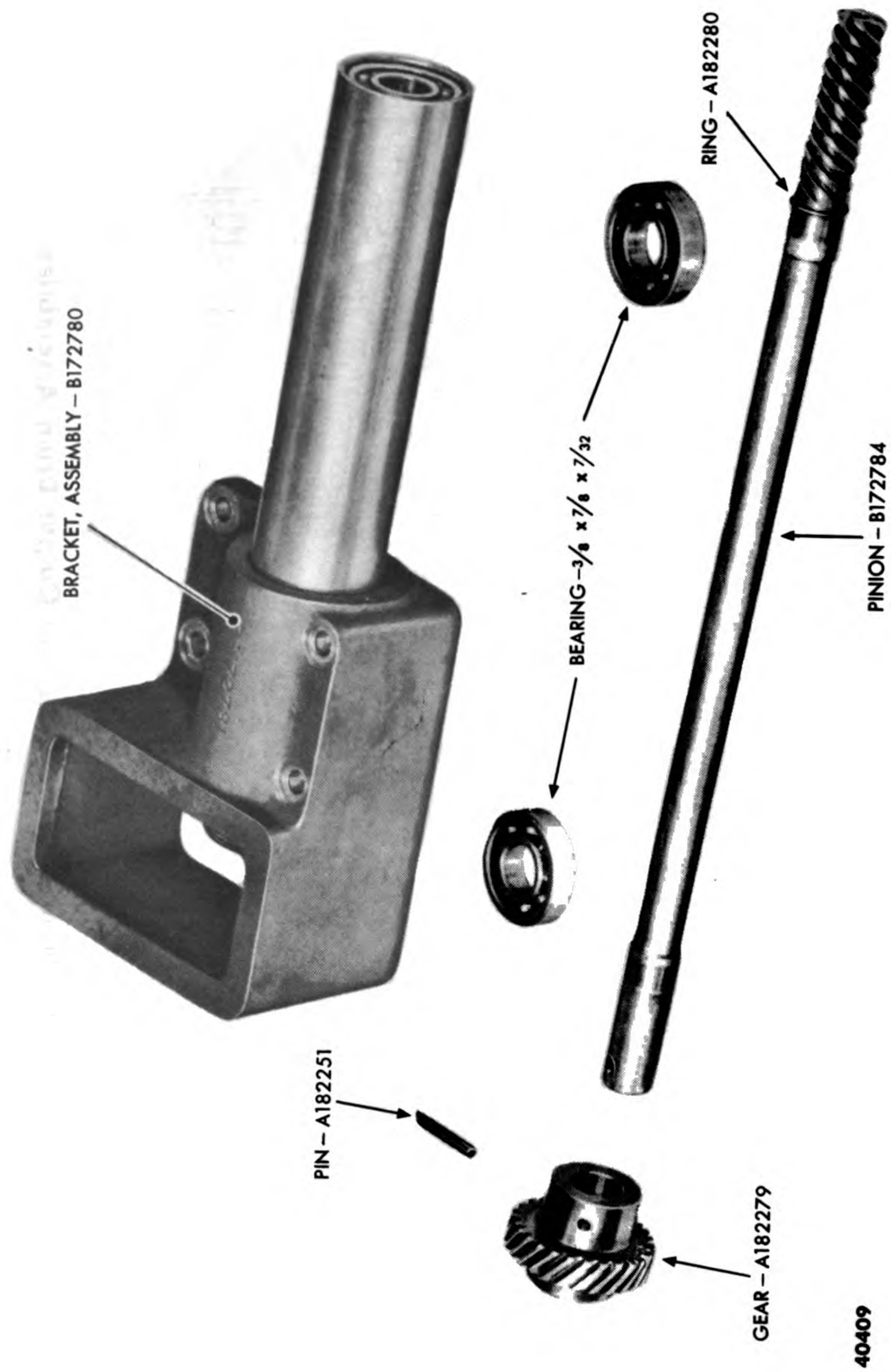


Figure 283 — Torque Amplifier Input Shaft, Assembly C78292 — Exploded View



RA PD 40409

Figure 284 — Torque Amplifier Housing Assembly C78289 — Component Parts

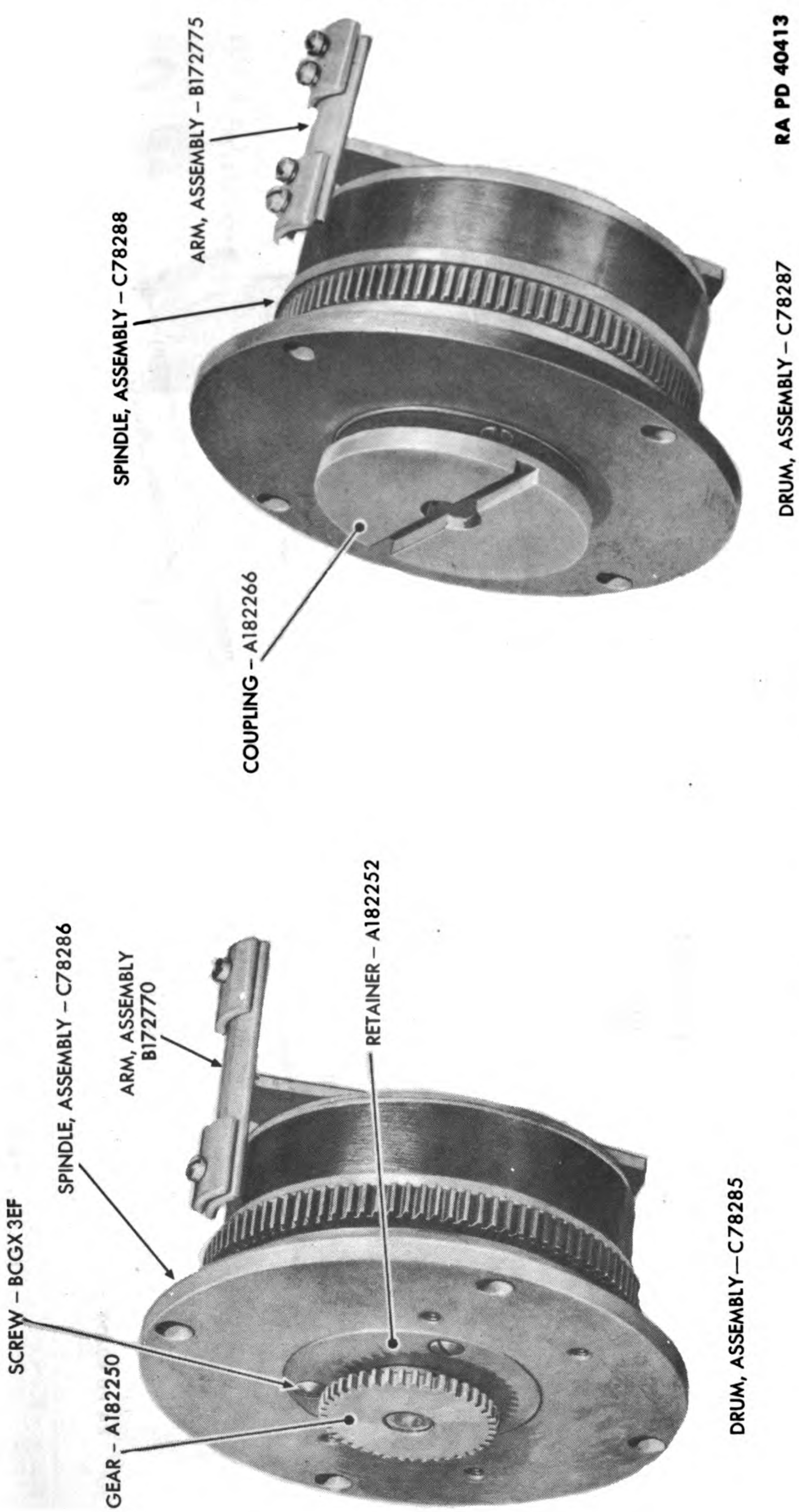


Figure 285 — Input Drum (at left) and Output Drum Assemblies

