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ABSTRACT

This packet of five learning modules on machine components is one of 20 such packets developed for apprenticeship training for stationary engineers. Introductory materials are a complete listing of all available modules and a supplementary reference list. Each module contains some or all of these components: goal, performance indicators, statement of purpose, objectives, learning activities (activities the student is expected to perform and their purpose), information summary, information sheets, worksheets, self-test, self-test answers, posttest, and posttest answers. The five training modules cover shafts, bearings, seals and gaskets, chain shafts, and belts and pulleys. (YLB)

APPRENTICESHIP

STATIONARY ENGINEERS

RELATED TRAINING MODULES

10.1 - 10.5 MACHINE COMPONENTS

STATEMENT OF ASSURANCE

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STATEMENT OF DEVELOPMENT

THIS PROJECT WAS DEVELOPED AND PRODUCED UNDER A SUB-CONTRACT FOR THE OREGON DEPARTMENT OF EDUCATION BY LANE COMMUNITY COLLEGE, APPRENTICESHIP DIVISION, EUGENE, OREGON, 1984.

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APPRENTICESHIP

STATIONARY ENGINEERS
RELATED TRAINING MODULES

COMPUTERS

1.1 Digital Language
1.2 Digital Logic
1.3 Computer Overview
1.4 Computer Software

SAFETY

2.1 General Safety
2.2 Hand Tool Safety
2.3 Power Tool Safety
2.4 Fire Safety
2.5 Hygiene Safety
2.6 Safety and Electricity

DRAWING

3.1 Types of Drawings and Views
3.2 Blueprint Reading/Working Drawings
3.3 Scaling and Dimensioning
3.4 Machine and Welding Symbols

TOOLS

4.1 Measuring, Layout and Leveling Tools
4.2 Boring and Drilling Tools
4.3 Cutting Tools, Files and Abrasive
4.4 Holding and Fastening Tools
4.5 Fastening Devices

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5.10 Kirchoff's Current Law
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5.15 Switches and Relays
5.16 Basics of Alternating Currents
5.17 Magnetism

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6.3 Individual Strengths
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6.7 Resumes
6.8 Interviews
6.9 Work Habits and Attitudes
6.10 Wider Influences and Responsibilities
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6.12 Expectations

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7.3 Addition and Subtraction of Common Fraction and Mixed Numbers
7.4 Multiplication and Division of Common Fractions and Whole and Mixed Numbers
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7.6 Percent
7.7 Mathematical Formulas
7.8 Ratio and Proportion
7.9 Perimeters, Areas and Volumes
7.10 Circumference and Wide Area of Circles
7.11 Area of Planes, Figures, and Volumes of Solid Figures
7.12 Graphs
7.13 Basic Trigonometry
7.14 Metrics

HYDRAULICS

8.1 Hydraulics - Lever
8.2 Hydraulics - Transmission of Force
8.3 Hydraulics - Symbols
8.4 Hydraulics - Basic Systems
8.5 Hydraulics - Pumps
8.6 Hydraulics - Pressure Relief Valve
8.7 Hydraulics - Reservoirs
8.8 Hydraulics - Directional Control Valve
8.9 Hydraulics - Cylinders
8.10 Hydraulics - Forces, Area, Pressure
8.11 Hydraulics - Conductors and Connectors
8.12 Hydraulics - Troubleshooting
8.13 Hydraulics - Maintenance

STATIONARY ENGINEER
SUPPLEMENTARY REFERENCE DIRECTORY

Note: All reference packets are numbered on the upper right-hand corner of the respective cover page.

Supplementary Packet #	Description	Related Training Module
12.1	Correspondence Course, Lecture 1, Sec. 2, Steam Generators, Types of Boilers I, S.A.I.T., Calgary, Alberta, Canada	12.1 Boilers, Fire Tube Type
12.2	Correspondence Course, Lecture 2, Sec. 2, Steam Generators, Types of Boilers II, S.A.I.T., Calgary, Alberta, Canada	12.2 Boilers, Water Tube Type
12.3	Correspondence Course, Lecture 2, Sec. 2, Steam Generators, Boiler Construction & Erection, S.A.I.T., Calgary, Alberta, Canada	12.3 Boilers, Construction
12.4	Correspondence Course, Lecture 4, Sec. 2, Steam Generators, Boiler Fittings II, S.A.I.T., Calgary, Alberta, Canada	12.4 Boilers, Fittings
12.4	Corresondence Course, Lecture 4, Sec. 2, Steam Generators, Boiler Fitting I, S.A.I.T., Calgary, Alberta, Canada	12.4 Boilers, Fittings
12.5	Correspondence Course, Lecture 10, Sec. 2, Steam Generation, Boiler Operation, Maintenance, Inspection, S.A.I.T., Calgary, Alberta, Canada	12.5 Boilers, Operation
12.7	Correspondence Course, Lecture 3, Sec. 2, Steam Generation, Boiler Details, S.A.I.T., Calgary, Alberta, Canada	12.7 Boilers Heat Recovery Systems
12.8	Refer to reference packet 14.3/12.8	
		PUMPS
13.1 13.2 13.4 13.6 13.7	Correspondence Course, Lecture 9, Sec. 2, Steam Generator, Power Plant Pumps, S.A.I.T., Calgary, Alberta, Canada	13.1 Types & Classification 13.2 Applications 13.4 Calculating Heat & Flow 13.6 Monitoring & Troubleshooting 13.7 Maintenance
13.3 13.5	Correspondence Course, Lecture 6, Sec. 3, Steam Generators, Pumps, S.A.I.T., Calgary, Alberta, Canada	13.3 Construction 13.5 Operation

Supplementary Packet #	Description	Related Training Module
14.3 12.8	Correspondence Course, Lecture 6, Section 3, Steam Generators, Steam Generator Controls, S.A.I.T., Calgary, Alberta, Canada	14.3 Steam, Transport 12.8 Boilers, Instruments & Controls
14.4	Correspondence Course, Lecture 11, Section 2, Steam Generators, Piping II, S.A.I.T., Calgary, Alberta, Canada	14.4 Steam, Purification
15.1	Correspondence Course, Lecture 1, Sec. 4, Prime Movers & Auxiliaries, Steam Turbines, S.A.I.T., Calgary, Alberta, Canada	15.1 Steam Turbines, Types
15.2	Correspondence Course, Lecture 4, Sec. 3, Prime Movers, Steam Turbines I, S.A.I.T., Calgary, Alberta, Canada	15.2 Steam Turbines, Components
15.3	Correspondence Course, Lecture 2, Sec. 4, Prime Movers & Auxiliaries, Steam Turbine Auxiliaries, S.A.I.T., Calgary, Alberta, Canada	15.3 Steam Turbines, Auxiliaries
15.4	Correspondence Course, Lecture 6, Sec. 3, Prime Movers, Steam Turbine Operation & Maintenance, S.A.I.T., Calgary, Alberta, Canada	15.4 Steam Turbines, Operation & Maintenance
15.5	Correspondence Course, Lecture 8, Sec. 3, Prime Movers, Gas Turbines, S.A.I.T., Calgary, Alberta, Canada	15.5 Gas Turbines
16.2	Boilers Fired with Wood and Bark Residues, D.D. Junge, F.R.L., O.S.U. 1975	16.2 Combustion Types of Fuel
16.2	Correspondence Course, Lecture 5, Sec. 2, Steam Generators, Fuel Combustion, S.A.I.T., Calgary, Alberta, Canada	16.2 Combustion Types of Fuel
16.3	Correspondence Course, Lecture 5, Sec. 2, Plant Services, Fuel & Combustion, S.A.I.T., Calgary, Alberta, Canada	16.3 Combustion, Air & Fuel Gases
17.1	Correspondence Course, Lecture 12, Sec. 3, Steam Generation, Water Treatment, S.A.I.T., Calgary, Alberta, Canada	17.1 Feed water, Types & Operation
17.2	Correspondence Course, Lecture 12, Sec. 2, Steam Generation, Water Treatment, S.A.I.T., Calgary, Alberta, Canada	17.2 Feed water, Water Treatments

Supplementary Packet #	Description	Related Training Module
17.3	Correspondence Course, Lecture 7, Sec. 2, Steam Generators, Boiler Feed Water Treatment, S.A.I.T., Calgary, Alberta, Canada	17.3 Feed Water, Testing
18.1	Correspondence Course, Lecture 2, Sec. 5, Electricity, Direct Current Machines, S.A.I.T., Calgary, Alberta, Canada	18.1 Generators, Types & Construction
18.1 18.2	Correspondence Course, Lecture 4, Sec. 5, Electricity, Alternating Current Generators, S.A.I.T., Calgary, Alberta, Canada	18.1 Generators, Types & Construction 18.2 Generators, Operation
19.1	Corrspondence Course, Lecture 5, Sec. 4, Prime Movers & Auxiliaries, Air Compressor I, S.A.I.T., Calgary, Alberta, Canada	19.1 Air Compressors, Types
19.1 19.2	Correspondence Course, Lecture 6, Sec. 4, Prime Movers & Auxiliaries, Air Compressors II, S.A.I.T., Calgary, Alberta, Canada	19.1 Air Compressors, Types 19.2 Air Compressors, Operation & Maintenance
20.1	Basic Electronics, Power Transformers, EL-BE-51	20.1 Transformers
21.1	Correspondence Course, Lecture 7, Sec. 5, Electricity, Switchgear & Circuit, Protective Equipment, S.A.I.T., Calgary, Alberta, Canada	21.1 Circuit Protection
22.1	Correspondence Course, Lecture 10, Sec. 3, Prime Movers, Power Plant Erection & Installation, S.A.I.T., Calgary, Alberta, Canada	22.1 Installation Foundations

RECOMMENDATIONS FOR USING TRAINING MODULES

The following pages list modules and their corresponding numbers for this particular apprenticeship trade. As related training classroom hours vary for different reasons throughout the state, we recommend that the individual apprenticeship committees divide the total packets to fit their individual class schedules.

There are over 130 modules available. Apprentices can complete the whole set by the end of their indentured apprenticeships. Some apprentices may already have knowledge and skills that are covered in particular modules. In those cases, perhaps credit could be granted for those subjects, allowing apprentcies to advance to the remaining modules.

We suggest the the apprenticeship instructors assign the modules in numerical order to make this learning tool most effective.

SUPPLEMENTARY INFORMATION

ON CASSETTE TAPES

Tape 1: Fire Tube Boilers - Water Tube Boilers and Boiler Manholes and Safety Precautions

Tape 2: Boiler Fittings, Valves, Injectors, Pumps and Steam Traps

Tape 3: Combustion, Boiler Care and Heat Transfer and Feed Water Types

Tape 4: Boiler Safety and Steam Turbines

NOTE: The above cassette tapes are intended as additional reference material for the respective modules, as indicated, and not designated as a required assignment.

INSTRUCTIONAL LEARNING SYSTEMS

10.1

MACHINE COMPONENTS -- SHAFTS

Goal:

The apprentice will be able to describe machine components that relate to shafts.

Performance Indicators:

1. Describe shaft inspection for damage or failure.
2. Describe considerations in supporting a shaft.
3. Describe shaft alignment.
4. Describe keyways and keys for mounting equipment on a shaft.
5. Describe camshafts.

103-B SHAFT INSPECTION

Shafts are generally not troublemakers and few symptoms directly related to shafts show up. However, when shaft troubles occur, they often show up as failures of other parts. A mechanic must be able to recognize why the part failed, because if it fails from an outside cause, the failure will occur again. When a machine is down for repair or inspection, shafts should be checked.

Upon successful completion of this package, you will be able to recognize many types of shaft failures or damage and take corrective action.

LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet	Provides additional background material to supplement the Information Sheets in the Learning Package.
Read: Crouse: <u>Automotive Mechanics</u>, McGraw Hill Book Company	
Read: Stockel: <u>Auto Service & Repair</u>, Goodheart-Willcox., Co.	
Do: Visually, and with accepted tools, inspect as described below, the shafts provided by your instructor.	Practical experience from inspecting, handling and identifying parts and adjusting to proper fit will enhance student learning.
Do: Check for straightness, trueness, smoothness, roundness, taper, cracks, damaged attachment areas, seal areas, etc.	
Do: Draw a sketch of the shaft on paper and report all defects for a given shaft, providing number values where micrometer readings are taken.	
Do: Report on whether the shaft is reuseable and under what circumstances.	

INFORMATION SHEET

<u>SHAFT INSPECTION</u>

Exposed shafts should be given a quick visual inspection daily.

Hidden shafts should be inspected any time a machine is torn down for other repairs. Regular maintenance, overhaul, or emergency repairs often bring hidden shafts out where they can be inspected with a minimum of added effort.

A faulty shaft may cause some strange noises or functions in a machine.

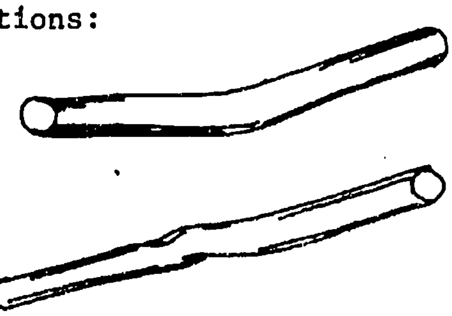
A bent shaft is often the cause of premature failure of seals and bearings.

CAUTION: Many shafts warp if incorrectly supported during down time. Support them as they normally rest, if possible.

WHAT TO INSPECT

Shafts should be checked for the following conditions:

- Alignment (Straightness)
  --See VIP Industrial Mechanics Learning Package 103-D "Shaft Alignment".

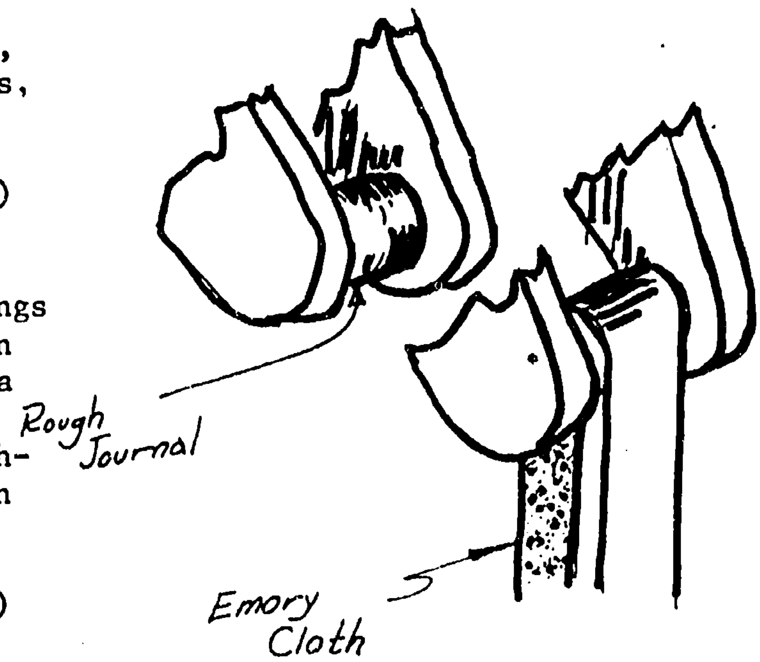


- Trueness

  Shafts are often subjected to severe pressures and may be twisted, warped, or distorted. Usually if this occurs, they must be replaced.

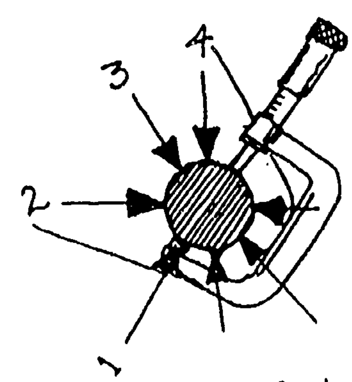
- Smoothness of journal (if applicable)

  Bearing journals must be completely smooth or severe damage to the bearings will occur. If the journal is within tolerances, it may be smoothed with a fine emory (crocus) cloth until no abrasions exist. Satisfactory smoothness occurs if no burrs or ridges can be detected.



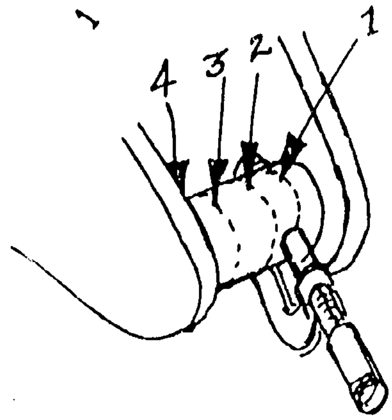
- Roundness of journals (if applicable)

  In an automobile engine for example, the journal should be measured with a micrometer near one side of a journal in three or four different positions. This type of measuring will detect wear that has caused the journal to go out-of-round.



- Rule of Thumb - If a journal of a high torque shaft is out-of-round more than .001 inch, per inch of journal diameter, the journal should not be placed in service until repaired.

  Refer to your manufacturer's technical manual for specific limits for this machine



- Taper on journals (if applicable)

Bearing journals may wear more on one end than on the other. The journals should be measured at either end with the micrometer. They should also be measured in several positions.

Rule of Thumb - If taper exceeds .001", the journal should be repaired prior to service.

Refer to your manufacturer's manual for technical limits.

- Ball or Roller Bearings Check-up

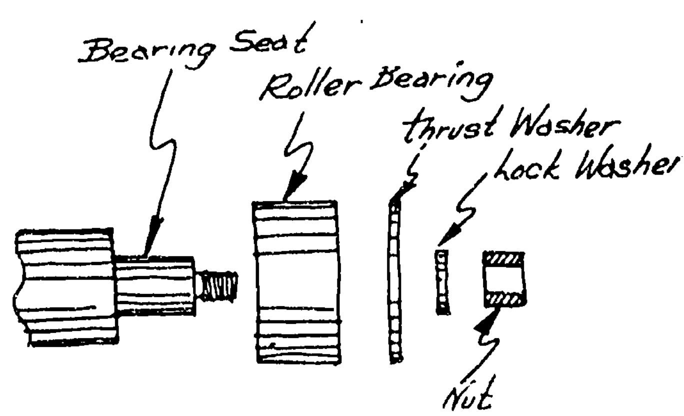
Shafts can be rolled within a bearing (ball or roller) and flat spots on the balls (rollers) may be detected by feel. A slight drag or catching in the shaft rotation will indicate a faulty bearing. Each bearing should be tested separately. See VIP Package 104-A "Inspecting Anti-Friction Bearings."

Shafts should turn freely by hand if they are to function properly under power.

Bearings do not wear in. Adjust for proper fit in their lubricated environment the first time.

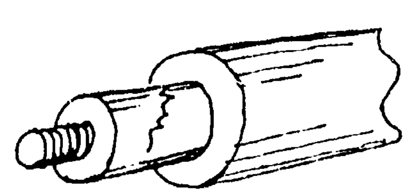
- Bearing position on shaft

Ball or roller type bearings must fit snugly on the shaft. The place where they seat must be free of damaging dirt scars, or spurs that would prevent proper positioning of the bearing. Many bearings require a press-fit. Others are held in place by thrust washers or thrust plates.



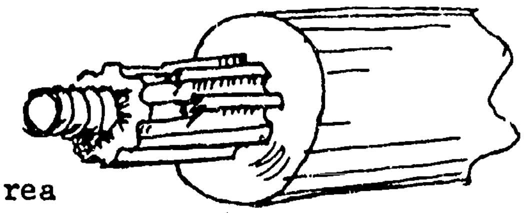
- Cracks

Shafts may have hairline cracks that open under stress. Continued use of a shaft with this type of damage will lead to failure of the shaft when the machine is in use. When in doubt about a shaft that is to be used in heavy equipment or a shaft to be reworked or "buried" inside a complex housing, it may be well to use some technique such as magnetism, dyes, sonar, or x-ray to test the shaft and locate any invisible cracks that may exist. A cracked shaft may be welded in some applications but more often is replaced.

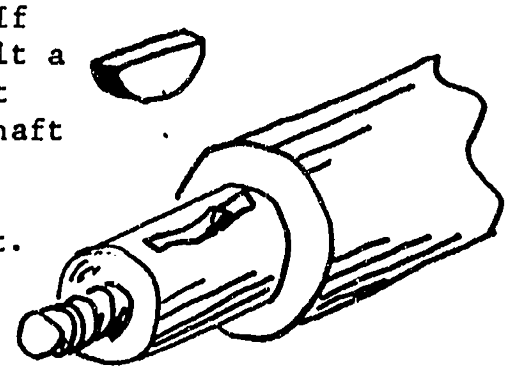


- Damaged Splines

A gear or wheel with a hub that is worn and loosely attached to the splines of a shaft may cause damage to the splines.



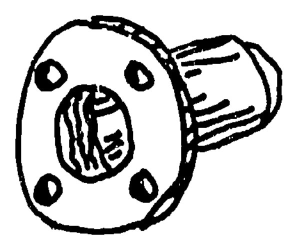
Sometimes a shaft may twist in the splined area from a sudden shock while underload. Be sure to check for straightness of the splines. If the splines are not straight enough to permit a new unit to slip easily on the shaft without lateral catching or rotary play, then the shaft should be replaced.



NOTE: Never hammer the splined end of a shaft. It may expand and no attachments will fit properly.

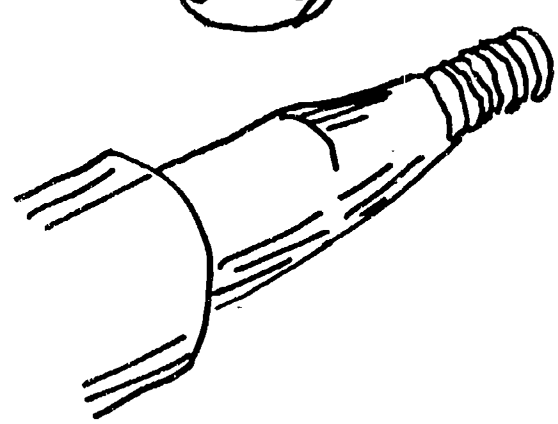
- Damaged Keyway (including a woodruff key)

If the key has worked loose in operation of the device, the shaft keyway may be severely damaged. If the key slot cannot provide a secure lock for the key, the shaft should be replaced.



NOTE: It is not advisable to lubricate a tapered shaft area with a keyway. The lack of friction between the tapers may cause the key to shear in normal use.

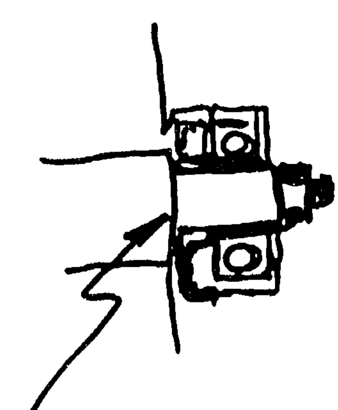
- Damaged Threads



If threads that hold the device to a shaft are worn, the device will not be fastened with the proper tension and may "work" on the shaft. This action can cause build-up of excessive heat which would be injurious to seals and lubrication. Undoubtedly, such looseness will be a safety hazard as well.

Shaft should be replaced or rethreaded.

- Damaged Seal areas



Seal Area

A seal that eliminates all seepage requires a smooth finish on the shaft. A seal that permits some seepage uses a coarser finish. Any burrs or ridges in the seal area will cause a seal to fail. Great care must be taken in refinishing a seal area to be certain it returns to the original type of surface. Critical seals are more safely handled by replacing the shaft.

SELF-TEST

Complete the sentence or circle the most correct answer.

1. Shafts should be inspected during normal machine down time unless unusual noises or wear occur. T or F

2. A shaft that lacks trueness should usually be (replaced, straightened).

3. Bearing journals must be so smooth that no burr or ridges are detectible. T or F

4. Bearings should be measured for correct tolerances (before, after) (both before and after) smoothing.

5. Rough surfaces may be smoothed using a "shoe shine" motion with ________________ cloth.

6. A check of roundness of a journal is made using a ________________.

7. If a journal has worn more on one end than on the other, the damage is classified as ________________.

8. Tolerances for either of the above is usually given in the ____________ manual.

9. Since ball and roller bearings are usually pressed on, they do not need a clean, smooth surface where they mount on the shaft. T or F

10. List 3 ways to locate hidden cracks in a shaft.

11. Damage to splines, keys or threading may cause the attached device to "work" on the shaft. This condition may cause excessive ______________.

12. A bent shaft will likely cause failures in ____________ and ______________.

SELF TEST ANSWERS:

1. T
2. replaced
3. T
4. both before and after
5. emory or crocus
6. micrometer
7. taper
8. manufacturer's or shop
9. F
10. magnetic, dyes, sonar, ex-ray
11. heat
12. seals bearings

SHAFT INSPECTION

1. maintenance or down time
2. manufacturer
3. T
4. micrometer
5. shape or roundness
6. cracks
7. F
8. T
9. T
10. T

POST—TEST

Package Number 103-B

Name ____________ Date ____________

INSTRUCTIONS: Complete the sentence or circle the most correct answer.

1. Normal inspection of hidden shafts should occur during machine ____________.

2. Final word on acceptable tolerances should come from the ____________.

3. Bent shafts are often acceptable when straightened. T F

4. Checking for taper is done with a ____________.

5. Caution should be exercised in smoothing a surface that you do not change its ____________.

6. Sonar, magnetics, dyes, etc. are used to detect ____________.

7. Shaft damage rarely affects other parts. T F

8. Seal seating areas should always be ground to a smooth finish. T F

9. Twisted shafts are usually replaced, not repaired. T F.

10. Damaged keyways, splines and threads may cause other parts to fail. T F

103-C SHAFT SUPPORT

In order to use a rotating shaft or a shaft on which devices rotate, a practical means to support the shaft and still permit rotation must be used. This lesson discusses shaft support considerations.

Upon successful completion of this lesson, the student will be able to:

1. Identify and discuss the makeup of 3 types of bearings.

2. Discuss flexible shaft bearing surfaces.

3. Identify and describe 4 types of pillow blocks.

4. State the differences in solid and hollow shaft heat dissipation.

5. Set up and align a shaft system, using pillow blocks.

LEARNING ACTIVITIES

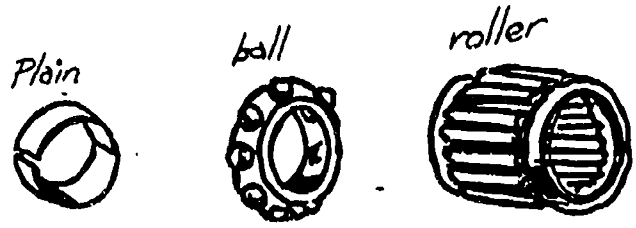
ACTIVITIES	PURPOSE
Read: Information Sheet	Provides added informational background to the lesson material contained in this learning package
Read: Crouse: Automotive Mechanics, McGraw Hill Book Company	
Read: Stockel: Auto Service & Repair, Goodheart-Willcox Co., Inc.	
Do: Identify each of the bearings and pillow blocks on the shop identification board.	Provides a good visual understanding that assures that you recognize and associate the correct part.
Do: Align a shaft with 2 pillow blocks on an uneven surface.	
Do: Align a shaft with 3 pillow blocks on an uneven surface.	Demonstrates your understanding of the problems of shaft and pillow block alignment and their solution.

INFORMATION SHEET

DEFINITION OF TERMS

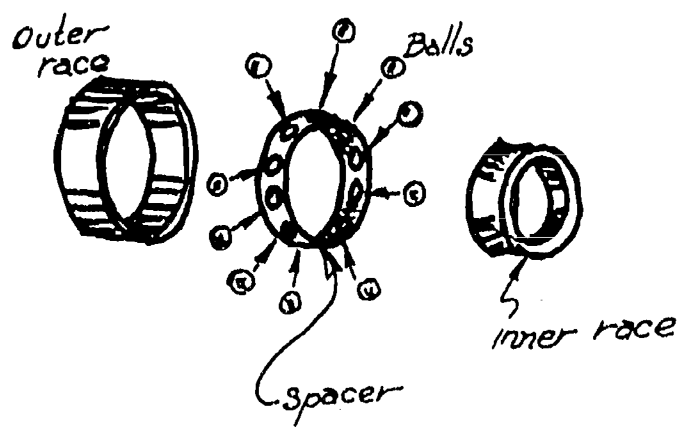
BEARINGS

A rotating shaft must be held in place and yet permitted to turn. Bearings are the parts on which the shafts are supported. Bearings fall into three categories; plain, ball, and roller bearings. There are several variations of each. Ball and roller bearings are generally categorized as "frictionless" bearings. See VIP Industrial Mechanics, Division Code 104 "Bearings" for details on bearings.



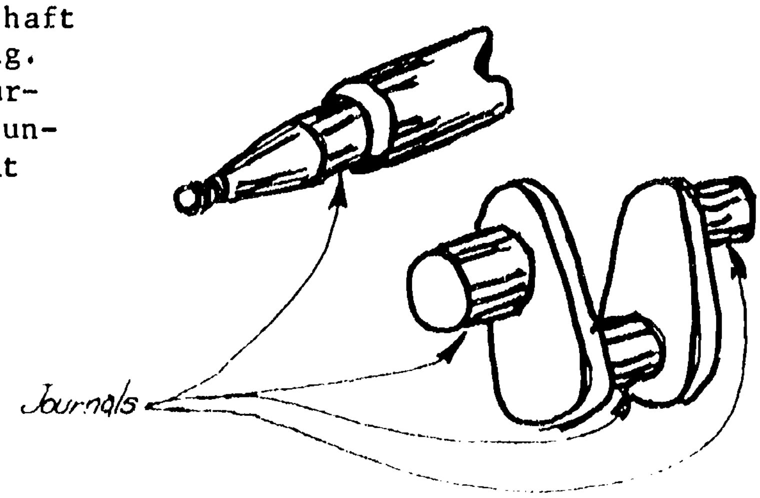
RACE

A race is the inner or outer ring of a ball bearing or roller bearing that holds the balls (or rollers) in place and provides a smooth rolling surface upon which the balls (or rollers) may roll. Usually, there is a spacer to keep proper separation between the balls (or rollers).



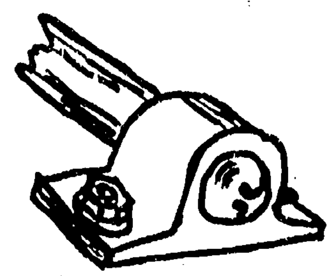
JOURNALS

Journals are the part of the shaft that rotates within the bearing. It may be a highly polished surface as on a crankshaft or an unpolished part of the shaft that rests on the inner race of a bearing.



PILLOW BLOCKS

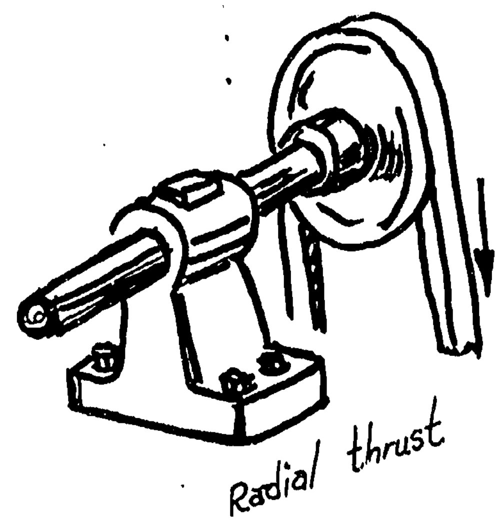
Pillow blocks are normally used to support the shaft bearings.



SHAFT SUPPORT

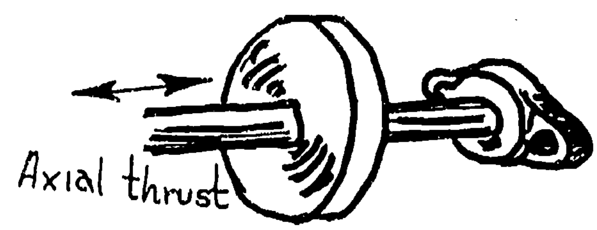
BEARINGS

All solid and hollow shafts are supported by bearings that have been dèsigned to support the weight of the shaft, flywheels, pulleys, the pull of the belt or gear that drives the shaft, and the maximum load to be turned by the shaft.

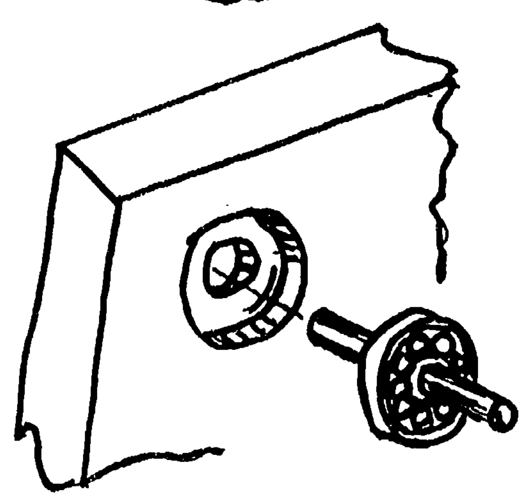


Bearings must be able to cope with the thrust of the shaft. Some bearings are designed to handle radial thrus' and others to handle axial thrust. Some bearings will allow both types of thrust.

