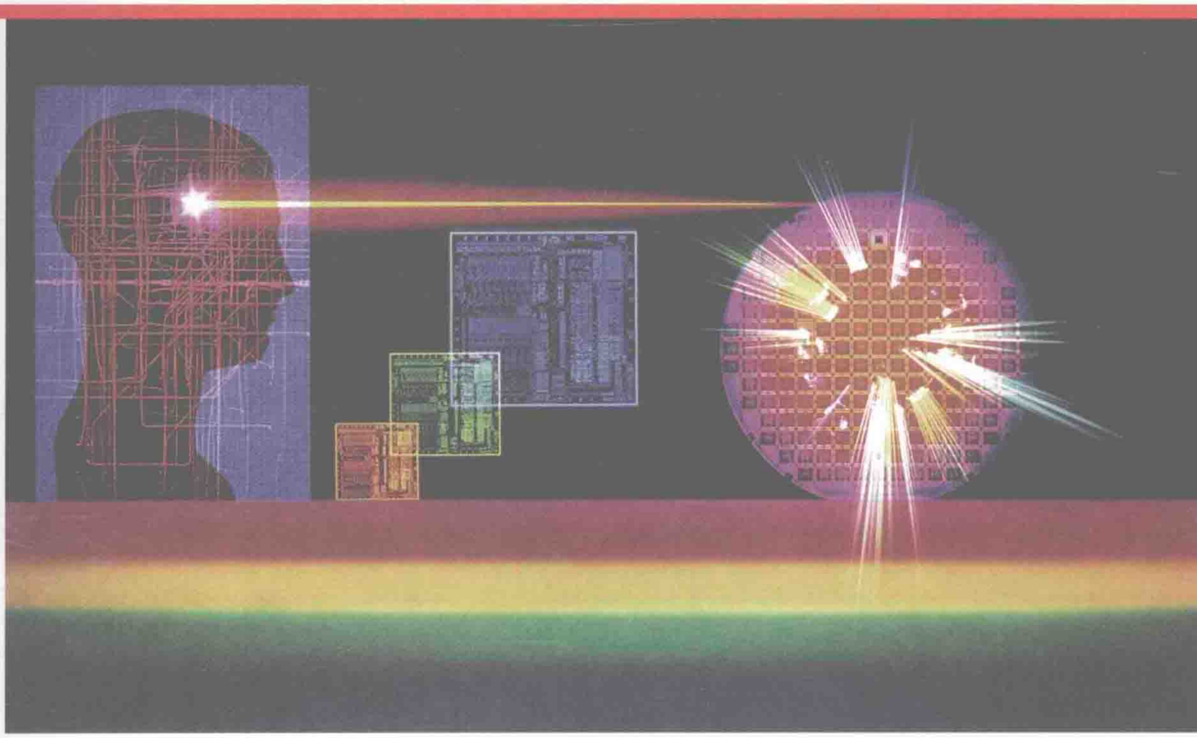
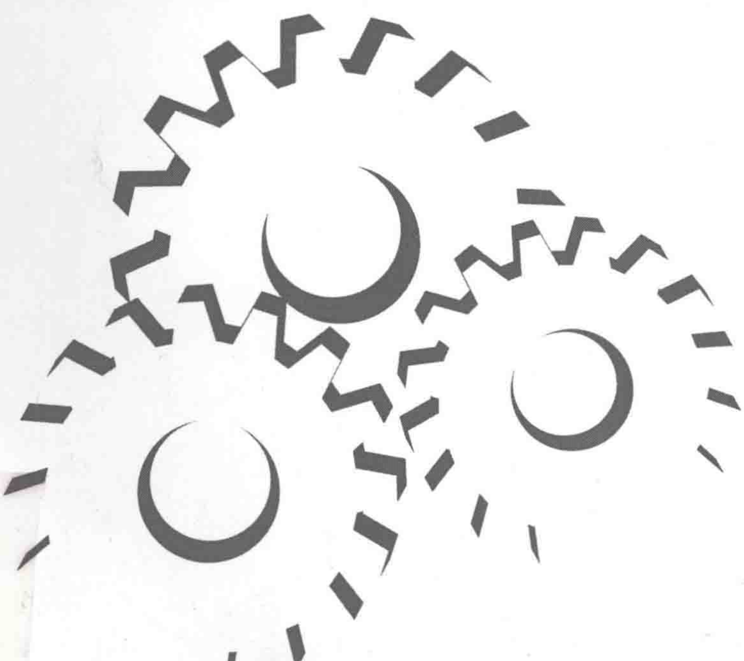
Power Transmission Devices

Mechanical Equipment Series 734.1





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Power Transmissions Devices

Editor:

Linda Warner

Graphic Design:

Robert A. Ravelo

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Chapter One

Belt Drives

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Uses of Belt Drives

1.01 If you have worked in maintenance, you probably have worked on a belt drive. If not, you have probably watched or helped someone working on one. Even if you have not been involved in maintaining belt drives, you probably have seen belt-driven equipment. Your observations will help you understand some of the terms used and the maintenance steps required to keep a belt drive operating properly.

1.02 In belt drives, power is transmitted by friction. The amount of friction force available depends on the materials in contact, their condition (dry or oily, rough or smooth), the tension in the belt, and the length of the arc of contact.

1.03 Before studying the different kinds of belts, belt drives, and their uses, you should become familiar with some of the terms used in belt applications.

- **Sheave** (pronounced *shiv*)—a grooved pulley over which a belt runs.
- **Driver sheave**—the sheave mounted on the motor, engine, or other component that supplies power. It usually has a small diameter and runs at high speed.
- **Driven sheave**—the sheave on the device that is being driven. This sheave usually has a large diameter and runs at low speed.
- **Idler sheave**—a sheave designed to regulate the tension of the belt, control the path of the belt, reduce belt vibration, and provide takeup if the sheaves move with respect to each other. It is not part of the power train.

