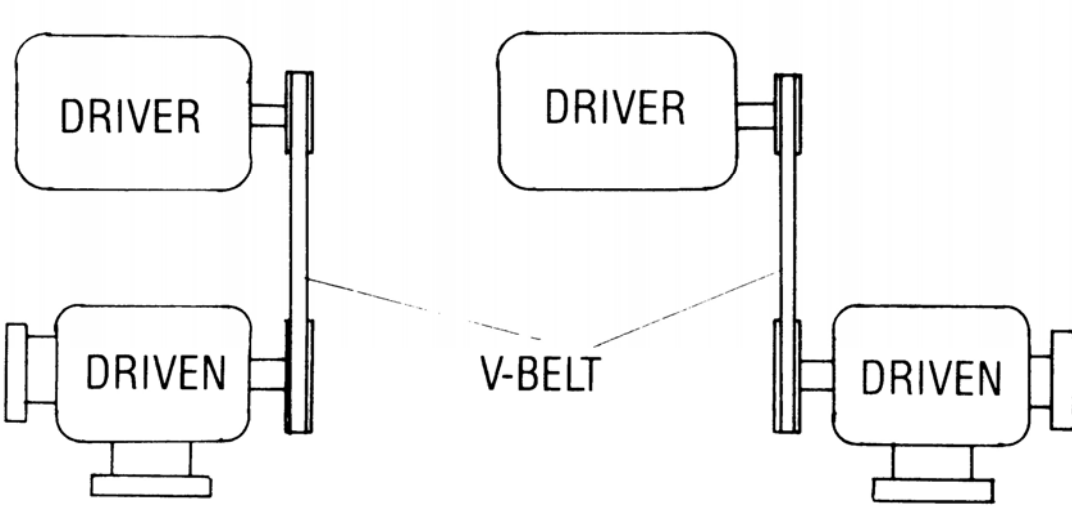
V-belt Drives

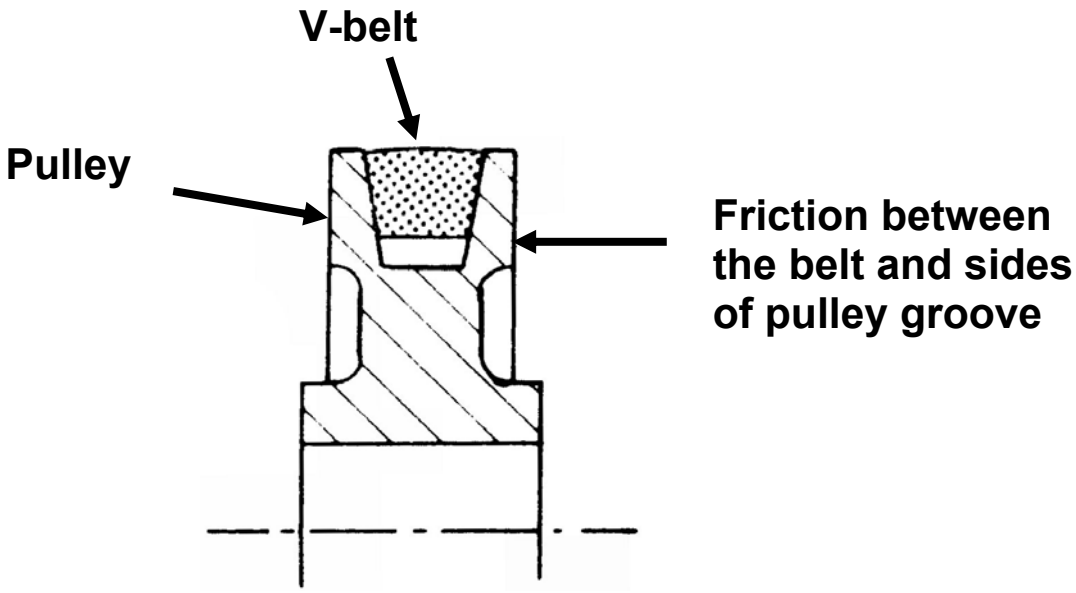
Although various other types of belt drives are also used, V-belts are the most common. However, many of the maintenance considerations that apply to V-belts are also relevant to other types of belt drive such as flat belts and timing belts.

Principles of Operation

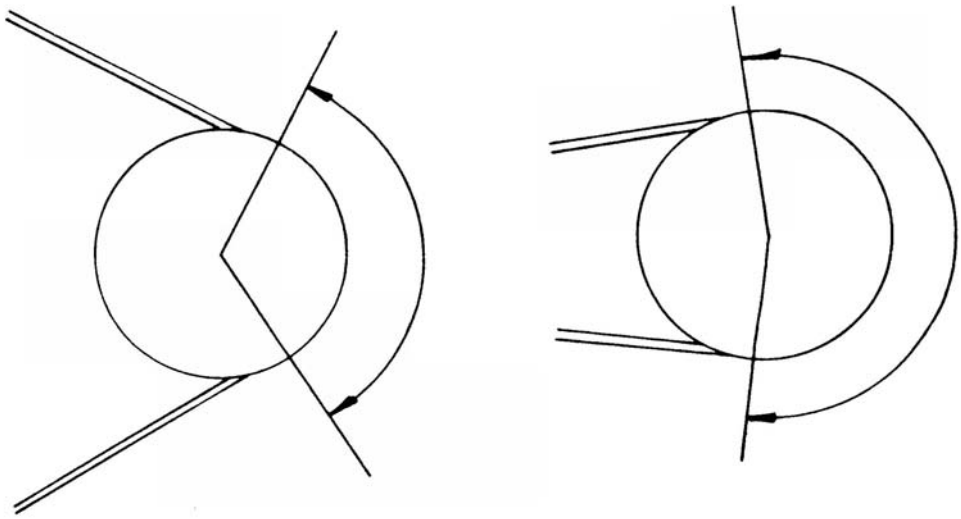
V-belts are normally used to transfer power between two shafts whose axes are parallel and some distance apart.



The belt is mounted on pulleys that are attached to the driving and driven shafts and the drive relies on friction between the belt and the pulleys for its operation. The belt sits in the groove of the pulley and makes contact with the sides of the groove as shown below:

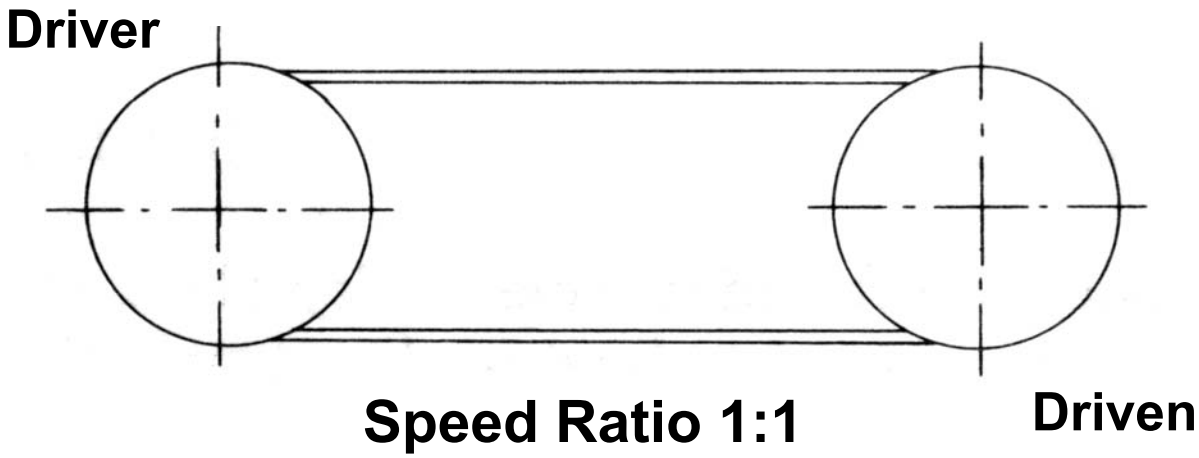


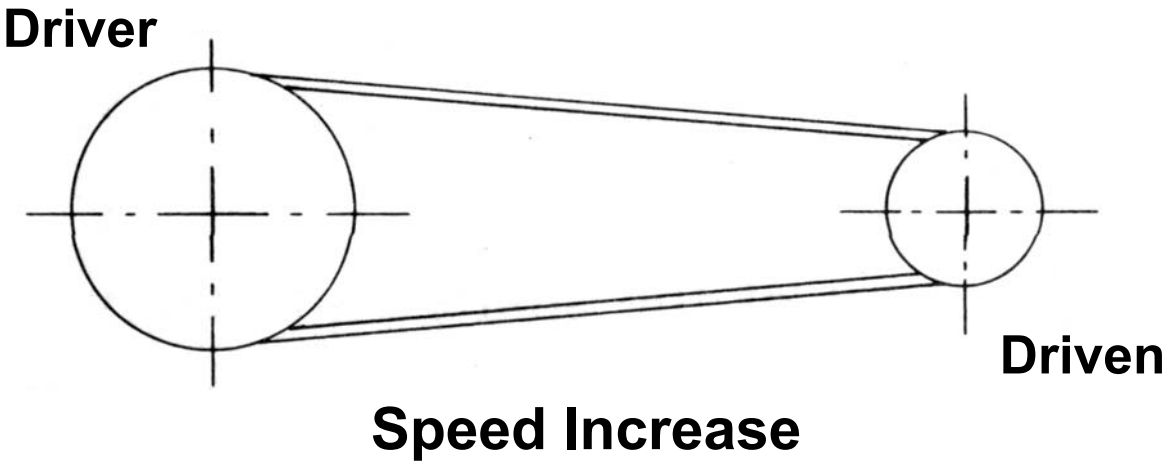
In order to be able to transmit power, the belt must be under tension so that it is forced down into the groove. The belt is squeezed and friction develops between the sides of the belt and the sides of the groove. The depth of the groove is always greater than the thickness of the belt, however, and the belt should never bottom in the groove. The operation of the belt and its ability to transmit power depend on the size of the friction force and the arc of contact of the belt. The greater the arc of contact the more power the belt can transmit.

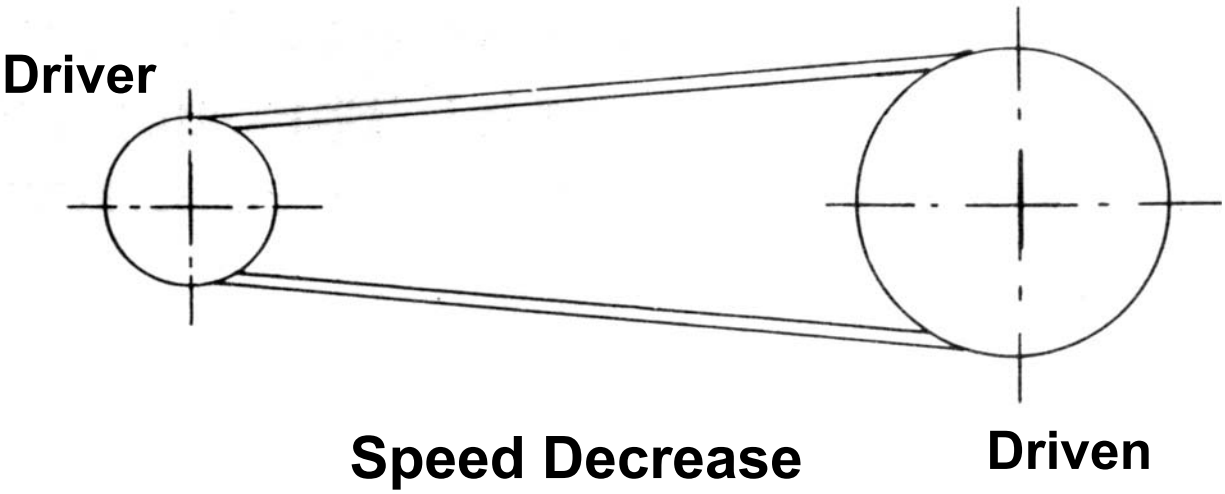


As well as performing its primary function of transmitting power, a V-belt can be used to change the speed of the driver output and hence the torque transmitted to the driven unit.

