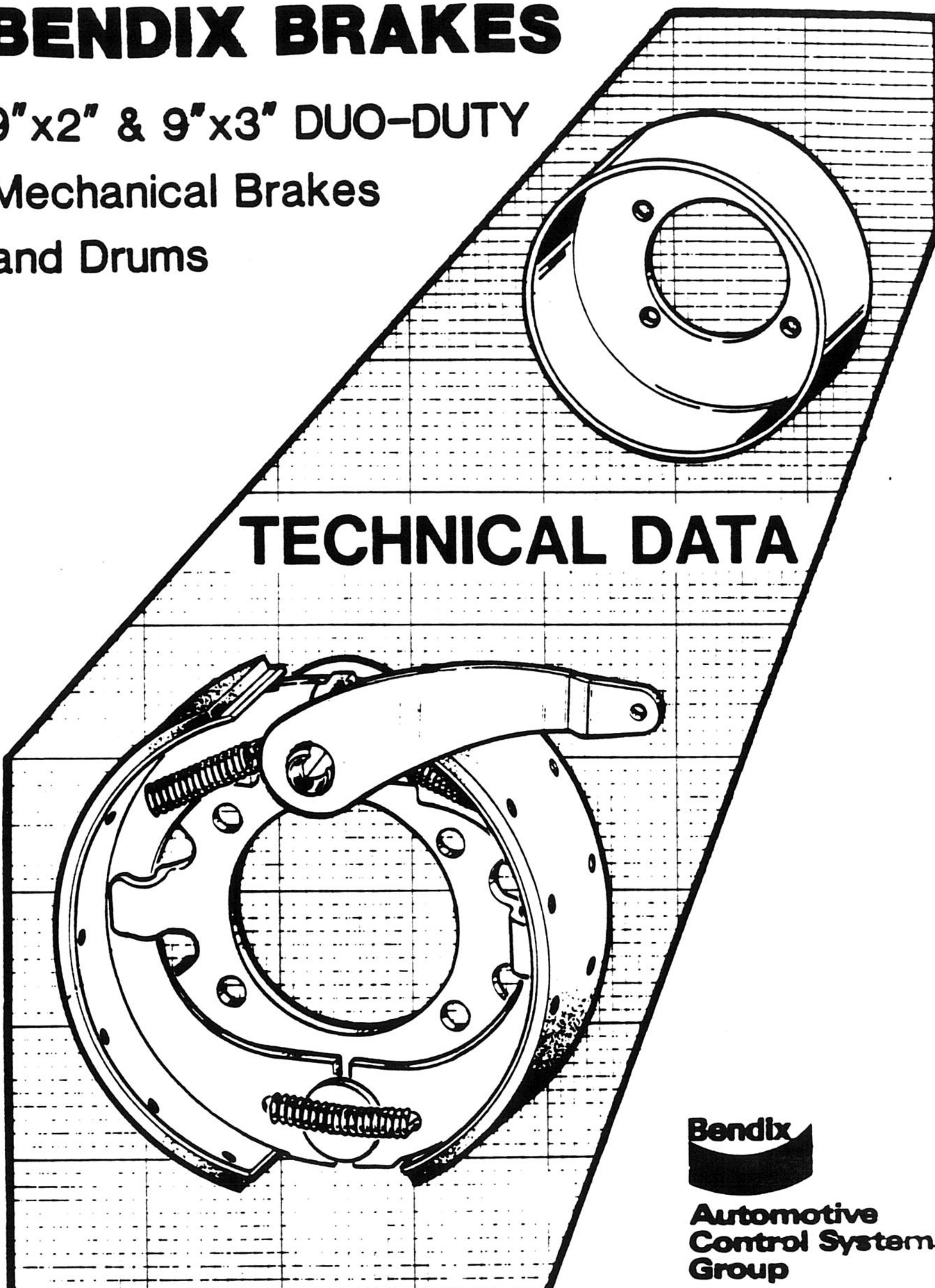
PARKING BRAKE

9x3
12x4

BENDIX BRAKES

9"x2" & 9"x3" DUO-DUTY Mechanical Brakes and Drums



TECHNICAL DATA

Bendix
Automotive Control Systems Group

Form WXA-48826 Revised & Reprinted

All correspondence concerning this brochure should be addressed to The Bendix Corporation, Automotive Control Systems Group, 401 Bendix Drive, P. O. Box 4001, South Bend, Indiana 46634, to the attention of the Automotive Brake Engineering Department.

Refer to Form No. WXA-48825

NOTE: The brake drums depicted herein are not available from Bendix at South Bend, Indiana, and are included for reference only.

For further information on drums, or for the purchasing of same from Bendix Subsidiary, please contact:

Toledo Stamping & Mfg. Co.
P. O. Box 596
Toledo, Ohio 43693

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SECTION I
GENERAL DESCRIPTION

The Bendix 9" Duo-Duty Mechanical Brake, Figure 1, is designed for parking or emergency brake usage. In special cases, however, the brake can be used as a service brake. Brakes are available in 9" x 2" or 9" x 3" width and with either a standard or a heavy duty camshaft and lever assembly.

Since the brake is mechanically actuated, it can be used in instllations where hydraulic brakes are not suitable or where regulations require a mechanical auxiliary brake to supplement air or hydraulic service brakes. Section VII, in this manual, can be used as a guide in analyzing the vehicle parking and auxiliary brake requirements and the potential usage of the 9" Duo-Duty Brake can then be determined.

Charts I through IV have been enclosed to provide pertinent brake and installation data for use in selecting the brake, the drum, and the actuating cam and lever.

FIGURE 1

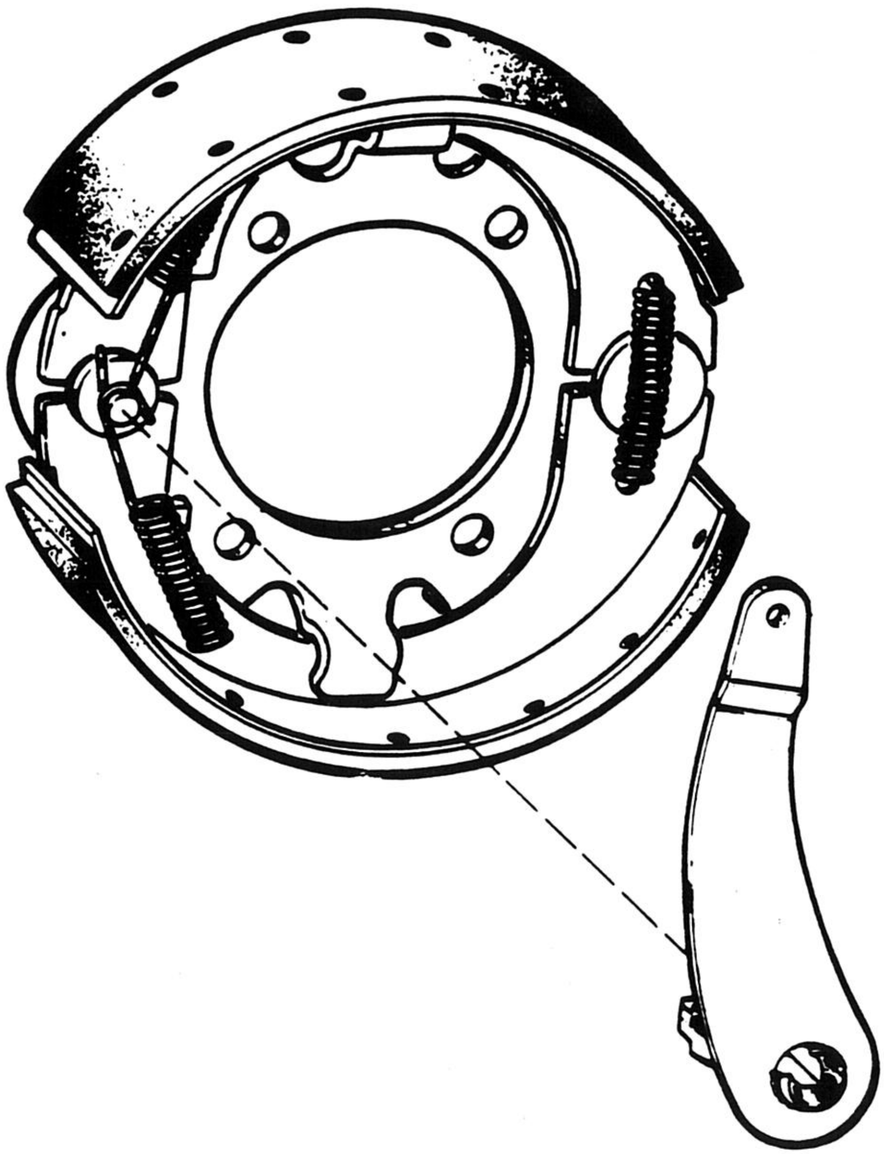


FIGURE 1

SECTION II
CONSTRUCTION

An exploded view of the Duo-Duty Mechanical Brake is illustrated in Figure 2. The brake consists of two shoe assemblies, two shoe return springs, a single shoe-to-shoe spring, and a support plate assembly.

The brake shoes are of "fabricated" construction with the shoe rim projection welded to the shoe web. Unit strength is obtained to withstand severe braking applications, yet the shoe has some flexibility to conform to the drum contour under braking pressure. Various lining materials are available. Lining selection is based upon the type of duty required for the application. A lined arc of 134° is provided on each shoe, giving a total lining area of 41.6 square inches on the 2" wide brake and 62.4 square inches on the 3" wide brake. The linings are riveted to the shoes to simplify service through the use of predrilled lining sets. Also available, are shoes with anti-shift varnish on inside radius of lining. Vehicle down time can be further reduced by the use of factory lined shoe sets.

The support plate assembly consists of a support plate and two anchor pins which are hot upset to the plate. Large shoulders on the pins, together with heavy plate thickness, gives the support plate the strength and rigidity necessary to withstand the bending loads imposed on the lower anchor pin.

FIGURE 2

The ends of the shoe webs are shaved to conform to the curved surfaces of the anchor pins. This allows the shoes to rotate on the lower anchor. Since there is no "floating" or vertical movement of the shoes on the anchor, the brake is considered to be a "fixed anchor" type.

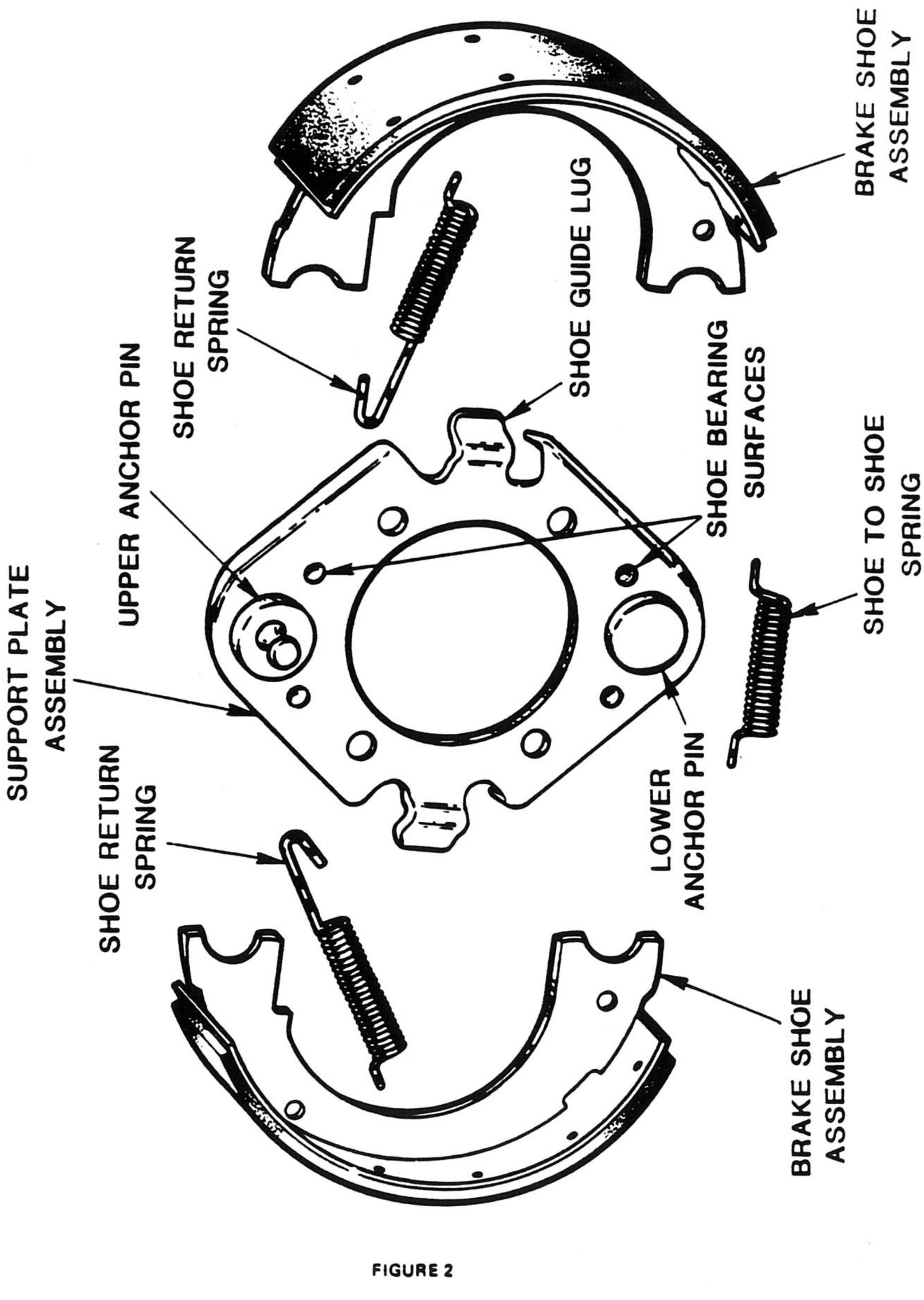

SUPPORT PLATE ASSEMBLY
SHOE RETURN SPRING
UPPER ANCHOR PIN
SHOE RETURN SPRING
SHOE GUIDE LUG
LOWER ANCHOR PIN
SHOE BEARING SURFACES
BRAKE SHOE ASSEMBLY
SHOE TO SHOE SPRING
BRAKE SHOE ASSEMBLY

FIGURE 2

Two return springs hold the shoes to the top anchor (applying end) and a single shoe-to-shoe spring holds the shoes to the lower anchor pin. The two return springs are hooked to a nib formed on the end of the anchor pin at the applying end. The standard brake uses the same spring on both sides; however, the heavy duty brake uses a different spring on one side for improved clearance with the heavy duty camshaft.

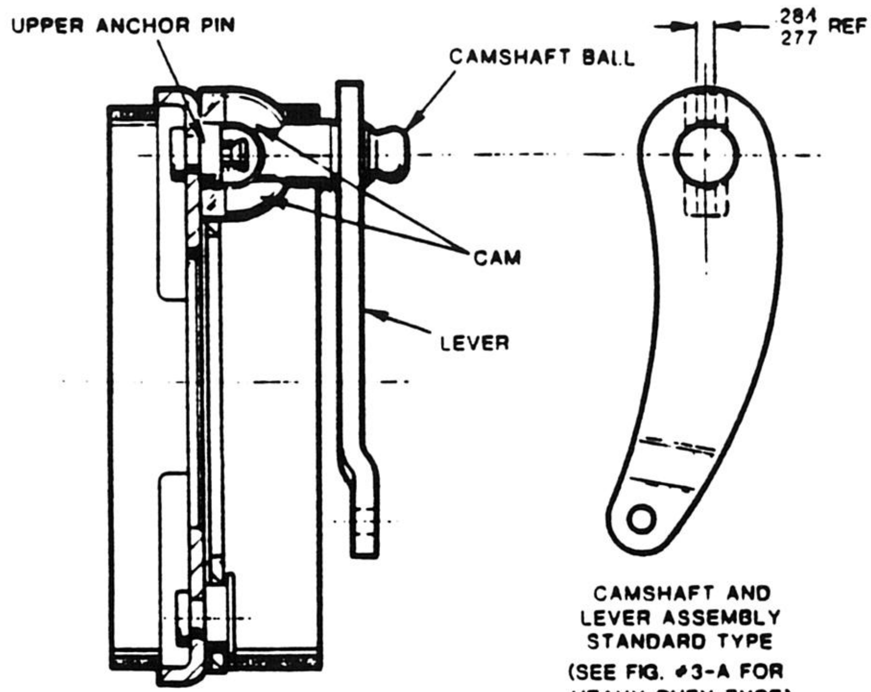
The web of each shoe is guided on both surfaces by the support plate. The shoe guiding points consist of a guide lug and two raised bearing surfaces on the plate. In addition, the lower ends of the shoe webs are held in position by a shoulder formed on the lower anchor pin, and the upper ends of the shoe webs are held in place by the ends of the return springs.

The brake is actuated by a cam and lever assembly typical of that shown in Figure 3. The cam and shaft is a forged unit and the cam is hardened at the shoe contact surfaces to give high strength and high wear resistance. The lever is pressed on the cam shaft and is brazed in place to form an integrated cam and lever unit.

FIGURE 3

Production lever and cam shaft assemblies are listed in Charts III-A to III-D. The angular location of the lever relative to the cam can be varied when necessary to adapt the brake to specific installation requirements. Overall shaft lengths are provided in two sizes for use with the 2" and 3" brake widths. When desired, the long length shaft can be used with the 2" wide brake, as well as with the 3" wide brake.

When the brake assembly is installed, the forked-shaped cam is installed over the upper anchor pin and the cams are located between the ends of the webs of the brake shoes. The ball on the opposite end of the cam shaft is a bearing surface for the shaft and means must be provided in the brake installation for proper support of the



CAMSHAFT AND
LEVER ASSEMBLY
STANDARD TYPE
(SEE FIG. #3-A FOR
HEAVY DUTY TYPE)

FIGURE 3

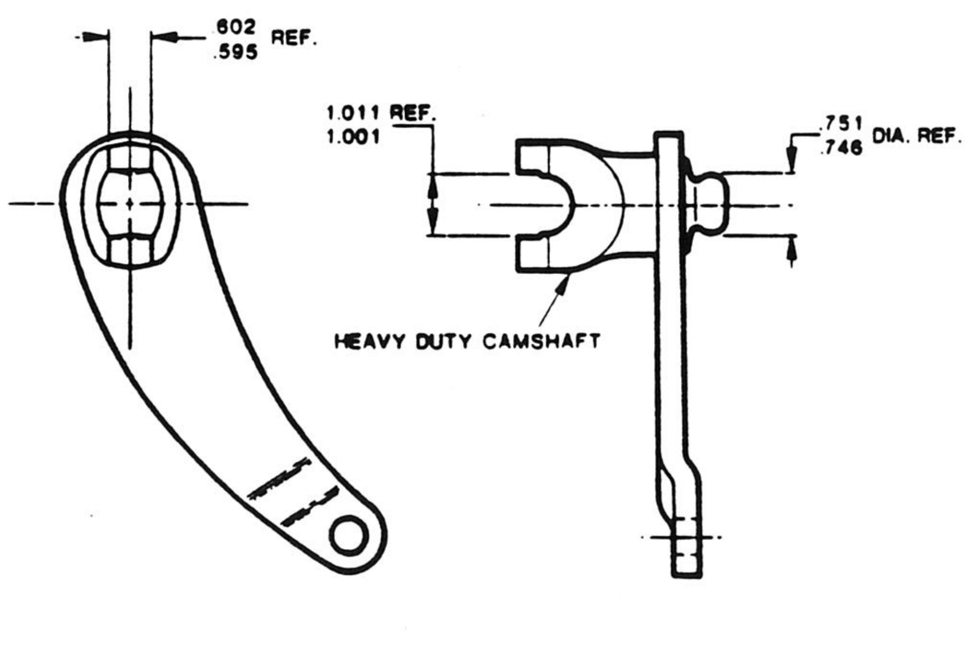


FIGURE 3-A

shaft. Lever installation data is given in Chart IV.

NOTE: The heavy duty camshaft cannot be used with a standard duty brake. Neither can a standard duty camshaft be used in a heavy duty brake. However, a standard duty brake can be converted to a heavy duty brake by changing the camshaft, brake shoe and lining assemblies (2) and one shoe return spring.

FIGURE 3-A

SECTION III
PRINCIPLE OF OPERATION

A simple schematic of the Duo-Duty Mechanical Brake is shown in Figure 4. For simplicity, the return springs and the shoe-to-shoe spring have been omitted. The Duo-Duty Brake is a non-servo type brake and the shoes operate independently of each other. One shoe is energizing (leading shoe) and the other shoe is a non-energizing shoe (trailing shoe). Whether a shoe becomes "leading" or "trailing" depends upon the direction of drum rotation.

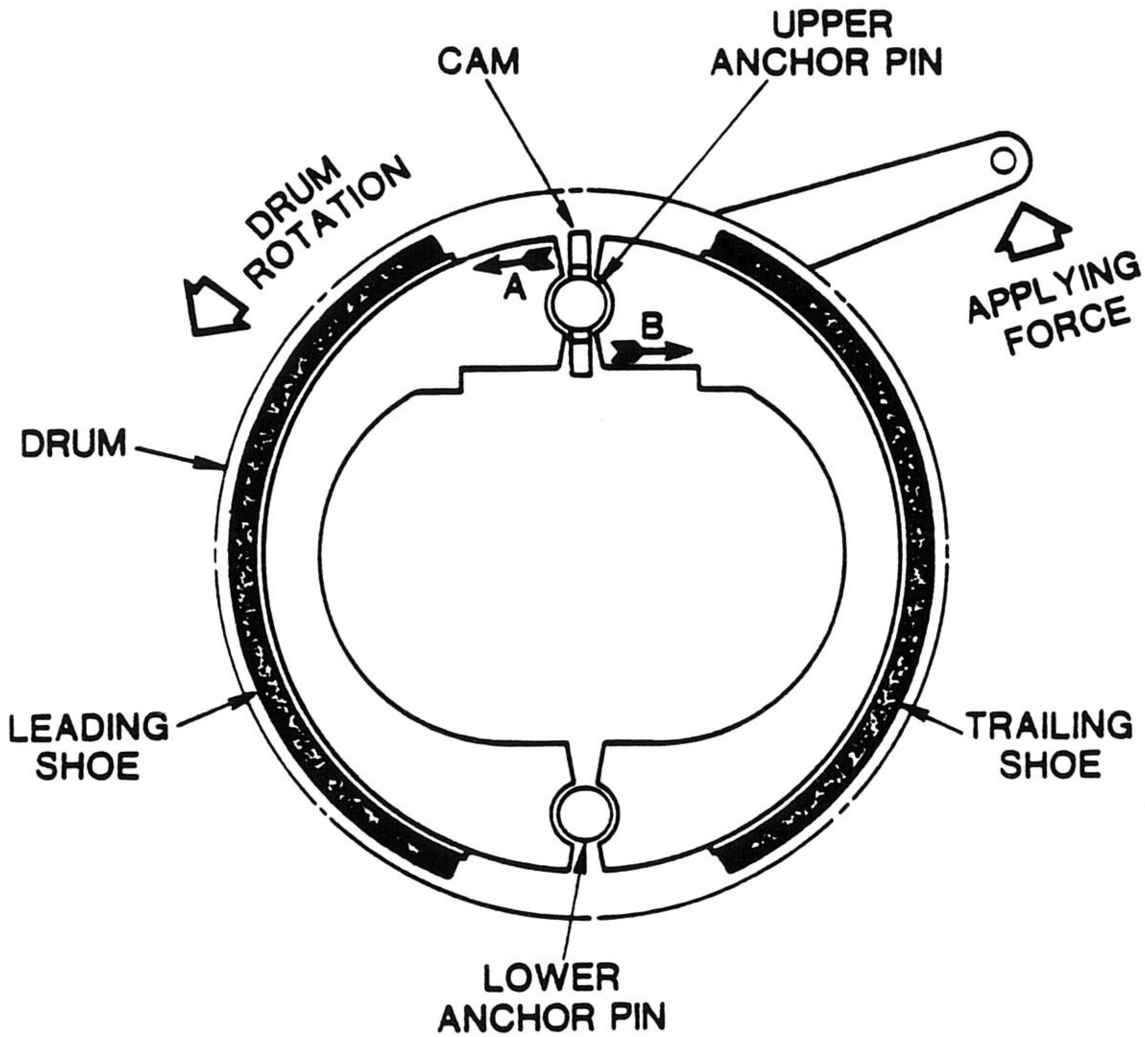
With the drum rotation counter-clockwise, as indicated by the arrow, an applying force as indicated is applied to the lever and the cam rotates counter-clockwise around the upper anchor pin. Forces A and B are applied to the brake shoes and the upper ends of the shoes move out toward the drum.

When the linings contact the drum braking surface, the friction force between the leading shoe and the drum forms a counter-clockwise moment around the lower anchor pin. Since this moment is in the same direction as the moment due to applying Force A, the shoe to drum friction force aids the applying force in holding the shoe against the drum. The leading shoe, therefore, becomes an "energized" shoe. On the other hand, in the case of the trailing shoe, the friction force opposes the applying Force B and the trailing shoe therefore, becomes a "non-energized" shoe. During braking, the leading shoe does the greater portion of the work. If the drum rotation of Figure 4 is reversed (e.g., clockwise) the right hand shoe becomes the leading shoe and the left hand shoe becomes the trailing shoe. The lever can be applied in either direction, however, the brake is usually more effective when the lever is applied in the forward direction, which corresponds to cam rotation in the same direction as the drum rotation.

Brake effectiveness and lever travel data for the Duo-Duty Mechanical Brake with FMD 9051-G linings is shown on Curves I and II.

Typical brake effectiveness curves and lever travel for standard and heavy duty brakes with FMD 9028 and FMD 9051-J linings are shown on Curves III through VIII.

FIGURE 4


CAM
UPPER ANCHOR PIN
DRUM ROTATION
APPLYING FORCE
A
B
DRUM
LEADING SHOE
TRAILING SHOE
LOWER ANCHOR PIN

SECTION IV
BRAKE INSTALLATION

General Description of the Installation

For auxiliary brake service, the brake is usually mounted on the rear of the transmission housing. A typical installation arrangement is shown in Figure 5.

A machined flange must be provided on the main shaft bearing retainer and the brake support plate is bolted to this flange. The flange has a pilot diameter, over which the pilot diameter of the support plate is installed, so that the brake will be concentric with the shaft and brake drum. Mounting dimensions of production brake assemblies are shown in Chart I. As shown in Figure 5, the ball end of the cam shaft must be supported by the main shaft bearing retainer. The hole for the ball must be properly centered with respect to the centerline of the upper anchor pin. Hole size and spacing must be such to prevent the cam shaft from binding during brake applications. Recommended installation data is tabulated in Chart IV.

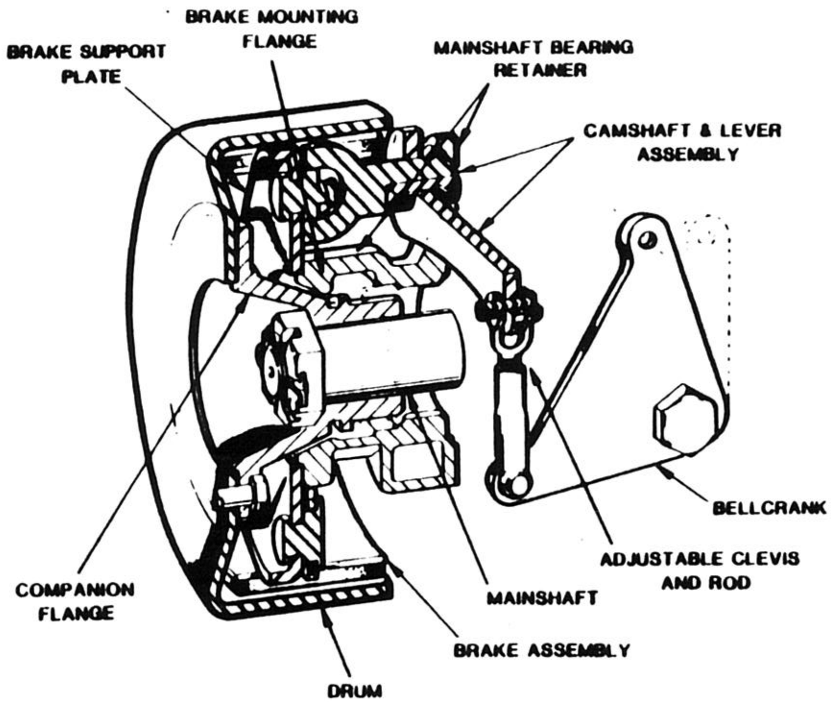
FIGURE 5

The drum is mounted to a companion flange which is attached to the main shaft. The drum thereby, rotates with the shaft. A machined pilot diameter on the flange must be provided to mate with the pilot diameter of the drum so that the drum will be concentric with the brake. Mounting dimensions of production drums are given in Charts II-A through II-D.

Installation of the Brake

The brake must be installed as a complete unit, including the cam and lever.

1. Clean all foreign matter, nicks or burrs from the mounting surfaces of the flange and brake support plate. The support plate must fit snugly on the flange.


BRAKE MOUNTING FLANGE
BRAKE SUPPORT PLATE
MAINSHAFT BEARING RETAINER
CAMSHAFT & LEVER ASSEMBLY
BELLCRANK
ADJUSTABLE CLEVIS AND ROD
MAINSHAFT
BRAKE ASSEMBLY
DRUM
COMPANION FLANGE

2. Coat ball and cam portions of the cam shaft with lubriplate grease. Grease #99 from Bendix Automotive Aftermarket; 1094 Bendix Drive; Jackson, Tennessee, 38301 is recommended.

3. Place assembled brake on mounting flange and also install cam shaft to bearing retainer and brake upper anchor pin. Lugs of cam must be between the ends of the shoes. Be sure lever position is toward actuation linkage and will align with clevis pin.

4. Align brake on mounting flange and install mounting bolts and washers. Torque nuts and bolts securely (Grade #8 or equivalent fasteners are recommended).

Installation of the Drum

1. Mount companion flange on the main shaft, per manufacturers instructions. Flange normally is either keyed or splined to the shaft and is attached with a castellated nut and cotter pin. Install nut and new cotter pin, making sure pin is bent over nut to prevent loss of pin.

2. Clean inside of drum, if necessary, and then mount drum to the companion flange. Rotate drum as necessary to match bolt hole locations with the mounting bolts.

3. Install yoke flange (or universal joint trunnion, depending upon transmission). Tighten all drum and flange (or trunnion) bolts and nuts securely.

4. Place drive shaft in position and install trunnion bolts.

5. Check drum runout with a dial indicator. If runout exceeds 0.015" total indicator reading, loosen drum bolts approximately 1/4 turn and tap high side of drum with a non-metallic mallet. Tighten bolts and recheck runout.

   NOTE: Runout of die formed steel drums is often reduced after brake use. If runout does not exceed 0.018" total indicator reading, complete brake installation. Make 6 - 8 moderate brake applications from

15 - 20 mph and recheck runout. If runout still exceeds 0.015" total indicator reading, install new drum.

Linkage Adjustment and Attachment

1. Check to make sure the auxiliary brake applying lever or pedal is in the full brakes released position.
2. Hold brake actuating lever in brake applying position sufficiently to take up slack between the cam and the ends of the shoe webs.
3. Turn adjustable clevis in or out as required to line up the holes in the lever and the clevis.
4. Lubricate the adjustable clevis with lubriplate grease and install the clevis pin and cotter pin. Spread ends of the cotter pin to prevent loss of pin.

SECTION V
MAINTENANCE AND SERVICING

Adjustment for Worn Lining

Adjust the brakes when more than 3/4 of the available travel of the pedal or hand lever is required to hold the vehicle.

