SAE The Engineering Society For Advancing Mobility Land Sea Air and Space® INTERNATIONAL
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SURFACE VEHICLE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

SAE J678

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Reaffirming J678 JUN84

SPEEDOMETERS AND TACHOMETERS - AUTOMOTIVE

Foreword—This Document has not changed other than to put it into the new SAE Technical Standards Board Format.

1. ***Scope***—This SAE Recommended Practice applies to speedometers, odometers, and speedometer drives typical of passenger vehicles, buses, and trucks used for personal or commercial purposes. The method of determining wheel revolutions per unit distance (3.1) and overall system design variation (3.3.3) are applicable to passenger cars only. Comparable recommendations for trucks and buses are under development. The data of tachometers is applicable to vehicular use, as previously described, and also to stationary and marine engines and special vehicles.

2. *References*

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J862 JUN81—Factors Affecting Accuracy of Mechanically Driven Automotive Speedometer-Odometers
SAE J966 AUG66—Test Procedure for Measuring Passenger Car Tire Resolutions per Mile

2.1.2 NATIONAL BUREAU OF STANDARDS—National Institute of Standards and Technology (formerly National Bureau of Standards), U. S. Department of Commerce, Gaithersburg, MD 20899.

National Bureau of Standards Handbook 44

2.1.3 OTHER PUBLICATIONS

Australia D Regulation 1019
Japan Article 46
United Nations ECE R 39
European Economic Commission EEC 75/443

3. *Speedometer*

3.1 Wheel Revolutions per Unit Distance[1]—The nominal number of vehicle wheel revolutions per mile (kilometer) is to be determined by the vehicle manufacturer and the information is to be used as a basis for design calculations of gearing and speedometer calibrations. Vehicle wheel revolutions shall be determined at 45 ± 2 mph (72.4 ± 3.2 km/h).[2] Tire inflation for measuring wheel revolutions is to be in accordance with the vehicle manufacturers' recommended pressure with tires at ambient test temperatures. This test is to be run immediately after a 5 mile (8 km) test run at 45 mph (72.4 km/h) to stabilize tire pressure, and with the vehicle at curb weight plus driver and one passenger [or 150 lb (68 kg)].

3.2 Types of Drive—The practice for cable-driven speedometers is to drive the system from either the transmission or the front wheel of the vehicle.

3.2.1 TRANSMISSION DRIVE—The design of a transmission drive for a speedometer requires that the vehicle manufacturer determine the nominal number of vehicle wheel revolutions per mile (kilometer). This information is then used as a basis for calculating the speedometer drive ratio. The number of teeth on the worm drive gear in the transmission and the number of teeth on the takeoff pinion gear (drive ratio) are selected to provide a proper odometer drive and speed indication, as defined in 3.3.1, 3.3.2, and 3.4.1. It is urged that those unfamiliar with conditions which affect vehicle wheel revolutions consult SAE J862 so that they may properly control conditions when determining the nominal value.

3.2.2 FRONT WHEEL DRIVE—This type of drive also requires that the nominal number of vehicle wheel revolutions be determined. The information is used to provide proper odometer drive gearing and for calibration purposes to achieve a proper speed indication.

3.3 Mileage Indication (Odometer)

3.3.1 INSTRUMENT DESIGN CONSIDERATION—Odometer tamper resistance should be considered when designing odometers for U.S. applications.

3.3.2 ALLOWABLE VARIATION WITHIN THE INSTRUMENT—The odometer shall indicate one mile for every 1000 or 1001 revolutions of the flexible shaft (one kilometer for every 616 thru 630 revolutions, depending on the odometer gear train drive) if driven from the transmission. The odometer of front wheel drive units shall indicate one mile (kilometer) when the flexible shaft is rotated a specified number of revolutions, as determined by the vehicle manufacturer.