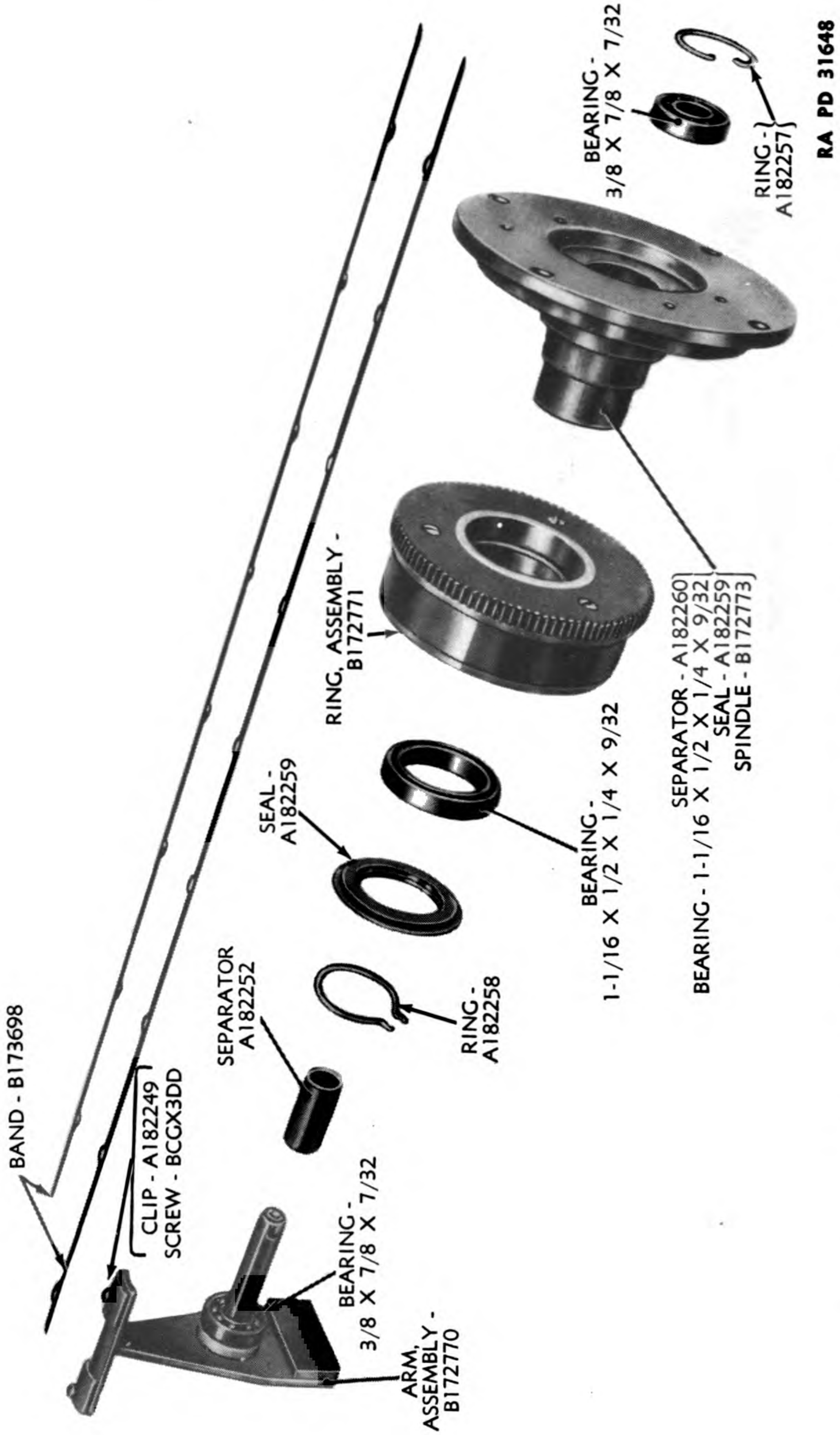
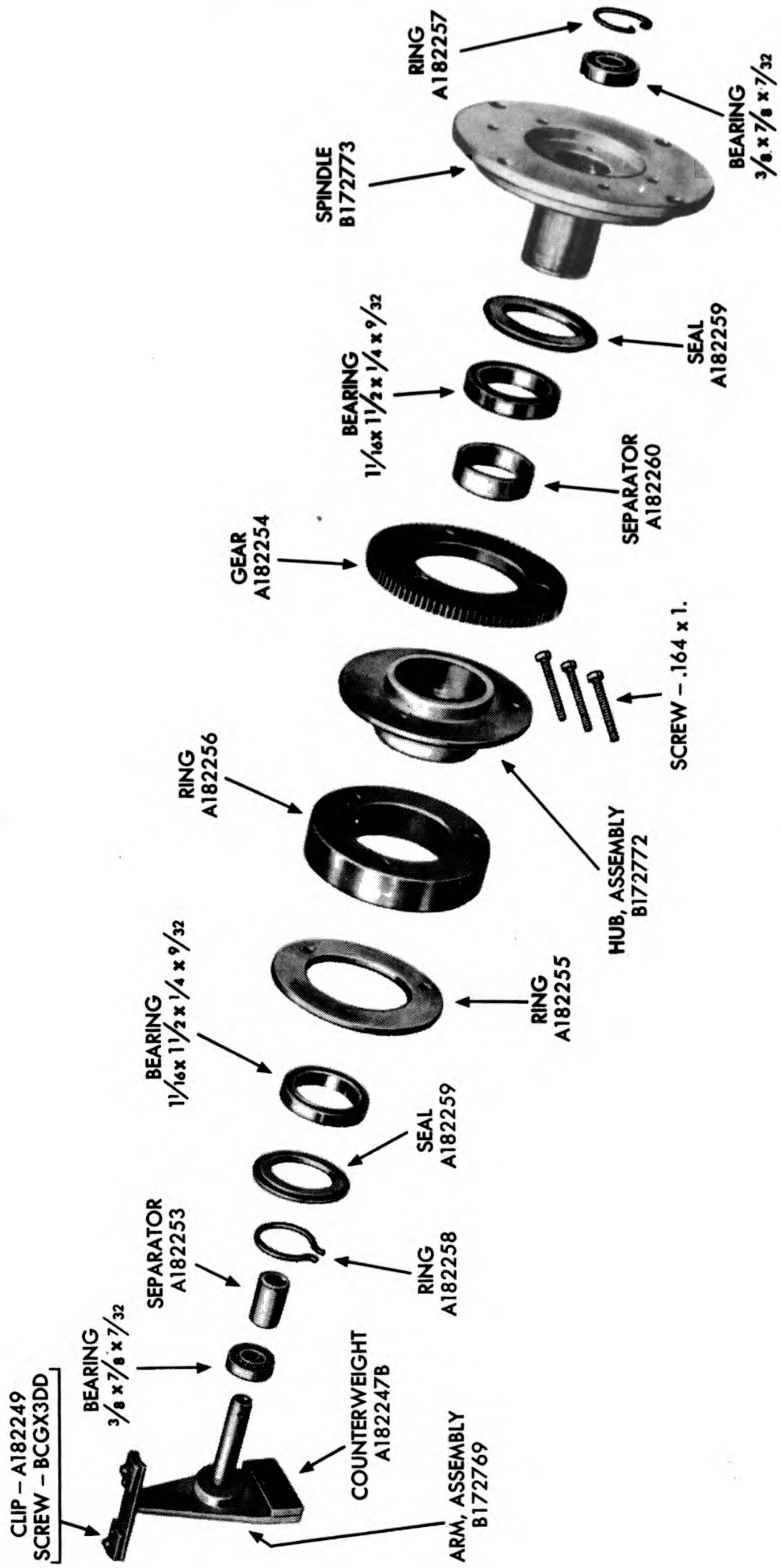


Figure 286 — Input Drum Assembly C78285 — Partial Disassembly With View of Bands

DISASSEMBLY AND ASSEMBLY



RA PD 40415

Figure 287 — Input Drum Assembly — Further Disassembly

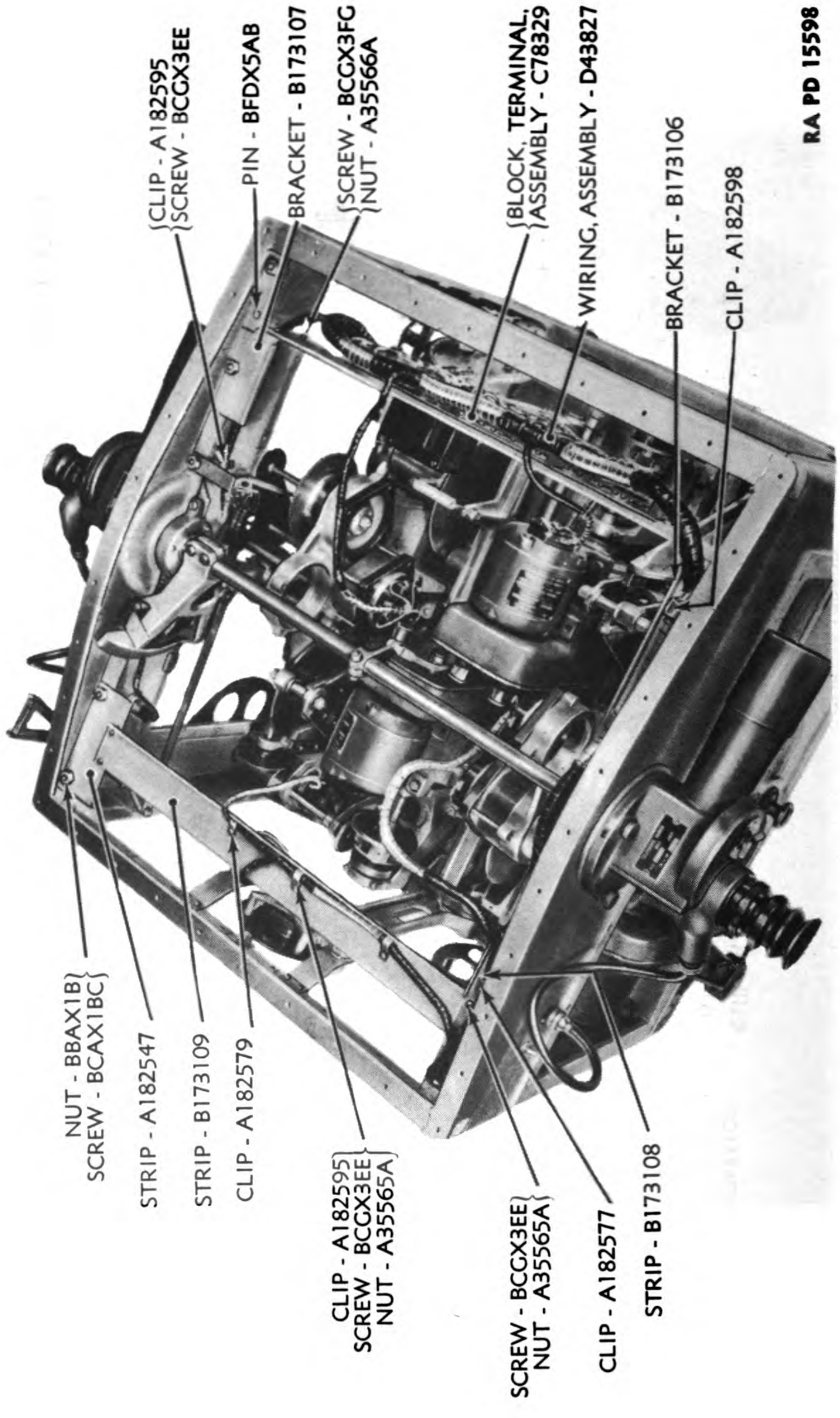
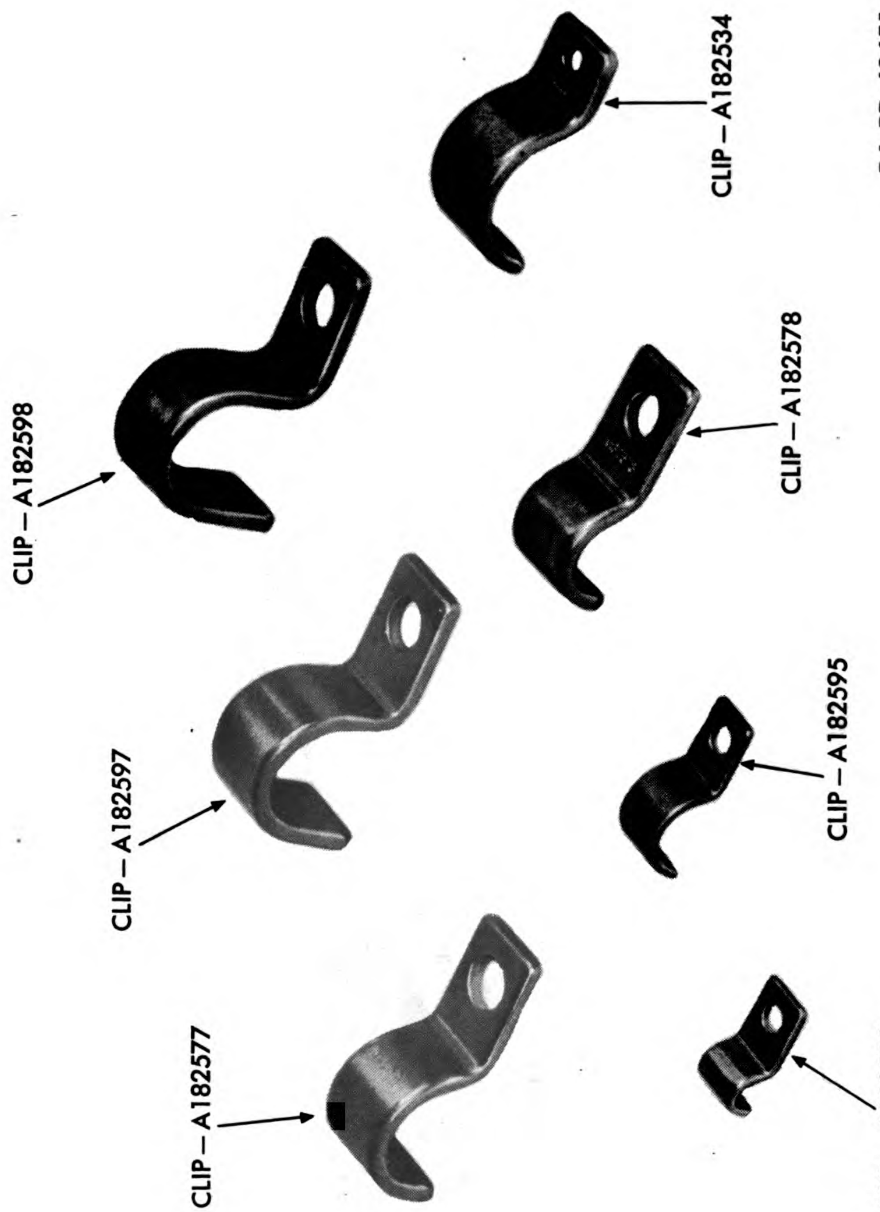