NOTE: If lining material is worn to .100 inch thick (or within .020 of the rivet head) at the thinnest location, replace the linings or shoe and lining assemblies.

1. Remove the cotter pin and clevis pin, Figure 5, from the adjustable clevis or from the bell crank - whichever is easier.
2. Check to see that the adjustable clevis turns freely. Use penetrating oil or kerosene to free the clevis, if necessary.
3. Check to make sure the auxiliary brake applying lever or pedal is in the full brakes released position.
4. Move brake actuating lever in brake applying position until shoes are tight against the drum. With shoes against the drum, adjust the clevis until clevis holes align with hole in lever.
5. Back off adjustment until brake is just free when drum is rotated. Clevis pin MUST be in place when this is checked.
6. Install cotter pin and spread ends of the pin apart.
7. Check all pivot points in the mechanical operating linkage for free operation. Lubricate all pivot points where necessary. Replace worn or damaged parts.

Removal of the Brake and Disassembly

1. Remove the universal joint trunnion bolts and lower the drive shaft to the floor.

   Remove bolts holding trunnion and drum to the companion flange, Figure 5. Remove flange from the main shaft.

3. Remove the brake assembly from its mounting flange and separate the brake from the actuating cam and lever.

4. To disassemble brake, remove the two shoe return springs and the shoe-to-shoe spring, Figure 2. A spring removing tool (# Gen. 2059, or equivalent) as shown in Figure 6, should be used to remove the return springs. After return springs have been removed, spread the free ends of the shoes apart to remove the shoes from the lower anchor pin. Remove shoe-to-shoe spring.

5. Clean grease and dust from the brake parts. Use care to prevent grease or oil from getting on the linings. If the linings have been contaminated with oil or grease, they must be replaced with new linings.

FIGURE 6

Inspection of Brake Parts

1. Inspect the springs for deformed hooks, fatigue cracks, and loss of spring tension. It is recommended that new springs be installed when linings are replaced.
2. Check the support plate for distortion or loose anchor pins.
3. Inspect shoes for bent webs and rims and worn linings. Lining worn down to (or within .020" of) the rivet heads must be replaced. Reline the shoes or replace with factory lined shoes.
4. Inspect the brake actuating cam.
5. Replace any damaged, broken, worn, or questionable parts.

Brake Lubrication

1. Coat the areas noted in Step 2 below with lubriplate grease. (See Section IV, Page 8, for source.)

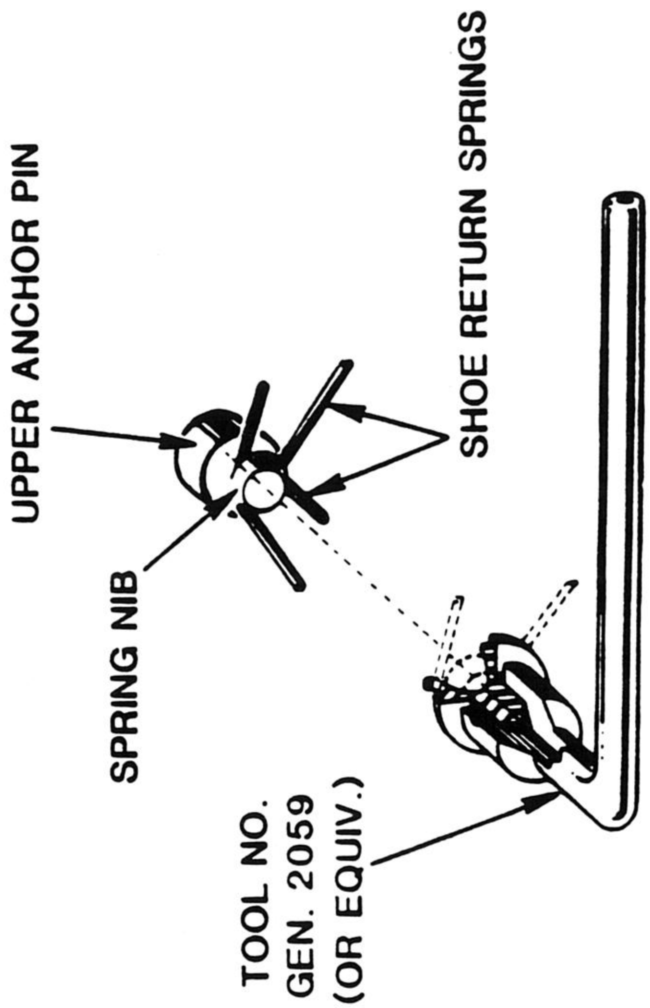

UPPER ANCHOR PIN
SHOE RETURN SPRINGS
SPRING NIB
TOOL NO.
GEN. 2059
(OR EQUIV.)

FIGURE 6

CAUTION: Use only a light coating of grease at points specified. Excess grease can melt from brake heat and drip on drum and lining surfaces. This will cause reduced brake performance.

2. Lubricate brake at:

   A. Camshaft lugs and ball.

   B. Support plate shoe-guide lugs and shoe bearing surfaces

   C. Support plate anchor pins.

   D. Contact surfaces at both ends of the shoe web. Use caution to keep lubricant off of the linings.

Reassembly of the Brake and Reinstallation

1. Install the ends of the shoe-to-shoe spring, Figure 2, into lower holes of the brake shoes.

2. Spread open upper (applying) ends of the shoes and assembly lower ends of the shoes over shoulder of lower anchor pin with a twisting motion of the shoes. Move upper ends of the shoes to the upper anchor pin, inserting the shoe webs between guide lugs and bearing surfaces of the support plate.

3. With upper ends of the shoes against the upper anchor pin, install the two return springs. Install short hooks of springs into upper holes of the brake shoes and hook opposite ends of the springs over the anchor pin nib. On heavy duty brakes (with red and brown springs) springs must be installed over anchor pin nib with open end of hooks toward centerline of brake to provide proper clearance for camshaft. A spring installing tool, Bendix No. BPD-41938F4, Figure 7 (or equivalent tool), should be used.

Figure 7

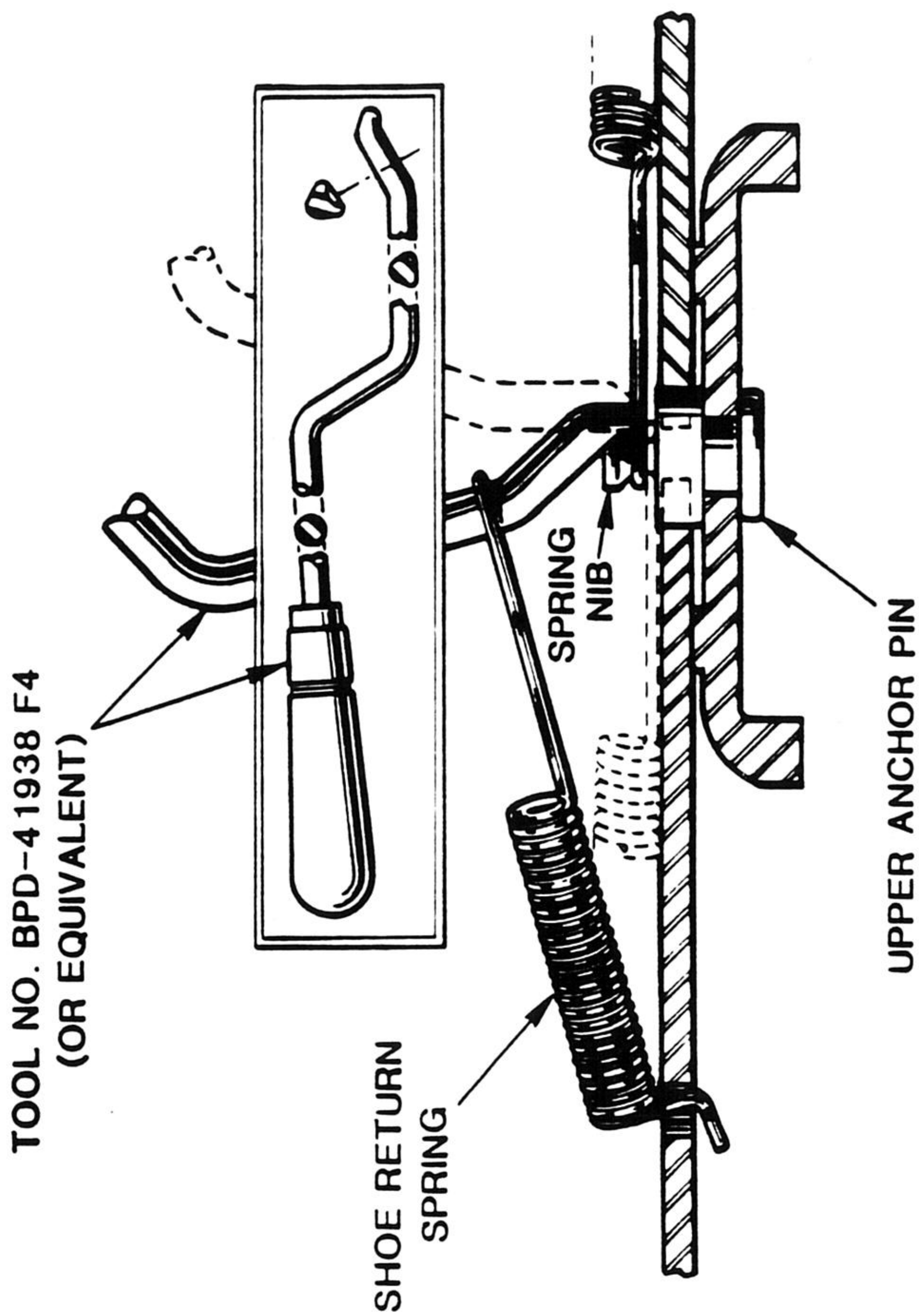

TOOL NO. BPD-41938 F4
(OR EQUIVALENT)
SPRING
NIB
UPPER ANCHOR PIN
SHOE RETURN
SPRING

FIGURE 7

4. The brake shoes must be square within 0.004 in. per inch of lining width. Shoes that are badly out-of-square will drag (rub against the drum) causing heat damage to the lining. Check shoe squareness by placing the brake assembly on a flat surface, as in Figure 8, and check shoes with a square as shown. To correct an out-of-square shoe, remove shoes and bend shoe guide lug slightly in vise in direction necessary to correct misalignment. Reassemble and recheck squareness. Shoes must be free to move within the slot provided by the guide lug and the shoe bearing surfaces.

5. Reinstall the brake assembly to the mounting flange and align the cam shaft ball in the bearing retainer, Figure 5, and the cam lugs between the brake shoe webs. Refer to the installation procedure in the "Brake Installation" section.

FIGURE 8

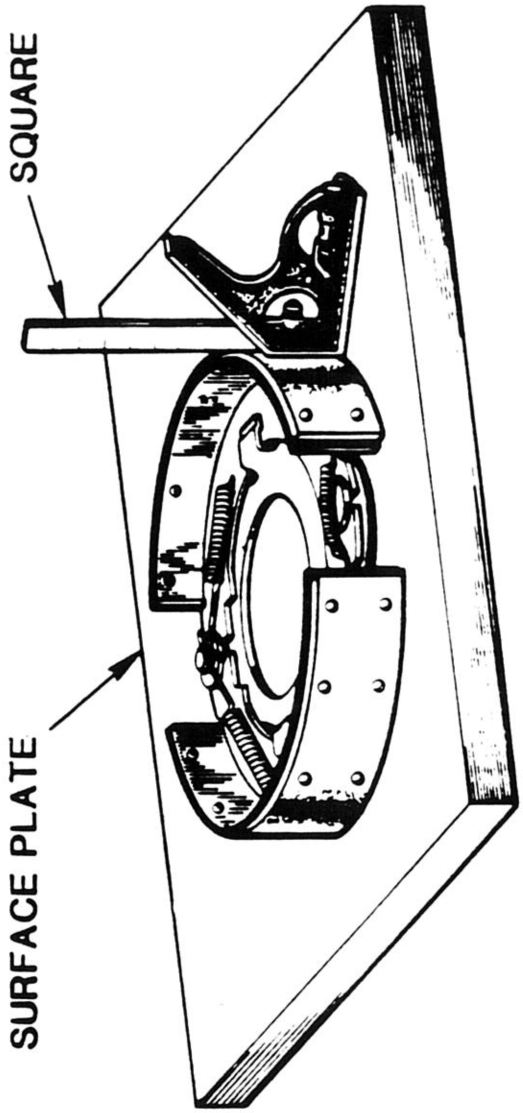


FIGURE 8

SECTION VI
BRAKE TROUBLE ANALYSIS

The brake troubles outlined in the following chart are typical of troubles that may occur in an auxiliary brake system. An investigation of the overall auxiliary brake system should be made to isolate the proper cause, or causes, of the trouble.

BRAKE TROUBLE ANALYSIS CHART

TROUBLE
Squeals or Groans
Wire Brush Noise
Clicks
Grabbing
Low Effectiveness
Excessive Lining Wear

Excessive c
complete bra
Grease soake
Excessive li
Worn out lin
Brake drag
Rough drum
dirt in drum

PROBABLE CAUSES

g
of parts
n
ning
ligned shoe
learance
wobbling drum
nkage friction
ant or transmission
g
earance preventing
ke application
d linings
nkage firction
ings
surface or abrasive

Glazed lini
Misalignmen
Dirt in drum
Worn out lin
Bent or misa
Excessive cl
Eccentric or
Excessive li
Brake lubric
oil on linin

Remov
Corre
or dr
Remov
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neces
Check
repla
Adjus
Inspe
on ma
Check
lubri
Repla
from
Adjus
slack
Repai
Check
all p
Relin
drum,
Brake
inspe
Smoot
is ba
CAUTI
excee

ce brake linings. Clean oil and excess brake lubricant
brake and drum. Replace faulty oil seal at main shaft.
t brake lining to drum clearance and also take up
in brake linkage.
source of oil leak and install new linings.
for linkage binding, and misalignment. Lubricate
ivot points
e brake shoes. Check drum for scoring and replace
if necessary
lever and camshaft adjustment too tight. Also
ct for broken or missing springs
drum with emery paper or replace drum, if drum
lly scored.
ON: Drum to be replaced if I.D. reconditioning
ds 9.030" dia.

CORRECTIVE MEASURES

e glaze from lining using file or emery paper
ct misalignment by tightening any loose brake
um mounting bolts.
e drum and clean out lining dust and dirt.
for lining worn down to rivets - reline shoes, if
sary.
for misaligned shoe rubbing against the drum -
ce with new shoes, if necessary.
t lining to drum clearance
ct drum runout. Also check for worn or loose bearing
in shaft. Check drum mounting bolts for tightness.
linkage pivot points for rust, binding, or lack of
cation
e brake linings. Clean oil and excess brake lubricant

SECTION VII

BASIC CALCULATIONS

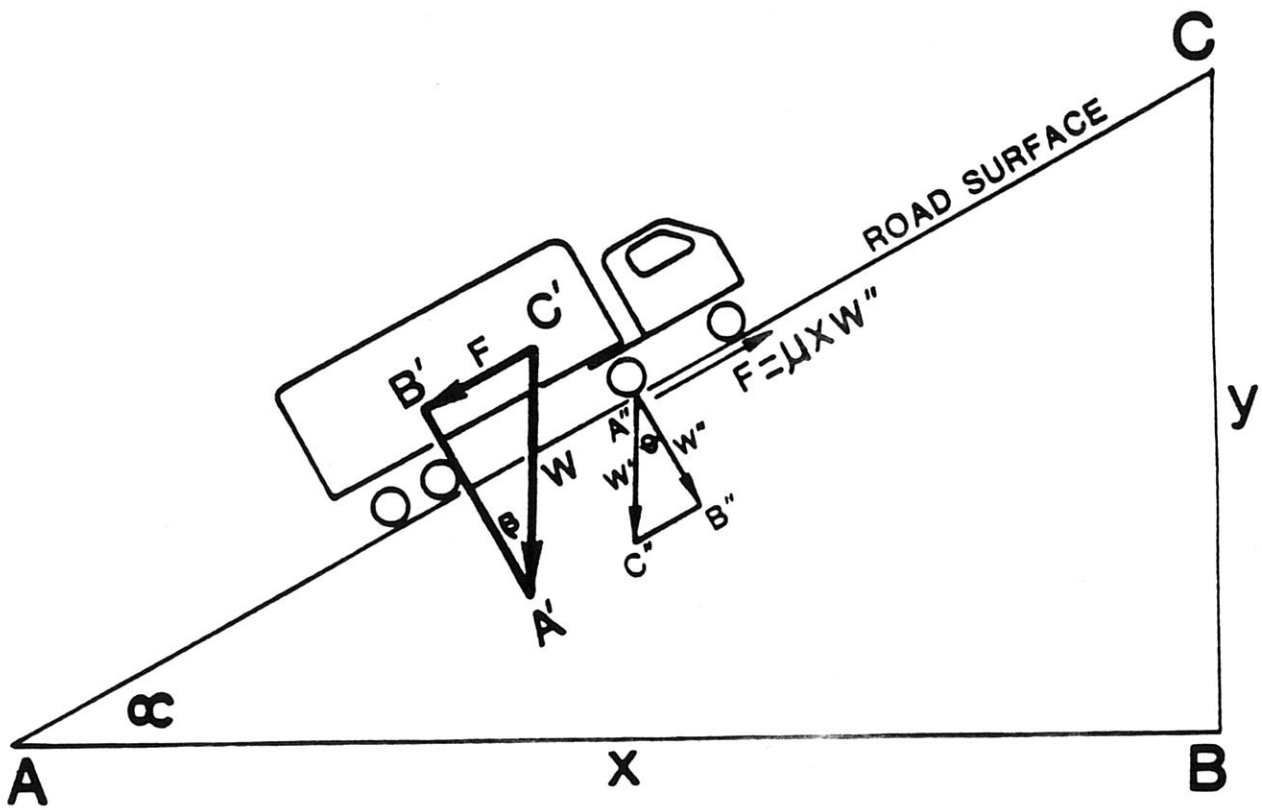
The following basic formulas can be used as a guide in analyzing the vehicle parking and auxiliary brake requirments.

Parking Brake Requirements

The parking brake should be designed to hold the vehicle, or combination, on any grade upon which the vehicle is operated under any condition of loading, on a surface free from snow or ice. It can be assumed that the vehicle may be operated on grades to the limit of traction of the rear wheels and the rear wheels are the ones upon which the parking brake acts.

The steepest grade, on which the vehicle can be operated, must be determined and the force necessary to hold the vehicle must be established. The holding force then must be translated into a brake torque.

The following diagram shows the forces involved when a vehicle of gross vehicle weight W is operating on a grade of slope $\frac{Y}{X}$.



W = Total weight of the vehicle or combination

W^1 = Portion of total vehicle weight that acts on the braked axle

W^{11} = Portion of the braked axle weight that acts normal to the road surface

F = Force needed to hold the vehicle on the grade

F^1 = Maximum friction force between the braked axle tires and the road surface

F^1 = μW^{11}, where μ is the coefficient of friction between the tires and the road. (.7 - .8 between rubber and dry pavement is normally assumed)

Since triangles ABC, $A^1 B^1 C^1$, and $A^{11} B^{11} C^{11}$ are similar, angles β and θ are equal to angle α .

The force required to hold the vehicle on grade $\frac{Y}{X}$ is F, and therefore -

$$(1) \qquad F = W \sin \alpha$$

The maximum force which is available for holding the vehicle on grade $\frac{Y}{X}$ is F^1 and therefore -

$$(2) \qquad F^1 = \mu W^{11}$$

$$(3) \qquad \text{where } W^{11} = W^1 \cos \theta = W^1 \cos \alpha$$

$$(4) \qquad \text{therefore } F^1 = \mu W^1 \cos \alpha$$

As the grade $\frac{Y}{X}$ increases, F increases. However, F^1 decreases since there is a corresponding decrease in the weight component W^{11} which is normal to the road surface. The maximum grade on which the vehicle can be held therefore occurs when $F = F^1$ and therefore - from equations (1) and (4),

$$(5) \qquad W \sin \alpha = \mu W^1 \cos \alpha$$

$$(6) \qquad \frac{\sin \alpha}{\cos \alpha} = \mu \frac{W^1}{W}$$

$$(7) \qquad \tan \alpha = \frac{Y}{X} = \mu \frac{W^1}{W}$$

Equation (7) expresses the relationship between the maximum slope $\frac{Y}{X}$, the coefficient of friction μ between the tires and the road, and $\frac{W'}{W}$ which is the ratio of the weight on the braked axle to the total vehicle weight.

Solving for angle α in equation (7) and substituting this into equation (1) will give the friction force required to hold the vehicle on the maximum grade. This friction force is then translated into an equivalent brake torque.

If the parking brakes are a part of the wheel brakes on the rear axle (single axle), it can be assumed that each brake handles an equal share of the axle load. Then the required brake torque T in inch-lbs. can be expressed as -

$$(8) \qquad T = 1/2\, W \sin \alpha\, R$$

When R is the tire rolling radius (inches), W is total vehicle weight (lbs.) and α is the angle as determined in equation (7).

When a single brake operates on the drive shaft, this brake must develop all the torque necessary to hold the vehicle and the torque equation becomes -

(9) $$T = \frac{W \sin a \; R}{K}$$

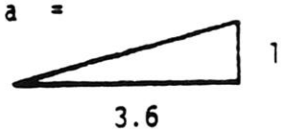
where K equals the lowest numerical axle ratio.

<u>Sample Calculation</u>:

Gross vehicle weight of vehicle (or combination)	=	20,000 lbs.
Weight on rear (driving axle)	=	8,000 lbs.
Tire rolling radius	=	19"
Axle ratio	=	6:1
Tire-to-road coefficient	=	.7

$$\tan a = \mu \frac{W'}{W} = .7 \times \frac{8{,}000}{20{,}000} = .28, \; a = 15^{\circ}\ 38'$$

maximum grade upon which vehicle can be held = tan a =



Friction force required for maximum grade,

$$F = W \sin_a = 20{,}000 \times .27 = 5{,}400 \text{ lbs.}$$

Brake torque required with parking brakes part of wheel brakes (single axle, two brakes per axle) -

$$T = 1/2\ W \sin a\ R = 1/2 \times 20{,}000 \times .27 \times 19 = 51{,}300 \text{ in.lbs.}$$

Brake torque required with single parking brake in drive shaft -

$$T = \frac{W \sin a\ R}{K} = \frac{20{,}000 \times .27 \times 19}{6} = 17{,}100 \text{ in.lbs.}$$

Referring to the static effectiveness curve (Curve I) for the 9" Duo-Duty Mechanical Brake, it can be seen that the 51,300 in.lbs. required in the first case is beyond the static torque capacity rating of the brakes and, therefore, this arrangement is not satisfactory. In the second case, the torque is within the brake capacity and is suitable. In this case for a brake torque output of 17,100 in.lbs., a lever force of 320 lbs. would be required for forward cam rotation (or 400 lbs. if reverse cam rotation) with burnished linings (FMD 9051-G). See Curve IV for static effectiveness of brakes with other linings.

Reference SAE Handbook for Vehicle Grade Parking Performance Requirements and Recommendations for various vehicles. See ANSI B 56.1 Specifications for Lift Truck Parking Brake Requirements.

<u>NOTE</u>: State and Federal Laws must also be considered and adhered to for acceptable parking brake systems for some vehicles.

AUXILIARY BRAKE REQUIREMENTS

When the brake is to be used for emergency braking purposes, reference can be made to the following example for determining the brake requirements and comparing them to the 9" auxiliary brake capacity.

For trucks, bus, and combination of vehicles, SAE J992b recommends 85 ft. maximum stopping distance from 20 mph which requires a minimum deceleration rate of 5.5 ft./sec.^{2}.

To comply with normal type recommendations, and with the inclusion of a moderate safety factor allowance, it is recommended that a 20 mph speed with a 10 ft./sec.^{2} deceleration rate be used for calculations.

It is recommended that the maximum kinetic energy absorption rate of the brake not be over 1500 ft.lbs. per square inch of lining per second. In installations where the brake is enclosed, making heat transfer to the surrounding air difficult, the energy absorption rate should be less than 1500 ft.lbs./in.^{2}/sec.

The following equations can be used when determining the auxiliary brake requirements.

(10) 20 mph - 29.3 ft./sec.

(11) Stopping time (per 10 ft./sec.^{2} decel.) $= \frac{29.3}{10} = 2.93$ sec.

(12) Vehicle kinetic energy at 20 mph,

$$KE = 1/2 \text{ mass} \times \text{velocity}^2$$

$$= 1/2 \times \frac{\text{Gross Vehicle Wt. (lbs.)}}{32.2} \times 29.3^2, \text{ ft.lbs.}$$

(13) Kinetic energy absorption rate during a stopping time of 2.93 sec.

KE per sq.in. of lining per sec. =

$$\frac{\text{Gross Vehicle Wt. (lbs.)} \times 29.3^2}{2 \times 32.2 \times \text{lining area (in.}^2) \times 2.93}$$

(14) Substituting the maximum energy absorption rate of 1500 ft.lbs./in.^{2}/sec.

$$1500 = \frac{\text{Gross Vehicle Wt. (lbs.)} \times 29.3^2}{2 \times 32.2 \times \text{lining area (in.}^2) \times 2.93}$$

or, Gross Vehicle Wt. (lbs.) = 329 x lining area (in.^{2})

The following lining areas are provided on the 9" Duo-Duty Mechanical Brake:

Brake Width	Lining Area
2"	41.6 in.^{2}
3"	62.4 in.^{2}

From the above lining area chart, the fc owing maximum gross vehicle weights can be calculated as based on the 20 mph speed and the 10 ft./sec.^{2} deceleration requirement -

For a 2" wide brake, 329 x 41.6 = 13,700 lbs.

For a 3" wide brake, 329 x 62.4 = 20,500 lbs.

To obtain the required braking deceleration, a sufficient portion of the gross vehicle weight must bear on the rear (driving axle) to which the braking is applied. If only one axle, of a tandem axle arrangement is braked, only the portion of the weight on the braked axle should be considered. The minimum weight necessary on the braked axle during braking can be calculated as follows:

(15) $$W^1\mu = \frac{W}{g} d$$

W^1 = Weight on the braked axle, lbs.
W = Gross vehicle weight, lbs.
d = Deceleration required, ft./sec.^{2}
μ = Coefficient of friction between the tires and the road
g = Acceleration due to gravity = 32.2 ft./sec.^{2}

For the required deceleration of 10 ft./sec.^{2} and μ = .7, equation 15 becomes -

$$W^1 = \frac{Wd}{g\mu} = W \times \frac{10}{32.2} \times \frac{1}{.7} = .444W$$

Therefore, for 10 ft./sec.^{2} deceleration, the weight on the braking axle during braking must be at least 44% of the gross vehicle weight. It must be emphasized that this is during dynamic braking and static load on the axle must be greater by the effects of weight transfer.

When a single brake operates on the drive shaft, this brake must develop all the torque necessary to decelerate the moving vehicle under emergency conditions. The brake torque required can be calculated as follows:

(16) $$T = \frac{W}{g} d \times \frac{R}{K}$$

T = Brake torque required, in.lbs.
W = Gross vehicle weight, lbs.
d = Vehicle deceleration, ft./sec.^{2}
g = Acceleration due to gravity = 32.2 ft./sec.^{2}
R = Wheel rolling radius (braked axle), inches
K = Axle to drive shaft ratio

For a vehicle deceleration of 10 ft./sec.^{2}, equation (16) becomes

$$T = W \times \frac{10}{32.2} \times \frac{R}{K} = .31\,W\,\frac{R}{K}$$

Sample Calculation:

Gross vehicle weight of vehicle (or combination)	=	15,000 lbs.
Weight on rear (driving axle)	=	8,000 lbs.
Tire rolling radius	=	19"
Axle ratio	=	6:1
Tire to road coefficient	=	.7
Deceleration required	=	10 ft./sec.^{2}

(From equation No. 15)

$$d = \frac{W1}{W} g \mu = \frac{8,000}{15,000} \times 32.2 \times .7 = 12 \text{ ft./sec.}^2$$

Since 10 ft./sec.^{2} is required, there is sufficient weight on the braking axle to provide the required deceleration. It is necessary, however, to determine the braking torque required per the following calculation:

The braking torque required is - (from equation 16)

$$T = \frac{Wd}{g} \times \frac{R}{K} = \frac{15,000 \times 10 \times 19}{32.2 \times 6} = 14,750 \text{ in.lbs.}$$

Referring to the dynamic effectiveness curve (Curve II) for the 9" Duo-Duty Mechanical Brake, it can be seen that the maximum torque capacity is 9,500 and 8,700 in.lbs. respectively for forward and reverse cam rotation. Therefore, the gross vehicle weight in the above example must be decreased to 9,650 lbs. in order to be able to obtain the 10 ft./sec.^{2} deceleration with the 9" Duo-Duty Brake torque capacity of 9,500 in.lbs. An alternate solution is the use of two auxiliary brakes on the drive shaft, or increase the axle ratio along with a corresponding decrease in the rolling radius, or use the Heavy Duty 9 x 3 Brake with FMD 9051-J linings that allows greater input torque to the brake camshaft for increased brake torque output. Care should be taken that brake torque, kinetic energy requirements, drum speed and brake camshaft input torques are within acceptable limits.

NOTE:

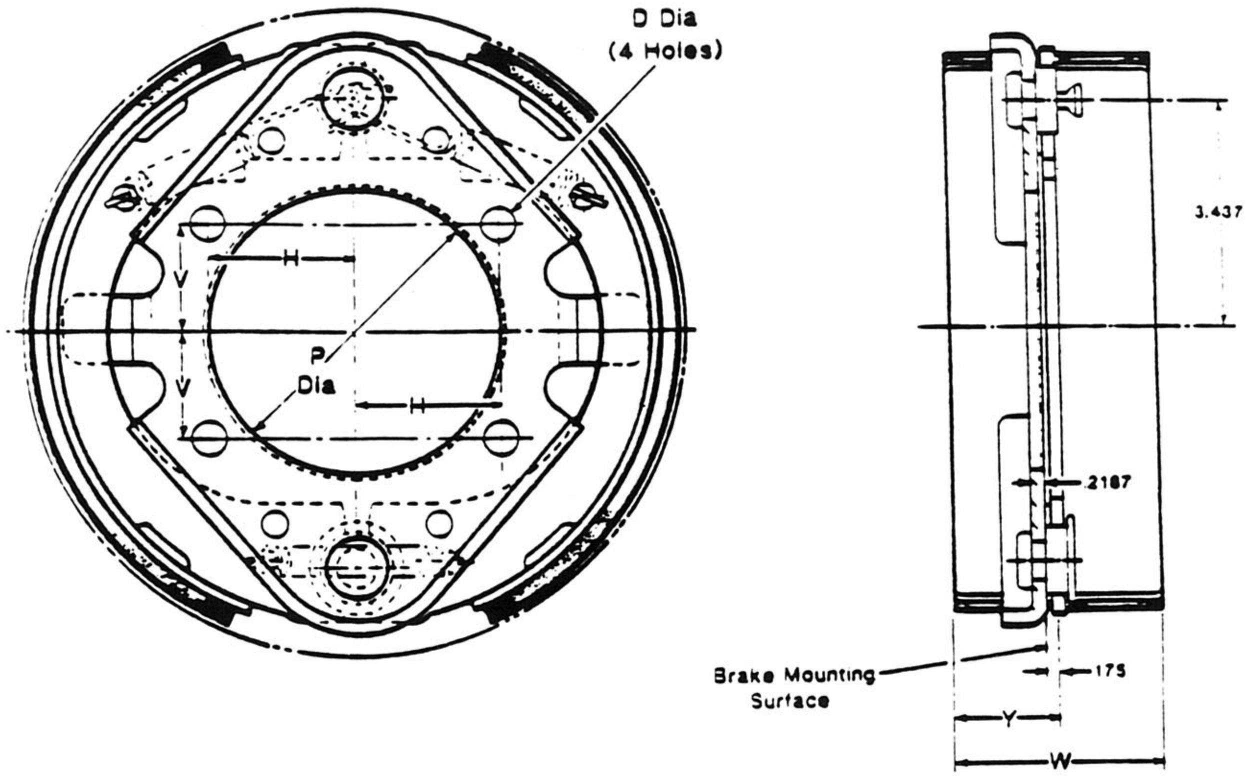
Bendix recommendation is that the 9" Mechanical Brakes described herein be used in applications where the maximum normal or use torque level does not exceed 50-75% of the ultimate brake torque rating. The lesser the torque level, the greater number of applications the brake will tolerate.