There are three basic alternatives as shown below:







The speed ratio between the two pulleys of a belt drive can be calculated from this simple formula.

$$\text{driven speed (RPM)} = \frac{\text{driver pulley diameter (mm)}}{\text{driven pulley diameter (mm)}} \text{ x driver speed (RPM)}$$

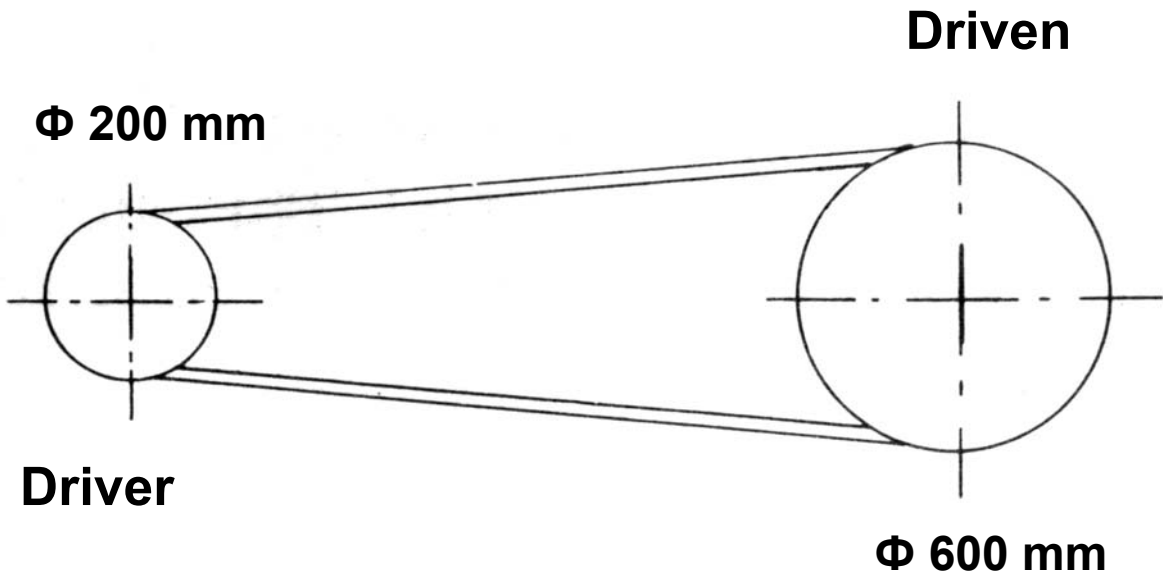
It is generally accepted that V-belt drives are limited to belt speeds between 300 and 3000 metres per minute. If required to operate at higher speeds, then dynamic balancing of the pulleys becomes increasingly important.

Example

In an arrangement a motor runs at 450 rpm. The diameter of the driver pulley is 300mm and the diameter of the driven pulley is 150mm. Calculate the output speed.

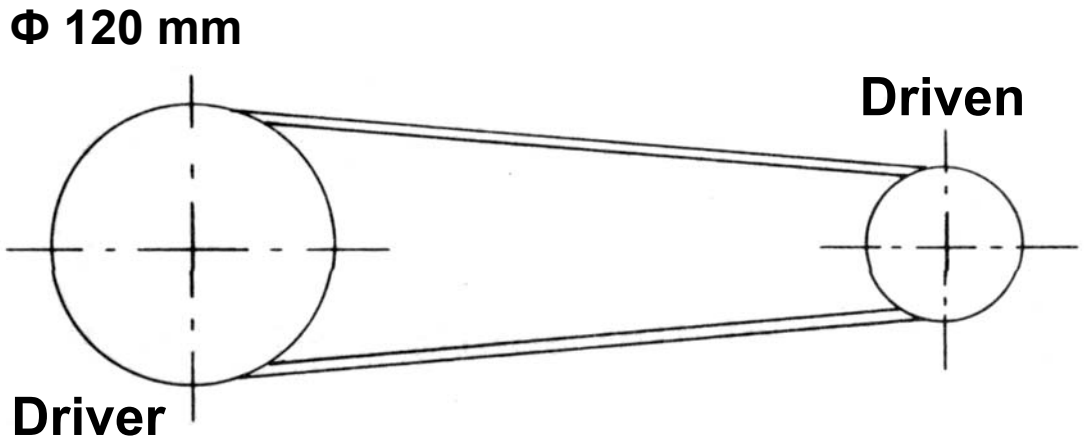
Example

In the arrangement shown below calculate the output speed if the driver is running at 500 rpm.



Example

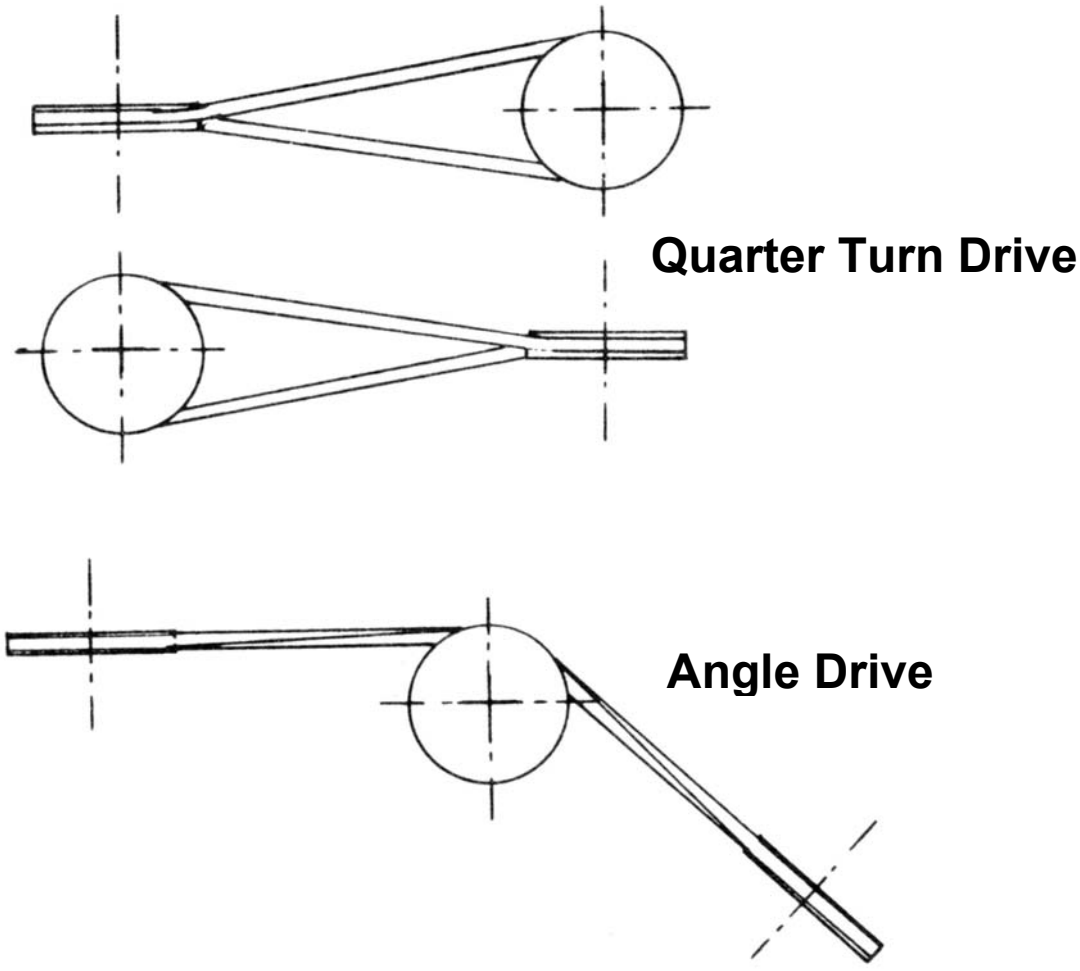
In the arrangement shown below calculate the diameter of the driven pulley if the output speed needs to be 600 rpm. The motor runs at 300 rpm.



Types and Arrangements

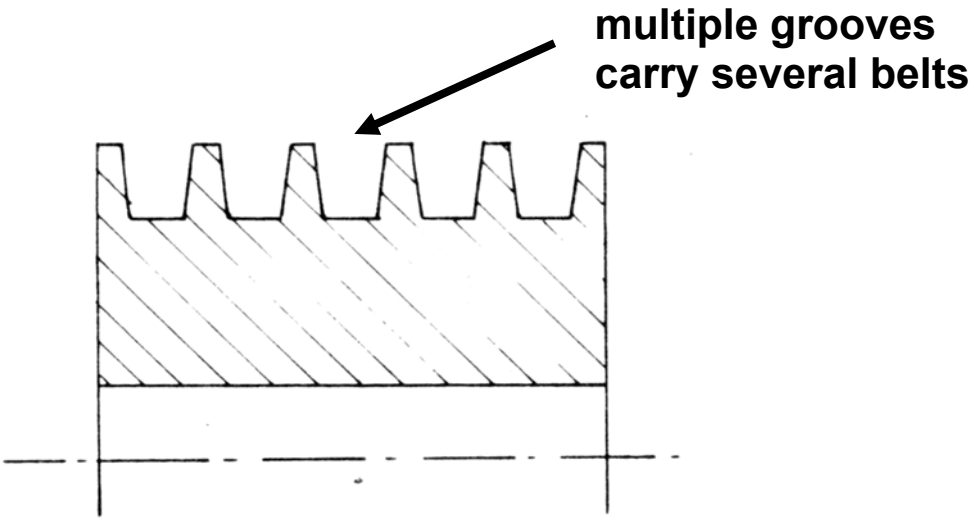
Single V-belt

The most common type is the single belt arrangement whose operation has been described in the illustrations above. In addition to being used to transmit power between parallel shafts, the single belt can also be used for quarter turn drives and angle drives as shown below.



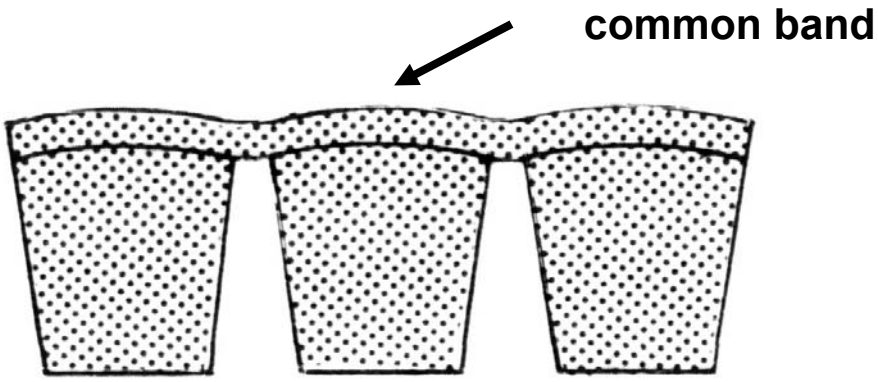
Multiple V-belt

In order to increase the capacity of the drive an arrangement which uses several belts mounted on multi-grooved pulleys is often used.



Banded V-belts

In order to overcome the tendency of belts to whip, twist or jump off, a banded V-belt, in which the V-sections are vulcanised to a common band can be used.

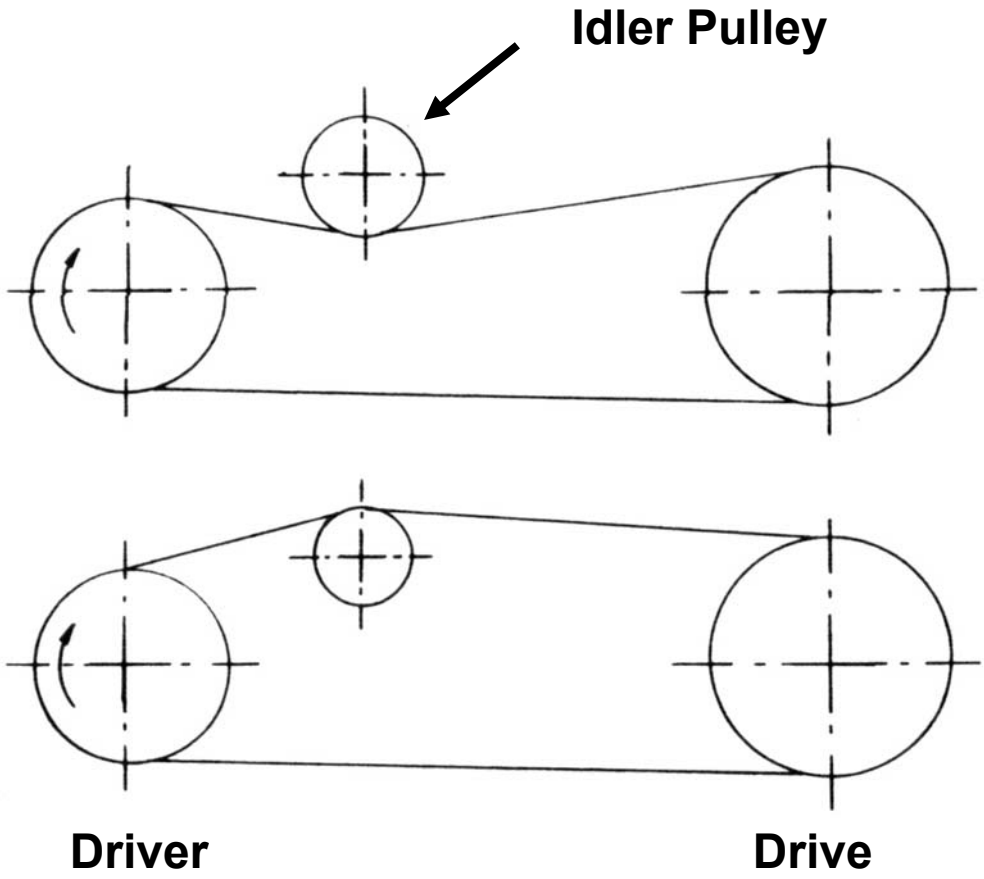


Belt Tension

V-belts are often tensioned by means of an idler pulley for the following reasons:

- If the relative position of the shafts cannot be adjusted then an idler pulley can be used to assist installation of the belt.
- If the driver is subject to varying loads then a spring loaded idler can provide automatic adjustment of belt tension.
- The inclusion of an idler pulley can help to increase the arc of contact and hence the power transmission capacity of the drive.