3.3.3 OVERALL SYSTEM DESIGN VARIATION—The vehicle manufacturer shall specify odometer drive ratios that will produce one unit of distance indication within ±4% for each actual unit of distance travelled at 20, 40, and 55 mph (32.2, 64.4, and 88.5 km/h).[3] The design limits thus derived should not, however, be construed as absolute. Factors which cause variation from nominal wheel revolution per unit distance travelled under operating conditions are covered in SAE J862. It is recommended that SAE J862 be studied to determine probable effects on odometer accuracy under operating conditions.

1. See also SAE J966.
2. Direct metric conversions in parentheses.
3. Some states and local regulations require an accuracy of ±3.75% under specified test conditions for vehicles introduced into rental or leasing markets. Test conditions are specified in the National Bureau of Standards Handbook 44.

3.4 Speed Indication

3.4.1 Allowable Variation Within the Instrument—Two philosophies exist in calibrating the instrument for overall vehicle system accuracy.

a. Calibrate the speedometer at the center of the graduations so that overall vehicle system accuracy will be within a specified amount, as established by the vehicle manufacturer. The intent is to have an instrument with no system bias. Generally ±4.0 mph (±6.4 km/h) is an acceptable limit for the vehicle system.
b. Bias the speedometer calibration high so that overall vehicle system calibration will be higher than true vehicle speed. Generally +6.0, –0.0 mph (+9.6, –0.0 km/h) is an acceptable limit for the vehicle system.

The specific calibration of the instrument relative to vehicle system limits should be determined by the instrument manufacturer and vehicle manufacturer.[4] The speedometer head should be calibrated in approximately the same angular position that it will have when mounted in the vehicle.

Factors influencing vehicle system accuracy are described in Figure 2 of SAE J862. In addition, the following factors also affect the speedometer head accuracy:

Temperature—The speed indication will vary with changes in temperature. Temperature affects the reaction between the speed cup and magnet - Refer to Figure 3 in SAE J862. To counteract this effect, an element called a temperature compensator is incorporated in all speedometers. Due to variations in materials which cannot be perfectly controlled, the change in indicated speed from temperature compensation may be as much as ±4% between temperatures of 20 and 130 °F (–7 to 55 °C).

Vibration—Another condition which affects speed indication is vibration. At 55 mph (88.5 km/h) an effect of 0.5 to 1 mph (0.8 to 1.6 km/h) may be noted.

Friction—A minor error which affects speed indication is frictional lag. This is a condition in which the speedometer will not read exactly the same under acceleration and deceleration. Investigations indicate that the error from frictional lag is less then 1 mph (1.6 km/h) at 55 mph (88.5 km/h).

3.5 Identification—Identification should appear on all speedometers. It should consist of a distinct marking of model number or part number on the instrument and the date of its manufacture. All kilometer speedometers should be identified by marking "Kilo" on the back of the speedometer case, unless identification of sufficient nature appears on the face dial or other suitable means of identification is applied, such as marking the speedometer head with a red dot. Drive ratio information shall appear on front-wheel drive instruments in an area readily visible when the instrument is removed.

4. Speedometer and Tachometer Drive—Flexible shafts for driving mechanical speedometers and tachometers shall consist of a flexible casing and a flexible cable capable of transmitting motion from a suitable takeoff to operate the instrument. Recommended takeoff and instrument fittings are shown in the following illustrations.

In routing of flexible shafts, bends of less than 6 in (150 mm) radius should be avoided. Figures 1–5 and Table 1 give dimensions for SAE light, regular, square, and heavy-duty drive for speedometers and tachometers.

4. The following regulatory requirements for speedometers should also be consulted:
Australia D Regulation 1019
Japan Article 46
United Nations ECE R 39
European Economic Comm. EEC 75/443

4.1 Miscellaneous Drive Ends of Flexible Shafts—Specific detail and dimensions to be determined between user and supplier.