Figure 288 — Method of Attaching Wiring Assembly in Early Directors M5 and M6



RA PD 40451

Figure 289 — Wiring Clips Used in Early Directors M5 and M6

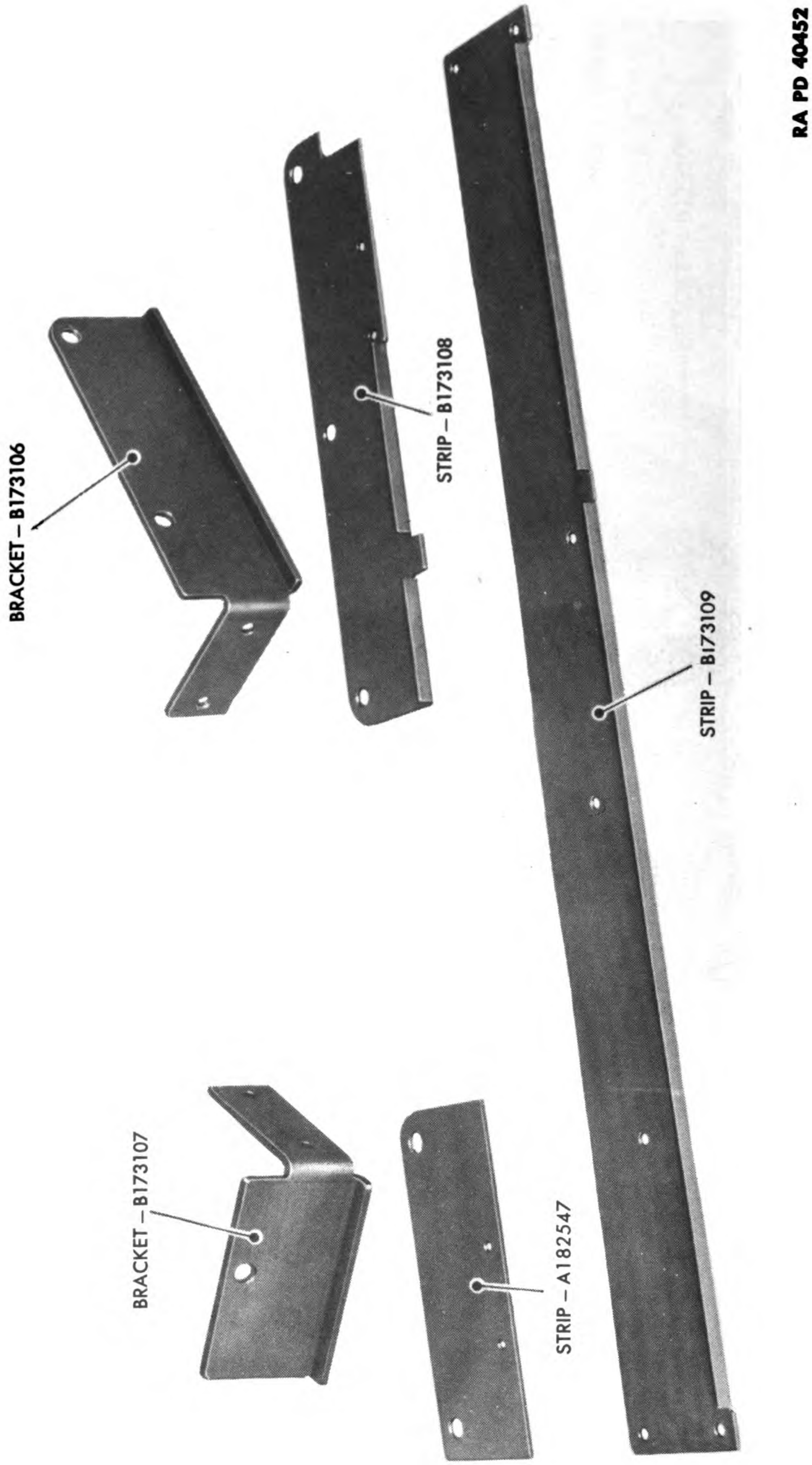


Figure 290 — Wiring Brackets and Strips Used in Early Directors M5 and M6

DISASSEMBLY AND ASSEMBLY

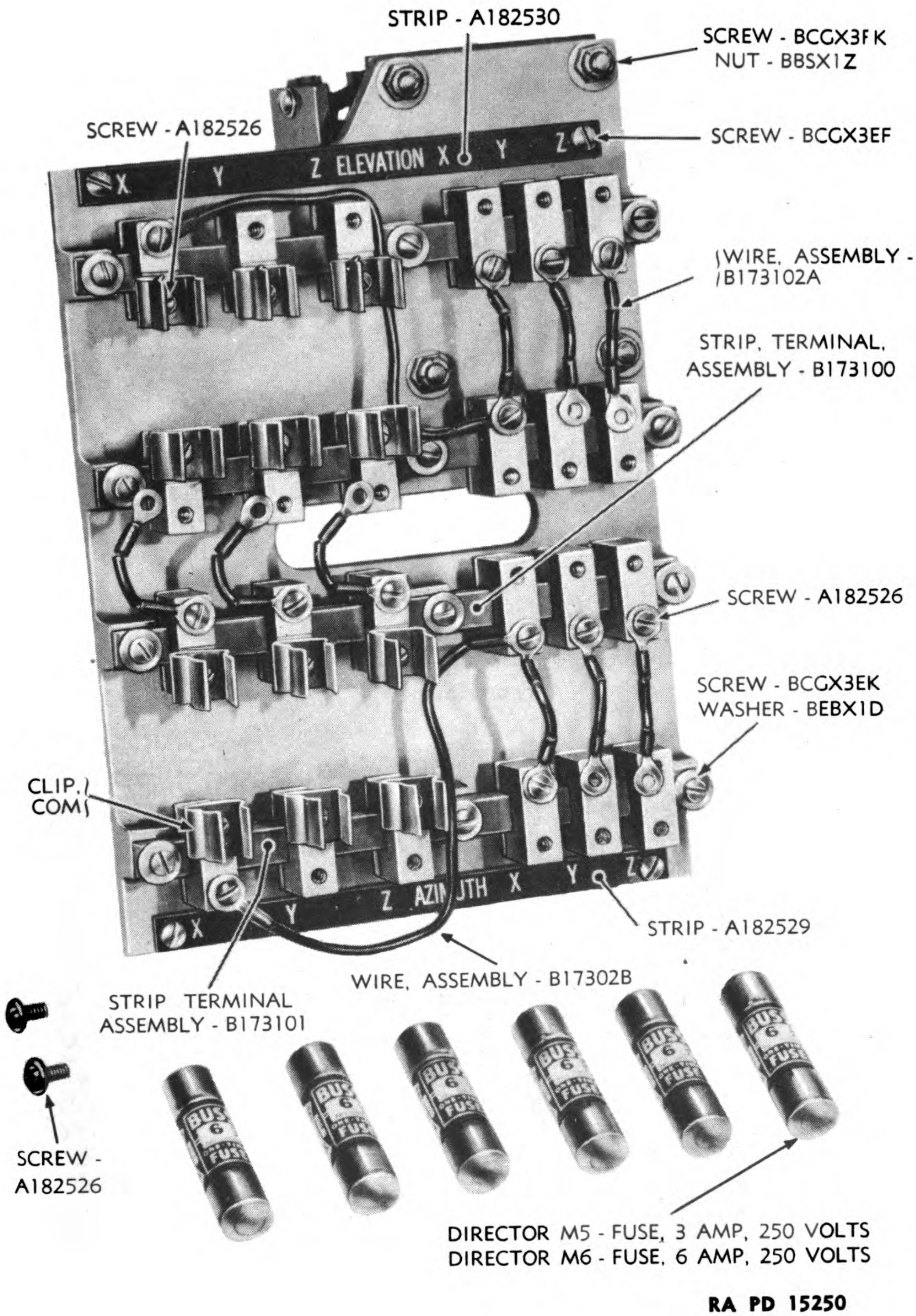


Figure 291 — Old Style Fuse Block Assembly C78443

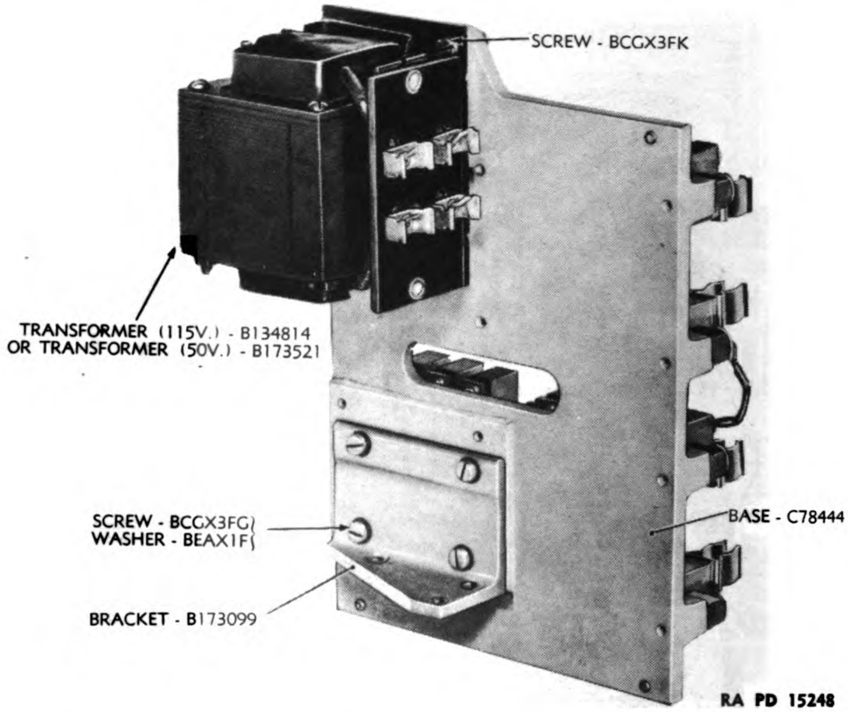


Figure 292 — Rear View of Old Style Fuse Block Showing Lighting Transformer

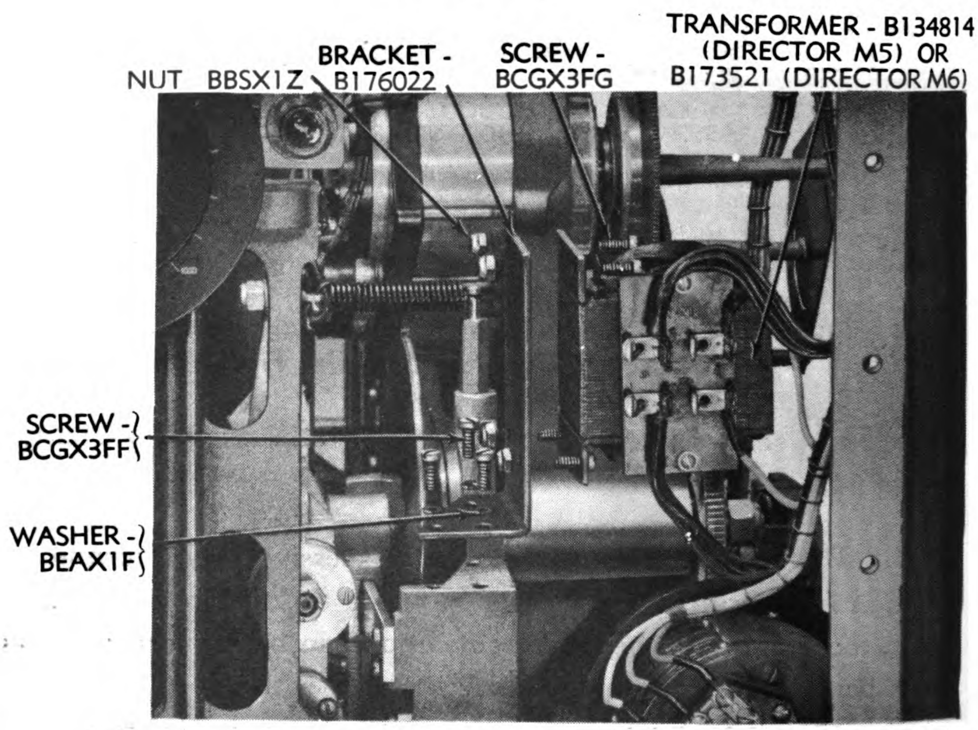


Figure 293 — Mounting of Transformer on Later Directors M5 and M6

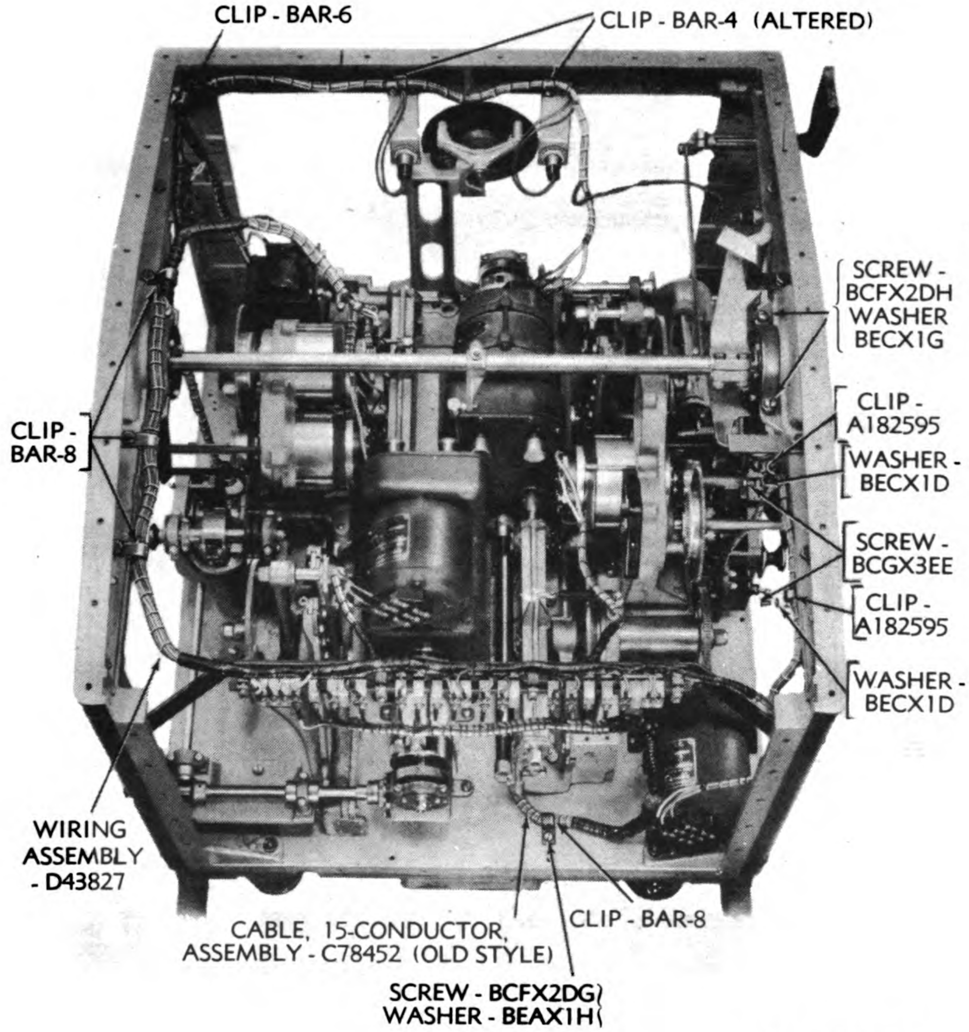


Figure 294 - Method of Attaching Wiring Assembly — Later Directors M5 and M6 (See also Figure 296)

the scale shown in fig. 77), see the trouble shooting chart, paragraph 43 e.