- **Belt pitch length**—the length of a V-belt along its neutral axis.

- **Neutral axis**—a line located about two-thirds of the distance from the bottom (narrow part) to the top (wide part) of a V-belt.

- **Sheave pitch diameter**—the diameter of the circle formed by the neutral axis of a belt as it runs around the sheave. In a V-belt sheave, the pitch diameter is always less than the outside diameter of a sheave.

- **Arc of contact**—the length of the arc (measured in degrees) of the circle where a belt makes contact with the sheave. Reducing this arc reduces the belt's ability to transmit power.

- **Center distance**—the distance from the center of the driver sheave to the center of the driven sheave. V-belts work best when the center distance is about equal to or slightly less than the sum of the sheave diameters.

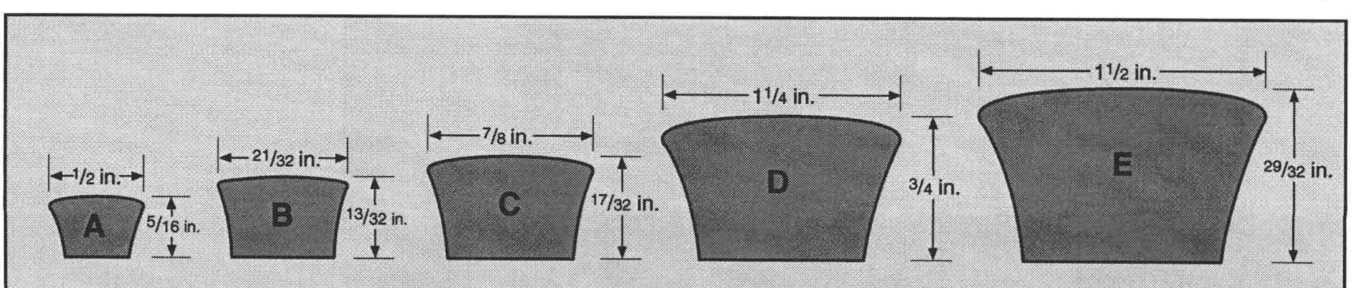
- **Speed ratio**—the speed (measured in rpm) of the high-speed shaft divided by the speed of the low-speed shaft. This ratio equals the ratio of the pitch diameter of the low-speed sheave to the pitch diameter of the high-speed sheave.

V-Belts

1.04 V-belt drives are the most widely used belt drives in industrial plants. Originally, only one or two simple belts of this type were manufactured. Today there are many kinds of V-belts available.

1.05 Most V-belts with similar cross sections are interchangeable and can be used on related kinds of equipment. One type of belt might be chosen over another based on the experience of the equipment manufacturer, the engineering staff, or the maintenance workers.

Fig. 1-1. Conventional V-belts



1.06 V-belts are made in several sizes for industrial use. The strength or power rating of a belt is defined in terms of its cross-sectional area.

- Belts with large cross sections are used for heavy-duty applications involving high power.
- Belts with small cross sections are used for light-duty (fractional-horsepower) applications.

1.07 V-belts are divided into three categories based on their size, shape, and application. Each of these types is described in the paragraphs that follow.

1.08 **Conventional.** These belts are designated by the letters A, B, C, D, and E, as shown in Fig. 1-1. Each letter indicates a specific combination of thickness and width. These sizes are indicated by the dimensions shown. The belts made by some manufacturers vary slightly from the dimensions shown. These belts are sometimes called *classical* or *standard* belts.

1.09 **Narrow**. These high-capacity belts make up the second group. They are used where the power or loading conditions exceed the capacity of standard belts. They are also used where high temperature, high moisture, or other severe environmental conditions require special belts. In some machines, there is too little space for a standard V-belt. A special belt is then required to fit into the narrow space.

1.10 Narrow belts and their dimensions are shown in Fig. 1-2. You can compare them to the standard belts to see the differences between the two styles.

- Standard belts are considerably wider than they are high.
- Narrow belts have widths that are about the same as their heights.

The two kinds of belts require different sheaves because of the difference in their shapes.