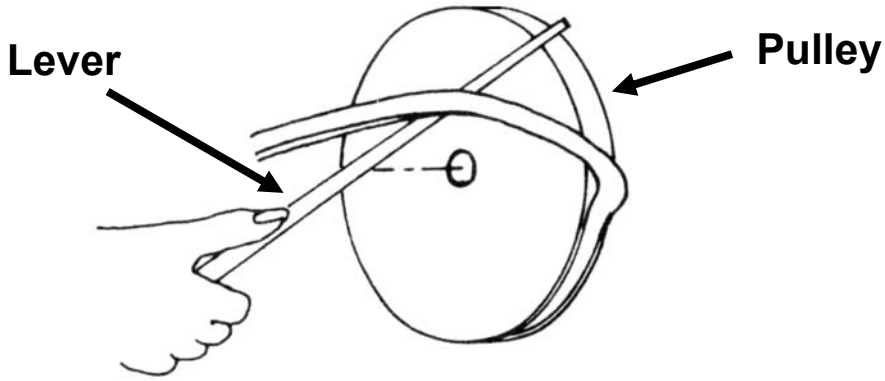
It is generally recommended that idler pulleys be mounted on the slack side of the belt, as shown below and positioned close to the drive pulley.



Maintenance Practices

The following general points should be taken into account in the maintenance of V-belts.

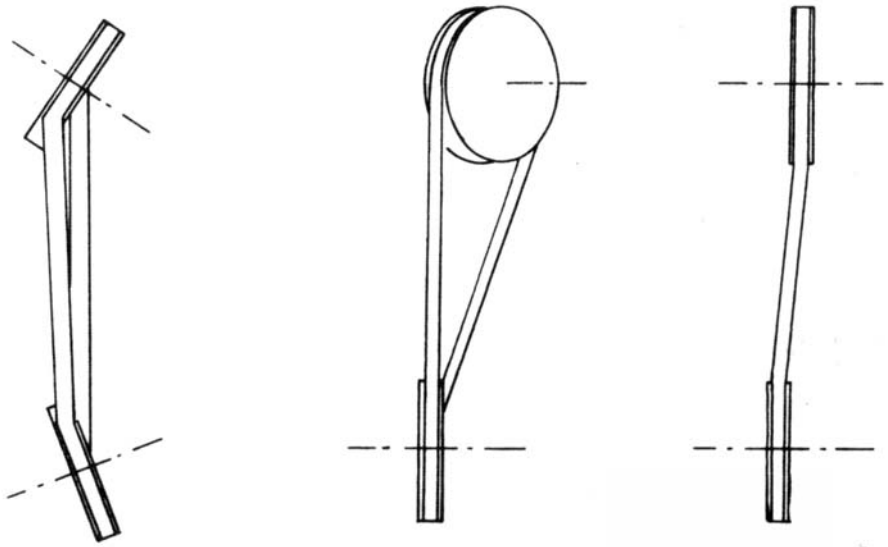
- The operation of V-belts depends largely on the condition and correct positioning of the pulleys.
- V-belt pulleys should be kept clean, free of oil and grease and free from damage and wear.
- Pulleys should be installed parallel and in line with each other.
- Belt tension should be adjusted according to the manufacturer's recommendations.
- V-belts should never be forced or levered on to the pulley as shown in the illustration below.



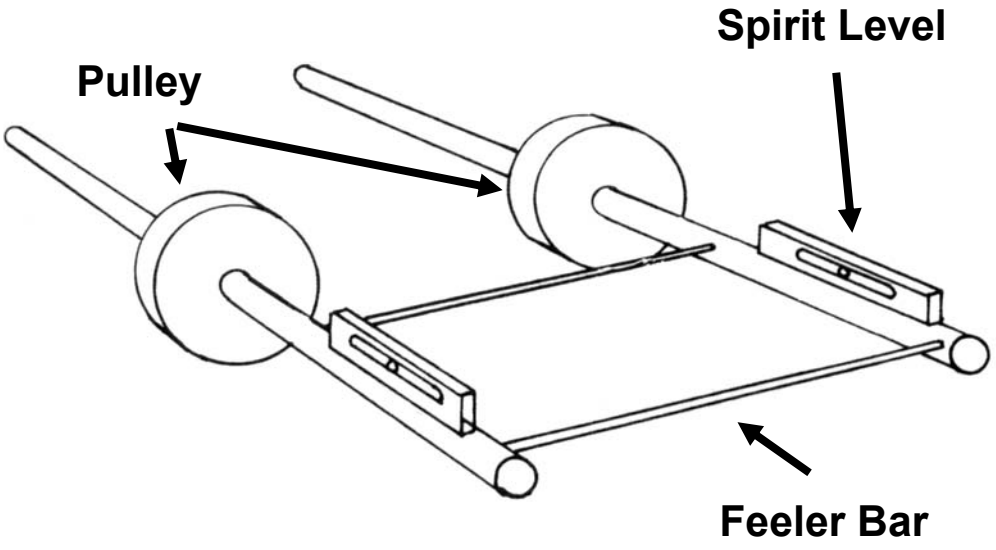
- Multiple V-belts should be correctly matched to ensure the load is evenly distributed. As well as being the same size it is preferable that all belts are supplied by the same manufacturer.
- Multiple V-belts should be changed as a set. A single new belt will be shorted than the worn, stretched belts and will tend to carry more than its fair share of load. It is therefore likely to fail prematurely.
- No dressing of any kind should be applied to the V-belt.
- V-belts should be stored in a clean, dry place and should not be exposed to heat or direct sunlight.
- Do not hang V-belts on nails or small pegs while in storage. Store flat if possible.

Alignment

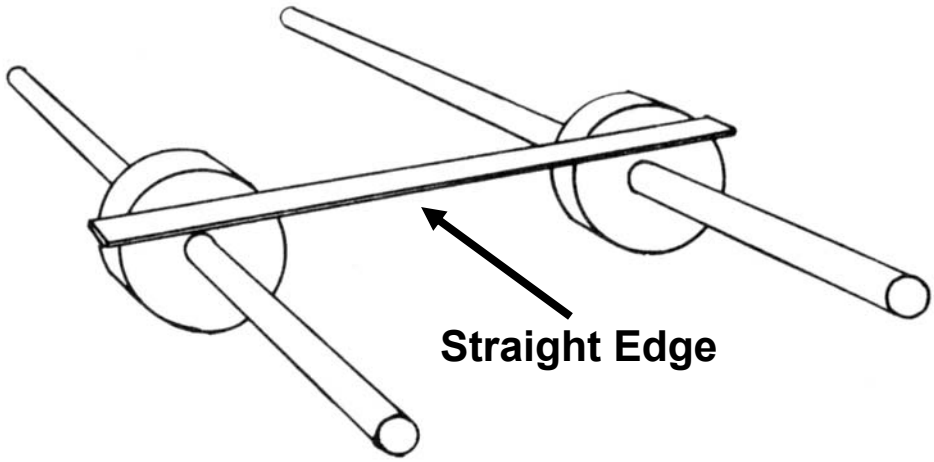
The correct alignment of the shafts and pulleys is vital to the operation of a V-belt drive. Misalignment of pulleys can occur in several ways.



The first step in aligning the pulleys is to check that the shafts are level and parallel. This should be done by using a spirit level on the exposed shafts to check for level, and then by using a feeler bar or gauge to check the distance between the shafts on both sides of the pulleys.



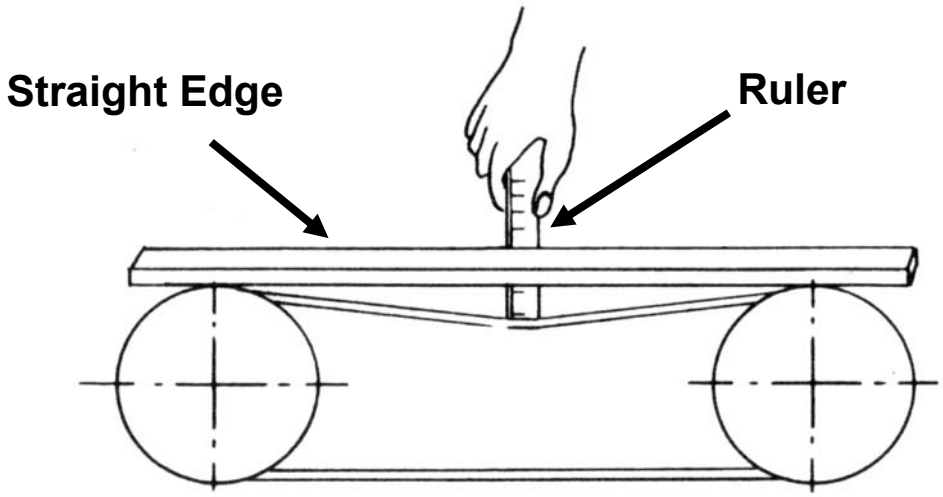
Once the shafts are parallel then the pulleys can be brought into line by using a straight edge across the faces as shown below.



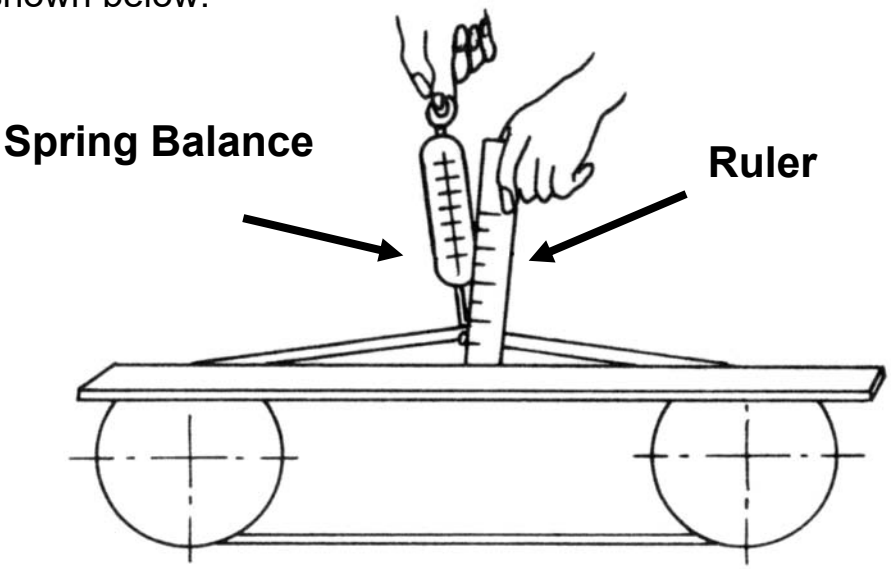
Reposition either of the pulleys until they are properly aligned. If either shaft is subject to end float make sure that it is in the normal running position when the alignment is checked. Rotate the shafts and check the alignment in several positions before it is finally accepted.