i. Reducing the Amplification. Excessively high torque amplification is generally due to rings on which the surfaces are too smooth and too highly polished. Amplification can be reduced by removing the bands and roughing the ring surfaces with No. 00 flint paper or in some cases even a fine file as in subparagraph b, above. ***CAUTION:*** *Aluminum-oxide abrasive cloth should not be used.*

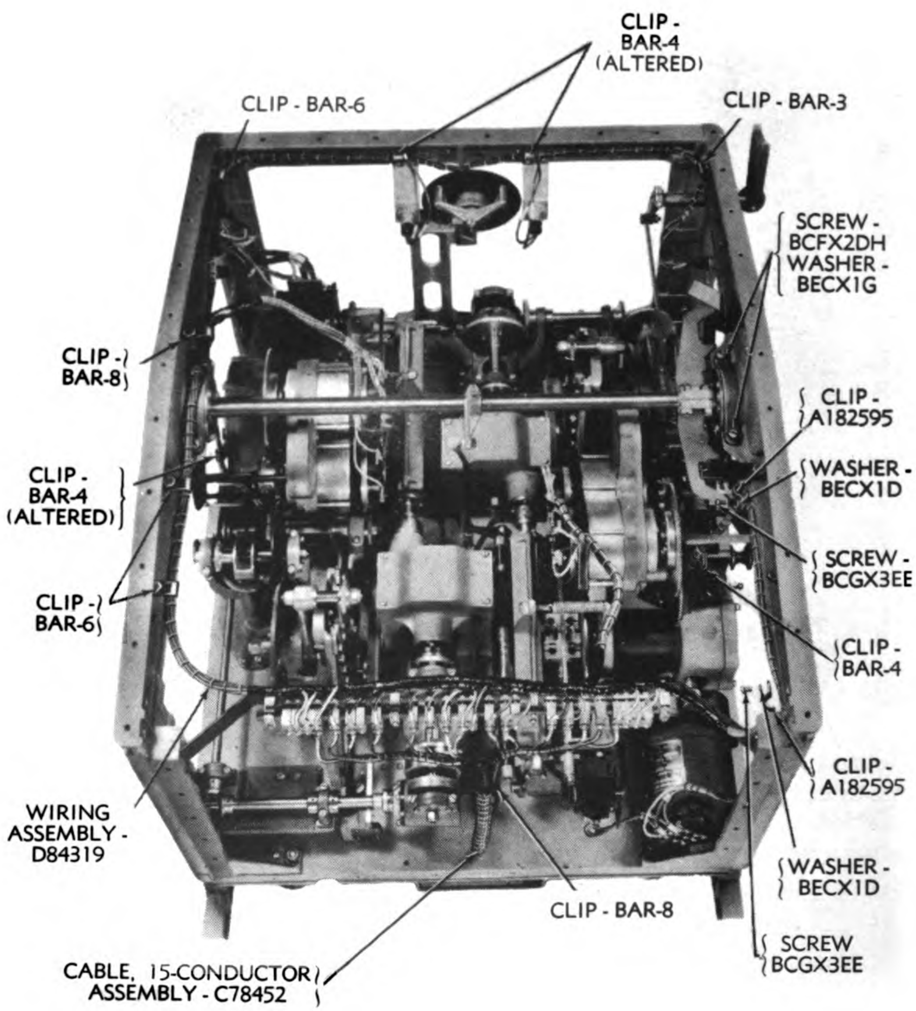


Figure 295 — Method of Attaching Wiring Assembly on Director M5A1

j. **Increasing the Amplification.** Excessively low amplification is generally due to rings on which the surfaces are too rough. In this case, the surfaces may be polished with crocus cloth and a clean dry cloth as in subparagraph b, above.

k. **Lubrication.** For lubrication of the torque amplifier see paragraph 40 d.

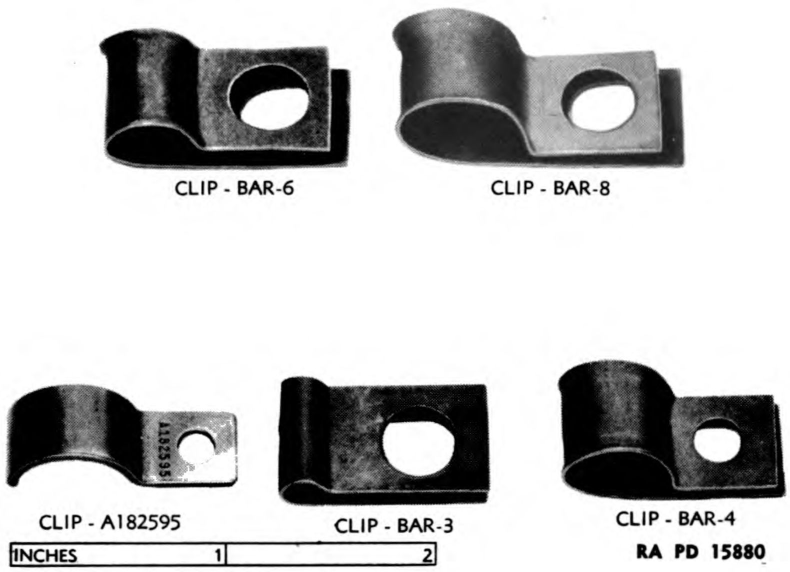


Figure 296 — Clips for Attaching Wiring and Cable Assemblies (See also Figure 289)