4.1.1 PLUG TYPE LOWER FERRULE—This type of drive end (shown on Figure 6) is widely used for speedometer drives in the automotive industry. No specific dimensional standard is recommended because dimensions vary depending on design of transmission with which it is used. The end of the cable has a standard 0.101–0.104 in (2.56–2.64 mm) square for passenger car service.

4.1.2 FRONT-WHEEL DRIVE (SEE FIGURE 7)—Some speedometer drives are taken from the vehicle front wheel. This involves a spindle machined to accept the flexible shaft drive end and providing a watertight joint. The cable terminates in a standard 0.101–0.104 in (2.56–2.64 mm) square for passenger car service. No specific dimensional standard is recommended because of the many variations in front-wheel suspensions, steering mechanisms, and spindle designs which will affect the flexible shaft design.

4.1.3 QUICK CONNECT UPPER FERRULE—No specific dimensional standard is recommended because dimensions vary depending on the design of speedometer with which it is used. The end of the cable has a standard 0.101–0.104 in (2.56–2.64 mm) square for passenger car service.

5. Tachometers

5.1 Mechanical Eddy Current Tachometers

5.1.1 GENERAL—Illumination, waterproofness, and corrosion resistance are not within the scope of this recommended practice.

5.1.1.1 *Tachometer Drive Connections*—SAE regular, optional and heavy. Clockwise and counter clockwise rotation.

5.1.1.2 *Tachometer Dials*—Recommended dial ranges in rpm are: 0-2500, 0-4000, 0-6000, and 0-8000, for a minimum of 270 deg full deflection, clockwise or counter clockwise rotation. Light graduations, numerals, and pointers on a dark background and with graduations having outside numerals for highest accuracy in scale readings are also recommended.

5.1.1.3 *Tachometer Drive Ratio*—Tachometer to indicate two times flexible shaft speed and to be driven 0.5 times engine speed.

5.1.1.4 *Tachometer With Hour Meter*—Hour meter to indicate, as closely as practical, engine hours at a specific speed on an hour meter recording up to 9999.99 h before repeating from zero. See Figure 8.

5.1.1.5 *Tachometer Mounting*—Tachometer case to be provided with studs for easy mounting by suitable U-clamp or similar means. The mounting position to be with tachometer faced backward 5–45 deg from a vertical plane. See Figure 8 for general dimensions of tachometer housing.

5.1.1.6 *Tachometer Calibration*—Recommended calibration limits are as follows:

0-2500 scale ±50 rpm From 250 to 2250 indicated rpm
0-4000 scale ±80 rpm From 400 to 3600 indicated rpm
0-6000 scale ±120 rpm From 600 to 5400 indicated rpm
0-8000 scale ±160 rpm From 800 to 7200 indicated rpm

5.2 Mechanical Centrifugal Speedometers and Tachometers—Illustrations of these speedometers and tachometers with their principal features and mounting dimensions are shown in Figure 9.