There may be combinations of conditions which would allow brake usage at greater torque. Bendix Marketing should be consulted for special applications.

Also, it is recommended that Bendix Engineering approval be obtained by submitting vehicle data with description of use requirements to Bendix Marketing Manager, Automotive Control Systems Group, P. O. Box 4001, South Bend, Indiana 46634.

CHART I

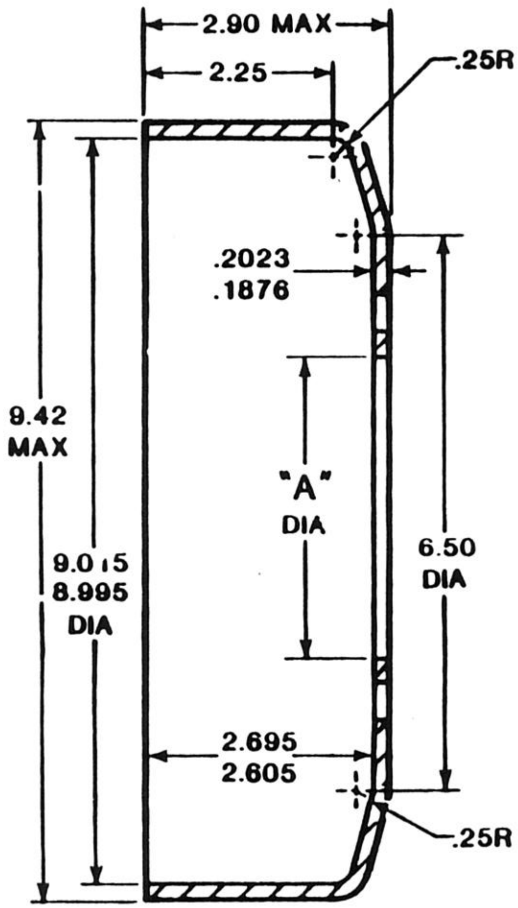
MOUNTING DATA – 9" DUO-DUTY MECHANICAL BRAKES



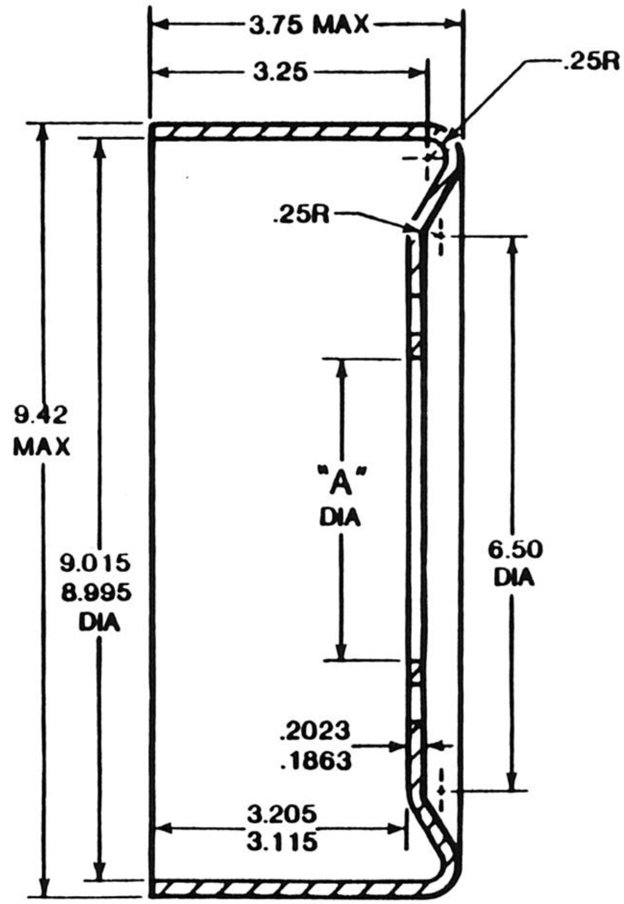
Brake Number	Dia. Inches	Width–inches W	Width–inches Y	Mounting Dimensions–inches P	V	H	D	Lining Material	Remarks
308653	9	2.00	1.00	3.693	1.437	1.875	.444-.439	FMD 9051-J	STD. ASSY.
308947	9	2.00	1.00	4.192	1.562	2.031	.507-.502	FMD 9051-G	..
309251	9	3.00	1.50	4.192	1.562	2.031	.507-.502	FMD 9028	..
315350	9	3.00	1.50	4.192	1.562	2.031	.507-.502	FMD 9051-J	..
312443	9	3.00	1.50	3.693	1.437	1.875	.444-.439	FMD 9028	..
314501	9	2.00	1.00	3.693	1.437	1.875	.444-.439	FMD 9028	..
314502	9	2.00	1.00	4.192	1.562	2.031	.507-.502	FMD 9028	..
321791	9	2.00	1.00	4.192	1.562	2.031	.507-.502	FMD 9051-J	..
324457	9	2.00	1.00	3.693	1.437	1.875	.444-.439	FMD 9028	..
324727	9	3.00	1.50	4.192	1.562	2.031	.634-.630	FMD 9028	..
4150201	9	2.00	1.00	3.693	1.437	1.875	.444-.439	FMD 9051-J	HEAVY DUTY
4150078	9	3.00	1.50	4.192	1.562	2.031	.507-.502	FMD 9051-J	..
3202445	9	3.00	1.50	4.192	1.562	2.031	.634-.630	FMD 9028	STD. ASSY.
3203245	9	3.00	1.50	4.192	1.562	2.031	.634-.630	FMD 9028	HEAVY DUTY
3203350	9	3.00	1.50	4.192	1.562	2.031	.507-.502	FMD 9028	.. ..
4150565	9	3.00	1.50	4.192	1.562	2.031	.634-.630	FMD 9028	.. ..

CHART II-A

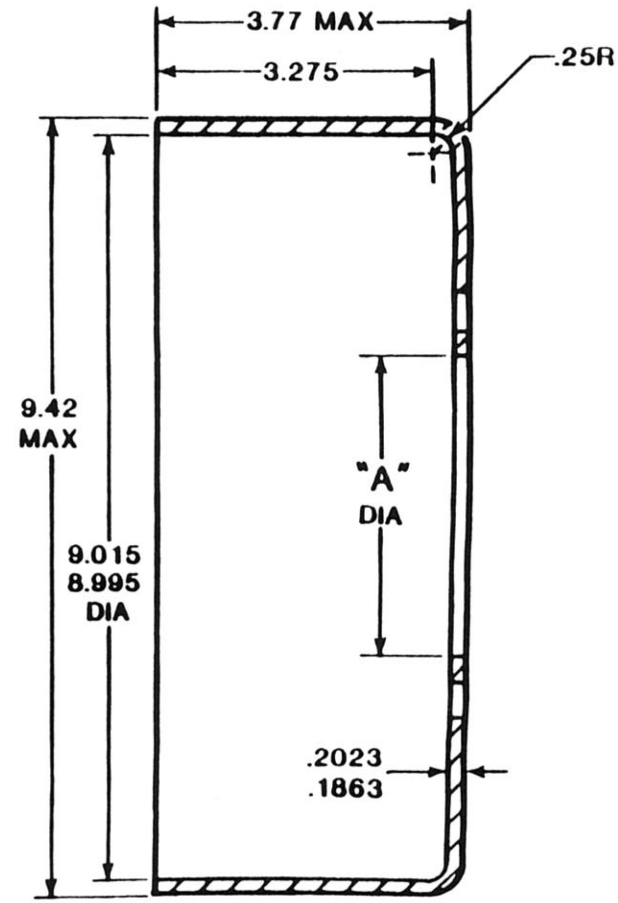
9" STEEL DRUMS FOR DUO DUTY MECHANICAL BRAKES



TYPE I
FOR 9" x 2"



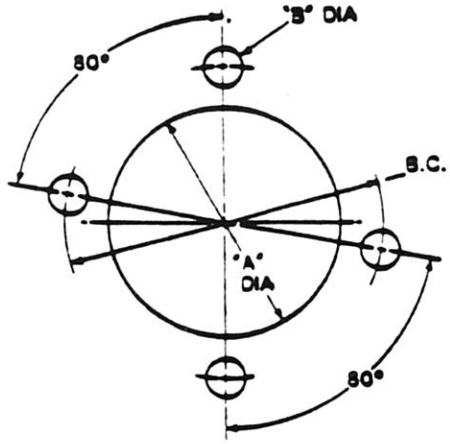
TYPE II
FOR 9" x 3"



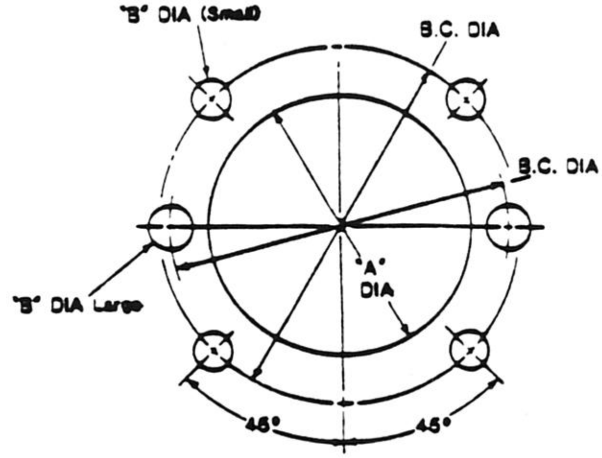
TYPE III
FOR 9" x 3"

CHART II-B

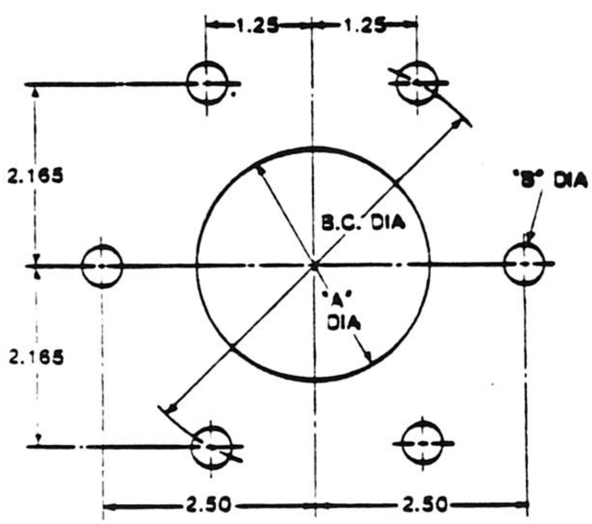
MOUNTING PATTERNS FOR TYPE I BRAKE DRUM



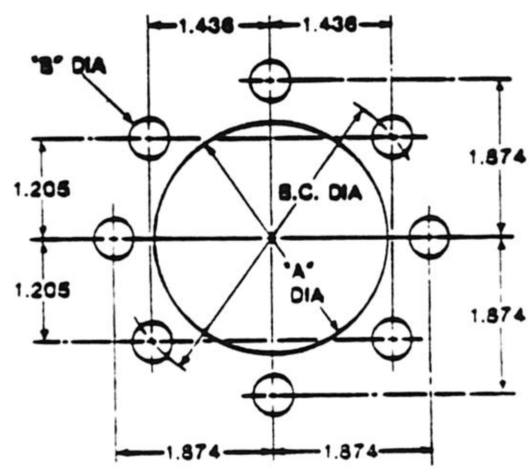
MOUNTING PATTERN #1



MOUNTING PATTERN #2



MOUNTING PATTERN #3

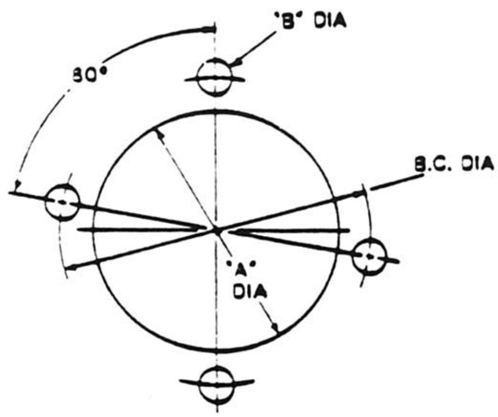


MOUNTING PATTERN #4

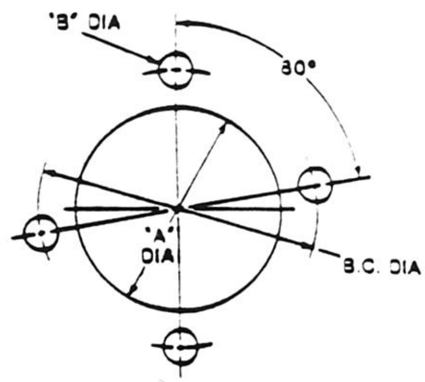
Drum Number	Mounting Pattern	Pilot Hole "A" Dia	Number of Holes	Bolt Holes "B" Dia	Bolt Circle Diameter	Protective Finish
309383	1	2.755-2.751	4	.458-.443	3.750	Zinc Plated
324461	1	2.755-2.751	4	.458-.443	3.750	Primer
324490	1	2.755-2.751	4	.458-.443	3.750	None
321792	3	2.755-2.751	6	530-.520	5.000	Zinc Plated
321832	3	2.755-2.751	6	.530-.520	5.000	None
3200732	2	3.131-3.127	2 & (4)	.500-.480 & (.451-.447)	4.00 & (4.25)	None
3200733	2	3.131-3.127	2 & (4)	.500-.480 & (.451-.447)	4.00 & (4.25)	Zinc Plated
3201769	4	2.755-2.751	8	.473-.458	3.750	None
3201770	4	2.755-2.751	8	.473-.458	3.750	Primer

CHART II-C

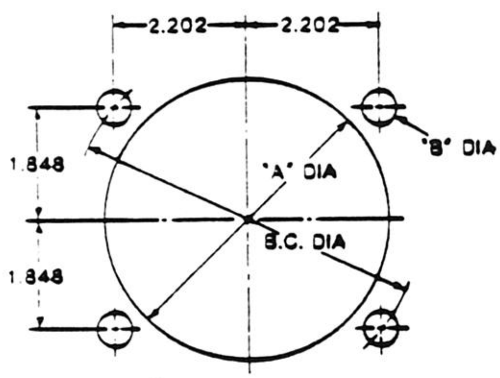
MOUNTING PATTERNS FOR TYPE II BRAKE DRUM



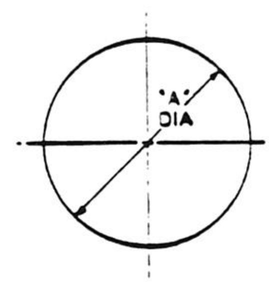
MOUNTING PATTERN #5



MOUNTING PATTERN #6



MOUNTING PATTERN #7

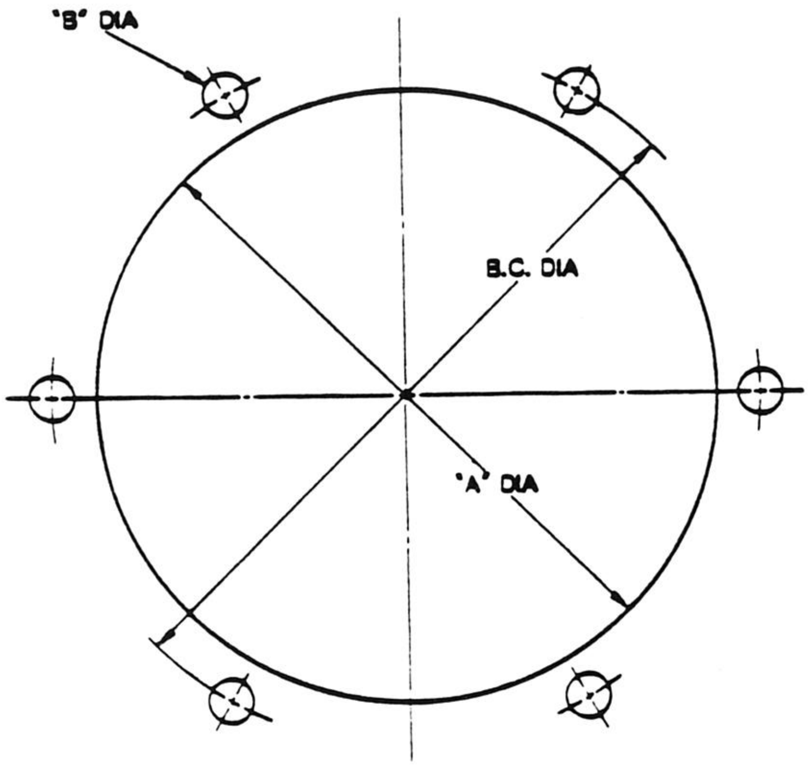


MOUNTING PATTERN #8
(To Be Added By Customer)

Drum Number	Mounting Pattern	Pilot Hole "A" Dia	Number of Holes	Bolt Holes "B" Dia	Bolt Circle Diameter	Protective Finish
310270	5	3.755-3.751	4	.521-.506	4.750	Zinc Plated
310327	5	3.755-3.751	4	.521-.506	4.750	None
3200753	6	2.755-2.751	4	.476-.466	3.750	None
3200754	6	2.755-2.751	4	.476-.466	3.750	Zinc Plated
4150081	7	4.755-4.750	4	.521-.506	5.750	None
4150082	7	4.755-4.750	4	.521-.506	5.750	Zinc Plated
312378	8	2.755-2.751	Blank	Blank	Blank	None

CHART II-D

MOUNTING PATTERNS FOR TYPE III BRAKE DRUM

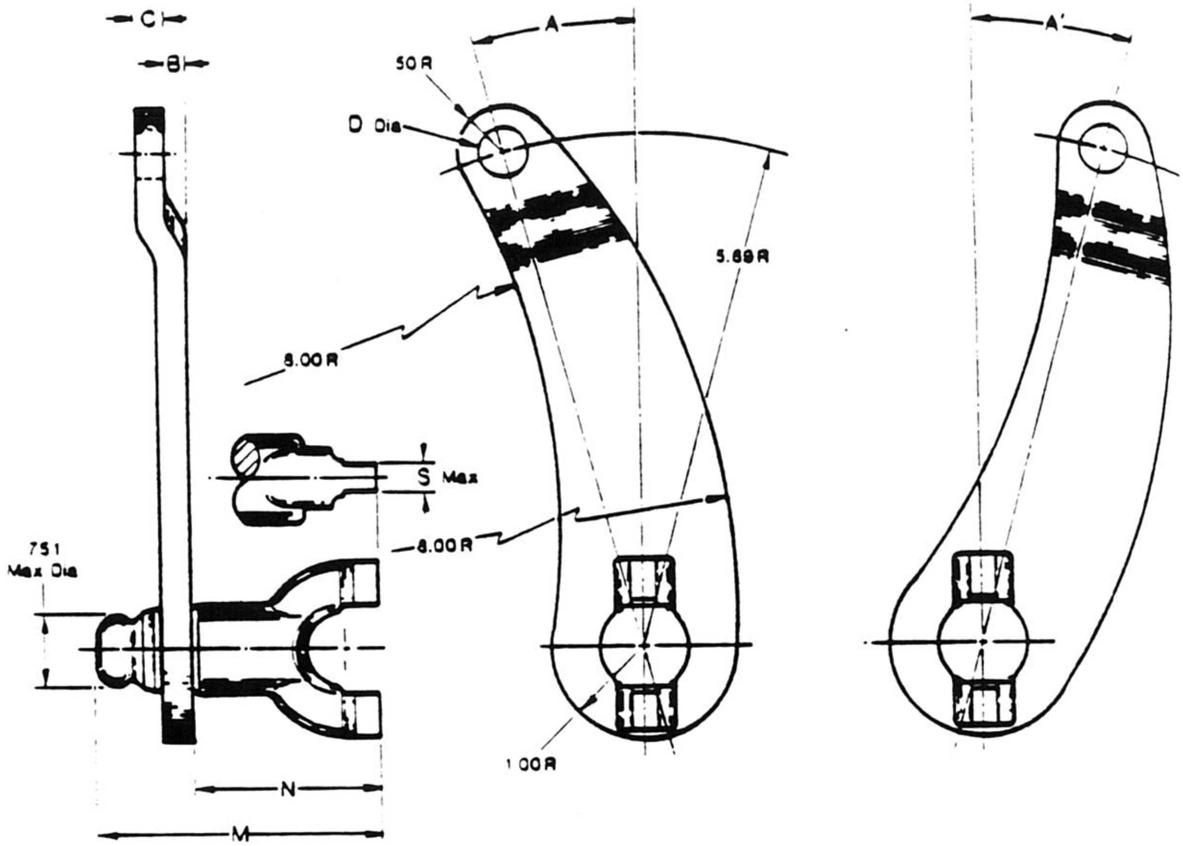


MOUNTING PATTERN #9

Drum Number	Mounting Pattern	Pilot Hole 'A' Dia	Number of Holes	Bolt Holes "B" Dia	Bolt Circle Diameter	Protective Finish
310244	9	6.452-6.448	6	.409-.404	7.250	Zinc Plate
310328	9	6.452-6.448	6	.409-.404	7.250	ES-0426 (COSMOLINE)

CHART III-A

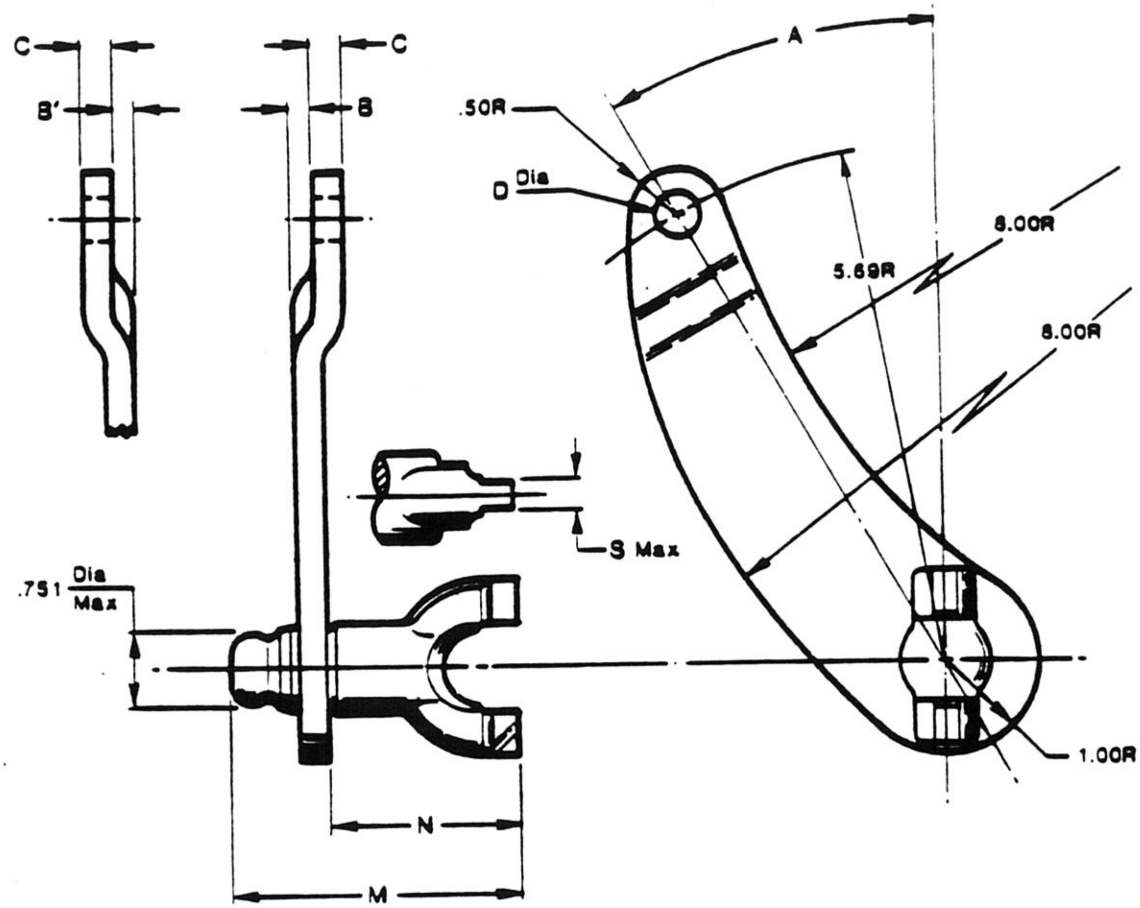
LEVER DIMENSIONAL DATA



Lever Assembly	Dimension – Inches								Coated Part Number
	M	N	A	A'	B	C	D	S	
314900	3.06	2.09	10°	-	.22	.281	.406	.284	314907
309024	3.06	2.09	-	9°	.22	.281	.406	.284	309125
308666	2.44	1.47	-	9°	.22	.281	.406	.284	308988
311673	2.44	1.47	-	28°47'	.22	.281	.41	.284	311674
3200456	3.06	2.09	36°	-	.22	.281	.531	.284	3200457
322830	3.06	2.09	10°	-	-	.281	.531	.284	322831
3203246	3.06	2.03	33°	-	.22	.344	.531	.602	3203365
315778	2.44	1.47	8°54'	-	.22	.281	.406	.284	315893
315988	3.06	2.09	-	9°	.22	.281	.406	.284	316025
315989	3.06	2.09	10°	-	.22	.281	.406	.284	316026
316824	3.06	2.09	36°	-	-	.281	.375	.284	316828
3202755	3.06	2.09	10°	-	-	.281	.375	.284	3202756
3203536	3.06	2.03	10°	-	-	.344	.531	.602	3203537

CHART III - B

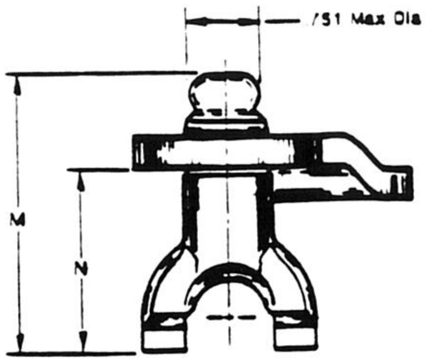
LEVER DIMENSIONAL DATA

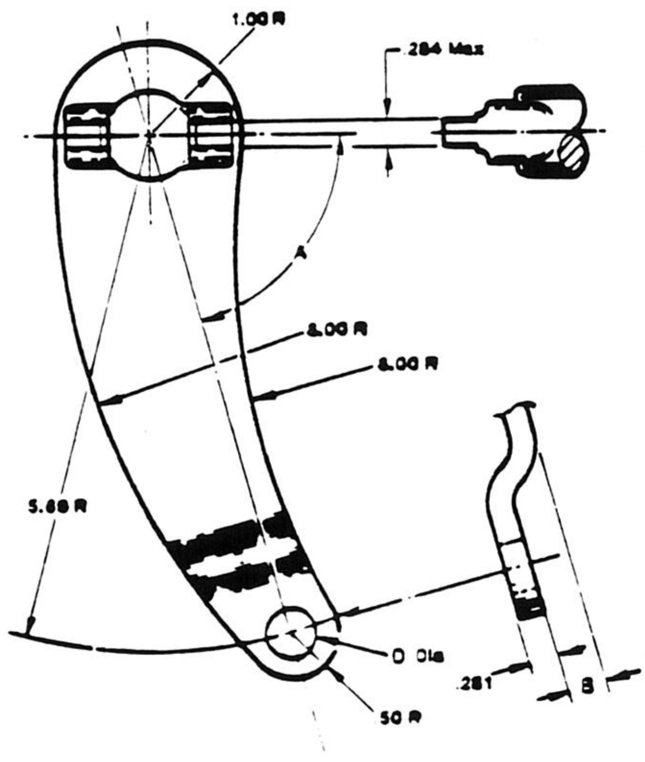


Lever Assembly	Dimensions - Inches								Coated Part No.
	M	N	A	B'	B	C	D	S	
312025	3.06	2.09	30°	-	.22	.281	.344	.284	3202620
308999	3.06	2.09	81°	-	.22	.281	.344	.284	309124
308670	2.44	1.47	81°	-	.22	.281	.344	.284	308987
3202753	3.06	2.09	81°	-	-	.281	.406	.284	3202754
3203351	3.06	2.03	120°	-	.22	.344	.531	.602	3203366
3201413	3.06	2.09	83°	-	.22	.281	.531	.284	3201583
323421	3.06	2.09	120°	-	.22	.281	.531	.284	323422
3200360	3.06	2.09	80°	-	.22	.281	.344	.284	3200361
3200751	3.06	2.09	81°	-	22	.281	.406	.284	3200752
3202541	2.44	1.47	110°	-	-	.281	.406	.284	3202542
4150072	3.06	2.09	67°30'	-	.22	.281	.344	.284	4150073
4150088	3.06	2.09	67°30'	.44	-	.281	.344	.284	4150089
3204238	3.06	2.03	83°	-	.22	.344	.531	.602	3204380
4150079	3.06	2.09	80°	-	.22	.281	.344	.602	4150080
4150442	2.44	1.47	120°	.44	-	.281	.344	.284	4150443

CHART III-C

LEVER DIMENSIONAL DATA

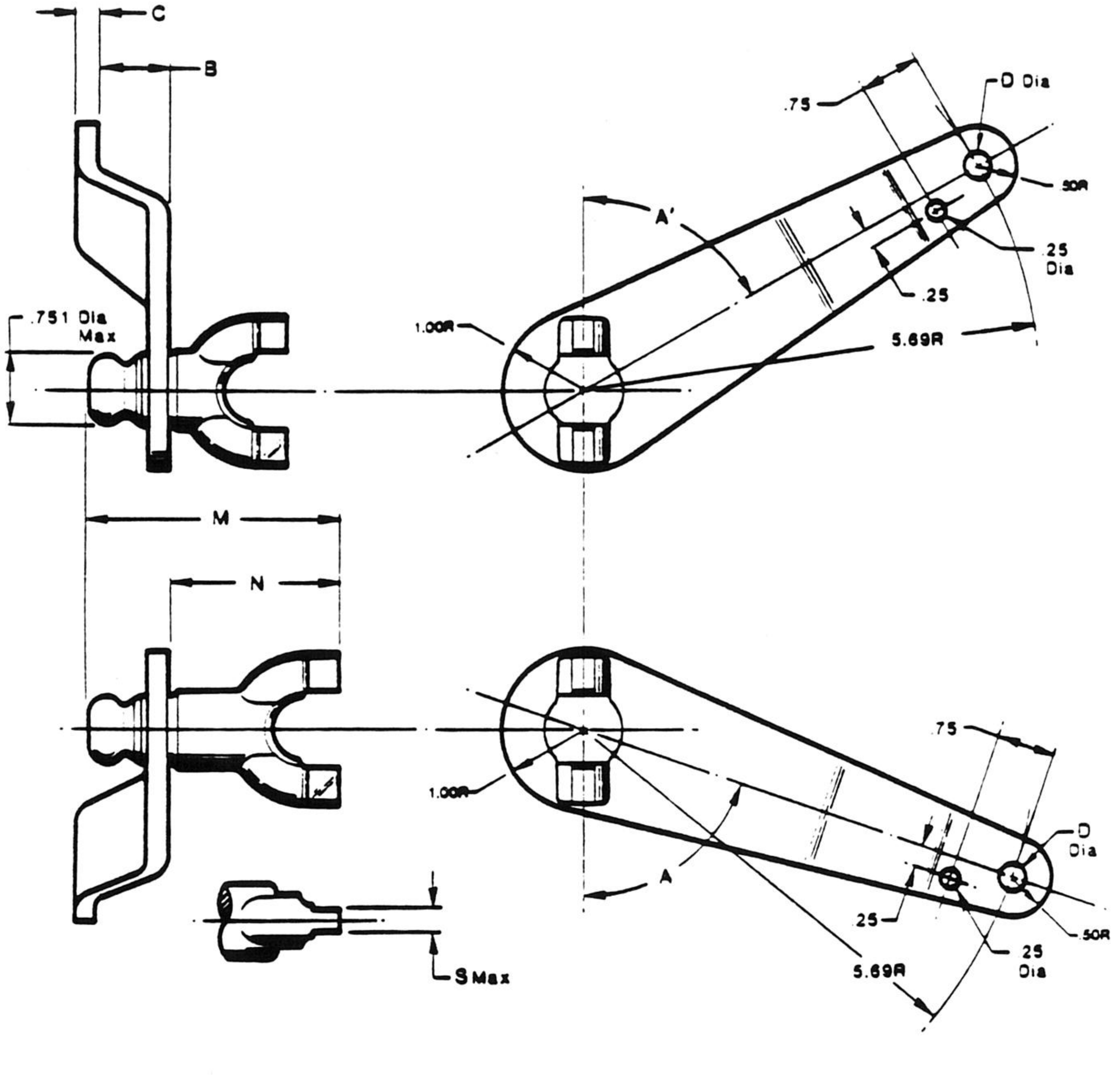




Lever Assembly	Dimension-inches					Coated Part Number
	M	N	A	B	D	
309094	3.06	2.09	31°	.44	.344	309219
324489	2.44	1.47	81°6'	-	.375	324046
4150207	2.44	1.47	95°	-	.531	4150208