Fig. 1-2. Narrow V-belts

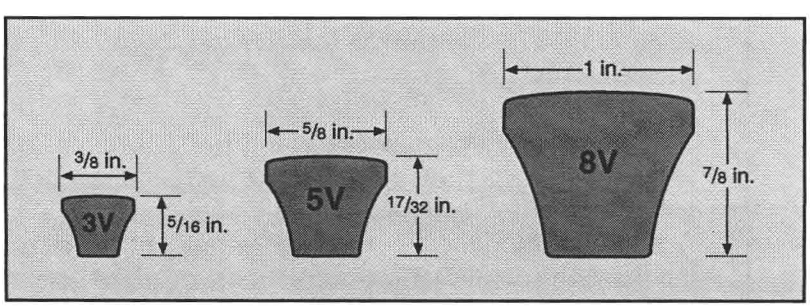


Fig. 1-3. Light-duty V-belts

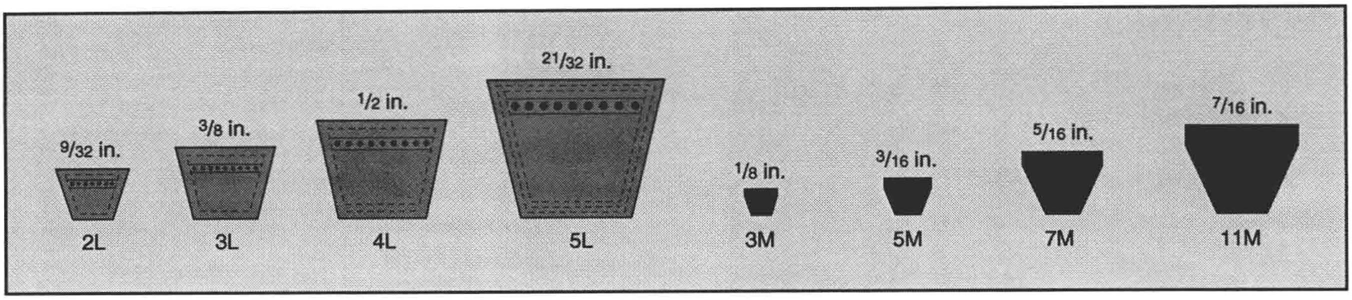
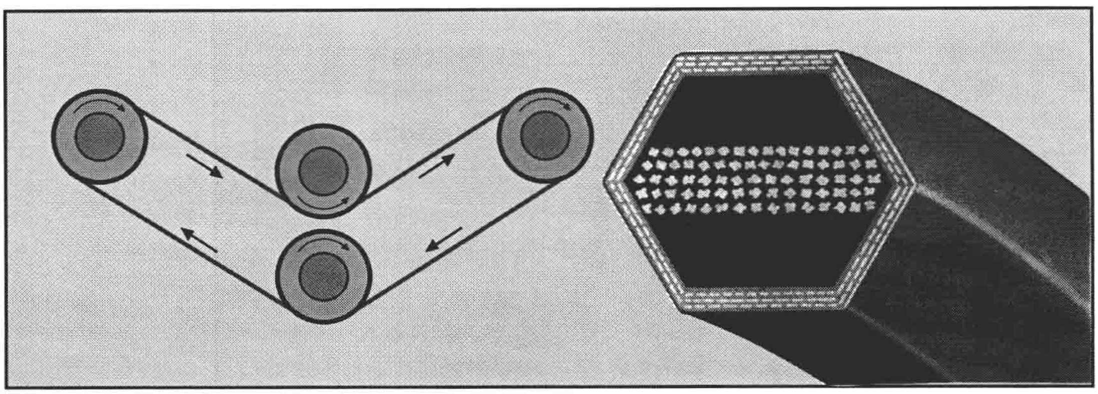


Fig. 1-4. Double-angle V-belt



1.11 **Light duty.** These belts are used with smaller sheaves for lighter-duty applications. The two types most commonly used are shown in Fig. 1-3. The belts labeled 2L through 5L are similar in cross section to standard belts and are used most often. The belts labeled 3M through 11M have a different shape and more flexibility.

1.12 Belts are made in standard lengths. However, you can buy a single strand of belt material, cut it to the required length, and splice the ends together to make a belt for a special application.

Special V-Belts

1.13 V-belts are commonly used to transmit motion from the drive sheave to only one other sheave and in only one direction. Sometimes it is desirable to shift a single belt among two or more pairs of sheaves and to reverse the direction. To accomplish these functions, belt manufacturers developed the *double-angle belt*, also called the *hex-shaped belt.*

1.14 The double-angle belt can drive sheaves from either side, as shown in Fig. 1-4. It can therefore drive different sheaves in opposite directions without twisting the belt. A double-angle belt can also be used as a clutch. A pivoting idler sheave controls the amount of friction the belt applies to the driven sheave. Double-angle belts are sized like standard belts, except they have twice the height. They are designated by double letters—AA, BB, CC, and so on.

1.15 When V-belts are used in multiples of three or more, unequal belt tension and belt flapping can become problems. These problems are especially common in cases where the sheave centers are far apart.

1.16 To solve these problems, the belts can be connected across the back by a backing fabric. The belts are then called *group belts*. The backing is applied during manufacturing and actually becomes part of the belt. It gives the belt uniform strength. Manufacturers also offer sets of matched V-belts that are pre-selected to operate as multiple belts.

1.17 Group belts are available in a number of styles, including the following:

- conventional, as shown in Fig. 1-5A
- narrow, high-capacity
- special narrow-ribbed belts, as shown in Fig. 1-5B. These belts are designated as J, L, and M, depending on the groove size, and require special sheaves with a close-V configuration.

1.18 Two kinds of adjustable link belts are shown in Fig. 1-5C. They are available in sizes A, B, and C. Link belts have three advantages:

- They can be used where the sheaves are on fixed centers and cannot be moved to adjust the belt tension.