Belt Tension

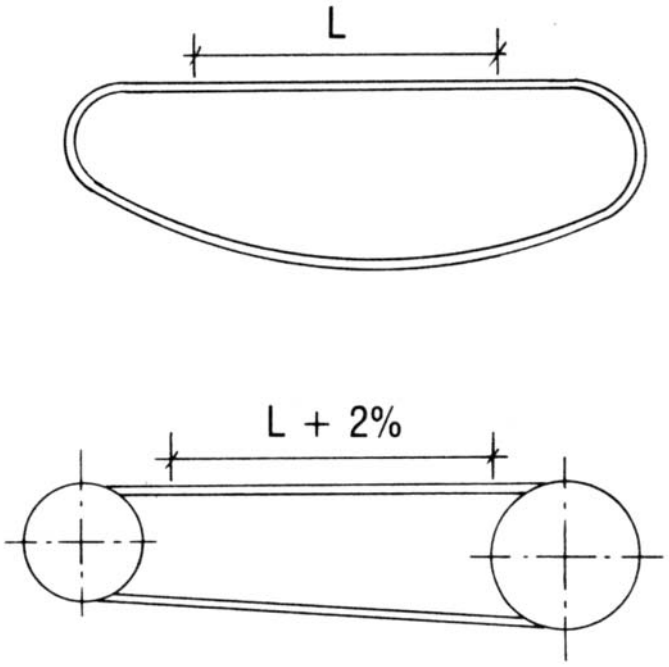
The most common is to depress the belt and measure the deflection using a ruler and a straight edge as shown below.



If this method is not considered to be sufficiently accurate then a spring balance can be used to deflect the belt against a specified pull as shown below.



A third alternative is to measure the elongation of the belt under tension. This is done by marking a defined length of the belt and then re-measuring between the same two marks when the belt is under tension as shown below.

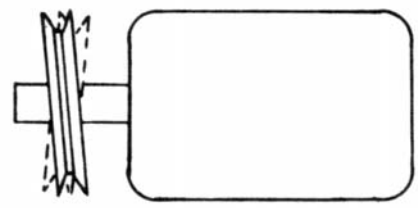


For normal drives the elongation of the belt should be around 2%. This may increase for high speed drives and should be checked against manufacturer's recommendations.

Installation of V-belt Drives

The following procedure should be adopted when installing V-belts.

1. Check the condition of the pulleys and check for wobble.



2. Align the pulleys according to the procedures outlined above.

3. Reduce the centre distance of the shafts by adjusting the position of the motor. If an idler pulley is used release the tension on the idler so that the belt can be fitted.

4. Fit the belt or belts taking care not to damage them in the process.

5. Adjust the belt tension as recommended above.

6. Run the unit for a short period, say 10 minutes, to allow the belt to seat correctly in the pulley grooves.

7. Readjust the tension.

8. Recheck the tension after 24 hours of operation.

9. Ensure that the drive is protected with a suitable guard at all times during operation. The guard should be provided with ventilation and secure against removal by unauthorised personnel.

Failure Patterns

Like most machine elements, V-belts do not have an unlimited life and will eventually wear out. Their normal life expectancy will depend on the operating conditions, speed and loading. When belts fail prematurely it is important to determine the precise cause of failure so that corrective action can be taken and performance improved for future operation. As with other machine elements an investigation of failure patterns can be divided into an analysis of symptoms and an analysis of causes.

Symptoms fall into two categories, those apparent during operation and those visible on shutdown of the machine and inspection of the drive.

Operating Symptoms

The following conditions can be considered to be evidence of malfunction.

Belt Slippage

Any tendency of a V-belt to slip will lead to rapid wear and premature failure. The common causes of belt slippage are insufficient tension, drive overload and the presence of oil or grease on the belt.

Belt Squeal

Squealing often accompanies belt slippage and is also caused by overload and insufficient tension. It may also occur when the arc of contact between the belt and pulley is insufficient..

Belt Ticking or Slapping

When the operation of a belt drive is accompanied by a ticking or a slapping sound this is often evidence that some form of mechanical interference is taking place. This may be due to poorly aligned guards or contact with other machine parts.

Belt Whipping

If a V-belt starts to whip it is likely to jump out of the pulley groove or to roll over and become damaged. Whipping may be the result of the drive centres being too far apart or due to wobbling pulleys. Sometimes a pulsating load will also cause belt whip, in which case the suitability of the drive should be reviewed.

Belts turned over

If the cords in the belt are broken during installation by levering the belt on to the pulley then the belt will stretch excessively and loose strength. Lack of tension may also allow a belt to roll over in the pulley groove. The affect of impulse loads and whipping may also cause the belt to roll over and this may be overcome by installing a spring loaded idler pulley. Once a belt has turned over it will be damaged and should be automatically discarded and replaced.

Belt Breakage

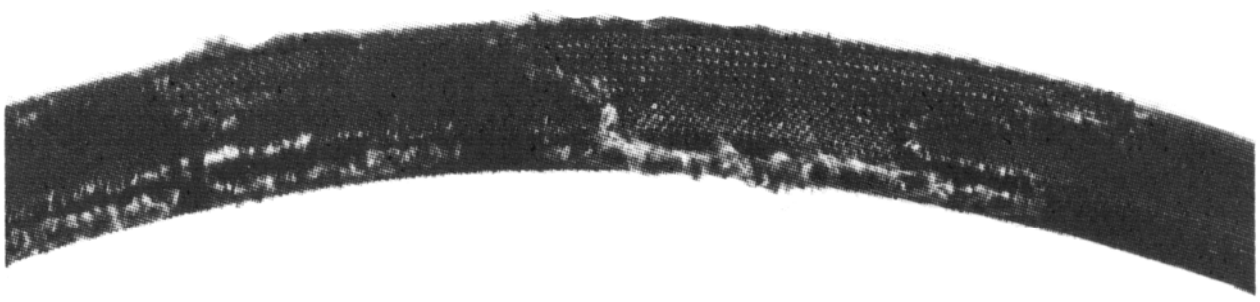
If a V-belt breaks immediate action is clearly required. Breakage may occur due to overloading in the form of shock loads or heavy starting loads but if the belt has been properly selected this should not occur. A belt that has been weakened by being levered on to the pulley is very likely to break prematurely. The presence of foreign objects or material may also damage the belt sufficiently for it to break.

Symptoms Found on Inspection

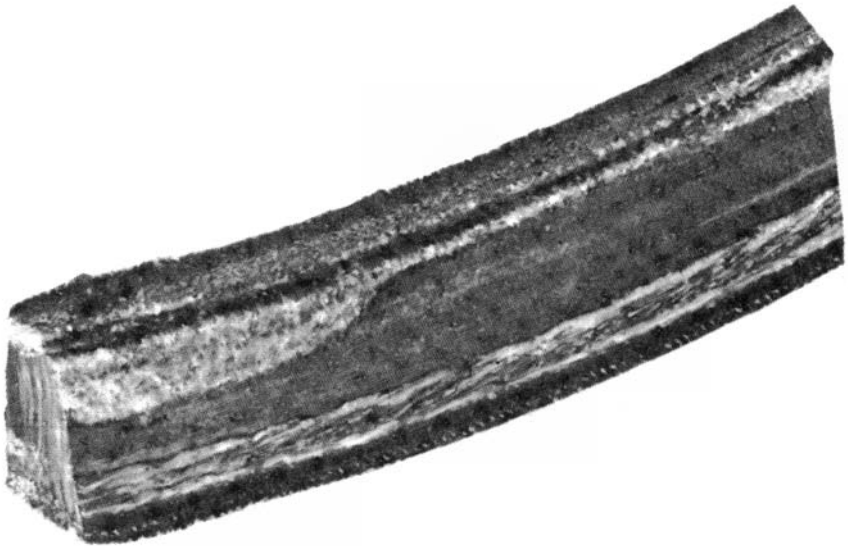
When the drive is shut down and examined the condition of the belts and pulleys will provide evidence from which the cause of failure may be determined. As for all machine elements, every failure is different in some way. However, the following conditions are commonly-found symptoms of V-belt malfunction.

Wear

A properly aligned and tensioned belt will wear along the sides and will eventually need to be replaced. If wear is rapid and leads to premature failure this may be due to misalignment or the presence of dust or other abrasives.

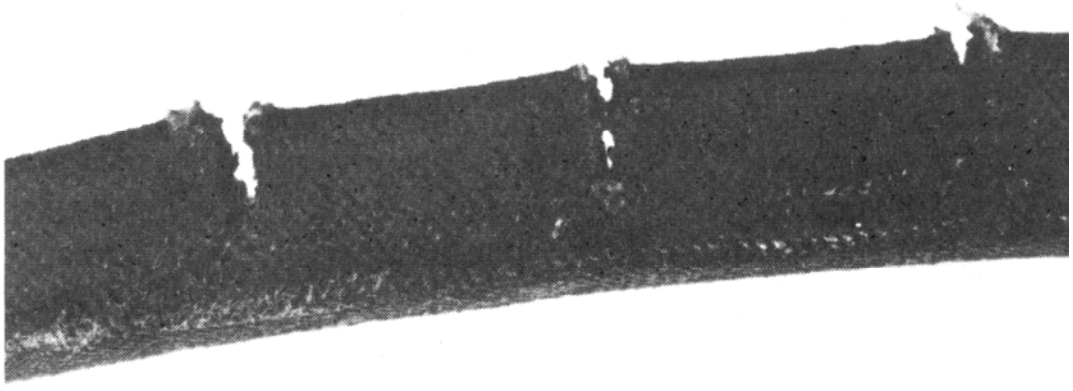


Uneven wear, as shown below, may be the result of either misalignment or damage to the pulley grooves.



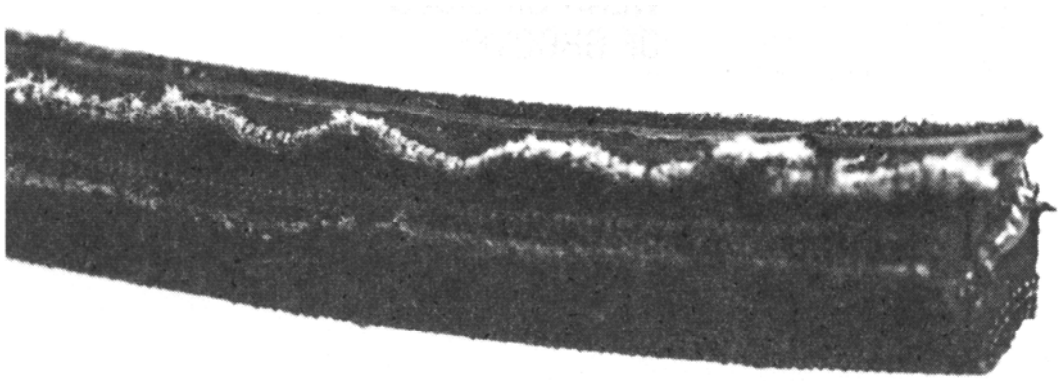
Cracking

When hardening and cracking appear on the underside of the belt this is usually caused by excessive heat build-up. This may be caused by poor ventilation or by slippage.



Fraying

Any tendency for the belt to fray along the edges or for the surface to tear and rupture as shown below is usually evidence that some mechanical interference is taking place or that the pulleys are worn or damaged in some way.



Stretching

If the belt stretches beyond the adjustment range of the tightener then the chances are that the internal cords are broken and the belt should be replaced.

Swelling

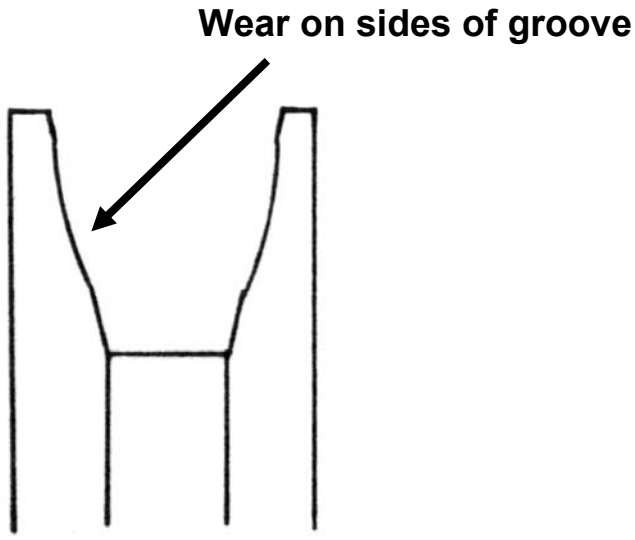
If the belt material becomes swollen or spongy it is likely that it has been exposed to oil, grease or other chemicals.

