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# SAE J901 MAR85

# Universal Joints and Driveshafts — Nomenclature — Terminology — Application Guidelines

**SAE Recommended Practice**
**Completely Revised March 1985**





**An American National Standard**

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# ϕ UNIVERSAL JOINTS AND DRIVESHAFTS—NOMENCLATURE—TERMINOLOGY—APPLICATION GUIDELINES—SAE J901 MAR85

**SAE Recommended Practice**

Report of the Transmission and Drivetrain Committee, approved June 1964, completely revised March 1985.

The following definitions and illustrations are intended to establish common nomenclature and terminology for universal joints and driveshafts used in various driveline applications. In addition, useful guidelines are included for the application of universal joints and driveshafts. For more specific details, see Universal Joint and Driveshaft Design Manual, AE-7.

*1. Basic Driveline Terms*

**1.1 Driveline**—An assembly of one or more driveshafts with provisions for axial movement, which transmits torque and/or rotary motion at a fixed or varying angular relationship from one shaft to another.

**1.2 Driveshaft**—An assembly of one or two universal joints connected to a solid or tubular shaft member (see Fig. 26).

**1.3 Halfshaft**—A driveshaft, normally one of two, that connects the chassis mounted final drive unit to the independently sprung driven wheel of a vehicle (see Figs. 34 and 35).

**1.4 Driveshaft Length, Center-to-Center**—The distance between the outermost universal joint centers on a driveshaft. On driveshafts with fixed centers, it is the nominal dimension, while on driveshafts with variable length centers, it is the compressed and extended lengths (see Fig. 26).

**1.5 Slip**—The permissible length of axial travel.

**1.6 Stroke or Plunge Distance**—The relative axial displacement of an end motion or stroking universal joint's driving and driven members.

**1.7 Phase Angle**—The relative rotational position of the universal joint yokes on a driveshaft or driveline (see Fig. 26).

**1.8 Critical Speed**—The speed at which the rotational speed coincides with the transverse natural vibration frequency of the driveshaft.

**1.9 Balancing**—A procedure by which the mass distribution of a rotating body is measured and, if necessary, altered in order to ensure that it is within specified limits.

**1.10 Mass Damper**—A concentrated mass generally clamped on a halfshaft midway between the universal joints. It is used to reduce the natural bending frequency of the halfshaft below a disturbing frequency (see Fig. 37).

**1.11 Torsional Damper or Vibration Absorber**—A torsionally tuned mechanical device which generally consists of an inertia ring attached to a drivetrain component by means of an elastomeric inner ring. It is tuned to a specific disturbing frequency (see Figs. 27 and 38).

**1.12 Isolation Damper**—A mechanical torque transmitting device incorporated in a halfshaft which functions as a disturbance isolator. It eliminates, by means of an elastomeric inner ring or rings, undesirable throttle or shift induced noises or disturbances resulting from transaxle gear lash. This device is normally installed only on one halfshaft in a vehicle (see Figs. 39 and 40).

*2. Basic Universal Joint Terms*

**2.1 Universal Joint**—A mechanical device which can transmit torque and/or rotational motion from one shaft to another at fixed or varying angles of intersection of the shaft axes.

**2.2 Nonconstant Velocity Universal Joint**—A universal joint which transmits rotational motion with a variation in angular velocity between the output and input members when operating at joint angles greater than zero. The average angular velocity ratio is unity (for example: the Cardan or Hooke joint).

**2.3 Constant Velocity of CV Universal Joint**—A universal joint which transmits rotational motion with an angular velocity ratio of unity between output and input members (for example: the Rzeppa joint).

**2.4 Near Constant Velocity Universal Joint**—A universal joint which transmits rotational motion with an angular velocity ratio of unity when operating at the design joint angle and at zero. When operating at other angles, the angular velocity ratio is near unity (for example: the double Cardan joint).

**2.5 Self-Supporting Universal Joint**—A universal joint supported by internal means (for example: the Rzeppa joint).

**2.6 Nonself-Supporting Universal Joint**—A universal joint which requires an external means of support (for example: the formerly used Tracta joint).

**2.7 Fixed Center Universal Joint**—A universal joint which maintains the joint center at a fixed location and can resist axial thrust forces (for example: the Cardan or Hooke joint).

**2.8 End Motion or Stroking Universal Joint**—A universal joint which permits relative axial movement between input and output members resulting in a variable joint center location (for example: the tripot joint).

**2.9 Outboard Joint**—A universal joint located at the wheel end of a halfshaft (see Fig. 34).

**2.10 Inboard Joint**—A universal joint located at the differential or final drive end of a halfshaft (see Fig. 34).

**2.11 Joint Angle**—The acute angle described by the intersection of the rotational axes of the input and output members of a universal joint and measured in the plane described by these axes (see Fig. 26).

**2.12 Swing Diameter**—The maximum diameter of the circular path described by a rotating universal joint (see Fig. 26).

**2.13 Constant Velocity, Bisecting Angle or Homokinetic Plane**—The plane described by all contact points of a universal joint which produces an angular velocity ratio of unity between the output and input members. This plane bisects the obtuse angle formed by the input and output member rotational axes and is perpendicular to the plane containing these axes.

**2.14 Torsional Equivalent Angle**—The joint angle of a single nonconstant velocity universal joint which produces the same speed variation as a driveline with two or more nonconstant velocity universal joints.

**2.15 Inertia Equivalent Angle**—The joint angle of a single nonconstant velocity universal joint which describes the inertia effects of a driveline.

**2.16 Inertia Drive Equivalent Angle**—The joint angle of the first nonconstant velocity universal joint in a two-joint system. In a three-or-more-joint system, it is the joint angle of a single nonconstant velocity universal joint which produces the same maximum acceleration as the maximum of the sum of the accelerations of all but the last nonconstant velocity universal joint in the driveline.

**2.17 Inertia Coast Equivalent Angle**—The joint angle of the last



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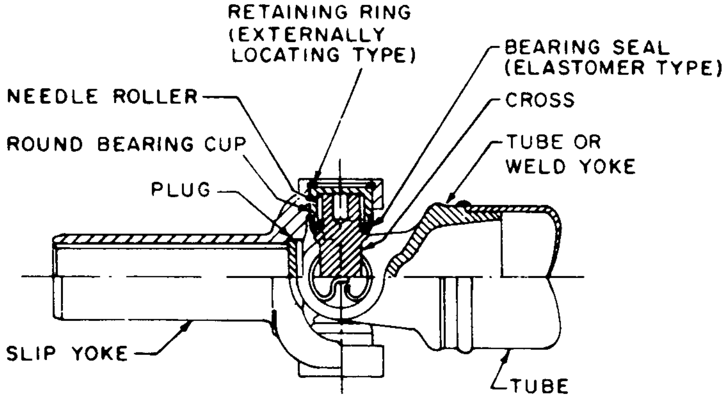


FIG. 1—CARDAN UNIVERSAL JOINT

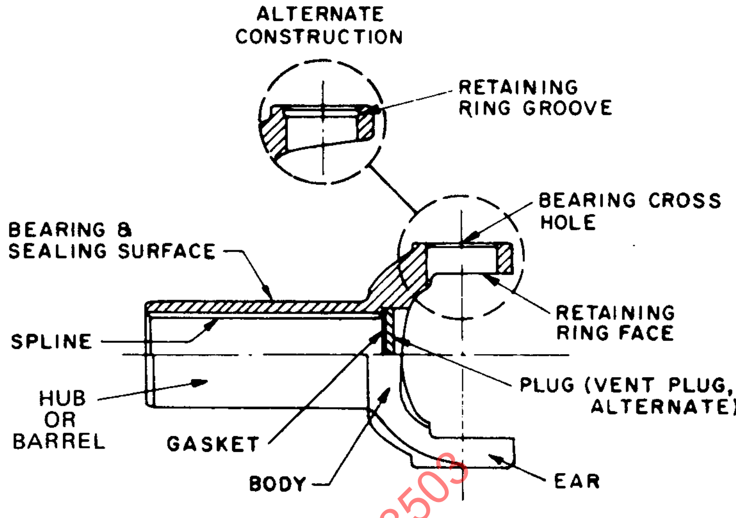


FIG. 2—SLIP YOKE

nonconstant velocity universal joint in a two-joint system. In a three-or-more-joint system, it is the joint angle of a single nonconstant velocity universal joint which produces the same maximum acceleration as the maximum of the sum of the accelerations of all but the first nonconstant velocity universal joint in the driveline.

**2.18 Secondary Couple**—A bending moment on the driving and driven members of a universal joint produced by an angular change in the direction of torque. It is a function of torque and joint angle. In a nonconstant velocity universal joint, the bending moment on the driving member oscillates from zero to maximum, while simultaneously on the driven member the moment varies from maximum to zero, twice per revolution. In a constant velocity universal joint, the bending moment on both driving and driven members is constant for all positions of joint rotation.

**2.19 Bearing Factor**—A size characteristic for comparing the various size Cardan and double Cardan type universal joints relative to bearing capacity. It is the product of the projected needle roller bearing area on the cross trunnion times the torque radius (see Fig. 42).

*3. Universal Joints*

**3.1 Nonconstant Velocity Types**

3.1.1 CARDAN OR HOOKE UNIVERSAL JOINT—A nonconstant velocity universal joint which consists of two yokes drivably connected by a cross through four bearings (see Fig. 1).

3.1.1.1 Yoke—The basic torque and/or motion input and output member with drivable means of attachment.

3.1.1.2 Slip Yoke—A yoke which accommodates axial movement (see Figs. 2 and 27).

3.1.1.3 Tube or Weld Yoke—A yoke with a piloting hub for attachment to a tube or other shaft member (see Figs. 3 and 27).

3.1.1.4 End Yoke—A yoke which attaches a driveshaft to another drivetrain component (see Figs. 4, 5, and 27).

3.1.1.5 Flange Yoke—A yoke which attaches a driveshaft to a companion flange (see Figs. 6 and 27).

3.1.1.6 Companion Flange—A flange member that fixedly attaches a driveshaft to another drivetrain component (see Figs. 7 and 27).

3.1.1.7 Ear—One of two projecting parts of a yoke symmetrically located with respect to the rotational axis (see Fig. 2).



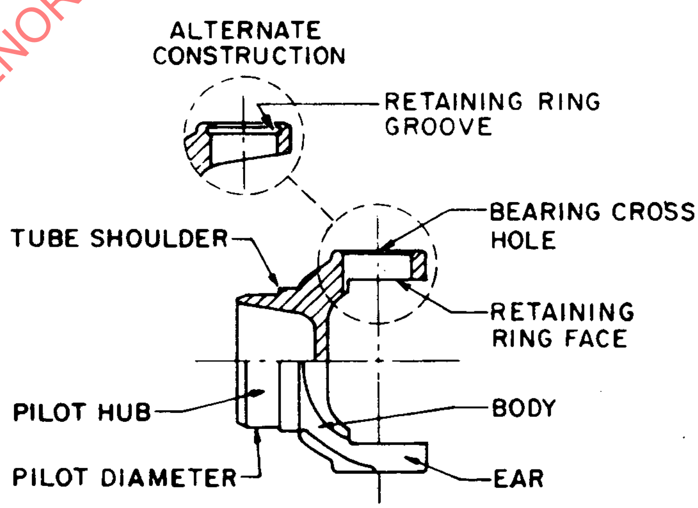


FIG. 3—TUBE OR WELD YOKE

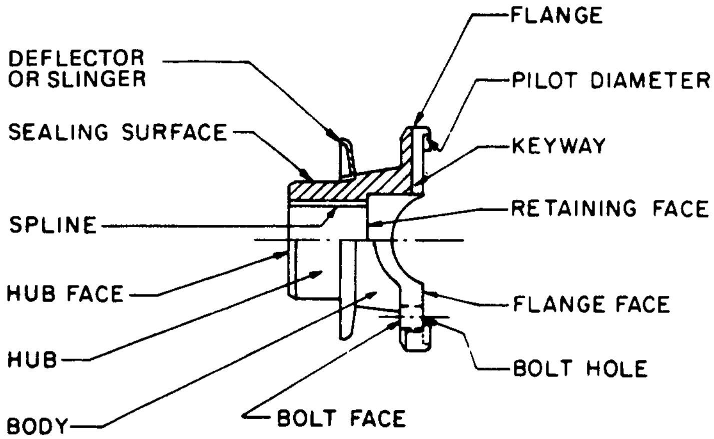

FIG. 4—END YOKE (WING BEARING TYPE)

3.1.1.8 Hub—The central part of a member used for attachment to another member (see Fig. 2).

3.1.1.9 Bearing Cross Hole—A through hole in each ear of a yoke used to locate a round bearing (see Fig. 2).

3.1.1.10 Half Round Cross Hole—A semicircular hole located on the end of each ear of some end yoke designs (see Figs. 5 and 27).