Fig. 1-5. Special V-belts

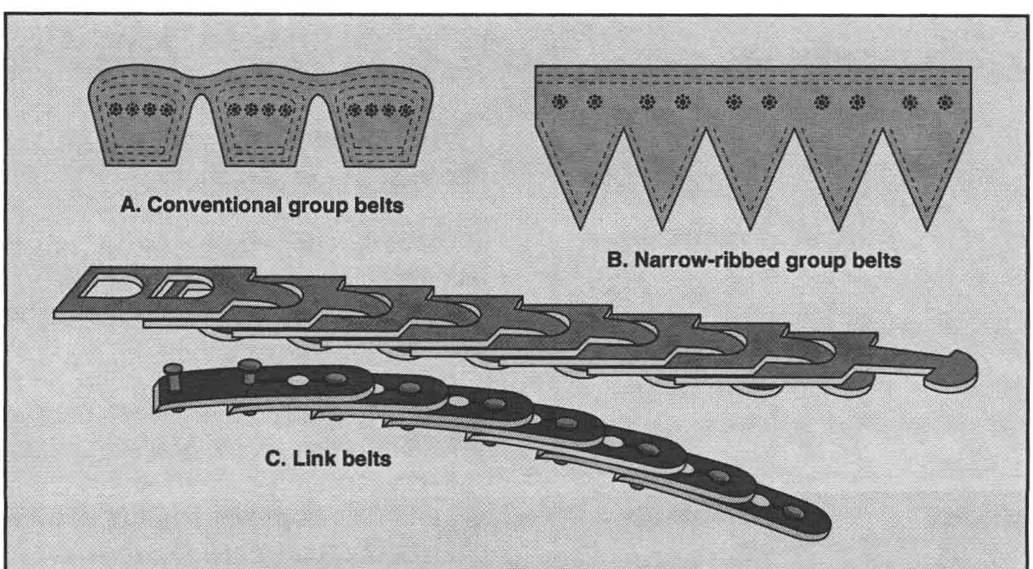
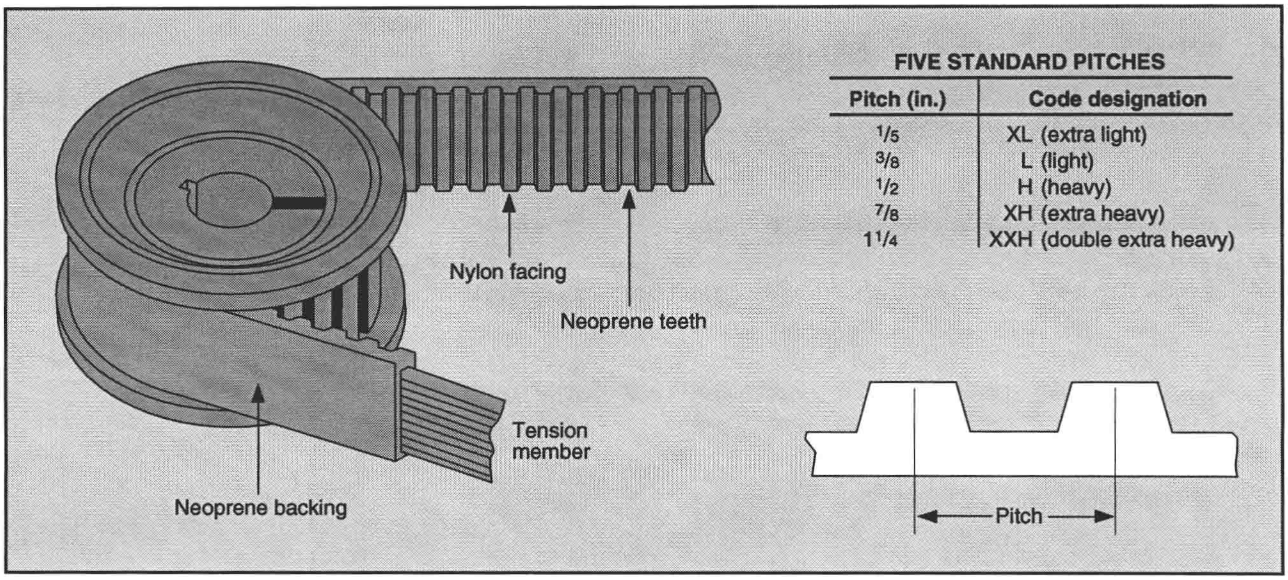


Fig. 1-6. Timing belt



FIVE STANDARD PITCHES

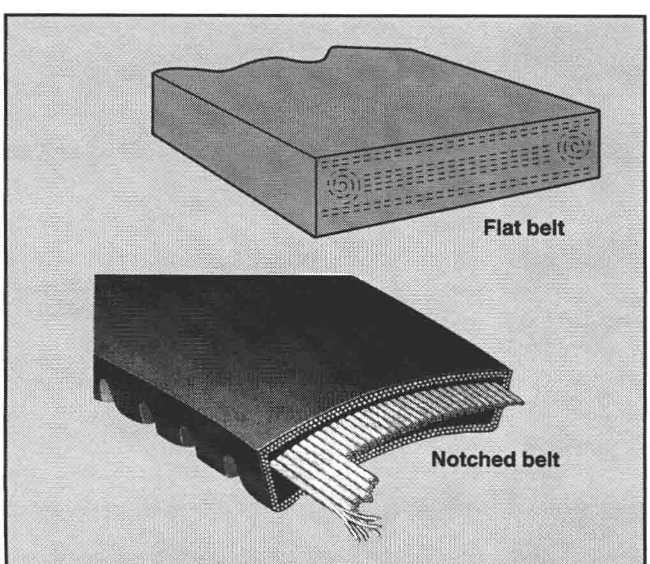
Pitch (in.)	Code designation
1/5	XL (extra light)
3/8	L (light)
1/2	H (heavy)
7/8	XH (extra heavy)
1 1/4	XXH (double extra heavy)

- They can be used for installations in which the drive is located between bearing housings and supporting frames—a setup that makes replacement of a belt a major task.

- Their nonrigid design allows them to be twisted to run on sheaves that are not in the same plane.