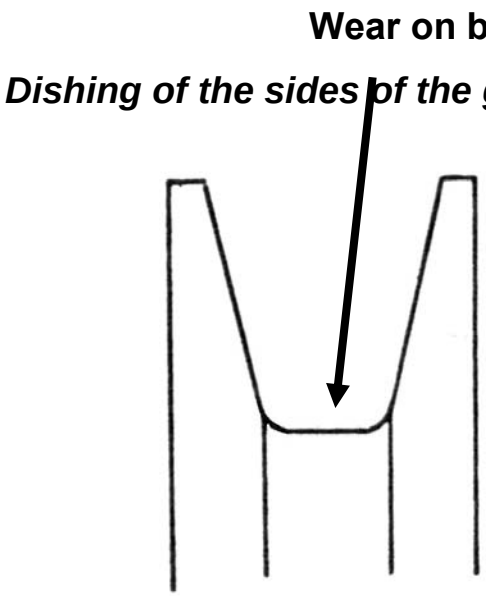
Burns

If the belt shows evidence of burning in one particular area this may indicate either that the belt has slipped during start-up or that the driven unit has jammed or stalled causing the belt to burn when the drive has run on.

Worn Sheaves

In addition to belt damage the pulley grooves may show evidence of wear. This may appear on the sides of the groove, or as a shiny surface on the bottom of the groove which indicates that the belt has been bottoming. A pulley which shows excessive wear of this type should be replaced and new belts installed.





Evidence that the belt has been bottoming.

Causes of Failure

The common causes of the types of V-belt failure listed above can be summarised as follows:

Misalignment

As with most mechanisms good alignment is critical. Misalignment of pulleys will cause rapid wear and damage to the belt surface, although alignment tolerances for V-belts are not as stringent as for other drives. The manufacturer's instructions should be consulted to establish the appropriate limits for a particular machine.

Incorrect Tension

Insufficient tension will cause the belt to slip and may also lead to belt breakage due to the grab-slip effect. Over-tensioning will increase the wear rate and shorten belt life and may also cause overloading of the shaft bearings.

Interference

Any contact between the belt and other part of the machine or the belt guard will cause rapid belt damage in the form of fraying or excessive wear of the belt surface.

Foreign Material

Belts and pulley grooves should be kept clean and free from dirt, grit and other contaminants which may cause accelerated wear or even belt breakage. Oil or other chemicals will attack the belt and cause deterioration of the material. A well-constructed belt guard should help to exclude foreign material.

Damaged Pulleys

Pulley grooves should be free from nicks, burrs, chips and other damage that may affect belts.

Overloading

The life of a belt drive will be reduced if it is subjected to loads or speeds beyond its designed capacity. Excessive wear and belt breakage is likely to occur if the loads and speeds are too high.

Overheating

Excessive heat is an enemy of V-belts and can lead to their rapid deterioration. Guards should be made of mesh to allow adequate ventilation, and belt slippage should be corrected as quickly as possible before the heat build-up affects the belt material.

Summary of the common symptoms and causes of V-belt failure

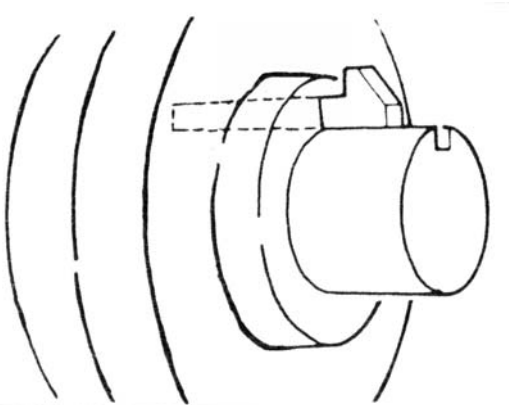
Symptoms		Causes
Operating	**Inspection**	
Slipping	Wear	Misalignment
Squealing	Cracking	Incorrect tension
Ticking	Fraying	Interference
Whipping	Stretching	Foreign material
Turn-over	Swelling	Overloading
Breakage	Burns	Overloading
	Worn sheaves	Damaged sheaves

Driving Members

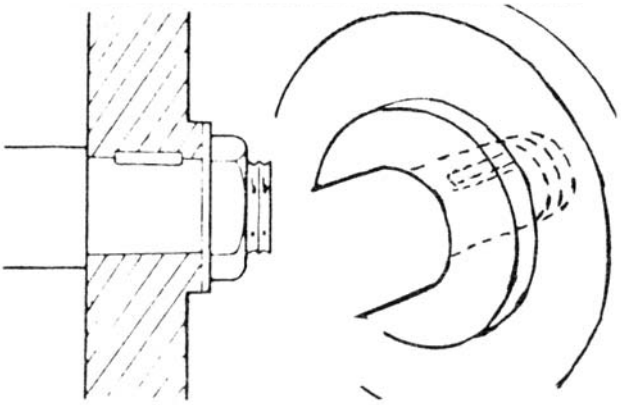
Methods of Securing

Drive wheels need to be located so that the driving power can be transmitted.

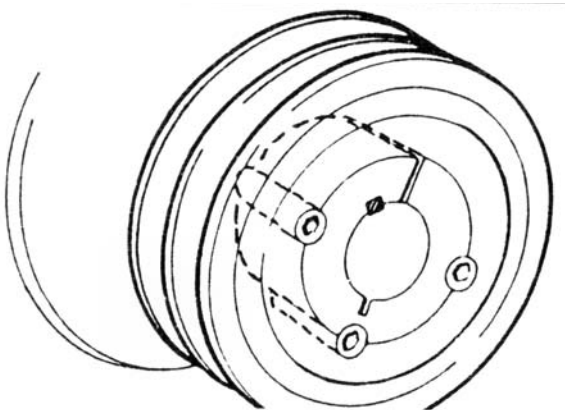
Tapered keys can be use to clamp a driving wheel in position along the shaft. They are normally used on larger shafts.



When plain keys are used, the driving wheel is normally held in position along the shaft by clamping against a shoulder. These are normally used for smaller shafts.

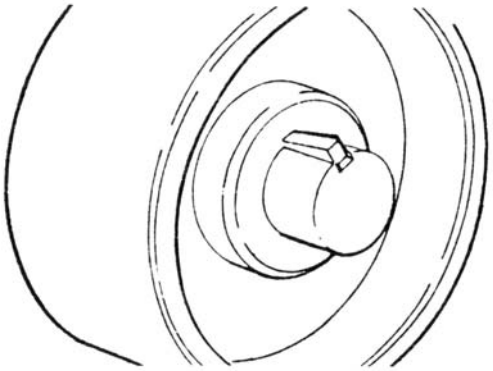


Tapered locking bushes are used to clamp a driving wheel in position along the shaft. They are sometimes keyed onto the shaft.

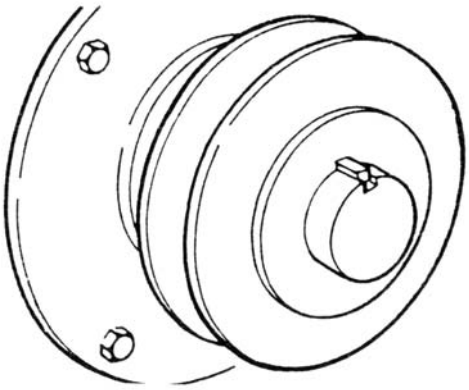


Types of Driving Wheel

Flat belt pulleys are normally held in position by a tapered key.

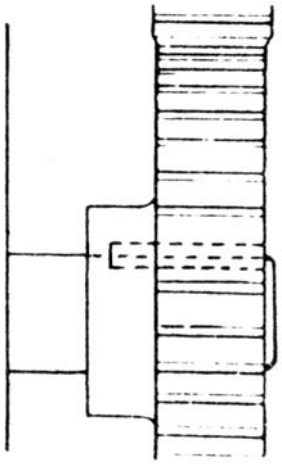


V-belt pulleys can be held in position by a key or tapered locking bush.



Chain wheels are normally held in position by plain or tapered key, but tapered locking bushes are sometimes used.

Gear wheels are normally held in position by plain or tapered keys.

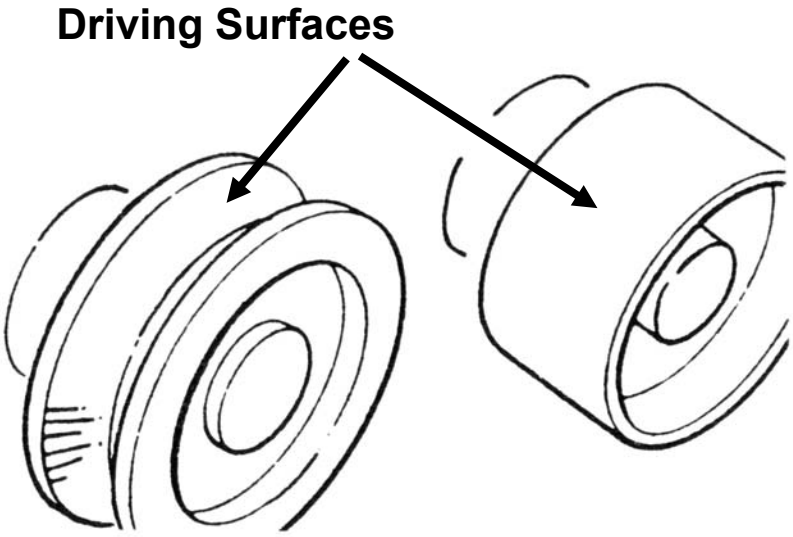


Installing and Tensioning Belts

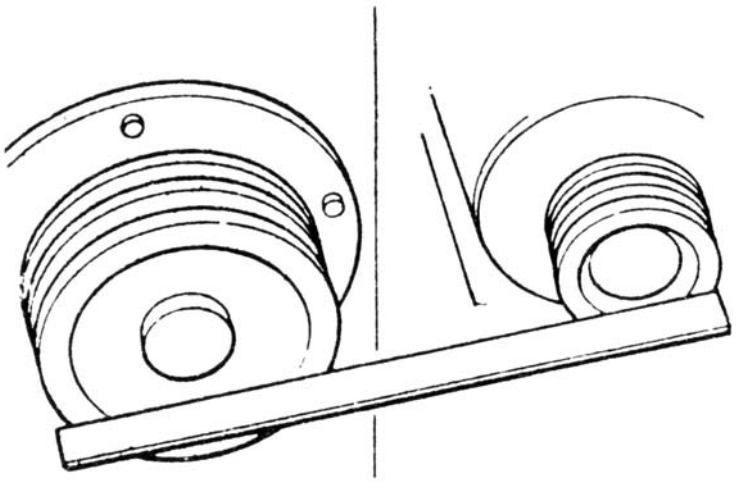
Installing Belts

Before installing any belt:

- Check that the safety precautions have been followed.
- Slacken off the tension adjustment completely.
- Clean the driving surfaces of the pulley.

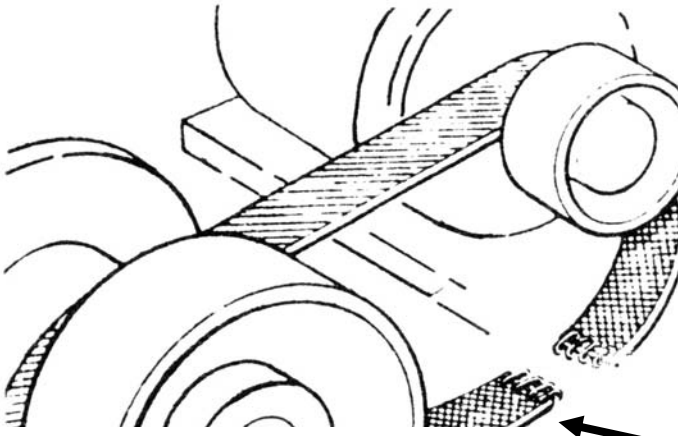


- Check the alignment of the pulleys.