3.1.1.11 Bearing Locator—A projection in a half round cross hole, of some end yoke designs, used to locate a round bearing with respect to the yoke centerline (see Fig. 5).

3.1.1.12 Retaining Ring Groove—A groove used to locate a retaining ring (see Fig. 2).

3.1.1.13 Retaining Ring—A removable member used as a shoulder to retain and position a round bearing in a hole (see Figs. 1, 8, and 27).

3.1.1.14 U-Bolt—A clamping type bolt with two threaded parallel legs used to retain a round bearing in some end yoke designs (see Figs. 8 and 27).

3.1.1.15 Round Bearing—Consists of a round bearing cup with needle rollers generally held in place by a needle roller retainer or a bearing seal (see Figs. 8 and 27).

3.1.1.16 Round Bearing Cup—A cup-shaped member used as the bearing bore of a round bearing and for positioning the thrust end of a cross trunnion (see Figs. 1 and 11).

3.1.1.17 Needle Roller—One of the rolling elements of a bearing (see Figs. 1 and 11).

3.1.1.18 Needle Roller Retainer—A member used to retain needle rollers in a bearing.

3.1.1.19 Bearing Seal—A flexible member which prevents the escape of lubricant from or entry of foreign matter into a bearing (see Figs. 1, 9, and 11).

3.1.1.20 Deflector or Slinger—A protective member whose function is to exclude foreign objects from the bearing seal (see Figs. 4 and 9).

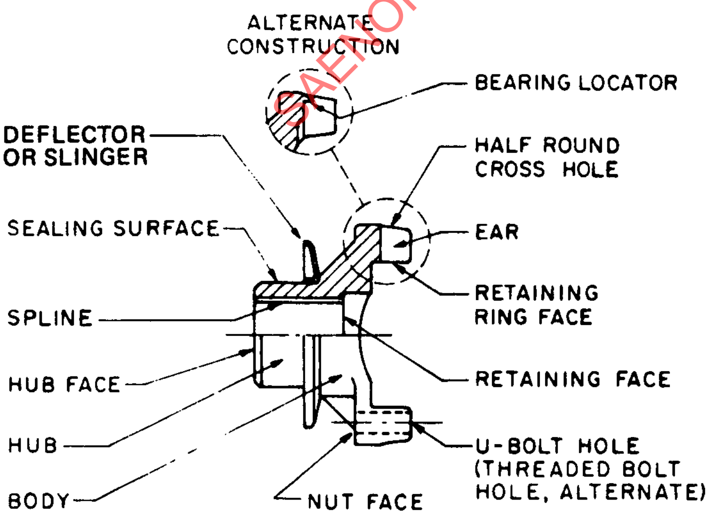

FIG. 5—END YOKE (ROUND BEARING TYPE)

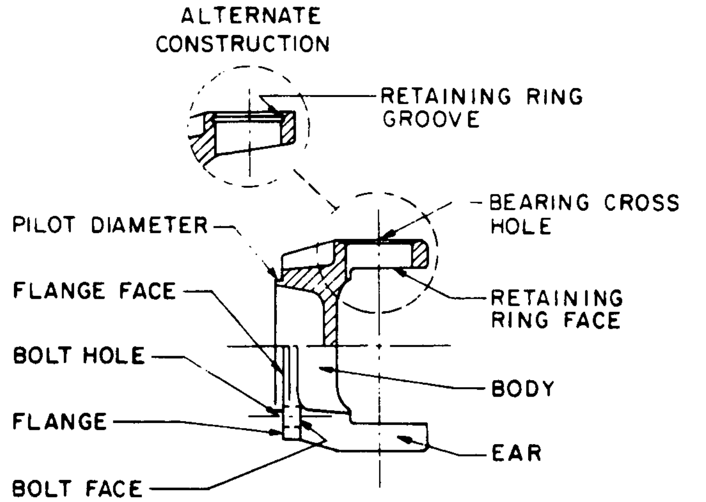

FIG. 6—FLANGE YOKE

3.1.1.21 Seal Retainer—A member used to hold a bearing seal in position on the bearing (see Fig. 9).

3.1.1.22 Wing Bearing—Consists of a wing bearing cup with needle rollers generally held in place by a needle roller retainer or a bearing seal (see Figs. 8 and 27).

3.1.1.23 Wing Bearing Cup—A member with a key and projecting wings used as the bearing bore of a wing bearing and for positioning the thrust end of a cross trunnion. The low wing bearing type cup has thin flanged wings for attachment. The high wing or block bearing type cup has thick flanged wings for attachment. The delta wing bearing type cup has delta-shaped flanged wings for attachment (see Fig. 8).

3.1.1.24 Round Bearing (Retainer Plate Type)—Consists of a round bearing with a generally integral retainer plate for retaining and positioning the bearing in a yoke (see Fig. 8).

3.1.1.25 Strap—A narrow plate type member used to retain a round bearing in some end yoke designs (see Figs. 8 and 27).

3.1.1.26 Retaining Ring Face—A surface used for positioning a round bearing with a retaining ring (see Fig. 2).

3.1.1.27 Thrust Face—The closed end of a bearing used as a thrust surface.

3.1.1.28 Cross—The intermediate drive member which has 4 equally spaced trunnions in the same plane (see Figs. 10 and 27).

3.1.1.29 Trunnion—Any one of the 4 projecting journals of a cross (see Fig. 10).

3.1.1.30 Trunnion Diameter—The diameter of a projecting journal of a cross (see Fig. 10).

3.1.1.31 Thrust End—The end of the cross trunnion used as a thrust surface (see Fig. 10).

**3.2 Constant Velocity Types**

3.2.1 Double Cardan Universal Joint—A near constant velocity universal joint which consists of 2 Cardan universal joints whose crosses are connected by a coupling yoke with internal supporting and centering means and has intersecting shaft axes. At the design joint angle and at

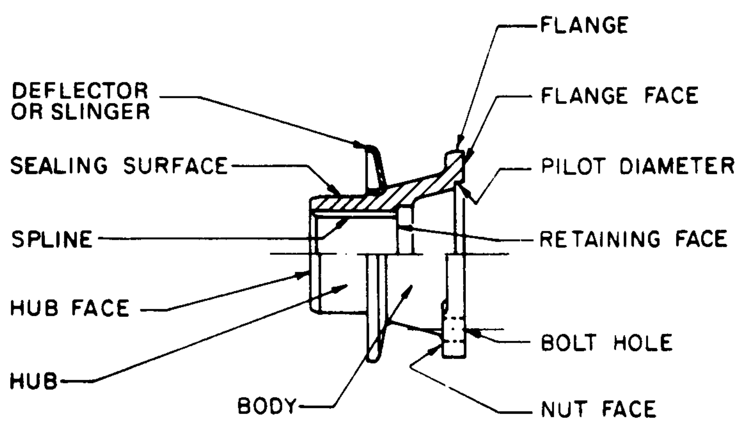

FIG. 7—COMPANION FLANGE

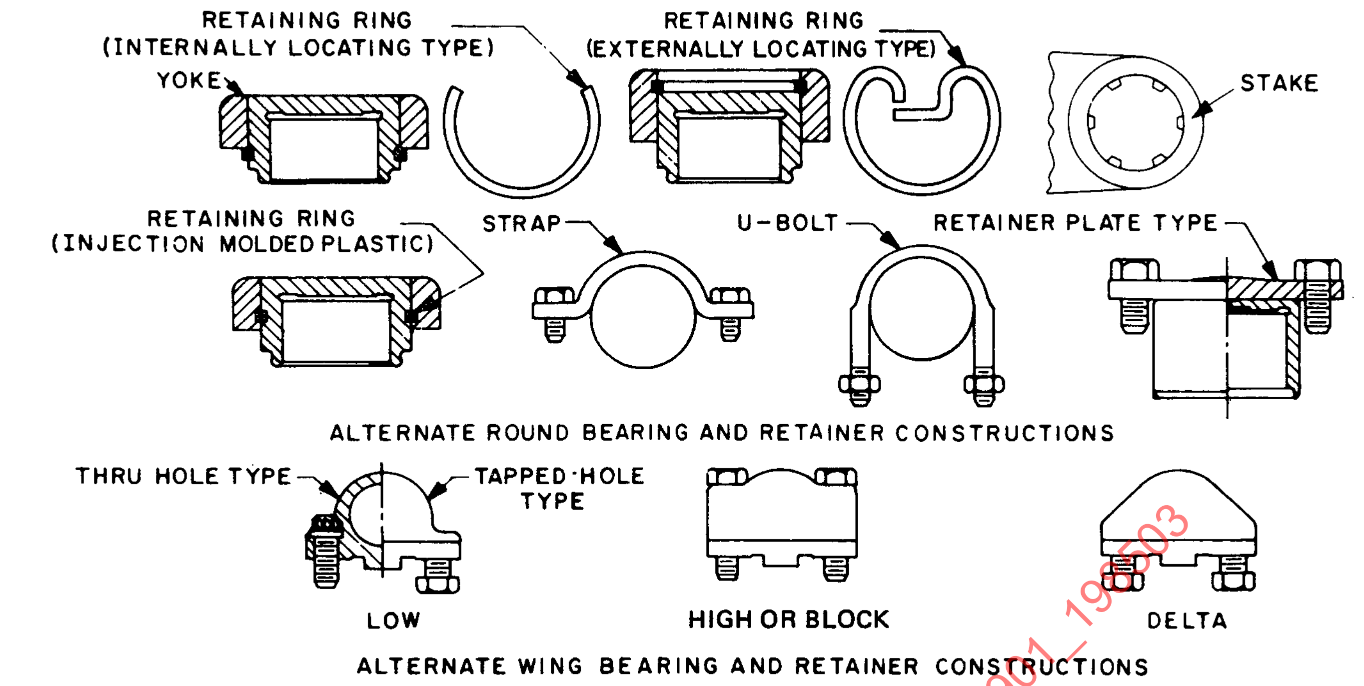


FIG. 8—BEARING AND RETAINER TYPES

zero, the instantaneous angular velocity ratio is unity, while at other joint angles it is near unity (see Fig. 11).

3.2.1.1 Coupling Yoke—A double yoke which connects the 2 halves of a double Cardan universal joint (see Fig. 11).

3.2.1.2 Socket Yoke—A yoke incorporating a socket (see Fig. 11).

3.2.1.3 Socket—A separate bearing member or integral cavity in a yoke used to pivotally locate and support the ball of a ball and socket type centering device (see Fig. 11).