HOUSING BORE



Equipment often supports bearings without pillow blocks. In these instances the bearings fit into the housing itself with close tolerances. The area in which the bearing fits is called a housing bore. Often the bore is nearly the same dimension as the bearing itself and the bearing must be pressed into place.

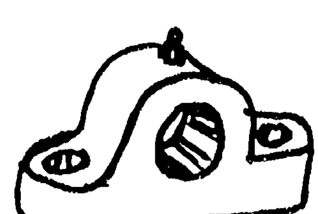


PILLOW BLOCKS

While bearings hold shafts, pillow blocks usually hold bearings. These pillow blocks fall into 4 types:

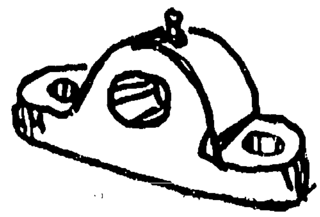
1. Solid Pillow Blocks

   Some inexpensive and short-lived pillow blocks are constructed entirely of bearing metal such as babbit or sintered bronze material. The shaft turns in the bearing material. Thus, the pillow block and the bearing are one.



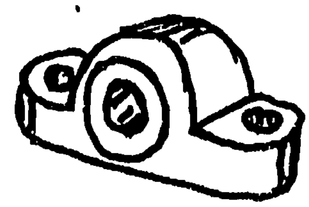
2. Plain Pillow Blocks

Plain pillow blocks hold plain bearings. Bearings of this nature, babbit, sintered bronze, etc. require oil and, therefore, oil holes in the blocks must provide a means to lubricate the bearings.



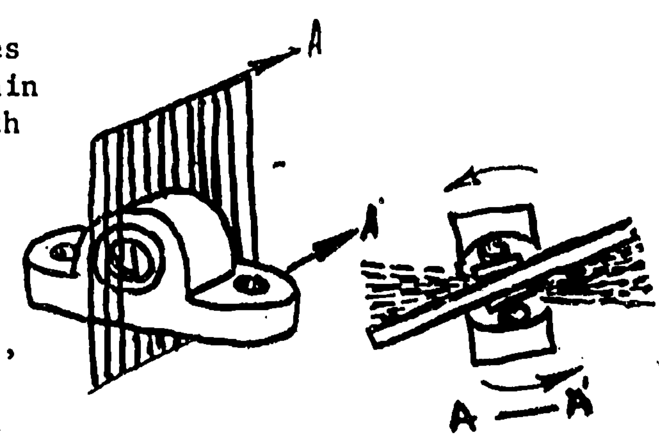
3. Sealed Bearing Pillow Blocks

Sealed ball or roller bearings do not require lubrication and, therefore, no oil hole is necessary.



4. Self-Aligning Pillow Blocks

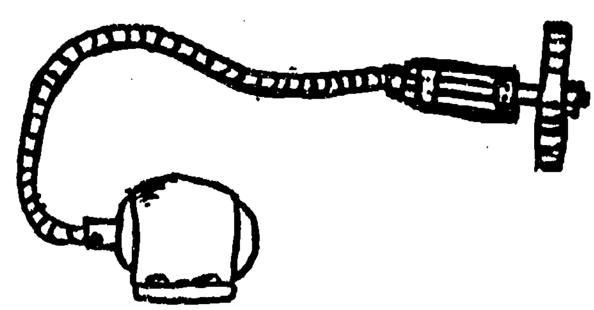
Self-Aligning pillow blocks contain bearings that have curved outer races to permit the bearing to rotate within the pillow block to align itself with the shaft on an irregular surface. Sometimes the inner race is secured to the shaft by bolts.



All pillow blocks, other than the self-aligning type, must be mounted on a flat, single, plain surface in such a way that they are in alignment in all directions.

FLEXIBLE SHAFT BEARING SURFACES

Bearings, as they are normally thought of, do not apply to flexible shafts. In heavy duty applications, bearings may be used at the end of the cover housing but most of the time the housing itself, properly lubricated, provides all the bearing surface necessary for the flexible part of the shaft. If the flexible shaft drives a solid shaft application, the bearings will be on the solid shaft.



HEAT DISSIPATION

Proper lubrication can permit higher temperatures of operation because lubrication has the effect of reducing friction. The lubricant may act as an agent to carry heat away from the friction area.

When selecting bearings, for use with shafts of various types, one must take into consideration, in addition to the lubricant, that a solid shaft will not generate a "hot spot" under heavy load as rapidly as the hollow shaft. There is more metal available to absorb heat away from the load point in a solid shaft. Therefore, the lubricant on the bearing surfaces will not be as sensitive to heat when using a solid as opposed to an internally dry hollow shaft. Thus, bearing or shaft journal damage is not as likely to occur.

Obviously, any load calculations must include the revolutions per minute at which the shaft turns in addition to other sources of heat because the "higher the speed - the greater the need" for lubricant on load bearing surfaces.

OUT-OF-BALANCE

Some shafts may ruin their supporting bearings because out-of-balance attachments have been mounted on the shafts. This is often the case when using shop equipment such as buffers, grinding wheels, and sanding drums.

The out-of-balance attachment causes a pounding action within the close tolerances of the bearing. As the machine is used, the pounding action of the shaft will gradually elongate (make egg-shaped) the soft bearing metal that supports the shaft. Eventually, the shaft will begin to "chatter" in use.causing it to slow, be less accurate, and to have severe bearing wear. Bushings (or plain bearings) should be replaced at this point.

WORKSHEET

- Locate some failing bearing units. These may be found in the school shop, the craft shop, home shop, farm equipment, lawn equipment, etc.

- Locate the bearing that has failed.

- Remove the bad bushing, press in replacement, and ream to fit the shaft (if necessary). Reassemble the device.

- Hand cycle for your instructor before running under power.

SELF-TEST

1. In order to remain in service, a rotating shaft must have a ______________________.

2. Proper lubrication helps to ___________________.

3. Bearings must be able to handle ________________ or __________________ thrust.

4. List 4 parts of a ball bearing.

5. Pillow blocks support ________________.

6. List 3 types of pillow blocks.

7. If a shaft is mounted on an irregular surface, the pillow block must be _________ __________________.

8. The inner race of a ball bearing may e pressed onto a _______________.

9. Flexible shaft housing surface is usually its __________ _________.

10. The faster a shaft turns, the more it needs ________________.

SELF-TEST KEY

1. bearing.
2. reduce friction
3. radial axial
4. outer race, balls, spacer, inner race
5. bearings
6. solid, plain, sealed, wear-in, self-aligning.
7. self-aligning
8. shaft
9. bearing
10. lubrication

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POST-TEST KEY

Package No. 103-C

SHAFT SUPPORT

1. rotating
2. heat
3. axial
4. radial
5. bearings

POST—TEST

Package Number 103-C

Name ______________ Date ______________

INSTRUCTIONS: Complete the following sentences:

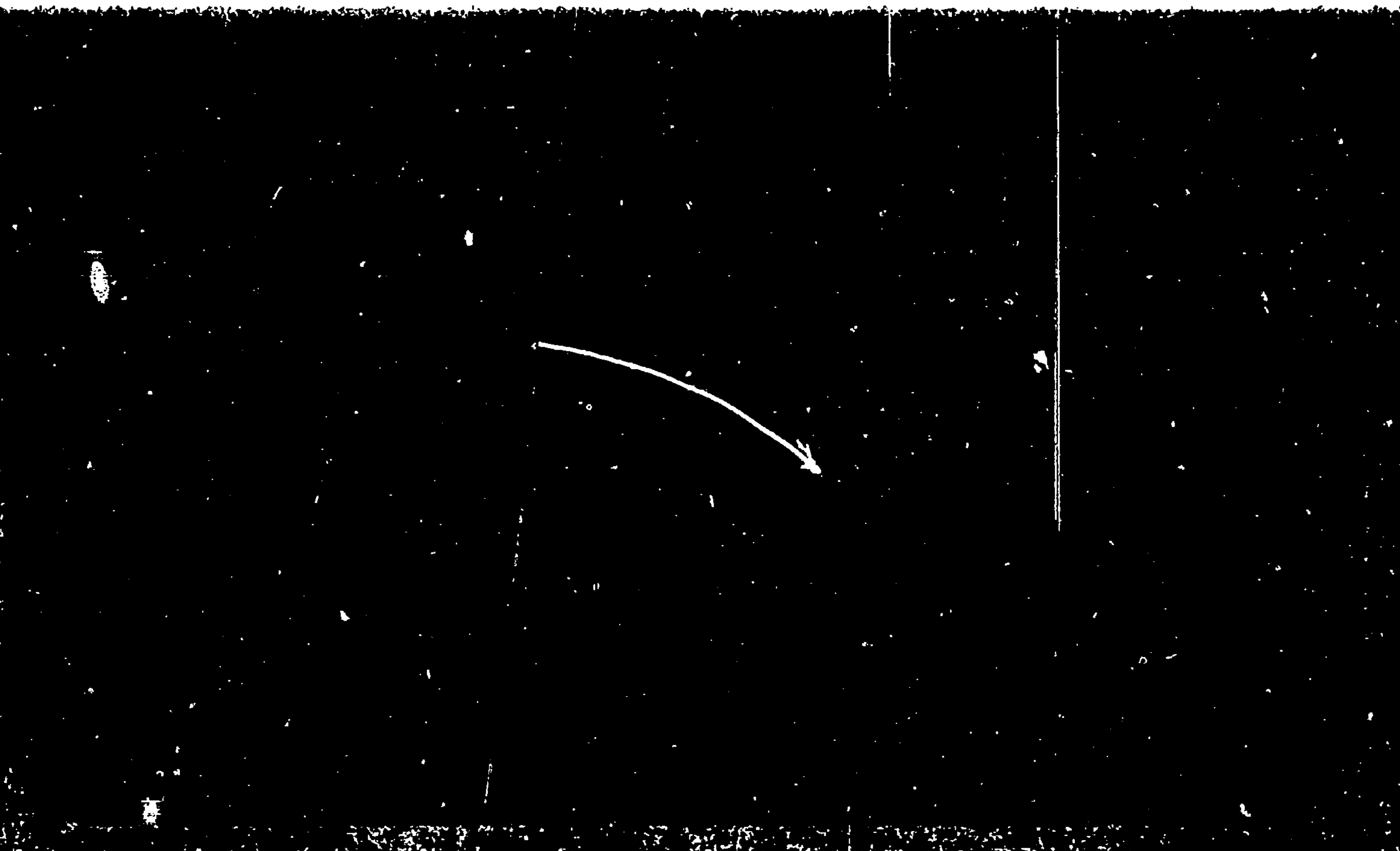
1. Bearings are required to keep ________________ shafts or devices from deteriorating from friction forces.

2. Lubrication will help to dissipate ____________________.

3. Shaft end play may be caused by excessive ________________ thrust.

4. A fan belt will add to the ______________ thrust.

5. Pillow blocks support ____________________.



Industrial Mechanics

It is important that shafts are straight on a centerline between the bearing surfaces. If they are not, heat and stress will cause bearings, seals, attachments and even the shafts to have a shorter life than normal. Heat generated by lack of alignment can ruin seals and attachments.

SHAFTS

Coordinated by
Jerry Ludlow
OREGON BOARD OF EDUCATION
DALE PARNELL

OBJECTIVES

Upon [illegible] completion of this lesson the student will be able to:

1. Check shafts for straightness.
2. Check shaft bores for alignment.
3. Describe tools and methods used in checking alignment.
4. Describe in your own words [illegible] technical terms.
5. Describe the effect of using bent shafts.

DEVELOPED WITH THE
COOPERATION OF: State of Oregon Department of Education
Lane Intermediate Education District
Lane Community College
Educational Coordinating Council

PROJECT DIRECTOR: Dick Barl

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Warren White

[illegible] CONTINUING EDUCATION PUBLICATIONS
EXTENSION HALL ANNEX, CORVALLIS [illegible]

LEARNING ACTIVITIES

<table>
<tr><th>ACTIVITIES</th><th>PURPOSE</th></tr>
<tr><td>Read: Information Sheet</td><td rowspan="3">Provid added information background to lesson material in this package.</td></tr>
<tr><td>Read: Crouse, <u>Automotive Mechanics</u>, McGraw Hill Book Co.</td></tr>
<tr><td>Read: Stockel, <u>Auto Service & Repair</u>, Goodheart-Willcox Co., Inc.</td></tr>
<tr><td>Do: Obtain a short shaft from the instructor, then do the following:

- clean shaft and surface plate.

- visually check bearing areas for pits, checks, and damage.
--check with micrometer to be certain they are within tolerances.
--roll on surface plate.
--record your examination and give the report to instructor.

- clean journals and V-blocks

- support a shaft on level surface with V-blocks on shaft journals.
--record dial reading and give to instructor.

- support an axle shaft between centers (or on a lathe) and check for out-of-alignment at the journal area with dial indicator.
--record and give to instructor.</td><td></td></tr>
</table>

DEFINITION OF TERMS

True - Straight, properly alighed, not warped or twisted.

Tolerance - A small deviation from the standards established for a setting. These may be either plus or minus variations.

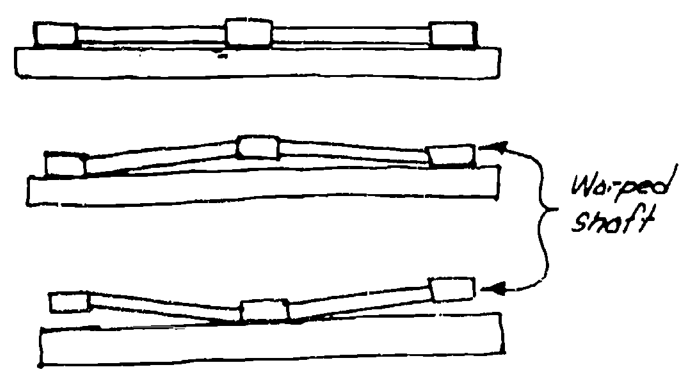
Out-of-Roundness - Bearing surfaces are manufactured as nearly round as possible. If wear has occured, it may have caused an out-of-round condition.

Taper - Shaft journals may have more wear on one end of the journal than on the other, causing them to be tapered. This is generally caused by mis-aligned bearing on the journal.

Bores - The part of the device that holds the shaft bearing in a housing when pillow blocks are not used.

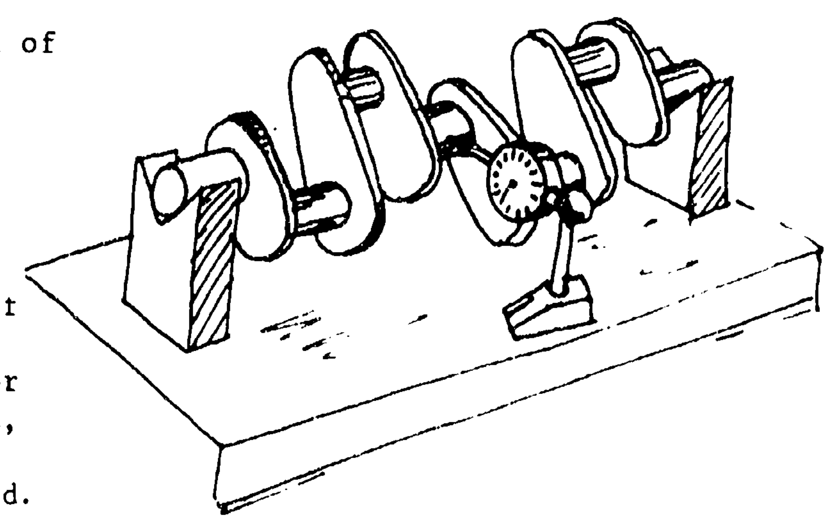
HOW TO CHECK FOR SHAFT ALIGNMENT

STRAIGHT SHAFTS (Round)



Most round, straight shafts may be inspected for trueness by placing on a flat, level surface. They should remain in place no matter in which position they are released. As the shaft is rolled on the surface plate, neither the center nor the ends should raise up, indicating a warped shaft. If it does, a feeler gauge under the center journal at maximum height can give the amount of the bend.

ALL SHAFTS



If the shafts are not round or if there are close tolerances to be measured, a more accurate method of testing for a true straight shaft is to mount two of the journals (or bearings) in a set of cks and, with a measuring device, eck a free journal as the shaft is rolled.

Commercially available tools permit a dial or needle read-out of the deviation from alignment (sometimes called run-out). This technique is the most accurate and easiest to use.

Measurements should be taken in several positions on the shaft.

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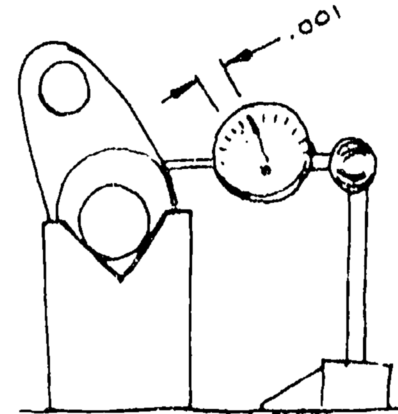
All bearing surfaces may be tested by alternating the positions of V-blocks and indicators.

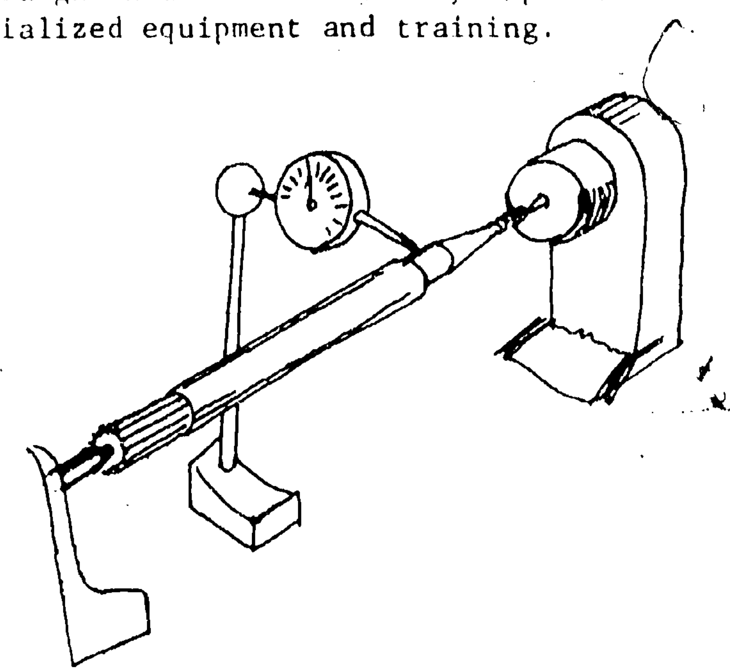


Variations in readings should not exceed those specified by the manufacturer. (In automotive, this is generally not more than .001" between journals or .002" over the entire shaft.

Remember that journals or bearings must be checked for our-of-roundness before this test can be made as out-of-round bearings will affect the measurements of this test.

NOTE: Bent shafts in many cases may be straightened. In heavy duty applications this must be done using specialized equipment and training.

TAPERED, SPLINED, UNFINISHED SHAFTS, ETC.

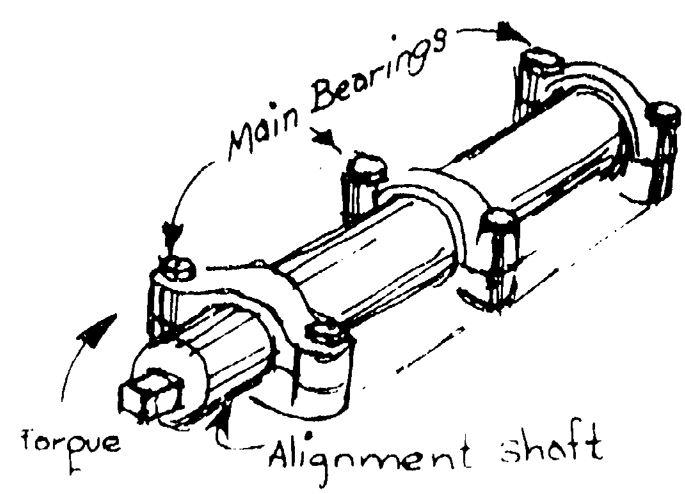


Shafts without bearing surfaces at both ends may be checked by mounting between centers and checking against a bearing surface with a dial or needle indicator.

BEARING BORES

Bearing housing bores may be out of line because of some change in the external structure. Straight shafts or their components will fail prematurely if mounted in a mis-aligned housing. Often this type of damage is easy to detect by checking the bearing for wear patterns as the device is disassembled.

Bores may be checked by placing a known straight shaft in the bores and checking for freedom.



In the case of an automobile engine, special bar shafts are designed for this purpose. The manufacturer specifies that the bar must be installed in place of the crankshaft, the bearings be torqued to their normal tension, and the bar must turn within a certain number of pounds pressure. Similar techniques can be used in other applications.

EFFECTS OF [illegible] OUT OF ALIGNMENT SHAFTS

[illegible] out of alignment [illegible] cause the problems described here [illegible] only two bearings, the problem [illegible] against [illegible] could not [illegible]

BEST COPY AVAILABLE

- Bearings fail prematurely. Bearings or journals on a misaligned shaft (unless they are self-aligning) cannot seat properly in their housing or bearing bores. This mispositioning of the surfaces will cause undue wear on the bearing and, perhaps, remove a requirement that provides proper oil pressure to the system.

- Induce overheating. When devices on the shafts are not in proper alignment, they often tend to try to align themselves with their mating gear pulley, etc. This working of the device may cause an overheating condition that will, in turn, induce other problems.

If the shaft has more than two bearings, all of the preceding are likely to occur, plus:

- Shaft stress is increased. In addition to the normal forces acting on the shaft, a misaligned shaft must flex each half revolution. The flexing will cause heat and will also tend to weaken the shaft and make it fail prematurely. It may break.
- Bearing stress is magnified. One or more bearings will now take the force of the flex load each revolution. This causes the bearing to carry loads and stress that were not included in the enginerring requirements for the bearing.

SELF-TEST

Complete the sentence or circle the most correct answer.

1. Shafts may bend in use because of stresses against them. T F.

2. Shafts may bend if left improperly stored, such as leaning against a wall. T F.

3. A device that has a flat plain for testing straightness of shafts is called a ______________ .

4. An odd-shaped shaft that will not roll is usually mounted on ______ for testing.

5. The shaft mounted in question 4 is mounted on its bearing ______________ .

6. The out-of-alignment reading is taken, using a ______________ or a indicator.

7. An ______ journal can affect the reading of the dial indicator.

8. In addition to the shafts, the pillow block and ______ that the shaft run in, must be checked for alignment.

9. List 4 possible results of continuing to run an out-of-aligned shaft.

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SELF-TEST ANSWERS

1. T
2. T
3. surface plate
4. V-blocks
5. journals
6. dial needle
7. out-of-round
8. bearing
9. ruined seals, bad bearings, overheating, shaft stress

SHAFT ALIGNMENT

1. dial, needle
2. centers
3. vee blocks
4. ends
5. round
6. heat
7. surface plate
8. turned
9. bearings, seals, shaft

POST—TEST

Package Number 103-D

Name ______ Date ______

Complete the sentences.

1. The 2 types of read-out indicators for testing shafts are ______ and ______.

2. A shaft with tapers, or only one journal, or for other reasons is difficult to mount, usually can be supported between ______.

3. ______ are used to support a crankshaft for testing.

4. For best results, a shaft should be supported near its ______.

5. An out-of- ______ journal may give a false reading of shaft straightness.

6. A bent shaft will usually generate ______ in operation.

7. A round, straight shaft may be tested on a ______.

8. Read-out indicators register their readings as the shaft is ______.

9. List 3 items that are affected by a twisted shaft.

______ ______ ______

Industrial Mechanics

In order for the shaft to transmit power, there must be a way to fasten gears, pulleys, other shafts, etc. to the shaft without permitting them to slip. This lesson describes several ways to do this.

SHAFTS

Coordinated by
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SUPERINTENDENT OF
PUBLIC INSTRUCTION

DEVELOPED [illegible]
COOPERATION [illegible] Department of Education
[illegible] Education District
[illegible] College
Educational Coordinating Council

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EXTENSION HALL ANNEX, CORVALLIS, OREGON 97331

LEARNING ACTIVITIES

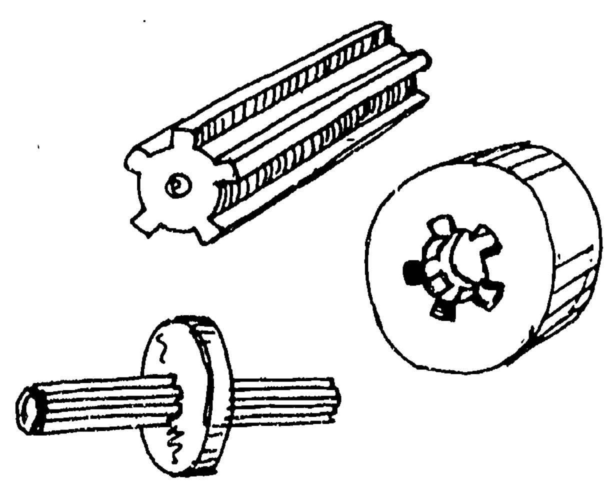
ACTIVITIES	PURPOSE
Read: Ir formation Sheet	
Read: Crouse: <u>Automotive Mechanics</u> McGraw Hill Book Co.	Additional material from a good text will add to the material in this learning package.
Read: Stockel: <u>Auto Service and Repair</u> Goodheart-Willcox Co., Inc.	
Do: Remove a device, inspect it, and replace with good parts, setting torques to instructor's directive, one each to fit the following: - splined attachment - key attachment - set screw attachment - taper attachment - tang attachment	Practice with each type of device provides both understanding and experience necessary to completion of this learning package.

INFORMATION SHEET

DEFINITION OF TERMS

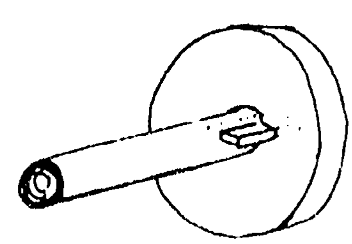
SPLINES

Splines are manufactured on shafts to permit a positive engagement to a pulley or gear. They consist of a series of grooves cut into (or ridges built up on) the shaft to provide a gear-like profile. The pulley or gear will have a matchin contour infits shaft bore.

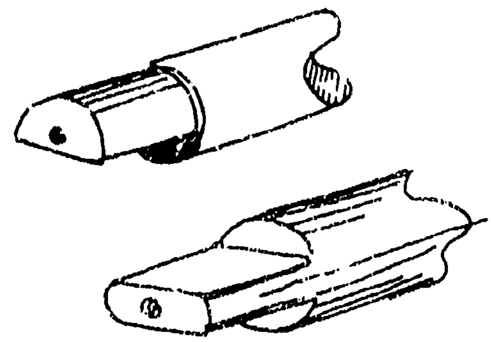


KEYS

Keys may be used instead of splines if the torque requirements of the shaft do not require a spline. A key is usually one piece of metal that fits into a slot on the pulley and shaft to prevent slippage.

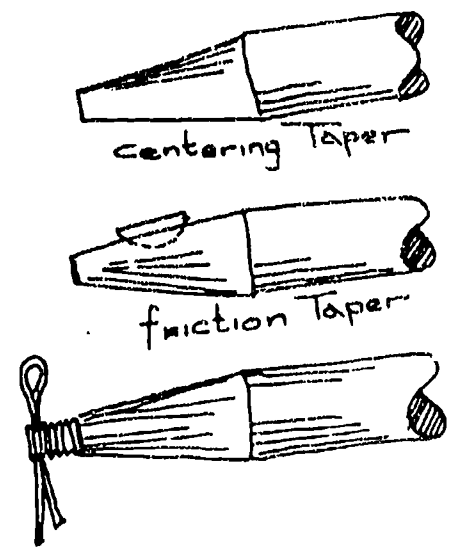


TANG



Tangs are created by shaping the end of a shaft and its matching mating device. The new shape is not round and, therefore, the device will not rotate on the shaft. The device must have some additional method to hold it on the end of the shaft, such as threading.

TAPER

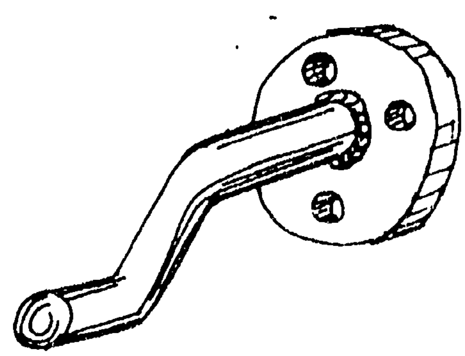


Devices may be mounted using taper as a method to center the device or to provide friction. Tapered attachments also require a key, spline, thread or other attachment technique to reinforce the taper to secure the device to the shaft.

MOUNTING EQUIPMENT ON SHAFTS

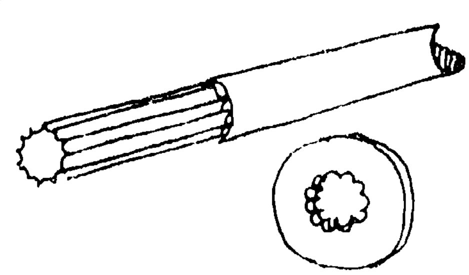
There are many ways to mount equipment on a shaft. These vary in regard to the requirements for function, speed, maintenance, and safety reqirements of the attachment.

WELDING



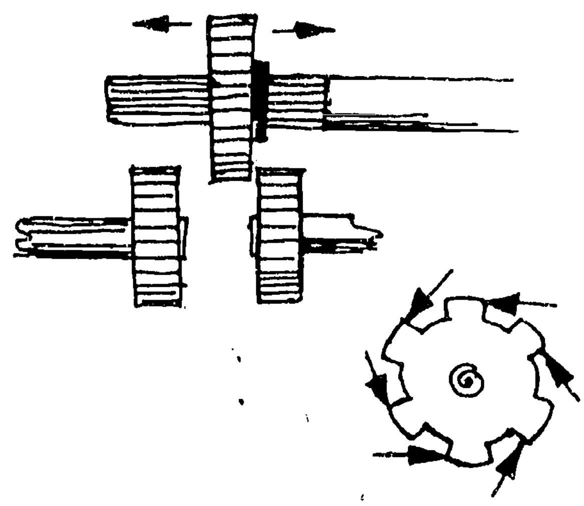
The most secure attachment of a pulley, gear, or other device to a shaft is to weld the two together. This is not always practical from either the manufacturing or maintenance point of view. Sometimes, a hub is welded to the shaft and the device attached to the hub. This technique is widely used in the automotive crankshaft flywheel hub.

SPLINES



A splined shaft has slots (or ridges) along the area in which the attachment is to fit. The attachment is cut to the same shape but with a slightly larger diameter and spline size than the shaft.

One advantage of the splined attachment is that the device may be bolted with a lock-nut into a fixed location on the shaft or it may be left loose to permit it to move.



Another big advantage of the splined attachment is the utilization of many pressure points around the shaft to drive the attachment.

Splines are commonly used on solid and hollow shafts that are subjected to great amounts of torque.

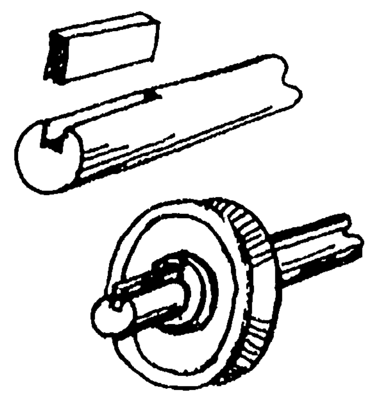
KEYS

Keyed attachment of devices is common in medium or light duty applications where multiple methods of attaching a device are used.

Two types of keys in common use are:

- Plain Key

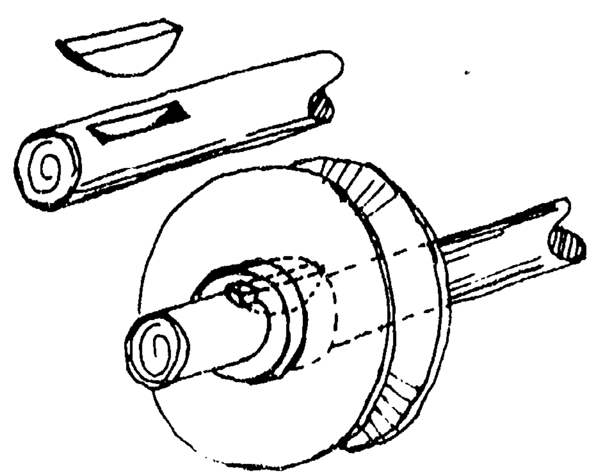
The plain key is applied when the pulley or other device is notched to accept a piece of metal that protrudes from the shaft.