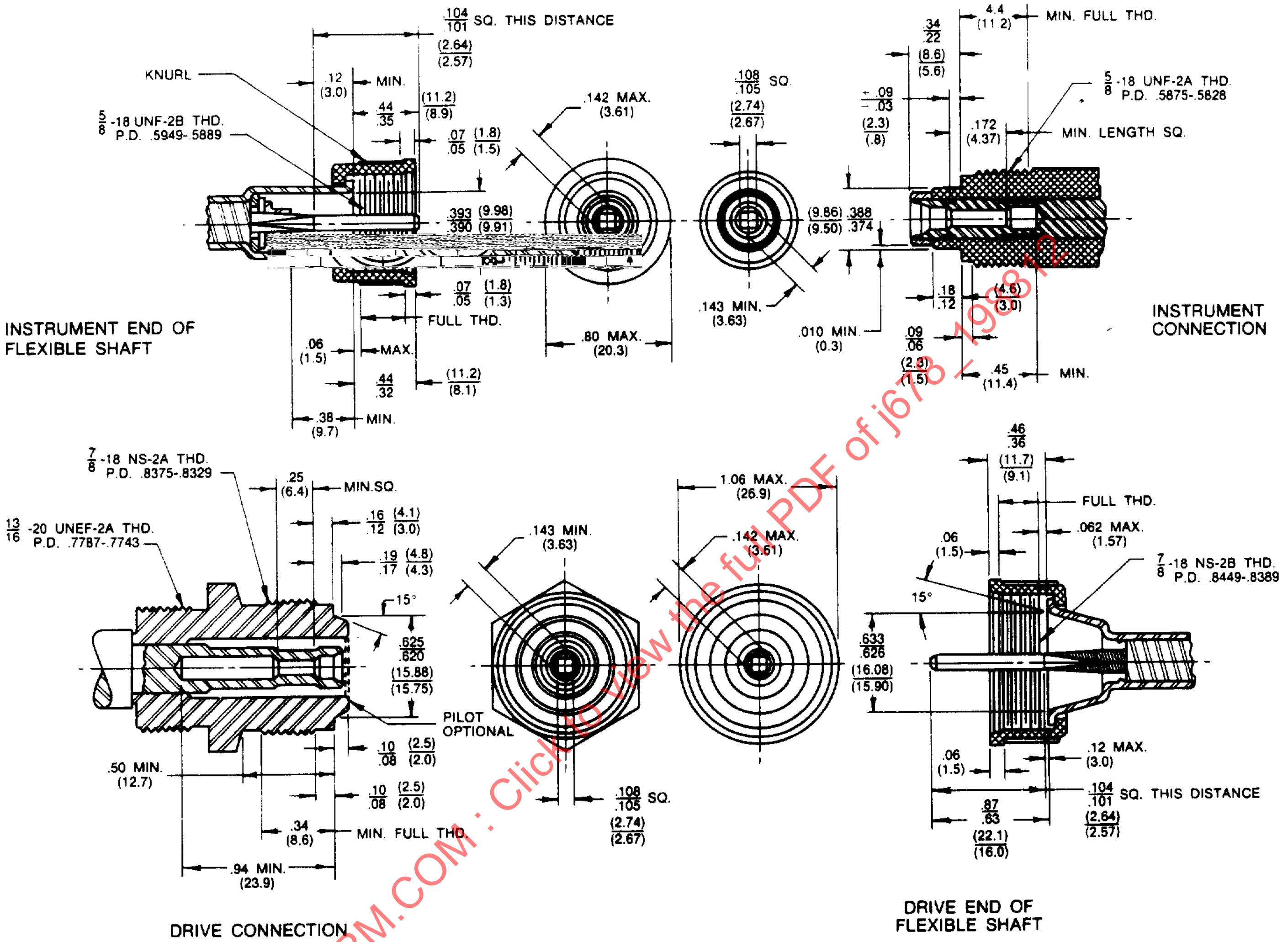

FIGURE 1—LIGHT-DUTY DRIVE (FOR USE WITH EDDY CURRENT TYPE INSTRUMENTS)