3.2.1.4 Ball and Socket Type Centering Device—A mechanism which functions as a self-aligning bearing and provides internal supporting and centering means for a double Cardan type universal joint. The 2 basic types of ball and socket designs are the centering ball and stud and the ball stud and seat constructions (see Fig. 11).

3.2.1.5 Centering Stud Yoke—A yoke incorporating a centering stud (see Fig. 11).

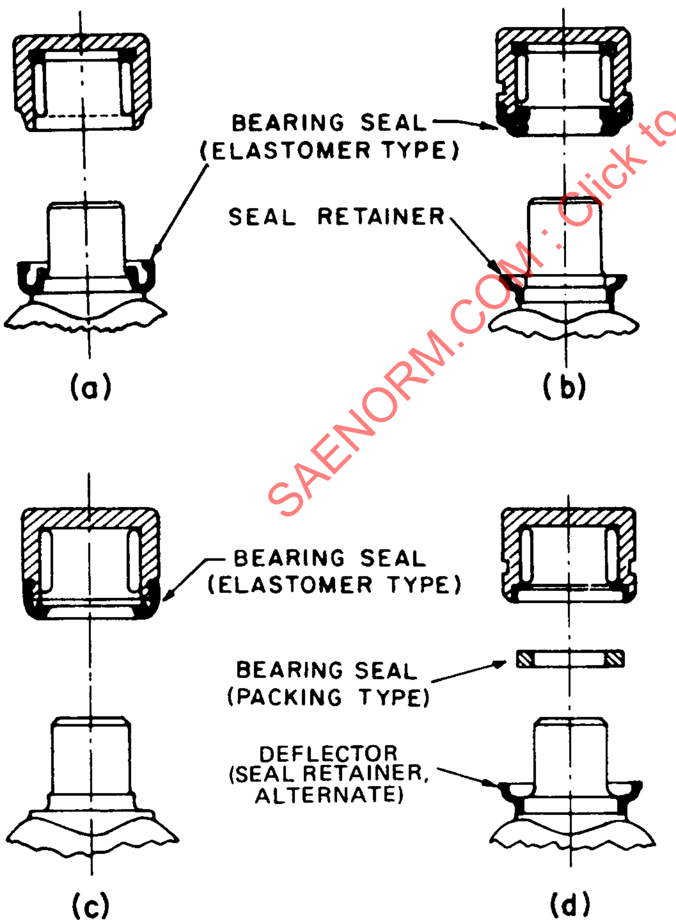


FIG. 9—BEARING SEAL TYPES

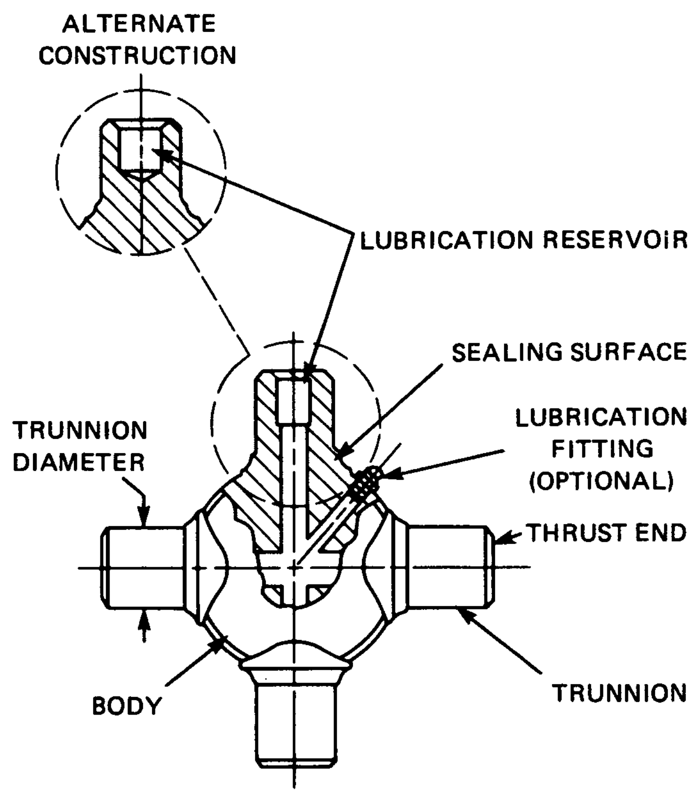


FIG. 10—CROSS

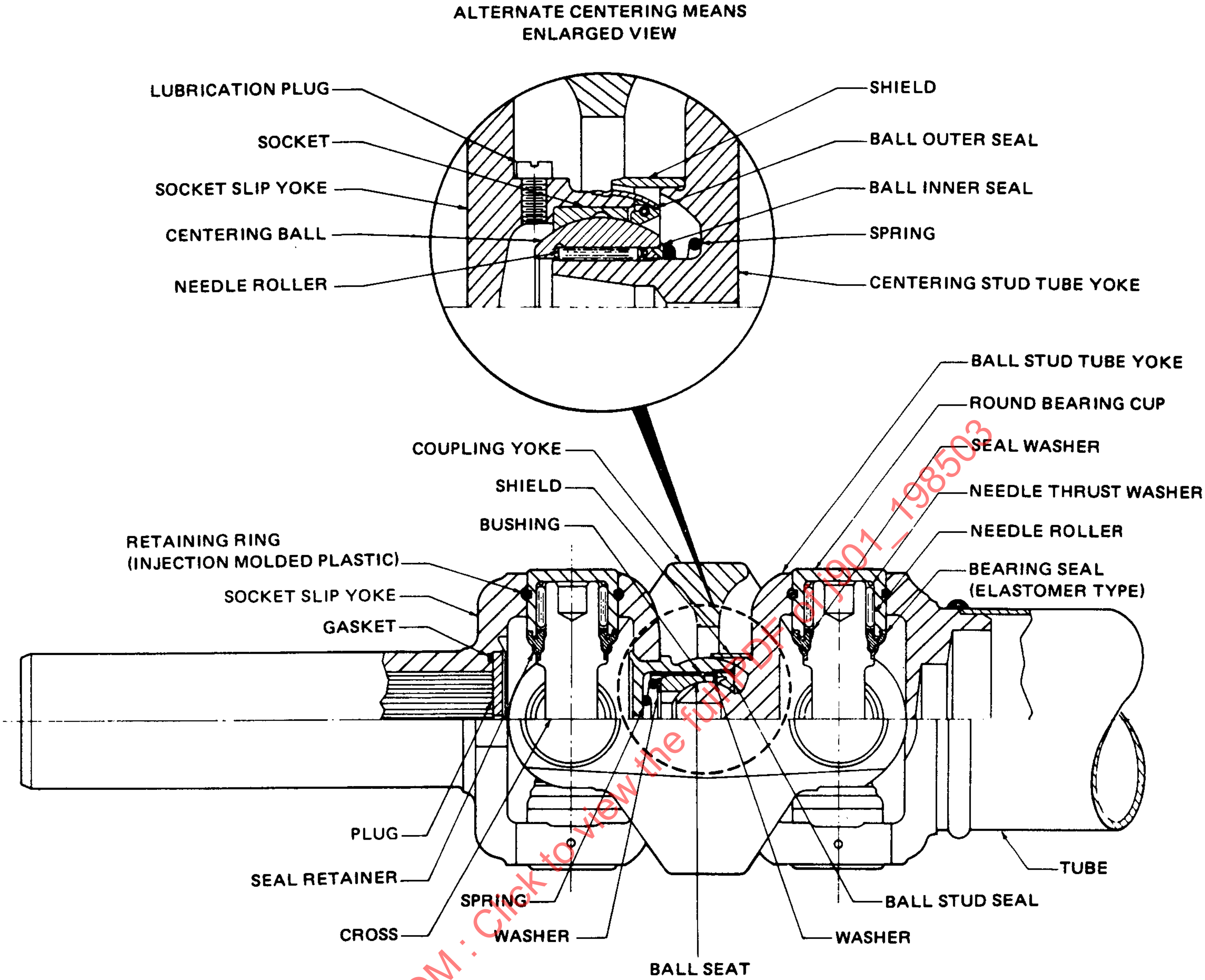


FIG. 11—DOUBLE CARDAN UNIVERSAL JOINT



3.2.1.6 Centering Stud—A part of a yoke used to support a centering ball (see Fig. 11).

3.2.1.7 Centering Ball—A partly spherical-shaped member which pivots and provides supporting and centering means (see Fig. 11).

3.2.1.8 Ball Stud Yoke—A yoke incorporating a ball stud (see Fig. 11).

3.2.1.9 Ball Stud—A partly spherical-shaped part of a yoke which pivots and provides supporting and centering means (see Fig. 11).

3.2.1.10 Ball Seat—A full or segmented ring-like angular contact bearing member located in a socket which supports and centers the ball stud (see Fig. 11).

3.2.2 Tripot or Tripod Universal Joint (End Motion Type)—A constant velocity universal joint, radially self-supported and permitting axial movement, which consists of a housing drivably connected to a shaft through 3 equally spaced trunnion mounted balls (see Fig. 12).

3.2.2.1 Housing—A member with 3 equally spaced, partly cylindrical axial ball bores on the cylindrical inner clearance surface and with drivable means of attachment. In the tulip type housing, these ball bores have open circular segments on the periphery, as well as on the inner clearance surface (see Figs. 12, 13, and 14).

3.2.2.2 Spider—A member with 3 equally spaced trunnions in the same plane and with internally splined drivable means of attachment (see Figs. 12 and 13).

3.2.2.3 Ball—A partly spherical-shaped member which pivots and transmits torque from the housing to the shaft through the spider and permits axial movement. Generally, needle rollers are used between the ball and the spider (see Figs. 12 and 13).

3.2.2.4 Boot Seal—A flexible member which prevents the escape of lubricant from or entry of foreign matter into the universal joint (see Figs. 12 and 13).

3.2.2.5 Band—A ring-like member used to hold the boot seal in position on the universal joint or shaft (see Fig. 12).

3.2.2.6 Clamp—An adjustable band used to hold the boot seal in position on the universal joint or shaft (see Figs. 12 and 13).

3.2.2.7 Needle Roller Retainer—A member which radially positions and retains the needle rollers on the spider trunnion (see Figs. 12 and 13).

3.2.2.8 Retaining Ring—A removable member used as a shoulder for retaining and positioning universal joint components in an assembly (see Figs. 12 and 13).

3.2.3 Tripot or Tripod Universal Joint (Fixed Center Type)—A self-supported constant velocity universal joint which consists of a housing drivably connected to a forked shaft through 3 equally spaced trunnion mounted balls and retained as an assembly by a retaining clip. The joint center is maintained in a substantially fixed axial location by means of a spring loaded centering device (see Fig. 15).