The shaft is grooved and the key fits into that shaft groove and a slot in the pulley bore to keep the pulley from spinning on the shaft. Usually the shaft is threaded to hold the pulley in place.

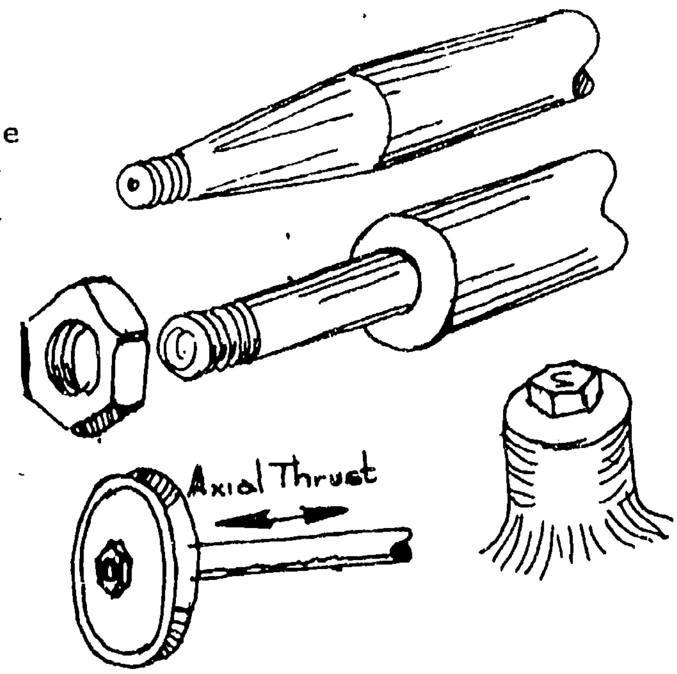
- Woodruff Key

The woodruff key is a variation of the plain key in that the shaft cut is just the key length and shape and is cut deeper into the shaft than a plain keyway. In addition, the key stands higher into the pulley slot, thus making a more positive keying of the attachment to the shaft. This key has superior holding qualities because the depth of cut reduces the rocking action of the key in the shaft groove.



NOTE: Do not lubricate a keyed attachment. The resultant loss of friction may cause the key to shear under normal use.

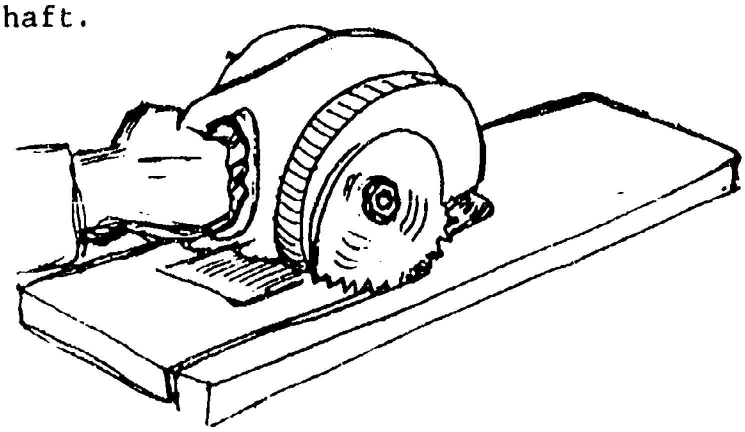
SHAFT THREADING

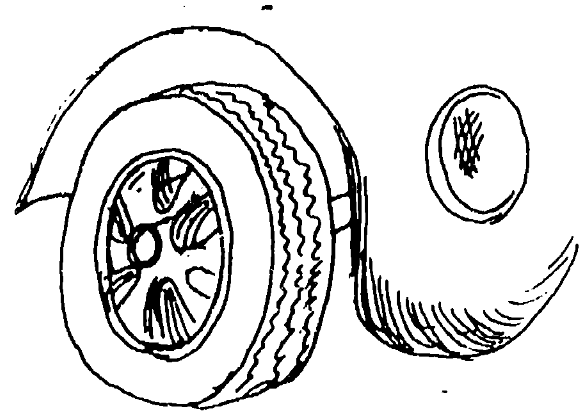


Shafts may be threaded to hold a device on the end of the shaft. Threads may be on the outside (external) or on the inside (internal) of the shaft. Internal threading is accomplished by drilling and tapping the shaft.

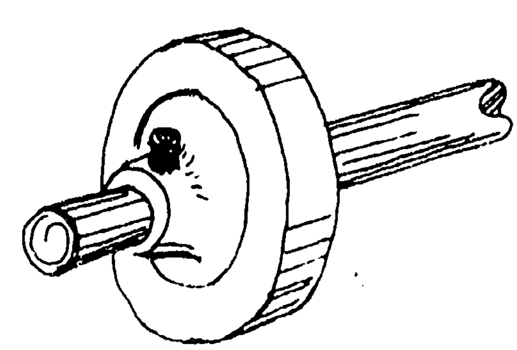
Usually the threading will protect the device from being pulled off by axial thrust. The device is protected from going too far onto the shaft by taper or ridging.

Threads permit a nut to hold against a washer and bearing in those applications that expect the device to spin on the shaft.



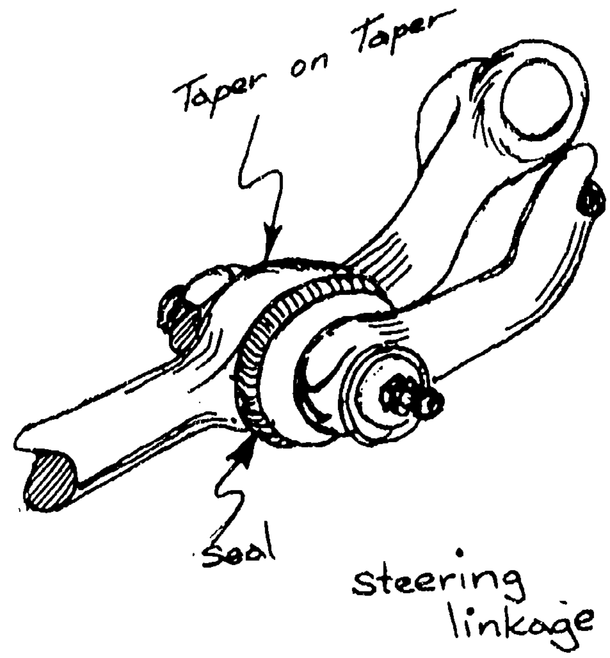


Threading may be used in conjunction with splines, keys, tangs, press-fit, etc. to lock a device so it will not rotate on the shaft.



Sometimes a friction set screw is used in the hub of the device being attached. This technique provides resistance to thrust in both axial and rotary direction. If used on a straight shaft, this technique is usually used where there are light stresses as it is a friction setting and will not withstand heavy pressures.

TAPERS ON TAPERS



Tapers on tapers are often used in applications where no slack is allowed and the shaft does not support a turning device.

A taper must be securely tightened into the other taper to be effective.

Many taper joints have seals next to them that are ruined when wedged forks are used to separate the tapers.

To loosen a tapered connection after the holding device has been removed, a sharp blow with a hammer on the side of the outer taper will usually free them.

CAUTION: Never pound on the end of a shaft with a steel hammer. If it becomes necessary to strike a shaft, protect it by using a brass, copper, or other soft metal, or a covernut between the hammer and the shaft end. If this is not done, the shaft end may mushroom expanding it so it will be impossible to remove the device or, if the shaft is threaded, to replace the nut.

SELF-TEST

Complete the sentence or circle the most correct answer.

1. List 5 methods of securing a gear to a shaft.

2. Which method permits the gear to slide on the shaft?

3. Which method creates the strongest fastening?

4. The key slot for a woodruff key is ______________ and ______________ than for a plain key.

5. Which keyway is the most secure?

6. A threaded hub with set screw permits a device to be re-positioned on the shaft. T F.

7. Endwise movement on the shaft is called ____________________ thrust.

8. A shaft with a special shape on the end that matches a pulley or gear is described as a ____________________ fitting.

9. Which removeable fitting has the most pressure points?

10. Which type of key has a long slot?

SELF-TEST ANSWERS

1. key, threads, spline, tang, welding, set screws
2. splines
3. welding
4. shorter deeper
5. woodruff
6. T
7. axial
8. tang
9. spline
10. plain

POST—TEST

Package Number 103-E

MOUNTING EQUIPMENT ON SHAFTS

Name ____________ Date ____________

INSTRUCTIONS: Complete the sentence or circle the most correct answer.

1. Attaching a device to a shaft by welding provides the ____________ attachment.

2. Two types of keys are the ____________ and ____________.

3. Of the two key types, the ____________ is the most secure.

4. It is most secure because of the ____________ of the cut in the shaft.

5. Threading provides security from ____________ thrust.

6. Where high torque application is required, the best attachment method to use is ____________.

7. Tangs (permit, do not permit) the device to rotate on the shaft.

8. Tangs will keep the device on a shaft when axial thrust is present. T F

9. ____________ permit axial movement while a shaft is turning.

POST-TEST KEY

Package No. 103-E

MOUNTING EQUIPMENT ON SHAFTS

1. strongest
2. plain/woodruff
3. woodruff
4. depth
5. axial
6. splines
7. do not permit
8. false
9. splines

Industrial Mechanics

103-F CAMSHAFTS

PURPOSE

Camshafts are a necessary part of timing reciprocal motion in mechanical applications. This lesson discusses camshafts and provides learning information and activities.

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OBJECTIVES

Upon successful completion of this learning package, you will be able to:

1. Describe the purpose of a cam.
2. Identify the parts of a simple cam and explain their functions.
3. Describe 5 different areas in which cams are used.
4. Describe the function of an automobile camshaft.
5. Build a simple cam operated device if given the parts.

DEVELOPED WITH THE COOPERATION OF ...... State of Oregon Department of Education
Lane Intermediate Education District
Lane Community College
Educational Coordinating Council

PROJECT DIRECTOR: Dick Earl

WRITERS:

Frank Bishop

Steve Brous

John Anderson

Warren White

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LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet	Additional material to supplement that contained in this learning package.
Read: Crouse: Automotive Mechanics, McGraw Hill Book Company	
Read: Stockel: Auto Service & Repair, Goodheart-Willcox Co., Inc.	
Do: Trace a cam on paper. - identify its parts (see definition of terms) Trace a distributor cam on paper. - identify its parts Obtain 3 automotive camshafts from the instructor. - inspect for consistency of lobes, including: --uniform height, shape, etc. - inspect for condition of parts -- on-ramps clean and not pitted	This exercise is designed to give student an understanding of the different shapes and sizes of cams.
Given a micrometer and a camshaft: - determine the amount of lift or drop the cam will produce to one thousandths of an inch.	Determine if cam is worn where replacement is necessary.

INFORMATION SHEET

DEFINITION OF TERMS

CAM

An irregularly shaped piece or projection as on a wheel or rotating shaft that imparts reciprocal or variable motion to another piece bearing on it.

CAMSHAFT

A shaft that has a cam mounted upon it. Automotive camshafts have cams molded into it and have journals to mount the shaft on bearings.

LOBES

A commonly used name for the cams or bumps on an automotive engines' camshaft.

CAM PARTS

- Toe

  The toe of the cam is the point of greatest lift (or distance from the shaft).

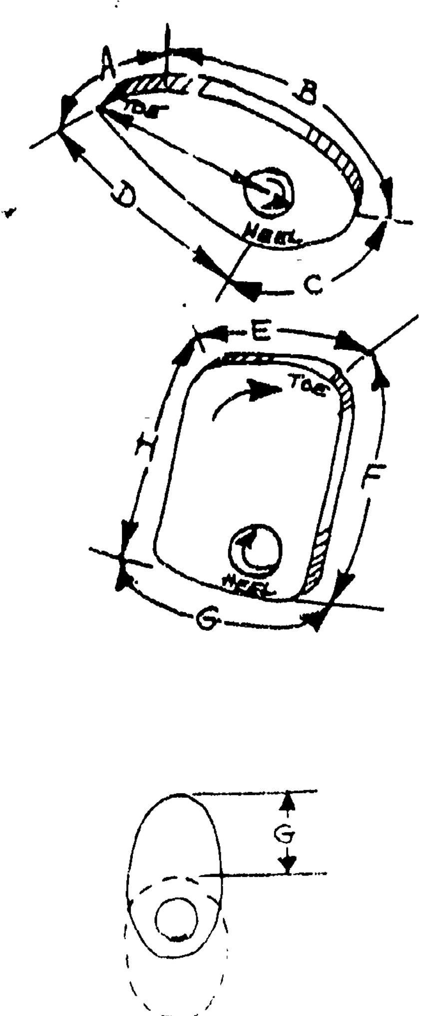
  The toe may be pointed (as in A) or it may have a long, flat area (as in E). The length of the flatness defines toe duration.

- Heel

  The heel of a cam is the portion nearest the shaft. It also may be rounded, pointed, or flat to determine heel duration (note C & G).

- Lift

  The lift of the cam is the difference between the heel height and the toe height. In the example, G is the lift of the second cam.



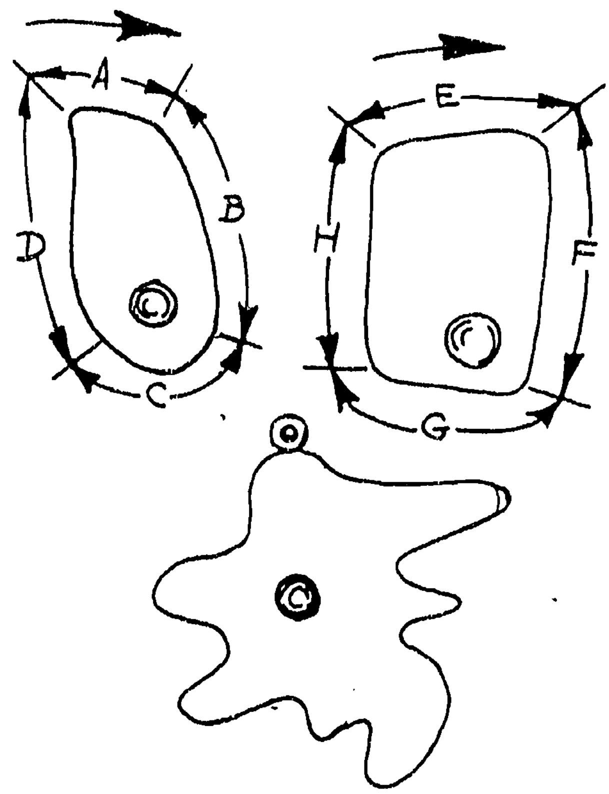
- On-ramp - Off-ramp

  The on-ramp of the cam, (sometimes called the power side) is that area of the cam in use as it rotates from heel to toe (B & F).

  The off-ramp is the surface of the cam used as the cam rotates from toe to heel (D & H). Speed of reciprocal action depends upon the slope to these ramps.

- General

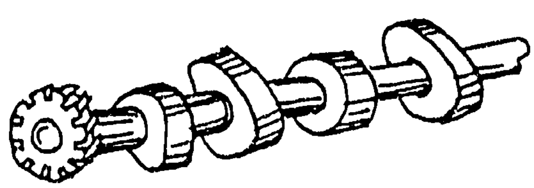
  The preceding terms are very simple to understand on most cams. However, some automatic machine tools, printing and other equipment have very complex patterns. These are not discussed in this unit.



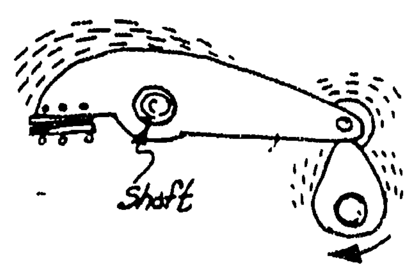
USES OF CAMSHAFTS

Camshafts are used wherever circular motion must be turned into some other motion by pushing against the cam surface.
Common uses are in:

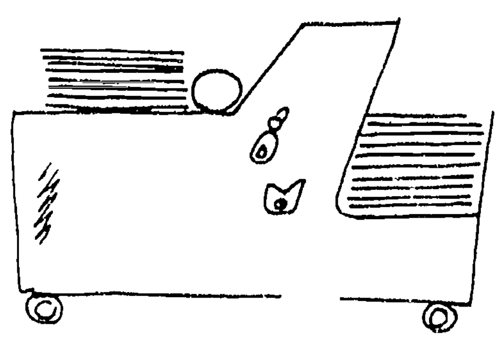
Automotive engines



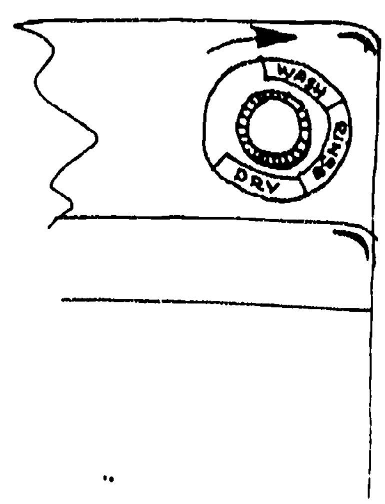
Automatic machine tools



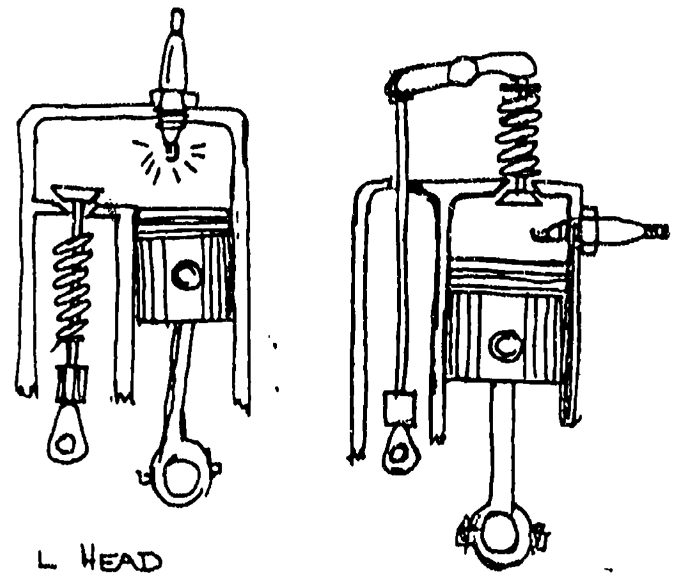
Printing equipment



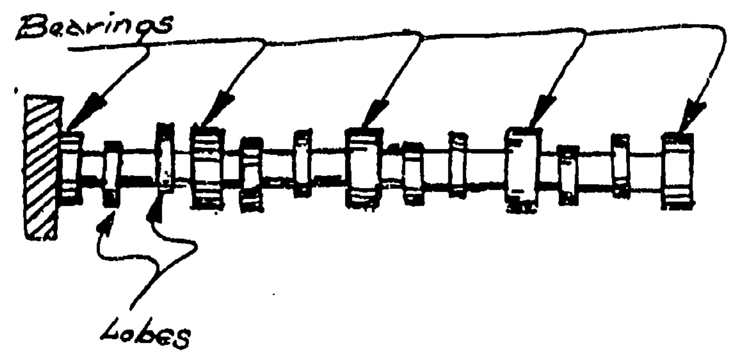
Washer timers



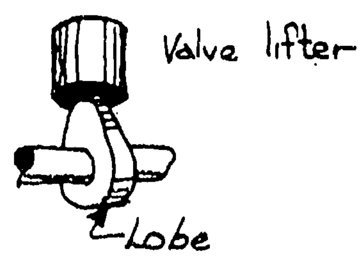
AUTOMOTIVE CAM SHAFT



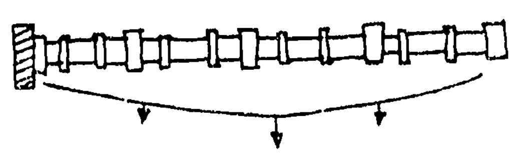
The automotive camshaft is designed to turn the rotary motion from the drive shaft into reciprocating to open and close the intake and exhaust valves on the engine.



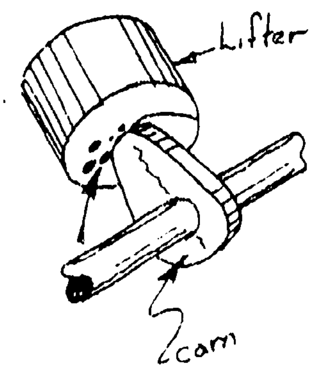
The lobes (cams) on the camshaft are positioned to they will raise the valve lifter on a precise timing basis. There is an extreme amount of downward pressure on the camshaft that is exerted by the valve springs. As a result, bearing and cam surfaces are designed for a heavy force. The shaft usually has a bearing between every two or four cam lobes. More bearings will permit a higher loading.



Adequate oil pressure is required to assure bearings do not score. Pressure is maintained by having correct tolerances in the bearing areas. Always use the micrometer when checking a camshaft to assure that bearing journals and lobes are consistent in height and withing the tolerances of the manufacturer. The lobes, ramps and toe whould be checked for pits. If lobes are defective, the shaft should be replaced.



Never store a camshaft horizontally. The weight of the shaft or other pressures may, in time, induce a small amount of sag in the shaft. Always store on end or support it by its bearings.



The bottom of the valve lifter should be checked for wear. The camshaft usually turns against the bottom of the valve lifter in a slightly off-center or angle faced position to cause the lifter to rotate in use. For this reason, the lifter should have a bearing surface on its bottom. If this surface is concave, pitted or scored, it should be replaced.

GENERAL

Although this description has been written around the automotive camshaft, similar shafts are required in other engines or compressors.

Printing equipment, feed mechanisms, and semi-automatic shop tools (cutters and pattern machines), typewriters, office machines, etc. use cams to accomplish their functions. Keyboards activate cams in electric typewriters, etc. Often, the camshafts are ordinary shafts with the cam itself being attached to a shaft in the same manner that a gear or pulley would be attached to a shaft.

In every case, a cam changes the direction of motion between rotary and reciprocating or to some variation in between.

SELF EVALUATION

Complete the sentences.

1. A common name for the bumps on the automotive camshaft is ____________.
2. Cams turn rotary motion into ______________ motion.
3. Cams are used in washing machine ________________ devices.
4. The lift of a cam is the distance between the _______________ and the toe of the cam.
5. The speed of action of the power side of the cam depends on the steepness of the _____________ _____________.
6. Return speed is controlled by the slope of the __________ ___________.
7. The duration of time taken in the rest position depends upon the length of the ____________.
8. When the camshaft works under heavy loads, more _________________ are required.
9. Automotive cams usually rotate ___________ ____________.
10. Check condition of lobe _________ and _________ for pits and wear when inspecting an automotive camshaft.

SELF EVALUATION ANSWERS:

1. lobes
2. reciprocating
3. timings
4. heel
5. on-ramp
6. off-ramp
7. heel
8. bearings
9. valve lifters
10. on-ramp, toe

CAMSHAFTS

1. rotary
2. toe
3. duration
4. heel, toe
5. slope
6. lobe
7. micrometer
8. keyboard
   timers
   paper feeds
   cutting guides
   valve timing

POST—TEST

Package Number 103-F

Name ____________ Date ____________

Complete the following sentences:

1. Cams are used to turn ____________________ motion into reciprocating motion.

2. The cam's ________________ is the point furtherest fro the shaft.

3. ______________________ is the amount of flatness at extreme ends of the cam lobe.

4. Lift is defined as the distance between the ______________________ and the _________________________.

5. Speed of cam action is determined by the ________________________ of the on-ramp and off-ramp.

6. Check lobe height of the automobile camshaft for consistency with a ___________________________.

7. Give examples of cam use in the following areas:

   Typewriter ____________________

   Printing equipment _____________________

   automobiles ___________________

   washers _______________________

   machine tools _________________

INSTRUCTIONAL LEARNING SYSTEMS

10.2

MACHINE COMPONENTS -- BEARINGS

Goal:

The apprentice will be able to describe bearings and their function as machine components.

Performance Indicators:

1. Describe plain bearings.
2. Describe materials used in main bearings.
3. Describe lubrication of plain bearings.
4. Describe removal and replacement of split bearings.
5. Describe anti-friction bearings.
6. Describe removal of anti-friction bearings.
7. Describe cleaning of anti-friction bearings.
8. Describe inspection of anti-friction bearings.
9. Describe lubrication of anti-friction bearings.
10. Describe installation of anti-friction bearings.

104-A INTRODUCTION TO PLAIN BEARINGS

This learning package provides an introduction to one type-plain (friction) bearings. These are extensively used in engines, compressors, pumps, home shop, and lawn and garden equipment.

Upon successful completion of this course, you will be able to:

1. Define a friction bearing.

2. Identify three types of friction actions for which bearings must be used.

3. Describe four types of split bearings.

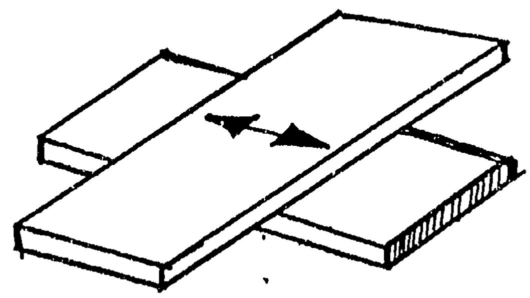
4. Sketch and identify the parts and function of those parts of an automotive crankshaft bearing.

LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet	
Read: John Deere, Fundamentals of Service Manual, Bearings and Seals	Much additional material is available on bearings of all types. Service manuals may be referred to for additional information.
Read: Crouse Automotive Mechanics McGraw-Hill Book Comp[illegible] chapter on Engine Co[illegible]ruction Block cranksh[illegible] and Bearings Chapter 6, page 100	
Do: Obtain several friction bearings from your instructor Be able to identify them by type and use. Also, identify all parts of the bearings.	By pointing out the features on real bearings, a better understanding of bearings is obtained.

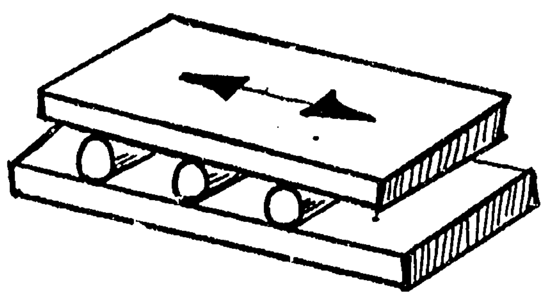
INFORMATION SHEET

BEARING INTRODUCTION



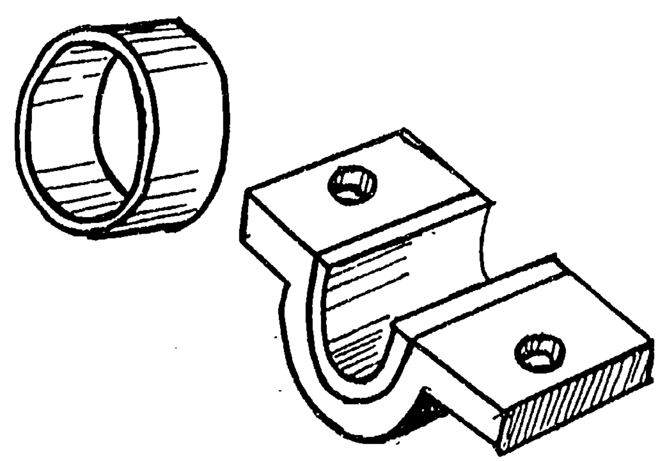
Whenever a shaft carrying a gear, wheel, or pulley turns within its supports, there must be some provision to reduce the friction which causes wear.

That provision is in the form of bearings. Bearings not only support the shaft but keep it in alignment as well.



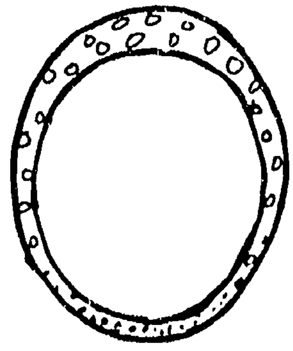
Friction is reduced by providing sliding friction on a smooth bearing surface (Friction Bearings) or rolling friction by placing balls or rollers between the shaft and its support. (Anti-friction Bearings).

FRICTION BEARINGS



Friction bearings are usually found in the form of bushings or plain bearings.

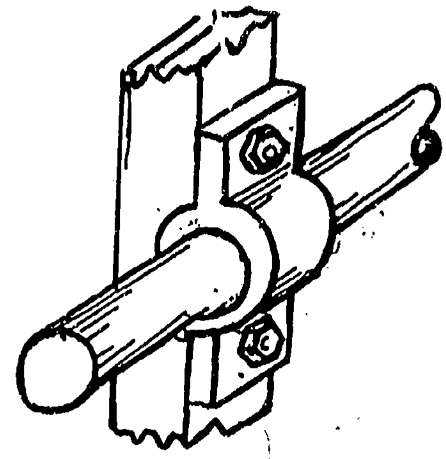
Friction bearings must have a softer surface than the surface of the journal facing it.



The bearing surfaces normally do not rub metal-on-metal except in extremely light duty use. Oil is usually forced into the area between the shaft journal and the bearing surface. The turning of the shaft forces oil to wedge beneath it, actually forming an oil cushion that will support the weight of the shaft. The oil that remains on a surface without pressure, "boundary lubrication", or viscuous friction caused by turning the oil molecules is not sufficient to prevent wear.

It is for this reason that automotive engineers claim that most engine wear occurs during cold start and warm-up.

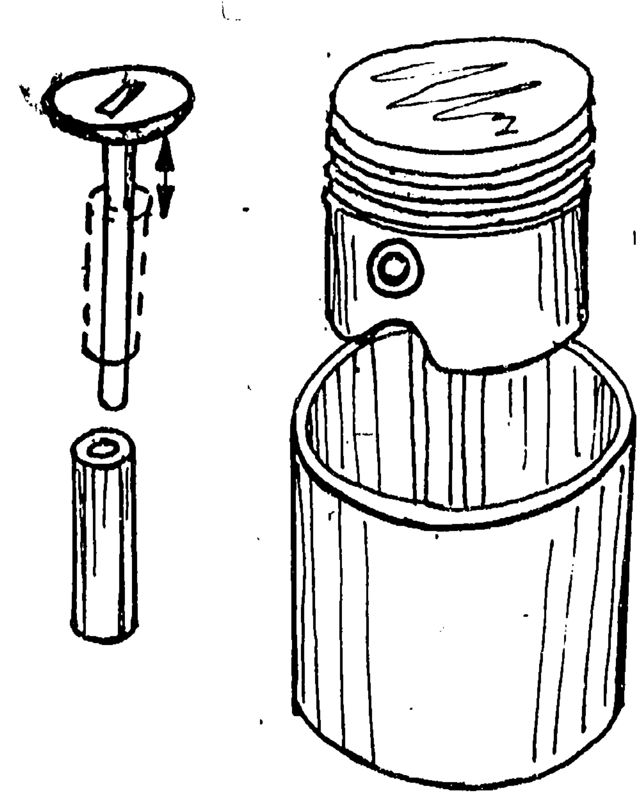
Friction bearings are used in automotive, truck, tractor, stationary engines, compressors, etc, to combat friction harmful from the following types of action:



JOURNAL

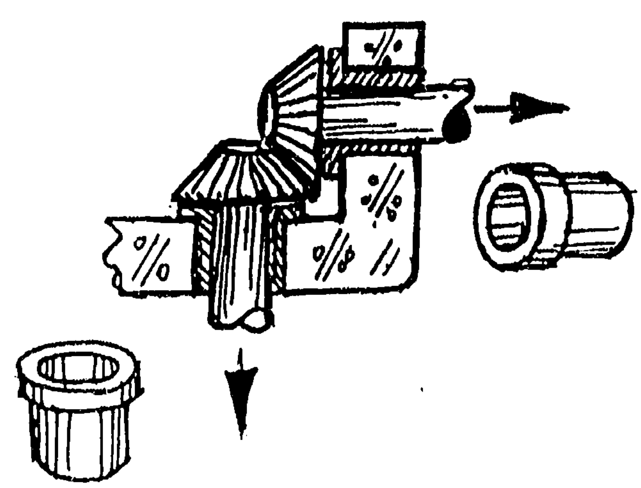
Journal action is the support of a spinning shaft. Bearing surfaces are required to reduce friction while supporting the rotating motion (radial loading).