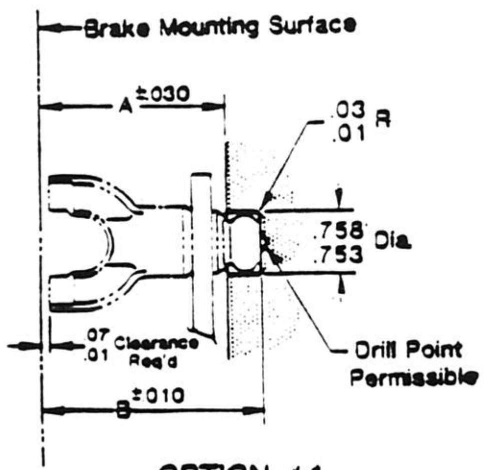
CHART III - D

LEVER DIMENSIONAL DATA

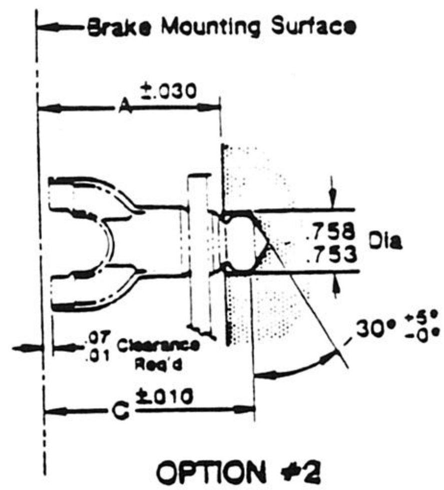


Lever Assembly	Dimensions - Inches								Coated Part No.
	M	N	A	A′	B	C	D	S	
3200729	3.06	2.09	71°	-	.92	.281	.344	.284	3200730
3202344	2.44	1.47	-	60°	.92	.28[illegible]	.344	.284	3202345

LEVER INSTALLATION DATA

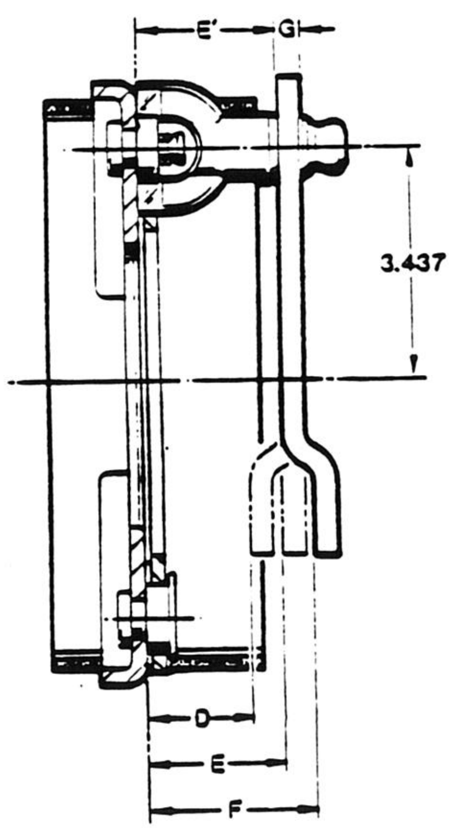


OPTION #1
(Preferred)

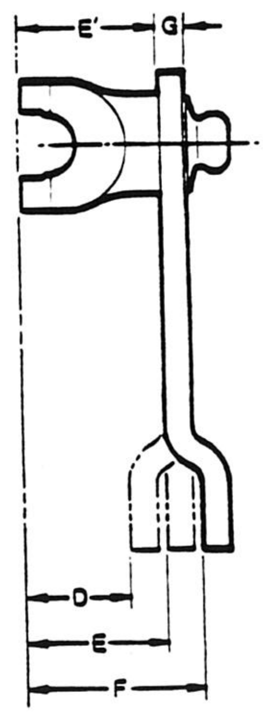


OPTION #2

Optional Methods of Machining Socket



BRAKE ASSEMBLY
(SHOWN WITH STANDARD
CAMSHAFT & LEVER ASSEMBLY)



HEAVY DUTY CAMSHAFT
& LEVER ASSEMBLY

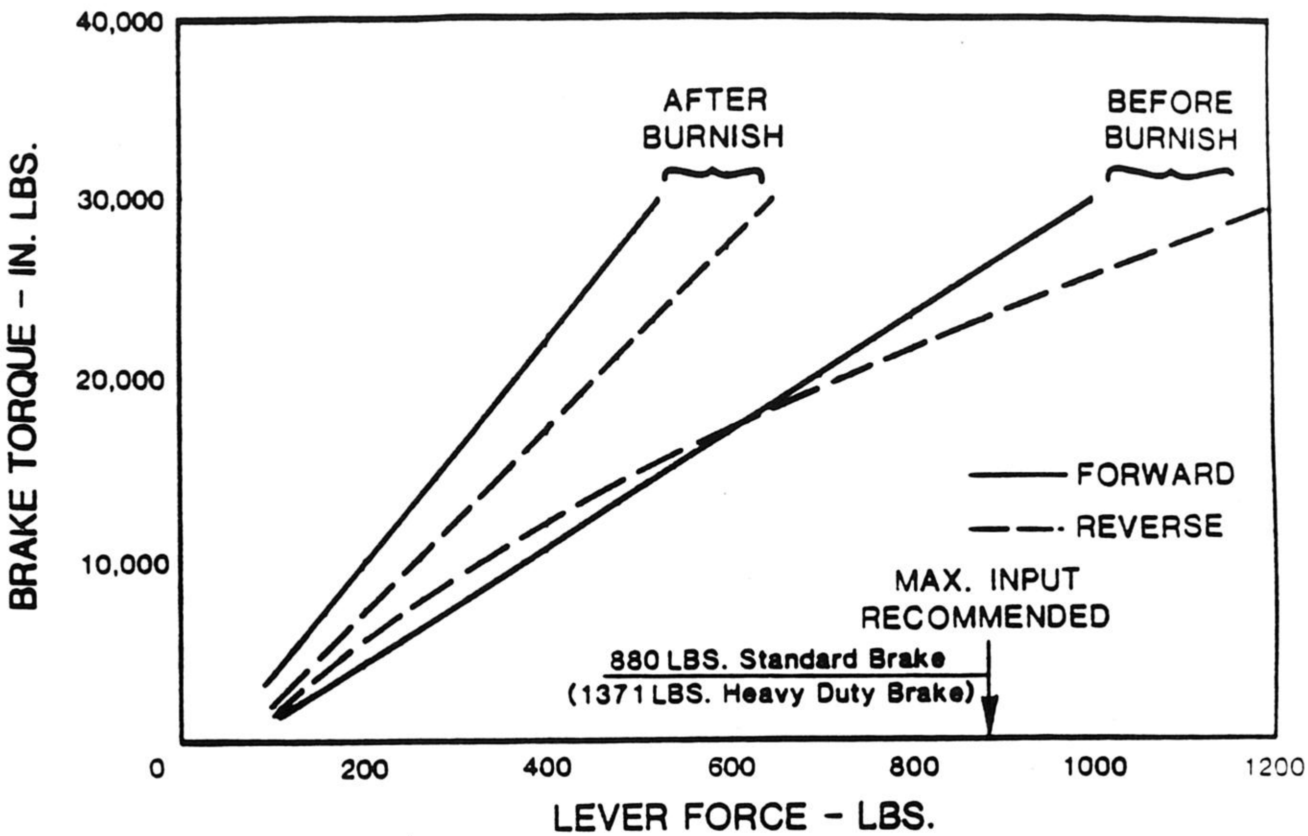
CHART IV

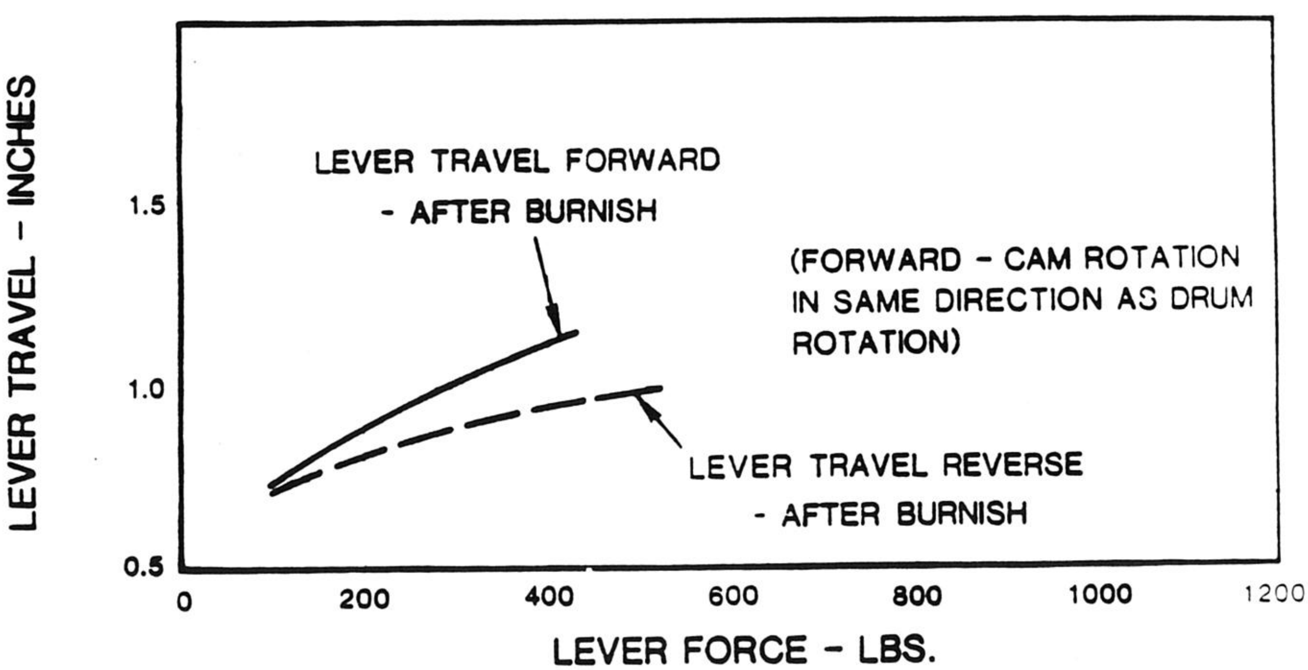
LEVER INSTALLATION DATA

Lever Assembly	Installation Dimensions - Inches								Type of Camshaft & Lever Assembly
	A	B	C	D	E	E'	F	G	
308999	2.645	3.100	3.015	1.87		2.09		.281	STANDARD
312025	2.645	3.100	3.015	1.37		2.09		.281	STANDARD
323421	2.645	3.100	3.015	1.87		2.09		.281	STANDARD
3200360	2.645	3.100	3.015	1.37		2.09		.281	STANDARD
3200751	2.645	3.100	3.015	1.87		2.09		.281	STANDARD
3201413	2.645	3.100	3.015	1.87		2.09		.281	STANDARD
4150072	2.645	3.100	3.015	1.37		2.09		.281	STANDARD
4150079	2.645	3.100	3.015	1.87		2.09		.281	HEAVY DUTY
309094	2.645	3.100	3.015	1.65		2.09		.281	STANDARD
3200729	2.645	3.100	3.015			2.09	3.01	.281	STANDARD
4150088	2.645	3.100	3.015			2.09	2.53	.281	STANDARD
309024	2.645	3.100	3.015			2.09	2.31	.281	STANDARD
314900	2.645	3.100	3.015			2.09	2.31	.281	STANDARD
315988	2.645	3.100	3.015			2.09	2.31	.281	STANDARD
315989	2.645	3.100	3.015			2.09	2.31	.281	STANDARD
3200456	2.645	3.100	3.015			2.09	2.31	.281	STANDARD
316324	2.645	3.100	3.015		2.09	2.09		.281	STANDARD
322530	2.645	3.100	3.015		2.09	2.09		.281	STANDARD
3202753	2.645	3.100	3.015		2.09	2.09		.281	STANDARD
3202755	2.645	3.100	3.015		2.09	2.09		.281	STANDARD
3203351	2.645	3.100	3.015	1.81		2.03		.344	HEAVY DUTY
3204238	2.645	3.100	3.015	1.81		2.03		.344	HEAVY DUTY
3203246	2.645	3.100	3.015			2.03	2.25	.344	HEAVY DUTY
3203536	2.645	3.100	3.015		2.03	2.03		.344	HEAVY DUTY
308670	2.025	2.480	2.395	1.25		1.47		.281	STANDARD
3202344	2.025	2.480	2.395			1.47	2.39	.281	STANDARD
308666	2.025	2.480	2.395			1.47	1.69	.281	STANDARD
311673	2.025	2.460	2.395			1.47	1.69	.281	STANDARD
315778	2.025	2.480	2.395			1.47	1.69	.281	STANDARD
324489	2.025	2.480	2.395		1.47	1.47		.281	STANDARD
3202541	2.025	2.480	2.395		1.47	1.47		.281	STANDARD
4150207	2.025	2.480	2.395		1.47	1.47		.281	STANDARD
4150442	2.025	2.480	2.395			1.47	1.91	.281	STANDARD

CURVE I
STATIC EFFECTIVENESS

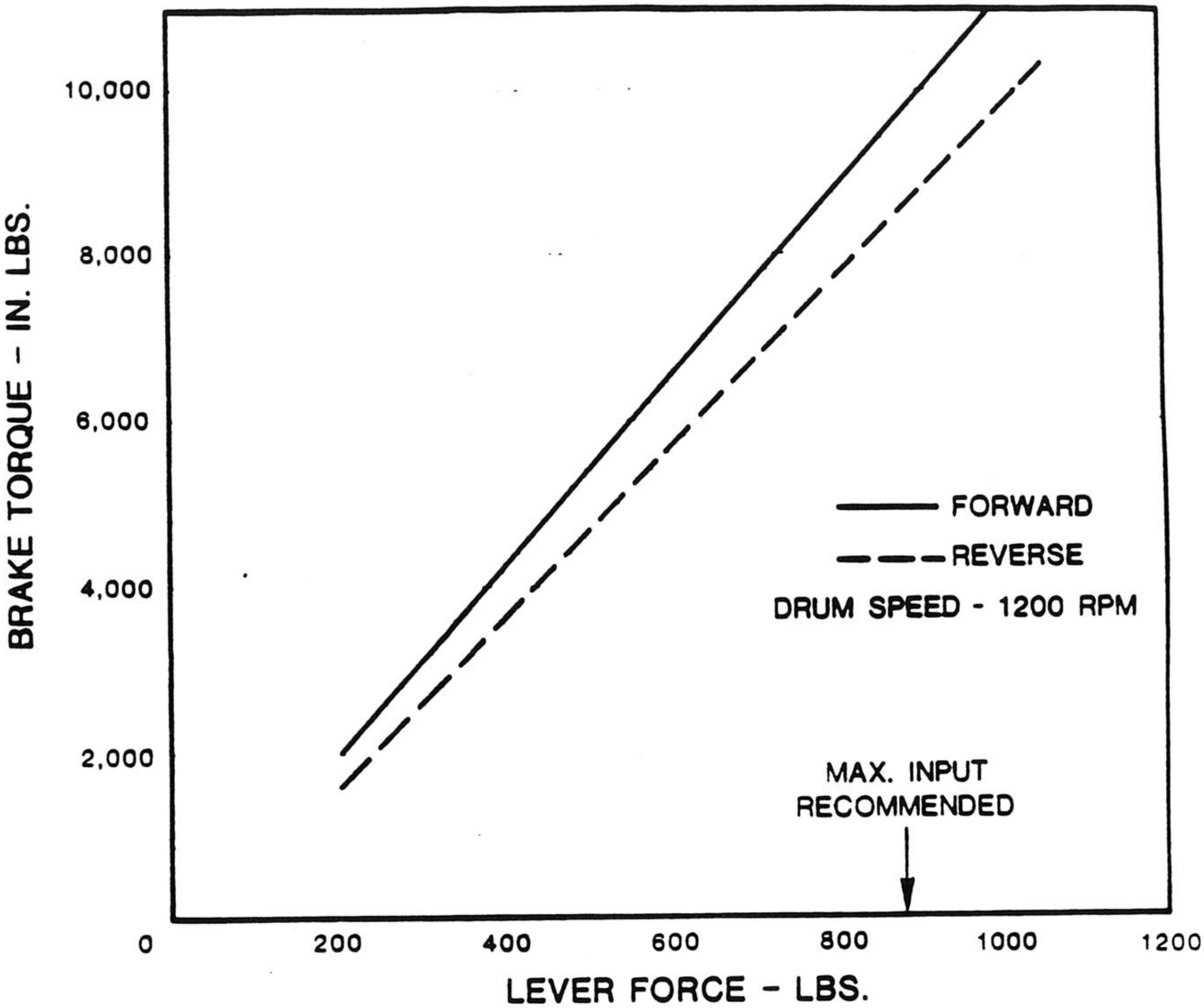
FMD 9051-G LININGS

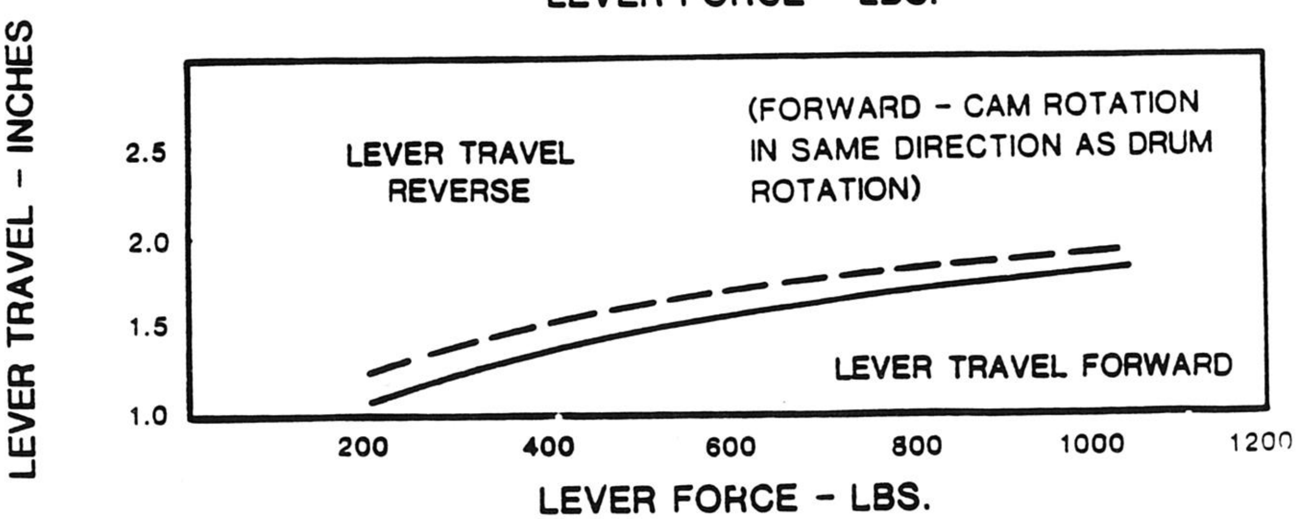




CURVE II
DYNAMIC EFFECTIVNESS

(BURNISHED LININGS FMD 9051-G)

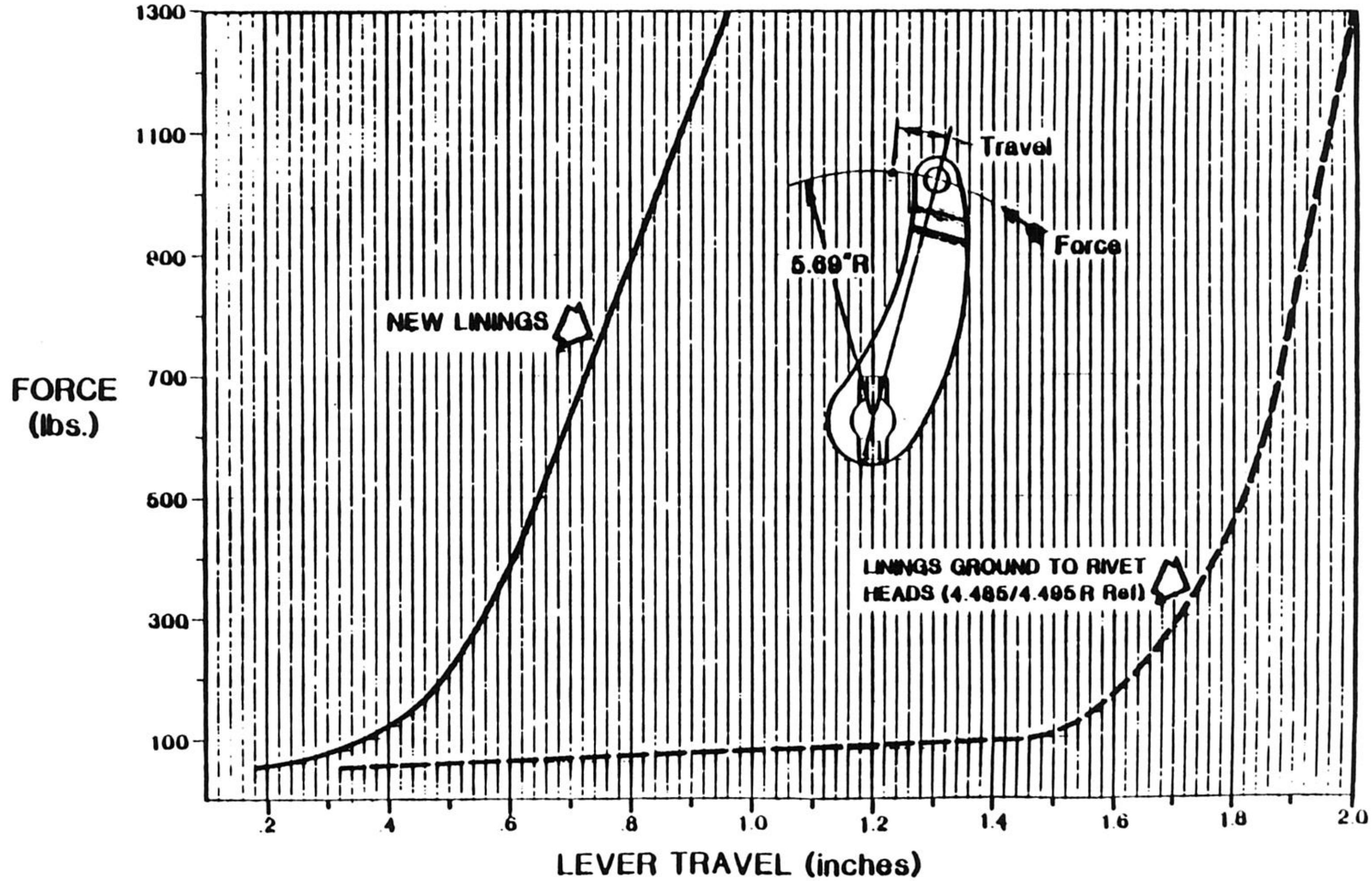




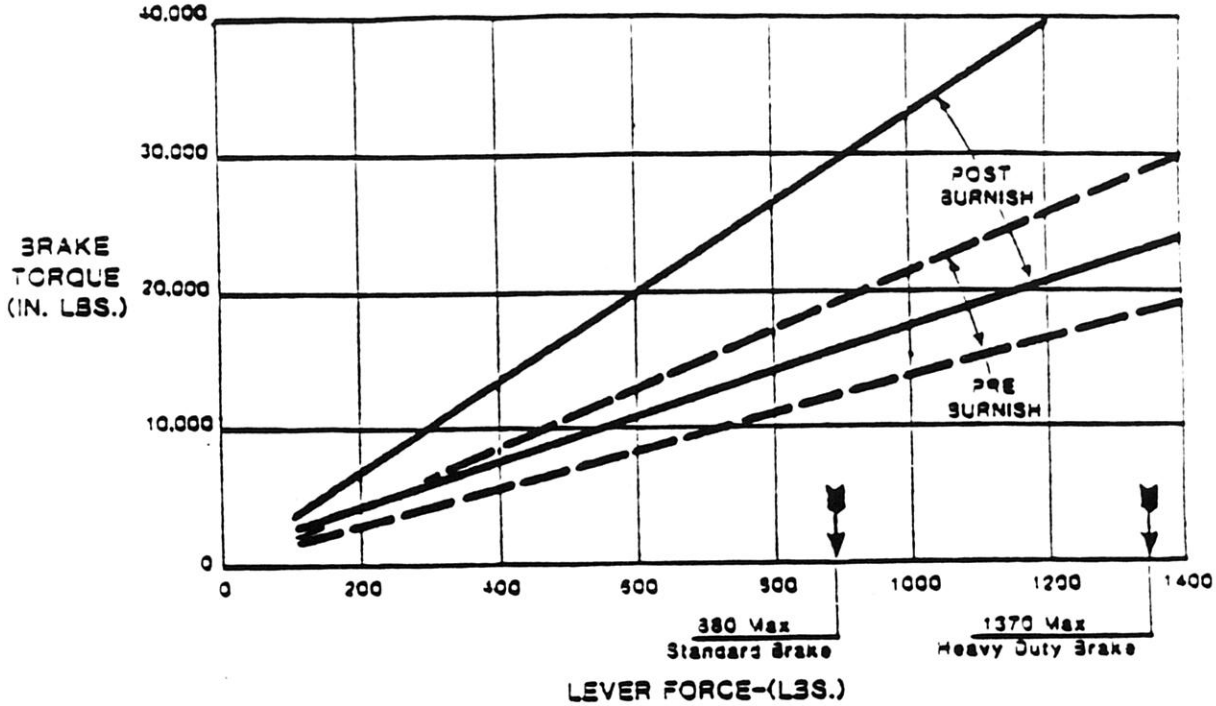
CURVE III

FORCE vs LEVER TRAVEL

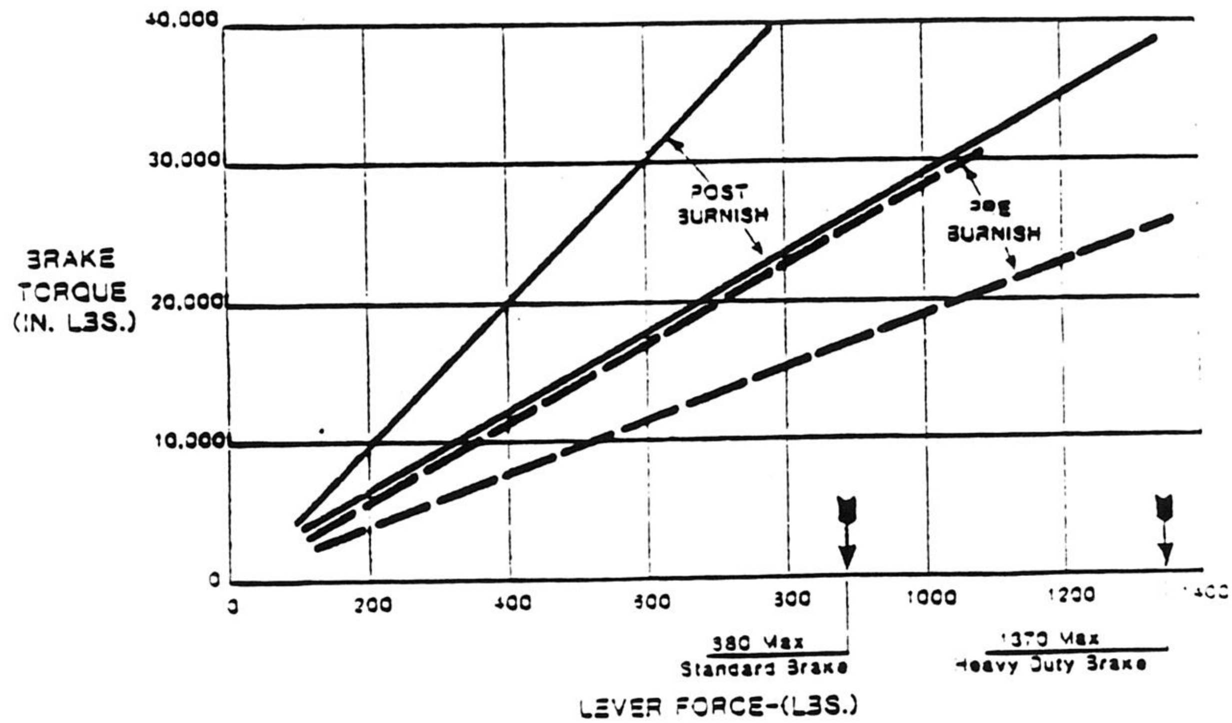
STATIC TEST – 9x2" & 9x3" Parking Brake with Stamped Drum



CURVE IV
STATIC EFFECTIVENESS
9x2 & 9x3 BRAKES



FMD 9028 LININGS WITH STAMPED STEEL DRUM
(FORWARD & REVERSE DRUM ROTATION)