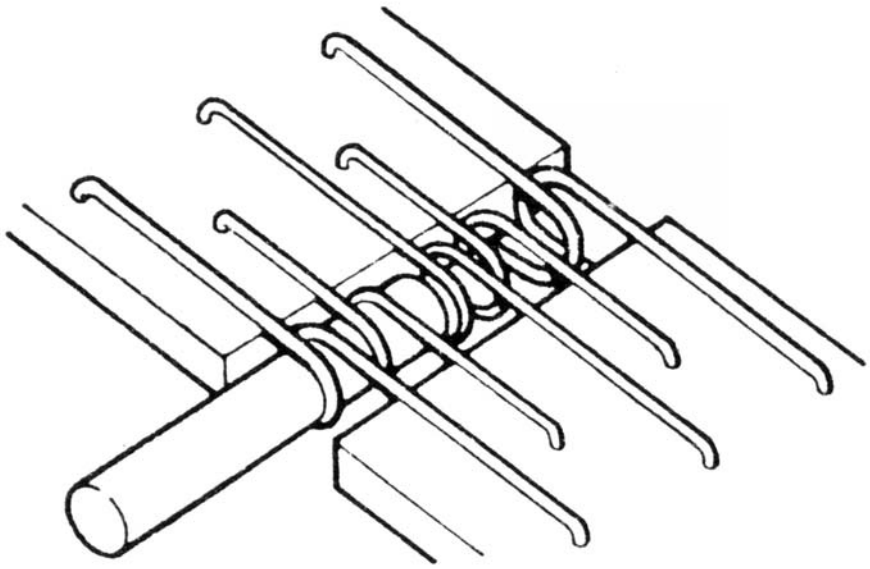


When installing a metal laced flat belt:

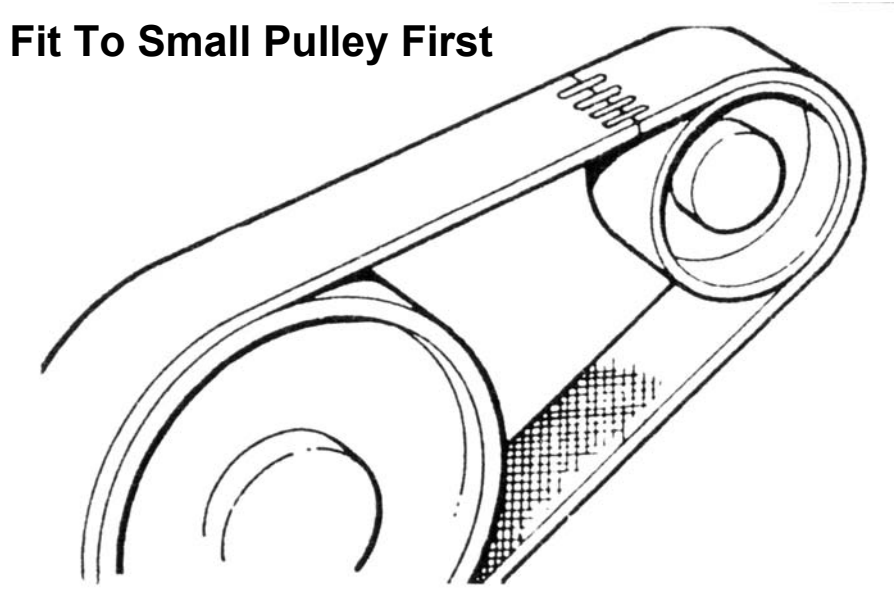
- Place the belt around the shafts beside the pulleys with the rough side against the pulleys.



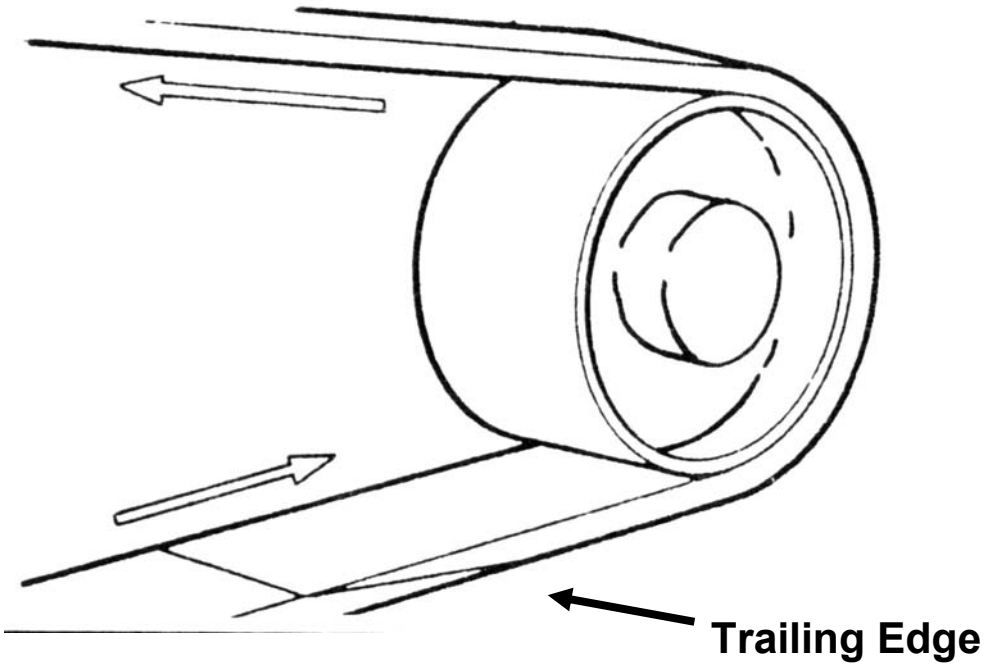
- Mesh the loops of the metal lacings together.
- Fit the joining pin through the loops. A pin of the correct material must be used.



- Run the belt onto the pulleys.

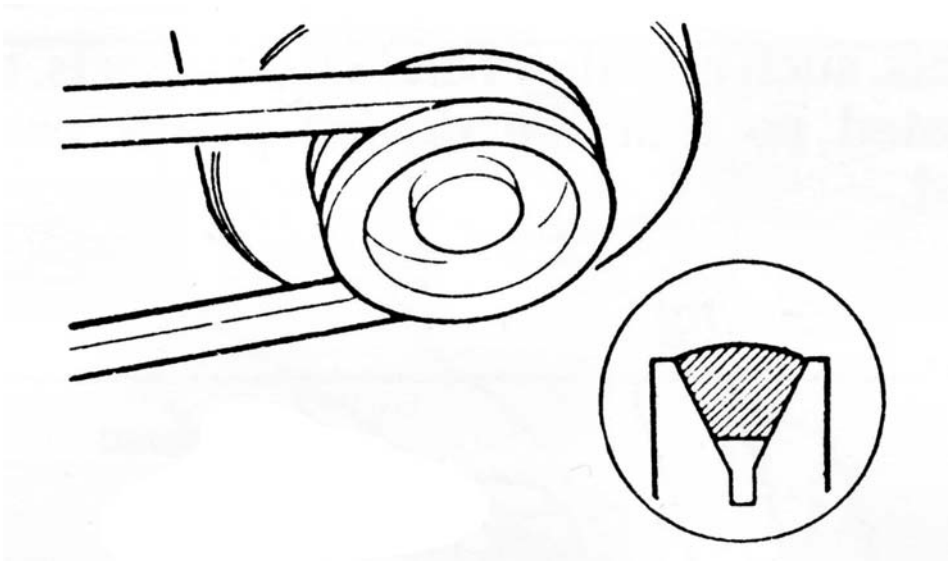


When installing a scarf joined flat belt, the rough side of the belt and the trailing edge of the join must both be inside.



When installing a V-belt:

- Check that the belt is of the correct length and angle of taper.
- Fit the belt into the grooves of the pulley.

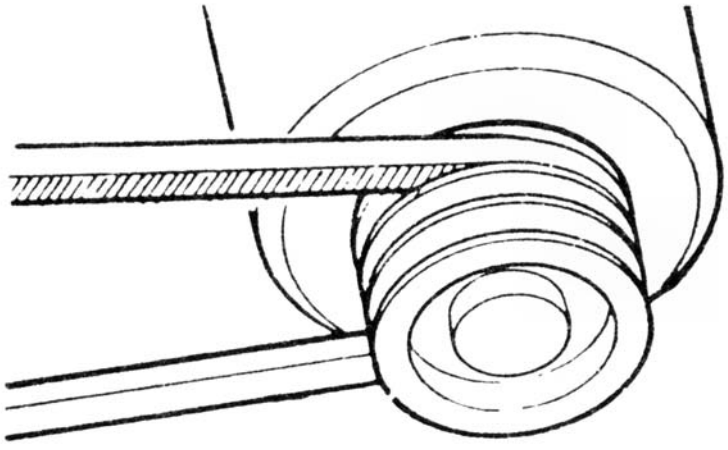


When installing a set of V-belts:

- Check that the belts are a matched set.
- Install the belts starting from the inside pulley and working outwards.

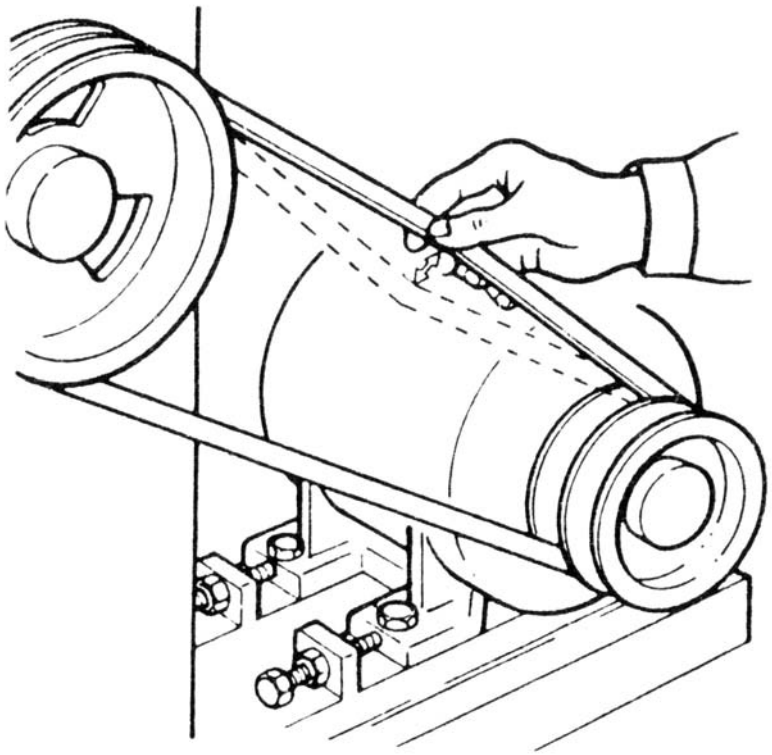
NOTE

Mountings must be slackened to avoid straining belts.



Tensioning Belts

Belts must be tensioned correctly to transfer the drive, and prevent unnecessary wear. As they stretch in use, their tension must be regularly checked and adjusted.

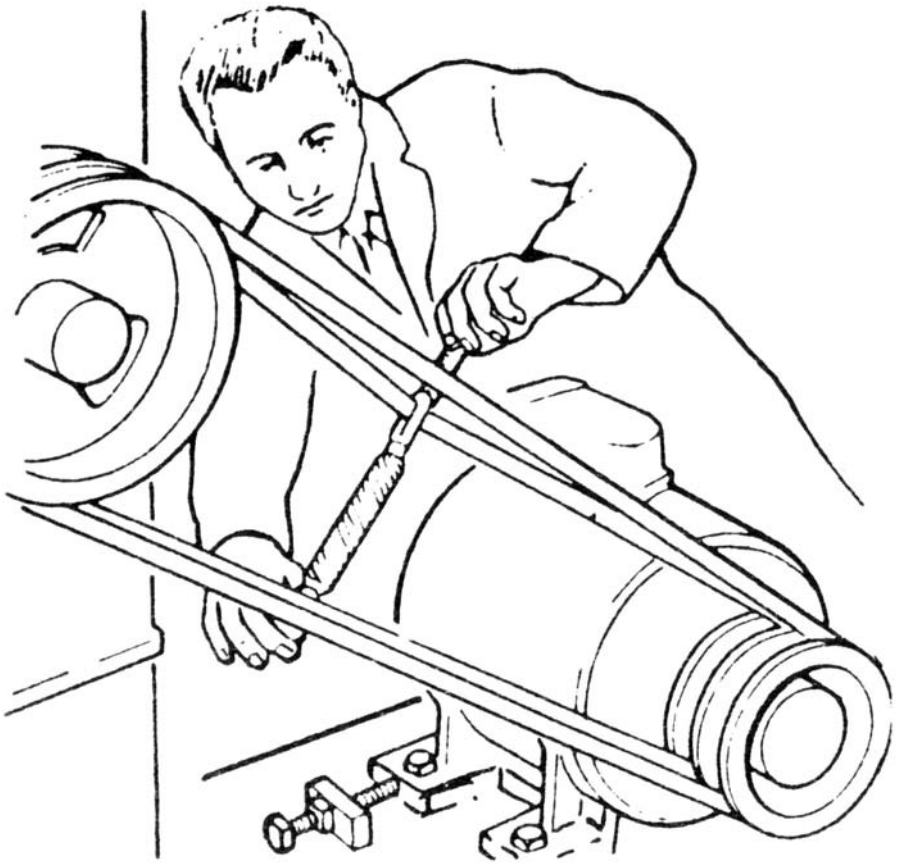


To measure deflection in a slack belt:

- Check the specified deflection in the manufacturer's instructions.
- Find the middle of the longest span of belt between pulleys.
- Push this midpoint inwards, then pull it out and note the total deflection, which should indicate the tension.
- Adjust the tension as necessary.