3.2.3.1 Housing—A bell-shaped member retaining a spider with rotating and sliding balls mounted on 3 equally spaced trunnions located

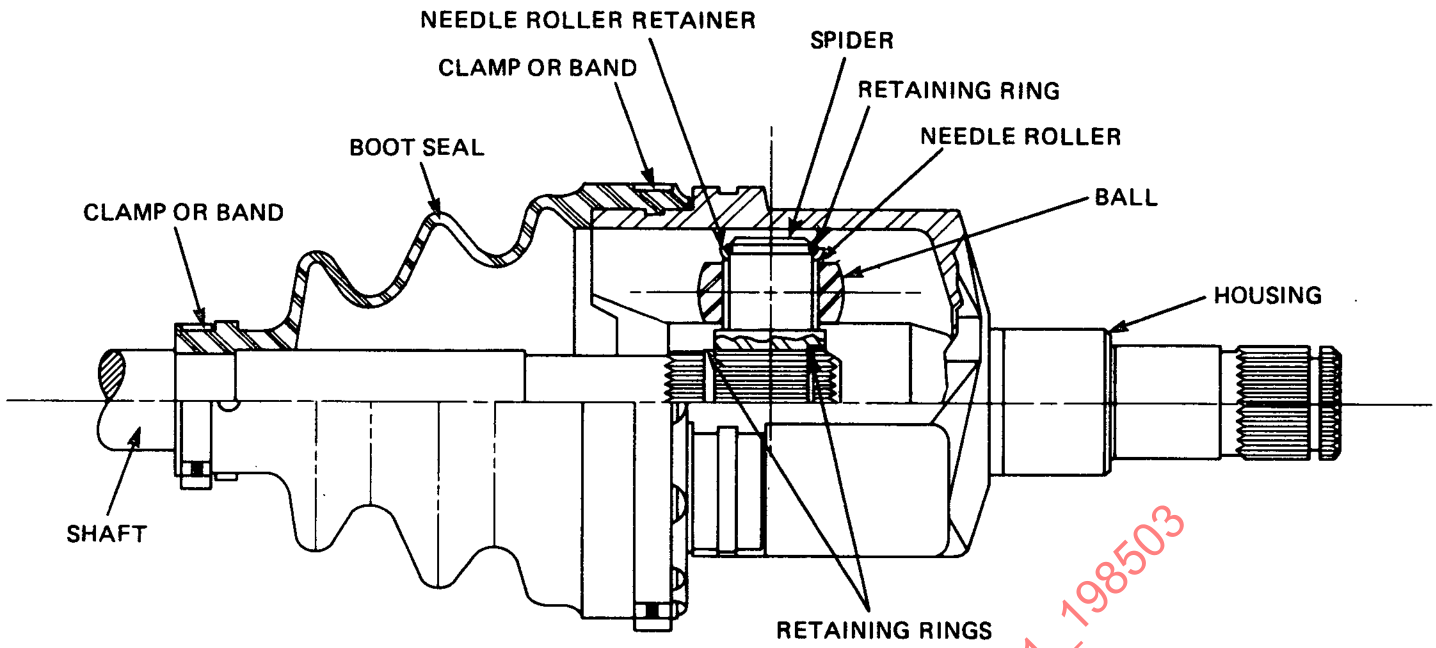


FIG. 12—TRIPOT OR TRIPOD UNIVERSAL JOINT (END MOTION TYPE)

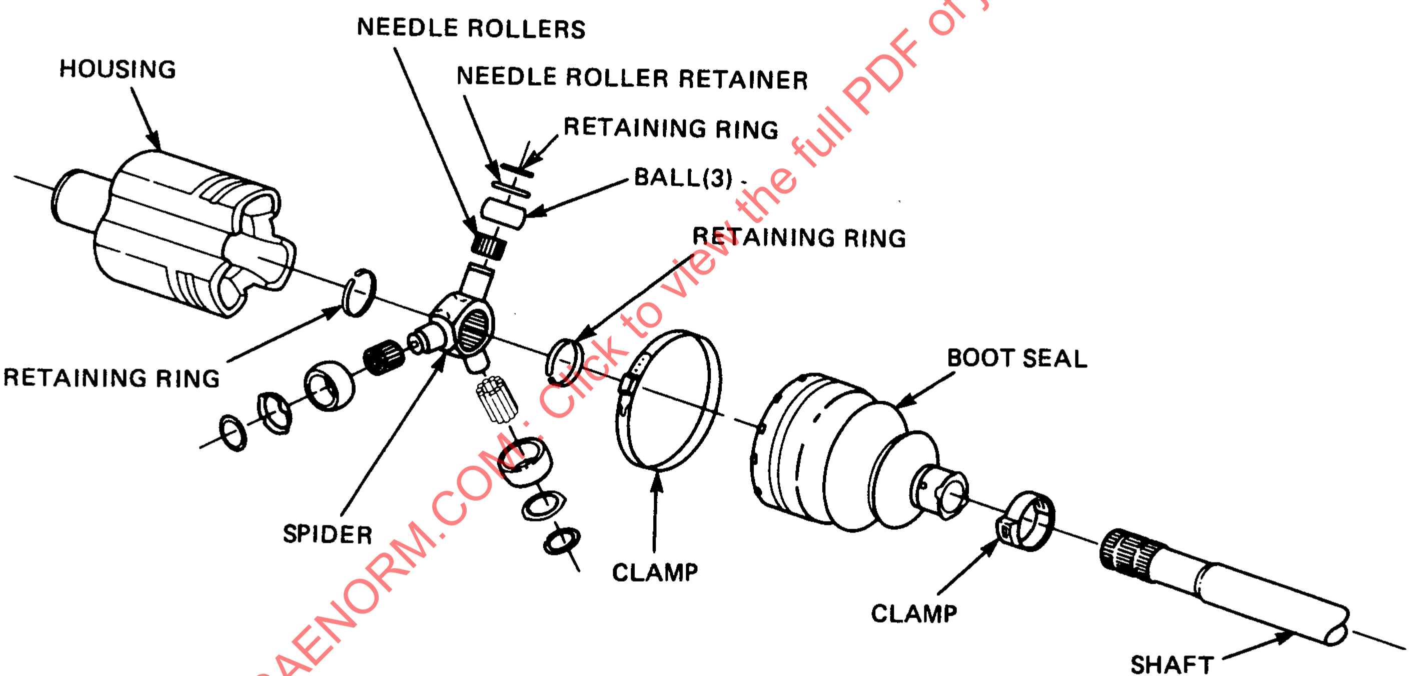


FIG. 13—TRIPOT OR TRIPOD UNIVERSAL JOINT (END MOTION TYPE)



in the same plane, and with drivable means of attachment (see Fig. 15).

3.2.3.2 Ball—A partly spherical-shaped member which pivots and transmits torque from the housing to the shaft through the spider (see Fig. 15).

3.2.3.3 Forked Shaft—A member with tulip-shaped prongs incorporating 3 equally spaced, partly cylindrical axial ball bores, and with drivable means of attachment (see Fig. 15).

3.2.3.4 Retaining Clip—A 3-pronged spider-like or dog muzzle-shaped resilient member which retains the universal joint as an assembly (see Fig. 15).

3.2.3.5 Centering Button—A thrust loaded member which locates the universal joint center (see Fig. 15).

3.2.3.6 Shim—A resiliently yieldable C-ring shaped member which axially preloads the universal joint to a desired value (see Fig. 15).

3.2.4 Rzeppa Universal Joint (Pronounced Sheppa)—A self-supported constant velocity universal joint which consists of an outer and inner race drivably connected through balls positioned in the constant velocity plane by axially offset meridionally curved grooves and maintained in this plane by a cage located between the 2 races (see Fig. 16).

3.2.4.1 Outer Race (Bell Type)—A bell-shaped member with axially offset meridionally curved ball grooves on the partly spherical inner bear-

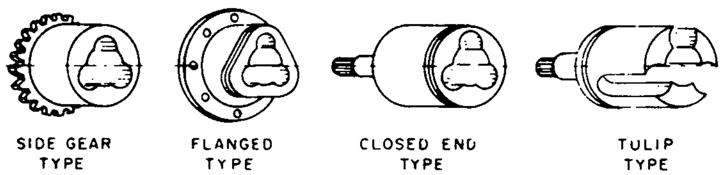


FIG. 14—TYPICAL TRIPOT OR TRIPOD JOINT HOUSING CONSTRUCTIONS

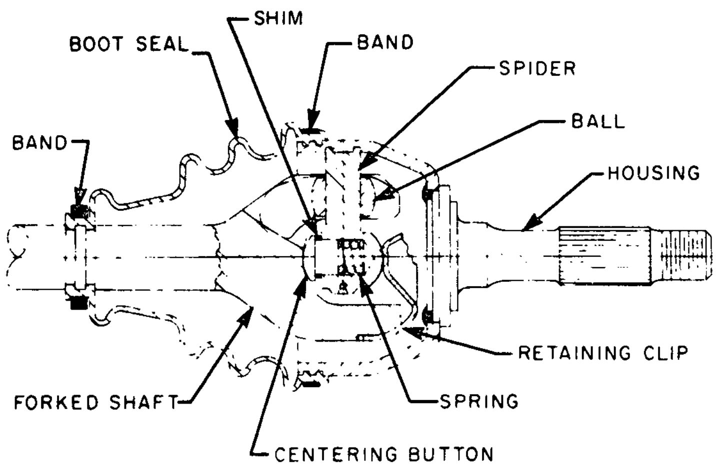


FIG. 15—TRIPOT OR TRIPOD UNIVERSAL JOINT (FIXED CENTER TYPE)

ing surface and with drivable means of attachment (see Figs. 16 and 17).

3.2.4.2 Outer Race (Disc or Flange Type)—An annular member with axially offset meridionally curved ball grooves on the partly spherical inner bearing surface and with drivable means of attachment.

3.2.4.3 Inner Race—An annular member with axially offset meridionally curved ball grooves on the partly spherical outer bearing surface and with internally splined drivable means of attachment (see Figs. 16 and 17).

3.2.4.4 Cage—A ring-like member with concentric outer and inner partly spherical bearing surfaces and with a circumferential series of openings or windows for maintaining balls in a common plane (see Figs. 16 and 17).

3.2.4.5 Ball—One of the intermediate drive members of a ball type constant velocity universal joint (see Figs. 16 and 17).

3.2.5 Cross Groove Universal Joint—A constant velocity universal joint, radially self-supported, which consists of an outer and inner race drivably connected through balls located in circumferentially spaced straight or helical grooves, alternately inclined relative to the rotational axis. The balls are positioned in the constant velocity plane by an intersecting groove relationship and maintained in this plane by a cage located between the 2 races. The joint permits axial movement since the cage is not positionably engaged to either race (see Figs. 18, 19, and 20).