GUIDE



Guide action will keep a device in alignment as it slides. Automotive valve stems and piston skirts are illustrations of this type of action. Anytime two surfaces make contact while moving, the bearing capabilities of the material from which these are made must be considered.

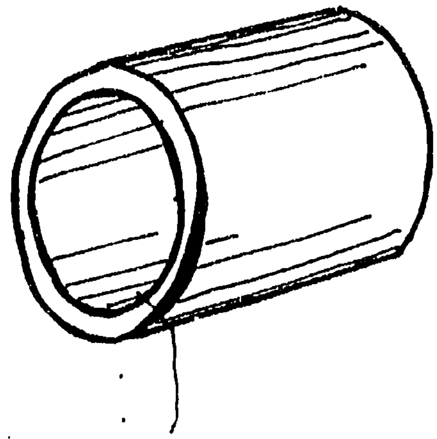
THRUST



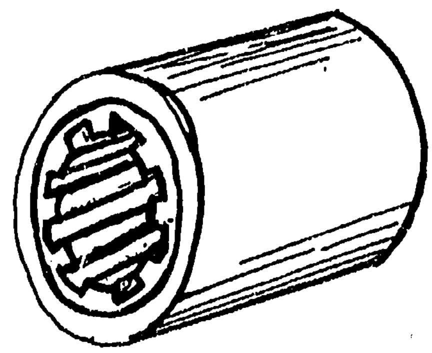
Thrust is the axial pressure that is applied to a rotating shaft. Not only is t' bearing required for the journal or ·tional motion, but is also re-quii.u to hold the shaft in position.

TYPES OF FRICITON (PLAIN) BEARINGS

SOLID BEARINGS (Bushing or Sleeve)



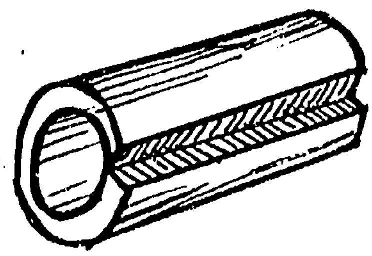
Bearings are usually made of copper, brass, bronze, or a combination of the above. Often they are made with a sintering process in order to hold graphite or oil. These go by many different trade names such as Graph-oil or Oillite, etc. These bearings provide radial or guide motion only.



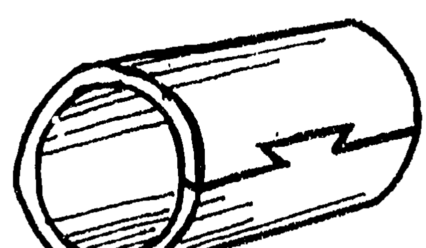
Another type of solid bearing is made of rubber and has a spline-like center to permit the lubricant (usually water) to flow through it to support the radial motion of the shaft. The outer support is usually of hard rubber.

NOTE: For more information on materials, see Learning Package 104 B "MATERIALS IN PLAIN BEARINGS".

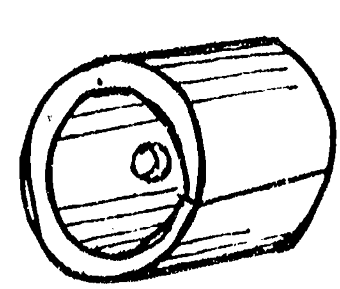
SPLIT BEARINGS



There are several types of split bearings. For the purposes of this Learning Package, they will be labeled by an artificial type number.

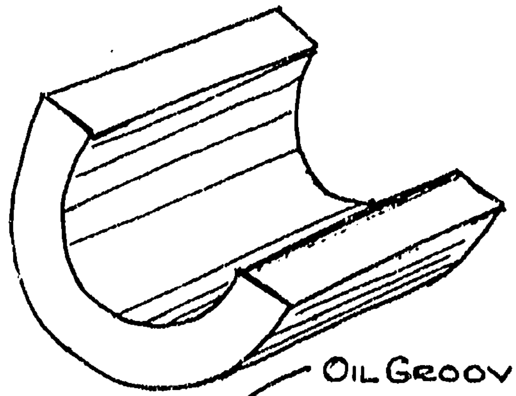


1. Type 1: This type of split bearing is made of solid copper, brass, bronze, etc. It starts out as a piece of flat metal but is stamped and shaped during its manufacturing process to the size and design required for a particular light duty, radial load application.



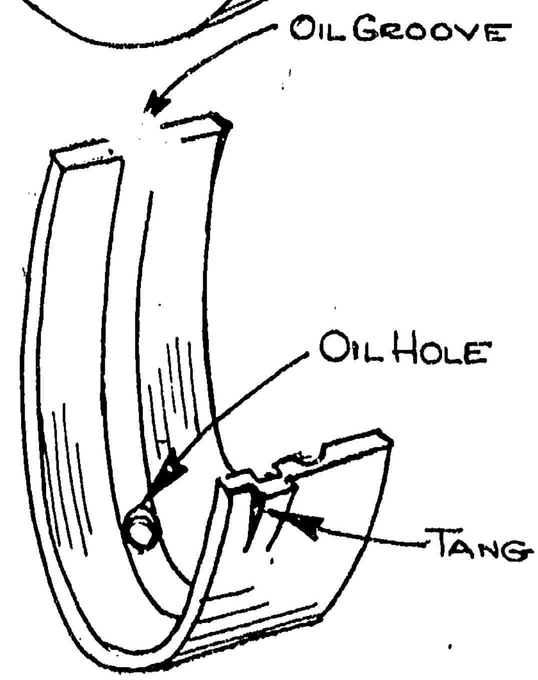
2. Type 2: This type of bearing is for heavier duty radial loads. It is constructed with bearing metal of bronze, babbit, etc. over a hard metal backing. This type of bearing is often used in automotive camshafts or other applications where heavier bearing loads and controlled lubrication are available. These bearings are generally used to support radial loads.

3. Type 3: Split bearings of this type are often constructed of wood, plastic, rubber, sintered metal or cast iron. They are usually one piece and are often molded to their final shape. These bearings are less expensive to construct but are very adequate for a large number of lighter duty radial and guide motion applications.

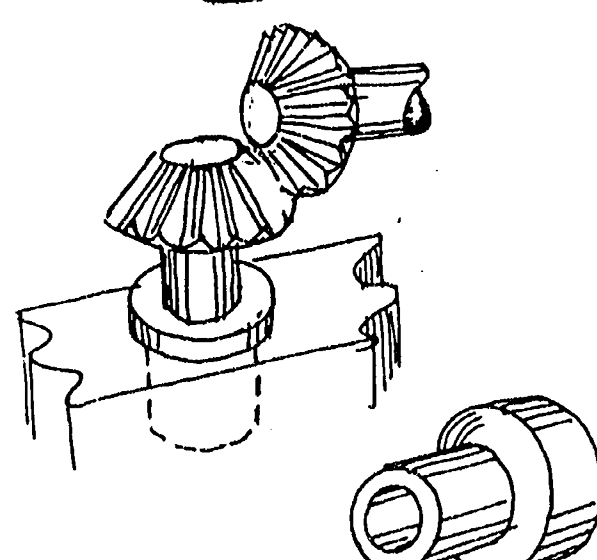


4. Type 4: The split bearing is most familiar to mechanics and those who have observed mechanical work. These bearings are most generally used on the automotive engine crankshaft.

   These bearings are manufactured in halves and are steel-backed with a lining of bearing metal, bronze, babbit, sintered metal, etc. Oil holes and grooves to distribute the oil are manufactured into the design of the bearing as are the locking tangs to hold them in place. These bearings generally control radial loads only.

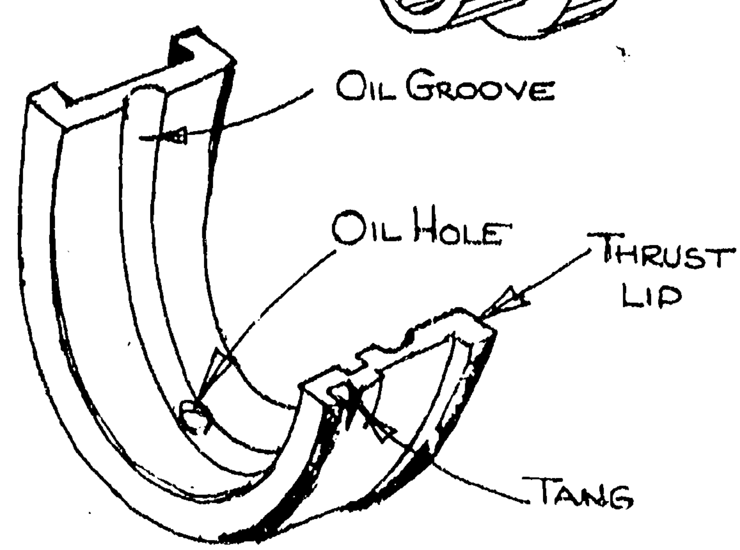


THRUST BEARINGS



Thrust bearings are constructed to support axial loadings on the shaft. Some axial loads are all one direction while others such as crankshafts require bearing support in both directions.

In plain bearings, thrust bearings are usually manufactured in the same manner as split bearings for particular loads. There must be a lip on one or both sides depending upon job requirements of the bearing.



SELF-TEST

Complete the sentence or circle the most correct answer.

1. Bearings are required whenever a shaft____________________ upon the support.
2. Bearings are divided into two classes, ____________ and ______________.
3. In audition to the bearings, ____________ helps remove shaft friction.
4. Plain bearings must have surface metal that is ________ than the shaft metal.
5. Another name for a plain bearing is a ____________________.
6. Normally, bearings and shafts (<u>do, do not</u>) rub metal on metal when in use.
7. Axial pressure applied to a bearing is called __________ pressure.
8. Piston skirts are really bearing surfaces. T. F.
9. Solid bearings are always made of metal. T. F.
10. Split bearings are used mostly for the support of ____________ loads.
11. The device that locks a split bearing into place is called a _________.

SELF-TEST ANSWERS:

1. rotates	8. T
2. friction, plain and anti-friction	9. F
3. lubrication	10. radial
4. softer	11. tang
5. bushing	
6. do not	
7. thrust	

INTRODUCTION TO PLAIN BEARINGS

1. plain friction, anti-friction
2. F
3. thrust
4. distribute oil
5. light
6. T
7. thrust

POST—TEST

Package Number 104-A

INTRODUCTION TO PLAIN BEARINGS

INSTRUCTIONS: Complete the sentence or circle the most correct answer.

1. Name the two main categories of bearings.

   ________________ ______________________.

2. Split bearings always have matching halves. T F

3. Axial pressure is usually called ____________________.

4. The groove in the middle of the bearing is designed to ______________.

5. Bearings made from solid bearing material are usually designed for (light, medium, heavy) loads.

6. Bearings are sometimes made of wood or plastic. T F

7. A lip on a bearing usually means that the bearing will handle ______________ loads.

Name ______________

Date ______________

Industrial Mechanics

This lesson explores a wide variety of materials used in plain bearings. Many more types of materials are used than the average person realizes.

BEARINGS

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COOPERATION [illegible]

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LEARNING ACTIVITIES

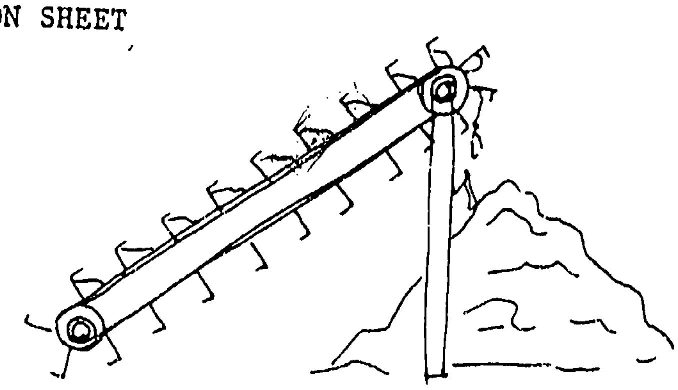
ACTIVITIES	PURPOSE
Read: Information Sheet	Added reading will provide a broader base of information for the student.
Read: John Deere, Fundamentals of Service Manual - Bearings and Seals	
Do: Obtain bearing samples from your instructor and identify the metals in each one.	Use of actual bearings to recognize the metals will provide more confidence than working with book explanations and pictures.

INFORMATION SHEET

MATERIALS IN PLAIN BEARINGS

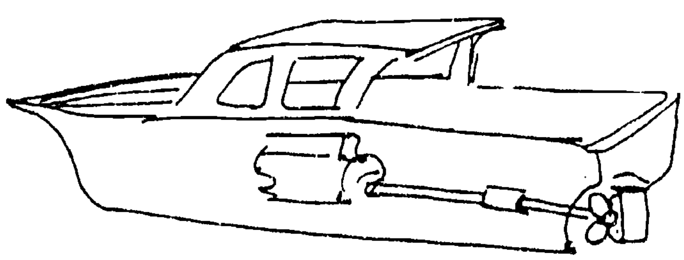
WOOD

Wooden bearings are used on large, slow-moving shafts such as conveyors that operate in very dirty conditions. They are not expensive, do not require much maintenance, and are relatively long-lived.



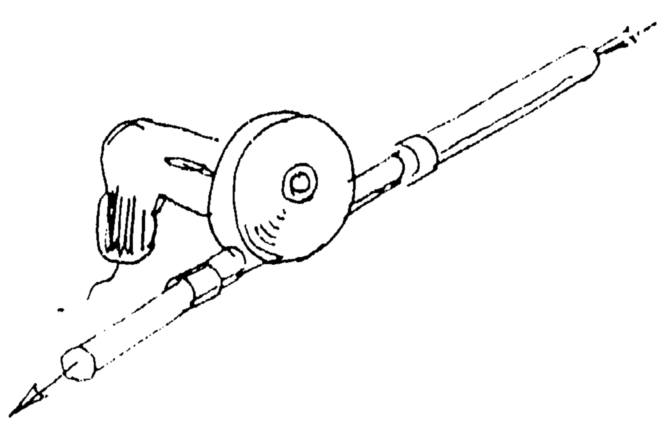
RUBBER

Rubber bearings are used primarily where there are large amounts of water. This would be in pumps, sand and gravel washers, turbines, boat propellers and shafts. Rubber helps reduce vibration and shock, giving quieter operation.



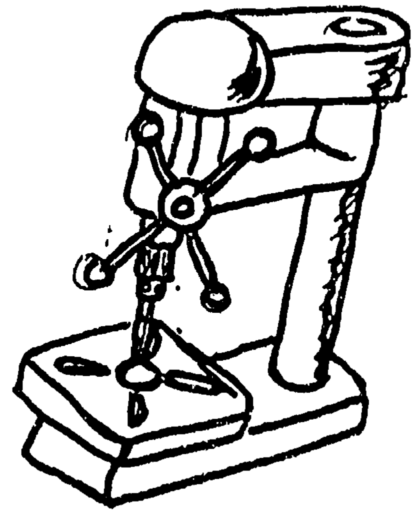
PLASTIC

Phenolic, teflon, nylon, etc. are becoming popular for bearings because they conform in shape, are partially self-lubricating and resist corrosion. Sometimes they are laminated (layered) with cotton fabric, absestos, or other materials for added strength and shock resistance. They do not transfer heat readily and, therefore, adequate cooling must be provided, as in pumps.



STEEL

Soft steel is sometimes used to support shafts where little movement is expected i.e., the main requirement is for support such as in the table of a drill press.

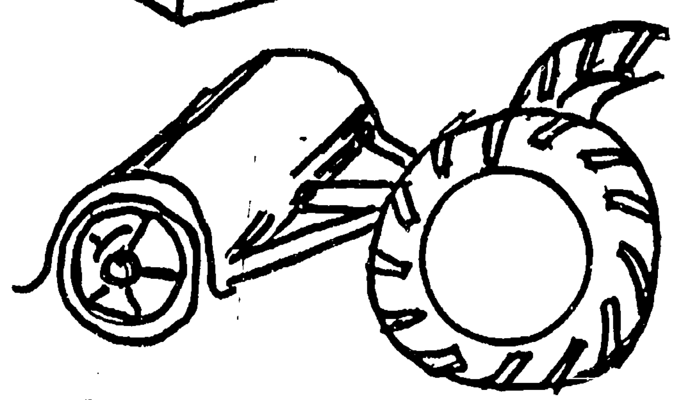


Hard steel bearings may be used to support slow moving shafts for wheels. An example of this would be in some hay rakes.

CAST IRON

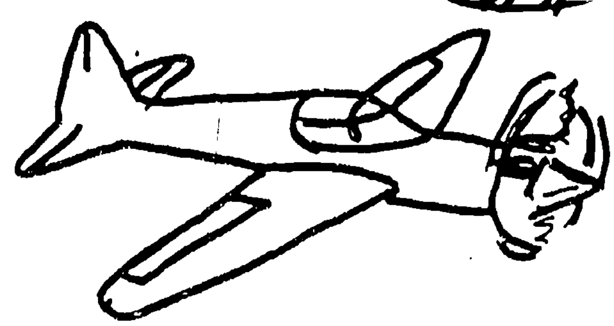
Both cast iron and hardened cast iron are used for slow moving shafts that operate in very dirty conditions.

These materials are used for bearings in farm equipment, conveyors, etc. because of the dirt wear-resistance.



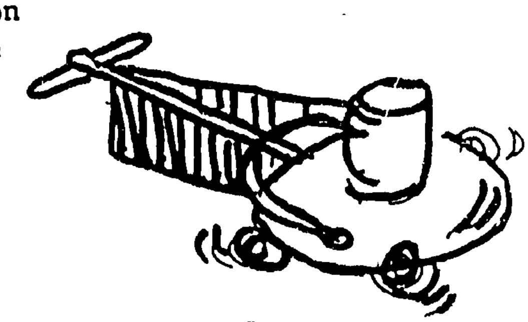
ALUMINUM

Aluminum bearings are often used where weight is a factor. They can function in high speed applications with proper lubrication.



SINTERED METAL

Sintered bearings are often used in low maintenance type of machines. Sintered metal bearings are constructed by crushin particles of metal to the shape of the bearing under extreme pressure and heat. This process leaves a porous surface that will retain bearing lubrication for an extended time. Bearings are made of iron, brass, bronze, graphite, etc. and are impregnated in lubricating oil prior to being installed.



COPPER, BRASS, AND BRONZE

Bearings of these materials are used in many applications. The particular metal in use depends upon the application and the wearing charcteristics of the metal to be used. Bronze, normally an alloy of copper and tin, is the most commonly used of the three metals.

COPPER AND LEAD

An alloy of these two metals is used where the support of copper and the softness of lead are required in the bearing. This alloy is often used as a backing for babbit, tin or silver in engine crankshaft bearings.

BABBIT

Babbit is an alloy of antimony and tin. It is a relatively soft material and is most often used in conjunction with a backing material as described under COPPER AND LEAD.

Babbit bearings are the most common in use today in the automotive or industrial engine crankshaft bearings.

SELF-TEST

Identify eight material from which bearings are made.

Give examples of use of the above.

SELF-TEST KEY

Wood, rubber, plasic, steel, cast iron, aluminum, sintered metal, babbit, copper & lead, copper, brass, bronze

wood - large, slow shafts

rubber - boats, pumps, etc.

plastic - pumps

steel- drill press beds

cast iron - farm equipment

aluminum - aircraft

sintered metal - lawn equipment

brass

copper - small motors, generators

bronze

babbit - automotive bearing face

copper and lead - automotive bearing back

POST-TEST KEY

Package No. 104-B

MATERIALS IN PLAIN BEARINGS

1. large
2. water
3. cast iron
4. heat
5. oil
6. combination
7. bronze, babbit
8. babbit
9. aluminum

POST—TEST

Package Number 104-B

INSTRUCTIONS: Complete the sentences or circle the most correct answer.

1. Wood bearings are used with (large, medium, small) shafts.
2. Rubber bearings are used when the shaft rotates in a large volume of ____________________.
3. Dirt resistance is best in ____________________ bearings.
4. Plastic bearings do not readily transfer ____________________.
5. Sintered metal makes provision for ____________________.
6. An alloy is a ____________________ of metals.
7. Name two alloys ____________________ & ____________________.
8. ____________________ bearing metal is most common in automotive engines today.
9. ____________________ is used for bearings where weight is a major consideration.

Name ____________________ Date ____________________

104-C LUBRICATION OF PLAIN BEARINGS

Bearings must never be allowed to run dry. This lesson provides material to introduce the student to various methods of distributing lubrication to bearings (for information on various types of lubrication and their uses, refer to Division Code 108 of the VIP Industrial Mechanics Cluster Guide "Lubrication".)

Upon successful completion of this course, the student will be able to:

1. List five systems for distributing oil or grease to a mechanism.

2. Describe the components and the function of each system.

3. Trace or diagram the oil passageways in a modern automobile engine.

4. Diagram and describe the purpose for different bearing oil groove patterns.

LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet	
Read: John Deere, Fundamentals of Service Manual-Bearings and Seals	Each text provides added information on oiling systems. The automotive books show both general and specific examples of all types of motor oiling systems.
Read: Motor Manual	
Read: Stockel Auto Service and Repair, Goodheart-Willcox Co., Inc.	
Do: Draw a sketch of a simple manual oiling system	
Do: Diagram a pressure grease fitting showing why the grease will not leak out	By drawing these diagrams and handling "live" component parts, the student increases his knowledge of the lubrication systems.
Do: Diagram an automobile full pressure oil system and show how the following are oiled: crankshaft bearings, rod bearings, camshaft bearings, rocker arms, valve stems	
Do: Obtain sample parts from instructor and identify all oil passageways.	

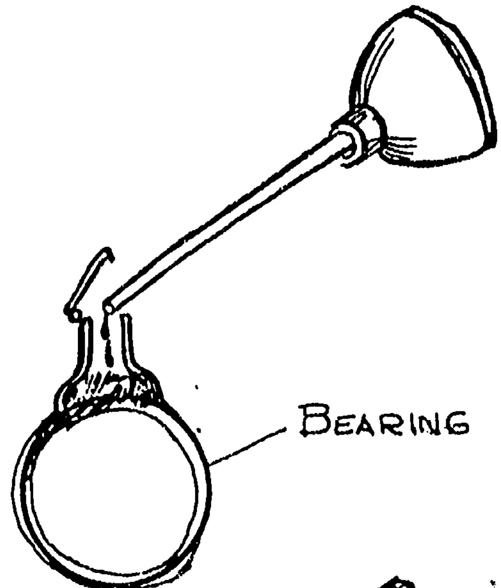
INFORMATION SHEET

DISTRIBUTION OF LUBRICANT TO PLAIN BEARINGS

Lubrication may be distributed to plain bearings in many ways.

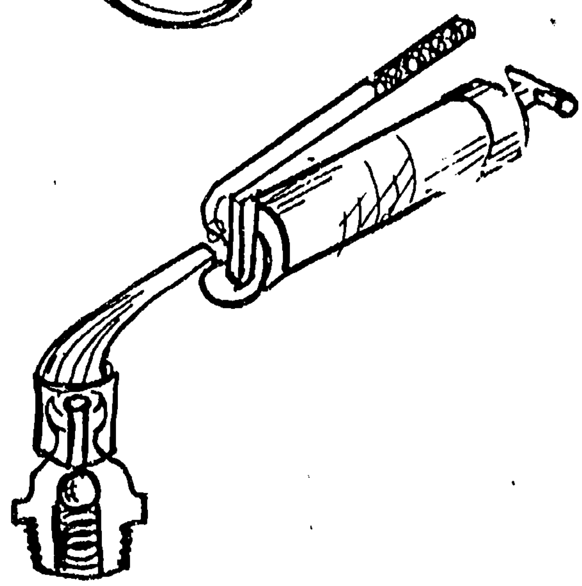
OIL CAN

Oil may be manually placed in an oil reservoir via an oil cup. This technique is used in sintered bearings and inexpensive equipment designed for occasional use, such as lawn equipment. Oiling should be done prior to each use.



GREASE GUN

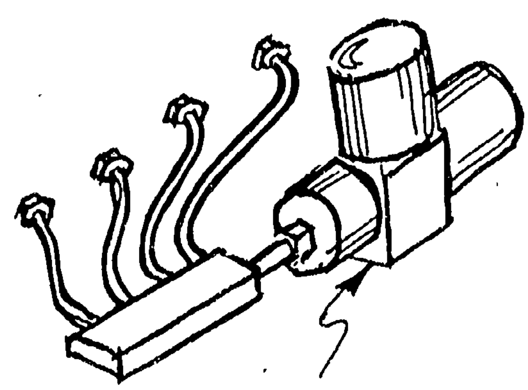
Some applications of lubricants use a grease gun to place grease in the bearing under pressure via a pressure fitting of some type. The fitting causes the grease to remain in the bearing area by not permitting it to back out the way it was injected. A ball check permits a one-way direction for the grease.



CENTRAL GREASING

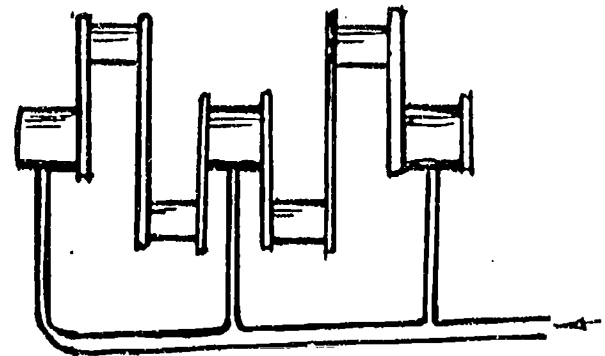
Sometimes several hard to reach fittings are connected with tubes to a central grease pump. As the need for lubrication arises, a central pump forces grease to all of them, simultaneous.

Caution should be exercised in this type of system that each area is checked for adequate lubrication. If one fitting becomes plugged, the hydraulic pressure may over-lube the other fittings while leaving the plugged fitting dry. If one of the tubes leading to a fitting breaks or comes off, the pressure is lowest at that point and all the grease leaks out without lubricating the bearings.



LUBRICATION OF CRANKSHAFTS

FULL PRESSURE OILING

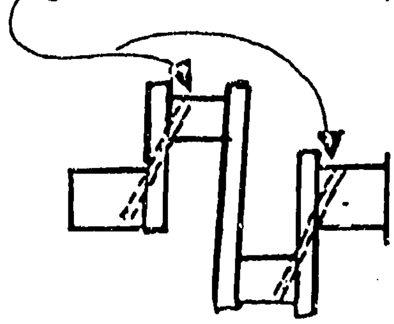


Oil Lines to Main Bearings

Crankshafts that turn at high speeds usually are oiled under pressure at the main bearings.

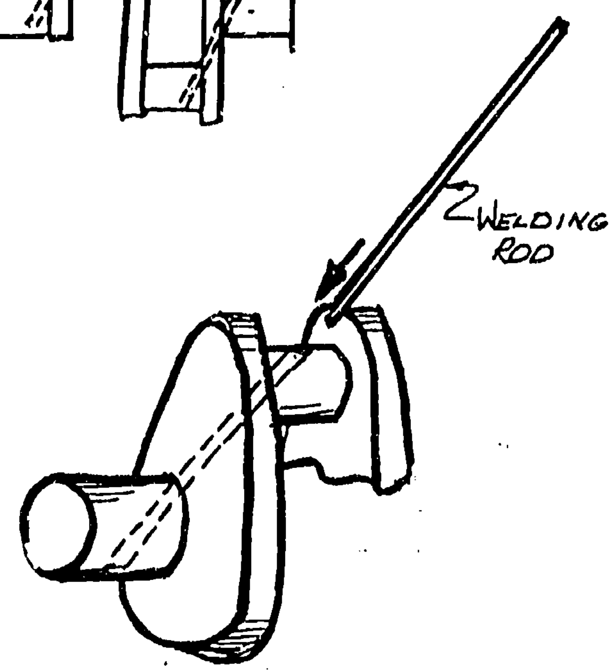
Oil lines or passageways are designed in the support mechanism to allow pressurized oil to be applied directly to the main journals.

Oil Lines from mains to Rod Journals



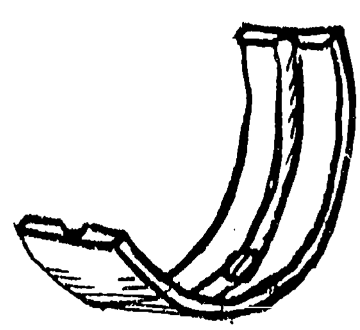
Usually the shafts are drilled to permit this oil a passageway through the crankshaft. It is important to have the main bearings and journals round and fitted closely to prevent the oil from leaking out at the main and not supplying the rod with sufficient oil pressure.

Rod bearing life will be shortened without enough lubrication.



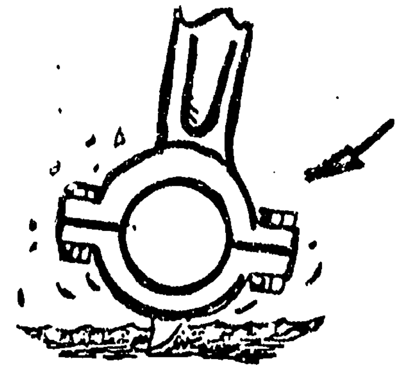
Anytime the crankshaft is removed for maintenance, that shaft's oil lines should be cleaned. A welding rod, drill bit, rifle brush, or other tool should be used to be certain the oil lines are clear. Use care not to leave metal particles, a rough surface, or burrs in the lines, as they may cause future oil obstructions.

In high speed, high compression engines, the bearings are usually made of an oil-absorbing metal (babbit) that permits a low friction surface. This metal is backed by a harder material to provide more shape-holding characteristics to the bearing insert. A bearing fails when the soft oil-absorbing materials wear away and the crank journal rubs directly on the backing metal. This occurs if enough oil to properly lubricate the bearing does not reach its surface. Often a defective bearing will be noticed before the crankshaft journal shows wear



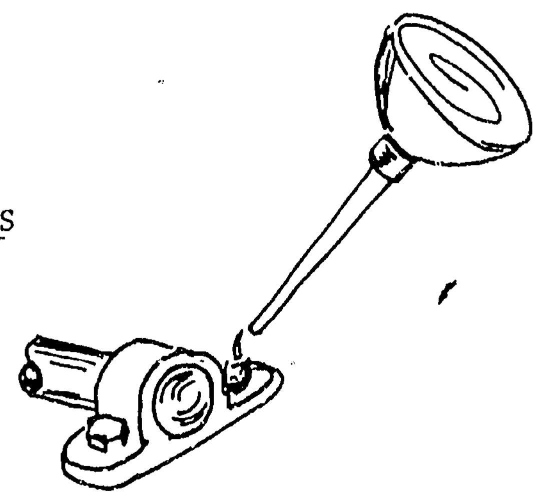
SPLASH OILING

Some low speed, low compression engines or heavy duty equipment that use ball or roller bearings on the crankshaft journals are oiled by the splash or combination splash and full pressure method. In the pure splash system, each connecting rod has a dipper on the rod bearing cap. These dippers move through oil trays throwing oil up into the engine. The action of splashing the oil inside the engine causes an oil mist to be constantly sprayed on all internal engine parts that move.



COMBINATION SPLASH AND FULL PRESSURE OIL SYSTEMS

A combination of the above are used in some engines. Pressure oil is fed to main bearings, camshafts and valve mechanism and the rest of the engine lubricated by the splash system. In all cases, oil level must be maintained.



LUBRICATION DISTRIBUTION INSIDE PLAIN BEARINGS

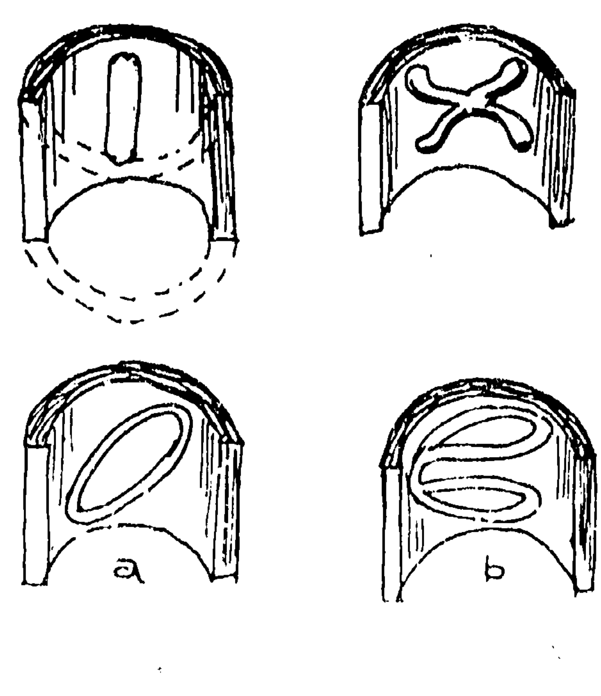
BEARING GROOVES AND CHAMFERS

Bearings may have oil or lubricant supplied to their exterior, but it is important to be certain that the lubricant is uniformly distributed to the entire area of contact between the bearing and the shaft journal. Depending upon the lubricant, the bearing, and the operational requirements, the bearings may be drilled, cut, grooved or chamfered to make most effective use of the lubricant.