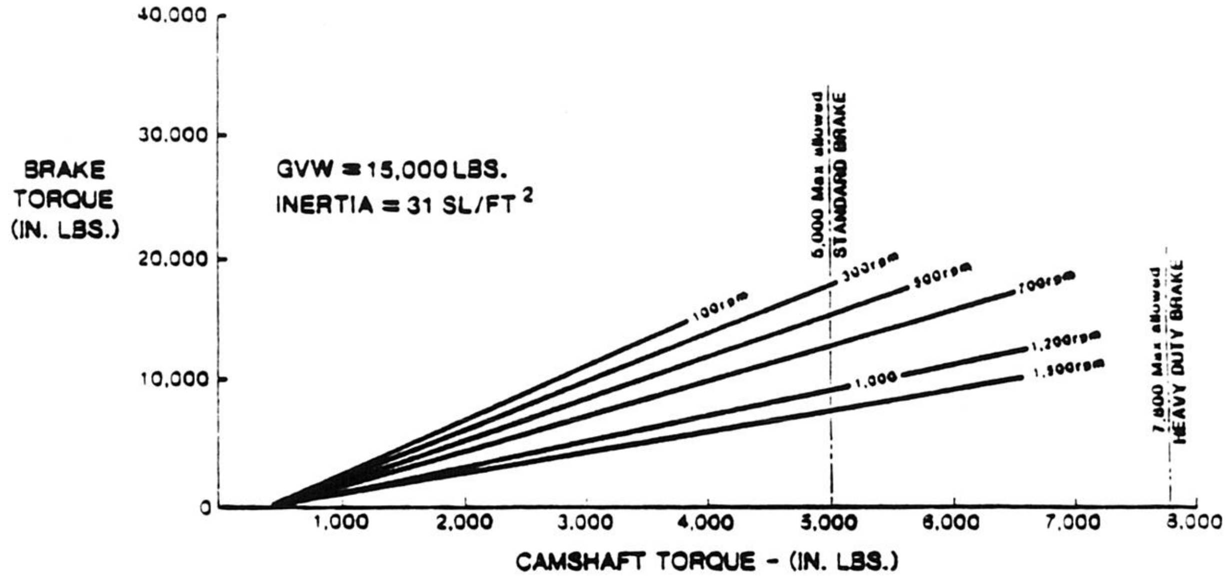


FMD 9051-J LININGS WITH STAMPED STEEL DRUM
(FORWARD & REVERSE DRUM ROTATION)

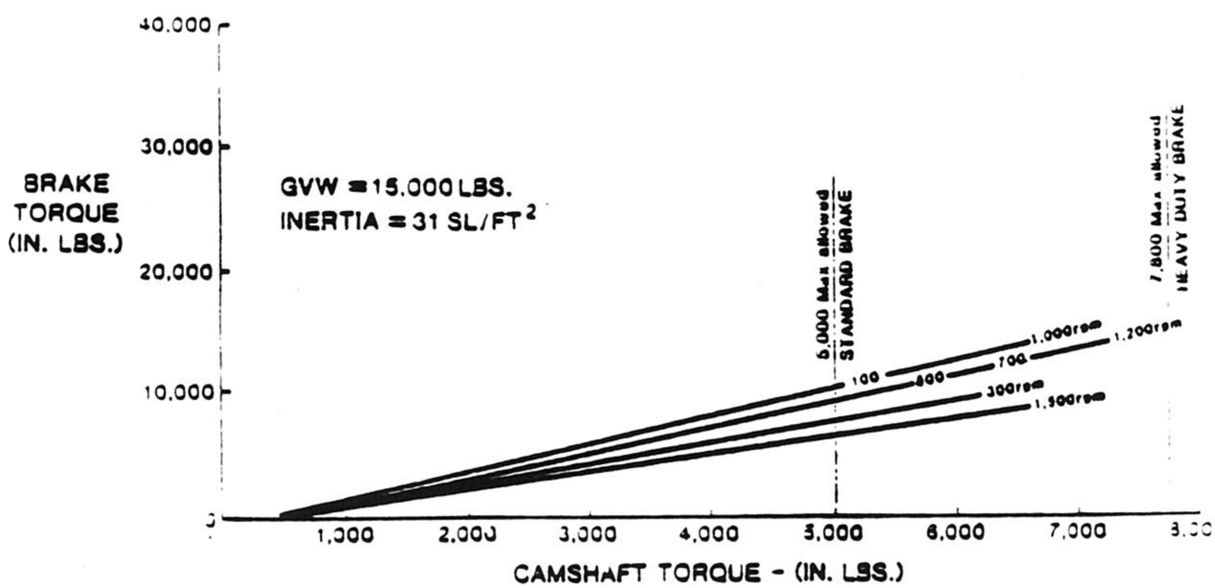
CURVE V

DYNAMIC EFFECTIVENESS

9x2 BRAKE——————FMD 9028 LININGS & STAMPED DRUM



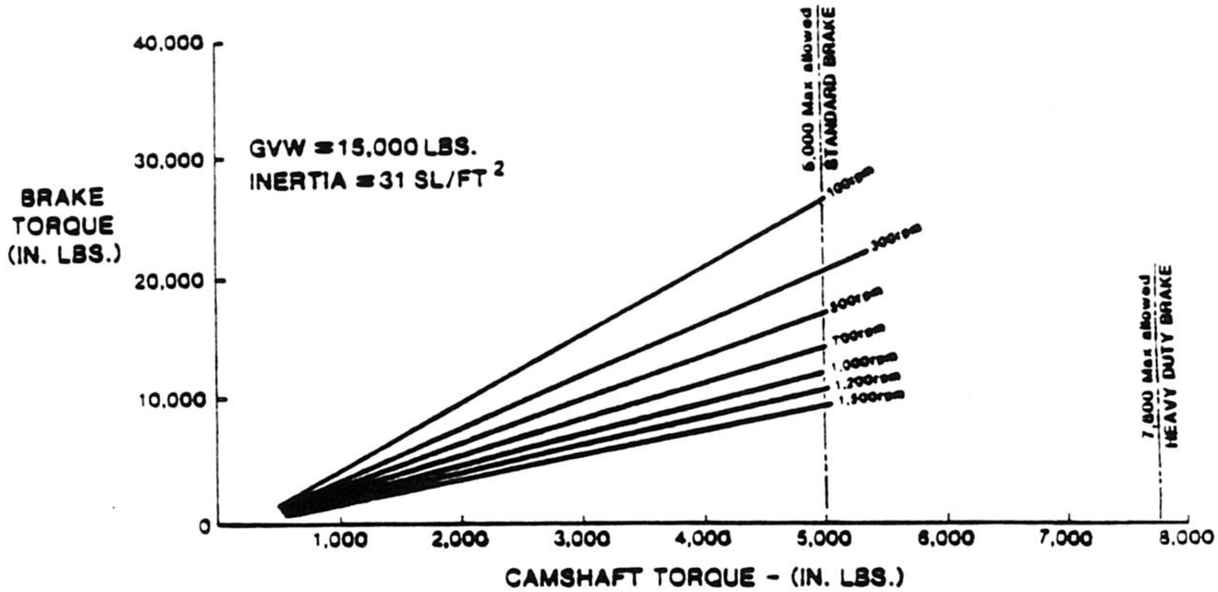
PRE-BURNISHED LININGS



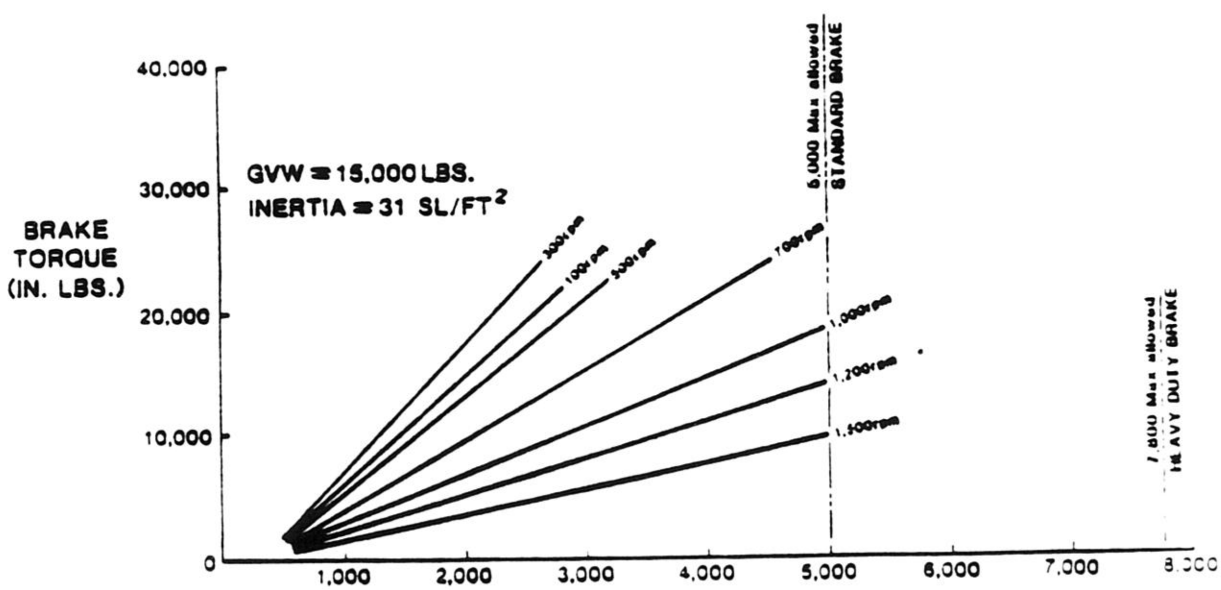
POST-BURNISHED LININGS

CURVE VI
DYNAMIC EFFECTIVENESS

9x2 BRAKE————FMD 9051-J LININGS & STAMPED DRUM



PRE-BURNISHED LININGS

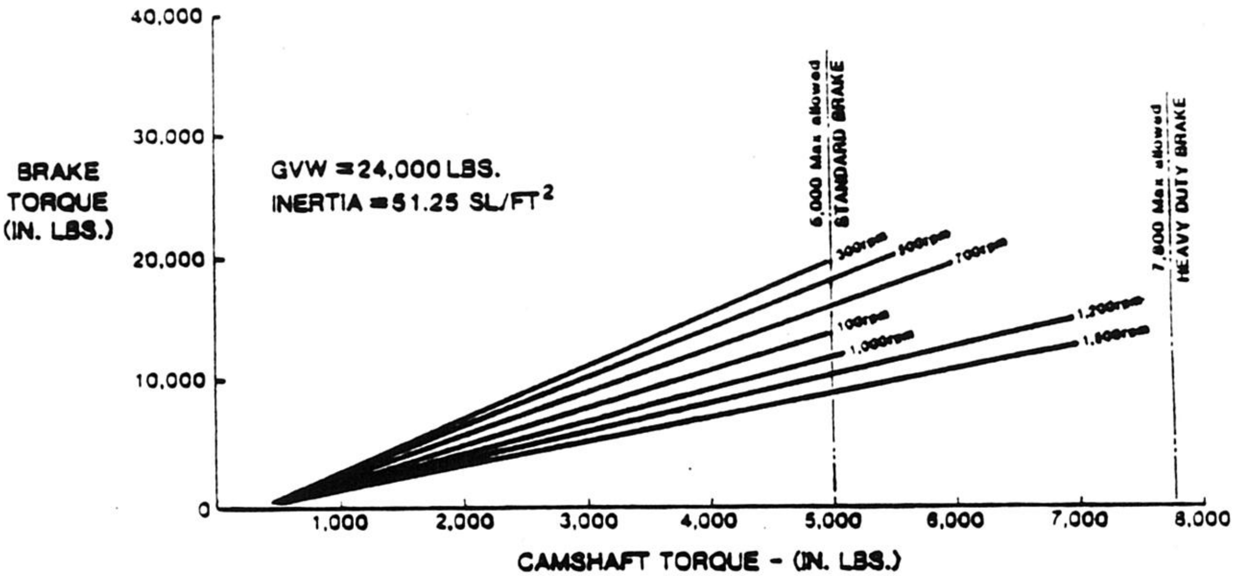


POST-BURNISHED LININGS

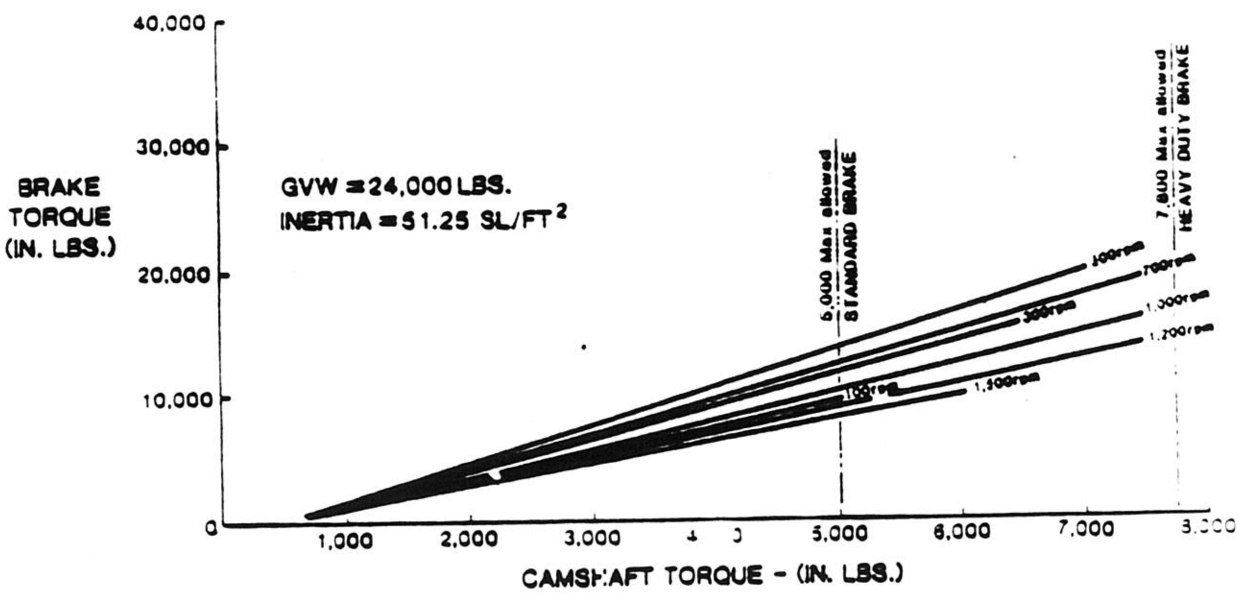
CURVE VII

DYNAMIC EFFECTIVENESS

9x3 BRAKE—————FMD 9028 LININGS & STAMPED DRUM



PRE-BURNISHED LININGS

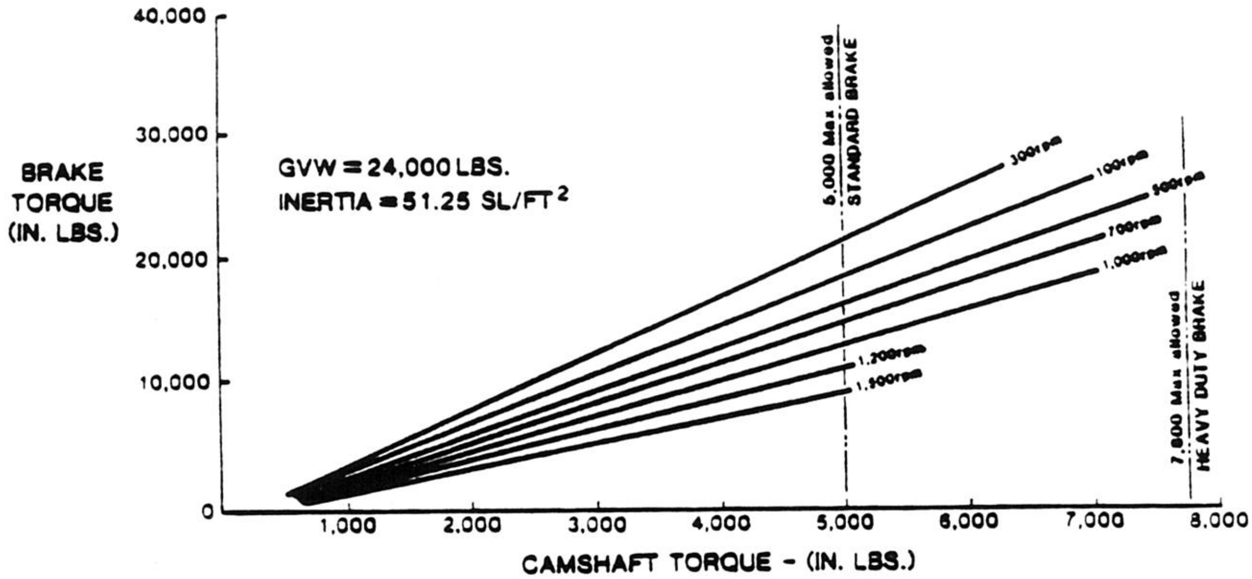


POST-BURNISHED LININGS

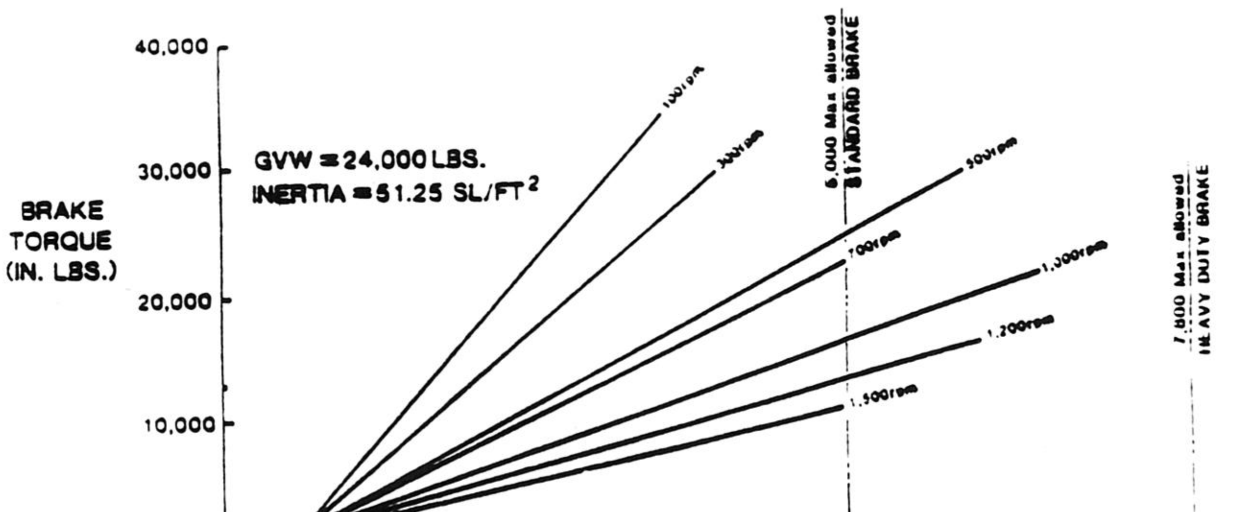
CURVE VIII

DYNAMIC EFFECTIVENESS

9x3 BRAKE————FMD 9051-J LININGS & STAMPED DRUM



PRE-BURNISHED LININGS



POST-BURNISHED LININGS

LIMITATIONS AND LEVER TRAVEL DATA
9" DUO-DUTY MECHANICAL BRAKE

BRAKE DATA FOR STANDARD DUTY BRAKES

REF: CURVES I & II

Lever Length . . . . 5.69"
Maximum Input Capacity of the Brake Cam . . . . 5,000 in.lbs.
(880 lbs. maximum force on 5.69" lever)
Maximum Lever Travel Arc . . . . 20° (1.946")
Lining Materials . . . . FMD-9028, FMD-9051-J, or FMD-9051-G *
Torque Capacity, Ultimate . . . . Static - 30,000 in.lbs.
Design Torque, Normal Maximum Use Level . . . . Static - 22,500 in.lbs.
Dynamic Effectiveness - FMD-9051-G Linings . . . . See Page 34
" " - FMD-9028 & FMD-9051-J Linings . . . . See Pages 37 thru 40
Maximum Kinetic Energy Absorption
2" Wide Brake 200,000 ft.lbs. at 1200 rpm drum speed in 3.4 sec.
3" Wide Brake 280,000 ft.lbs. at 1200 rpm drum speed in 3.4 sec.

* FMD 9051-G not active on current OEM Brakes at this time (February 1981)

BRAKE DATA FOR HEAVY DUTY BRAKES

REF: CURVES IV THRU VIII

Lever Length . . . . 5.69"
Maximum Input Capacity of the Brake Cam . . . . 7,800 in.lbs.
(1370 lbs. maximum force on 5.69" lever)
Maximum Lever Travel Arc . . . . 20° (1.946")
Lining Materials . . . . FMD 9028 or FMD 9051-J
Torque Capacity, Ultimate . . . . Static - 40,000 in.lbs.
Design Torque, Normal Maximum Use Level . . . . Static - 30,000 in.lbs.
Dynamic Effectiveness - FMD 9028 & FMD-9051-J Linings, ... See Pages 37 thru 40

Maximum Kinetic Energy Absorption
2" Wide Brake 200,000 ft.lbs. at 1200 rpm drum speed in 3.4 sec.
3" Wide Brake 230,000 ft.lbs. at 1200 rpm drum speed in 3.4 sec.

NOTE: See Page 21 for other important data relative to use of the 9" Duo-Duty Mechanical Brakes.

BRAKE

TECHNICAL DATA

12" DUO-SERVO, DOUBLE ANCHOR AUXILIARY BRAKE

Form No. WXA-67084
Printed 12-15-66

THE BENDIX CORPORATION
BRAKE and STEERING DIVISION
401 BENDIX DRIVE
SOUTH BEND, INDIANA 46620

All correspondence concerning this brochure should be addressed to The Bendix Corporation. Bendix Products Automotive Division, South Bend, Indiana 46620, to the attention of the Automotive Brake Engineering Department.

Refer to WXA-67084

CONTENTS

GENERAL DESCRIPTION

The Bendix Heavy Duty Auxiliary Brake, Figure 1, is a mechanically actuated Duo-Servo, double anchor type brake and is normally mounted on the propeller shaft of a truck or bus. The brake is designed for use as a parking brake to hold the vehicle on a grade. It is also capable of stopping the loaded vehicle from low road speeds should the service brakes fail due to accidental damage or other causes.

The auxiliary brake is designed for use with 12" diameter drums and basic brake assemblies in 3, 4 and 5 inch shoe widths are provided. The basic brake assemblies, together with available actuating levers, are listed in Charts I-V.

Force for operating the brake normally is provided by the driver by means of a hand lever connected to the brake actuating lever. This connection is made through a rod or cable and intermediate levers as required.

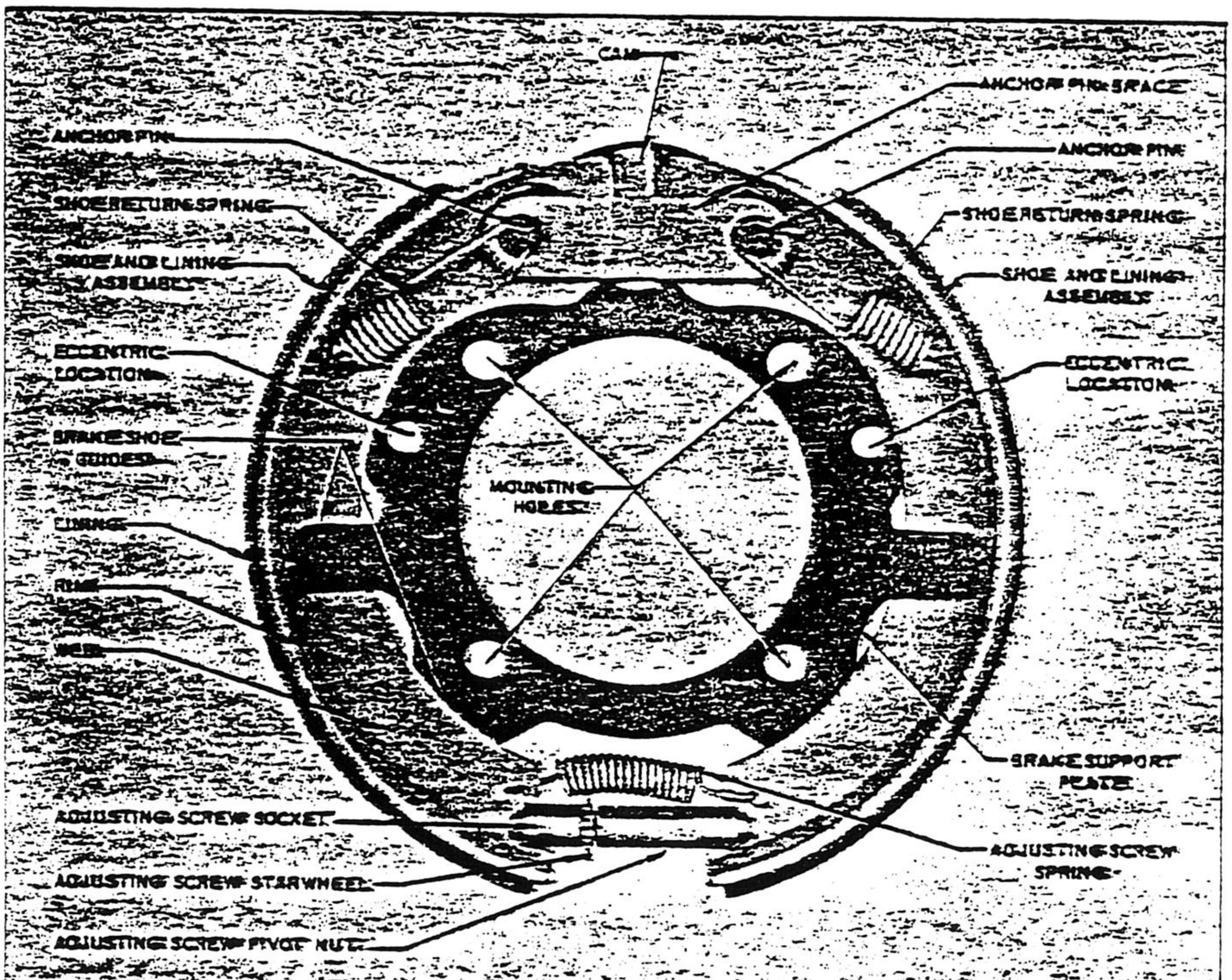


Figure 1

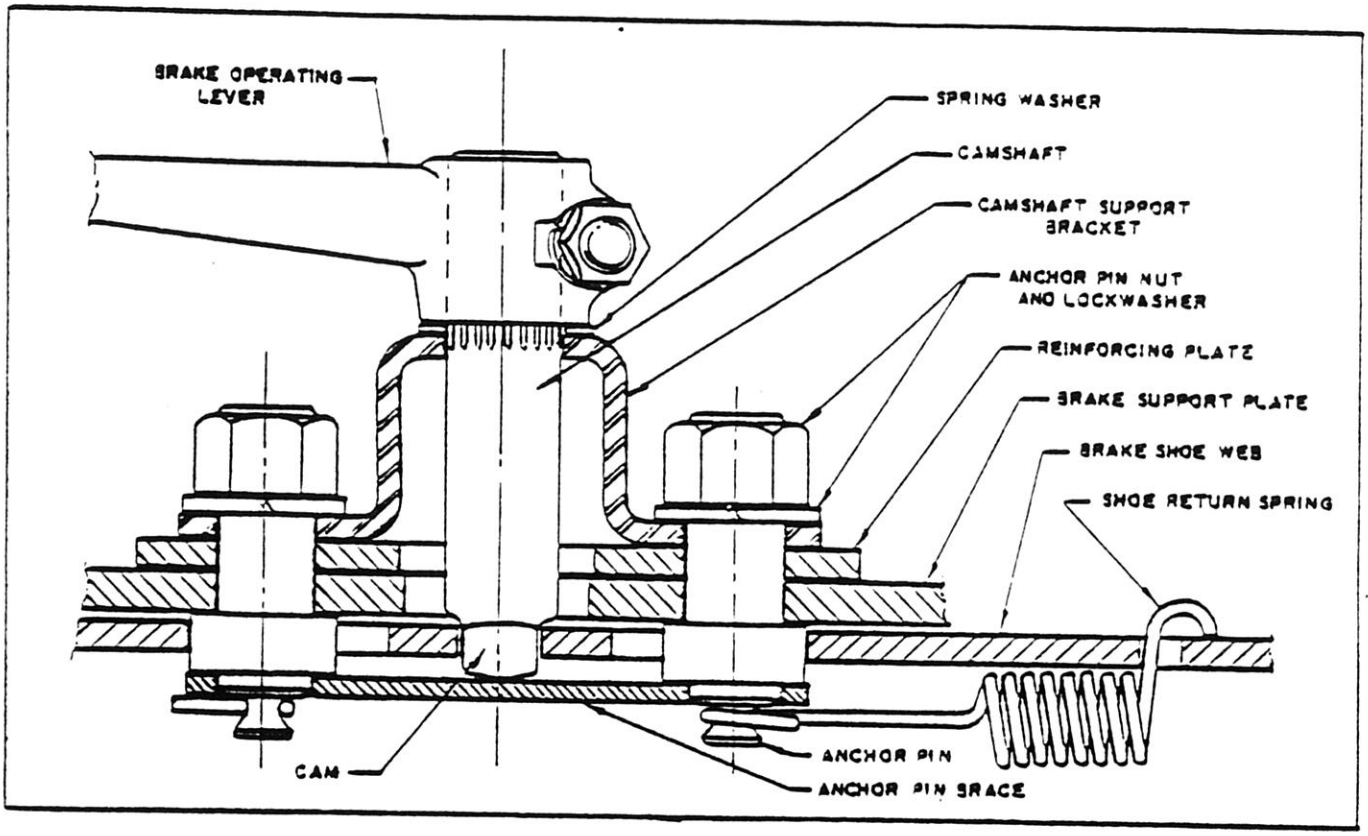


Figure 2

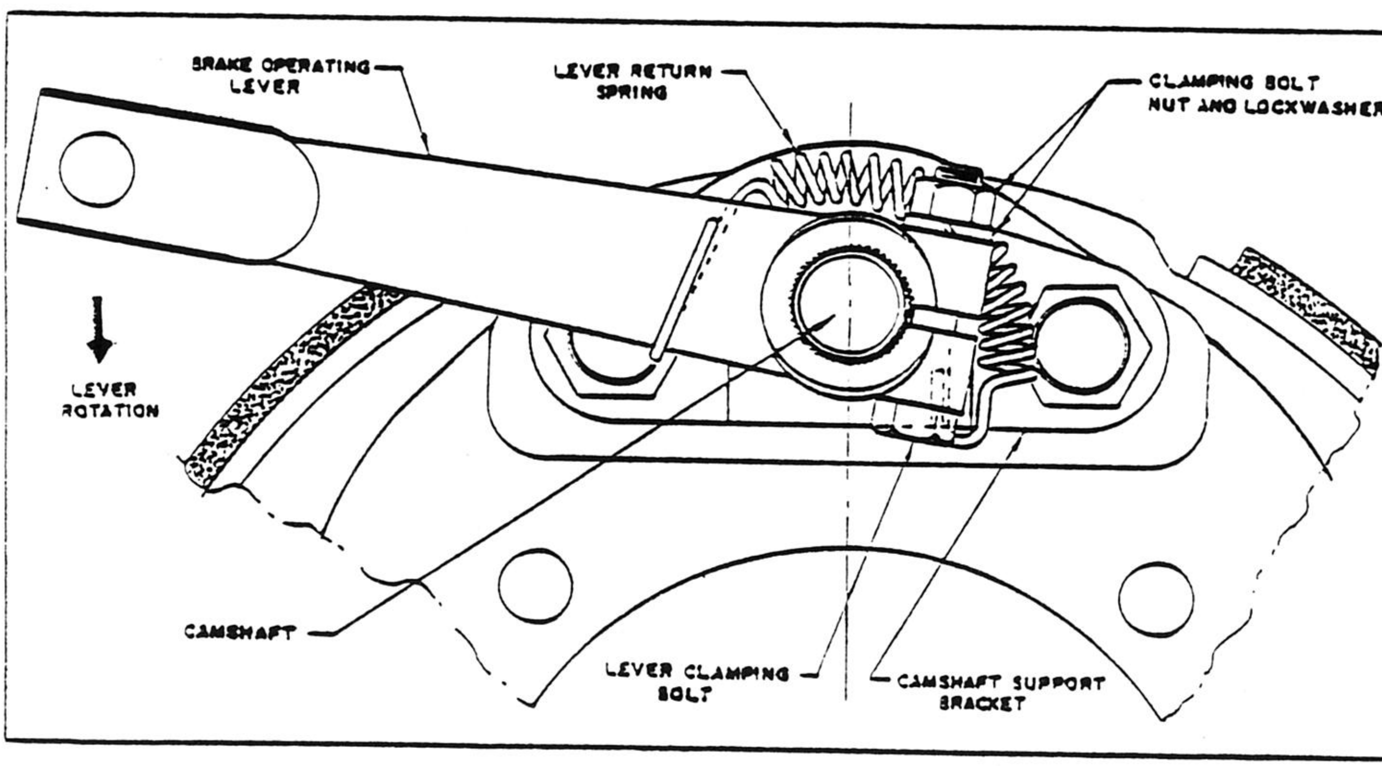


Figure 3

CONSTRUCTION

As shown in Figure 1, the auxiliary brake consists of two shoe and lining assemblies which are attached to a brake support plate. The support plate in turn is mounted to the transmission housing.