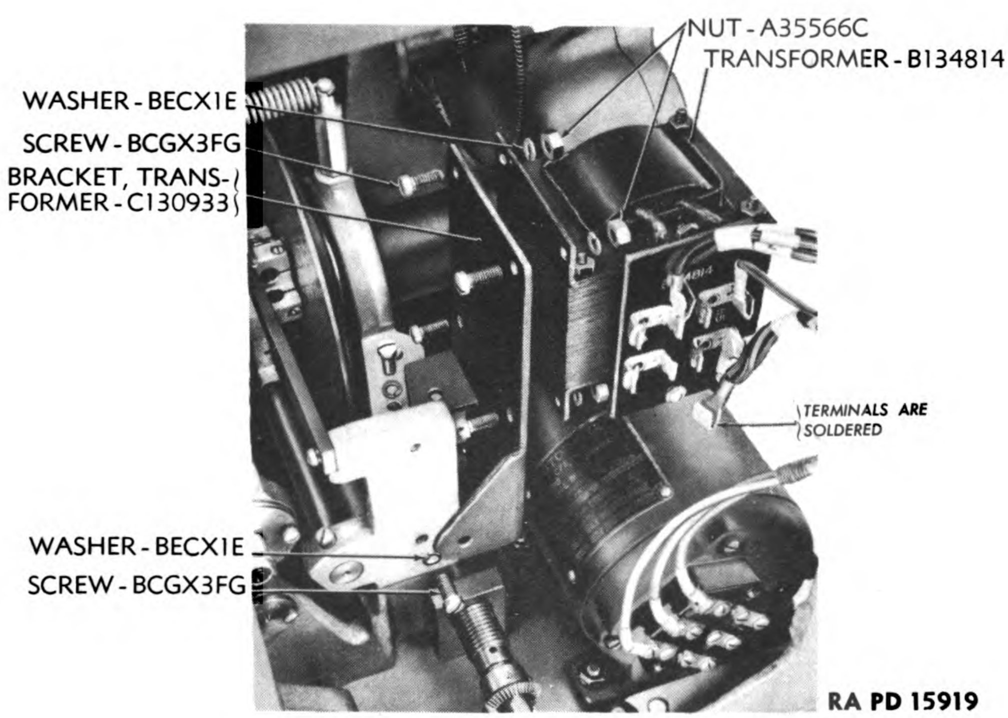
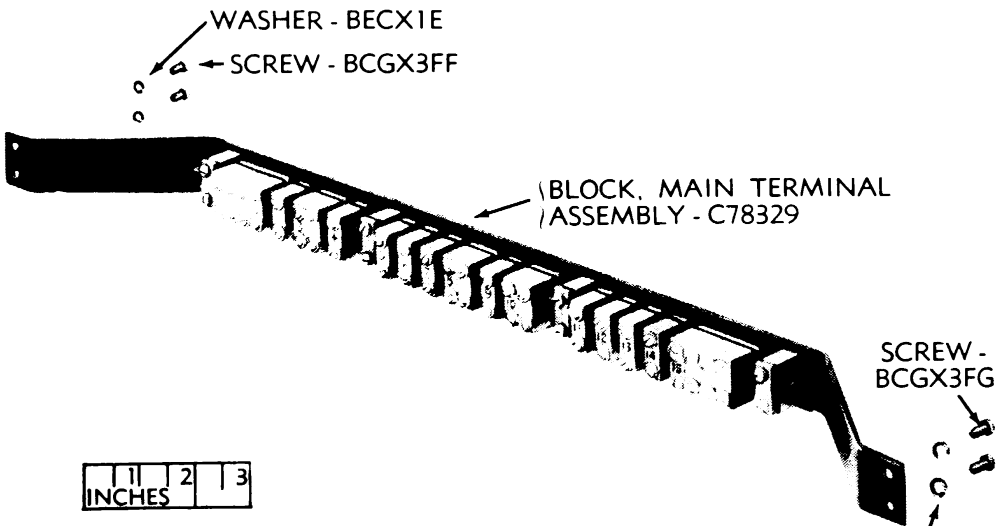
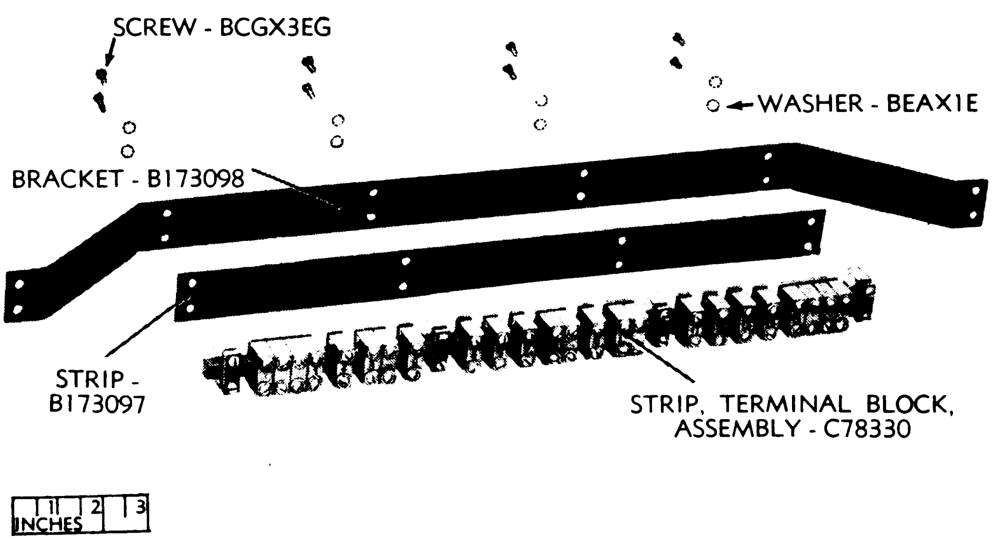