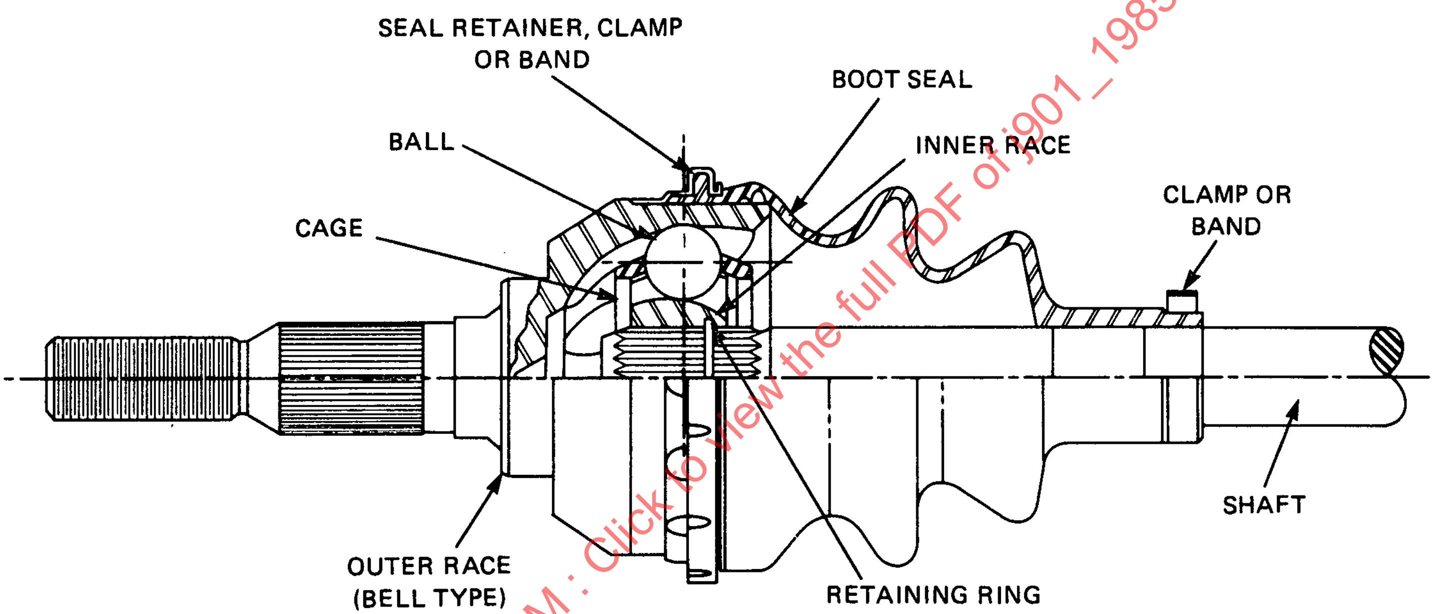


FIG. 16—RZEPPA UNIVERSAL JOINT

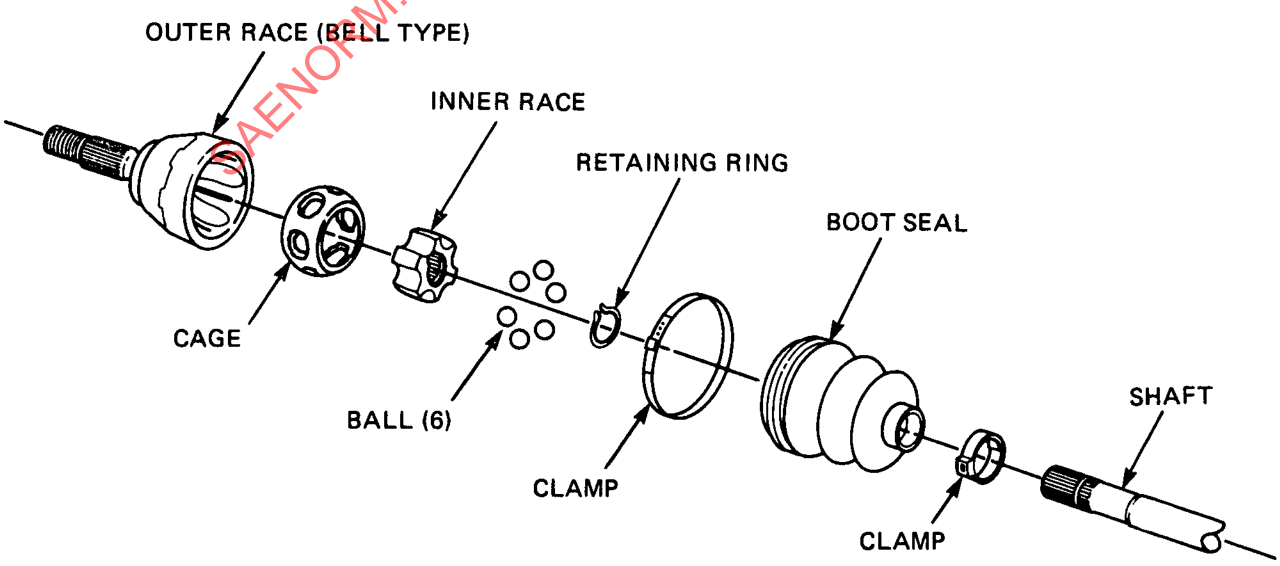


FIG. 17—RZEPPA UNIVERSAL JOINT

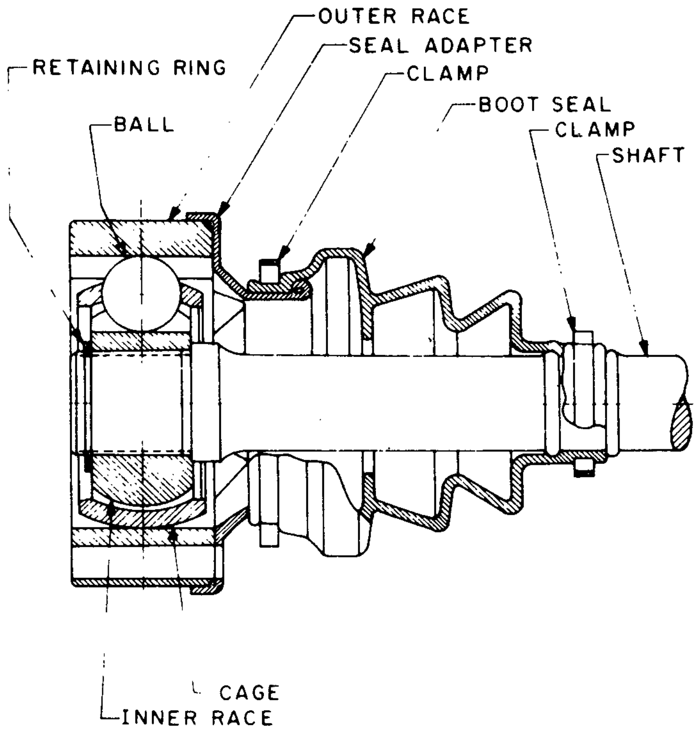


FIG. 18—CROSS GROOVE UNIVERSAL JOINT

3.2.5.1 Outer Race—A member with circumferentially spaced straight or helical ball grooves alternately inclined on the cylindrical inner surface and with drivable means of attachment (see Figs. 18, 19, and 21).

3.2.5.2 Inner Race—An annular member with circumferentially spaced straight or helical ball grooves alternately inclined on the partly spherical or conical outer surfaces and with internally splined drivable means of attachment (see Figs. 18 and 19).

3.2.5.3 Cage—A ring-like member with concentric outer and inner cylindrical or partly spherical or conical surfaces, and with a circumferential series of openings or windows for maintaining balls in a common plane (see Fig. 18).

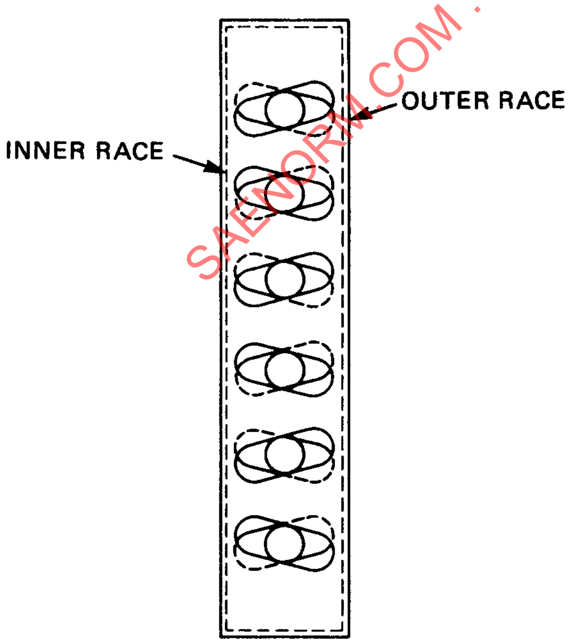


FIG. 19—DEVELOPMENT VIEW OF CROSS GROOVE JOINT ILLUSTRATING RELATIONSHIP OF OUTER AND INNER RACE BALL GROOVES AND POSITIONING OF BALLS

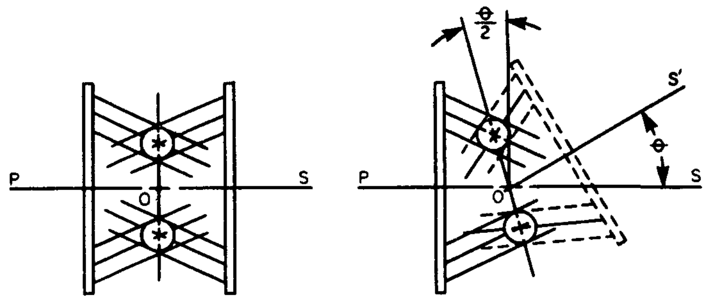


FIG. 20—DIAGRAM ILLUSTRATING POSITIONING OF BALLS IN CROSS GROOVE JOINT BISECTING ANGLE PLANE

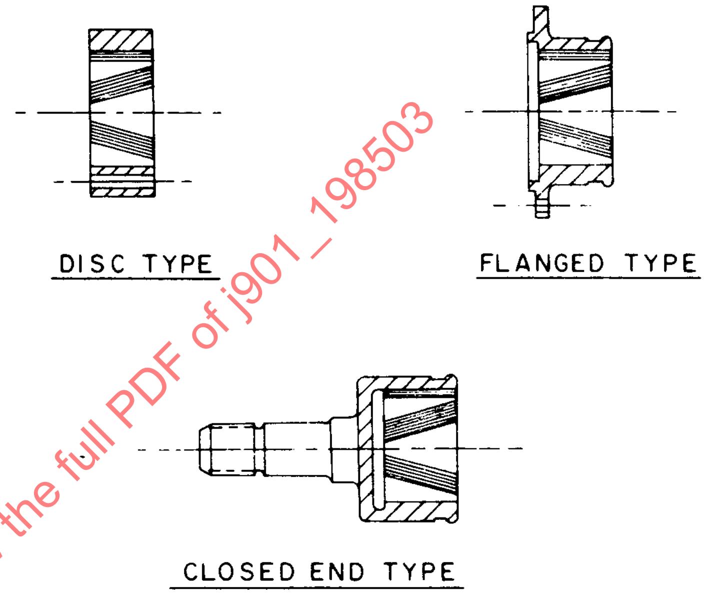


FIG. 21—TYPICAL CROSS GROOVE JOINT OUTER RACE CONSTRUCTIONS

3.2.5.4 Seal Adapter—A member used to connect the boot seal to the outer race (see Fig. 18).

3.2.6 Double Offset or DO Universal Joint (End Motion Type)—A constant velocity universal joint, radially self-supported which consists of an outer and inner race drivably connected through balls located in axially straight grooves. The balls are positioned and maintained in the constant velocity plane by a cage with axially offset spherical surfaces located between the 2 races. The joint permits axial movement since the cage is positionably engaged only by the inner race (see Figs. 22 and 23).

3.2.6.1 Outer Race—A member with axially straight ball grooves on the cylindrical inner bearing surface and with drivable means of attachment (see Figs. 22 and 24).

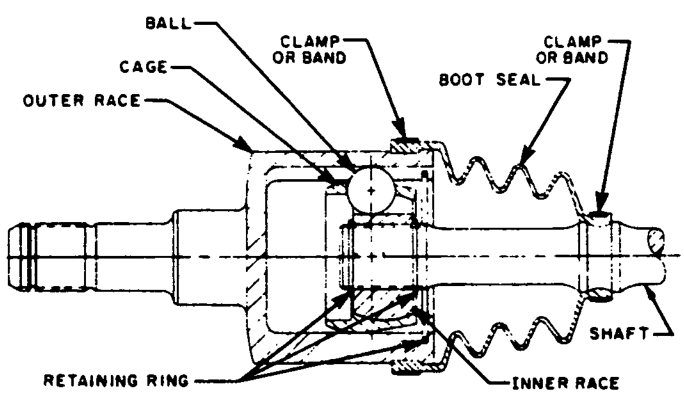


FIG. 22—DOUBLE OFFSET OR DO UNIVERSAL JOINT (END MOTION TYPE)

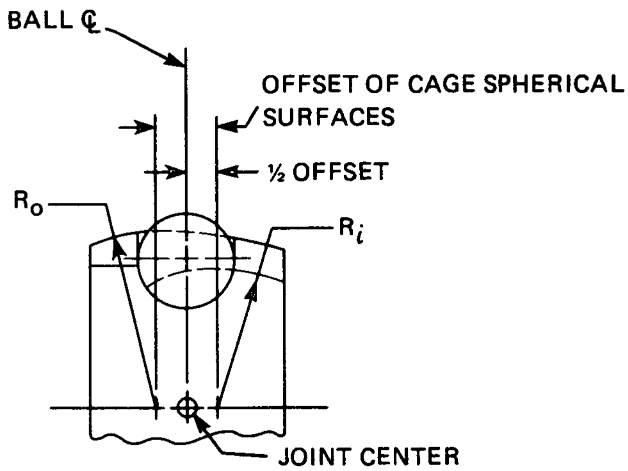


FIG. 23—DIAGRAM ILLUSTRATING OFFSET RELATIONSHIP OF DOUBLE OFFSET CAGE SPHERICAL SURFACES

3.2.6.2 Inner Race—An annular member with axially straight ball grooves on the partly spherical outer bearing surface and with internally splined drivable means of attachment (see Fig. 22).