General, light duty applications use simple oil grooves.

If oil is to be properly supplied to the bearing ends (a) or in fractional horse power motors (b), then these grrooves must be present.

Grease lubrication demands a more complex groove system.

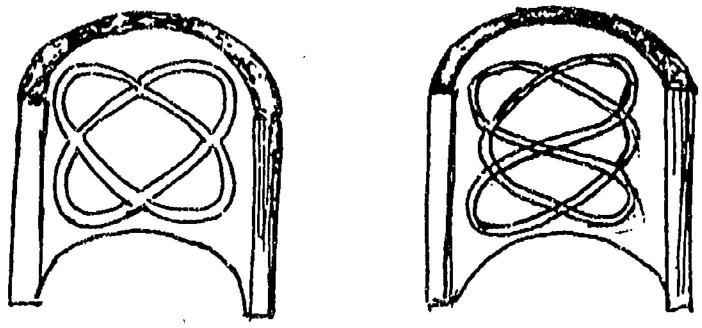


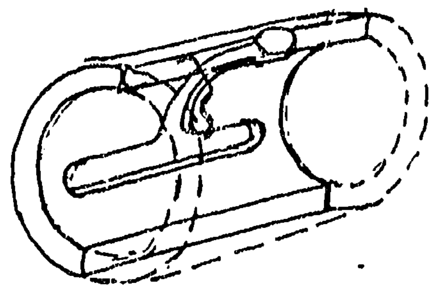
A feeder hold and axial distribution ring is often used on large, slow speed bearings.

Chamfered recesses in split bearings serve the function of lateral distribution of oil in some engine bearings.

Sometimes, the chamfers are grooved to permit more oil to cool the bearing.

Other designs are made up for special needs of unique equipment. For example: pulsating loads or water lubrication may use the spline-type grooves





SELF-TEST

Complete the sentence or circle the most correct answer.

1. Hard to reach grease fittings are often greased through a ____________ greasing system.

2. Oil cups should be filled prior to each ____________________.

3. Grease fittings often use a ball check to control the ________________ of the grease flow.

4. Today's automotive engines are usually oiled with the ________________ system.

5. Dippers on connecting rods cause the oil to form a ____________________.

6. The bearing fit is important because it controls the oil ______________.

7. Most U.S. engines use a bearing with a surface of ____________ ________.

8. Crankshaft oil passages should be ____________ when the engine is disassembled for repair.

9. Bearing failure always results in shaft failure. T F

10. Oil is distributed inside a bearing by the __________ ______________.

11. A feeder hold and an axial groove is usually found where ____________ ____________ shafts turn.

12. Lubrication may be done with oil, grease, and ____________________.

SELF-TEST ANSWERS

1. central
2. use
3. direction
4. full pressure
5. mist
6. pressure
7. babbit
8. cleared
9. F
10. oil grooves
11. large, slow
12. water

POST—TEST

Package Number 104-C

LUBRICATION OF PLAIN BEARINGS

Check the lubrication system of a given piece of equipment.

Explain the types of lubrication systems involved.

Describe why each of the above lubricating systems is used.

1. What kinds of bearings are being lubricated.

2. How the lubricating system works.

3. What other types of system could be used (if any).

Name ____________ Date ____________

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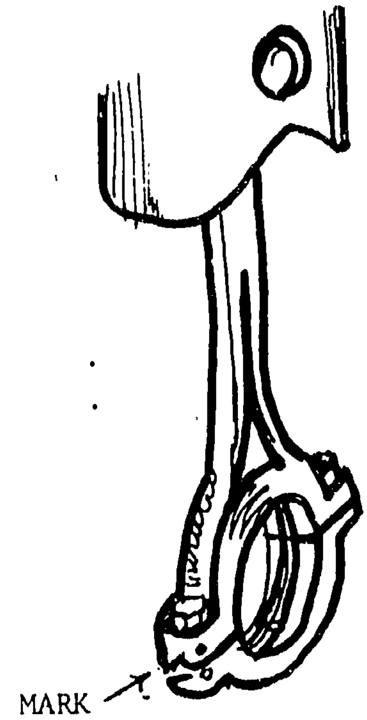
LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet	
Read: Auto Service and Repair, Stockel, Goodheart-Wilcox Company	
Read: Chapter on Friction Bearings, Chapter on Crankshaft, Main bearings, Flywheel Service	Read additional texts to expand the material in the information sheet.
Read: Fundamentals of Service, Bearings and Seals, John Deere	
Do: Obtain rod and crank systems from your instructor. - remove and replace inserts - adjust bearings in a bearing shim system	Teaches you how to remove and replace bearings and how to adjust them.
Do: Obtain set of used insert bearings. - identify cause of bearing failure for each bearing	Identify bearing failure.
Do: Using a micrometer, check a sample system and determine: - if shaft is within tolerance - if bearing shows wear	Be able to determine if shaft will need standard bearings or oversized bearings.

INFORMATION SHEET

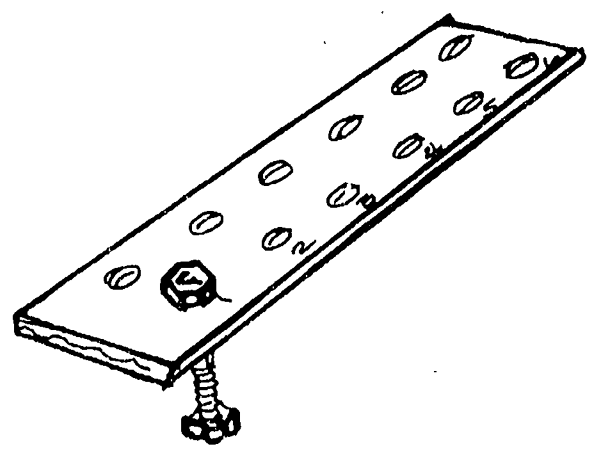
SPLIT BEARING REMOVAL

A visual awareness must be maintained when disassembling areas containing split bearings. Nearly all internal combustion engines use this type of bearing, from lawn mower engines and outboard engines through heavy duty truck and tractor engines.



Engines have been line bored after the caps were mated to the housing. Therefore, each cap is unique to the position it fits. Bearing caps should not be mixed.

Before the bearing caps are removed from the engine, the mechanic should note if all connecting rods and caps are identified to permit the replacement of the same rod and cap back to its original shaft journals. If they are not so marked, they should be identified by marking with a center punch to prevent placing them in a different location.

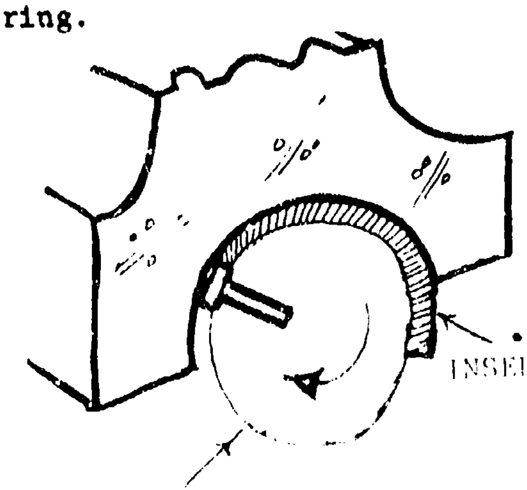


NOTE: Do not mark on cap top over the bearing area. The main bearings pillow blocks should be marked in a similar manner in order to facilitate reassembly of the motor.

After assurance of proper parts marking, the bolts may be removed from the pillow blocks. (Note: a good rule to practice is to store bolts in such a way as to be able to put them back into the holes form which they came.)

Split bearings are easily removed from each half of the bearing bore by sliding them toward the tang slot on the bearing.

It may be desirable to remove the upper main inserts while the crankshaft is still in the engine. A bearing insert removal tool may be placed in the oil passage of the crankshaft and the shaft rotated so the tool touches the side of the bearing away from the tang. Continue rotation to remove the insert. Reverse this procedure to install a new insert. NOTE: Don't forget to oil both sides of the insert.



INSPECTION OF SPLIT BEARINGS

Once the bearing halves are removed, they should be inspected to determine their condition. The condition of the bearing surface can tell the mechanic a great deal about the shaft journal.

- Overloading or Overheating Operating Conditions

  This type of failure causes metal fatigue which permits the plated bearing surface metal to break away.

- Tapered Shaft Journals

  If a journal is tapered, it will wear the bearing on the same side in both bearing halves.

- Misalignment of Shaft

  If a shaft and bearing are not in proper alignment, the bearing will wear on opposite sides. This wear is caused by undue pressure on one side of the bearing and the other side, having more clearance than was engineered, will permit the lubricant pressure for the bearing to drop.

- Lack of Lubrication

  Lack of lubrication can be caused by several conditions.

  --lubricant not at proper level
  --lubricant pump malfunction
  --faulty filter by-pass valves
  --lubricant lines or screens plugged
  --bearings incorrectly installed
  --badly worn bearings reduce oil pressure

Lack of lubricant will show up as premature, severe wear on the bearing surface. This wear is usually spread evenly across the surface of the load bearing area.

Before the bearing is replaced, the service technician should be certain the reason for lubricant starvation has been located and corrected.

- Corrosion

  Corrosion may be caused by contaminants in the lubrication fluids. Acids build up in certan types of use. Other contaminants may enter the lubrication system by malfunction of certain component parts. Fuel may enter when the diaphram of a fuel pump breaks. Anti-freeze may enter if a gasket fails. Any foreign matter may affect the life of the bearing.

- Dirt

  Bearing inserts must be installed in a clean environment and must be clean themselves. Pieces of dirt should be removed from the bore area as unequal pressure will result in abnormal wear.

PROPER INSTALLATION TECHNIQUES FOR SPLIT BEARINGS

Friction bearings are not repaired. They are replaced if any defects have been found.

CLEANLINESS

After the bearing has been removed and the bore area and bearing inspected, the bore area should be cleaned to assure that no grit, dirt, or foreign matter remains to disturb the new bearing.

NOTE: Do not handle the soft metal that faces the journal area more than necessary. Acids from the human hand will etch the surface of the bearing. Any handling is likely to contaminate the bearing surface.

MEASURING FOR PROPER BEARING

Be sure that the correct bearing is available for the installation. If the shaft has been found to be in a good, smooth condition visually, it should be measured with a micrometer to be sure it is within tolerances for roundness and taper. The micrometer will provide the size of the shaft, journal. Check manufacturer's technical manual to determine if the shaft remains within tolerances.

Reinstall the bearings (without the shaft) and, using an inside micrometer, measure the inside diameter of the bearing.

The difference between the inside measurement of the bearing and the outside measurement of the shaft represents the oil clearance between the shaft and the bearing.

Refer to manufacturer's specifications to obtain the correct clearance requirements for this application.

If the shaft is still within the manufacturer's tolerances, the wear probably has occured in the bearings. This may be checked by comparing a micrometer reading from the side and bottom of the bearing half.

Be sure to use a piece of round material to compensate for the curvature of the bearing.

Bearings are usually marked STD or .001 or .002 or .010 of an inch to fit a shaft that has worn or has been ground to a smaller than standard size. Markings usually appear on the bearings but sometimes may be found only on their shipping box.

REPLACING THE BEARINGS

If replacing the bearings in a crankshaft of an engine, compressor, etc., the following steps should be taken

1. Clean all of the bearing bore areas. Be sure they [illegible] are spotless.

2. Lay out all bearings in the proper order for installation. Some engines have different sizes for different locations.

3. Place the upper haves of each bearing in the block. (Do not intermix between bearing halves). NOTE: Be sure the oil holes of the block match the oil holes in the bearings.

   Be sure the locking tangs of the bearing fit in the proper slot in the bore area.

4. LUBRICATE THE BEARING HALVES LIBERALLY WITH OIL TO BE USED IN THE SYSTEM.

5. Place the shaft gently in the bearing halves. CAUTION: Care must be exercised so damage to the bearings is eliminated.

   NOTE: Prior to this step, be sure all shaft oil lines have been cleaned.

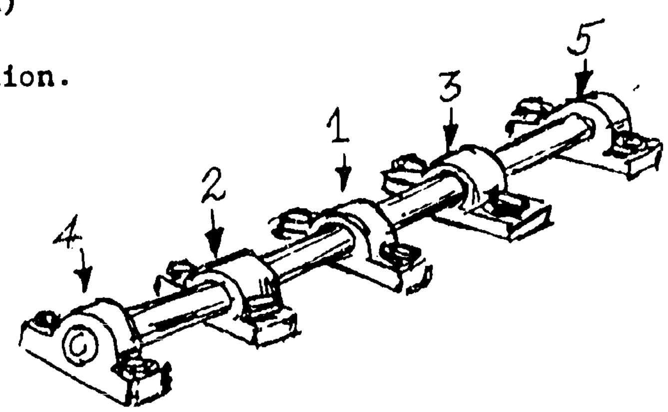
6. When shaft is freed, turn the shaft by hand to distribute oil over the journals.

7. Place the bottom halves of each bearing in the pillow block with bearing tang in the proper slot or the dowel in the bearing dowel hole.

8. Match each bottom bearing to its other half, place over the shaft journal and tighten bolts finger tight.

   NOTE: Be sure the tangs of the upper and lower half of the bearing are together. Check to assure the oil dippers (if installed) are in good condition and are pointing in the proper direction.

9. Torque the bolts of each cap to manufacturer's specifications, beginning at the center and working toward ends of shaft.



10. Turn shaft by hand to test for proper bearings after tightening each cap to specified tension.

    NOTE: If shaft will not turn freely, the bearings are the wrong size. Remove and replace with correct size bearings.

CAUTION: Even though the shaft must be turned after each journal is tightened, remember that only boundary lubrication is present and excessive rotation can damage the new bearings.

SMALL ENGINES AND COMPRESSORS

Sometimes small compressors and small engines, those driving lawn equipment, scooters, etc., do not use a conventional split bearing in their construction.

The rod itself may be made of bearing metal or the bearing metal may be poured into the rod. This was often done in older automobiles.

When the holes were bored to fit, many of the halves of the rod bearings were separated by shims. Shims are thin layers of brass of steel designed to permit removal of one or several to allow the bearing cap to be tightened on the shaft journal.

In those rods where shims were not used, the adjustments to tighten the rod on the shaft were made by filing the edges of the rod cap to reduce the size of the hole. If too much metal has been filed away, the opening may be adjusted by adding shims.

CAUTION: Be sure to take off metal evenly or the rod cap will be ruined which ruins the entire machine. For best results, remove by holding cap against a surface plate clamped at 90° to emory cloth while removing metal.

These techniques do not work with precision bearings because the insert bearing metal has been plated on and does not have an adequate thickness to permit adjusting by use of shims or filing.

ADJUSTMENT

The proper tension on a rod allows no rocking action or end play on the shaft. Also, the rod will rotate freely on the crankshaft.

SELF TEST

Complete the sentence or circle the correct answer.

1. Bearing caps should be marked on the (top, edge, end).
2. Bearings may be removed with the crankshaft still in the motor by placing a removal tool in the ______________________.
3. A ______________ shaft causes wear on the same side of both halves of the bearing.
4. A ______________ shaft will cause wear on one side of the top bearing half and the other side of the bottom.
5. Severe bearing wear that is spread evenly across the bearing is usually caused by ______________.
6. Most accurate measurements of shafts and bearings may be made, using a

7. The best source of information on bearing tolerances is to refer to the ____________________ specifications.

8. Before installing, bearings and shaft must be ____________________ liberally.

9. If bearings are new, it is not important to match up bearing halves.
T F

10. Always torque the ________________ caps first.

ANSWERS TO SELF-TEST

1. end
2. oil passageway
3. tapered
4. misaligned
5. lack of oil
6. micrometer
7. manufacturer's
8. oiled
9. F
10. center

POST--TEST

Package Number 104-D

Name ____________ Date ____________

Obtain shaft and rod systems from your instructor. Meet his requiremants in the following.

1. Removing inserts.

2. Inspecting and identifying cause of bearing damage.

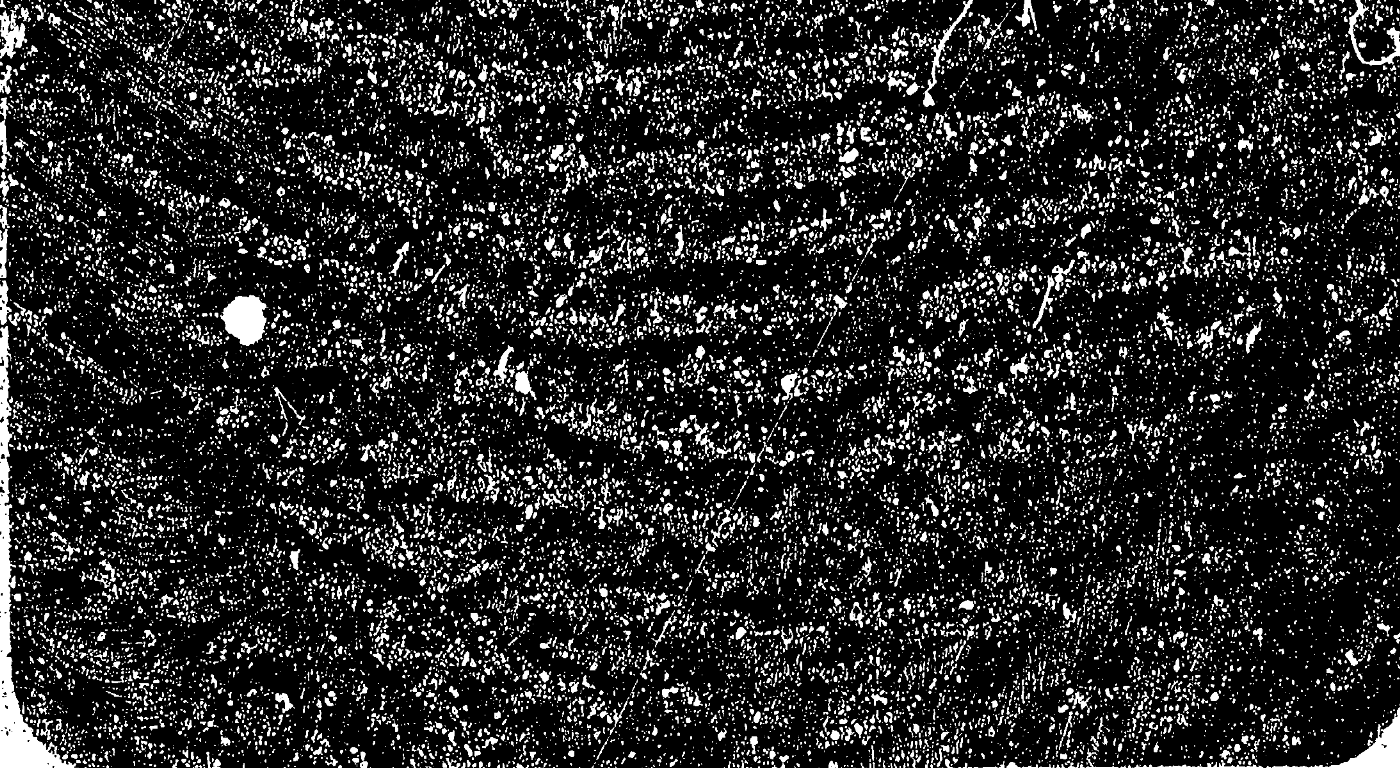
3. Replacing and adjusting to proper fit.

If a shimmed system:

1. Check bearing and shaft for condition.

2. If shaft is acceptable, clean and adjust to proper fit.

3. If shaft is not acceptable, state why, sketch damage.



Industrial Mechanics

104-F ANTI-FRICTION BEARING REMOVAL

Bearings must often be removed for service, inspection and lubrication. Improper removal techniques often damage an otherwise good bearing. This learning package provides information on correct removal techniques

OBJECTIVES

[illegible]

1. A puller to remove a bearing.
2. A press to remove a bearing.
3. The hammer and tube method of bearing removal.
4. The hammer and drift method of bearing removal.

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PROJECT DIRECTOR: Dick Earl

WRITERS:

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Steve Brous

John Anderson

Warren White

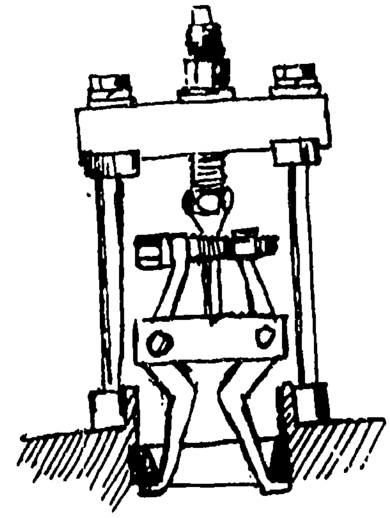
[illegible]

Always clean the area around the bearing housing and shaft prior to bearing removal. This will prevent unnecessary foreign material from entering the bearing area.

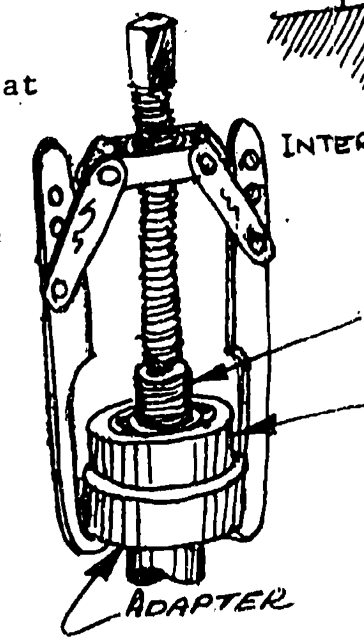
Consult the appropriate technical manual for correct procedures in bearing removal. If no procedures are available, then study the bearing mounting to see if the bearing may be removed by one of the following methods:

- use of a pulling device
- use of a press
- use of hammer and driver

NOTE: Regardless of the type of device that is used, be sure that the pressure applied to the bearing is applied against the press fit race. Never strike or pull the free race or the separator cage.



INTERNAL PULLER



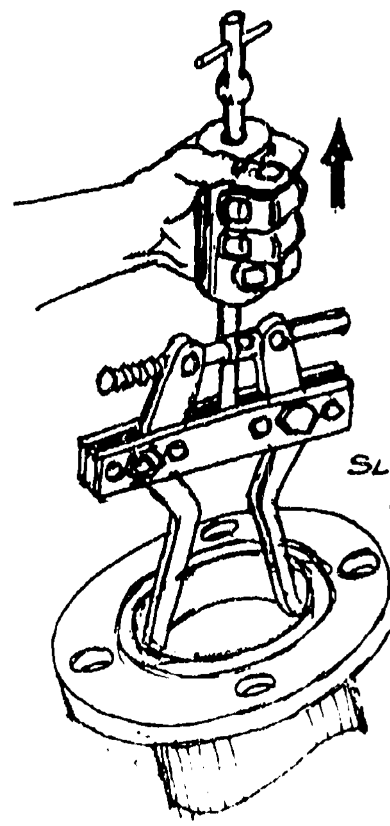
EXTERNAL PULLER

USING A PULLER TO REMOVE A BEARING

Generally speaking, a puller is a tool that will fasten firmly to a bearing or other device. The puller acts as a platform which will allow pressure to be applied to remove the device. Pullers are available in many sizes, shapes, and configurations. Most apply steady pressure by use of a threaded screw.

Some heavy-duty pullers use a hydraulic ram in place of the screw as a means to apply pressure. Still others use a weighted handle to apply a hammering action to force the bearing from its "press fit" location.

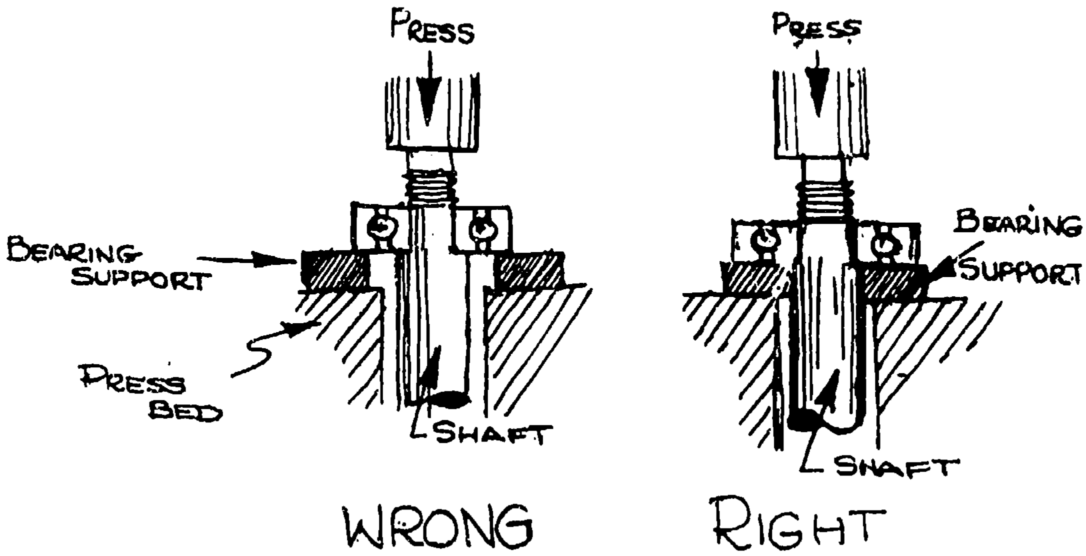
Though there are pullers of many sizes and shapes, all grip the bearing or have an attachment to provide a non-slipping grasp of the device and all apply pressure to pull away from a shaft or housing.



SLIDE HAMMER PULLER

USING A PRESS TO REMOVE A BEARING

When a puller is not available, or not as convenient to use, a bearing may be removed from a shaft and from some housings by use of a press. Again, be certain the bearing is supported so only the "press fit" race and not the free race or the separator cage has pressure applied to it. If this is not done, the bearing will be damaged or may "explode", causing pieces of metal to fly about in a dangerous manner.



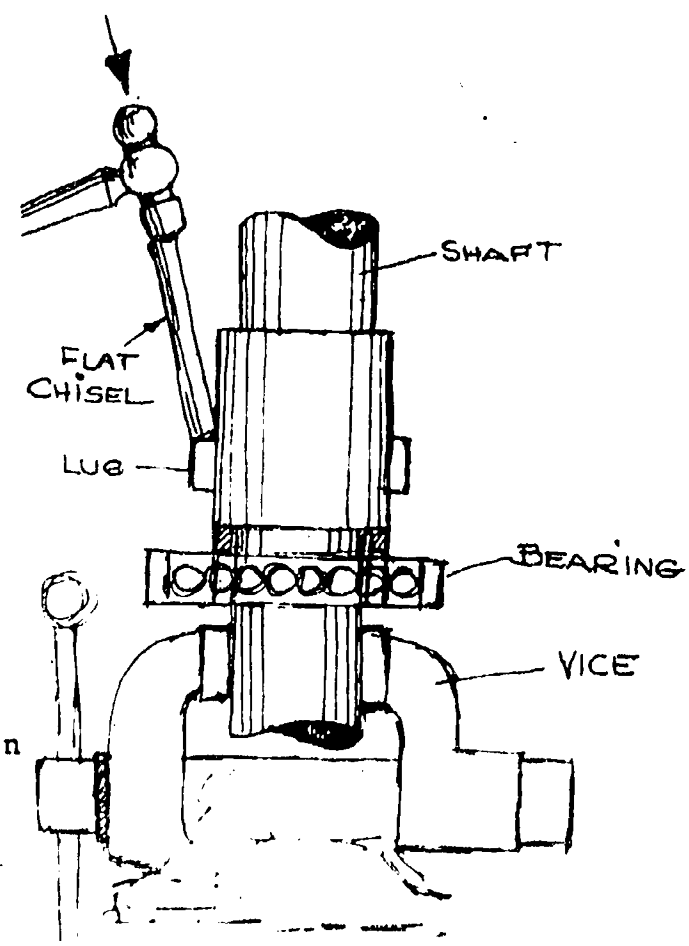
The outer race of a bearing may be removed by a press by using a bar or cup-shaped piece of metal or tubing the same size as the race. This piece is placed on the race and pressure is applied to it.

USING A HAMMER TO REMOVE A BEARING

There are times when a hammer is the only available tool to use to remove a bearing from a shaft. It may be used in either of the following ways with satisfactory results:

- the tube method

  Grip the shaft in vise jaws with the bearing in position to be hammered down. Place a piece of tubing over the shaft and let it rest on the "press fit" bearing race. (Be certain the tubing is the same size as the race.) The tubing should have lugs welded to it to support a flat chisel or drift.



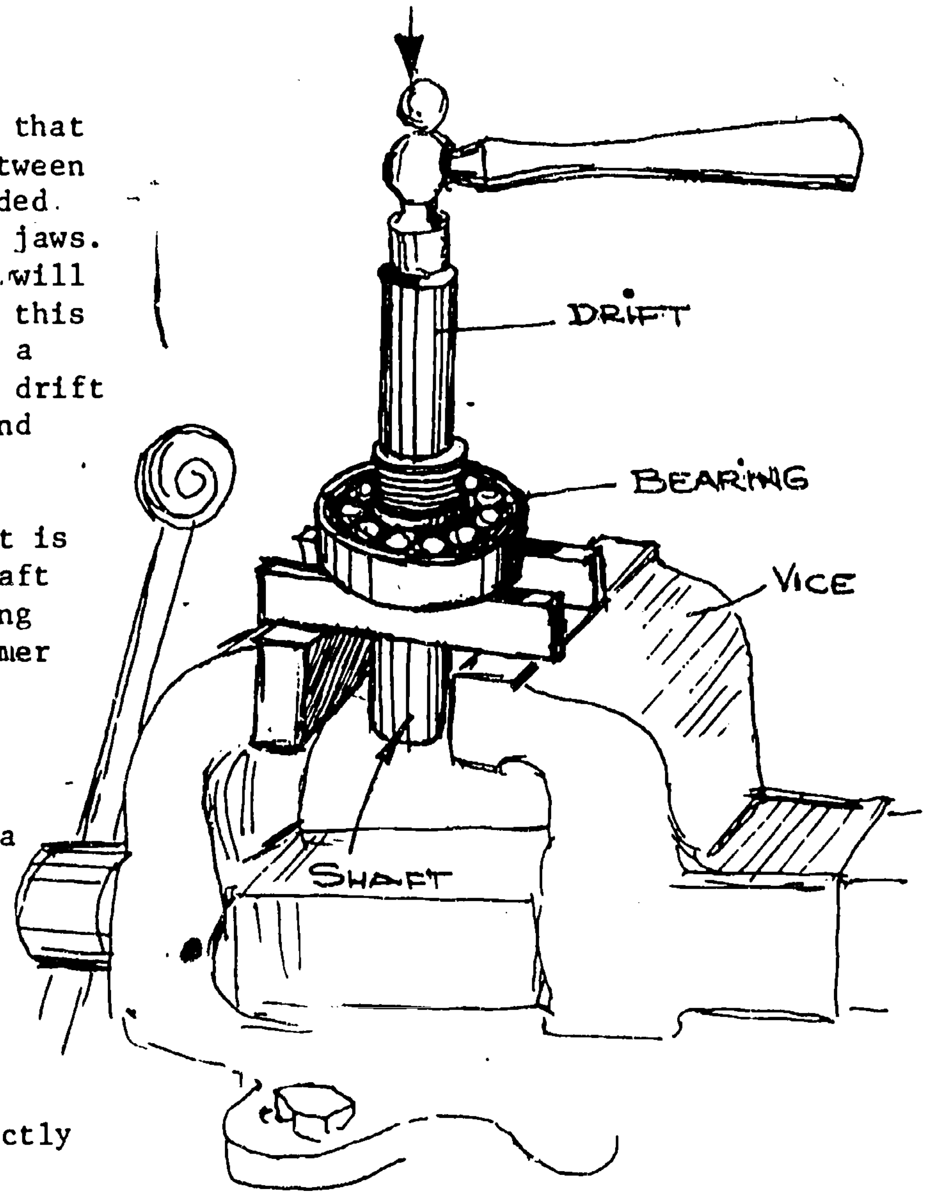
When shaft and tube are in position and a flat chisel or drift is placed against the lugs, the tube may be hammered down to remove the bearing race.

Hammering should be alternated from side to side or all around, if possible, to cause an even pressure to be applied to the bearing. This should prevent cocking of the bearing on the shaft, making it harder to remove and possibly damaging the bearing and the shaft.