Each shoe assembly consists of a shoe rim, which is welded to the shoe web, and a lining material that is riveted to the outer surface of the rim. The top of each shoe web bears against an anchor pin which is bolted to the support plate (Refer to figure 2). An elongated hole, around the anchor pin, is formed in the shoe web to allow movement of the shoe relative to the pin. A shoe return spring, assembled between the shoe web and the end of the anchor pin, holds the shoe in contact with the pin. The lower ends of the shoes are connected by an adjusting screw assembly and the shoes are held in contact with the adjusting screw parts by an adjusting screw spring. This spring, which is hooked between the webs of the two shoes, bears against the starwheel of the adjusting screw. The adjuster parts are typical of those found in the conventional Duo-Servo hydraulic brake which is manually adjusted. The adjuster consists of an adjusting screw a pivot nut and a socket. Slots on the pivot nut and the socket engages the webs of the shoes. The adjusting screw, which is threaded into the pivot nut, rotates in the socket. The teeth of the starwheel are moved against the force from the adjusting screw spring to rotate the adjusting screw and thereby move the lower ends of the shoes in or out. Adjustment for lining wear is made by turning the adjusting screw starwheel. Access to the starwheel is made through a small opening provided in the drum.

A cross section view through the brake at the anchor pins is shown in Figure 2. A reinforcing plate is welded to the back side of the brake support plate so as to stiffen the support plate around the anchor section. A camshaft support bracket is assembled against the reinforcing plate and the bracket is held in place by the anchor pin nuts. The cam, which is integral with the camshaft, is located between the ends of the brake shoe webs. After the camshaft is installed into the support bracket and the shoes are installed over the anchor pins, an anchor pin brace is assembled over the ends of the anchor pins. The brace is held in place by the ends of the two shoe return springs which are hooked to the anchor pins as shown.

Serrations, on the end of the camshaft, mate with serrations in the hub of the brake operating lever and a spring washer is installed between the lever and the camshaft support bracket. The lever is locked in position on the shaft by a clamping bolt, nut and lockwasher as shown in Figure 3. When the brake is fully released, both shoes contact the anchor pins, however, a small clearance remains between the faces of the cam and the ends of the shoe webs. An elongated bearing hole is placed in the support plate to allow the cam end of the shaft to move laterally when the brake is applied. This lateral movement insures that the camshaft will float relative to the support plate so that equalized forces from the cam can be applied to the ends of the brake shoes.

When a cable is used to apply the brake lever, it is usually desirable to add a lever return spring, Figure 3, to the brake assembly. When the brake is released, this spring will take up the slack between the cam and the brake shoes so as to prevent rattle between these parts. If the lever rotation is opposite to that shown, the spring is installed below the support bracket.

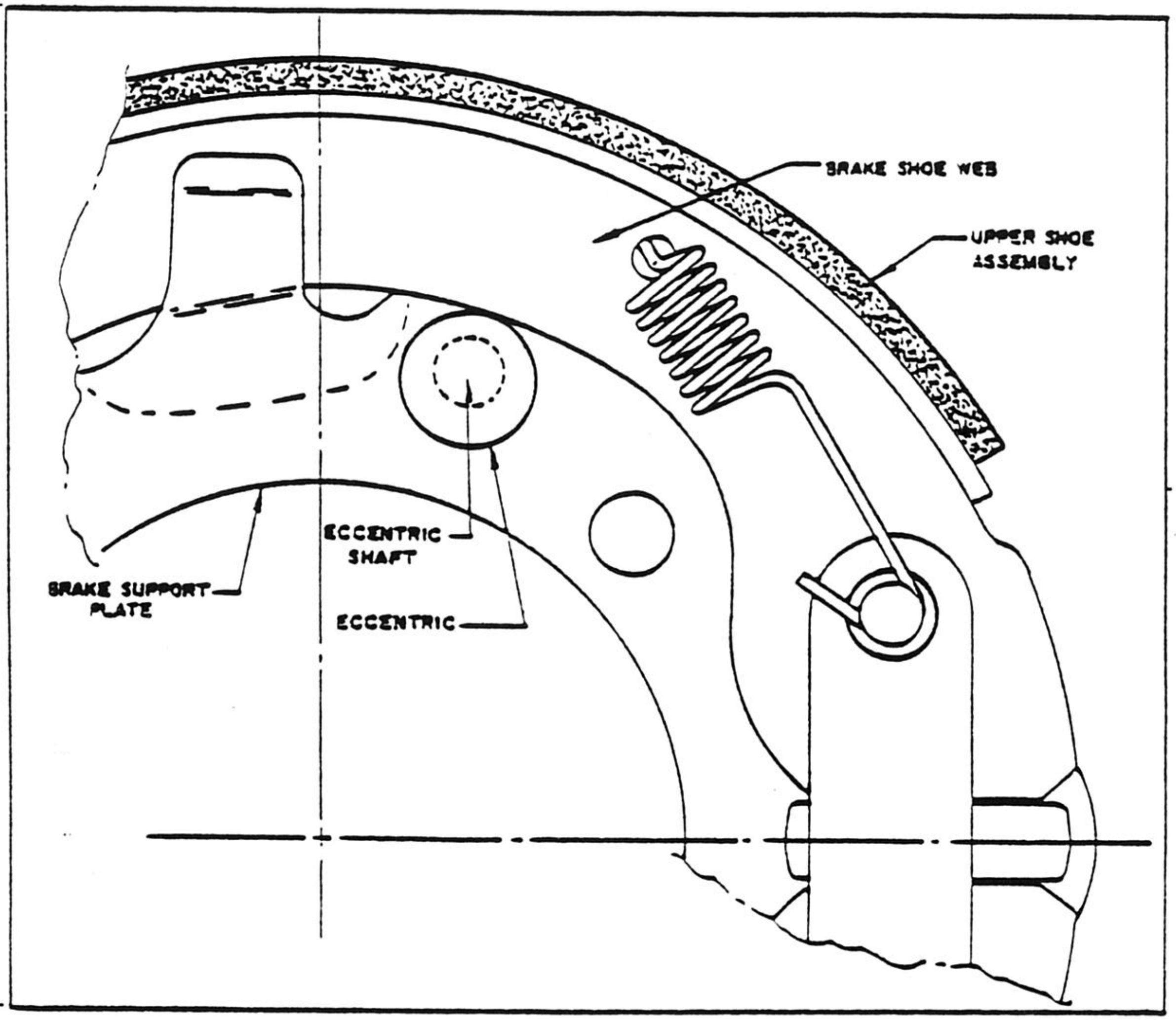


Figure 4

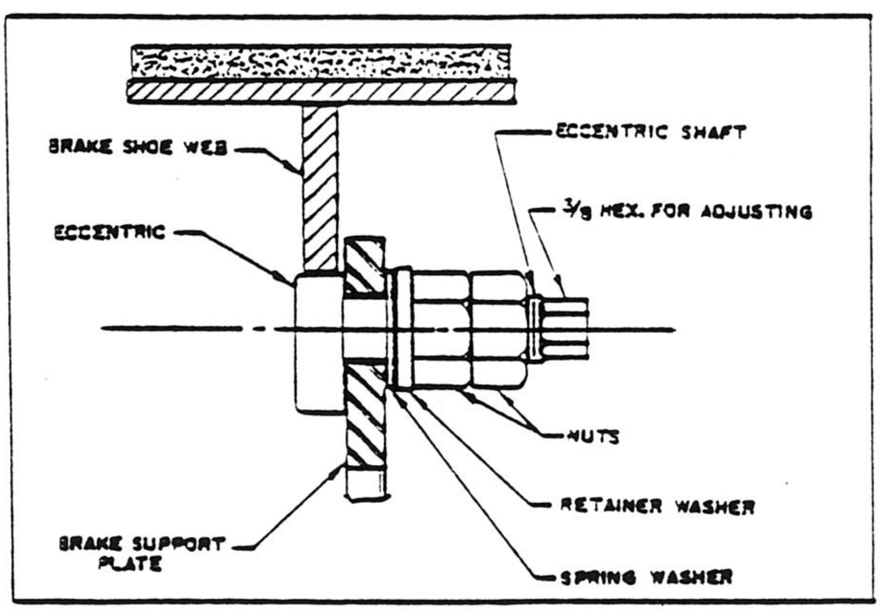


Figure 5

The brake shoes, Figure 1, are free to pivot around the anchor pins and the webs of the shoes are aligned to the support plate by guide flanges on the plate. In addition to the guide flanges, a small guide pad is formed in the support plate just below each anchor pin. The pad serves as a guide surface for the upper end of the shoe web.

When the brake is mounted with the cam located along the vertical centerline, the shoe-ring assembly centers itself with respect to the drum and no drag is exerted against the drum rubbing surface when the brake is released. If the brake is mounted so that the cam is not on the vertical centerline, in which case the weight of the shoes would cause the lower shoe to drag against the drum surface an eccentric can be installed in the support plate at one of the locations as noted in Figure 1. The eccentric is shown installed in Figures 4 and 5. The eccentric is placed under the upper shoe to support the weight of the shoe-ring assembly. This prevents drag of the lower shoe against the drum rubbing surface when the brake is released. The eccentric shaft, Figure 5, extends through the support plate and is secured in place by two nuts, a retainer washer and a spring washer. Sufficient torque is applied to the nuts to compress the spring washer to prevent loosening and rotation of the eccentric under road vibration. During installation of the brake, the eccentric can be rotated by using a 3/8 inch wrench on the hex end of the eccentric shaft. The eccentric thus can be adjusted to center the shoes with the drum.

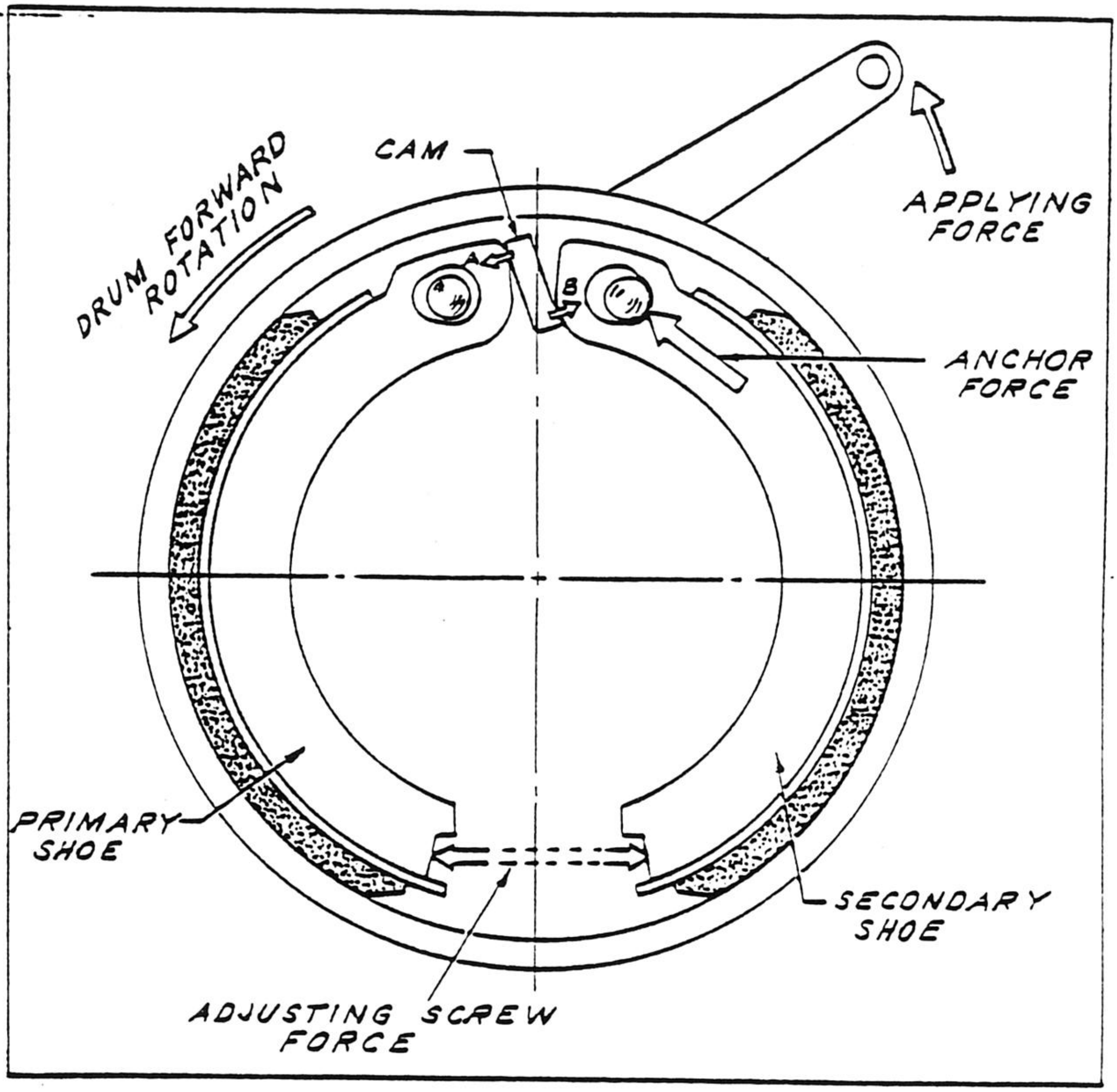

CAM
DRUM FORWARD ROTATION
A
B
APPLYING FORCE
ANCHOR FORCE
PRIMARY SHOE
SECONDARY SHOE
ADJUSTING SCREW FORCE

Figure 6

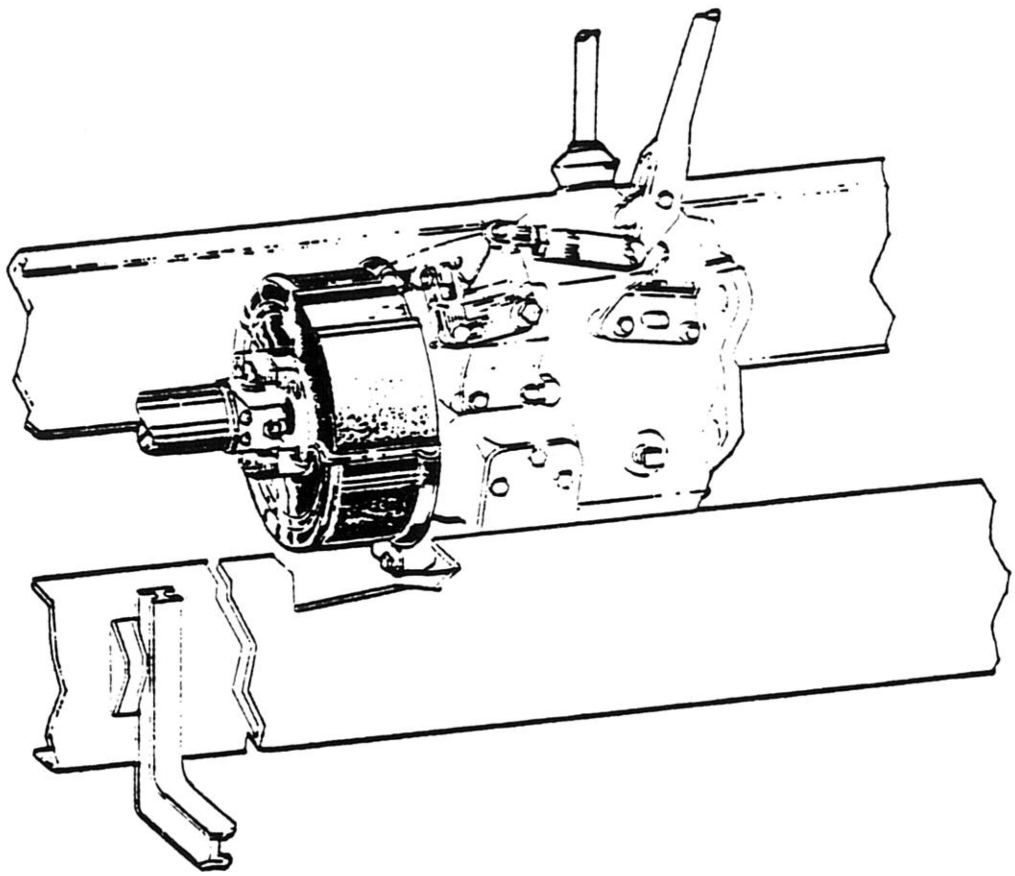
PRINCIPLE OF OPERATION

A simple schematic of the Duo-Servo, double anchor type, auxiliary brake is shown in Figure 6. For simplicity, the shoe return and adjuster springs have been omitted.

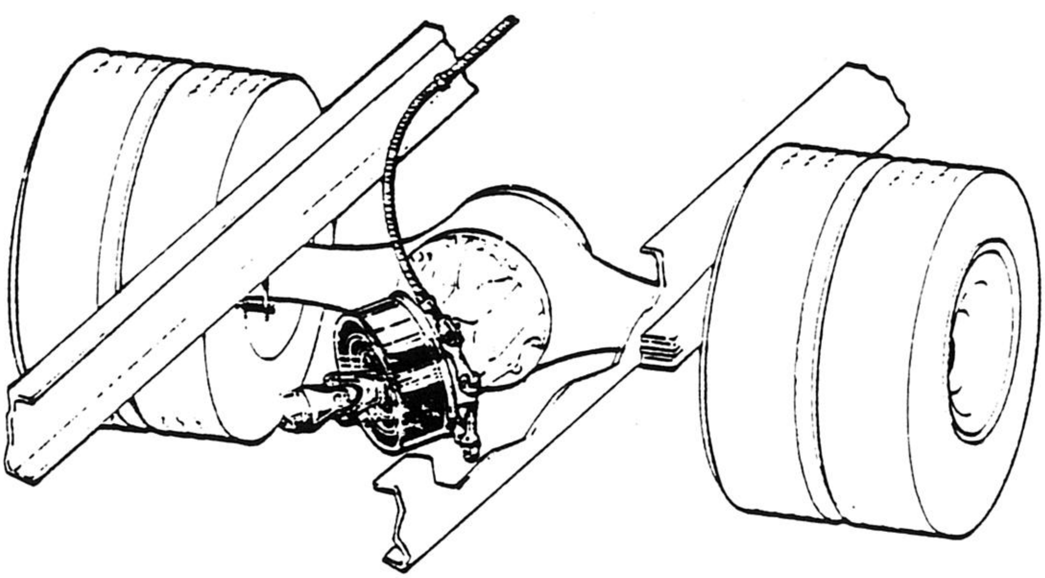
When the hand lever is pulled by the driver, the hand lever force is transmitted through the auxiliary brake linkage to the brake actuating lever. An applying force, as indicated in Figure 6, is applied to the lever and the cam is rotated counterclockwise. Forces A and B are applied to the brake shoes and the upper ends of the shoes move out toward the drum rubbing surface. When the linings contact the drum, the friction force between the primary shoe and the drum causes this shoe to move away from its anchor pin. A force, acting through the adjusting screw assembly is transmitted from the bottom end of the primary shoe to the bottom end of the secondary shoe. This force moves the secondary shoe against its anchor pin and applies the secondary shoe against the drum. In the servo type brake, the secondary shoe does the greater portion of the braking.

With the Duo-Servo Brake, the motion of the vehicle is utilized to aid the driver in applying the brakes and this servo action is particularly desirable on an emergency brake which is operated by hand.

If the direction of rotation of the drum is reversed from that shown in Figure 6, the right shoe would become the "primary" shoe and the left shoe would become the "secondary" shoe. The brake is equally effective in either direction of drum rotation. When the rotation of the brake applying lever is in the same direction as the drum rotation, the brake effectiveness will be slightly higher (per a given input force on the lever) than when the lever rotation is opposite to the drum rotation.



MAIN TRANSMISSION MOUNTING



REAR AXLE MOUNTING FOR REAR ENGINE DRIVE

Figure 7

BRAKE INSTALLATION AND ADJUSTMENTS

Installation Recommendations

The auxiliary brake is usually mounted on the rear of the main transmission housing or on the rear axle housing. Typical arrangements are shown in Figure 7. The brake is attached to a mounting bracket that adapts the brake mounting surface to the transmission housing. Attachment to the mounting bracket is by four 5/8" bolts equally spaced about the axis of the propeller shaft. Concentricity with the shaft is provided by a pilot flange on the bracket which mates with the pilot hole in the brake support plate. It is recommended that the brake mounting bolts be made of high tensile steel and so designed that the body diameter of the bolt fits into both the brake support plate and the mounting bracket.

It is recommended that the brake be mounted as close as possible to the bearing which supports the shaft on which the drum is mounted. This keeps to a minimum the distance from the bearing to the universal joint thereby reducing the vibration which may result from shaft deflection.

If possible, the brake should be mounted with the camshaft at the top and located on the vertical centerline. This location suspends the shoe-ring assembly from its top centerpoint. When the brake is in its released position, the weight of the shoes will tend to center the shoe-ring with respect to the drum. If other installation factors make it desirable to mount the brake so that the camshaft is not at the top, the next best location would be at the bottom on the vertical centerline.

When it is necessary to mount the brake with the camshaft off the vertical centerline, an eccentric must be incorporated as part of the brake assembly to keep the lower shoe from dragging on the drum when the brake is released. It is recommended that the eccentric support the anchoring (or secondary) shoe as defined by the forward direction of drum rotation. Recommended and non-recommended combinations are illustrated in Figure 8.

Since oil and grease on the lining and drum rubbing surfaces will adversely affect the brake performance, it is important that the installation include an efficient lubricant seal around the transmission shaft at the brake installation. Provision should be made for diverting the oil, which leaks past the seal, away from the drum braking surface. One method of doing this is to incorporate an annular groove in the bore of the brake mounting bracket in conjunction with an oil "slinger ring" machined on the shaft or on the drum mounting flange. A drain passage and tube should be provided at or near the lower point of the annular groove.

Adjustments

When the brake is installed, it should be adjusted to provide proper brake shoe lining to drum clearance. This adjustment must be made before attaching and adjusting the brake actuating linkage. To make brake adjustments, jackup at least one rear wheel to permit rotation of the prop shaft and the drum.

If the brake contains an eccentric and is mounted with the brake actuating cam off the vertical centerline, the upper shoe must be adjusted first to provide proper clearance between the upper shoe and the drum. To provide this clearance, rotate the eccentric in the same direction as forward drum rotation until the

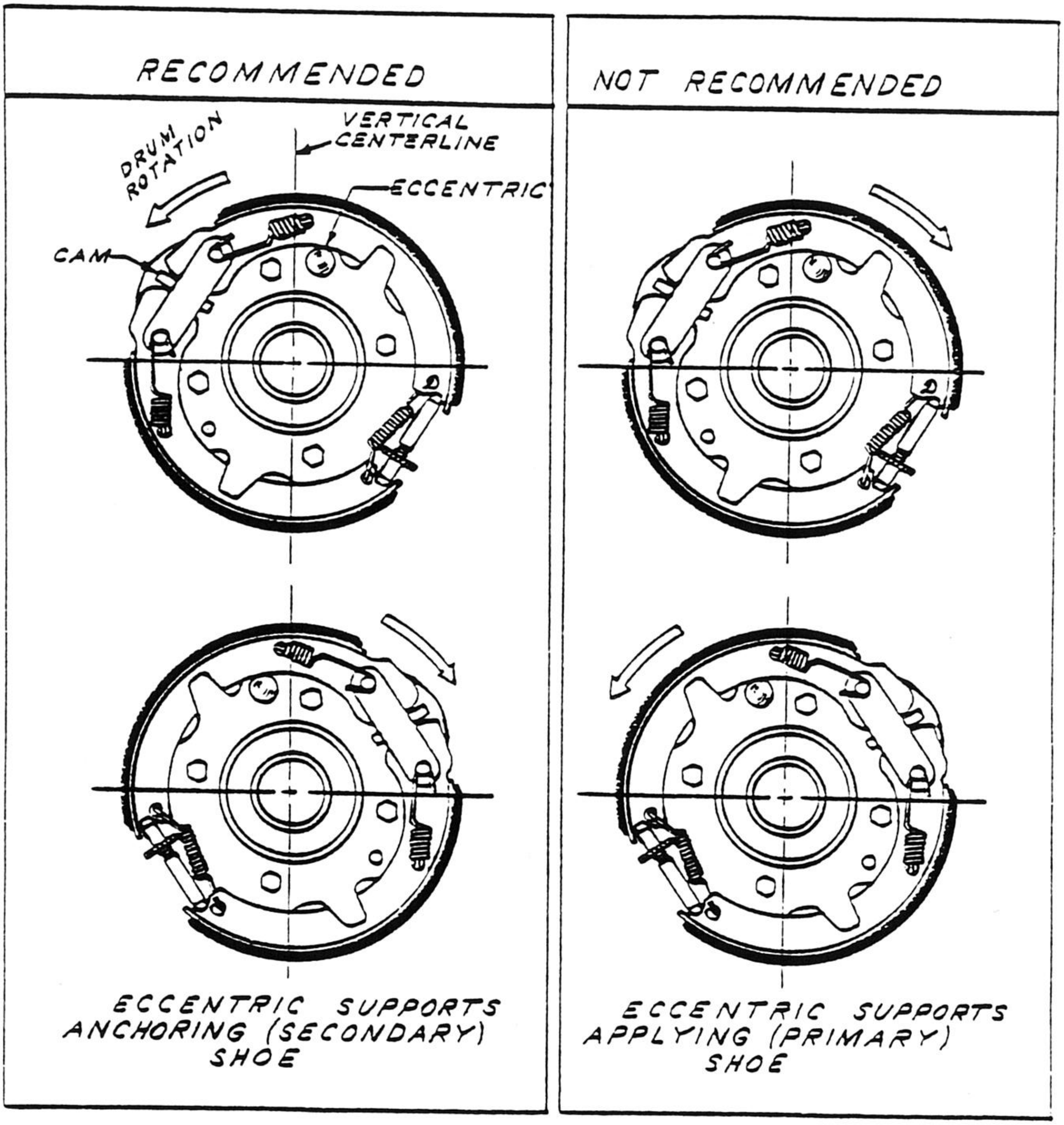

RECOMMENDED
NOT RECOMMENDED
DRUM ROTATION
VERTICAL CENTERLINE
ECCENTRIC
CAM
ECCENTRIC SUPPORTS ANCHORING (SECONDARY) SHOE
ECCENTRIC SUPPORTS APPLYING (PRIMARY) SHOE

Figure 8

clearance (as measured with a feeler gage) between the drum and the lining is .010". Take this measurement at the center of the shoe lined arc. Leave the .010" feeler gage in place between the upper shoe and the drum and then adjust the lower shoe. To adjust the lower shoe, rotate the drum until the adjustment slot is in line with the starwheel of the brake adjusting screw. Insert a brake adjusting tool into the drum slot and adjust the lower shoe out towards the drum. (This corresponds to movement of the adjuster handle away from the vehicle prop shaft.) Insert a second .010" feeler gage between the drum and the lower shoe (at center of the shoe lined arc) and adjust the lower shoe out until the feeler gage is snug between the shoe and the drum. After both shoes are adjusted, remove the two feeler gages.

If the brake does not contain an eccentric, rotate the drum to align the adjustment slot of the drum with the starwheel of the adjusting screw. Insert a brake adjusting tool into the drum slot and adjust the brake shoes out toward the drum. Insert a .020" feeler gage between one shoe and the drum (insert gage near the center of shoe lined arc) and adjust shoes out until the feeler gage is snug between the shoe and the drum. After the brake is adjusted, remove the feeler gage.

After adjustment of the brake shoes, the control linkage should be adjusted and connected to the brake lever. Place the hand lever in its fully released position. Move the brake lever slightly in its applying direction (corresponding with forward drum rotation) sufficiently to take up any slack between the cam and the ends of the brake shoes. Adjust the linkage length to permit free assembly of the clevis pin through clevis and the hole in the brake lever.

To keep the brake in efficient operating condition, the brake shoes should be periodically adjusted to compensate for lining wear. Brake usage determines how often adjustment is necessary. Need of an adjustment is indicated when almost all of the available hand lever travel is used in making a brake application. While adjusting for lining wear, disconnect the applying mechanism from the brake lever to insure complete release of the brake shoes. Adjust the brake shoes out toward the drum using procedures and clearances previously outlined for brakes with or without eccentric. The actuating mechanism normally will not have to be readjusted. Reconnect the mechanism to the brake lever after brake adjustment.

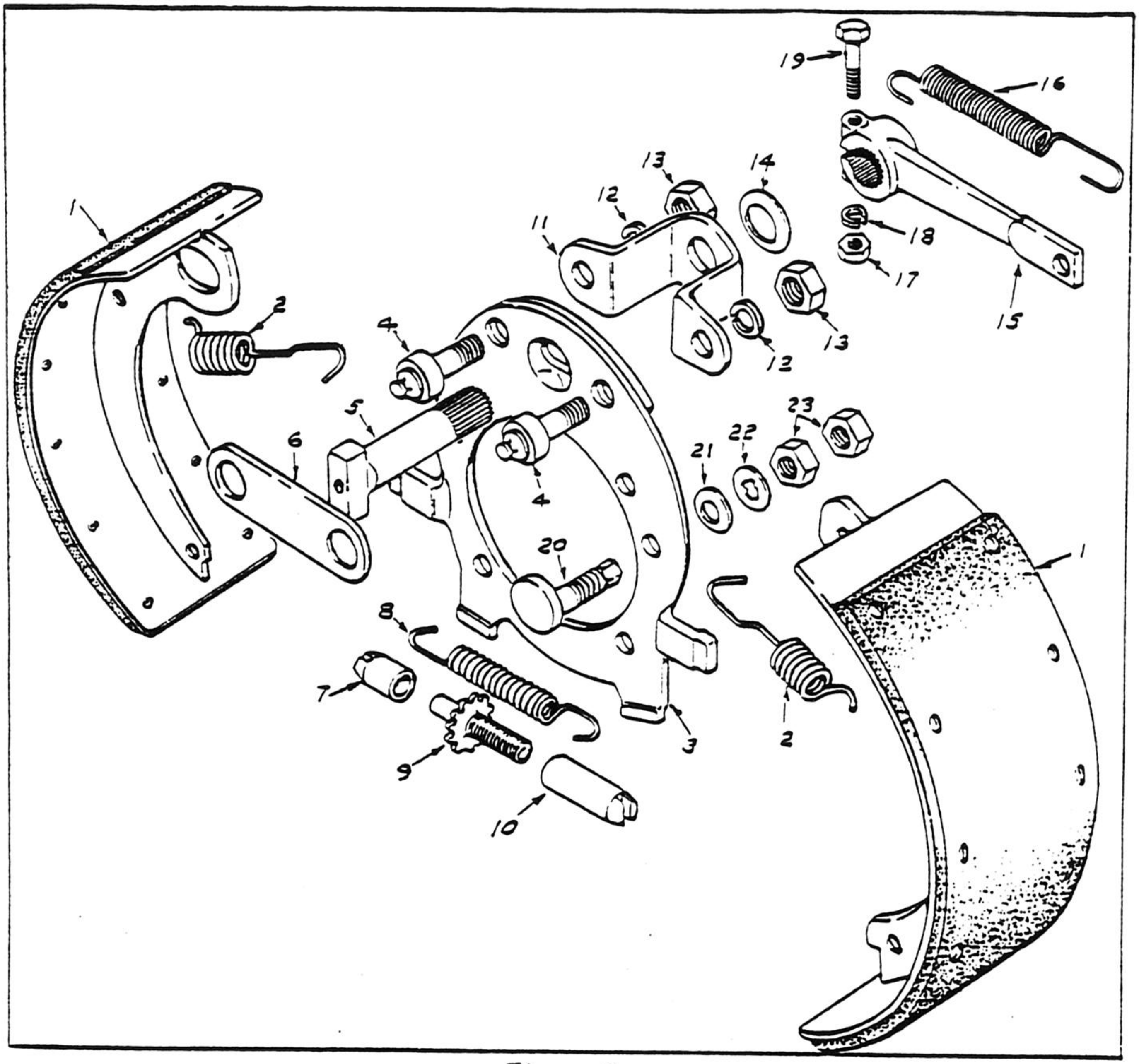


Figure 9

12" DUO-SERVO, DOUBLE ANCHOR AUXILIARY BRAKE
PARTS DESCRIPTION (REFER TO FIGURE 9)

1. Brake Shoe Assembly
2. Shoe Return Spring
3. Brake Support Plate
4. Anchor Pin
5. Cam and Shaft
6. Anchor Pin Brace
7. Adjusting Screw Socket
8. Adjusting Screw Spring
9. Adjusting Screw
10. Adjusting Screw Pivot Nut
11. Camshaft Support Bracket
12. Lockwasher - Anchor Pin
13. Nut - Anchor Pin
14. Spring Washer - Camshaft
15. Lever
16. Lever Return Spring
17. Nut - Clamping Bolt
18. Lockwasher - Clamping Bolt
19. Lever Clamping Bolt
20. Eccentric
21. Spring Washer - Eccentric
22. Retainer Washer - Eccentric
23. Nut - Eccentric

BRAKE SERVICING

Brake Drum Removal

1. Jackup at least one rear wheel to allow the brake drum and propeller shaft to be rotated. If the vehicle propeller shaft has an intermediate or "amidship" support bearing, provide a jack or other support for the shaft at this point and remove the support bearing mounting bolts.