Timing Belts

Fig. 1-7. Flat belts

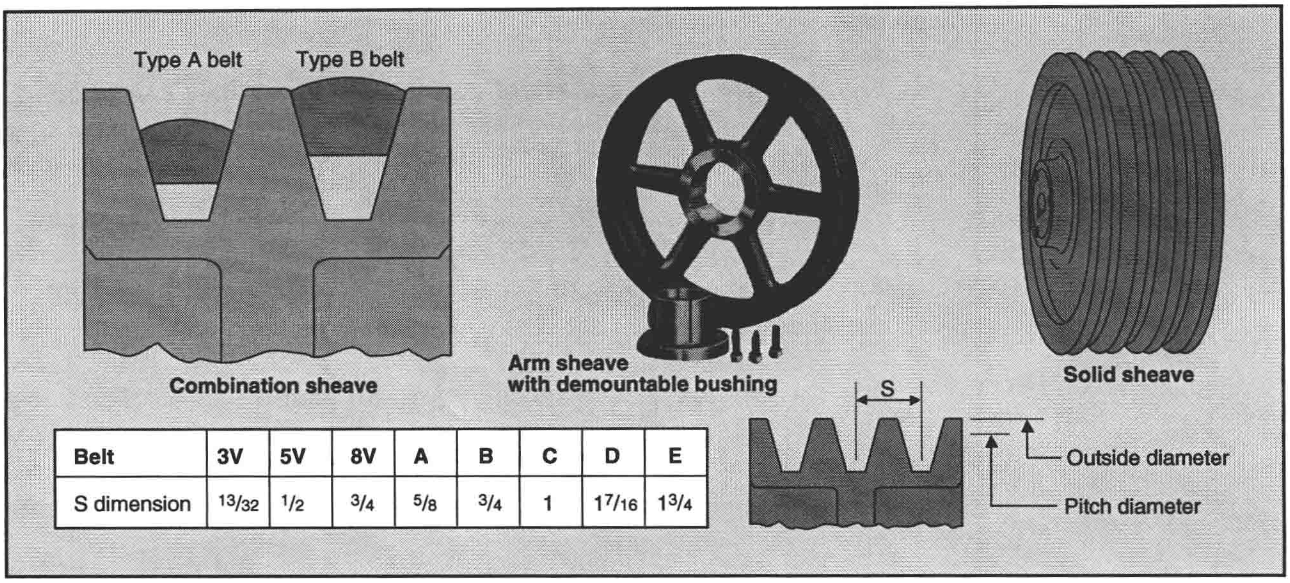


1.19 Timing belts have found increasing use in drive systems. Some timing belts are used on drives that require specific timing of related moving parts. Others are used on drives that require the transfer of power without slippage. An example of a timing belt is shown in Fig. 1-6.

1.20 Timing belts have molded teeth that fit into notches in the sheaves. The teeth serve the same purpose as the teeth on a gear. They enter and leave the notches in a smooth, rolling manner. Unlike most other belts, timing belts do not get their strength from their thickness, nor do they depend on friction to exert a driving force.

1.21 In construction, timing belts are similar to V-belts. Cords give the belt strength under tension, and synthetic rubber in the body makes the belt flexible. The belt shown in Fig. 1-6 has teeth made of synthetic rubber and faced with nylon.

Fig. 1-8. V-belt sheaves



Belt	3V	5V	8V	A	B	C	D	E
S dimension	13/32	1/2	3/4	5/8	3/4	1	17/16	13/4

1.22 Timing belts are made in five standard pitches. Standard widths range from 1/2 to 5 in. Special widths range from 1/4 to 10 in. Most pitches are available in several widths.

Flat Belts

1.23 Flat belt drives are used in relatively few applications today. In most cases, they have been replaced by V-belts. However, a flat belt is sometimes preferred for driving certain kinds of machinery because it will slip if it becomes overloaded. Flat belts are used in the printing and textile industries, on sheet metal presses, and on various older machines.

1.24 Figure 1-7 shows the construction of two typical kinds of flat belts. In each case, the belt is made of synthetic rubber with inner cords to provide tensile strength. A fabric cover encloses the belt.

1.25 Notice in Fig. 1-7 that the underside of one belt resembles a timing belt. However, the belt does not act like a timing belt. The notches are closely spaced and provide gripping edges when they contact the sheave. The edges increase the amount of friction between the belt and the sheave.

1.26 Several variations of the flat belt are used in variable-speed drives. The drives may be simple open-belt drives or reducer drives.

V-Belt Sheaves

1.27 There are only two major kinds of V-belts but three kinds of sheaves: *conventional, narrow,* and *combination* sheaves. Combination sheaves are used with both A and B belts, as shown in Fig. 1-8.

Combination sheaves are found in plants having both A and B drives. They permit interchanging the drives, and they reduce the number of spare parts needed in the storeroom.

1.28 Most sheaves are made of cast iron or steel. They can be solid, or nearly solid, from the hub to the outer rim. Or the sheave can have spokes that connect the rim to the hub. Those with spokes are called *arm sheaves.* Both solid and arm sheaves are shown in Fig. 1-8.

1.29 Many V-belt sheaves are made of die-formed sheet steel. They are used on light-duty drives. Some sheaves have plain bores, including set screws and/or keyseats. Others have demountable bushings or hubs.

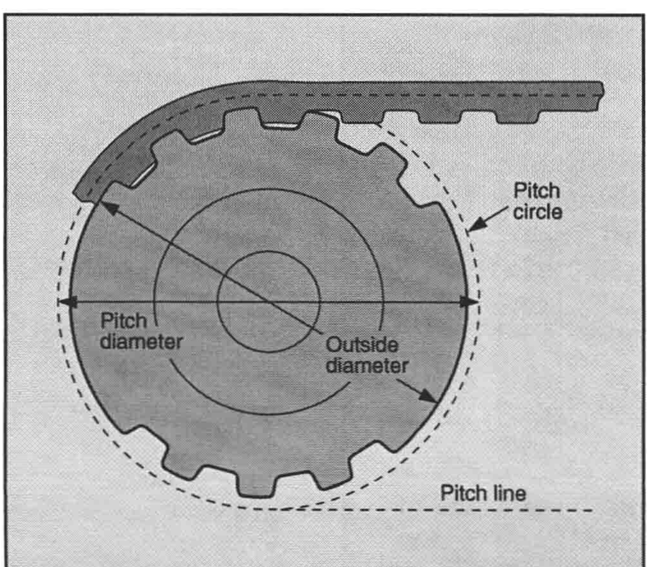
1.30 The various groove spacings for multibelt drives are listed in the table in Fig. 1-8. These dimensions and the belt widths will help you determine the size of a V-belt drive if you cannot identify it in any other way.

1.31 The outside diameter of a sheave is never the same as its pitch diameter. A combination sheave has two pitch diameters, one for each kind of belt. In high-capacity sheaves, the belt extends slightly beyond the outside diameter of the sheave. When grouped belts are used with standard sheaves, the belt covers the outer surface of the sheave, except along the two outside edges.