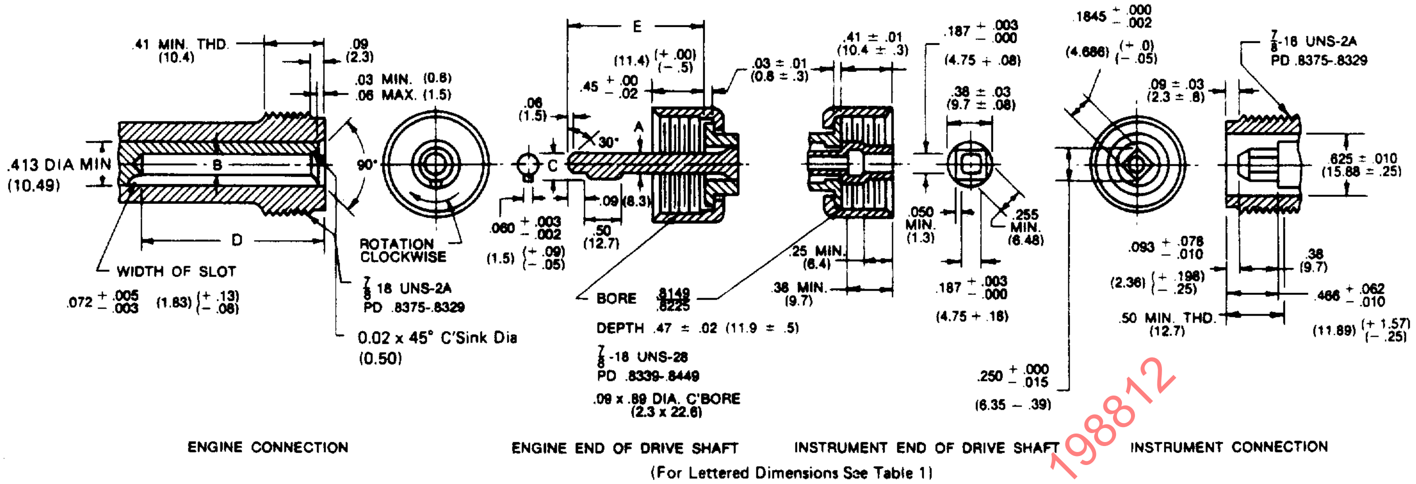

FIGURE 2—SAE REGULAR DRIVE FOR SPEEDOMETERS AND TACHOMETERS
(FOR LETTERED DIMENSIONS SEE TABLE 1)