3.2.6.3 Cage—A ring-like member with axially offset outer and inner partly spherical bearing surfaces, and with a circumferential series of openings or windows for maintaining balls in a common plane (see Figs. 22 and 23).

3.2.7 Double Offset or DO Universal Joint (Fixed Center Type)—A self-supported constant velocity universal joint which consists of an outer and inner race drivably connected through balls located in axially straight grooves. The balls are positioned and maintained in the constant velocity plane by a cage with axially offset spherical surfaces located between the 2 races (see Fig. 25).

3.2.7.1 Outer Race—An annular member with axially straight ball grooves on the partly spherical inner bearing surface and with drivable means of attachment (see Fig. 25).

*4. Driveshaft Types*

**4.1 Two-Joint Outboard Slip Driveshaft**—A driveshaft or part of a driveline having a universal joint at each end. Axial movement is provided outboard of joint centers (see Fig. 26).

**4.2 Two-Joint Inboard Slip Driveshaft**—A driveshaft or part of a driveline having a universal joint at each end. Axial movement is provided inboard of joint centers (see Fig. 26).

**4.3 Single Joint Coupling Shaft**—The coupling member or members of a multiple joint driveline consisting of 1 universal joint, tube, shaft support, and slip spline or fixed spline shaft (see Fig. 26).

An exploded view of a typical 2-joint outboard slip driveshaft with alternate component constructions is illustrated in Fig. 27. An exploded

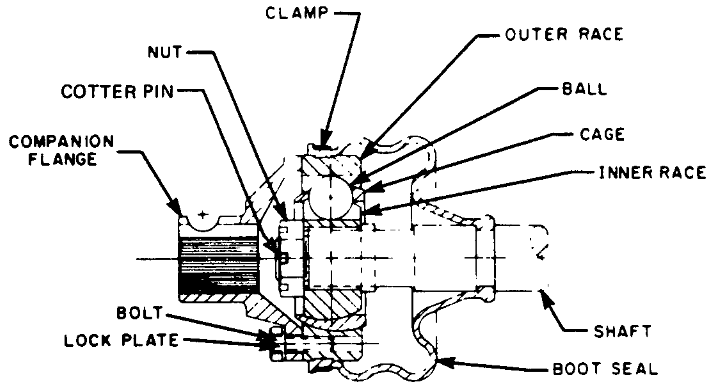


FIG. 25—DOUBLE OFFSET OR DO UNIVERSAL JOINT (FIXED CENTER TYPE)—STEERING SHAFT DESIGN ILLUSTRATED

view of a typical 2-piece heavy-duty truck driveline is shown in Fig. 28, and Fig. 29 illustrates a typical short coupled driveshaft.

Trucks, as well as numerous other on/off-highway type vehicles, have widely varying application requirements. In addition to 1 or 2 rear axles, such vehicles may also incorporate a front steer axle or front-wheel drive halfshafts in all-wheel drive configurations. Various typical driveline arrangements are shown schematically in Figs. 30, 31, 32, and 33.

*5. Front and Rear Wheel Drive Halfshafts*

**5.1 Front-Wheel Drive Halfshaft**—A halfshaft having an outboard fixed center universal joint and an inboard end motion universal joint (see Fig. 34).

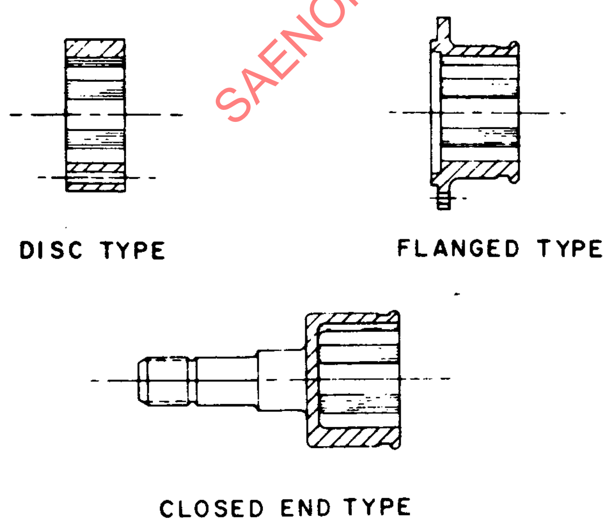


FIG. 24—TYPICAL DOUBLE OFFSET JOINT OUTER RACE CONSTRUCTIONS

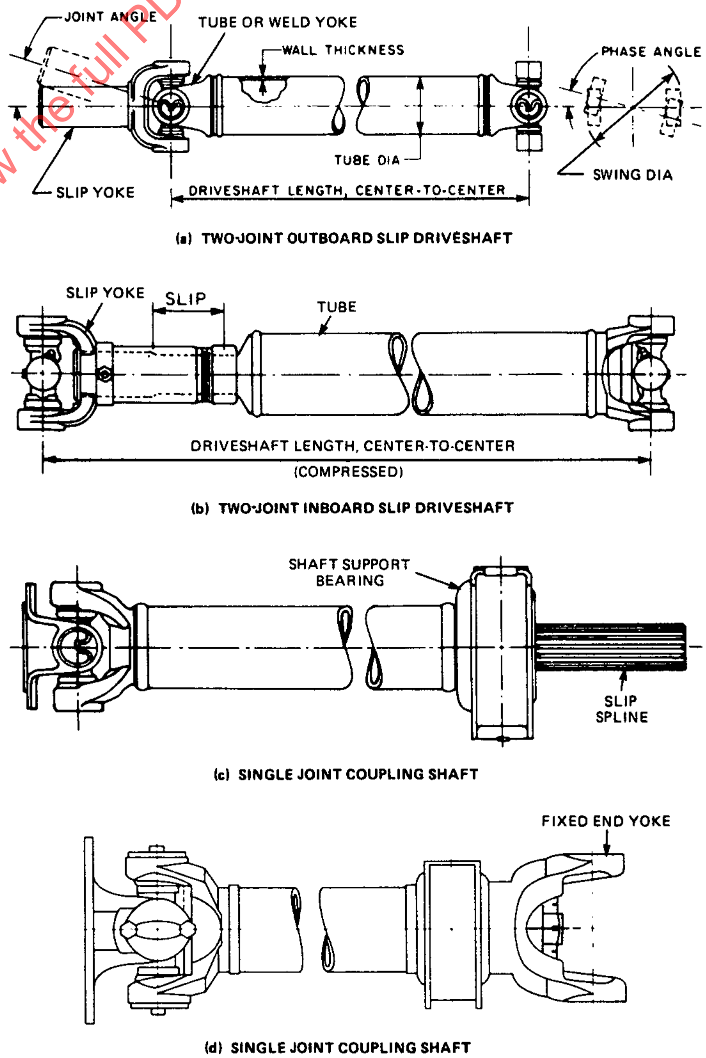


FIG. 26—BASIC DRIVESHAFT CONSTRUCTIONS

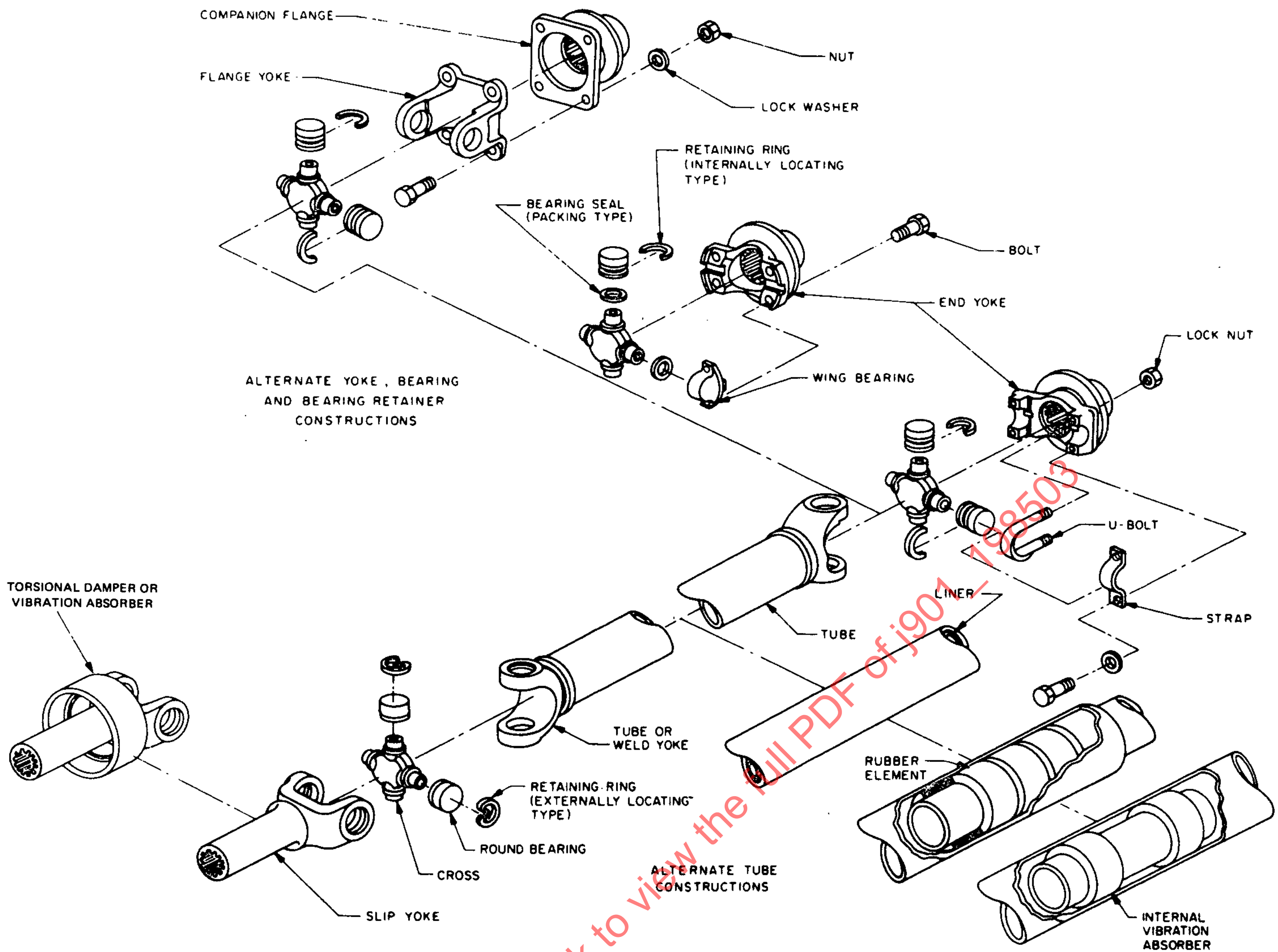


FIG. 27—TYPICAL TWO-JOINT OUTBOARD SLIP DRIVESHAFT



**5.2 Rear-Wheel Drive Halfshaft**—A halfshaft having 2 universal joints which may be both either fixed center or end motion universal joints, or, 1 may be a fixed center and the other may be an end motion universal joint (see Fig. 35).