Timing-Belt Pulleys

1.32 The pulleys for timing belts are made from many materials, including cast iron, plastics, molded fiber, steel, and aluminum. Flanges are usually included on small-diameter pulleys to prevent the belt from slipping off. Large-diameter pulleys do not require flanges, because the pulleys provide greater contact area with the belt. However, belts that run horizontally require flanges on both pulleys.

Fig. 1-9. Timing belt and pulley



1.33 Figure 1-9 shows how a timing belt matches the shape of the pulley. Notice in this diagram that the pitch line of the belt and the pitch circle of the pulley are both located beyond the outside diameter of the pulley. This arrangement is just opposite the arrangement for a V-belt sheave.

1.34 Timing belts have specific pitch characteristics for different sizes. Therefore, if a pulley or belt needs to be replaced or interchanged, the replacement must have the same pitch size. For example, a belt with a pitch of 1/2 in. can be used only with a pulley that also has a pitch of 1/2 in.

Flat-Belt Pulleys

1.35 Flat-belt pulleys are not always flat. They usually have a slight *crown* (raised center). The crown may be curved, or it may have flat sides with a slight peak, depending on the application. The crown serves two purposes.

- It helps *track* (guide) the belt to prevent it from slipping off the pulley.
- It increases the friction between the belt and the pulley by increasing the tension in the belt fibers.

On idler and other nondriving pulleys, the pulley face may be either flat or crowned.

1.36 Using a flat belt with a crowned pulley is not a sufficient assurance that the belt will track automatically. You must also align the pulley with the belt. If the pulley is not aligned properly, the belt will run off the edge of the pulley.

Variable-Speed Sheaves

1.37 Variable-speed sheaves are used in applications where the speed must be adjusted. Speed adjustments might be required only occasionally, or they might be necessary often. The changes might be only a few rpm, or they might be several hundred rpm. The amount of speed change possible depends on the drive and on the sheave arrangement.

1.38 Variable-speed sheaves are divided into two general classes:

- manually adjusted sheaves
- spring-loaded sheaves.

1.39 Manually adjusted sheaves have a smaller range of adjustment than do spring-loaded sheaves. Various models differ slightly in appearance and features, but the basic design and operating principles apply to all models.

Manually Adjustable Sheaves

1.40 Manually adjustable sheaves are usually used on drives requiring only small, occasional adjustments. Sheaves are selected to provide the approximate desired speed, based on the pitch diameters. An adjustable driver sheave then permits small adjustments in the speed after the drive is operating. Manually adjustable sheaves allow a reduction in pitch diameter of about 20 to 25%, which changes the speed by the same percentage. The variation in speed depends on the speed of the sheaves.

1.41 Examples of manually adjustable sheaves are shown in Fig. 1-10. Notice each example shown has some means of locking the adjusting ring. The locking mechanism prevents the adjusting ring from turning as the drive is rotating.

1.42 The locking mechanism can damage the sheaves when you make speed adjustments. The damage occurs when you fail to loosen the locking screws or collars before trying to adjust the sheave. For this reason, it is important to loosen all locking devices before trying to adjust a sheave. Usually, adjusting procedures are printed on the nameplate of the sheave. Unfortunately, many sheaves are located so that you cannot read the nameplate.

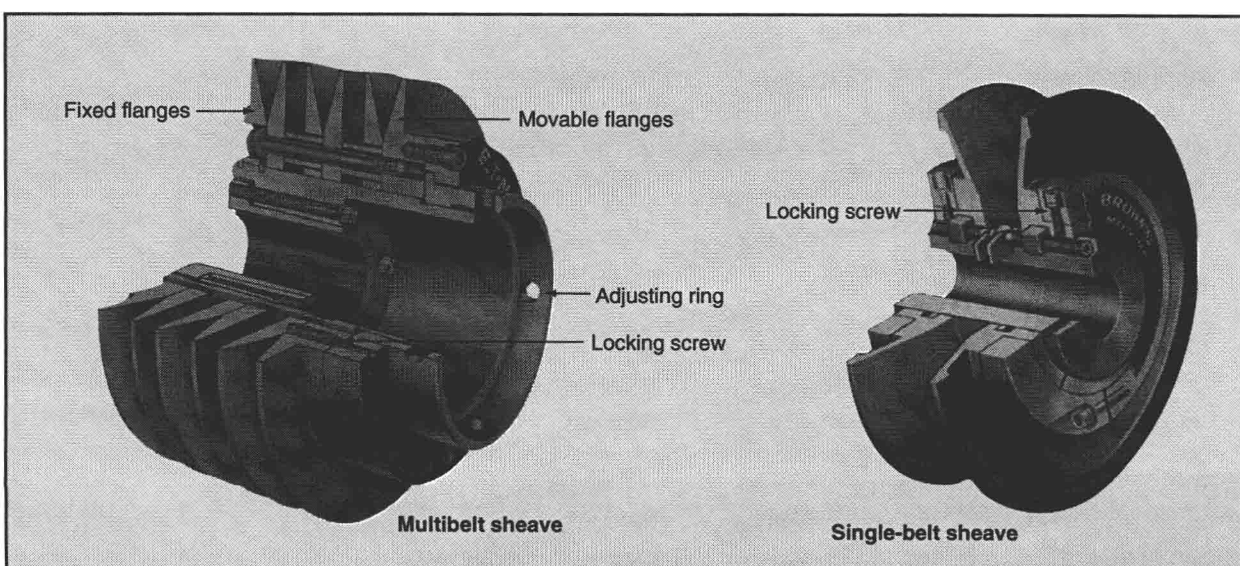
1.43 Some single-belt, manually adjustable sheaves are made with one flange fixed and one movable. The movable flange is usually threaded internally so that it can screw onto a threaded portion of the hub. Keyways at various points around the hub ensure transmission of the driving force through the mechanism with even the smallest adjustment.