- the brass drift method

This use of a drift requires that the shaft be held loosely between vise jaws with support provided by two blocks that cross the jaws. The bearing "press fit" race will rest on these blocks. After this set-up has been established, a brass or other soft material drift is used between the hammer and the end of the shaft.

The purpose of the soft drift is to protect the end of the shaft from mushrooming or distorting from the pressure of the hammer blows.



CAUTION:

- Do not strike the race with a hammer.
- Do not use a punch on the bearing.
- Do not load the outer race.
- Do not strike the shaft directly with the hammer.

NEEDLE BEARING REMOVAL

Instructions for the removal of needle bearings will be found in the shop manual for the device being disassembled. NOTE: If a technician accidentally opens a needle bearing area, be sure that all needle elements are accounted for or the entire bearing will require replacement.

WORKSHEET

Sometimes a "push fit" bearing will not remove easily because of rust, dirt, or a heated case, etc.

When this happens, the mechanic may have to resort to non-standard removal methods.

CAUTION: The methods illustrated in this quest are unorthodox and may ruin an otherwise satisfactory bearing. All standard methods should be exercised before attempting these methods. Remember to check thoroughly to be certain that there is no other bolt, set screw, snap ring, or gear, etc. to hold the shaft that you are trying to remove.

The following methods should be attempted in order:

- Tapping housing

  If the "push fit" will not move under hand pressure, a hammer may be used to provide a sharp blow to the outside of the housing. Sometimes, a drift or flat chisel can be used if the housing bore is in an awkward position.

  The sharp blow should loosen rust or scale and permit the "push fit" race to move.

- Use of puller

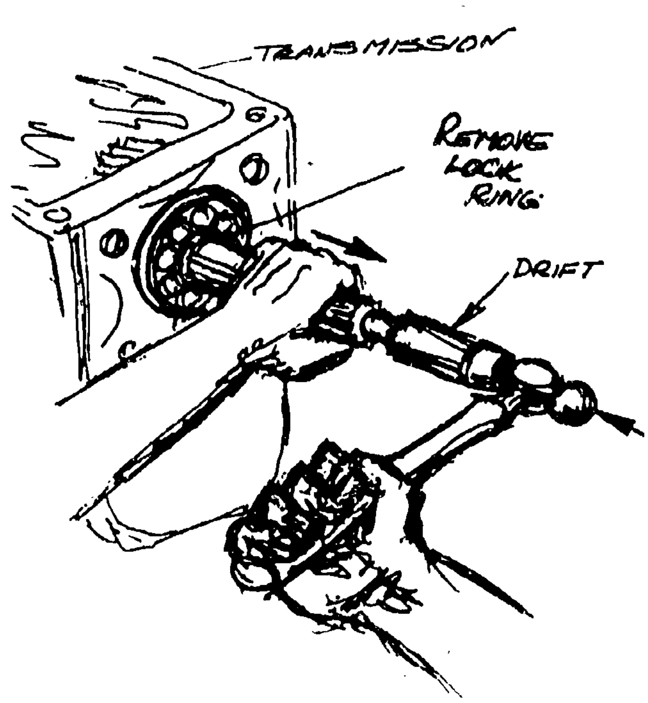
  If the shaft still does not move after tapping the housing, then a puller may be used on the shaft to attempt to free the shaft from the housing bore.

NOTE: You are now using a puller to apply pressure against the wrong race. This will likely damage the bearing.

- Tapping the shaft

  Sometimes, when other methods fail, bearings may be removed from a shaft by placing a brass drift (or other soft drift) against the end of the shaft and then striking a sharp blow to the drift with a medium weight hammer. The "answering" inertia of the bearing may cause it to "walk" out of its housing.

  CAUTION: Be sure some kind of pressure is exerted against the inner race of the bearing to keep the end play of the shaft moving toward the blows of the drift. Care must be taken not to damage the other end of the shaft.



- Use of a chisel or torch

When all else has failed, it is sometimes possible, <u>as a last resort</u>, to remove the balls or rollers from a bearing by using a chisel or cutting torch to open the separator and remove the rolling elements of a bearing. Once these are taken out, the shaft is usually removable. After the shaft is out, the bearing races may be removed with a puller or other conventional method. Damage to the bearing nearly always requires it to to be replaced.

<u>NOTE</u>: Extreme care must be used to avoid damage to shaft or housing bore when using this technique.

SELF-TEST

Complete the sentence or circle the most correct answer.

1. When a device is forced into place under pressure, it is said to be ____________ ____________.

2. The best source for bearing removal procedural information is a ________________ — ______________.

3. Regardless of type of removal equipment, pressure must be applied against the ____________ ____________ race.

4. A ____________ is a platform which allows pressure to be steadily applied to a device.

5. If pressure is applied to the wrong race, the bearing may ____________.

6. A soft ____________ is used when hammering to protect the end of the shaft.

7. When a ____________ is used, a hammer should alternately strike either side.

8. A punch may be used to loosen a bearing. T F.

9. A hammer may be used directly on the bearing. T F.

10. A hammer may be used directly on a shaft. T. F.

SELF-TEST KEY

1. press fit
2. shop or technical manual
3. press fit or tight
4. puller
5. explode
6. drift
7. tube
8. F
9. F
10. F

POST—TEST

Package Number 104-F

Name ____________ Date ____________

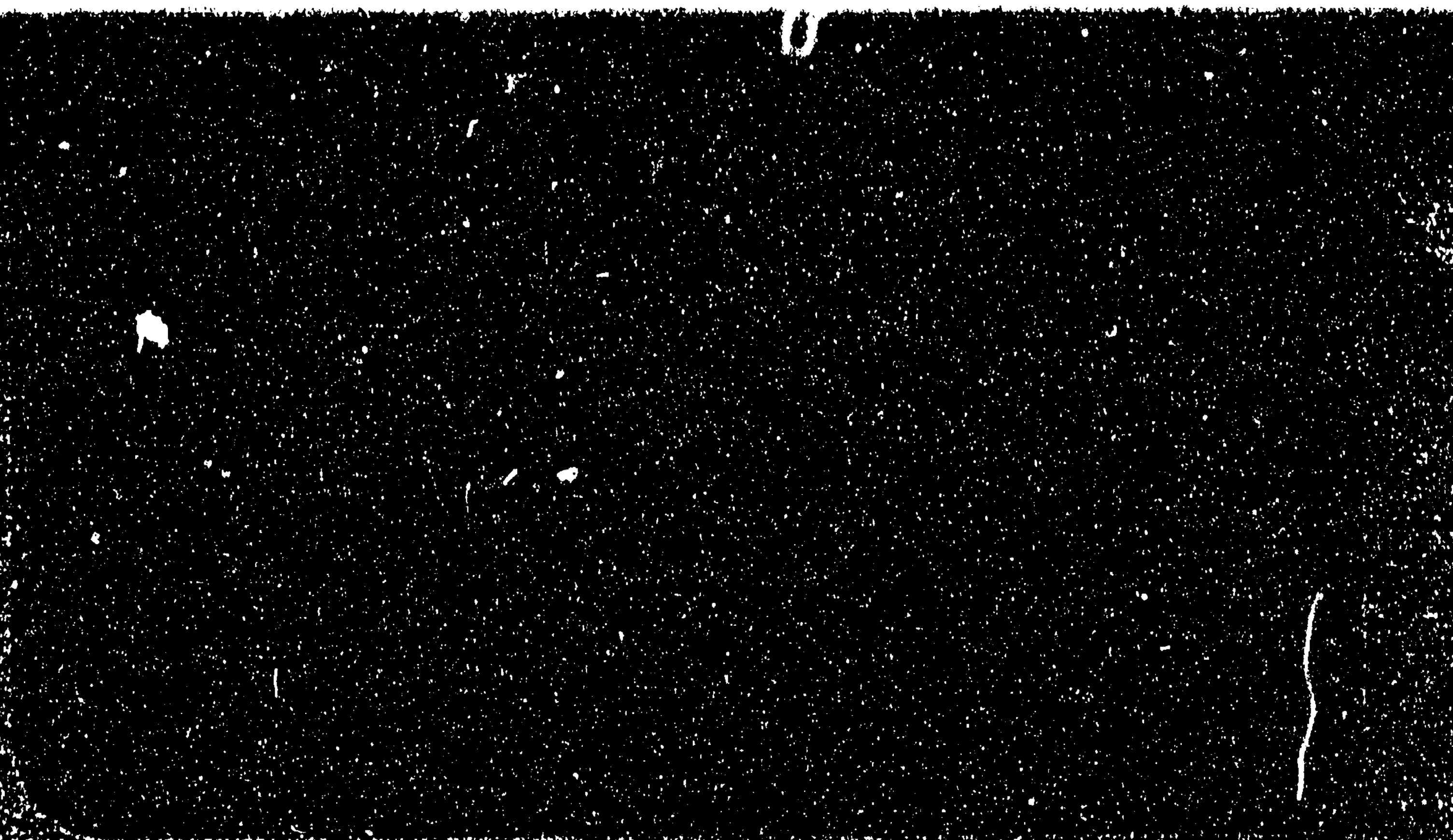
ANTI-FRICTION BEARING REMOVAL

Obtain test unit from your instructor.

Select equipment required to remove the bearing.

Demonstrate or sketch and describe set-ups to remove the bearing by utilizing:

- a puller
- a press
- the hammer and tube
- the hammer and dritt



Industrial Mechanics

104-H INSPECTING AN[illegible]

Bearing defects, even though they appear to be slight, can cause strange noise, vibrations, or malfunctions. A mechanic must be able to recognize a bearing failure.

Coordinated [illegible]
Jerry Ludlow [illegible]
[illegible]

OBJECTIVES

[illegible]

1. Detect and describe [illegible] shielded bearings.

2. Detect and describe [illegible] types of bearing damage by [illegible] methods.

DEVELOPED WITH THE
COOPERATION OF: State of Oregon Department of Education
Lane Intermediate Education District
Lane Community College
Educational Coordinating Council

PROJECT DIRECTOR: Dick Earl

WRITERS:

Frank Bishop

Steve Brous

John Anderson

Warren White

[illegible]

LEARNING ACTIVITIES

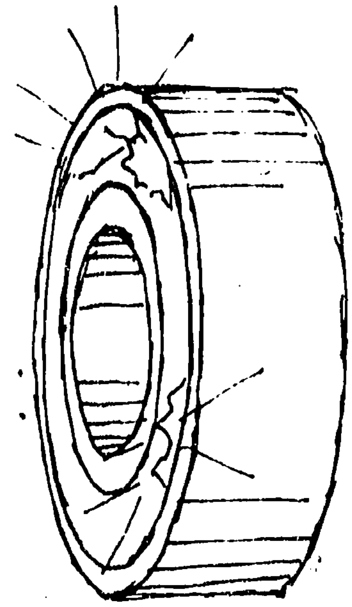
ACTIVITIES	PURPOSE
Read: Information Sheet	
Read: John Deere, <u>Fundamentals of Service, Bearings and Seals</u> Stockel, <u>Auto Service & Repair, Anti-friction Bearings</u> Other text on anti-friction bearings	Each author expands the information available to add to your knowledge.
Do: Obtain bearings from instructor Find as many examples of failures from the information sheet as possible Correlate bearing number to failure	Practical examples from real bearing failures help you to recognize failings in trouble shooting.

INFORMATION SHEET

BALL AND ROLLER BEARING INSPECTION TECHNIQUES

Normally ball, roller, and needle bearings are able to be placed back into service after they have been disturbed, if they do not show wear or damage from installation or removal. Proper removal, cleaning, inspection, lubrication and installation is a must whenever a bearing is replaced.

INSPECTING A SHIELDED BEARING

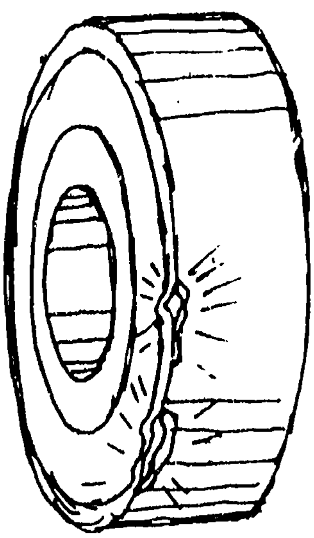


A shielded sealed bearing is not to be washed in solvent but it must be wiped clean of grease and dirt. This bearing may be visually inspected to determine if there has been damage to the seals by denting or distortion during installation of removal of the bearing. Any distortion of the shield may cause the lubricant to leak out or dirt to enter the bearing area.

The sealed bearing should also be checked for broken races, scored races (shaft or housing slippage), dented races or shields from hammer or drift damage.

Check sealed bearings for smoothness of roll described below.

INSPECTING BALL AND ROLLER BEARINGS



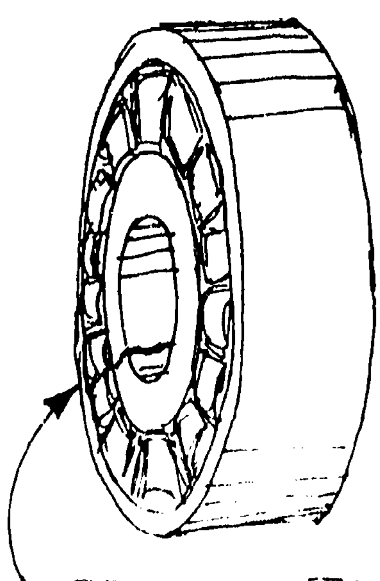
After the bearing has been cleaned and dried, it should be kept free of dust and dirt while it is being inspected and until it is reinstalled.

- Visual check

  Check for dents and breaks

Dented races, broken separator cages, etc. are the result of improper installation or removal procedures, or perhaps too severe a load for which the bearing was not designed. Never place a damaged bearing back in service.

Check for pits, scratches and flaked metal on balls, rollers and races. Also check for a bluish-black or brown color which indicates the bearing has been overheating. If the bearing comes apart, check all the parts visually. If the bearing does not come apart, use a light source to visually check the bearing in the rolling element to race contact area.

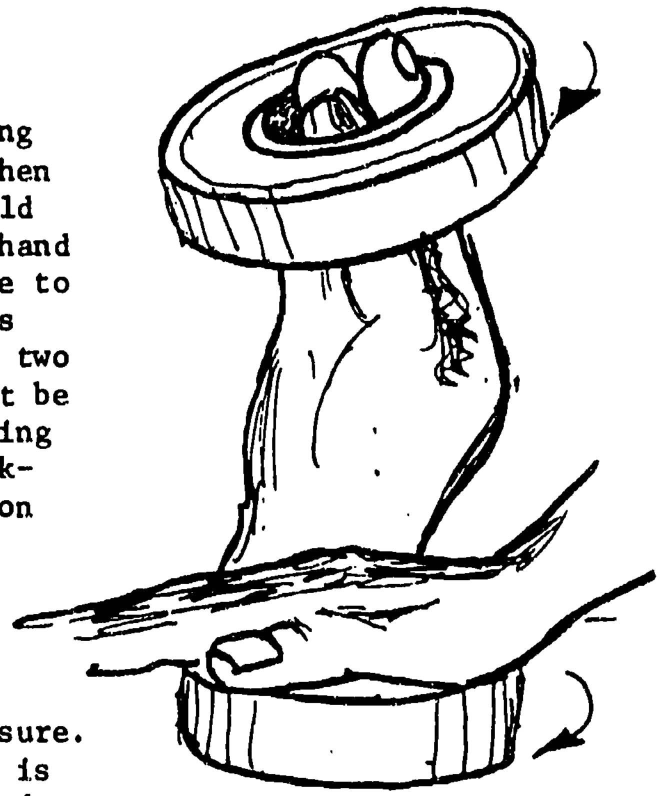


CRACKED RACE

Any signs of pits, scratches, flaking or discoloration are signs that the bearing is failing and should not be replaced.

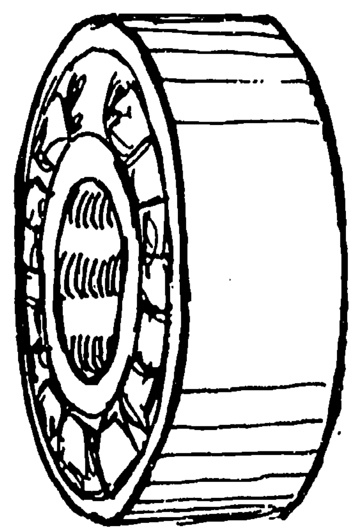
- Touch Check

The last test for an assembled bearing (and for those that have been down when they have been reassembled) is to hold the bearing over the fingers of one hand and slowly turn the bearing. Be sure to turn the bearing a number of times as the damage may be confined to one or two elements and the damaged spot may not be in contact every rotation. The bearing should be completely free from "clicking" or sticking. If such a condition persists, replace the bearing. At least one element is dented, pitted, flattened, etc.



A thrust bearing may be placed on a table and rotated by light hand pressure. Noise, chatter, high pitched whining is generally caused by one or more pitted bearings, not the meshing of gears. Transmissions have been known to shift hard because of vibrations set up in the gear train by a failing bearing. The pressures created by speed shifting can skid the bearings of a transmission, causing early bearing failure.

Never save part of a bearing to be used with parts of another bearing. These have not been factor mated and will probably not work well under load.

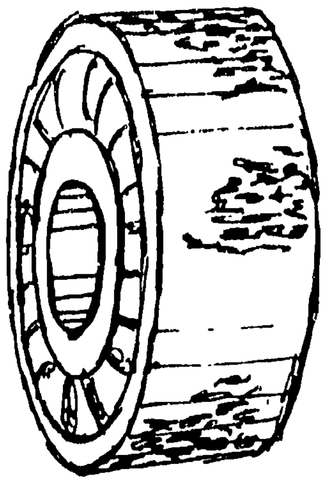


CREEP WEAR

-Premature Failures- are generally due to the following:

--improper fit of bearing
--contamination
--distortion
--misalignment
--improper lubrication
--vibration on still bearing
--electrical current through bearing
--defective material
--lack or improper service
--improper fit
--improper operation

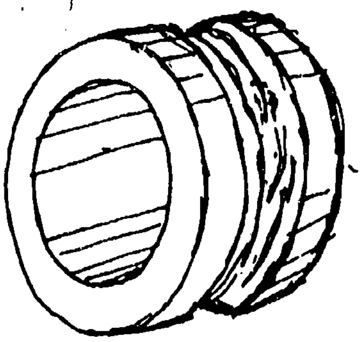
Check the internal and external race to be certain there are no cracks. It may be necessary to place some pressure on the race to cause the hairline crack to open.



FIT RUST

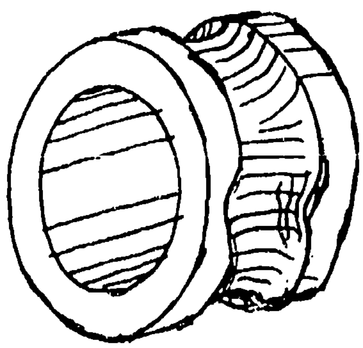
--fit rust

Fit rust is the result of the bearing fitting too loosely in the bearing bore housing. Rust is permitted to form in the air gap area. Do not sand off the area and re-use the bearing--it is already too small. Replace the bearing with one that will fit.



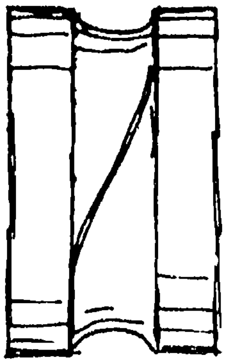
--contamination

A bearing may be contaminated by any foreign matter entering the ball and race area. This will cause scratching and pitting of the race and rolling elements.



--distortion

A bearing race may be forced out-of-round. When this happens, the balls are loose on one side and too tight on the other. This causes undue pressure and the metal will flake.



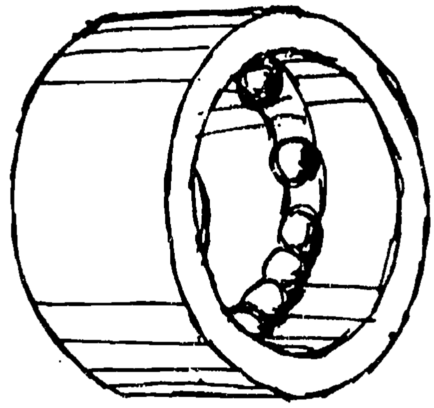
--misalignment

A bent shaft, housing, or improper installation may cause the bearing to be misaligned. Misalignment forces the elements to roll off of their regular track and to exert too much pressure.

--wrong lubricant

Wrong or insufficient lubrication may cause the metal to smear in the race. If so, the elements have rolled dry causing excessive heat which may cause them to slide instead of roll.

--vibration damage



Bearings were designed to be under load while rolling. Occasionally, they may be loaded when standing. This will cause the element to flatten or will cause it to dent the race.

--electrical damage

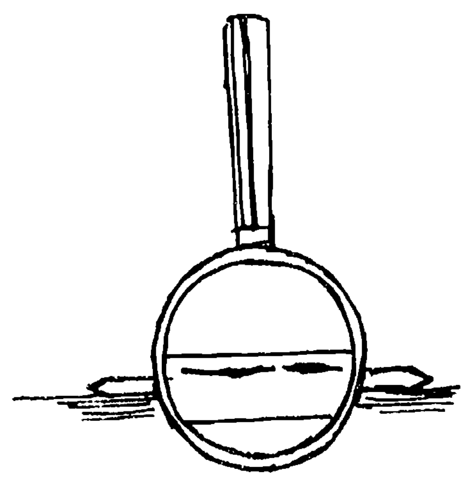
Electrical damage is caused by the current making an arc between the element and the races. The arc causes the metal to fail. Be certain to find the electrical leak or the new bearing will also fail.

--defective material

Rarely does this occur today but, occasionally, you will see bearings that have failed for no apparent reason.

--improper service

Improper installation, removal, inspection, lubrication, or use of the bearing will cause premature failure.



INSPECTING NEEDLE BEARINGS

The race surfaces for any needle bearings should be visually inspected for the types of damage discussed for ball and roller bearings. Each needle element should also be inspected for signs of deterioration.

Because the needles are usually very fine, a magnifying or enlarging glass is very helpful in inspecting needle bearings.

SELF-TEST

Complete the sentence or circle the most correct answer.

1. A ________________________ bearing must be inspected even though it is not completely clean.

2. A bluish-black or brown color in the metal indicates possible ____________________________ damage.

3. A bearing that "clicks" when turned may be all right.

   T F

4. Pressure may be placed on a race to detect __________________________.

5. If the bearing fits too loosely in its housing bore, it may accumulate ________________________.

6. ____________________ wear is caused by the bearing being too loose on the shaft.

7. Wrong ___________________ may cause metal to smear.

8. If a unit vibrates when standing still, rollers may flatten.

   T F

9. A ___________________ bearing may cause the elements to run out of their track.

10. Needle bearings are so fine that a _______________ ________________ is desirable for proper inspection.

ANSWERS TO SELF-TEST

1. shielded
2. heat
3. T
4. cracks
5. rust
6. creep
7. lubrication
8. T
9. misaligned
10. magnifying glass

POST—TEST

Package Number 104-H

Name ____________ Date ____________

Obtain post test bearing set from the instructor.

Detect and identify damaged bearings.

Sketch damage.

Industrial Mechanics

104-G CLEANING ANTI-FRICTION BEARINGS

Often the mechanic must disassemble a part to clean and inspect bearings for damage. When procedures for cleaning are not spelled out by the manufacturer, the procedures outlined in this learning package will provide adequate cleaning.

BEARINGS

Coordinated by Jerry Ludlow for
OREGON BOARD OF EDUCATION
942 LANCASTER DRIVE, NE
SALEM, OREGON 97310
DALE PARNELL
SUPERINTENDENT OF PUBLIC INSTRUCTION

OBJECTIVES

[illegible]

3. Recognize [illegible]

[illegible]

DEVELOPED WITH THE
COOPERATION OF: State of Oregon Department of Education
Lane Intermediate Education District
Lane Community College
Educational Coordinating Council

PROJECT DIRECTOR: Dick [illegible]

WRITERS:

Frank Bishop

Steve Brous

John Anderson

Warren White

PUBLISHED BY: CONTINUING EDUCATION PUBLICATIONS
EXTENSION HALL ANNEX, CORVALLIS, OREGON 97331

LEARNING ACTIVITIES

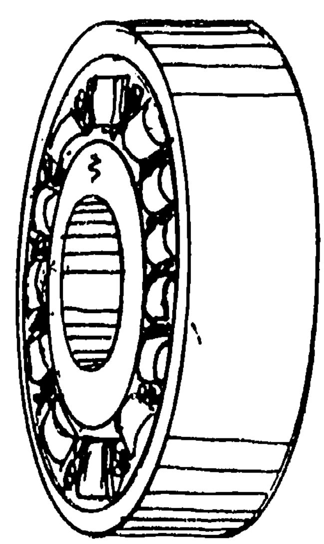
ACTIVITIES	PURPOSE
Read: Information Sheet	Techniques for cleaning some bearings may vary by manufacturer or author. Multiple points of view will permit personal selection of the best methods for you as a student.
Read: **Fundamentals of Service, Bearings and Seals**, John Deere	
Read: **Auto Service and Repair**, Stockel, Goodheart-Willcox, Anti-friction Bearings	
Do: Obtain one of each type of bearing from your instructor and: -clean, if appropriate, by accepted methods -obtain approval of the cleaning operation -hold for next lesson	"Hands-on" experience can show details of cleaning that may be missed in using just the written text as an only source of information.

INFORMATION SHEET

CLEANING BEARINGS

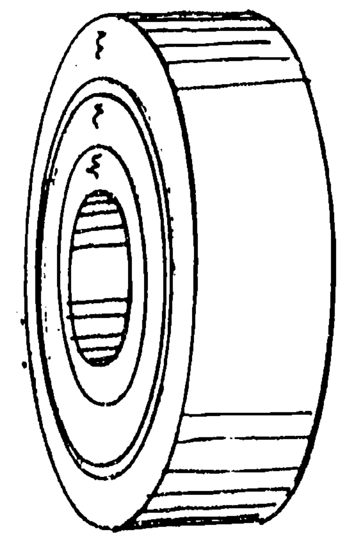
CLEANING BALL AND ROLLER BEARINGS

After the bearing has been removed from the shaft and housing bore, it must be cleaned, inspected, and re-lubricated before it can be placed in service again.



OPEN BEARING

An exception to this is the sealed bearing with non-removable seals which has been lubricated and sealed at the factory. DO NOT place this bearing in cleaning solvent or it will be damaged These bearings should be wiped clean so their exteriors are free from grease and dirt. They can be checked for external damage and sealed on just one side, it should be considered as an open bearing and should be cleaned and inspected in the same manner as an open bearing.



SEALED BEARING

Follow the manufacturer's instructions for cleaning bearings. If none are available, use the following procedures:

- wipe off the surplus grease or oil from the bearing.

- place bearing in a tray or, in some manner, suspend the bearing in a clean container holding cleaning solvent.

Do not allow the bearing to rest on the bottom of the container as it will rest in residue that has been washed off parts that have been cleaned. Be certain container is large enough to permit thorough washing of the bearing.

NOTE: Do not use gasoline or other fuels for cleaning. Carbon tetrachloride will produce poisonous fumes. Use commercially available washing solvents. These have been produced especially for cleaning and have less danger from fire as they have a higher flash point.

After the bearing has soaked long enough to loosen the grease and dirt, use a sturdy brush to scrub the bearing, rolling the components to clean all surfaces. When the bearing appears to be clean, blow dry with compressed air. If more grease and dirt appear during drying, repeat the soaking and brushing cycle. Spin slowly by hand to be certain all grease has been removed. Bearings are now ready for inspection.

CAUTION!! NEVER SPIN BEARINGS WITH AIR PRESSURE!

- The tremendous force generated may cause the bearing to fly apart.

- If bearing "freezes" while spinning, a thumb or finger may be twisted off.

- Bearing is likely to be ruined by high speed spinning when it is in a dry condition.

CLEANING NEEDLE BEARINGS

As stated in the introduction lesson 104E, some needle bearings do not have the normal components of roller and ball bearings. Usually, the separator cage is missing, often one and sometimes both races are not used in a particular needle bearing design.

In cases where a race is not used in either or both of the housing bore and shaft journals, the area is ground smooth and hardened to act as a race. Needle bearings are then placed between the journal and the bore with shaping or thrust washers to hold them in place during operation. Examples of this are found in some transmissions.

Removal and installation of needle bearings is directed by shop manuals. Caution should be exercised to be certain all parts of the needle bearing are accounted for. Place all removable parts, needle bearing elements and races, if any, into a container with fresh cleaning solvent. Wash thoroughly and dry with compressed air or clean cloth. Lay all parts out on a clean cloth for inspection.

CAUTION: Be certain to account for all parts. If one element is missing, the entire bearing must be replaced.

SELF-TEST

Complete the sentence or circle the most correct answer.

1. A ____________________ bearing should not be cleaned in solvent.

2. Gasoline, kerosene, and diesel fuel should not be used for cleaning because of the danger from ______________________________.

3. Carbon tetrachloride should not be used because it is ________________.

4. Bearings should not be allowed to rest on the bottom of the cleaning solvent pan because of the __________________________.

5. After brushing the bearing, it should be dried with ____________ ________________.

6. A bearing with one shield is considered to be an ________________ bearing in respect to washing.

7. List three reasons why it is dangerous to spin a bearing at high speeds?

8. ____________________ bearings do not always have all of the normal components of an anti-friction bearing.

ANSWERS TO SELF-TEST

1. shielded
2. fire or explosion
3. poisonous
4. dirt or residue
5. compressed air
6. open
7. it may break (explode) at some stressed point if it freezes, it may take off a finger.
8. needle

POST–TEST

Package Number 104-G

Name ________________ Date ________

INSTRUCTIONS: Obtain post-test bearing from instructor.

Clean and dry bearing. Give to the instructor for evaluation.

Industrial Mechanics

104-I ANTI-FRICTION BEARING LUBRICATION

Anti-friction bearings do not wear out in normal use when properly installed and maintained. Proper lubrication techniques are discussed in this learning package.

Anti-friction bearing lubrication

BEARINGS

Coordinated by Jerry Ludlow for
OREGON BOARD OF EDUCATION
942 LANCASTER DRIVE NE
SALEM, OREGON 97310
DALE PARNELL
SUPERINTENDENT OF PUBLIC INSTRUCTION

OBJECTIVES

[illegible]

1. Select the proper grease for the bearing.
2. Use a bearing grease packer (if available)
3. Pack bearings by hand.

DEVELOPED WITH THE
COOPERATION OF . . . . State of Oregon Department of Education
Lane Intermediate Education District
Lane Community College
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PROJECT DIRECTOR: Dick Earl

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LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet	
Read: Stockel, Auto Service & Repair, Goodheart-Willcox Anti-friction Bearings	Additional texts provide other points of view in this subject area. Broaden your knowledge wherever you can.
Read: John Deere, Fundamentals of Service, Bearings and Seals	
Read: Other text on bearings	
Do: Obtain clean bearings from your instructor. Lubricate in proper grease, using: - a grease packer (if available - hand pack method Be sure to show finished product to instructor for evaluation.	This practical experience will teach the degree of penetration required and also permits instructor to point out an over-greased condition.

INFORMATION SHEET

LUBRICATING ANTI-FRICTION BEARINGS

SELECTION OF PROPER LUBRICANT

A lubricant for bearings must do three things:

- maintain a film of lubricant between parts to prevent rubbing.
- reduce friction between ball or roller elements and the separators.
- prevent rust by providing a protective coat of lubricant over all the bearing parts.

Bearings normally do not wear out. However, when an improper or an insufficient amount of lubricant is used, the bearing may fail prematurely.

Operator's manuals sometimes say very little about the type of grease to use on bearings. They may say to use "pressure-gun" grease, "wheel bearing" grease, or "multi-purpose" grease.

Greases usually consist of lubricating oil that is incorporated into some kind of a thickening agent. These thickeners, known as soaps, provide many different functions. Some have good water resistance, others heat resistance and still others are very fibrous and cling to the parts that they touch. A variety of soaps provide a variety of types of grease.

For years, it was necessary for the equipment operator to stock and use many types of grease for a single piece of equipment. Today's technology has developed good multi-purpose greases that, generally, may be used in all situations. These may be available in several temperature ranges. Be sure to use the one that will adequately meet the needs of your application. Always follow the equipment manufacturer's recommendations, if available, on the lubricant to use.

PROCEDURE FOR LUBRICATING BALL OR ROLLER BEARINGS

Greases must be kept clean and free from dirt and moisture. If these are allowed to collect in the grease, the grease will carry the contamination into the bearings and cause premature failure of the bearing components.

When available, a grease packer for bearings should be used. A grease packer forces grease through the bearing from one side, assuring a solid pack without gaps or air bubbles.