Fig. 34 illustrates a typical front wheel drive halfshaft with alternate inboard end motion universal joints. A typical rear-wheel drive halfshaft with 2 end motion universal joints is shown in Fig. 35.

6. ***Halfshaft Tuning Devices***—A tuning device may have to be incorporated in a front-wheel drive halfshaft depending upon the requirements of the specific vehicle application. Fig. 36 shows a solid and tubular axle shaft, while Fig. 37 illustrates an axle shaft mounted mass damper. With these 3 axle shaft constructions, it is possible to achieve a desired shaft natural bending frequency by altering their transverse bending stiffness. Fig. 38 shows an axle shaft mounted torsional damper, which consists of an inertia ring attached to an axle shaft by means of an elastomeric inner ring. In this tuning device, the inertia ring can oscillate torsionally and is tuned to a specific disturbing frequency.

In addition, a halfshaft tuning device can function essentially as a disturbance isolator. Fig. 39 illustrates a split axle shaft mounted isolation damper, while Fig. 40 shows an inboard CV joint mounted isolation damper. Both of these devices can transmit relatively low torsional loads through an elastomeric ring or rings. When the angular travel limitation stops in forward or reverse rotational directions are reached, the transmission of higher torque loads is by means of a solid connection. These devices eliminate disturbances during throttle tip-in and tip-out as well as forward and reverse shift clunk or thud due to transaxle gear lash.

7. ***Application Guidelines***—Fig. 41 is an application guide for operating joint angles of a 2-joint driveshaft with Cardan joints installed at equal angles where the angle and speed are continuous and the maximum angular acceleration limit of 1000 rad/s$^2$ is acceptable. In certain applications, the shaft length used, usually a very short or a very long center-to-center distance, may require a reduction of the suggested maximum operating angles. Whenever the joint angles do not lie in a common plane, phasing of the joints with respect to one another is required.

Also, considerable variation can exist in different vehicles due to sensitivity of components and mountings. The suggested speed-angle combinations tabulated in Fig. 41 have been established as satisfactory for the majority of automotive applications.

The Cardan joint can be rated in a manner which establishes a common size characteristic for comparison with other size Cardan joints. Fig. 42 shows a cross-sectional view of the cross trunnion and bearing configuration of a joint. The bearing is acted upon by the torque couple force F which is assumed to be concentrated at the centroid of the projected bearing area on the cross trunnion, formed by the cross trunnion diameter D and the effective length L of the needle rollers. This couple force is at a distance R from the center of the cross and is called the torque radius.

The size characteristic of the joint can be expressed by a term called the "bearing factor," BF, which is determined as follows:

$$BF = DLR$$

Where: D = Trunnion diameter, in
L = Effective needle roller length on cross trunnion, in
R = Torque Radius, in