1.44 A variation of the single-belt adjustable sheave has both flanges adjustable. By adjusting both flanges, the belt remains centered on the driving sheave, thus eliminating uneven wear on the sides of the belt.

1.45 In a two-belt adjustable sheave, the center flange is fixed and both outer flanges are threaded. You must use care in adjusting a two-belt sheave to make sure both flanges are adjusted equally.

1.46 Multigroove sheaves are similar in construction to one- and two-groove sheaves. Some multigroove sheaves have one outer flange fixed, and the other adjustable. The interior flanges are self positioning. When

Fig. 1-10. Manually adjustable variable speed sheaves



you adjust the movable outer flange, the interior flanges shift to new positions in response to the increase or decrease in belt tension.

1.47 In other multigroove adjustable sheaves, all the flanges on one side of the belts are attached to a fixed flange. All the opposing flanges are attached to an adjustable flange. When you adjust this sheave, all the adjustable flanges shift position together.

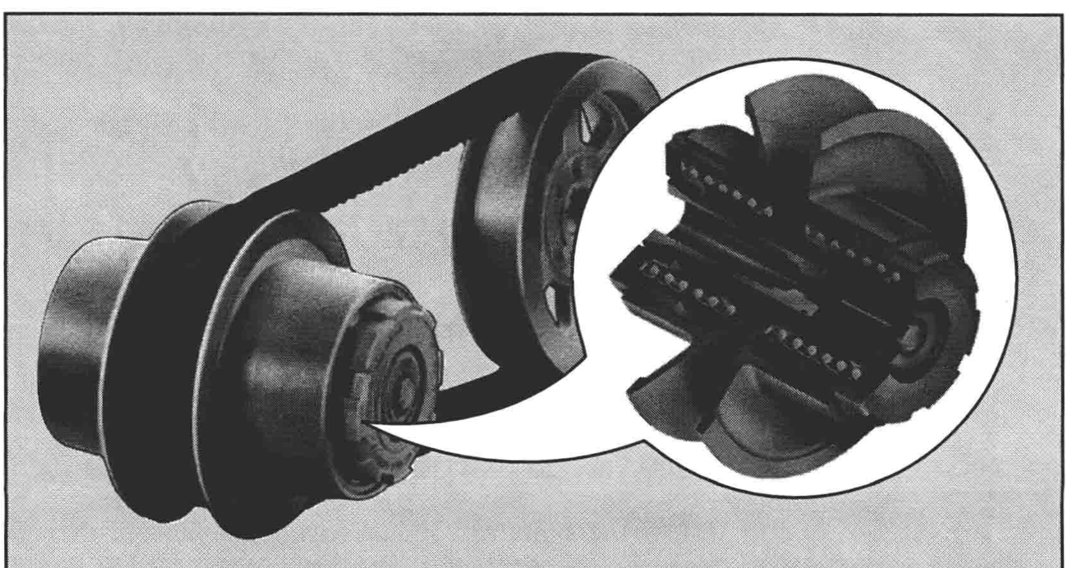
1.48 In another kind of adjustable sheave, all the flanges are movable. They are controlled with right- and left-hand threaded adjusting screws. The flanges sometimes have locking screws to keep them from moving during operation. When the sheave is adjusted, all the locking screws and collars must be loosened first. Then the adjustment is made, and finally all locking members are retightened. Failing to loosen the locking devices or forcing the flanges beyond their intended adjustment usually results in damaged sheaves.

Spring-Loaded Sheaves

1.49 Spring-loaded sheaves are quite different from the manually adjustable kind. Instead of being adjusted with screws, the sheave flanges move in response to changes in the tension of the drive belt. The tension changes as the motor moves closer to or farther from the driven sheave. The belt has a fixed length, so moving the motor changes the position of the belt on the sheave. This change, in turn, affects the speed of the drive. Springs inside the hubs allow the flanges to move with the changing position of the belt.

1.50 An example of the spring-loaded variable-speed sheaves often used in drive systems is shown in Fig. 1-11. Like manually adjustable

Fig. 1-11. Spring-loaded variable-speed sheaves



sheaves, some spring-loaded sheaves have one fixed flange and one movable flange. Other spring-loaded sheaves have two movable flanges so that the belt remains centered on the drive. The sheaves having two movable flanges often have two counterbalancing springs, cam mechanisms, or other controlling devices to ensure that the two flanges move together.

1.51 In some installations where the spring-loaded sheaves have a fixed flange, the drive belt is positioned and tensioned by a special motor base. The base is hinged at one edge so the weight of the motor helps maintain the proper tension on the belt.

1.52 Because the motion in the spring-loaded sheave is created by outside forces, it is usually impossible to tell whether or not the mechanism within the sheave is free or tight. For this reason, some manufacturers include lubrication fittings on the unit. Others have included prelubricated bearings or an oil reservoir.

1.53 When working on spring-loaded sheaves, remember that the pressure springs in many units are retained by only a snap ring or bolts. Use extreme caution in removing this spring retainer and following the manufacturer's instructions carefully.

V-Belt Installation

1.54 The following instructions are general. They apply to any kind of belt. Belt manufacturers provide specific instructions for their belts. You should, of course, make the installation according to the manufacturer's instructions if they differ from these:

- Make sure all power is locked out and switches are properly tagged.
- Inspect sheaves to make sure they are clean, free of nicks and burrs, and that the grooves are not worn.
- Make sure you use the proper belt for the sheave, and that you use a matched set on a multibelt drive.
- Slack off on takeups so the belts can be placed in grooves without forcing them.
- Adjust takeup until the belts are snug.
- Check alignment of belts and sheaves.
- Adjust the belts for proper tension.
- Allow the belts to run for several days, and then readjust the takeups.