Bearing grease packers vary in size and shape but, generally, follow the same principles. The bearing is held in place over a source of grease. As pressure is applied, grease is forced through the bearing elements from one side. Force should be maintained until grease flows through, all around the bearing. The bearing is then removed and wiped clean. It is ready for installation.

If a packer is not available, then bearings may be packed by hand. Be certain hands are clean and dry. Place a "gob" of clean grease on the palm of one hand. Then, holding the bearing in the other hand, work the grease <u>into one side of the bearing</u>. Be certain to rotate the bearing to apply the grease evenly around the race. Continue this process until the grease comes through the bearing all the way around the top of the opposite side of the bearing.

<u>NOTE</u>: A bearing is always greased <u>from just one side</u> until grease forces through all the way around the bearing to prevent gaps or air bubbles in the grease from forming.

It is not desirable nor advisable to fill the bearing completely full. Too much grease will cause a churning and will generate heat. A good rule of thumb is to fill the bearing, then wipe all of the excess grease from the outside. The bearing is now ready to be installed or to store.

If bearings are to be stored, they should be wrapped in grease-proof paper and tagged for identification.

NOTE: Never let bearings that have been cleaned sit around without lubrication. Rust and dust may start a bearing failure if they are left unprotected for just a short time.

NEEDLE BEARING PACKING

Needle bearings are lubricated as a part of the installing process. Often the lubricant is the force that holds the needle elements in place as they are being assembled.

SELF-TEST

INSTRUCTIONS: Complete the sentences.

1. The difference between oil and grease is the ______________________.
2. Best source of lubricant information is from the ______________________.
3. Modern greases are available in different ______________________ ranges.
4. Some ______________________ solved special problems, depending upon the characteristics of the thickening agent.
5. It is important to keep all grease ______________ and ______________.
6. The fastest, easiest, most thorough way to grease a bearing is to use a ______________________ ______________________.
7. Bearings should be greased on ______________________ side (s).
8. Gaps or ______________ will form in the grease if it is not properly applied.
9. Too much grease can cause the bearing to ______________________.
10. A clean bearing should never sit out without grease or it will ____________.
11. A bearing to be stored must be ______________ & ______________.

SELF-TEST ANSWERS

1. thickener
2. equipment manufacturer
3. temperature
4. greases
5. clean dry
6. bearing packer
7. one
8. air bubbles
9. overheat
10. rust
11. greased wrapped

POST—TEST

Package Number 104-1

ANTI-FRICTION BEARING LUBRICATION

Name ____________ Date ____________

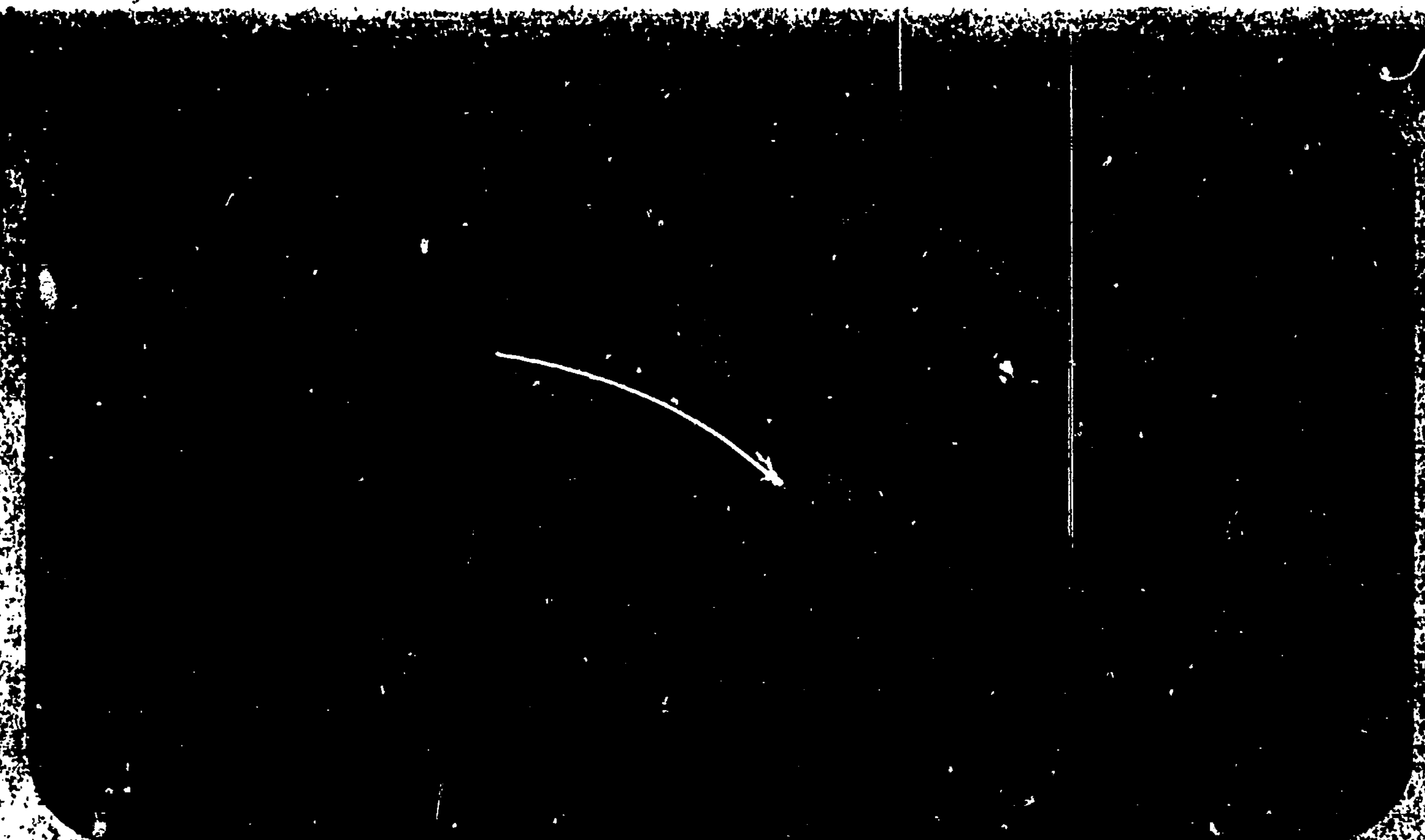
Obtain two bearings from your instructor.

Grease one with a bearing grease packer (if available.)

Grease the other by hand.

Wrap for storage.

104-J Installation of Anti-Friction Bearings



Industrial Mechanics

104-J INSTALLATION OF ANTI-FRICTION BEARINGS

A large number of bearing failures are the direct result of poor installation practice. This lesson shows the proper methods to be used when installing anti-friction bearings.

BEARINGS

OREGON BOARD OF EDUCATION
DALE PARNELL

OBJECTIVES

Upon successful completion of this unit the student will be able to:

1. Select the correct replacement bearing.
2. Clean and inspect the housing bore and journal.
3. Use heat or cold to assist in bearing installation.
4. Align and press on the bearing.
5. Tension or pre-load the bearing.
6. Install needle bearings.

DEVELOPED WITH THE COOPERATION OF . . . State of Oregon Department of Education
Lane Intermediate Education District
Lane Community College
Educational Coordinating Council

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Frank Bishop

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John Anderson

Warren White

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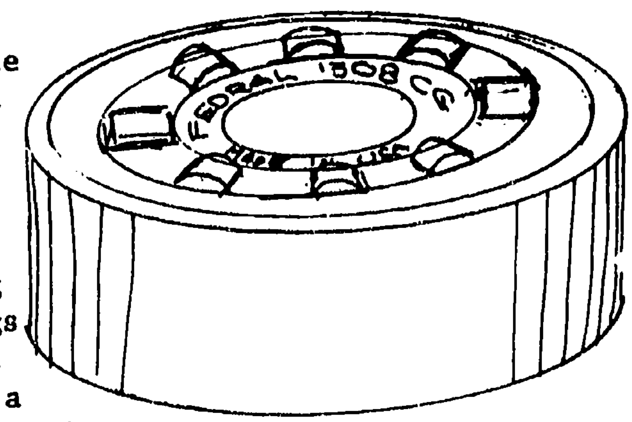
LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet #1	
Read: John Deere, Fundamentals of Service, Bearings and Seals.	En hment from additional sources provides depth to student understanding of bearing installation.
Read: Stockel: Auto Service & Repair, Goodheart-Wilcox Co. Anti-friction Bearings.	
Do: Obtain bearing kits from instructor. Install bearings - with a press - with a puller - with a heat application (if available) - With a cold application (if available)	Experience will assist the student understanding of the problems in installing for proper alignment and cleanliness.

INFORMATION SHEET #1

BALL AND ROLLER BEARING INSTALLATION



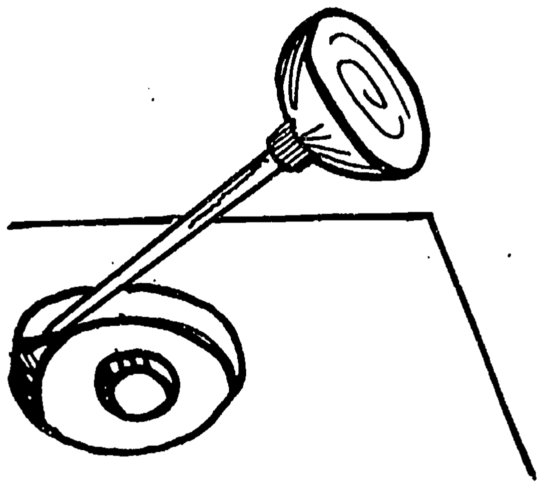
Proper bearing installation is critical to the life expectancy of the bearing. Installation calls for care and intelligent use of tools.

THE RIGHT BEARING

Be certain the bearing is the correct bearing for the position you are installing. Bearings look much alike and it may be easy to replace with the wrong bearing. When replacing with a new bearing, be certain the number on the old and the new are the same. Eliminate guesswork when installing bearings.

CLEAN BORES AND SHAFT JOURNALS

If the bearing has passed inspection, then the bores and shaft journals must pass also. They must be free from burrs and grooves. The housing bore must be true and smooth without obstructions (dirt, carbon, metal chips, etc.) in the corners which might have a tendency to cock the outer bearing race. If burrs exist, file or sand with fine emory cloth to remove. If carbon exists, clean out with a sharp tool.

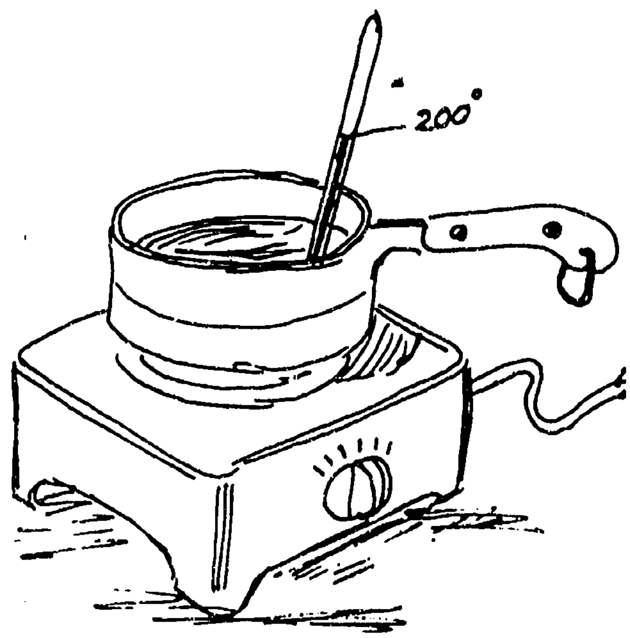


LUBRICATE

Oil on the journal or in the housing bore will assist installation of the bearing.

USE OF HEAT OR COLD

Heat makes metal expand. Cold makes metal contract. It may be necessary to use heat to permit a ring to slip on a tight journal. CAUTION NEVER HEAT WITH A TORCH. A bearing may be heated in clean oil to approximately 200 degress F. After the bearing has reached this temperature, it has expanded and the inner ring can slip or be driven into place on the shaft journal.



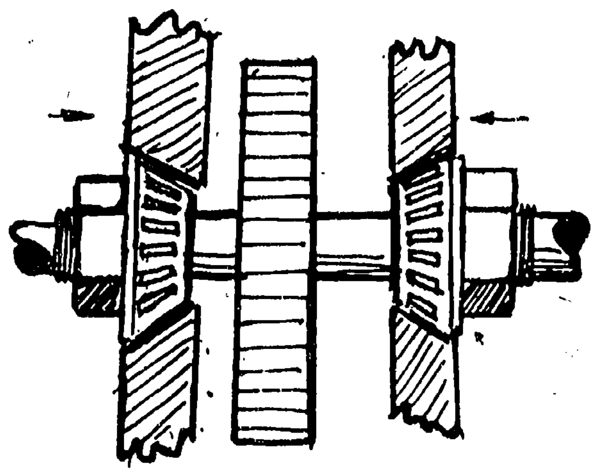
If the bearing is to be slipped into a housing bore, it (the bearing) may be packed in dry ice to make it contract.

POSITION FOR START

First, be certain all retainers, seals, snap rings, and fittings, that are to be installed before the bearings are in place. Next, check the bearing for proper installation position.
<u>NOTE</u>: Bearings will often accept partial thrust loads. Be certain that the bearing is <u>facing the proper direction</u> to carry its load properly.
Attach puller o[illegible] t up press and force bearing into posi[illegible]on.

Be sure that:
- bearing is properly aligned on shaft of housing
- bearing is pressed into position until properly seated.
  (That is, the full distance required, but not beyond this point).
- Press or puller is forcing <u>only the tight race</u>!

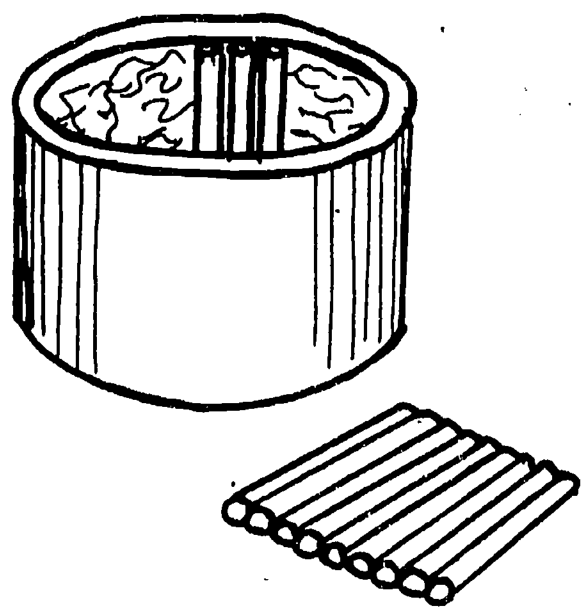
BEARING ADJUSTMENT



Some bearings require adjusting after they have been installed. This adjustment is sometimes called "pre-loading." Adjustments are usually done by tensioning the bearing to a specified torque in place with a threaded nut on a shaft. Often the bearing must be tensioned while turning the wheel to secure proper seating of the bearings and then, the pressure is removed or "backed off" a specified amount to provide clearance, preventing heat build-up.

The mechanic should know the specifications for the machine being serviced. They are available in that unit's service manual.

INSTALLATION OF NEEDLE BEARINGS



Usually needle bearings are made without one or more races. The technique for installation normally requires that the needles be coated in grease and then placed into position in the housing bore. The grease coating will hold the needle in place. Be sure all needle bearings are present or the looseness will cause the bearing to fail when placed in use.

Once the needles are all in place, the journal may be fitted into the needle cluster.

NOTE: Often the last needle will have to be slid in from its end because the fit is so tight.

SELF-TEST

Complete the sentences or circle the most correct answer.

1. Replacement bearings should be compared to original ____________ on the bearing.

2. Housing bores or shaft journals must be clean and ____________.

3. Before installation, both the bearing and the housing should be ____________.

4. Heat causes metal to (expand, contract).

5. Cold is used on a bearing when it is to be installed ____________ on a shaft.

6. A bearing should not be heated beyond _______ degrees F.

7. A bearing should be heated in clean __________.

8. The direction it faces is important in bearings that have partial ________________ loads.

9. Force must be applied only to the __________ race.

10. Bearing tension adjustment is sometimes called ____________________.

11. All bearings are adjusted to the same tension. (T or F)

12. Needle bearings are held in place during assembly by the ________________.

SELF-TEST ANSWERS

1. number
2. smooth
3. oiled
4. expand
5. in a housing bore
6. 200
7. oil
8. thrust
9. tight
10. pre-loading
11. F
12. grease

POST—TEST

Package Number 104-J

INSTALLATION OF ANTI-FRICTION BEARINGS

1. Obtain bearing, shaft, and/or housing from instructor.

   Set up to install the bearing.

   Check with instructor before pressing in place.

2. Obtain needle bearing from instructor.

   Install needle bearings.

   Check with instructor before installing the shaft.

Name ____________ Date ____________

Industrial Mechanics

104-E INTRODUCTION TO ANTI-FRICTION BEARINGS

The anti-friction (rolling element type) bearing is the second of two major types of bearings. The first type, friction (or plain) bearings, has been covered in the earlier lessons of this series. Material in this lesson will familiarize you with the categories, make-up, and characteristics of the anti-friction bearing.

Coordinated by
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SALEM, OREGON 97310
DALE PARNELL
SUPERINTENDENT OF PUBLIC INSTRUCTION

2. Describ... of bearin...

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4. ... bearin...

5. Describe ...

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COOPERATION OF: ... Department of Education
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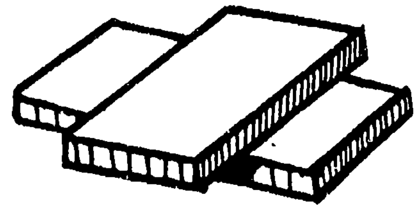
LEARNING ACTIVITIES

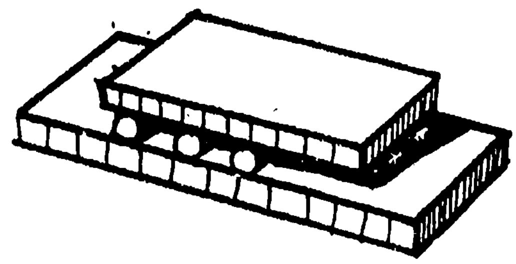
ACTIVITIES	PURPOSE
Read: Information Sheet	Added enrichment reading will add to your understanding of the anti-friction bearings, and where and why they are used in particular applications.
Read: John Deere, Fundamentals of Service, Bearings and Seals	
Read: Stockel, Auto Service & Repair Goodheart-Willcox, Anti-friction Bearings	
Read: Other text on anti-friction bearings.	
Do: Obtain a set of samples from the instructor. Identify bearing's parts for each category of bearing. Dismantle and reassemble a Conrad type, a full type, a roller bearing and a needle bearing. Be Sure all parts are reassembled before instructor tests your capacity.	Physical handling of bearings, especially assembly and disassembly, provides added understanding of bearing structure and components.

INFORMATION SHEET

ANTI-FRICTION BEARINGS

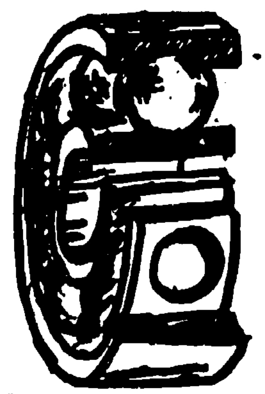
Some bearings are called anti-friction bearings because, instead of a journal slipping on a lubricated bearing surface, a roller turns between the two surfaces.



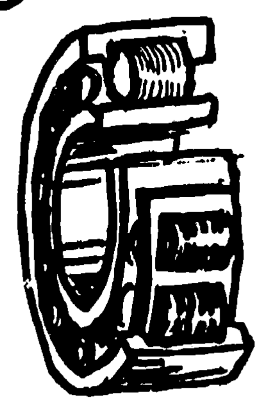


Generally, there are three basic types of anti-friction bearings. They fall into the general classification of ball bearings, roller bearings and needle bearings.

These bearing support the weight of the shaft and attachments in addition to the pressure caused by torque on the shaft. The amounts of pressure, the amount of maintenance required, and other factors determine the bearings to be used.

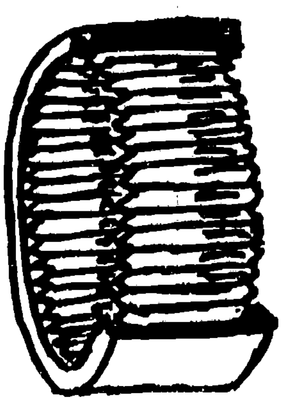


Ball Bearing



Roller Bearing

The material from which the bearing is made and the amount of surface contact are a big factor in determining which type of anti-friction bearing is used. Most anti-friction bearing elements and cases are constructed of hardened steel but some are made of other materials (i.e., plastics).

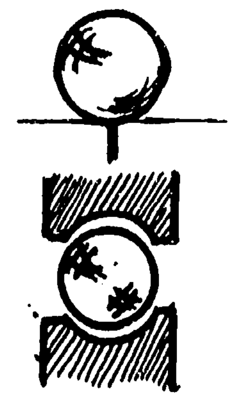


Needle Bearing

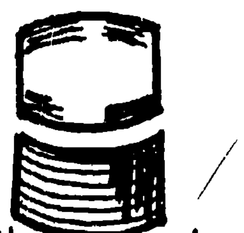
BALL BEARINGS

TRACK WIDTH

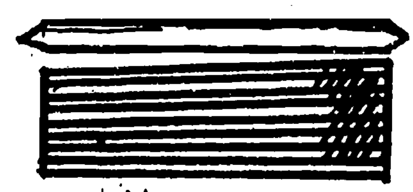
A ball normally has a line contact with a flat surface. When it rests between the curves of the inner and outer race of a ball bearing, the track is wider. A roller bearing provides a slightly wider track and the needle bearing the widest of them all.



Ball tracks



Roller tracks

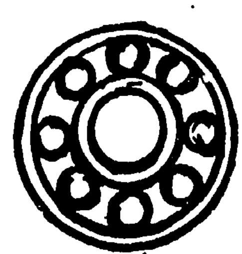


Needle tracks

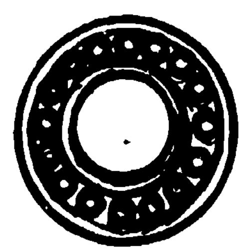
NUMBER OF ROLLING ELEMENTS

As the number of units supporting the shaft increases, the amount of support also increases.

Ball bearings may be spaced differently, depending upon manufacturer or design type, ranging from the Conrad-type to the full-type. The more balls in the race, the more support for the load. As may be seen from the illustration, the full-type carries the basic load on five lower and five upper balls where the Conrad-type carries it on three and three.



Conrad-Type



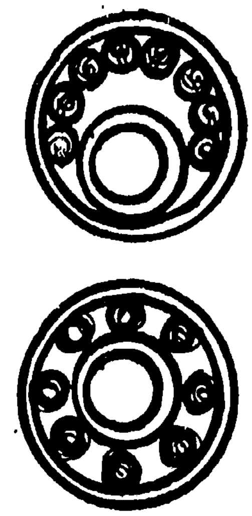
Full Type

ROLLING ELEMENT SIZE

The size of the ball affects the load carrying capacity of the bearing. Within limits, the larger the ball, the greater the load carrying capacity.

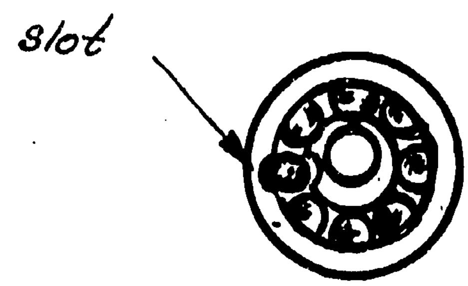
THE CONRAD-TYPE BALL BEARING

The balls of the Conrad-type bearing are placed in the race in an off-center manner. The inner race is put into position, the balls are then distributed evenly around the inner race and the spacer rings are snapped into place. Spacer rings will hold the balls in place while the bearing is in use.



FULL-TYPE BALL BEARING

The full-type ball bearing is loaded through a slot in both the inner and outer race. This type of race permits more balls to be placed in the bearing but the bearing is limited to radial loading.

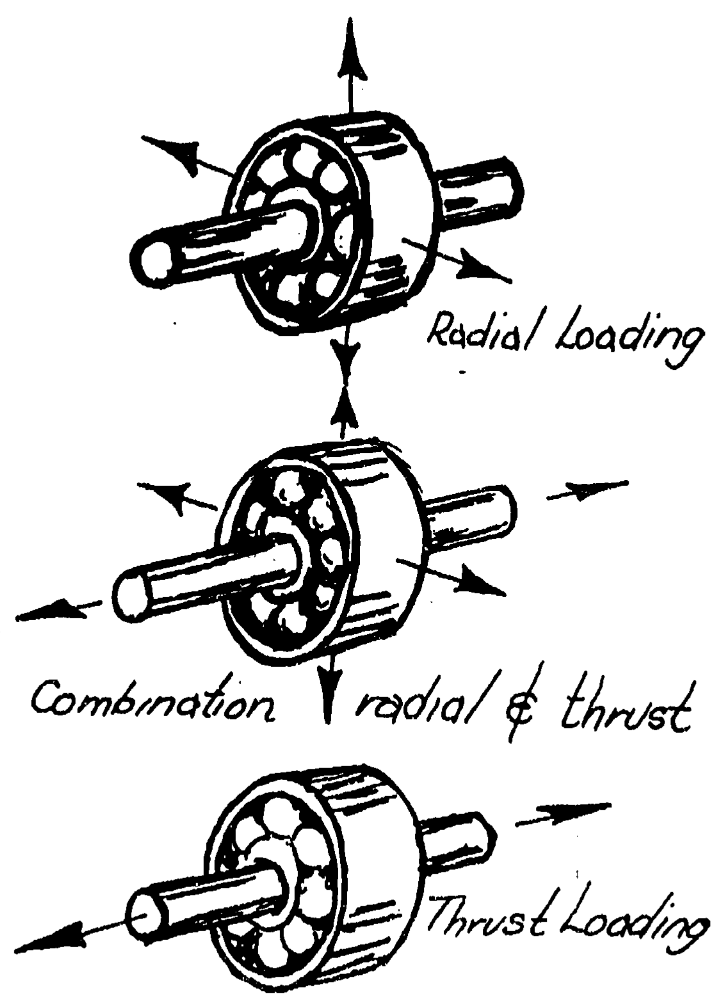


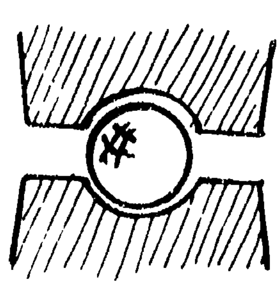
BALL BEARING LOADING DESIGN

Ball bearings may be designed for radial loads only, combination radial and thrust, or thrust only.

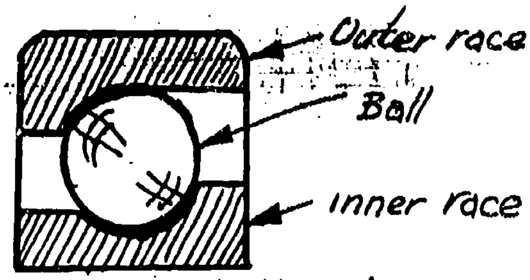
The full-type ball bearing permits only radial loading. If thrust loading is applied to the bearing, the loading slots will damage the balls, leading to premature bearing failure.

The Conrad-type of ball bearing is useful in both thrust and radial applications. The inner and outer races of the Conrad design are more deeply curved and are without a loading slot.



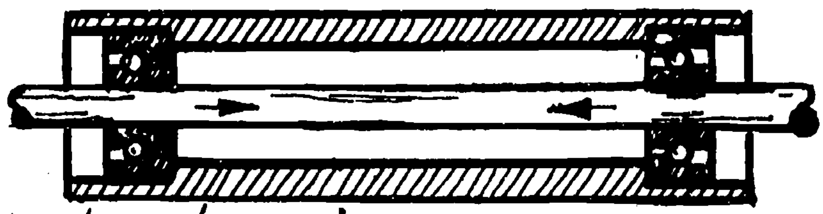


Other types of ball bearings also have a combination thrust and radial loading capability.



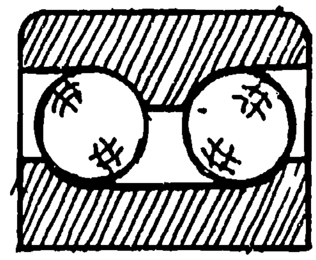
Single row radial-thrust

The single row radial-thrust bearings will support thrust loading in only one direction and, therefore, are usually used in pairs. Generally, when they are installed in pairs, they must face opposite directions to provide bearing against thrust in both directions.



Mount single row bearings in pairs

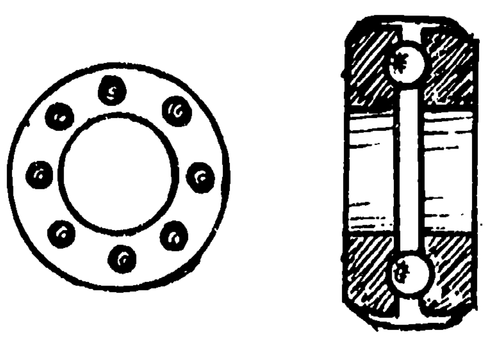
The double row ball bearings will support thrust in both directions in a single bearing.



Double row radial-thrust

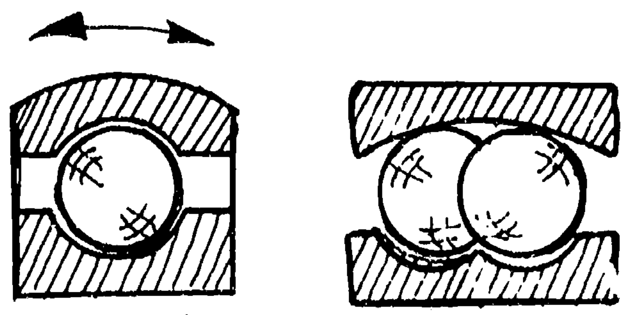
Some ball bearings are designed to provide for axial thrust support only.

These bearings are used in locations where the only force acting against them is a lateral thrust force.



SELF-ALIGNING BALL BEARINGS

Radial supporting ball bearings may be available in a self-aligning design. It may be self-aligning because of the shape of the outer race (externally self-aligning) which permits the entire beafing to move. Some designs permit the ball to move to the correct position.

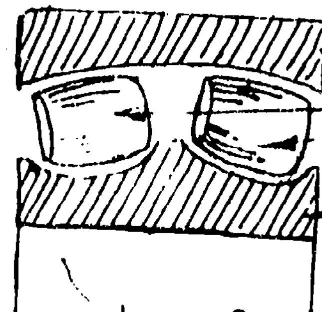


Externally Self aligning

Internally Self aligning

SPHERICAL ROLLERS

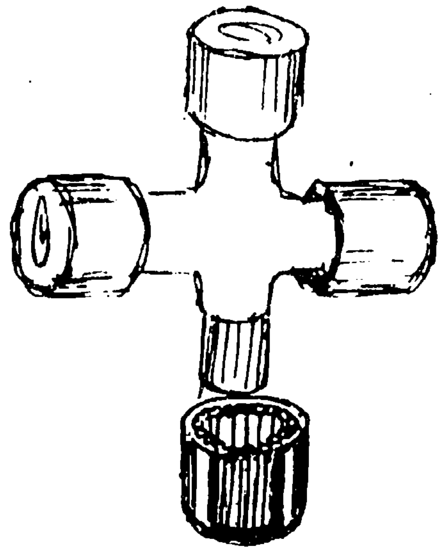
Spherical rollers (sometimes called barrel rollers) are similar to straight rollers except their sides are curved. These bearings can accept more thrust load than the straight bearings but less than the tapered. A principal advantage of a spherical shape of the roller is its adaptability to self-aligning.



A cross-section of a double row spherical internally self aligning roller bearing

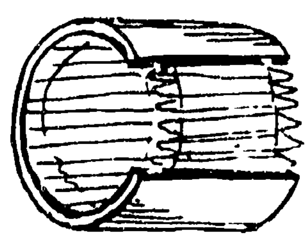
NEEDLE BEARINGS

Needle bearings have the same component requirements as ball and roller bearings. However, in many instances, the needles function with the parts being made up from the shape of the unit being supported.



For example, the automotive drive (propeller) shaft universal joint on most models uses a hardened and ground end of the spider as the "inner race" and shaft combined. The outer race is then clamped into position. In some instances, the hardened and ground surfaces being supported become both the inner and outer race.