2. Remove the drum mounting bolts and then remove the yoke flange and drum and the companion flange nut. Separate the flange from the transmission shaft. (If drum and propeller shaft are connected by trunnion bolts, remove the trunnion bolts.)

3. Lower the propeller shaft to the floor.

Brake Shoe Removal

(Refer to the brake exploded view Figure 9.)

1. Mark shoes and note position of the adjusting screw starwheel so that these parts can be reassembled in their correct position.

2. Using a spring removal tool (Bendix No. GEN 2059) remove the two shoe return springs. Separate the anchor pin brace from the anchor pins.

3. Remove the shoes, the adjusting screw assembly and the adjusting screw spring from the brake support plate. To remove the shoes from the support plate, pull the shoe outward and twist the shoe sufficiently in the support plate guides until the anchor end of the shoe will clear the anchor pin.

4. To remove the adjusting screw from the shoes, move the anchor ends of the shoes toward each other and overlap the webs of the shoes. This will permit the separation of the adjusting screw assembly from the shoes.

5. Unhook the adjusting screw spring from the shoes.

6. Separate the socket from the adjusting screw and turn the adjusting screw out of the pivot nut.

Removal of the Cam

(Refer to the brake exploded view Figure 9.)

1. Remove the clevis pin to separate the brake actuating lever from the control linkage.

2. Unhook and remove the lever return spring if the brake contains a return spring.

3. Scratch a mark on the end of the camshaft adjacent to the center of the slot in the hub of the lever. This will identify the proper position of the lever to the shaft when the parts are reassembled. Also note position of scratch mark relative to brake so that cam will be reassembled with mark in same position.

4. Remove the lever from the camshaft by loosening the lever clamping bolt. Drive the camshaft out of the lever using a brass or hardwood punch to prevent damage to the shaft. Remove the spring washer from the camshaft and pull the cam from the camshaft support bracket.

   NOTE - If it is necessary to remove the support plate from the brake mounting bracket in order to separate the lever from the camshaft, remove the four brake mounting bolts.

5. The camshaft support bracket normally need not be removed from the support plate unless it is necessary to replace the bracket or the anchor pins. To remove the bracket, remove the anchor pin nuts from the two anchor pins.

6. If it is necessary to replace the eccentric (on brakes which incorporate an eccentric), hold the hex end of the eccentric shaft with a 3/8" wrench and loosen the two nuts. Remove the nuts, the retainer washer and the spring washer from the eccentric shaft.

Cleaning and Inspection of Parts

Remove lining dust and road dirt from the brake parts and the inside of the drum. Wipe the lubricant from the support plate, the shoe webs and from the cam. Clean the threads of the adjusting screw and pivot nut with a solvent and blow dirt and cleaning fluid off parts with an air hose.

Inspect the brake parts as follows and replace with new parts where necessary.

1. Check the brake shoes for lining wear, and contamination due to oil or brake lubricant. If linings are worn down to within 1/32" of the rivet heads, the shoes should be relined or replaced with new lined shoes. Inspect shoe webs for severe wear at cam contact surfaces.

2. Inspect the adjusting screw and pivot nut for nicked or sheared threads.

3. Check the cam for severe wear at the shoe web contact surfaces.

4. Inspect the adjusting screw spring and the two shoe return springs for any loss of tension. The springs, when not assembled on the brake, should not show any opening between the coils.

5. Check the anchor pins and the cam support bracket for any signs of distortion.

6. Inspect the mounting holes in the brake support plate and the brake mounting bracket for cracks.

7. Inspect the drum for scoring or distortion.

Brake Reassembly Procedure

(Refer to the brake exploded view Figure 9.)

NOTE - Lubricate the brake parts, as noted in the following reassembly procedure, with Lubriplate Grade No. 630-AA. Do not over lubricate to the extent that the excess lubricant will become thin due to heat and will spread to the lining and drum rubbing surfaces.

1. Coat the threads of the anchor pins with lubricant. Install the anchor pins in the brake support plate and assemble the camshaft support bracket to the brake support plate using the anchor pin nuts and lockwashers. Tighten the anchor pin nuts with a wrench torque of from 1500 to 2000 inch-pounds.

2. Coat the threads of the adjusting screw and the socket end of the adjusting screw with lubricant. Thread the adjusting screw all the way into the pivot nut. Install the socket over the end of the adjusting screw.

3. Install the adjusting screw assembly between the ends of the brake shoes. Engage the notches of the socket and pivot nut with the webs of the brake shoes. Note position of the starwheel. When the shoe-ring assembly is installed with the adjusting screw at the bottom (as in figure 1) the starwheel should be toward the left shoe.

4. Move anchor ends of the shoes together, overlapping the shoe webs, and hook the adjusting screw spring into the holes of the shoe webs.

5. Lubricate the shoe guides on the brake support plate. Place lubricant on the surfaces of the guides which contact the webs of the brake shoes. Lubricate the anchor pins on surface which contacts the brake shoe webs.

6. With the adjusting screw assembly and adjuster screw spring in place on the shoes, install one of the shoes in place on the guides of the support plate. Twist shoe slightly to clear the end of the anchor pin so as to permit assembly of large, oblong hole in shoe web over body of anchor pin. Install the other shoe to the support plate and twist the shoe as required to clear the end of the anchor pin.

7. Coat the camshaft and the cam with lubricant, spread the ends of the shoes apart, and install the shaft through the holes in the support plate and the cam support bracket. Center cam between the ends of the shoes. Position shaft so that the scratch mark on the end of the shaft corresponds to its original position relative to the brake.

8. Install the anchor pin brace over the anchor pins.

9. Hook the shoe return springs in the shoe webs and then assemble the springs to the ends of the anchor pins. Use special spring installing tool (Bendix No. BPD-41938-F4) to stretch and hook the springs over the ends of the anchor pins.

10. Coat the camshaft spring washer with lubricant and assemble washer over the camshaft. Assemble the brake operating lever over the serrated end of the shaft, centering the slot in the lever hub with the scratch mark on the end of the shaft.

11. Install the clamping bolt, lockwasher and nut to the lever. Hold cam in contact with the anchor pin brace and push lever onto shaft sufficiently to compress the spring washer. With spring washer compressed, tighten the lever clamping bolt nut to 300-360 inch-pounds torque.

    NOTE - If a new cam and shaft or new lever is installed on the brake, assemble the lever as near as possible to the original lever position. It may be necessary to move the lever one serration on the shaft to realign the lever with the control linkage.

12. If the brake contains a lever return spring, hook the spring between the camshaft support bracket and the lever. Refer to Figure 3.

13. If the brake contains an eccentric, reinstall the eccentric shaft through the hole in the support plate. (The eccentric must be located below the web of the upper shoe - refer to Figures 4 and 8.). Place the spring washer and the retainer washer over the shaft of the eccentric and assemble the two nuts to the shaft. Adjust the nuts so that the eccentric will rotate through 360° with an applied torque of 50 to 150 inch-pounds on the eccentric shaft. Make check after eccentric has been rotated one complete revolution.

14. If the brake support plate was removed from the mounting bracket located on the transmission, reinstall the brake to the bracket. Tighten the four brake mounting bolts to 1200-1400 lb.-inch wrench torque.

Brake Drum Reinstallation

1. If brake assembly contains an eccentric, rotate eccentric to allow upper shoe to move in toward the center line of the transmission shaft.

2. Assemble the drum to the yoke flange and attach the yoke to the transmission shaft. (If the drum and propeller shaft are connected by trunnion bolts, reinstall the trunnion bolts.)

3. If the vehicle propeller shaft has an intermediate or "amidship" support bearing, raise and support the propeller shaft and reinstall the support bearing mounting bolts.

4. With the rear wheel jacked up to allow the drum and the propeller shaft to be rotated, rotate the drum until the drum adjusting slot coincides with the brake adjusting screw starwheel.

5. Adjust the brake as outlined under "Adjustments" in the "BRAKE INSTALLATION AND ADJUSTMENT" section.

6. After the brake has been adjusted, install the cover plug into the drum adjusting slot to keep dirt from entering the drum and brake.

7. Remove jack from the rear wheel.

TROUBLE SHOOTING

The 12" Auxiliary brake, when properly installed and adjusted, gives trouble free service over a long period of time. Varying conditions, however, can cause changes that will adversely affect the brake operation. To aid in quickly diagnosing and correcting faulty operation, reference to the following chart can be made.

TROUBLE	PROBABLE CAUSE	CORRECTION
I. Brake fails to hold vehicle when parked on grades or ramp after proper lining burnish.	1. Excessive shoe clearance.	1. Adjust shoe clearance.
	2. Binding in control linkage.	2. Repair or lubricate control linkage.
	3. Cracked drum.	3. Install new drum.
	4. Wornout linings.	4. Reline shoes or install new lined shoes.
II. Brakes fail to release.	1. Binding at camshaft bearings	1. Remove, clean and lubricate the camshaft and mating components.
	2. Restriction or binding in the control linkage.	2. Repair or lubricate the control linkage as required.
III. Brake grabs or locks instead of applying smoothly.	1. Excessive shoe to drum clearance.	1. Adjust shoe clearance or reline shoes if required.
	2. Grease or oil on linings.	2. Locate cause of oil leakage and make necessary repairs. If the linings are oil soaked replace linings or install new lined shoes. Thoroughly clean the drum.
	2. Excessive drum runout.	3. Reduce, the drum runout to .015" maximum or replace, if necessary, with new drum.

BASIC CALCULATIONS

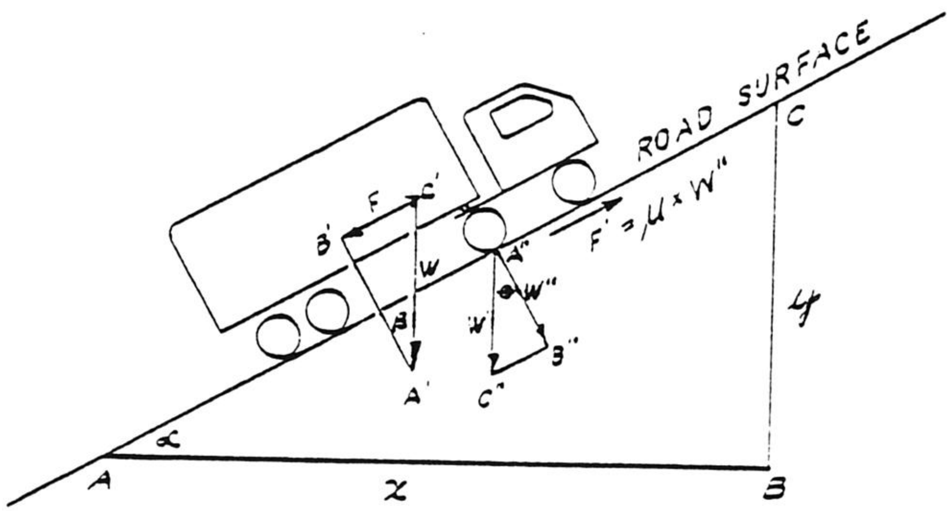
The following basic formulas can be used as a guide in analyzing the vehicle parking and auxiliary brake requirements.

Parking Brake Requirements

The parking brake should be designed to hold the vehicle, or combination, on any grade upon which the vehicle is operated under any condition of loading, on a surface free from snow or ice. It can be assumed that the vehicle may be operated on grades to the limit of traction of the rear wheels and the rear wheels are the ones upon which the parking brake acts.

The steepest grade, on which the vehicle can be operated, must be determined and the force necessary to hold the vehicle must be established. The holding force then must be translated into a brake torque.

The following diagram shows the forces involved when a vehicle of gross vehicle weight W is operated on a grade of slope y/x.



W = Total weight of the vehicle or combination.

W' = Portion of the total vehicle weight that acts on the braked axle.

W'' = Portion of the braked axle weight that acts normal to the road surface.

F = Force needed to hold the vehicle on the grade.

F' = Maximum friction force between the braked axle tires and the road surface.

$F' = \mu W''$, where μ is the coefficient of friction between the tires and the road. (.7 - .8 between rubber and dry pavement is normally assumed.)

Since triangles ABC, A'B'C' and A"B"C" are similar, angles β and θ are equal to angle α.

The force required to hold the vehicle on grade y/x is equal to F, and therefore:

(1) $F = W \sin \alpha$

The maximum force which is available for holding the vehicle on grade y/x is F' and therefore:

(2) $F' = \mu W''$

(3) where $W'' = W' \cos \theta = W' \cos \alpha$

(4) therefore $F' = \mu W' \cos \alpha$

As the grade y/x increases, F increases. However, F' decreases since there is a corresponding decrease in the weight component W" which is normal to the road surface. The maximum grade on which the vehicle can be held therefore occurs when F = F' and therefore - from equation (1) and (4),

(5) $W \sin \alpha = \mu W' \cos \alpha$

(6) $\frac{\sin\alpha}{\cos\alpha} = \mu \frac{W'}{W} = \tan \alpha$

(7) $\tan \alpha = y/x = \mu \frac{W'}{W}$

Equation (7) expresses the relationship between the maximum slope y/x, the coefficient of friction μ between the tires and the road, and $\frac{W'}{W}$ which is the ratio of the weight on the braked axle to the total vehicle weight. Solving for angle α in equation (7) and substituting this into equation (1) will give the friction force required to hold the vehicle on the maximum grade. This friction force is then translated into an equivalent brake torque.

The portion of the vehicle weight (W') which acts on the braked or traction axle varies slightly depending upon whether the vehicle is pointed up or down the grade since the grade causes a slight weight transfer factor.

If the parking brakes are a part of the wheel brakes on the rear axle (single axle), it can be assumed that each brake handles an equal share of the axle load. Then the required brake torque T in inch-pounds can be expressed as:

(8) $T = 1/2\ W \sin \alpha\ R$

Where R is the tire rolling radius (inches), W is the total vehicle weight (lbs.) and α is the angle as determined in equation (7).

When a single brake operates on the drive shaft, this brake must develop all the torque necessary to hold the vehicle and the torque equation becomes:

$$(9) \quad T = \frac{W \sin \alpha R}{K}$$

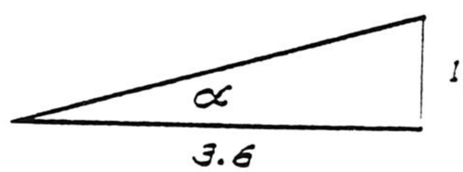
where K equals the lowest numerical axle ratio.

<u>Sample Calculation</u>

Gross vehicle weight of vehicle (or combination)	=	40,000 lbs.
Weight on rear (driving axle)	=	16,000 lbs.
Tire rolling radius	=	19"
Axle ratio	=	6:1
Tire to road coefficient	=	.7

$$\tan \alpha = \mu \frac{W'}{W} = .7 \times \frac{16,000}{40,000} = .28, \text{ and } \alpha = 15.6°$$

Maximum grade upon which vehicle can be held is 28% or represented graphically this is.



Friction force required for maximum grade,

$$F = W \sin \alpha = 40,000 \times .27 = 10,800 \text{ lbs.}$$

Brake torque required with parking brakes part of wheel brakes (single axle - two brakes per axle.)

$$T = 1/2\, W \sin \alpha\, R = 1/2 \times 40,000 \times .27 \times 19 = 102,600 \text{ in-lbs.}$$

Brake torque required with single parking brake in drive shaft:

$$T = \frac{W \sin \alpha R}{K} = \frac{40,000 \times .27 \times 19}{6} = 34,200 \text{ in-lbs.}$$

Referring to the static effectiveness curve (curve I) for the 12" Duo-Servo, double anchor auxiliary brake, it can be seen that 102,600 in-lbs. required in the first case is above the recommended maximum torque (90,000 in-lbs.) of the brake and therefore this arrangement is not satisfactory. In the second case the torque is under the recommended maximum and is therefore suitable. In this case for a torque output of 34,200 in-lbs., an input torque of 1500 in-lbs. to the brake cam shaft is required. Lever travel required is shown in Curve II.

When the brake is to be used for emergency braking purposes, reference should be made to the following "Auxiliary Braking Requirements" to determine braking requirements and vehicle weight limitations.

Auxiliary Brake Requirements

State laws, governing auxiliary brake requirements, vary but Service No. 3 "Equipment Requirements for Motor Vehicles" published by National Highway Users, Inc. shows that the most stringent state regulation requires that the vehicle be brought to a stop within 50 feet from a speed of 20 mph, or a deceleration rate of 8.6 ft./sec^2.

To comply with the most stringent regulation, with the inclusion of a moderate safety factor allowance, it is recommended that a 20 mph speed with a 10 ft./sec^2 deceleration rate be used for calculations.

It is recommended that the maximum kinetic energy absorption rate of the brake not be over 1500 ft.-lbs. per square inch of lining per second.

Minimum stopping distances for various gross vehicle weights are listed in Chart I.

In installations where the brake is enclosed, making heat transfer to the surrounding air difficult, the energy absorption rate should be less than 1500 ft. llbs./in^2/sec.

The following equations can be used when determing the auxiliary brake requirements.

(10) 20 mph = 29.3 ft/sec

(11) Stopping time (per 10 ft/sec^2 decel.) $= \frac{29.3}{10} = 2.93$ sec

(12) Vehicle kinetic energy at 20 mph,

$$KE = 1/2 \text{ mass} \times \text{velocity}^2$$

$$= 1/2 \, \frac{\text{Gross Vehicle Wt. (lbs.)}}{32.2} \times 29.3^2 \text{ ft.-lbs.}$$

(13) Kinetic energy absorption rate during a stopping time of 2.93 sec,

$$\text{KE per sq. in. of lining per sec.} = \frac{\text{GVW (lbs.)} \times 29.3^2}{2 \times 32.2 \times \text{lining area (in}^2) \times 2.93}$$

(14) Substituting the maximum energy absorption rate of 1500 ft.-lbs./in^2/sec,

$$\text{Gross Veh. Wt. (lbs.)} = 329 \times \text{lining area (in}^2)$$

The following lining areas are provided on the 12" Duo-Servo auxiliary brake:

Brake Width	Lining Area
3"	83 in^2
4"	111 in^2
5"	139 in^2

From the above lining area chart, the following maximum gross vehicle weights can be calculated as based on the 20 mph speed and the 10 ft./sec^2 deceleration requirement:

For a 3" wide brake, 329 x 83 = 27,200 lbs. GVW

For a 4" wide brake, 329 x 111 = 36,500 lbs. GVW

For a 5" wide brake, 329 x 139 = 45,700 lbs. GVW

To obtain the required 10 ft./sec^2 deceleration, a sufficient portion of the gross vehicle weight must bear on the rear (driving) axle to which the braking is applied. If only one axle, of a tandem axle arrangement is braked, only the portion of the weight on the braked axle should be considered. The minimum weight necessary on the braked axle can be calculated as follows:

(15) $$W'\mu = \frac{W}{g} d$$

W' = Weight on the braked axle, lbs.

W = Gross vehicle weight (lbs.)

d = Deceleration required, ft./sec^2

μ = Coefficient of friction between the tires and the road

g = Acceleration due to gravity = 32.2 ft./sec^2

For the required deceleration of 10 ft./sec^2 and μ = .7 equation (15) becomes:

$$W' = \frac{Wd}{g\mu} = W \times \frac{10}{32.2 \times .7} = .444W$$

Therefore for 10 ft./sec^2 deceleration, the weight on the braking axle must be at least 44% of the gross vehicle weight.

When a single brake operates on the drive shaft, this brake must develop all the torque necessary to decelerate the moving vehicle under emergency conditions. The brake torque required can be calculated as follows:

(16) $$T = \frac{W}{g} d \times \frac{R}{K}$$

T = Brake torque required, in-lbs.

W = Gross vehicle weight-lbs.

d = Vehicle deceleration, ft./sec^2

g = Acceleration due to gravity = 32.2 ft./sec^2

R = Wheel rolling radius (braked axle), inches

K = Axle to drive shaft ratio

For a vehicle deceleration of 10 ft./sec^2, equation (16) becomes:

$$T = W \times \frac{10}{32.2} \times \frac{R}{K} = .31\ W\frac{R}{K}$$

Sample Calculation

Gross vehicle weight of vehicle (or combination)	= 40,000 lbs.
Weight on rear (driving) axle	= 16,000 lbs.
Tire rolling radius	= 19"
Axle ratio	= 6:1
Tire to road coefficient	= .7
Deceleration required	= 10 ft./sec^2

Checking the braked axle weight, it can be seen that the percent of the braked axle weight to the gross vehicle weight is only 40% as compared to the desired 44.4%. It is therefore recommended that approximately 18,000 lbs. be placed on the braked axle to give the required 10 ft./sec^2 deceleration. With a braked axle weight of 18,000 lbs,

$$d = \frac{W'}{W}\ g\ \mu = \frac{18,000}{40,000} \times 32.2 \times .7 = 10.2\ ft./sec^2$$

The braking torque required for a 10 ft./sec^2 deceleration is:

$$T = \frac{Wd}{g} \times \frac{R}{K} = \frac{40,000}{32.2} \times 10 \times \frac{19}{6} = 39,400\ in - lbs.$$

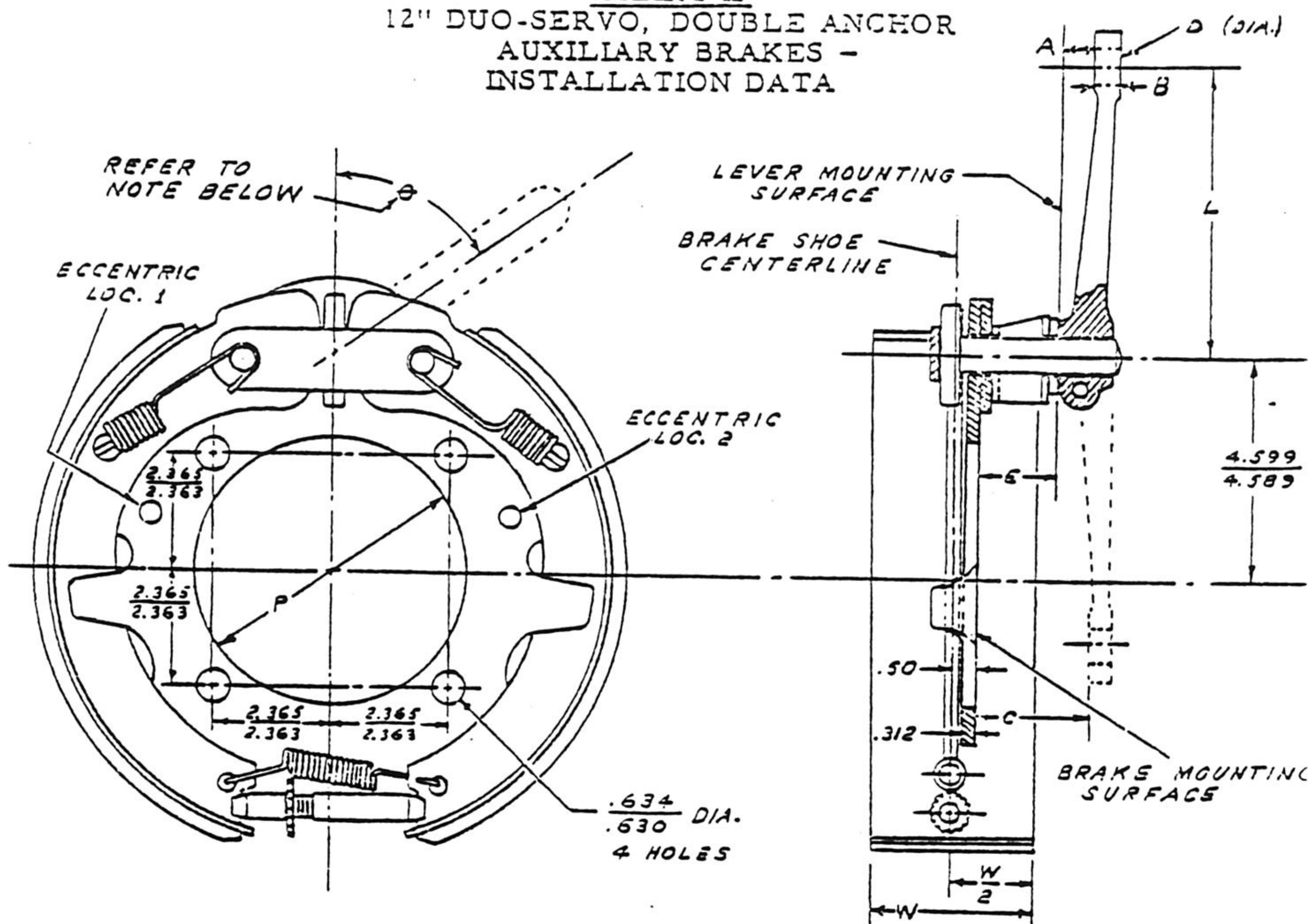
Referring to the dynamic effectiveness curves (Curve I) 5000 inch-pounds input torque normally will be required to provide sufficient brake output torque. Lever travel required is shown in Curve II.

CHART I

MINIMUM STOPPING DISTANCES FOR A MAXIMUM ENERGY ABSORPTION RATE OF 1500 FT.-LBS./IN^2 OF LINING/SEC.

GROSS VEHICLE WT.-LBS.	MINIMUM STOPPING DISTANCE-FT. FROM 20 MPH		
	BRAKE SIZES		
	12 x 5	12 x 4	12 x 3
30,000	26	30	50
40,000	37	44	68
50,000	48	58	38
60,000	57	70	103
70,000	67	73	117
80,000	77	93	134
90,000	85	100	153
100,000	96	114	173

CHART II
12" DUO-SERVO, DOUBLE ANCHOR AUXILIARY BRAKES - INSTALLATION DATA



Brake Assembly No.	Brake Width W -In.	Cam-shaft Length	* Distance E -In.	Pilot Dia. P -In.	** Lever Basic Forging No.	DIMENSIONS -IN.				
						C	A	B	** L	** D
310843	3	Short	1.454	5.506/5.501	47753	2.234	.78	.550/.540		
					49010	2.264	.81	.510/.490		
					304007	2.424	.97	.550/.540		
	3	Long	1.894	5.506/5.501	47753	2.674	.73	.550/.540		
					49010	2.704	.31	.510/.430		
					304007	2.864	.97	.550/.540		
308691	4	Short	1.454	5.506/5.501	47753	2.234	.78	.550/.540		
					49010	2.264	.31	.510/.490		
					304007	2.424	.97	.550/.540		
309521	4	Long	1.894	5.506/5.501	47753	2.674	.78	.550/.540		
					49010	2.704	.81	.510/.490		
					304007	2.364	.97	.550/.540		
308692	5	Long	1.894	5.506/5.501	47753	2.674	.78	.550/.540		
					49010	2.704	.81	.510/.490		
					304007	2.364	.97	.550/.540		

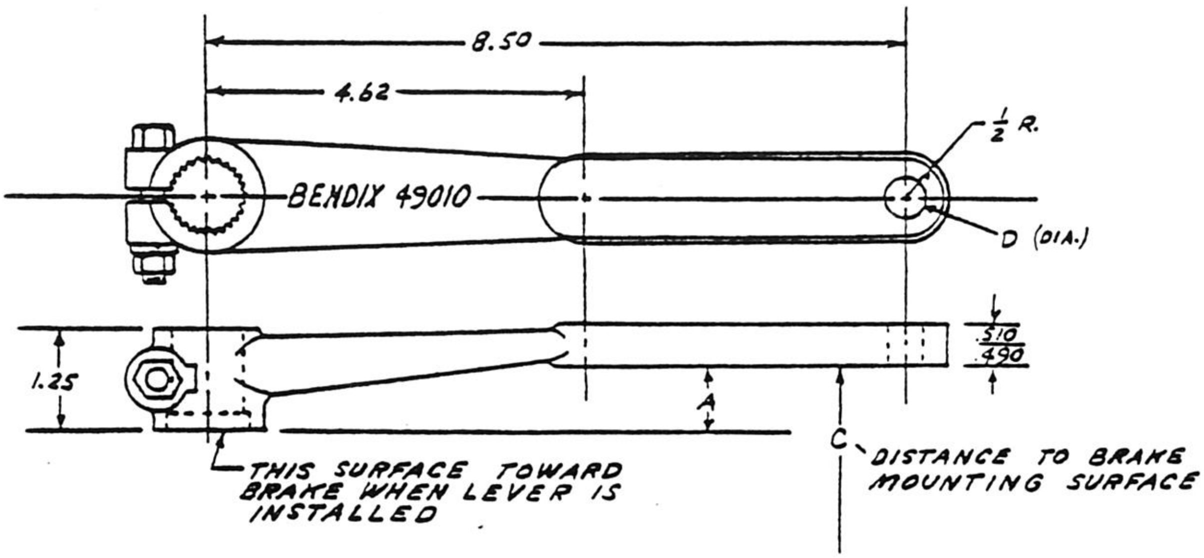
* Distance includes thickness of wave washer compressed.

** Refer to lever charts for additional dimensional details and levers available.

NOTE - Lever can be located as desired. Exact angle will be subject to ±3-3/4° variation due to tolerances in parts. A lever travel of 12° should be allowed for brake actuation.