1.55 In addition, you should observe special safety precautions at all times when you work around V-belt drives. The following are especially important:

- Do not wear loose clothing.
- Replace the guard after servicing a drive.
- Always inspect a V-belt for wear.
- Install the belts properly.
- Do not use old belts that have been in storage for a long time.
- Store the belts in a cool, dark, dry place.
- Store belts flat or on a curved support, never on a single peg or nail.

1.56 Remember that the selection of a belt is a complicated process if the belt is not an exact replacement for the existing belt. You must consider the relationships among speed, horsepower, length, and belt sag. Before making such a selection, you should always consult a maintenance engineer or the manufacturer of the belt or the equipment.

1.57 Because of their design, V-belt drives are frequently selected to provide the additional reduction that will produce a specific output speed. The size and type of a V-belt drive are determined by the input power and speed.

1.58 When V-belt drives are used, some means of take-up must be provided to maintain proper tension on the belts. If the motor is mounted to one side of the reducer, a slide base or slotted holes in the supporting framework can serve this purpose. If the motor is attached to the reducer, adjusting screws on the bed plate of the motor ensure proper tension. Because V-belts are frequently used near other operating equipment, it is important that safety guards be installed to protect plant personnel from injury.

1.59 Most shaft-mounted reducers are equipped with a *tie rod* (usually incorporating a turnbuckle). This device prevents rotation of the reducer during operation, especially when the motor is mounted directly on the reducer. In certain cases, the tie rod also provides a means of keeping proper tension in the V-belt drive.

1.60 As an alternate to the turnbuckle tie rod, most manufacturers of shaft-mounted drives also supply a spring-loaded tie rod. An example is shown in Fig. 1-12. Spring-loaded tie rods are classed as *overload releases* and

Fig. 1-12. Spring-loaded tie rod

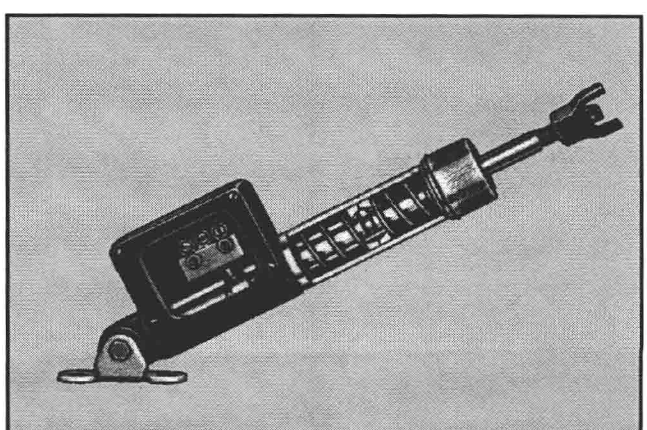
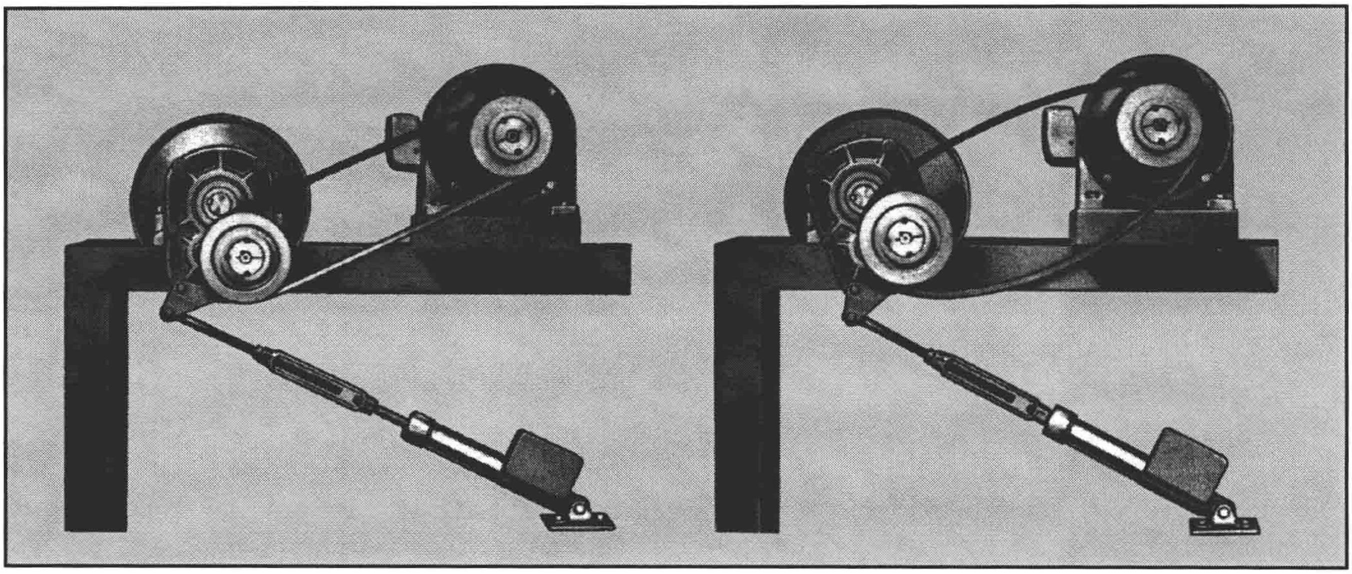


Fig. 1-13. Spring-loaded tie rod in operating and tripped positions



are installed in a position that will disengage the V-belt drive when an overload occurs. These overload releases can be adjusted to release at any overload limit within a certain range. When they are overloaded and tripped, the reducer input shaft moves closer to the motor. This movement puts slack in the driving belts, allowing the input sheave to turn freely, as shown in Fig. 1-13. Most of these overload devices are constructed with electric contacts. If an overload occurs and the release is trapped, an alarm signal is sent to the operator's control panel. In a large material-handling system, a signal from the overload release can also shut down any equipment preceding the unit.