Figure 297 — Mounting of Transformer on Director M5A1



RA PD 85780

Figure 298 — Main Terminal Block Assembly With Mounting Screws



RA PD 85781

Figure 299 — Exploded View of Terminal Block Assembly

DISASSEMBLY AND ASSEMBLY

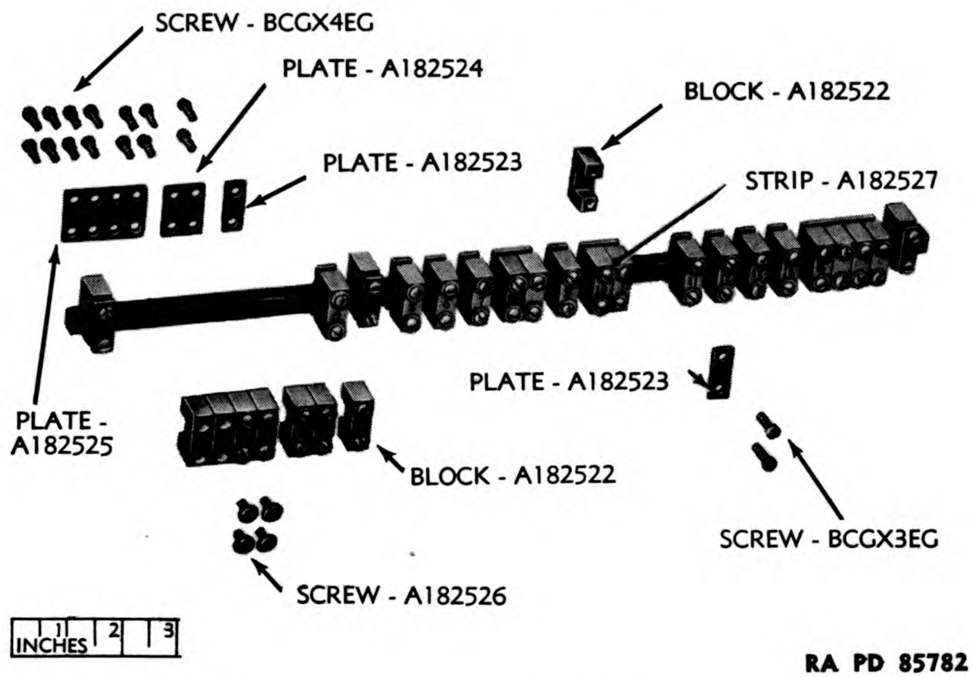


Figure 300 — Parts of Terminal Strip C78330

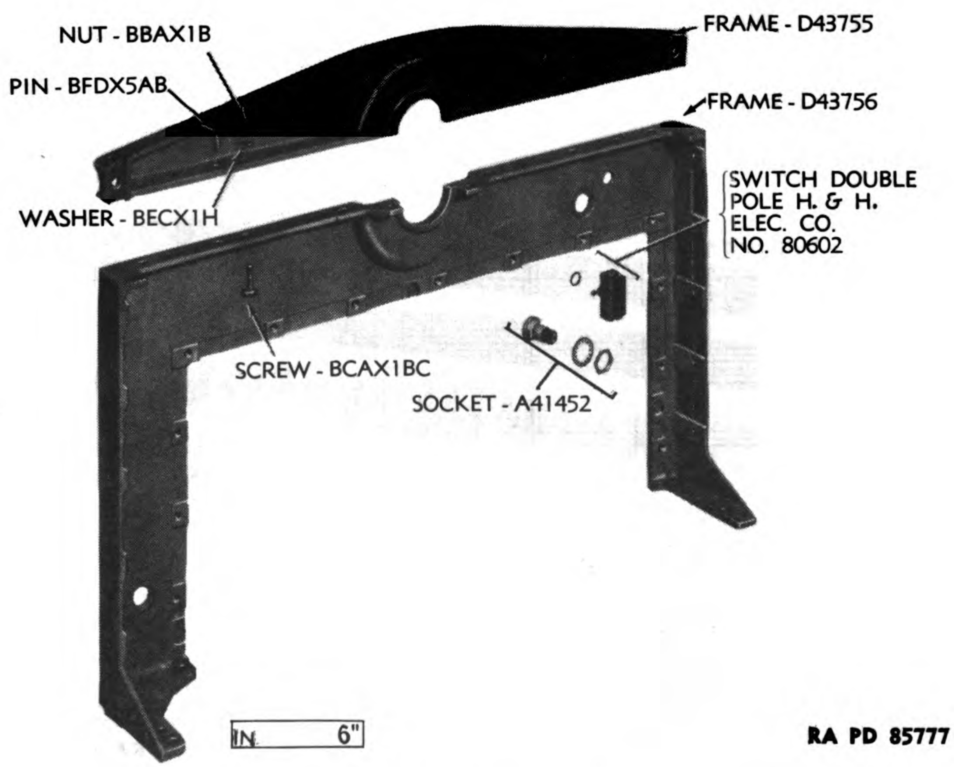


Figure 301 — Parts of Right Frame Group Assembly

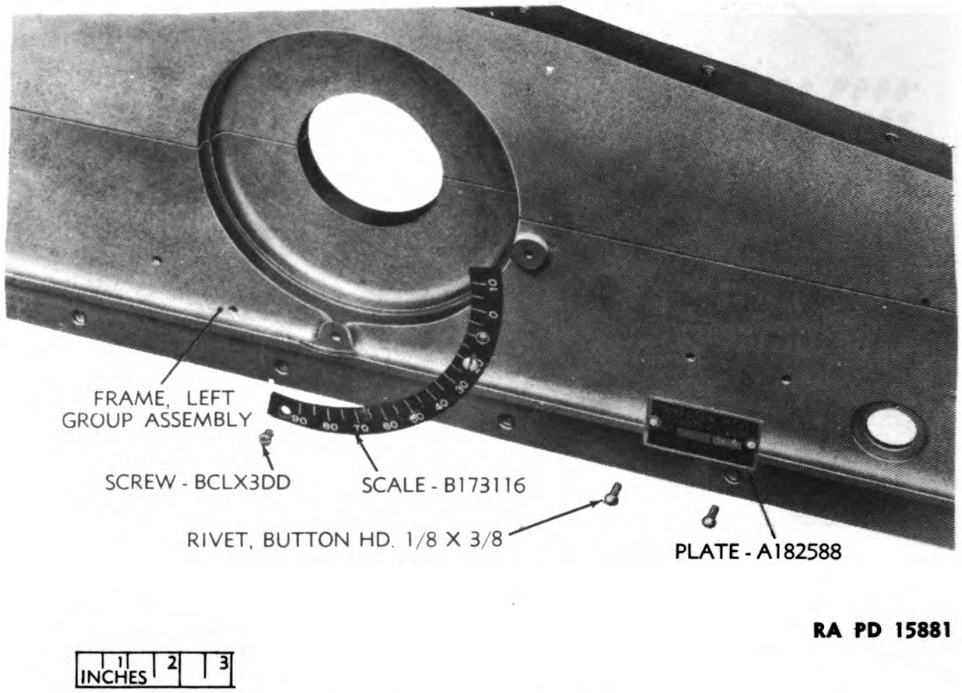


Figure 302 — Elevation Scale and Serial Number Plate

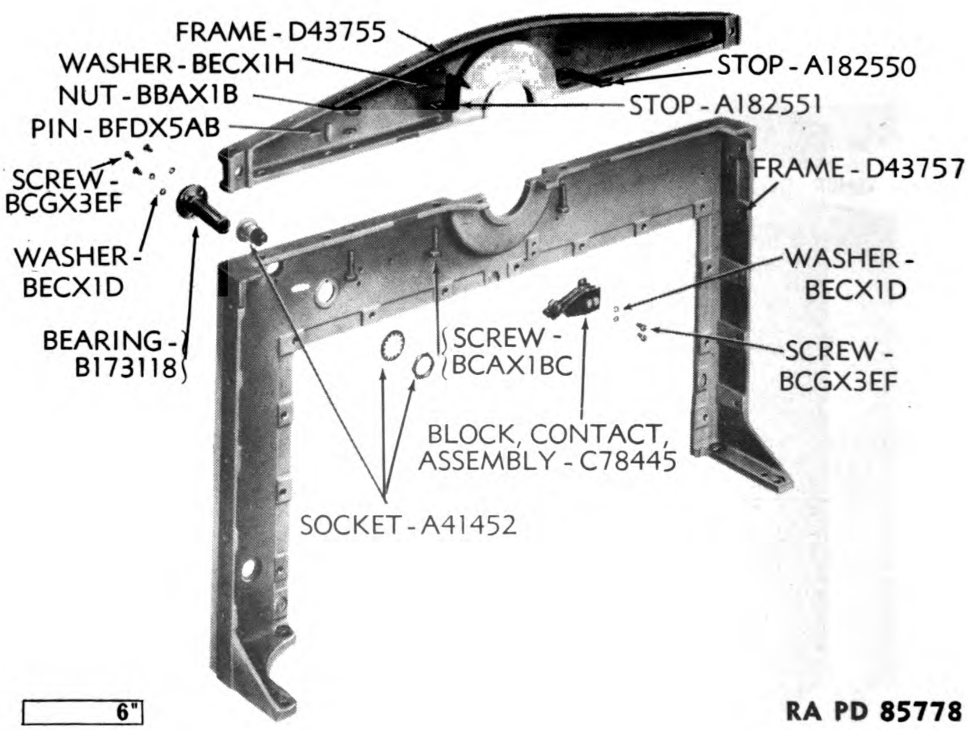


Figure 303 — Parts of Left Frame Group Assembly

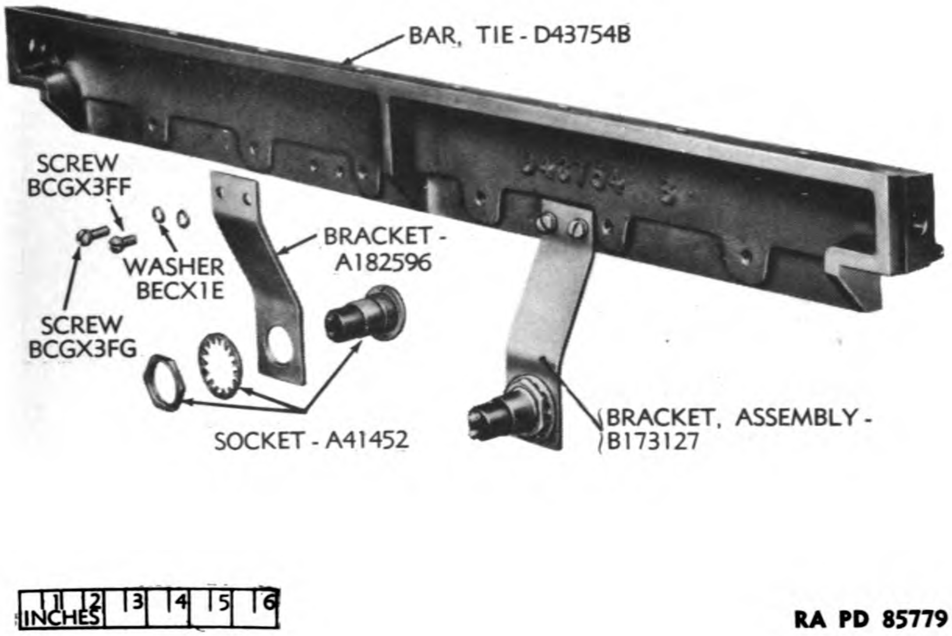


Figure 304 — Attachment of Range Dial Lights to Rear Tie Bar

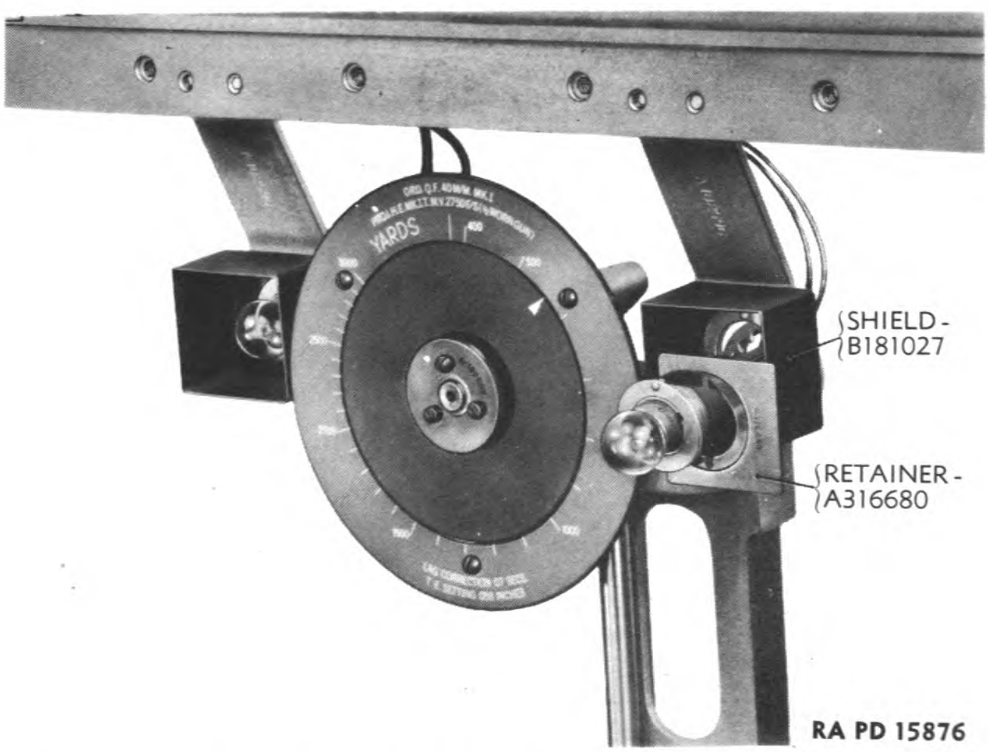
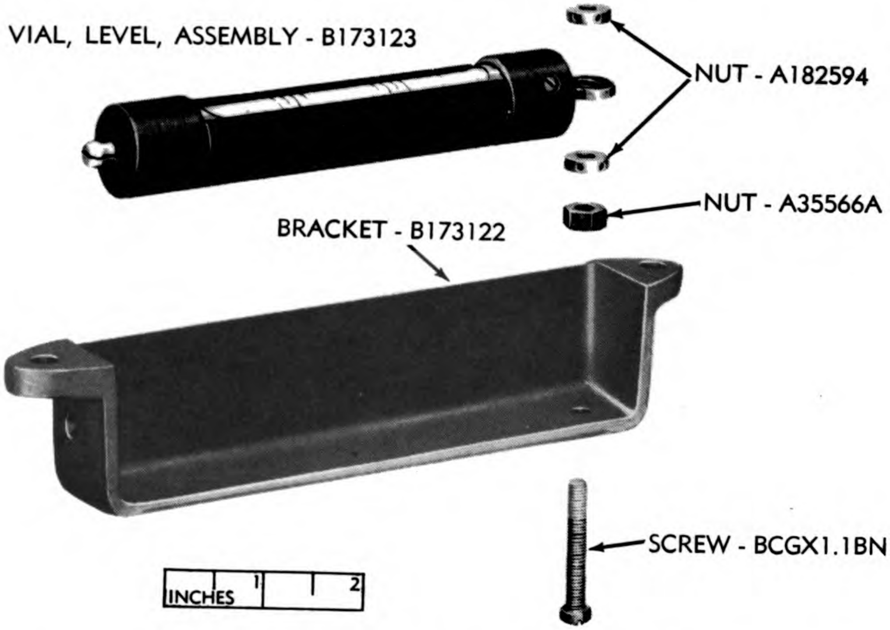
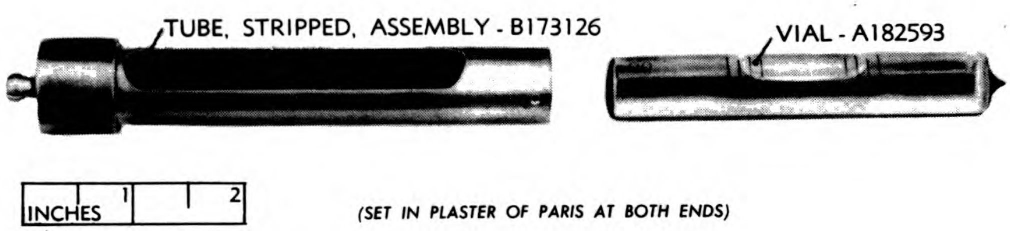


Figure 305 — Method of Attaching Range Light Shields Used With Luminous Dial



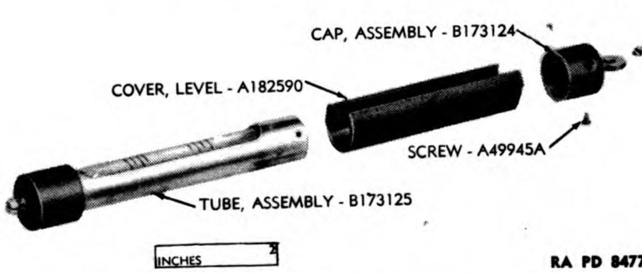
RA PD 84769

Figure 306 — Level Bracket Assembly C78450 Showing Method of Adjusting Level



RA PD 85789

Figure 307 — Parts of Level Vial Assembly



RA PD 84770

Figure 308 — Parts of Vial Tube Assembly B173125 (Note that the cap is brazed to the tube)