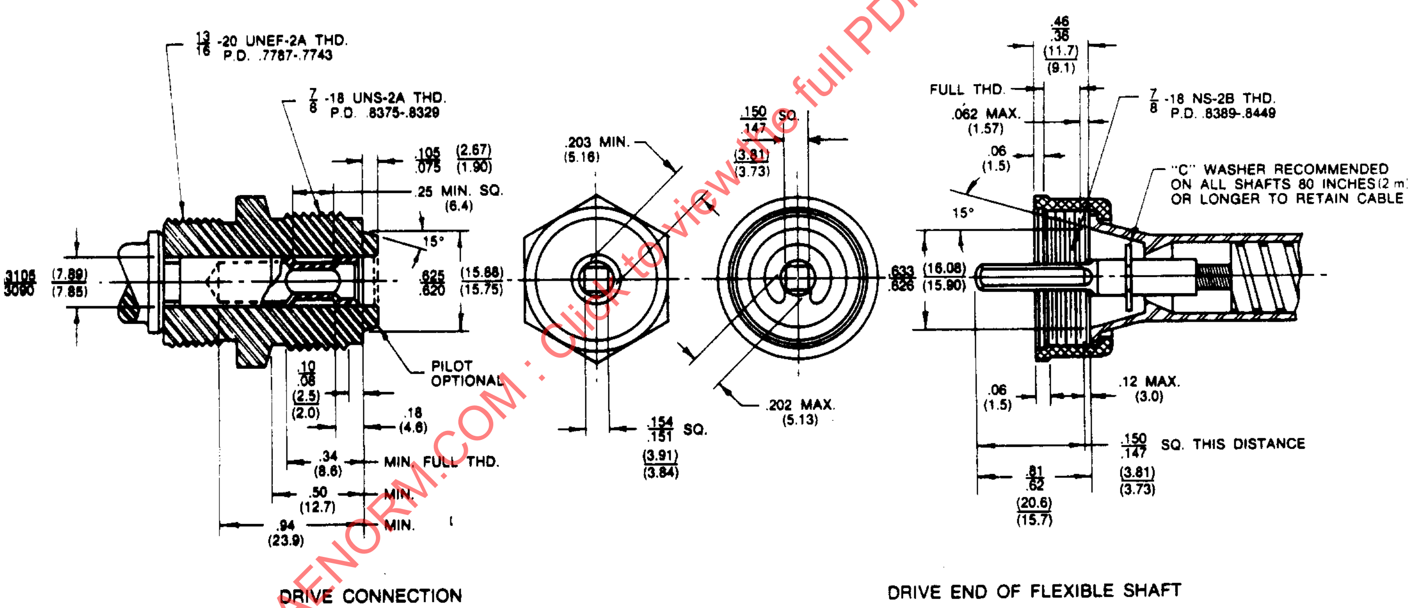

FIGURE 3—SQUARE DRIVE

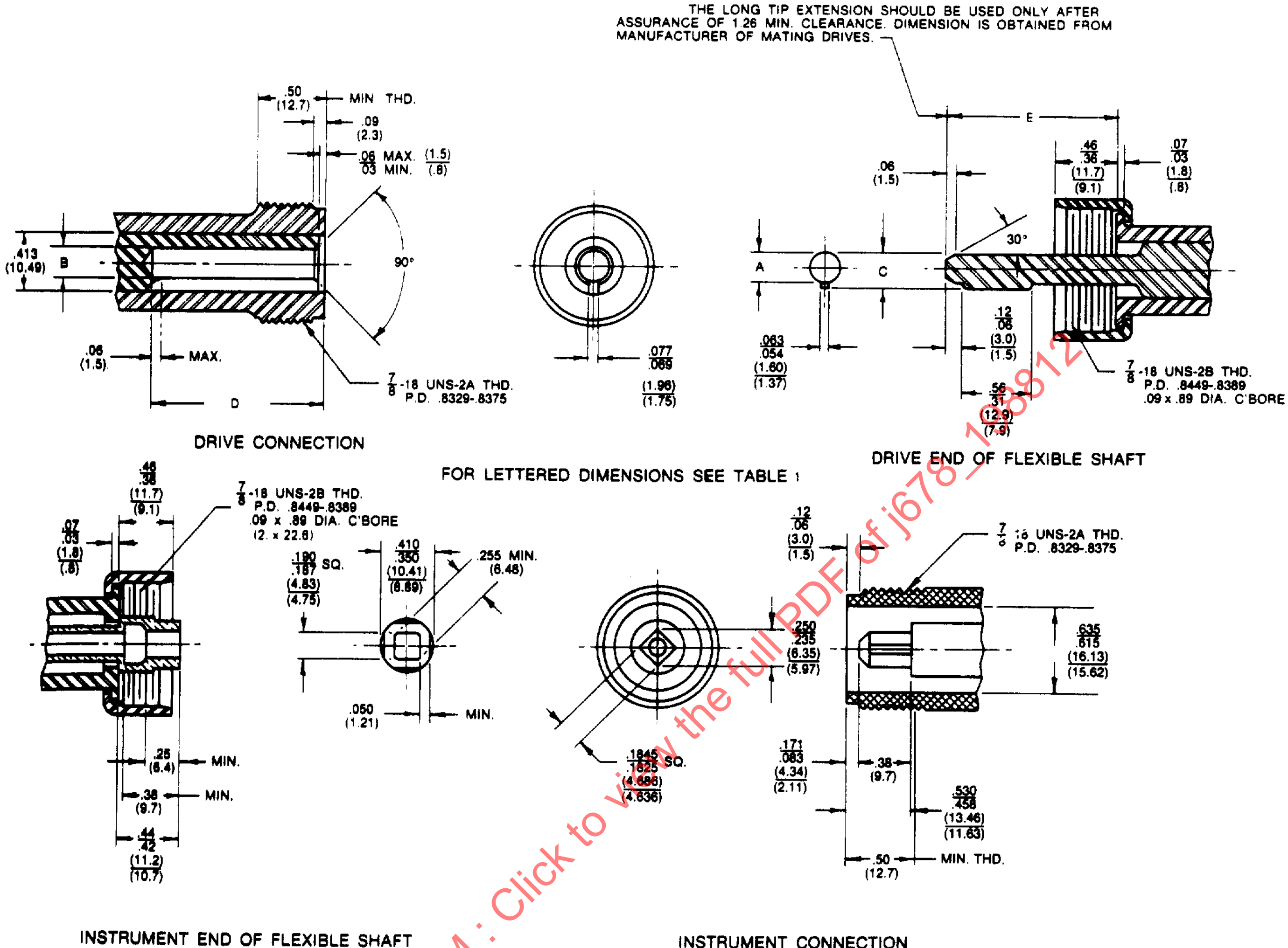

FIGURE 4—HEAVY-DUTY DRIVE (FOR USE WITH CENTRIFUGAL TYPE INSTRUMENTS)

KEY DRIVE
FOR LETTERED DIMENSIONS SEE TABLE 1

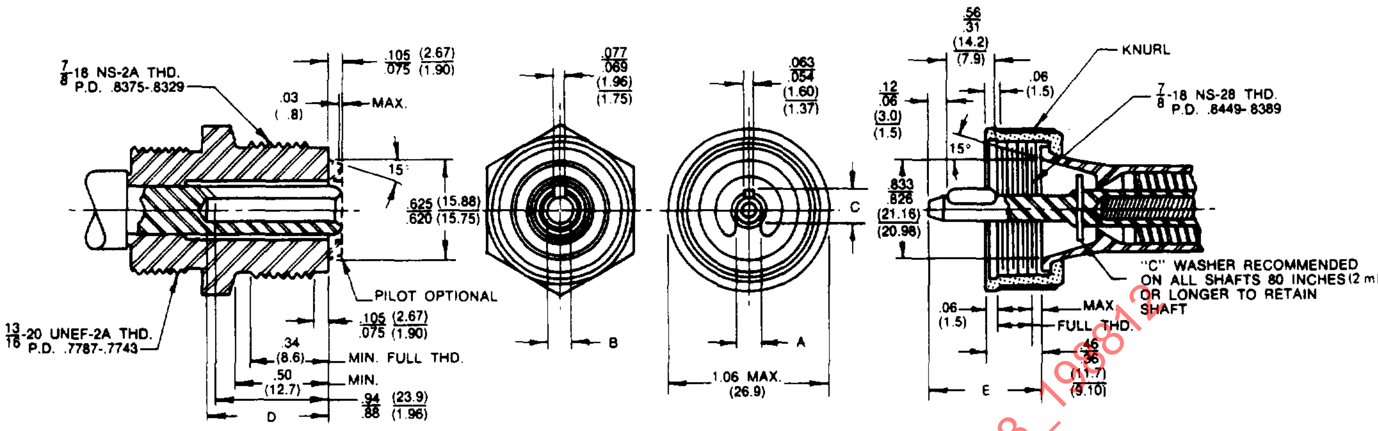

FIGURE 5—HEAVY-DUTY DRIVE (FOR USE WITH EDDY CURRENT TYPE INSTRUMENTS AND KEY DRIVE)

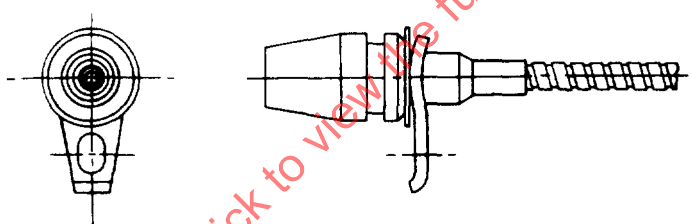

FIGURE 6—PLUG TYPE LOWER FERRULE

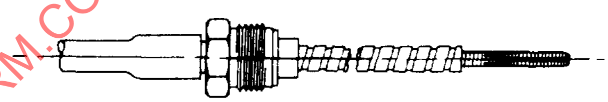

FIGURE 7—FRONT WHEEL DRIVE