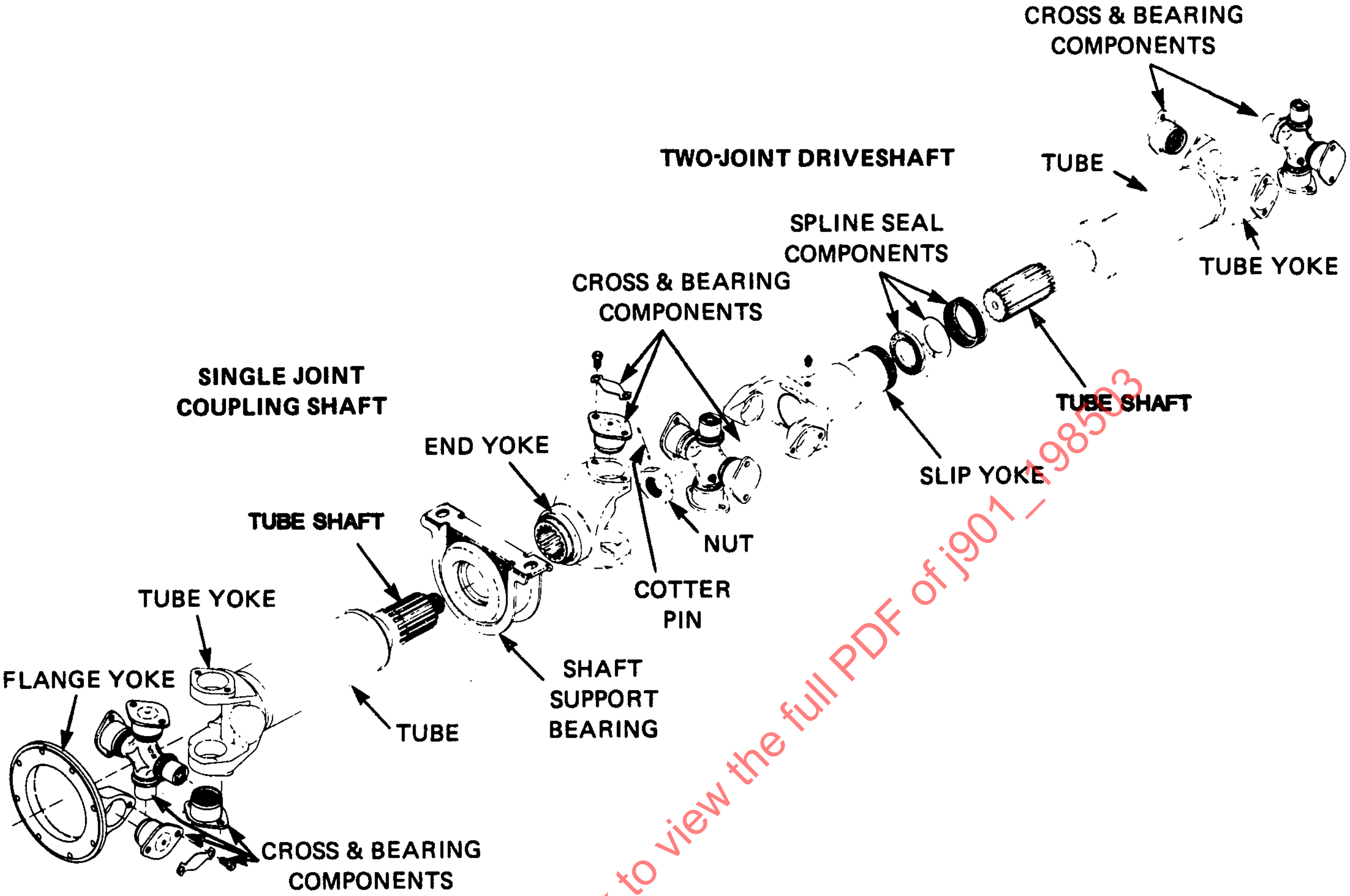


FIG. 28—TYPICAL TWO-PIECE HEAVY-DUTY TRUCK DRIVELINE

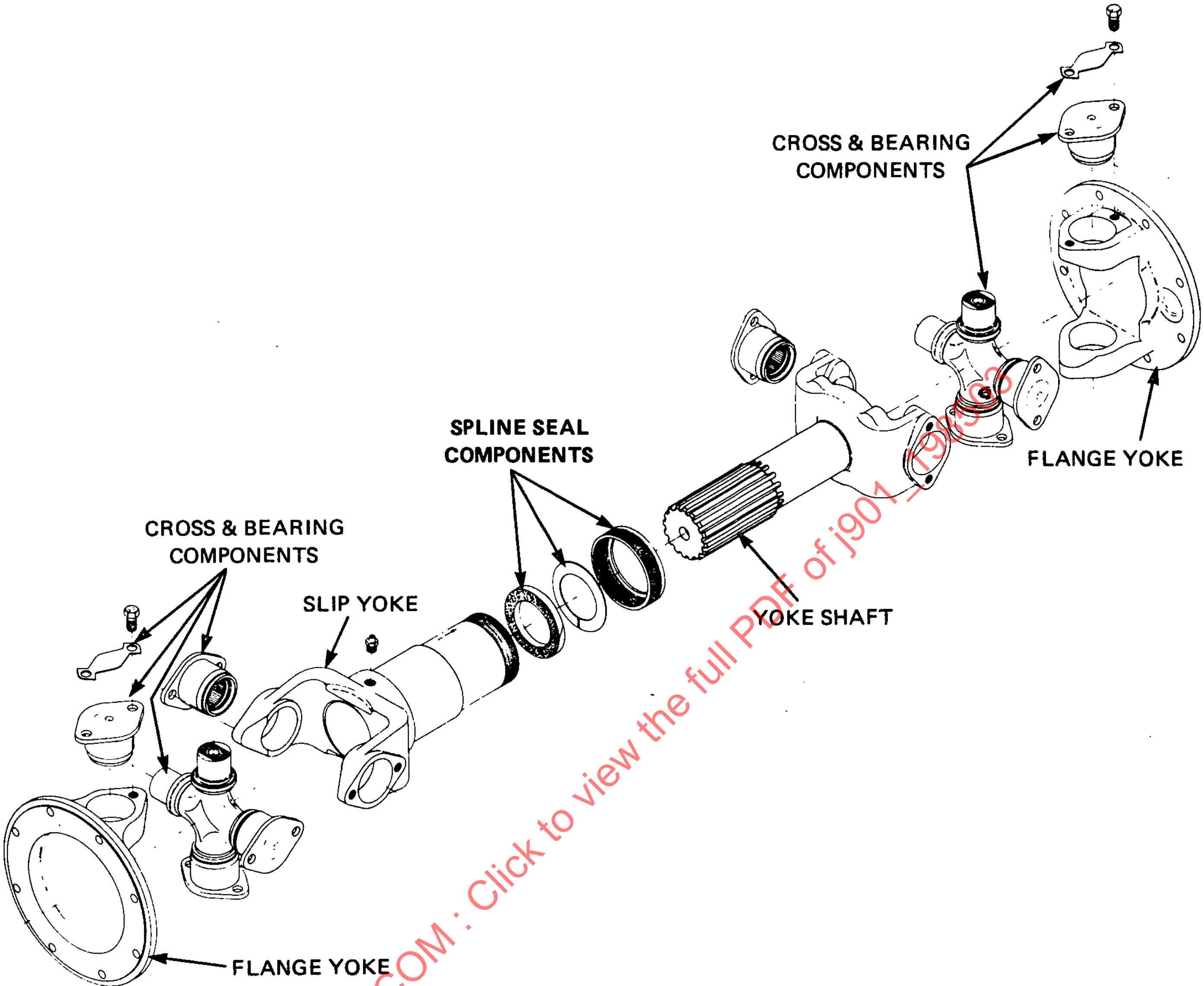


FIG. 29—TYPICAL SHORT COUPLED DRIVESHAFT

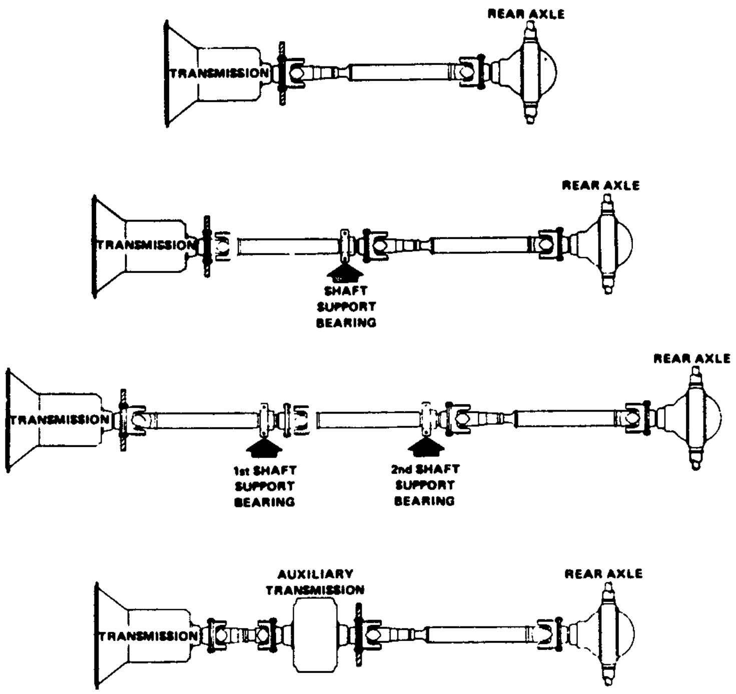


FIG. 30—TYPICAL 4 X 2 AND 6 X 2 TRUCK DRIVELINE ARRANGEMENTS

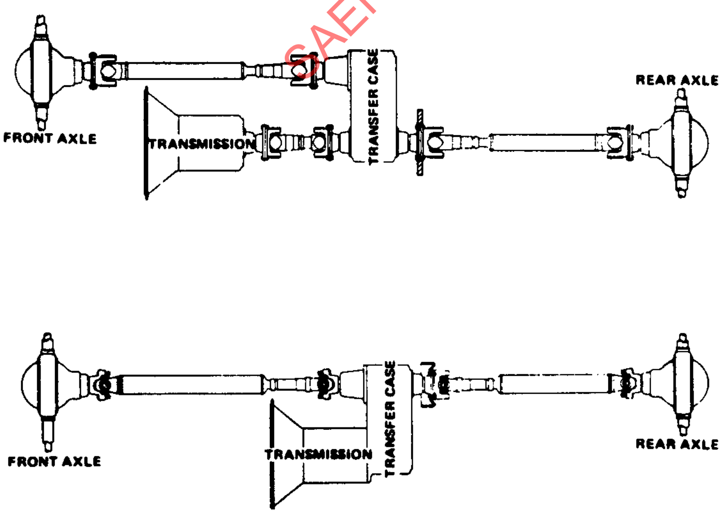


FIG. 31—TYPICAL 4 X 4 TRUCK DRIVELINE ARRANGEMENTS

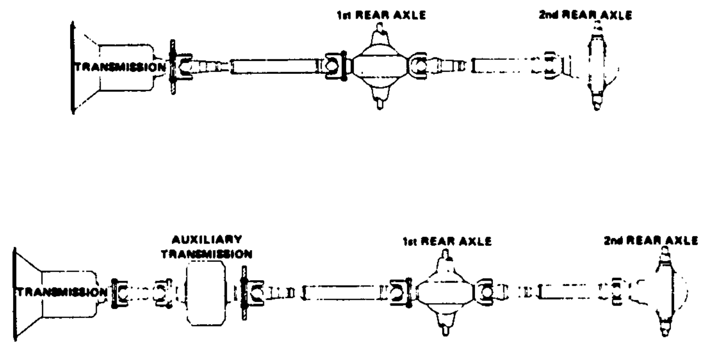


FIG. 32—TYPICAL 6 X 4 TRUCK DRIVELINE ARRANGEMENTS

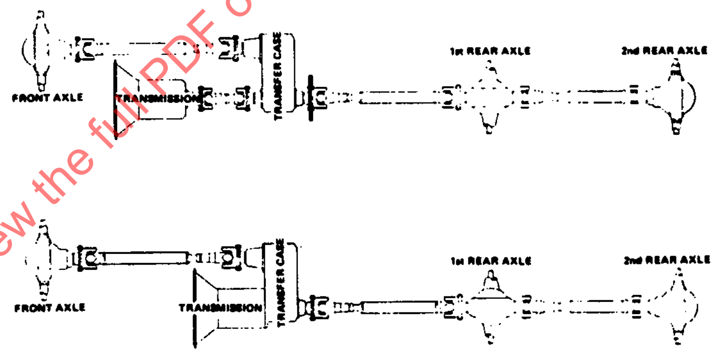


FIG. 33—TYPICAL 6 X 6 TRUCK DRIVELINE ARRANGEMENTS

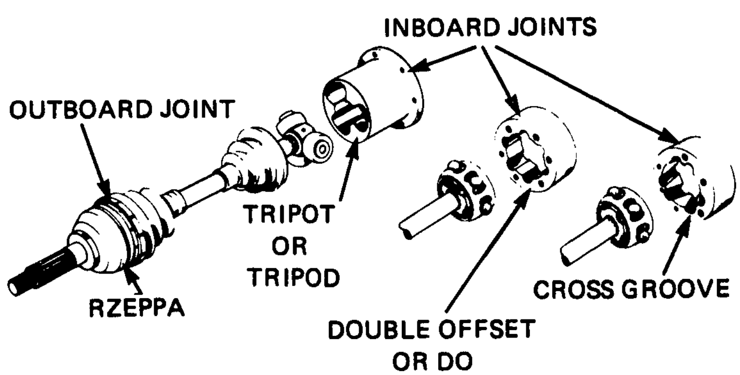


FIG. 34—TYPICAL FRONT WHEEL DRIVE HALFSHAFT WITH ALTERNATE INBOARD END MOTION UNIVERSAL JOINTS

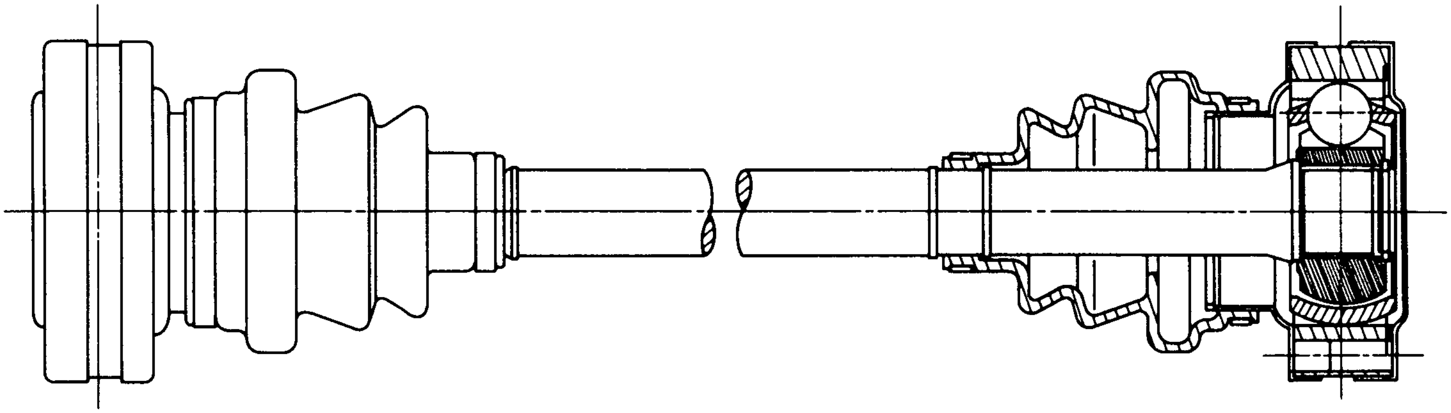

FIG. 35—TYPICAL REAR WHEEL DRIVE HALFSHAFT WITH END MOTION UNIVERSAL JOINTS (CROSS GROOVE TYPE SHOWN)

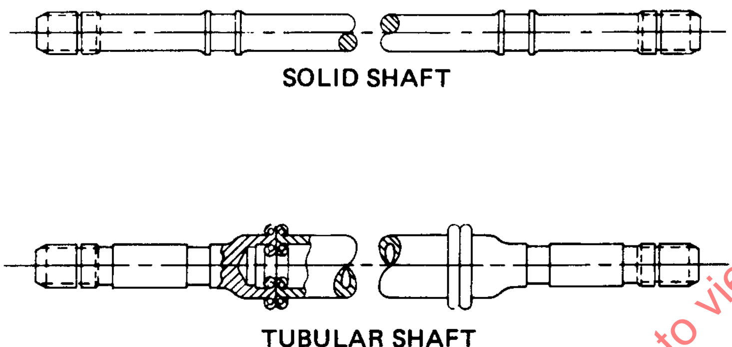


FIG. 36—SOLID AND TUBULAR AXLE SHAFTS

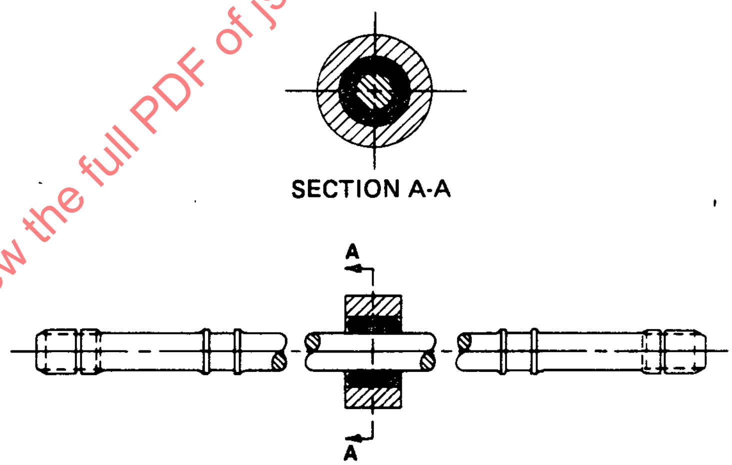


FIG. 38—AXLE SHAFT MOUNTED TORSIONAL DAMPER

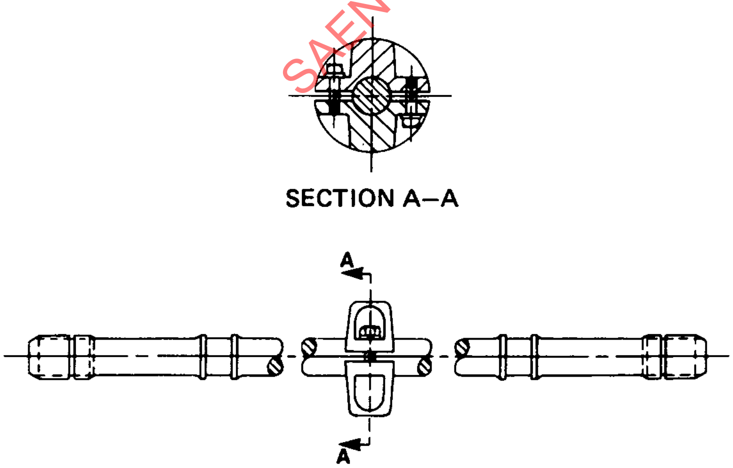


FIG. 37—AXLE SHAFT MOUNTED MASS DAMPER

Therefore, the "bearing factor" is simply the product of the projected bearing area on the cross trunnion times the torque radius, and serves as an "index" by providing a simple means for comparing various size joints with regard to relative bearing capacity.

The operating speed of driveshafts can be found by means of a nomogram shown in Fig. 43. In this nomogram, the operating speed can be determined by tubing size and length for driveshaft quality welded steel tubing. It is applicable for on/off-highway truck type vehicles and is not intended for passenger cars.

Typical drivetrain component efficiency values for driveline computation procedures are shown in Figs. 44, 45, and 46.

For the various CV joints, Table 1 shows typical applications and capabilities. The advantages and disadvantages or limitations of these CV joints are described in detail in Universal Joint and Driveshaft Design Manual, AE-7.