CHART III
LEVER DATA
12" DUO-SERVO, DOUBLE ANCHOR AUXILIARY BRAKES

LEVER FORGING NO. 49010

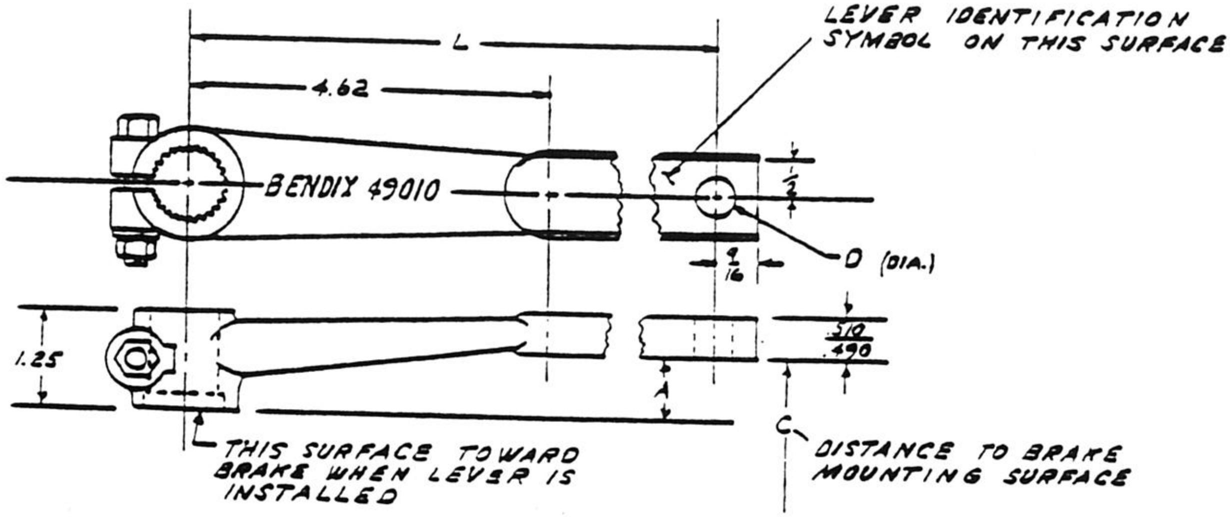


Lever Forging No.	Lever No.	Lever Assembly No. *	D -In.	A -In.	C -In. Short Cam-shaft	C -In. Long Cam-shaft	Remarks
49010	309357	309739	None	.81	2.264	2.704	Hole to be Provided by Customer.
49010	311896		.560	.81	2.264	2.704	Clamping Bolt to be Provided by Customer.
49010	49054	309745	.560	.81	2.264	2.704	

* Lever assembly includes lever and bolt, lockwasher and nut as shown.

CHART IV
LEVER DATA
12" DUO-SERVO, DOUBLE ANCHOR AUXILIARY BRAKES

LEVER FORGING NO. 49010



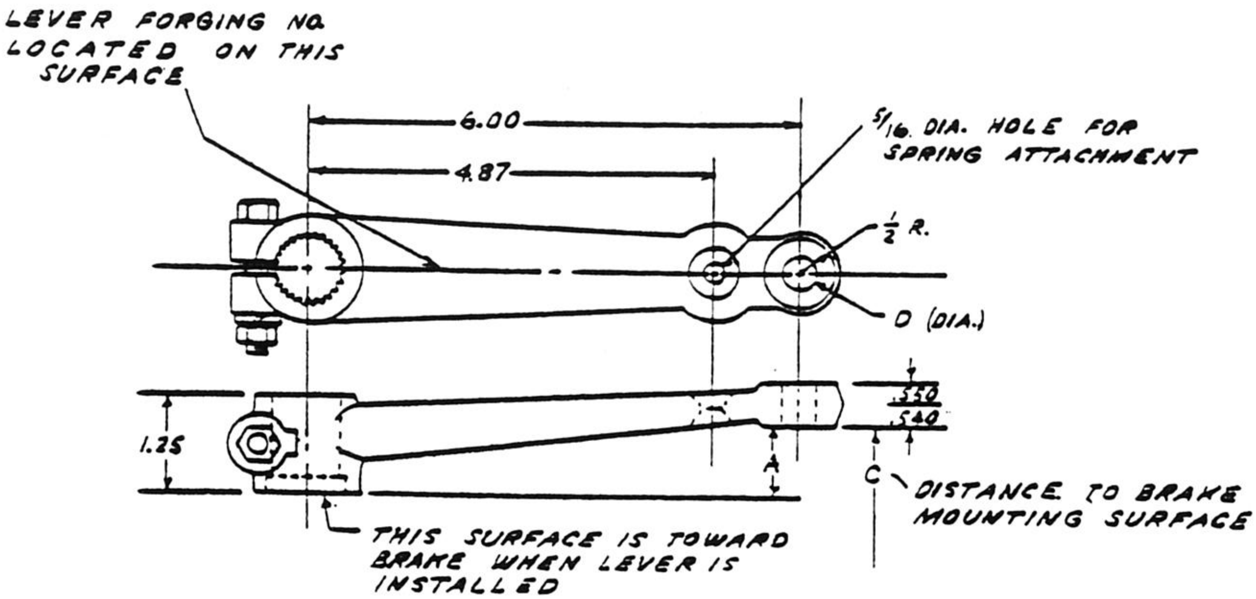
Lever Forging No.	Lever No.	Lever* Assembly No.	** L -in.	** D -in.	A -in.	C -in. Short Cam-shaft	C -in. Long Cam-shaft	Ident. Symbol	Remarks
49010	314945		4.62	.504	.81	2.264	2.704	∩	Clamping Bolt to be Provided by Customer.
49010	49053	309742	4.62	.560	.31	2.264	2.704	NONE	
49010	302647	309744	6.00	.560	.31	2.264	2.704	X	
49010	49052	309743	6.12	.560	.31	2.264	2.704	O	
49010	308099	309740	6.25	.560	.31	2.264	2.704	5	
49010	49051	309737	6.75	.560	.31	2.264	2.704	□	
49010	307928	309741	6.31	.560	.31	2.264	2.704	♣	
49010	307929	309738	7.12	.560	.31	2.264	2.704	☆	
49010	310847	310848	7.12	.380	.31	2.264	2.704	⬠	
49010	302391	309746	7.17	.500	.81	2.264	2.704	8	
49010	49009	309747	7.38	.560	.31	2.264	2.704	△	
49010	302153	309748	7.64	.500	.31	2.264	2.704	7	

* Lever assembly includes lever and bolt, lockwasher and nut as shown.

** Lever lengths and hole sizes other than those listed can be provided to meet specific customer requirements.

CHART V
LEVER DATA
12" DUO-SERVO, DOUBLE ANCHOR AUXILIARY BRAKES

LEVER FORGING NO'S 47753 & 304007

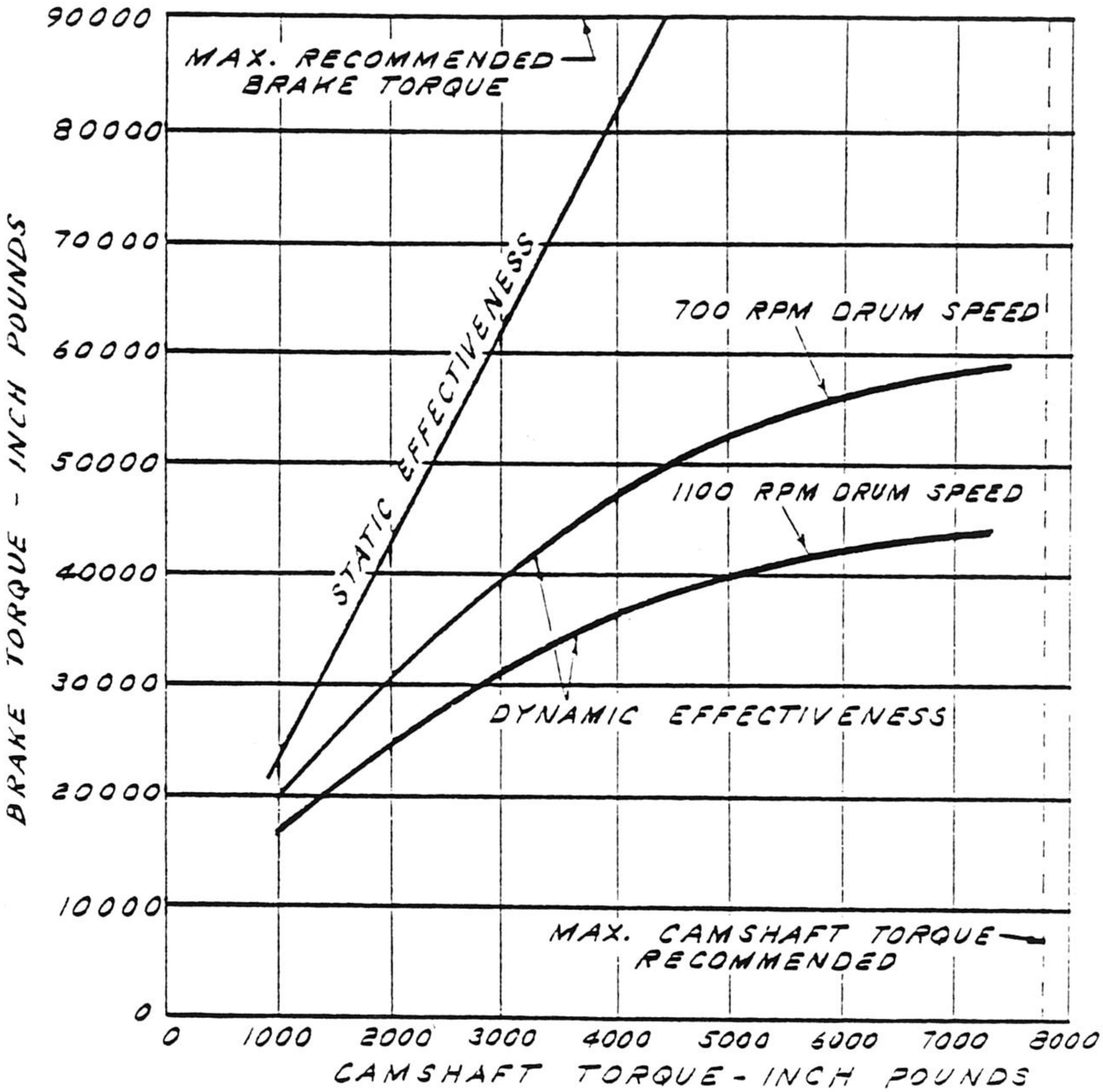


Lever Forging No.	Lever No.	Lever* Assembly No.	D -In.	A -In.	C -In. Short Cam-shaft	C -In. Long Cam-shaft	Remarks
47753	48195	309751	.50	.78	2.234	2.674	
304007	302043	309749	.50	.97	2.424	2.864	Hole "D" Provided with a Hardened Steel Bushing

* Lever assembly includes lever and bolt, lockwasher and nut as shown.

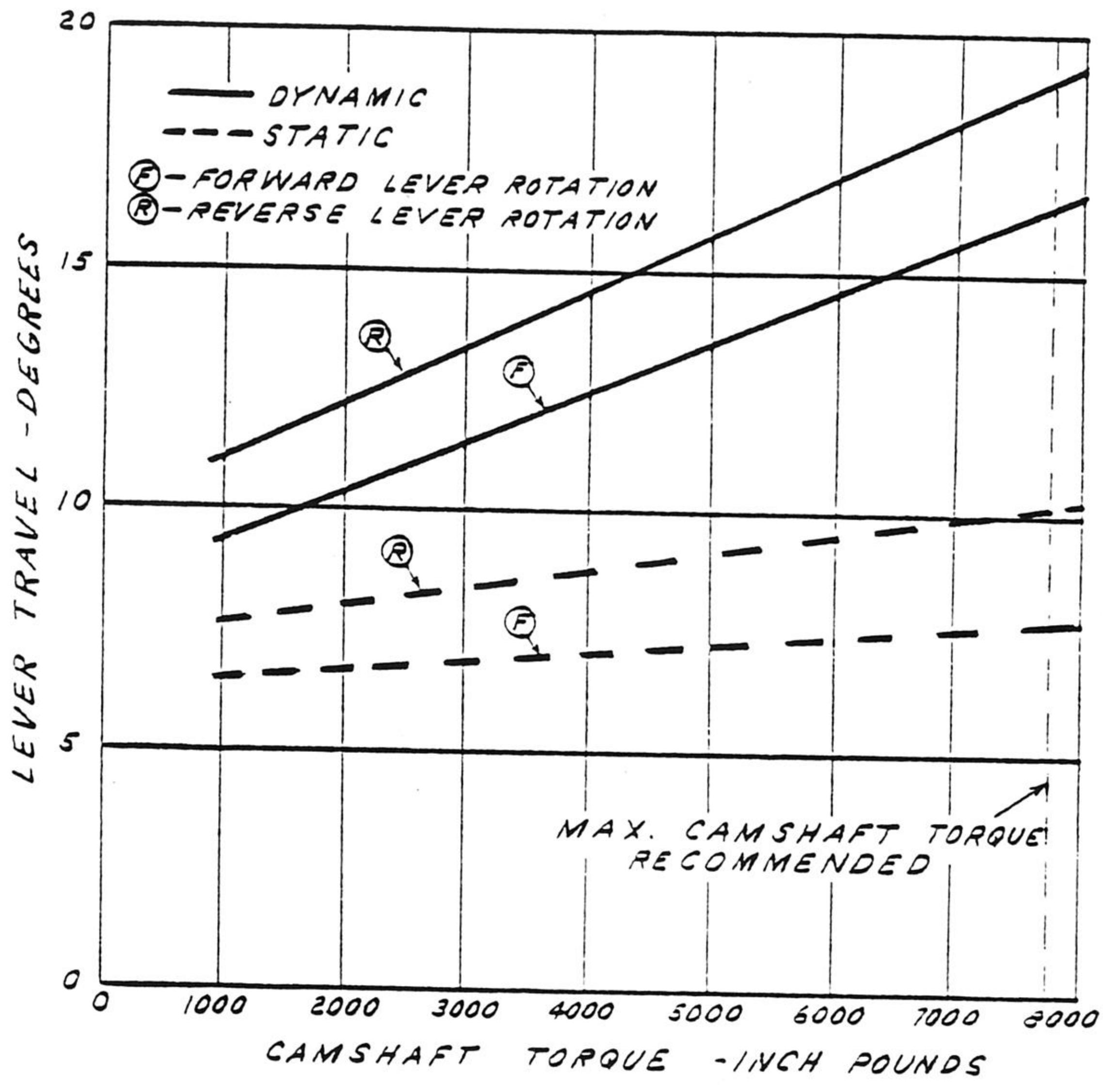
CURVE I

12" DUO-SERVO, DOUBLE ANCHOR AUXILIARY BRAKE
STATIC AND DYNAMIC EFFECTIVENESS CURVES
(LINING MATERIAL MAR H-3133-E)



CURVE II

12" DUO-SERVO, DOUBLE ANCHOR AUXILIARY BRAKE
LEVER TRAVEL CURVES
(.015" LINING TO DRUM CLEARANCE)



BULLETIN

Subject: Hydraulic Brake System Training
1990 Schedule

Bendix
and hydraulic
The air brake experts

o REF: School Schedule (attached)
Enrollment Application (attached)

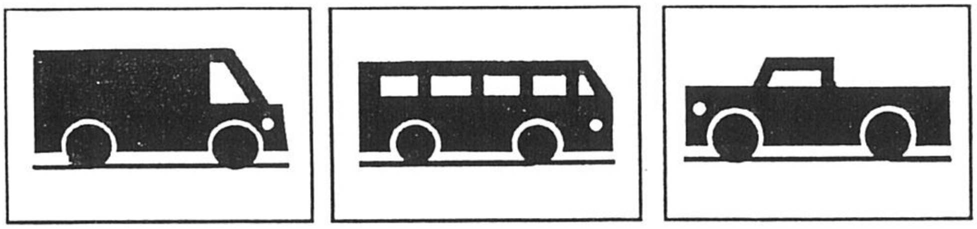
Bendix is pleased to announce that beginning in March of this year we will be offering the first of four scheduled Hydraulic Brake Schools for the 1990-91 school year. The school schedule with dates, locations and starting times, along with enrollment forms are attached.

The curriculum includes the fundamentals of component operation and service along with troubleshooting of typical hydraulic brake systems in use today. Coverage will include systems utilizing air, vacuum and hydraulic boosters as well as foundation brakes and hydraulic parking brakes and systems.

In addition to classroom lectures, cutaways, visuals aids and quizzes are used to assist those attending in understanding the hydraulic brake system.

As with all Bendix training schools, the Hydraulic Brake School is open to Bendix HVS distributors and their customers at no charge; however, the cost of transportation, lodging and meals is defrayed by the student. The size of the classes is limited and enrollment is on a first come, first serve basis. Please provide a 1st, 2nd and 3rd choice and indicate on the attached enrollment form in the event that your original choice may not be available. You will receive a confirmation letter indicating the class you will be attending. Should you be unable to attend the school you are registered in, notify us immediately at the Elyria, Ohio facility. Training at all listed locations will begin at 8:30 a.m. with dismissal at 4:30 p.m.

Motel reservations and transportation during the school are the responsibility of the student. For your convenience, we will provide a list of hotels/motels conveniently located to the training centers in the letter confirming enrollment.



1991 SCHEDULE

HYDRAULIC BRAKE SYSTEM TRAINING

*DALLAS, TX	
DATE	CLASS #
April 16	DH-041

*RENO, NV	
DATE	CLASS #
March 13	RH-031

*SALISBURY, NC	
DATE	CLASS #
April 10	SH-041

*ELYRIA, OH	
DATE	CLASS #
April 4	EH-041

*Location addresses will be noted on confirmation letter.

Bendix

Allied Signal

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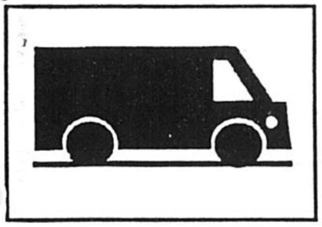
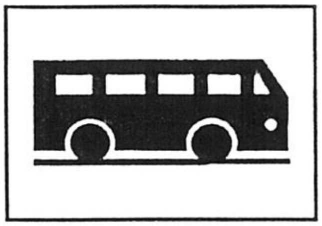
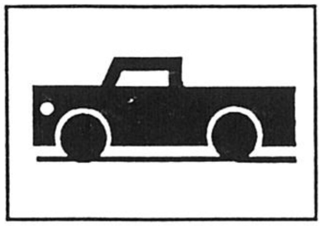

ENROLLMENT APPLICATION

HYDRAULIC BRAKE SYSTEM TRAINING

Name ______________________________

Firm ______________________________

Address ______________________________

City ______________ State ________ Zip ________

Phone ______________________________

SELECT ONE OF FOLLOWING:

- ☐ Bendix H.V.S. Distributor
- ☐ Associate Distributor (Provide Service Dist.) ______________________
- ☐ Fleet Operator
- ☐ O.E. Manufacturer
- ☐ Other ______________________

Please register the following individual(s):

NAME	POSITION OR TITLE	CLASS NO.	*DATES*	LOCATION

PLEASE LIST A 1st, 2nd & 3rd CHOICE.

Please return this form to the address below for confirmation and instructions.

Bendix H.V.S.
P.O. Box 4016
901 Cleveland Street
Elyria, OH 44036-2016
ATTN: MAIL CODE S31

Bendix

AlliedSignal

DEVICE	SLIDE NO.	SLIDE DESCRIPTION
Fundamentals	FUND-31	Dual Air Brake System
Fundamentals	FUND-32	Dual Air Brake System
Fundamentals	FUND-33	Dual Air Brake System
Fundamentals	FUND-34	Dual Air Brake System
Fundamentals	FUND-35	Dual Air Brake System
Governor	503-1	D-2 Governor (exterior)
Governor	503-2	D-2 Governor (sectional)
Governor	503-3	D-2 Governor (operational)
Governor	503-4	D-2 Governor Cut-Out Compressor Unloaded
Governor	503-5	D-2 Governor Cut-In Compressor Loaded
Hose Couplings	2801-1	Tru-Cupl Hose Couplings (exterior)
Hydraulic - AH-1B	1326-1	AH-1B Air/Hydraulic Intensifier (exterior)
Hydraulic - AH-1B	1326-2	AH-1B Air/Hydraulic Intensifier (sectional)
Hydraulic - AH-1B	1326-3	AH-1B Air/Hydraulic Intensifier applying (sectional)
Hydraulic - AH-1B	1326-4	AH-1B Air/Hydraulic Intensifier (schematic)
Hydraulic - AH-4	1357-1	AH-4 Air/Hydraulic Intensifier (sectional & exterior)
Hydraulic - AH-4	1357-2	AH-4 Air/Hydraulic Intensifier applying (sectional)
Hydraulic - AH-4	1357-3	AH-4 Air/Hydraulic Intensifier releasing (sectional)
Hydraulic - Air Pak	6605-1	Air Pak System (schematic)
Hydraulic - Air Pak	6605-2	Air Pak Released (sectional)
Hydraulic - Air Pak	6605-3	Air Pak Applying (sectional)
Hydraulic - Air Pak	6605-4	Air Pak System (schematic)
Hydraulic - Air Pak	6605-5	Air Pak Tractor/Trailer (schematic)
Hydraulic - Brake Fluid	6707-28	Brake Fluid Chart Types & Temps (word)
Hydraulic - Brake Fluid	6707-29	Brake Fluid Characteristics (word)
Hydraulic - Disc Brake	6800-1	Disc Brake (exterior)
Hydraulic - Disc Brake	6800-2	Floating & Fixed Calipers (sectional)
Hydraulic - Disc Brake	6800-3	Sliding Caliper & Axle Flange (explode)
Hydraulic - Disc Brake	6800-4	Single Piston Caliper & Anchor (explode)
Hydraulic - Disc Brake	6800-5	Twin Piston Caliper/Axle Flange (explode)
Hydraulic - Disc Brake	6800-6	Caliper/Piston Seal Operation (sectional)
Hydraulic - Disc Brake	6800-7	Single Piston Caliper (explode)
Hydraulic - Disc Brake	6800-8	Twin Piston Caliper/Anchor Plate (explode)
Hydraulic - Disc Brake	6800-9	Twin Piston Caliper/Anchor Plate (explode)
Hydraulic - Disc Rotor	6609-1	Disc Brake Rotor Inspection
Hydraulic - Drum Brake	6706-1	Drum Brake Assembled
Hydraulic - Drum Brake	6706-2	Drum Brake (explode)
Hydraulic - Drum Brake	6706-3	Drum Brake (explode)
Hydraulic - Drum Brake	6706-4	Drum Conditions (sectional)
Hydraulic - HR-1 Relay	4550-1	HR-1 Hydraulic Relay (sectional & exterior)
Hydraulic - HR-1 Relay	4550-2	HR-1 Hydraulic Relay (operational system—sectional)
Hydraulic - HR-1 Relay	4550-3	HR-1 Hydraulic Relay (operational system—sectional)
Hydraulic - Hoses	6707-32	Brake Hoses (exterior)
Hydraulic - Hydraulic	6604-1	Hydrovac/Convac System
Hydraulic - Hydromax	6602-1	Hydromax (exterior)
Hydraulic - Hydromax	6602-2	Hydromax & Balanced Gear System
Hydraulic - Hydromax	6602-3	Ford Hydromax System
Hydraulic - Hydromax	6602-4	Ford Hydromax System (installation drawing)
Hydraulic - Hydromax	6602-5	Ford Hydromax System (color position)
Hydraulic - Hydromax	6602-6	Hydromax (sectional)
Hydraulic - Hydromax	6602-7	Hydromax Initial Apply Position (sectional)
Hydraulic - Hydromax	6602-8	Hydromax Holding Position (sectional)
Hydraulic - Hydromax	6602-9	Hydromax Normal Applying (sectional)
Hydraulic - Hydromax	6602-10	Hydromax Auxiliary Electric Pump (exterior)
Hydraulic - Hydromax	6602-11	Hydromax Performance Graph
Hydraulic - Hydromax	6602-12	Hydromax Reserve Operating Mode (sectional)
Hydraulic - Hydromax	6602-13	Hydromax Ford System Tandem (schematic)

DEVICE	SLIDE NO.	SLIDE DESCRIPTION
Hydraulic - Hydromax	6602-14	Hydromax Ford System 2 Axle (schematic)
Hydraulic - Hydromax	6602-15	Hydromax Ford System 2 Axle (schematic)
Hydraulic - Hydrovac	6604-3	Hydrovac Applying Position (sectional)
Hydraulic - Hydrovac	6604-4	Hydrovac Balanced Position (sectional)
Hydraulic - Hydrovac	6604-5	Hydrovac Control Valve (sectional)
Hydraulic - Hydrovac	6604-9	Hydrovac System Troubleshooting (word)
Hydraulic - Hydrovac	6604-10	Hydrovac System & Sectional In Phantom Truck
Hydraulic - Hydrovac	6604-11	Hydrovac (exterior)
Hydraulic - Hydrovac	6604-12	Hydrovac System (schematic)
Hydraulic - Hydrovac	6707-31	Hydrovac Air Filter (exterior)
Hydraulic - Hydrovac	6707-33	Various Hydrovac Components (exterior)
Hydraulic - Lucas Girling	6707-1	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-2	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-3	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-4	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-5	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-6	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-7	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-8	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-9	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-10	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-11	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-12	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-13	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-14	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-15	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-16	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-17	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-18	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-19	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-20	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-21	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-22	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-23	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Lucas Girling	6707-24	Lucas Girling Hydr Drum Brake w/Mech Wedge Parking (A2LS)
Hydraulic - Master Cylinder	6606-1	Single Circuit Master Cylinder (sectional)
Hydraulic - Master Cylinder	6606-2	Single Circuit Master Cylinder (sectional)
Hydraulic - Master Cylinder	6606-3	Single Circuit Master Cylinder Applying (sectional)
Hydraulic - Master Cylinder	6606-4	Single Circuit Master Cylinder Released (sectional)
Hydraulic - Master Cylinder	6606-5	Single Circuit Master Cylinder Releasing (sectional)
Hydraulic - Master Cylinder	6606-6	Dual Circuit Master Cylinder (sectional)
Hydraulic - Master Cylinder	6606-7	Dual Circuit Master Cylinder Releasing (sectional)
Hydraulic - Master Cylinder	6606-8	Dual Circuit Master Cylinder Releasing (sectional)
Hydraulic - Master Cylinder	6606-9	Dual Circuit Master Cylinder (exterior)
Hydraulic - Master Cylinder	6606-10	Single Circuit Master Cylinder (sectional)
Hydraulic - Master Cylinder	6606-11	Dual Circuit Master Cylinder (sectional)
Hydraulic - Master Cylinder	6606-12	Master Cylinder Compensating/Intake (sectional)
Hydraulic - Master Cylinder	6606-13	Master Cylinder Compensating/Intake (sectional)
Hydraulic - Master Cylinder	6707-25	Master Cylinder & 2 Drum Brakes (sectional)
Hydraulic - Master Cylinder	6707-26	Master Cylinder & 1 Drum Brake (sectional)
Hydraulic - Master Cylinder	6707-27	Dual Master Cylinder & 2 Drum Brakes (sectional)
Hydraulic - Mastervac	6604-8	Master Vac Released Position (sectional)
Hydraulic - Mastervac	6604-13	Master Vac Applying (sectional)
Hydraulic - Tandem Hydrovac	6604-6	Tandem Hydrovac Released (sectional)
Hydraulic - Vac Chk Vlve	6707-30	Vacuum Check Valve (exterior)
Hydraulic - Vac Dual System	6604-7	Hydrovac Dual System (schematic)
Hydraulic - Vacuum Pumps	6610-1	Convac Vacuum Pump (sectional)

DEVICE	SLIDE NO.	SLIDE DESCRIPTION
Hydraulic - Vacuum Pumps	6610-2	Convac Vacuum Pump (end view sectional)
Hydraulic - Vacuum Pumps	6610-3	Convac Vacuum (exterior)
Hydraulic - Vacuum System	6604-2	Hydrovac Released Position (sectional)
Hydraulic - Wheel Cylinder	6608-1	Wheel Cylinder (sectional)
Hydraulic - Wheel Cylinder	6608-2	Wheel Cylinder (sectional)
Hydraulic - Wheel Cylinder	6608-3	Wheel Cylinder Expander (sectional)
Inversion Valve - TR-2	4650-1	TR-2 Inversion Valve (sectional & exterior)
Inversion Valve - TR-3	4650-3	TR-3 Inversion Valve (sectional & exterior)
Inversion Valve - TR-4	4650-2	TR-4 Inversion Valve (sectional)
Low Pressure Indicator	1600-1	LP-2 Low Pressure Indicator (exterior)
Low Pressure Indicator	1600-2	LP-2 Low Pressure Indicator (sectional)
Low Pressure Indicator	1600-3	LP-2 Low Pressure Indicator (sectional & exterior)
Piping Diagrams	110-1	Rapid Build Up System SA-1778.47
Piping Diagrams	110-2	SD-3 Safety Actuator System
Piping Diagrams	110-3	Piping for Dolly
Piping Diagrams	110-4	Piping for Trailer
Piping Diagrams	110-5	Ford "L" Series (system normal-service)
Piping Diagrams	110-6	Ford "L" Series (primary system failure)
Piping Diagrams	110-7	Ford "L" Series (system normal-park)
Piping Diagrams	110-8	Ford "L" Series (secondary failure)
Piping Diagrams	110-9	Spring Brake Piping-Dual Circuit
Piping Diagrams	110-10	Spring Brake Piping-Single Circuit
Piping Diagrams	110-11	Spring Brake Piping-Single Circuit
Piping Diagrams	110-12	Spring Brake Piping-Single Circuit
Piping Diagrams	110-13	121 Dual Air System (inter-city coach)
Piping Diagrams	110-14	121 Dual Air System (tractor w/adapter)
Piping Diagrams	110-15	Tandem Axle Trailer (w/SR-2 spring brakes)
Piping Diagrams	110-16	Dual Air Brake System Series
Piping Diagrams	110-17	Dual Air Brake System Series
Piping Diagrams	110-18	Dual Air Brake System Series
Piping Diagrams	110-19	Dual Air Brake System Series
Piping Diagrams	110-20	Dual Air Brake System Series
Piping Diagrams	110-21	Dual Air Brake System Series
Piping Diagrams	110-22	Dual Air Brake System Series
Piping Diagrams	110-23	Dual Air Brake System Series
Piping Diagrams	110-24	Dual Air Brake System Series
Piping Diagrams	110-25	Dual Air Brake System Series
Piping Diagrams	110-26	Dual Air Brake System Series
Piping Diagrams	110-27	Dual Air Brake System Series
Piping Diagrams	110-28	Off Highway Air Brake Schematic
Piping Diagrams	110-29	Two Valve Parking & Tractor Protect. System (operational)
Piping Diagrams	110-30	Two Valve Parking & Tractor Protect. System (operational)
Piping Diagrams	110-31	Two Valve Parking & Tractor Protect. System (operational)
Piping Diagrams	110-32	Three Valve Parking & Tractor Protect. System (operational)
Piping Diagrams	110-33	Three Valve Parking & Tractor Protect. System (operational)
Piping Diagrams	110-34	Three Valve Parking & Tractor Protect. System (operational)
Piping Diagrams	110-35	Three Valve Parking & Tractor Protect. System (operational)
Piping Diagrams	110-36	Converter Dolly Standard
Piping Diagrams	110-37	Converter Dolly with Booster
Piping Diagrams	110-38	Four Axle Dolly w/Relay Emergency & Booster Valve
Piping Diagrams	110-39	Six Wheel Coach w/Two Step Parking Brake Release (DD-3)
Piping Diagrams	110-40	Six Wheel Coach w/Two Step Parking Brake Release (DD-3)
Piping Diagrams	110-41	Six Wheel Coach w/Two Step Parking Brake Release (DD-3)
Piping Diagrams	110-42	Six Wheel Coach w/Two Step Parking Brake Release (DD-3)
Piping Diagrams	110-43	Six Wheel Coach w/Two Step Parking Brake Release (DD-3)
Piping Diagrams	110-44	Six Wheel Coach w/Two Step Parking Brake Release (DD-3)
Piping Diagrams	110-45	Six Wheel Coach w/Two Step Parking Brake Release (DD-3)