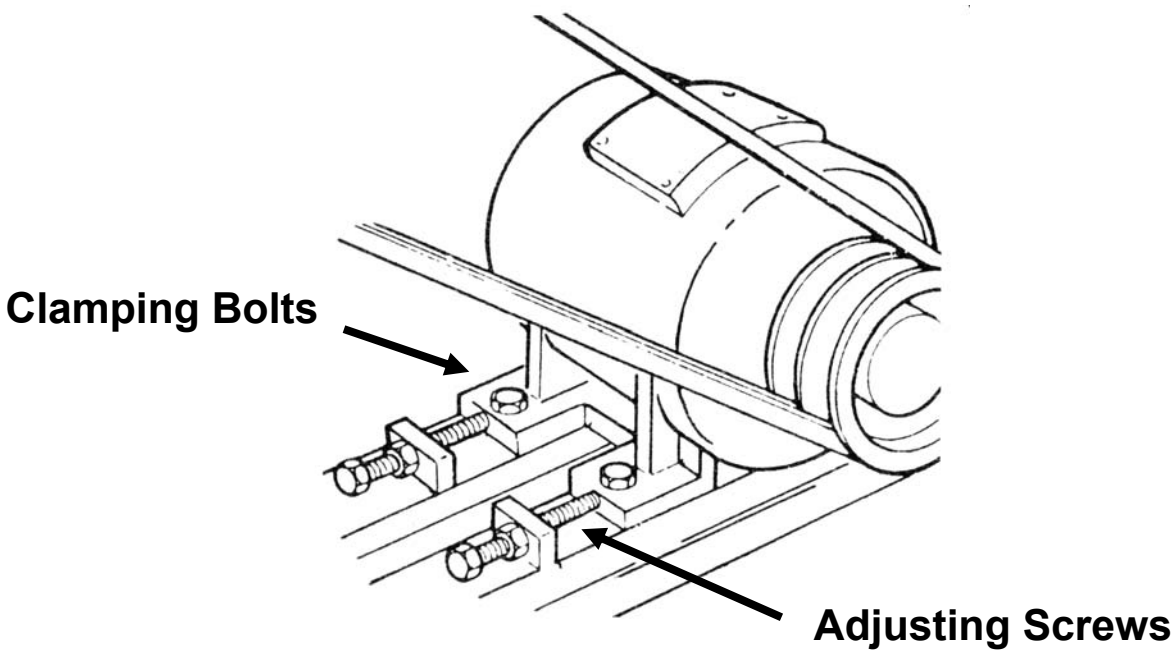
To measure tension in a taut belt as follows:

- Check the manufacturer's instructions for the deflection used and the force needed to reach it.
- Find the middle of the longest span of belt between the pulleys.
- Attach a spring balance to this point.
- Pull the belt out to the required deflection and note the reading.
- Adjust tension as necessary.

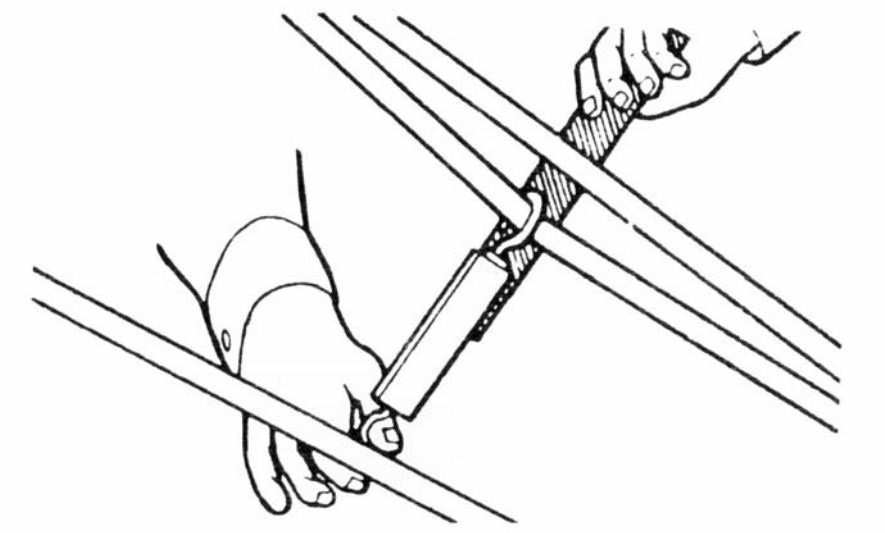


To adjust belt tension:

- Loosen the locknuts
- Slacken off the clamping bolts.
- Move the pulley with the adjusting screws to alter the tension. The adjusting screws must be turned equally to keep the pulleys correctly aligned.



- Check the tension
- Readjust until correct
- Tighten the clamping bolts
- Tighten the locknuts

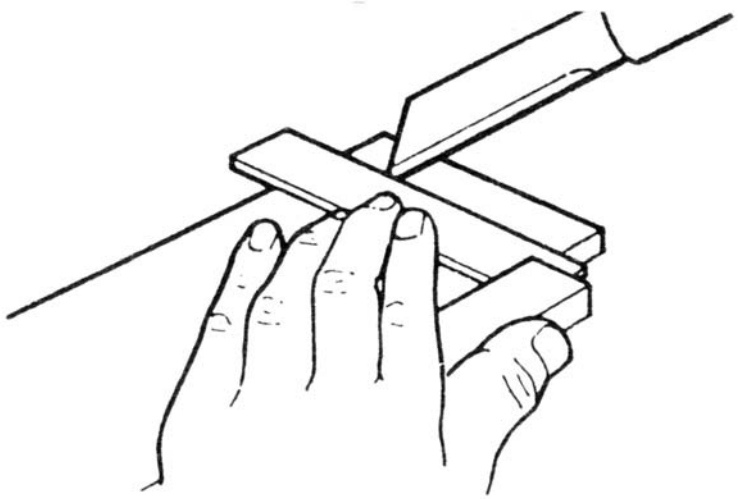


Flat belt Joints

Cutting a belt to length.

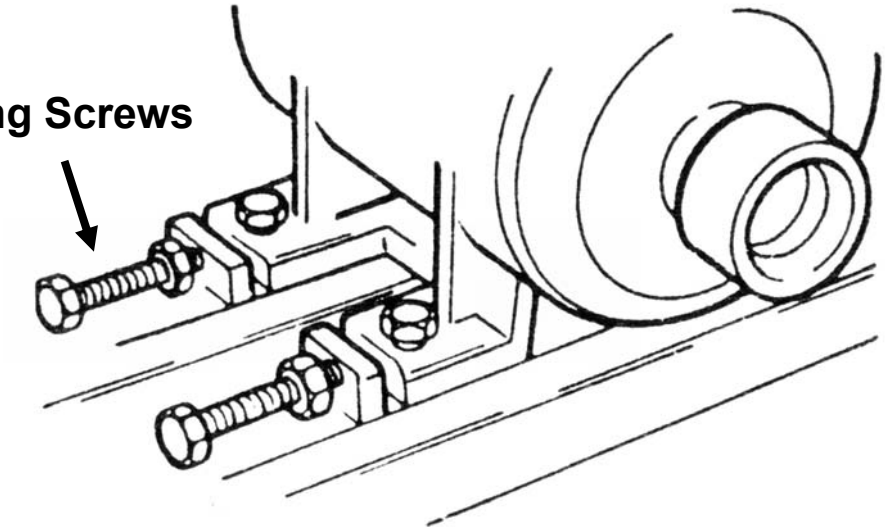
When measuring the belt length for a complete loop:

- Check that the belting is the correct size and type for the pulleys.
- Cut one end of the belt square.

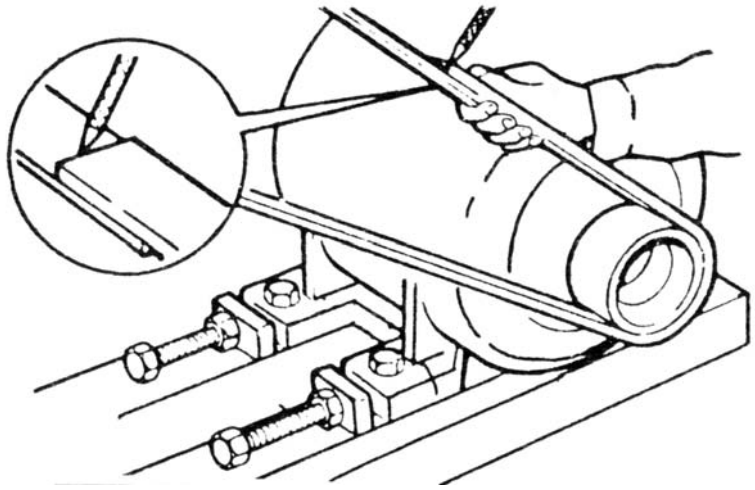


- Slacken off the drive tension completely.

Adjusting Screws

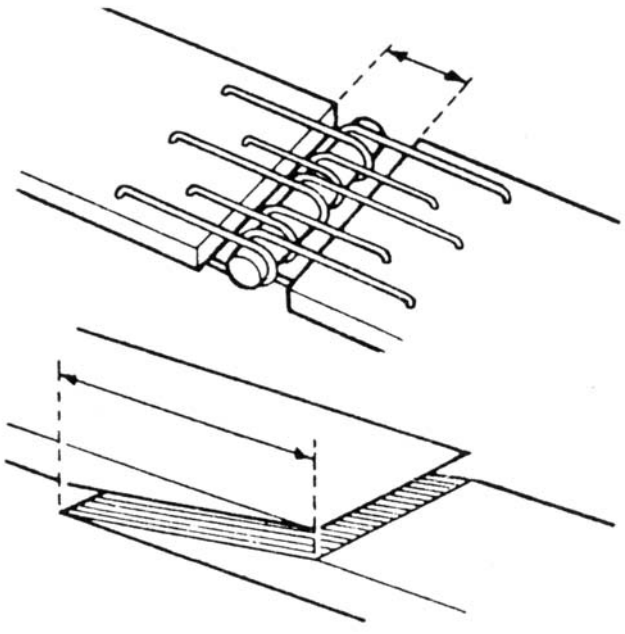


- Place the belt over the pulleys with the rough side against the pulleys.
- Overlap the ends with the square end outside.
- Hold the belt taut and mark the position of the square end on the back of the inner length.



When cutting a belt to the required length:

- Measure the belt length required for a complete loop.
- Check the gap or overlap required by the joint.
- Subtract the gap length from, or add the overlap length to, the length of the belt required for a complete loop.
- Cut the belt to length.

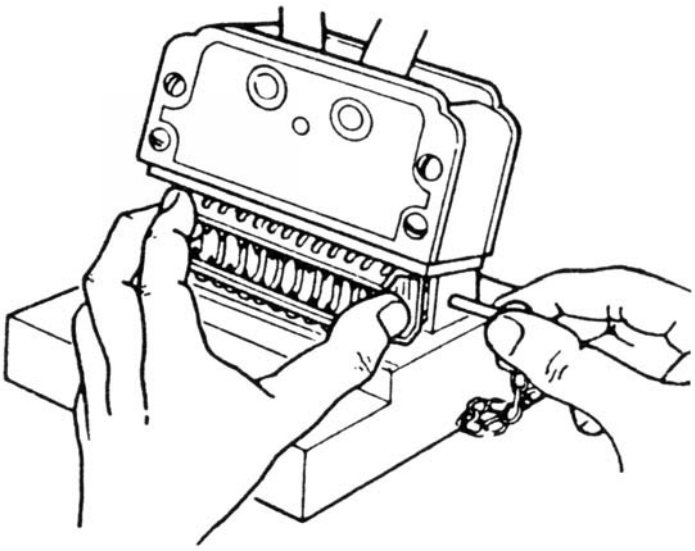


Steel Lacings

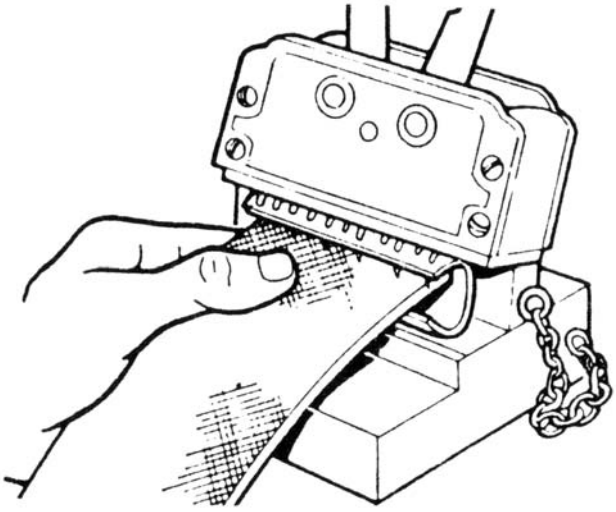
Steel lacings are used on belts which need to be removed. The lacing set must be the correct size for the thickness of belt.