DISASSEMBLY AND ASSEMBLY

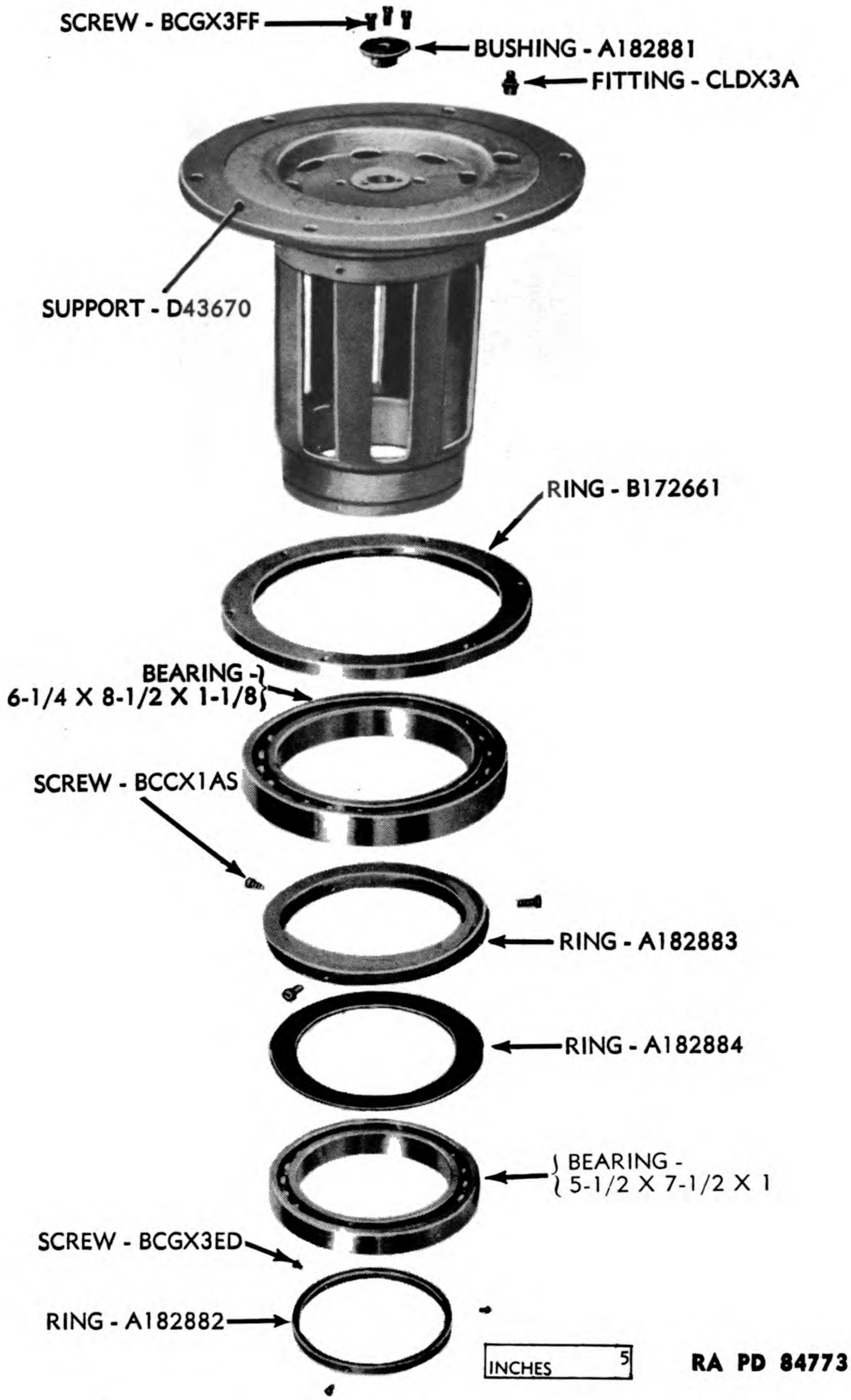


Figure 309 — Support Assembly C78354 — Exploded View

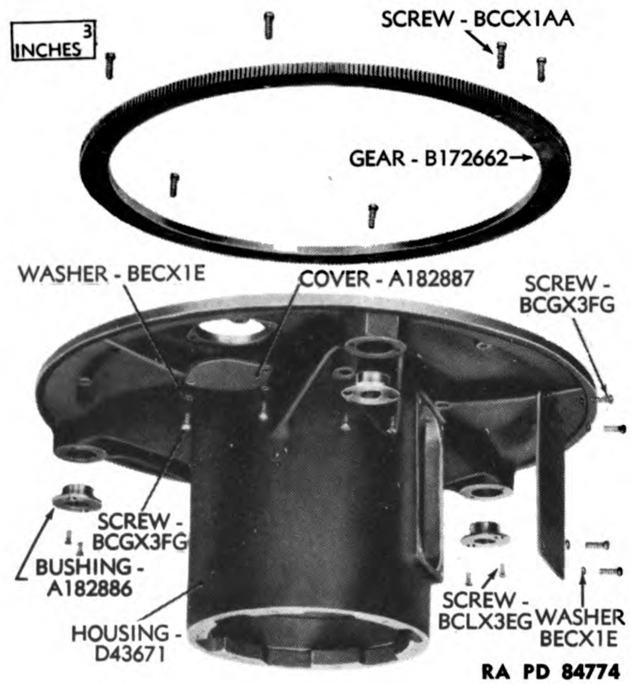


Figure 310 — Parts of Housing Assembly C78346

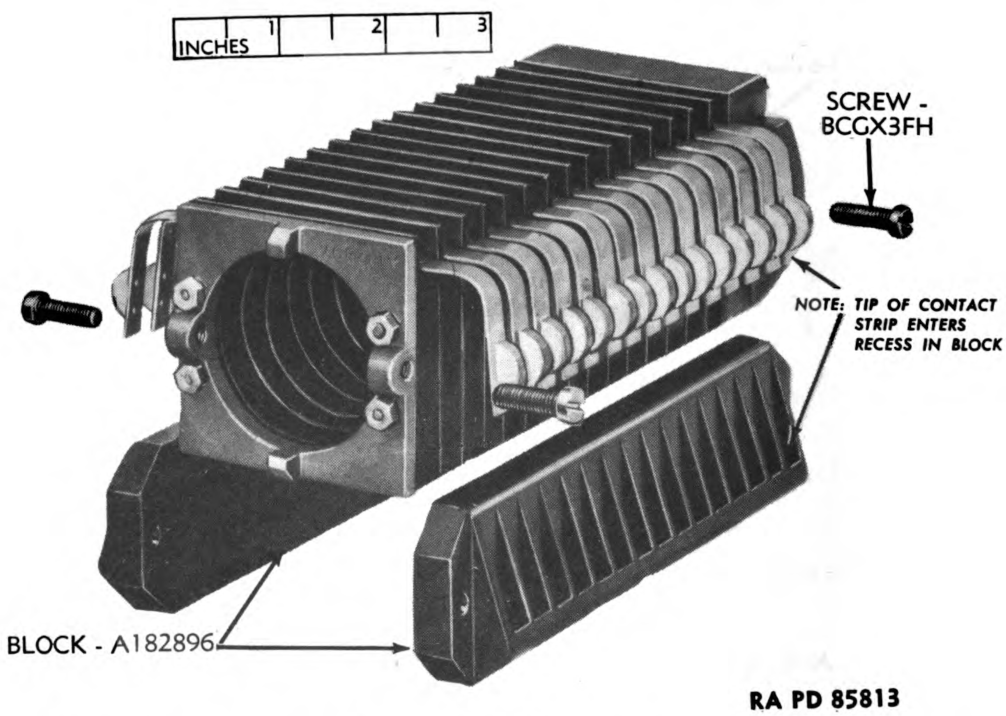


Figure 311 — Brush Assembly C78342 — Removal of Blocks (See Figure 11 for complete brush support assembly)