When fitting a lacing to a belt:

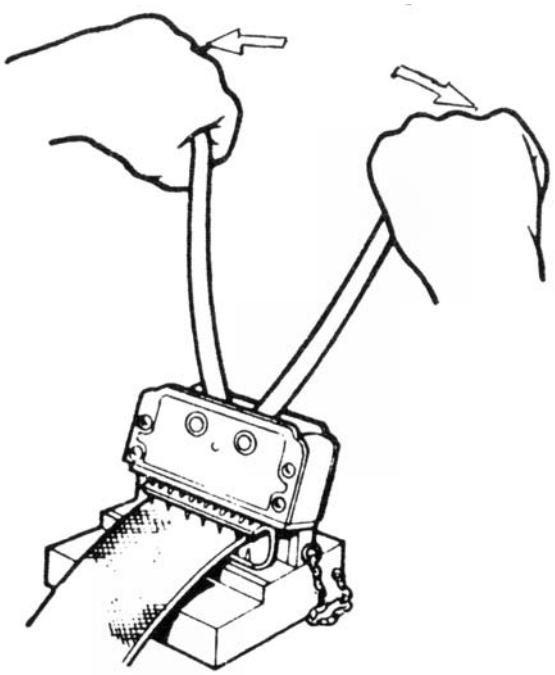
- Press the lacing centrally into the jaws of the lacing machining.
- Fit the pin into the side of the jaws to hold the lacing in the machine.



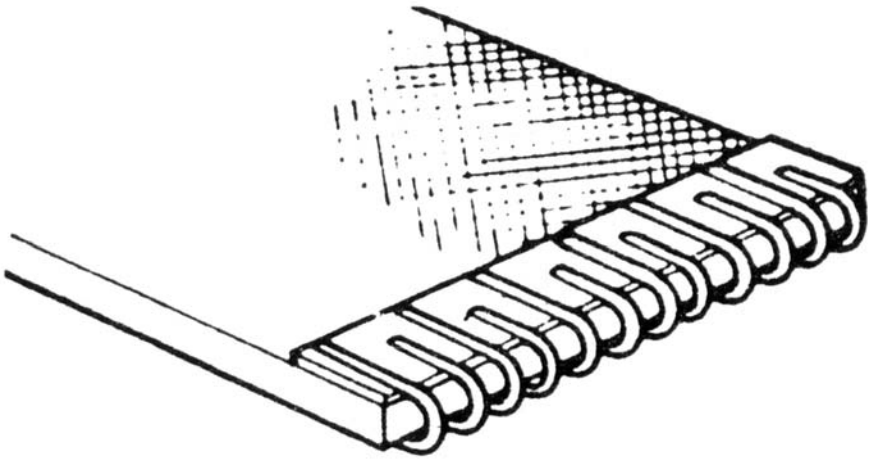
- Place the belt centrally between the jaws of the lacing machine and hard against the pin or lacing.



- Operate the machine to press the lacing into the belt until it is flush with the belt.



- Trim the edges of the lacing to the width of the belt.

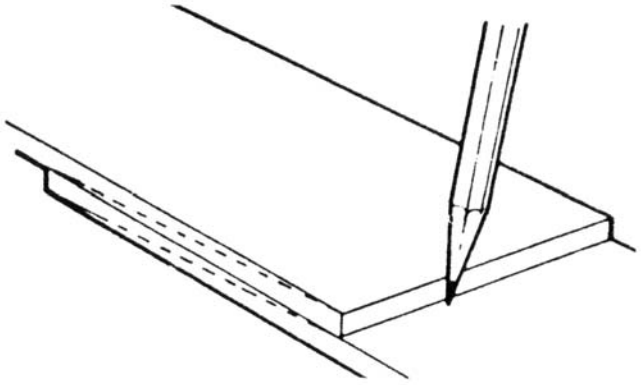


Scarf Joints

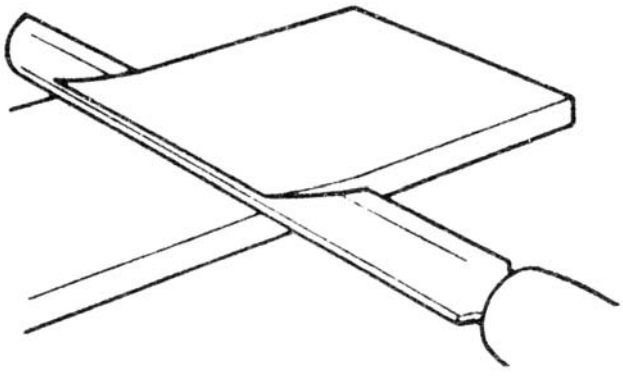
A scarf joint is used when a smooth drive is required or part of the belt is to be replaced.

When tapering the belt ends:

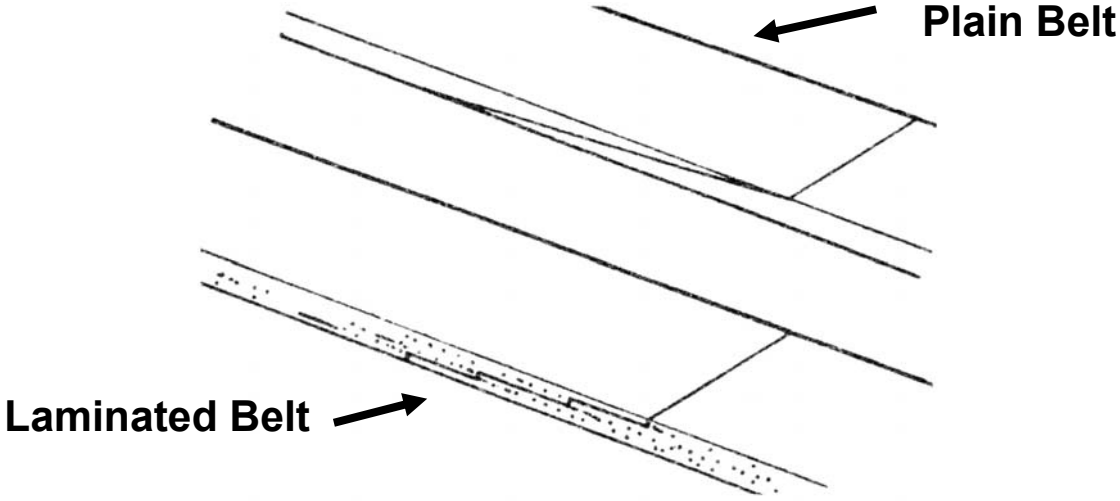
- Check the length of taper required.
- Mark the beginning of the taper on the belt.



- Cut away the excess material.
- Cut the mating taper on the other end of the belt.



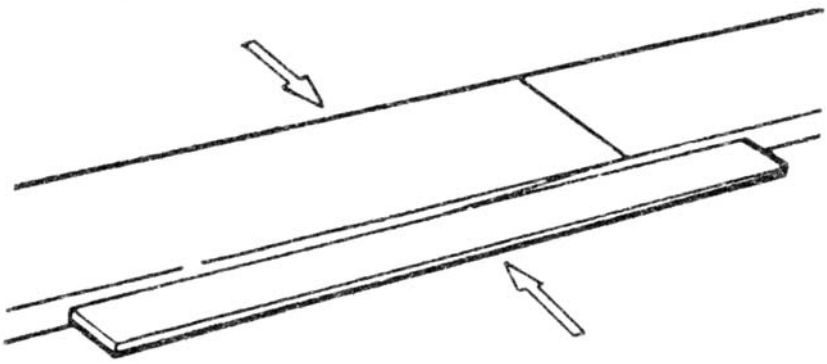
- Place the ends together and check that they fit together properly. If necessary remove more material.



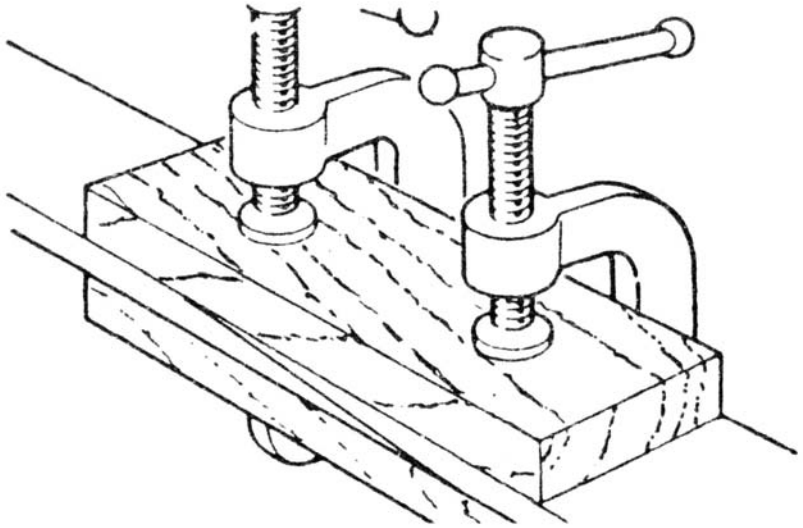
Making a Scarf Joint

When using adhesives:

- Coat both tapered surfaces with the appropriate adhesive.
- Allow the adhesive to become tacky.
- Place the tapered faces together and push the edge of the belt against a straight edge so that the belt is straight.

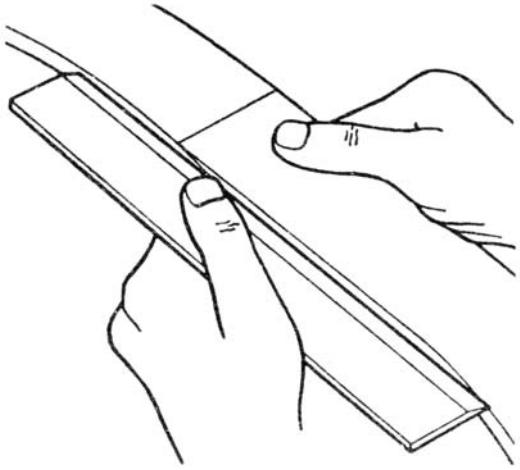


- Clamp the joint between wooden blocks and allow the adhesive to dry.

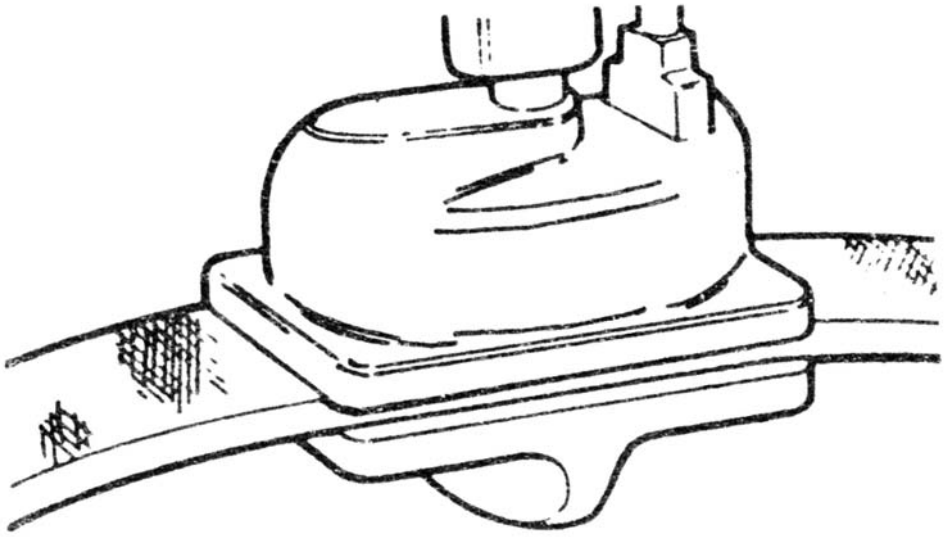


When vulcanising:

- Check the manufacturer's instructions for the vulcanising equipment.
- Coat both tapered surfaces with the vulcanising material.
- Place the tapered faces together and push the edge of the belt against a straight edge so that the belt is straight.



- Clamp the joint in the vulcanising press and heat the joint for the required time.



When sewing:

- Make the joint with adhesive.
- Sew through the joint with the correct strength of cord using a heavy duty sewing machine.