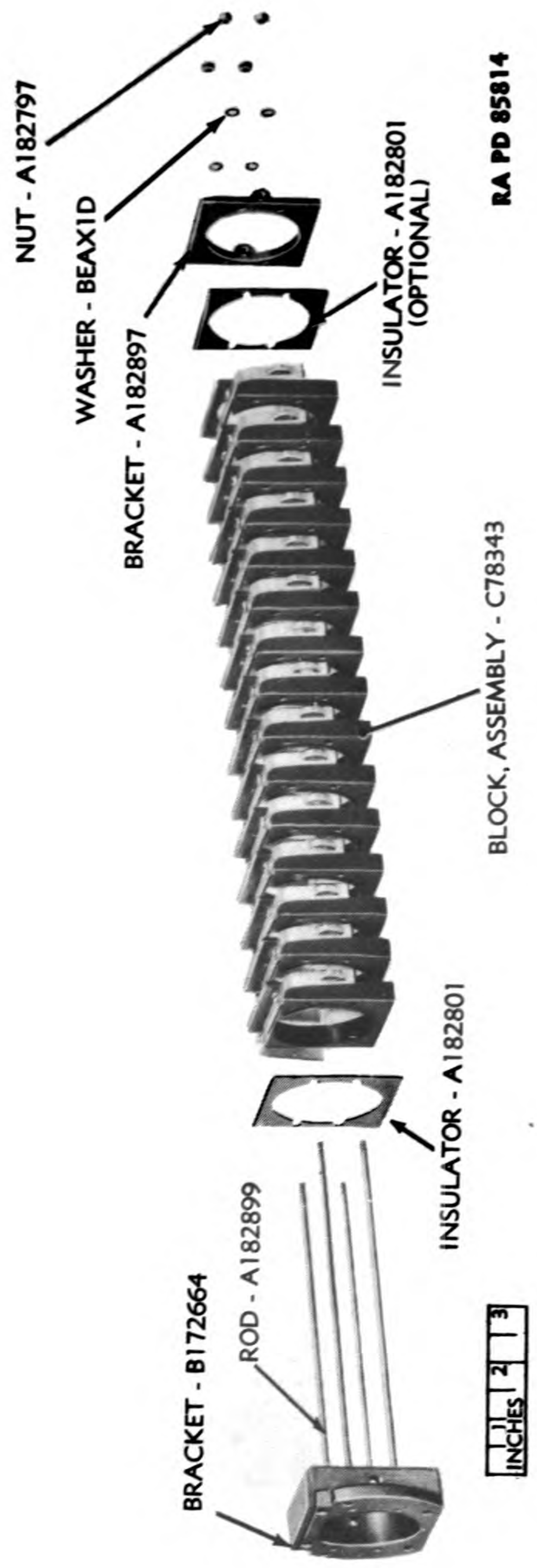


Figure 312 — Further Disassembly of Brush Assembly C78342

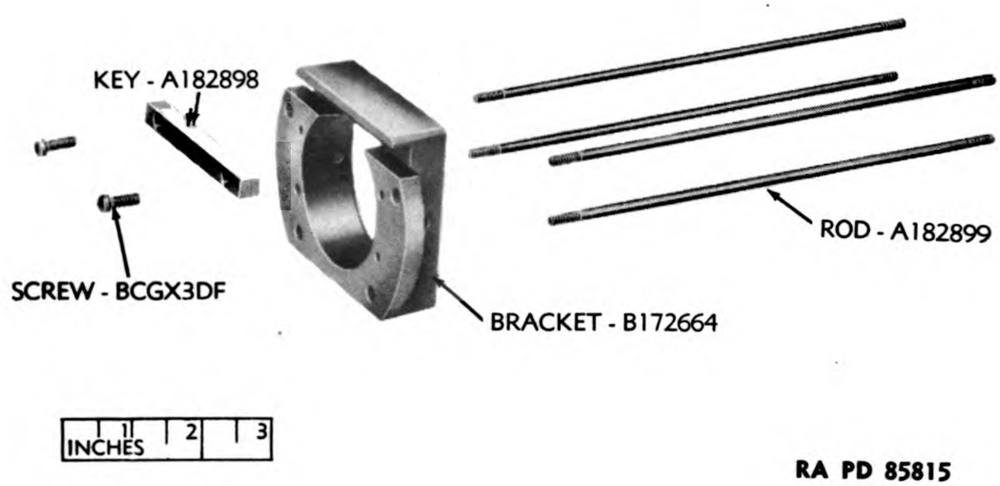


Figure 313 — Further Disassembly of Brush Assembly C78342

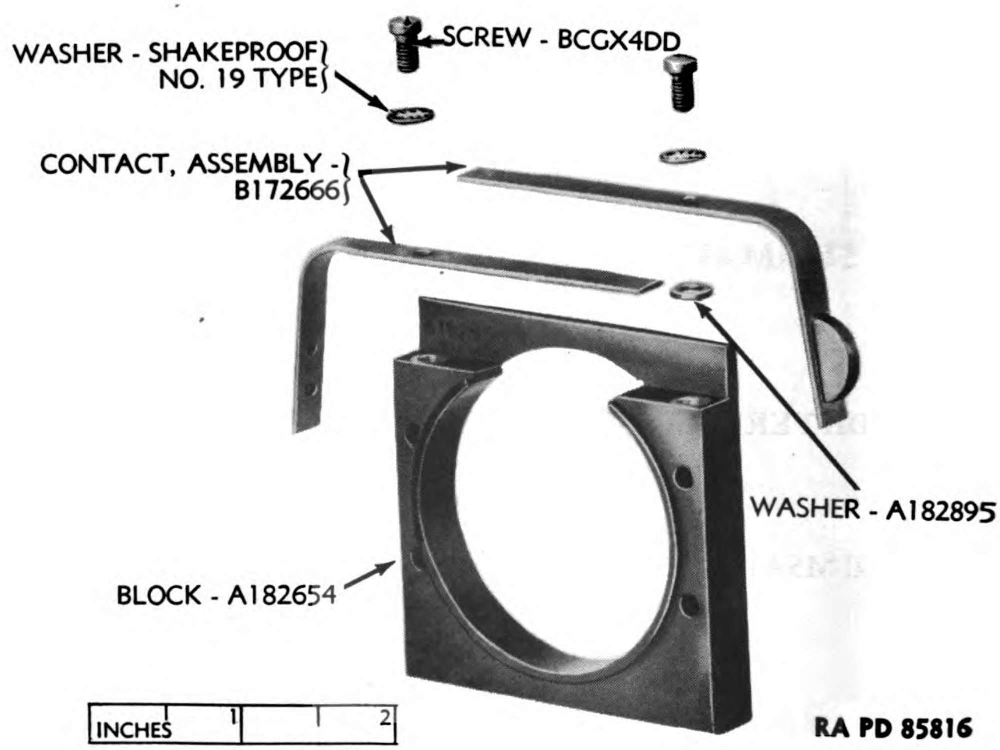


Figure 314 — Parts of Block Assembly C78343

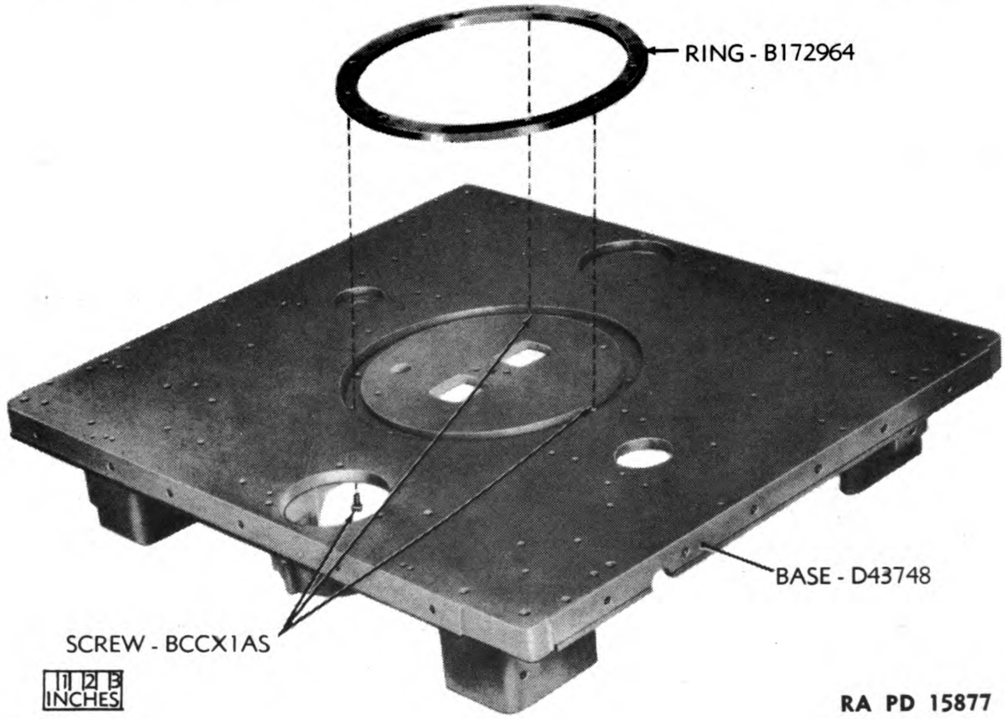


Figure 315 — Removal of Director Support Retaining Ring

Section IX

SUMMARY OF MAINTENANCE DIFFERENCES AMONG MODELS

87. DIFFERENCES IN POWER SUPPLY.

Director	Power at Director	Power at Generator
M5 and M5A1	115 volts, 60 cycles	125 volts (approx.), 60 cycles
M6	50 volts, 50 cycles	135 volts (approx.), 50 cycles

88. MAINTENANCE DIFFERENCES IN DIRECTOR M5A1.

Directors M5 and M6	Director M5A1	Par. Ref.
Variable-speed mechanism operates at low speed and 7- to 8-pound spring tension. Balls which transmit motion from disk to roller are held in cylindrical ball slider.	Variable-speed mechanism operates at higher speed and 20-pound spring tension. Balls are supported in ball bearing ball slider. Slightly different location of zero creep adjustment locking screw.	11 h 83 f
Torque amplifier required to increase output torque of variable-speed mechanism. This unit requires considerable maintenance.	No torque amplifier. Higher speed of variable-speed mechanism is reduced in gear reduction unit, and torque is sufficient to drive director. Gear reduction unit requires little attention.	40
Worm drive assembly drives open worm gear. Unbalance of wormwheel shaft may cause jerkiness.	Spiral drive enclosed. Grease cup provided. Higher speed of variable-speed disk makes jerkiness unlikely. Constant-speed governor identical but operates at slightly higher speed.	40
Running into upper or lower elevation limits at high deflection rates will disengage telescope shaft segment.	Solenoid brake on elevation variable-speed disk prevents mechanism from coasting past limit switch. Brake should be adjusted whenever cover plates are removed.	57

Coarse azimuth transmitter controls orienting dial at gun. Electrical zero position not very important. No coarse elevation transmitter.	Designed for self-synchronous gun control. Azimuth and elevation transmitter assemblies identical (except for coarse dials). Coarse and fine transmitters must be at electrical zero at same time.	52 – 53
Orienting clutch operated by two thumb nuts. Possible to damage mechanism by leaving both tightened.	Same construction on earlier models. Latest models have lever type orienting clutch.	11 k
	Removal of rate setting clutch requires taking off cover of spiral drive assembly for clearance.	73 c
	Some of latest directors have luminous dials; luminous index on spiral drive housing and deflection gear may be separately removable, but the assembly retains same number as part it replaces (specify "with luminous paint"). Range light shields used with luminous dials are attached without removing wires, as shown in figure 305.	

Section X

REFERENCES

89. PUBLICATIONS INDEXES.

The following publications indexes should be consulted frequently for latest changes or revisions of references given in this section and for new publications relating to materiel covered in this manual:

a. Introduction to Ordnance Catalog (explaining SNL system)	ASF Cat. ORD 1 IOC
b. Ordnance Publications for Supply Index (index to SNL's)	ASF Cat. ORD 2 OPSI
c. Index to Ordnance Publications (listing FM's, TM's, TC's, and TB's of interest to Ordnance personnel, OPSR, MWO's, BSD, S of SR's, OSSC's, and OFSB's, and includes alphabetical listing of Ordnance major items with publications pertaining thereto)	OFSB 1-1
d. List of Publications for Training (listing MR's, MTP's, T/BA's T/A's, FM's, TM's, and TR's concerning training)	FM 21-6
e. List of Training Films, Film Strips, and Film Bulletins (listing TF's, FS's, and FB's by serial number and subject)	FM 21-7
f. Military Training Aids (listing graphic training aids, models, devices, and displays)	FM 21-8

90. STANDARD NOMENCLATURE LISTS.

a. Cleaning, preserving and lubricating materials; recoil fluids, special oils, and miscellaneous related items	ORD 5 SNL K-1

b. Fire Control Materiel.

Director A. A., M5 (for 37-mm and 40-mm A. A. gun carriages) and M6 (British)	SNL F-209
Gun, automatic, 37-mm, M1A2; and Carriage, automatic gun, 37-mm, M3, M3A1, M3A2, and M3E1	SNL A-29
Gun, automatic, 40-mm, M1; and Carriage, gun, 40-mm, M2 and M2A1 (A. A.)	SNL A-50

REFERENCES

System, remote control, M1 (for 37-mm A. A. gun carriage M3A1) and M5 (for 40-mm A. A. gun carriage M2) .... SNL F-208

Telescope, elbow, M17 (for Director M4, M5, M5A1, M6, M7, M7A1, M9, M9B1, and M10) .... SNL F-231

Tools, maintenance, for repair and overhaul of fire control and sighting equipment .... SNL F-272

Unit, generating, M5 (for Directors M5 and M5A1 and for seacoast uses) and M6 (for Directors M4 and M7 with data transmission system and for seacoast uses) .... SNL F-227

91. EXPLANATORY PUBLICATIONS.

a. Fire Control Materiel.

37-mm A. A. gun materiel .... TM 9-235

40-mm automatic gun M1 and 40-mm antiaircraft gun carriage M2 .... TM 9-252

Antiaircraft artillery: Gunnery .... FM 4-110

Antiaircraft artillery: Gunnery, fire control, position finding, and horizontal fire, antiaircraft automatic weapons (case I firing) .... FM 4-112

Antiaircraft artillery: Service of the piece, 40-mm fire unit .... FM 4-160

Directors M5A1, M5, and M6 .... TM 9-659

Generating units M5 and M6 .... TM 9-616

Instruction guide: The instrument repairman .... TM 9-2602

Ordnance maintenance: Generating units M5 and M6 .... TM 9-1616

Ordnance maintenance: Remote control systems M1 and M5 and cable system M8 .... TM 9-1643

b. Maintenance and Inspection.

Cleaning, preserving, lubricating, and welding materials and similar items issued by the Ordnance Department .... TM 9-850

Decontamination .... TM 3-220

Defense against chemical attack .... FM 21-40

ORDNANCE MAINTENANCE — DIRECTORS M5, M5A1, AND M6

INDEX

INDEX

INDEX

RAPD26JUN44-23M

PUBLICATIONS DEPARTMENT - RARITAN ARSENAL

NOTES