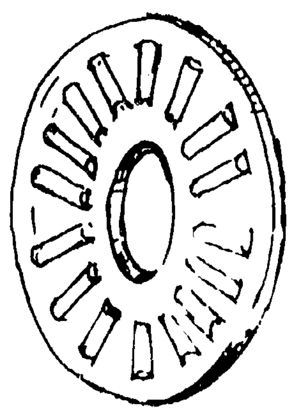
Needle bearings are long, very small diameter, straight rollers. They have a very high load-carrying capacity. They do not perform at high speed as well as roller or ball bearings and do not tolerate much misalignment.


A radial needle bearing

TYPES OF NEEDLE BEARINGS

The bearing elements are very similar but the race design differs to permit a radial load or a thrust load.

Needle bearings are not satisfactory in use as a combination radial-thrust loading.


A thrust needle bearing

The thrust needle bearing illustrated is little more than a cage to keep needles in position as the smooth, hardened surfaces of the machine come together over the needle bearings.

SELF-TEST

Complete the sentence or circle the most correct answer.

1. A ball normally has a very ______________ track.

2. A ______________ ball bearing has offset leading capability.

3. A ______________ ball bearing has the most ball elements.

4. A __________ ball bearing has radial capability only.

5. A __________ ball bearing is loaded through race slots.

6. A __________ ball bearing has the deepest race grooves.

7. A __________ ______________ bearing has a curved race surface.

8. List four parts of a roller bearing.

9. List three types of rollers.

10. A ______________ roller withstands radial loads only.

11. A ______________ roller withstands both radial and thrust loads.

12. A ______________ roller adapts to self-aligning.

13. ______________ bearings can withstand the most pressure.

14. The ______________ of a needle bearing is sometimes formed by its housing.

SELF-TEST ANSWERS

1. narrow
2. Conrad
3. full
4. full
5. full
6. Conrad
7. self-aligning
8. inner race, outer race, roller, separators
9. straight, tapered, barrel (splined)
10. straight
11. tapered
12. barrel (spherical)
13. needle
14. race

INTRODUCTION TO ANTI-FRICTION BEARINGS

1. needle
2. roller
3. pairs
4. needle
5. Conrad
6. full
7. Conrad
8. wide track
9. separator (cage)
10. needle

POST—TEST

Package Number 104-E

INTRODUCTON TO ANTI-FRICTION BEARINGS

INSTRUCTIONS: Complete the sentences.

1. A ____________________ bearing provides the widest bearing track.

2. A ____________________ bearing permits heavy loading and some radial and thrust.

3. Combination radial thrust bearings should be mounted in ____________________.

4. A ____________________ bearing may have some of its parts built into the housing or journal.

5. A ____________________ ball bearing has the fewest ball elements.

6. A ____________________ ball bearing of like material and size will carry the heaviest load.

7. A ____________________ radial ball bearing will take the most axial loads.

8. The main advantage of a roller bearing over a ball bearing over a ball bearing is its ____________________.

9. A ____________________ is designed to keep rolling elements a fixed distance from each other.

10. The ____________________ bearing is very sensitive to bearing alignment.

Name ____________________ Date ____________________

INSTRUCTIONAL LEARNING SYSTEMS

10.3

MACHINE COMPONENTS -- SEALS AND GASKETS

Goal:

The apprentice will be able to describe seals and packing types.

Performance Indicators:

1. Describe types of seals and their uses.
2. Describe axial seals.
3. Describe pre-formed seals and molded packing.
4. Describe static seals.
5. Describe exclusion seals.
6. Describe felt packing.
7. Describe compression packing.
8. Describe radial lip seals.

Industrial Mechanics

107 A SEALS AND GASKETS

Failure of a seal or gasket can result in expensive damage to a machine and to your reputation as a mechanic. No repair job is complete until all leaks are sealed.

Coordinated by
Jerry Ludlow for
OREGON BOARD OF EDUCATION
SALEM OREGON 97310
DALE PARNELL
SUPERINTENDENT OF PUBLIC INSTRUCTION

SEALS AND GASKETS

OBJECTIVES

[illegible] of this learning package, you [illegible] the following:

1. [illegible] different types of commonly used [illegible] their construction and functions.

2. Given needed materials, demonstrate to [illegible] oil seal removal and [illegible] procedures.

3. [illegible] are used and the [illegible] for each job.

4. [illegible] worksheet, the various uses [illegible] sealers as applied to the automobile.

DEVELOPED WITH THE
COOPERATION OF:

State of Oregon Department of Education
Lane Intermediate Education District
Lane Community College
Educational Coordinating Council

PROJECT DIRECTOR: Dick Earl

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Frank Bishop

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LEARNING ACTIVITIES

OBJECTIVE #1

1. IDENTIFY FIVE DIFFERENT TYPES OF COMMONLY USED SEALS; EXPAIN THEIR CONSTRUCTION AND FUNCTIONS.

ACTIVITIES	PURPOSE
Read: Information Sheet #1	Contains information to learn construction and function of seals.
Read: Autc Service and Repair, Stockel	
Read: C/R Handbook of Seals	
Do: Worksheet #1	Gives you a chance to check your information.

WORKSHEET #1

1. Name the three basic parts of a seal.

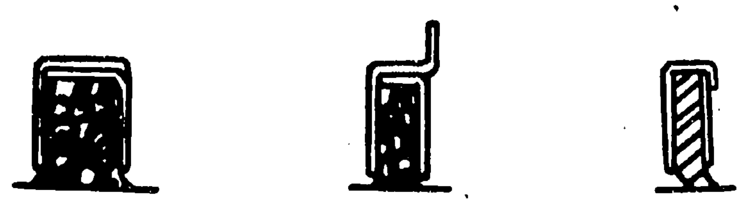
2. Of what materials are seals commonly constructed?

3. Describe the five types of oil and grease seals that the teacher gave to meet the objective. List lip type and function.

INFORMATION SHEET #1

Oil seals vary by their type of lip seal. Shown are examples of common oil-seal lips.

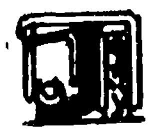
NON-SPRING LOADED SEALS



SINGLE-LIP, SPRING LOADED

DUAL-LIP, SINGLE ELEMENT

DUAL-LIP, DUAL ELEMENT



OBJECTIVE #2

2. GIVEN NEEDED MATERIAL, DEMONSTRATE TO THE TEACHER CORRECT OIL SEAL REMOVAL AND INSTALLATION PROCEDURES.

ACTIVITIES	PURPOSE
Read: Auto Service and Repair; Stockel	Gives basic information concerning their operation.
Attend: Demonstration on seal removal and installation	Shows you correct steps to follow when working with seals.
Read: Information Sheet #2	

Each student will remove and install an oil seal in the prepared demonstration setup.

____

Demonstration approved by

INFORMATION SHEET #2

INSTALLATION RECOMMENDATIONS

1. Check Dimensions - to be sure that shaft and bore diameters match those specified for the seal selected. If not, replace seal with one having the proper shaft size and/or outside diameter.

2. Check Seal - for damage that may have occurred prior to installation. A sealing lip that is turned back, cut or otherwise damaged will leak and the seal should be replaced.

3. Check Bore - to see that entering edge is deburred. A rounded corner or chamfer should be provided wherever possible.

4. Check Shaft - remove surface nicks, burrs, and grooves and look for spiral machine marks that can damage the seal lip. Also not the C/R recommendations for shaft hardness and finish.

5. Check Shaft End - and remove burrs or sharp edges. Where the installation requires that the shaft enters the seal against the sealing lip, the shaft end should be chamfered.

6. Check Splines and Keyways - for sharp edges and protect seal lip with an assembly sleeve or shim stock. If not available, round the edges of the spline or keyway as much as possible and lubricate with a hard, fibrous grease.

7. Check Seal Direction - making sure that the new seal faces in the same direction as the original. Generally, the lip faces the lubricant or fluid to be sealed. When shaft must enter seal from the direction in which the lip points, Types G, A and AM can be installed using piloting tools.

8. Prelubricate the Sealing Element - immediately before installation by wiping or dipping in the lubricant to be retained.

9. Use Correct Installation Tool - Press fitting tools should have an outside diameter .010" smaller than the bore size. If possible, center of tool should be relieved so that pressure is applied only at the O.D. of the seal. Otherwise, seal distortion may cause leakage.

   Never hammer directly on the surface of the seal.

10. Use Proper Driving Force - where possible, an arbor press; otherwise, a soft-faced hammer to avoid popping the spring out of the seal. C/R rawhide mallets are ideal for this purpose.

    To prevent seal distortion and leakage, do not exceed the force necessary to seat the seal in the bore.

11. <u>Bottom Out the Tool or Seal</u> - to avoid cocking of the seal in the bore. This also positions the seal correctly on the shaft.

12. <u>Check for Parts Interference</u> - from other machine parts that might rub against the seal to cause friction and damaging heat.

AFTER INSTALLATION

1. In painting machine be sure to mask seal to avoid getting paint on the lip or shaft where lip rides. Also, mask vents so they will not become clogged.

2. If paint is to be baked or the mechanism otherwise subjected to heat, seals should not be heated to temperature higher than the sealing members can tolerate.

3. In cleaning or testing do not contact seals with fluid which will be injurious to them.

4. In any operation such as testing (for seal or other machine elements) previous to actual use of machine, avoid subjecting seals to conditions other than those for which the seal was designed. This may cause damage which may not show up until much later.

OBJECTIVE #3

3. DESCRIBE WHERE GASKETS ARE USED AND THE TYPE OF GASKET NEEDED FOR EACH JOB.

ACTIVITIES	PURPOSE
Read: <u>Auto Service and Repair</u>; Stockel	Describes gaskets and their uses.
Do: Worksheet #2	Tests your understanding of gaskets.

WORKSHEET #2

GASKETS

1. What is the function of a gasket?

2. What determines the material for gasket construction?

3. Name various materials used in gasket construction.

4. Why should you not re-use a gasket?

5. List 5 steps to follow when installing a new gasket.

OBJECTIVE #4

4. LIST ON THE SEALANT WORKSHEET,-THE VARIOUS USES OF GASKET SEALERS AS APPLIED TO THE AUTOMOBLE.

ACTIVITIES	PURPOSE
Read: <u>Auto Service and Repair</u>, Stockel	Sealants are explained in this text.
Do: Worksheet #3	Checks your knowledge of sealants

WORKSHEET #3

Write in the sealant needed to best do described job.

Job for Sealant	Sealant Needed
1. Glass to glass	________
2. Rubber to rubber	________
3. Paper gaskets, general repair	________
4. Close fitting	________
5. Threaded flanges and fittings	________
6. Air conditioner hoses	________
7. Permanent assembly jobs	________
8. Semi-permanent assembly	________
9. Can be used over oil and grease film	________
10. Repair gaskets	________

SELF TEST

GASKETS AND SEALS

1. Define each of the following terms by stating what it does in the auto:

   a. gasket -
   b. seal -
   c. sealant -

2. Of what are the following most commonly constructed?

   a. gasket
   b. seal

3. The following statements are true or false. Answer them to the best of your knowledge.

   ________ 1. When applying sealer, use a liberal amount.

   ________ 2. All oil seals are

_____3. Careful re-use of gaskets is a good economical procedure.

_____4. Oil-seal lip should face the liquid to be contained.

_____5. Leather sealers are used more often than synthetic rubber.

_____6. Sealant should always be used.

_____7. Creasing has little effect on the usability of a gasket.

_____8. A shrunken gasket can often be brought back to size.

_____9. Seals may be properly removed by prying.

_____10. Never strike the inner portion of a new seal.

_____11. Do not re-use seals.

_____12. Most sealants have similar properties.

_____13. Oil seals are found throughout the mechanical parts of the car.

_____14. A seal that drives in easily will leak.

_____15. Lubricate seal and shaft before installing.

_____16. Once a part has been torqued, the pressure will always remain constant.

SELF-TEST ANSWER

1. a. gasket - provides
   b. seal - contains liquids
   c. sealant - seals gaskets tight to uneven hard surfaces

2. a. gaskets - paper, cork, rubber, asbestos, steel, copper
   b. seals - leather, synthetic rubber, felt

3. 1. F

   2. F

   3. F

   4. T

   5. F

   6. F

   7. F

   8. T

   9. T

   10. T

   11. T

   12. F

   13. T

   14. T

   15. T

   16. F

GASKETS AND SEALS

1. a. gasket - provides leak proof joints
   b. seal - contains liquids
   c. sealant - seals gaskets tight to uneven hard surfaces

2. a. gaskets - paper, cork, rubber, asbestos, steel, copper
   b. seals - leather, synthetic rubber, felt

3. 1. F
   2. F
   3. F
   4. T
   5. F
   6. F
   7. F
   8. T
   9. T
   10. T
   11. T
   12. F
   13. T
   14. T
   15. T
   16. F

POST-TEST

Package Number 107-A

GASKETS AND SEALS

1. Define each of the following terms by stating what is does in the auto.

   a. gasket

   b. seal

   c. sealant

2. Of what are the following most commonly constructed?

   a. gasket

   b. seal

3. The following statements are true or false. Answer them to the best of your knowledge.

   ____1. When applying sealer, use a liberal amount.

   ____2. All oil seals are of one piece construction.

   ____3. Careful re-use of gaskets is a good economical procedure.

   ____4. Oil-seal lip should face the liquid to be contained.

   ____5. Leather sealers are used used often than synthetic rubber.

   ____6. Sealant should always be used.

   ____7. Creasing has little effect on the usability of a gasket.

   ____8. A shrunken gasket can often be brought back to size.

   ____9. Seals may be properly removed by prying.

   ____10. Never strike the inner portion of a new seal.

   ____11. Do not re-use seals.

   ____12. Most sealants have similar properties.

   ____13. Oil seals are found throughout the mechanical parts of the car.

   ____14. A seal that drives in easily will leak.

   ____15. Lubricate seal and shaft before installing.

   ____16. Once a part has been torqued, the pressure will always remain constant.

Name ____________ Date ____________

Axial Seals

Industrial Mechanics

107-B AXIAL SEALS

In seals, as in other areas, many different methods are used to accomplish similar objectives because the job requirements are different. In pumps, higher pressures are used than in other sealed areas. A stronger seal is available in radial seals than in lip seals. This learning package discusses radial seals.

SEALS AND GASKETS

Coordinated by Jerry Ludlow for
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SUPERINTENDENT OF PUBLIC INSTRUCTION

OBJECTIVES

Upon completion of the learning package, you will be able to:

1. Describe the parts of radial seals.

2. Discuss the principle of operation of radial seals.

3. Describe 2 major reasons why radial seals fail.

4. Inspect and identify damaged seals.

5. Use proper procedures to replace axial seals.

DEVELOPED WITH THE COOPERATION OF ...... State of Oregon Department of Education
Lane Intermediate Education District
Lane Community College
Educational Coordinating Council

PROJECT DIRECTOR: Dick Earl

WRITERS:

Frank Bishop

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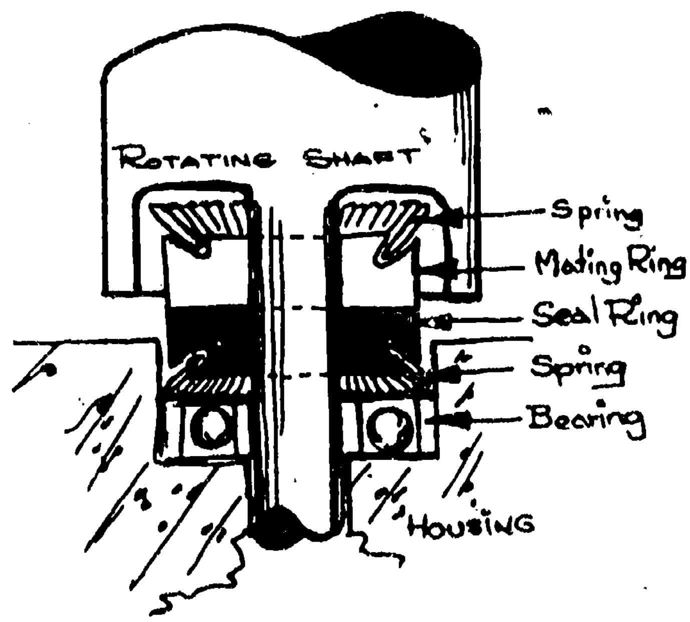
EXTENSION HALL ANNEX, CORVALLIS, OREGON 97331

LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
READ: Information Sheet	This added material will expand the knowledge of the student beyond the information sheet of this learning package.
READ: John Deere, Fundamentals of Service - Bearings and Seals	
DO: Given a leaking pump, disassemble and find the parts with the flaw. Identify the part and sketch the flaw. Replace with correct components and demonstrate that the seal holds.	Practical experience will permit the student to demonstrate his grasp of this subject area.

INFORMATION SHEET

AXIAL SEALS



Axial seals are used in applications of greater pressure where the radial seals are not adequate to seal the fluid.

Areas such as pressure pumps which are used in water supply, gasoline stations, hydraulic components, automotive water pumps, and etc. are examples.

The axial seal does not use the lip principle which was used in the radial seal. The axial seal contains a seal ring and a mating ring. These rings are both made of a hard material, or one is hard and the other is soft. If they both are hard, they are usually made of wrought, cast or sintered metals and are lapped (ground) to a precision finish. If one is soft, it is made of leather, plastic or some other elastic material.

The mating ring is mounted on the shaft and the seal ring is mounted on the housing. One, or both, are spring-loaded to apply pressure toward the opposite ring. In this way, axial contact pressure is applied against both rings to prevent the fluid from leaking at the rings. This type of seal requires cooling and the fluid under pressure being moved through the seal area will normally cool it.

CAUTION: Do not run an axially sealed unit without fluid in the system as the friction may generate enough heat to ruin the sea.

AXIAL SEAL FAILURES

- Contamination
Rust, scale or other contaminants in the pump or reservoir will cause damage to the seal. If possible, some kind of inhibitor should be used. Where this is not possible, filters should be employed to keep contamination down.

Heat
If the seal is required to run at temperatures greater than those to which it was designed, it may fail.

REPLACEMENT OF SEALS

1. Disassemble the sealed device and clean all parts.

2. Remove rust and burrs by wet polishing with fine emory cloth (400 to 600 grit)

3. Replace shaft if it is pitted or damaged.

4. Apply appropriate grease or soak seals in the proper oil.

5. Reassemble, assuring that sealing surfaces are clean, mating properly and under the correct spring tension.

6. Turn by hand to be certain the seal turns freely before attempting to run under power.

CAUTION: Never run under power without the fluid (to be pumped) in the system. Heat, caused by this type of running, would ruin the new seals.

SELF - TEST

Complete the sentence or circle the most correct answer.

1. Axial seals are used where greater ____________ work on the seals.

2. The seal ring and mating ring are ____________ ______________ against each other.

3. The mating surfaces of the 2 rings are extremely ______________.

4. One ring is usually ______________ than another.

5. If both are the same, they are ground to ______________.

6. Usually, the mating ring is mounted on the ______________.

7. The fluid moving through the pump acts as a ______________.

8. Axial seal failures are generally caused by ______________ or ______________.

9. A pitted shaft should usually be ______________.

10. A rebuilt pump should be ______________ to be certain it turns freely.

SELF - TEST ANSWERS:

1. pressures
2. spring-loaded
3. flat
4. softer or harder
5. precision smoothness
6. shaft
7. coolant, lubricant
8. heat contaminant
9. replaced, discarded
10. hand cycled

AXIAL SEALS

1. mating seal
2. flatness
3. elastic
4. spring loaded
5. cooling, lubricating
6. rust, scale, etc.
7. rust or scale, corrosion
8. cleaned
9. emory, crocus
10. greases
11. clean, mated, tension
12. hand cycle

POST—TEST

Package Number 107-B

Name ____________ Date ____________

Complete the sentence or circle the most correct answer.

1. Axial seals are made of a ____________ ring and a ____________ ring.
2. If both seals are hard, they are made of wrought or cast or sintered metals and are ground to precision ____________.
3. If one is soft, it is made of leather, plastic or some ____________ material.
4. The sealing rings are ____________ to insure a tight contact.
5. The fluid being pumped is used as a ____________ agent.
6. Filters or inhibitors are used to remove ____________.
7. ____________ may cause the seals to fail.
8. After disassembly of a sealed area, all parts should be ____________.
9. Rust and scale may be removed by use of ____________ cloth.
10. Radial seals should be ____________ when assembled.
11. While reassembling, care should be taken that seal surfaces are ____________, ____________ and under correct ____________.
12. The last step before applying power should be to ____________.

Industrial Mechanics

107-C PRE-FORMED SEALS OR MOLDED PACKINGS

Hydraulic and fluid power units are coming into common use more and more. These units depend upon proper sealing in order to operate. A serviceman must be able to diagnose problems and replace seals. An equipment operator must be aware of the way the seals function. Basic material to teach this is provided in this learning package.

Coordinated by
Jerry Ludlow for
OREGON BOARD
OF EDUCATION

SEALS AND GASKETS

OBJECTIVES

Upon successful completion of this package, you will be able to:

1. Describe 3 types of molded and pre-formed seals.

2. Properly install molded seals and O-rings.

DEVELOPED WITH THE COOPERATION OF ..... State of Oregon Department of Education
Lane Intermediate Education District
Lane Community College
Educational Coordinating Council

PROJECT DIRECTOR: Dick Earl

WRITERS:

Frank Bishop

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LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet	Added reading material broadens the student's background in this field
Read: John Deere, <u>Fundamentals of Service-Bearings and Seals</u>	
Do: Secure from your instructor a unit whose seals are to be changed, then: -inspect to determine the cause of seal failure -repair or replace defective parts -replace the seal, using proper techniques and tools	Practical experience in changing the seals will help the student to be a better operator of equipment and will begin to train him for proper servicing techniques.
Do: Do the same to other units until you have replaced: -an O-ring -a V-ring set or U-ring set -a cap seal	

INFORMATION SHEET

MOLDED PACKINGS

Molded packings and pre-formed seals fit into three categories:

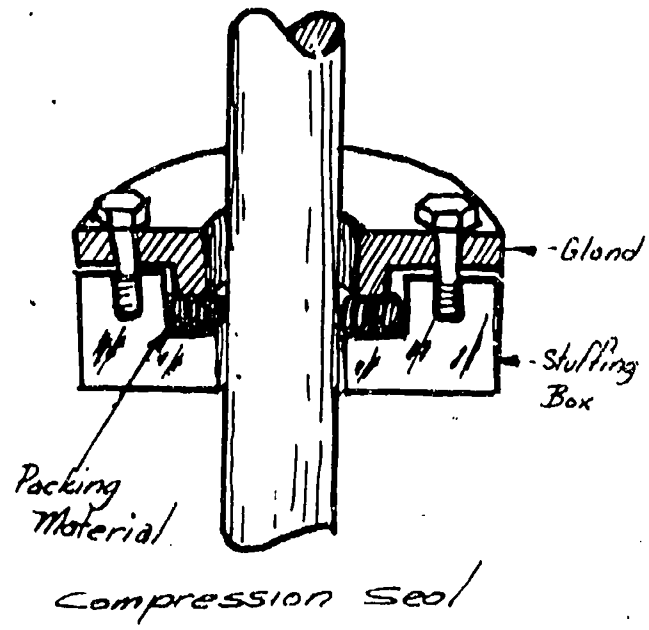
- Lip types
  Lip packings included flange, cup, U-cup, U-ring, and V-ring packings

- Squeeze types
  O-rings, compression packings, felt packings, and related types fall into this category

-Bushings and Ring seals.

LIP PACKINGS

Lip packings normally are used in reciprocating applications. A lip type packing is sealed by the forces of the pressure being sealed. The gland should not be tightened to provide high pressure on the seal as this conforms them to the compression seal category. Molded seals function without excessive gland pressure by their own expansion and contraction characteristics. This is called breathing. If too loose, however, they may create a pumping action and lose fluid in this manner. Glands normally do not have to be adjusted during use.



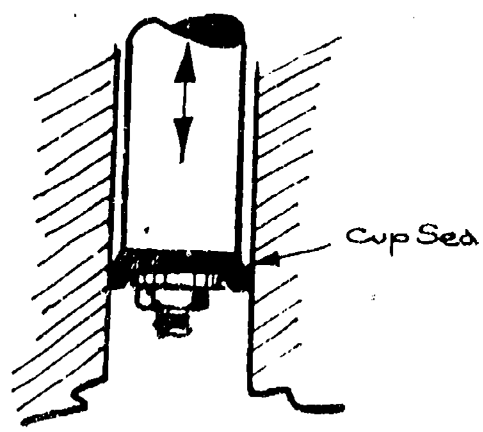
Usually, support rings are necessary to provide proper shape.

These seals are used on highly polished shaft surfaces, straight and round. If these shafts are exposed to the atmosphere, they are usually chrome-plated.

V-rings are usually installed in sets. The number of rings in the set depends upon the material they are made of and pressure against the seals. Generally, V-rings are not spring-loaded.

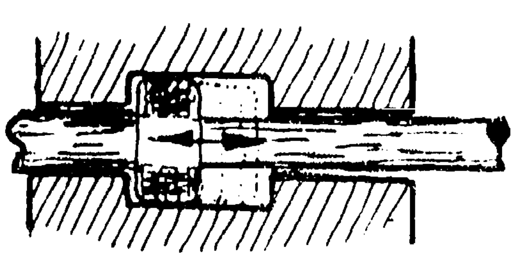
Cup packings are widely used for hydraulic and pneumatic service at both high and low pressures.

Cups have a single lip and are classified as unbalanced seals because of this single lip.

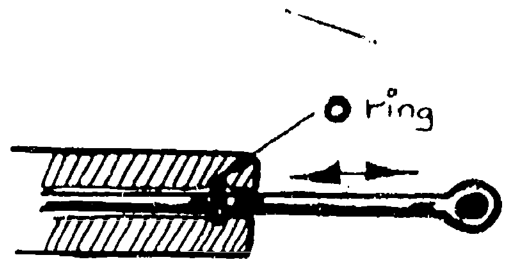


SQUEEZE PACKINGS

The most common form of squeeze packing is the O-ring. O-rings are usually fitted into machined grooves in the housing to provide a fluid stop. Felt packings and other squeeze or compression packings are covered in VIP Industrial Mechanics Learning Package 107-E, "Exclusion Seal Introduction and Felt and Compression Packings".



Often, dynamic applications require a very small amount of movement. O-rings may be used where they are required to roll, if sufficient room is allowed for them to do so without distortions. Three applications of O-rings fit into the above:



-Reciprocating shaft will slide inside an O-ring.

-Oscillating, where the seal rotates through a limited cycle.

-Rotating shaft at low speed may turn inside the seal.

Static applications are explained in VIP Industrial Mechanics Learning Package 107-D, "Static Seals".

O-RING INSTALLATION

O-rings are easily damaged, and during installation the following procedures should be used:

1. Be certain O-ring is compatible with the fluid in the reservoir.

2. Clean entire area that O-ring will contact.

3. Inspect O-ring area and remove burrs or rough edges with file, then smooth with fine emory cloth (400 to 600 grit).

4. Inspect shaft and remove burrs or rough area as above (both 3 and 4 require a re-cleaning of area to remove metal particles).

5. Lubricate O-ring, groove, and shaft with same fluid as in system. (Always use equipment manufacturer recommended fluid, O-ring size and O-ring quality).

6. Protect from cutting, stretching, and twisting during O-ring installation.

7. Align parts to prevent O-ring damage as parts are assembled.

8. Hand-cycle installation.

9. Tighten evenly. Don't overtighten, seal may crush or otherwise be destroyed.

BUSHING AND SEAL RINGS

Bushing seals are close fitting, metal, stationary sleeves in which a shaft rotates. These are usually somewhat softer than the shaft metal so any wear that occurs, occurs in the bushing, not on the shaft.

Leakage of fluids is controlled by the close fit between the bushing and the shaft. More on bushings in VIP Industrial Mechanics Learning Package 104-A, Types of Plain Bearings", 104-B "Materials in Plain Bearings" and 104-C "Distribution of Lubrication to Bearings".

RING SEALS

Ring seals are divided into split rings for reciprocating parts and circumferential seals for rotary devices. Usually, they are designed for high temperature, high pressure applications and are made of metal.

A prime example of split rings is the piston ring. These are used in pumps, compressors and internal combustion engines.

Cicumferential are high performance, low leakage contact type seals. They are used in rotary pumps where high head pressure exists. These seals are smaller than face seals and are light weight.

NOTE: Information on piston rings is available in quality texts, manufacturer's service manuals and from ring seal suppliers. Therefore, with so many sources available, they will not be covered in depth in this lesson.

SELF-TEST

Complete the sentence or circle the most correct answer.

1. List the 3 categories of molded and pre-formed seals.

2. ______________ type packings are usually used in reciprocal applications.

3. If excessive pressure is applied to the gland, the V-ring acts as a ______________ type packing.

4. The contraction and expansion action of a seal is called ______________.

5. In lip seal applications, glands normally do not have to be ______________ during service.

6. Lip seals require shafts that are highly ______________.

7. 3 V-rings make up the standard set size. T. F.

8. V rings (are, are not) spring-loaded.

ANSWERS TO SELF-TEST

1. lip type, squeeze type, bushing and ring seals
2. lip
3. compression
4. breathing
5. tightened
6. polished
7. F
8. are not
9. unbalanced
10. T
11. fluid
12. T
13. T
14. fluid
15. clean
16. burrs or roughness
17. lubricate
18. twist, stretch, cut
19. align
20. split circumferential

9. Cup seals are classified as ______________ because of the single lip.

10. Sometimes, O-rings are designed to roll. T F.

11. O-rings are affected by the type of ______________ in the system.

12. O-rings permit rotary action. T F.

13. O-rings slip on a shaft in reciprocating motion. T F.

In O-ring installation be certain that:

14. O-ring is compatible with ______________.

15. O-ring contact area is ______________.

16. Remove ______________ from O-ring area.

17. ______________ both ring and shaft before installing ring.

18. During installation, do not ______________ ______________ or ______________ O-ring.

19. ______________ parts to prevent damage during assembly.

20. Two kinds of ring seals are ______________ and ______________.

PRE-FORMED OR MOLDED PACKINGS

1. should not
2. lip seal
3. O-ring
4. V-ring
5. material and pressure
6. F
7. hand-cycled
8. F
9. F
10. cleaned
11. F
12. split ring
13. T
14. high
15. straight and round

POST—TEST

Package Number 107-C

PRE-FORMED OR MOLDED PACKINGS

INSTRUCTIONS: Complete the sentence or circle the most correct answer.

1. The gland (should, should not) be tightened to high pressure on lip seals.

2. The pressure of the fluid being sealed helps seal a ________________.

3. An ________________ may seal as it rolls.

4. ________________ are usually installed in sets.

5. Set size depends upon ________________ and ________________.

6. V-rings are usually spring-loaded. T F

7. After seals are installed, the device should be ________________.

8. O-rings are not sensitive to installation damage. T F

9. A person may use other fluids for lubricating O-rings than that of the system. T F

10. After removing burrs from shaft, the parts must be ________________.

11. O-rings are not designed to roll. T F

12. A piston ring is classified as a ________________.

13. A bushing, normally considered a bearing is also a seal under certain circumstances. T F

14. Circumferential metal seals are used in pumps that have a ________________ pressure head.

15. V-ring seals are usually used on shafts that are highly polished ________________ and ________________.

Name ________________

Date ________________

INDIVIDUALIZED LEARNING SYSTEMS

Industrial Mechanics

107-D STATIC SEALS

PURPOSE

Static seals are generally known as gaskets, tapes, and liquid sealants. Even though these are in very common use, there are many functions in preparation, installation, and in tightening that should be followed. The purpose of this learning package is to provide some of the required information.

OBJECTIVES

Upon successful completion of this learning package, you will be able to:

1. Describe [illegible]
2. Describe general construction of several types of gaskets.
3. Discuss torquing of head bolt.
4. Discuss 2 types of sealants.
5. Remove and replace static seals.

DEVELOPED WITH THE COOPERATION OF . . . . State of Oregon Department of Education
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LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet	Added reading material will broaden the student's background knowledge in the field
Read: John Deere, <u>Fundamentals of Service - Bearings and Seals</u>	
Do: Replace a valve cover or other gasket as follows: -remove cover and old gasket -clean all oil and old gasket material from head -coat gasket and cover with proper sealant (coat one side of gasket only) -install gasket and cover -torque to proper tension (NOT TOO MUCH)	Practical experience in changing gaskets will expose the student to requirements of cleanliness, handling and tensions involved.
Do: Replace an engine head gasket -remove old gasket -inspect area for damaged parts -clean carbon from the head and cylinder block -be certain both head and block surfaces are true and flat -re-tap head bolt holes -re-tap head bolts (oil them) -torque bolts in proper sequence to proper tension.	

INFORMATION SHEET

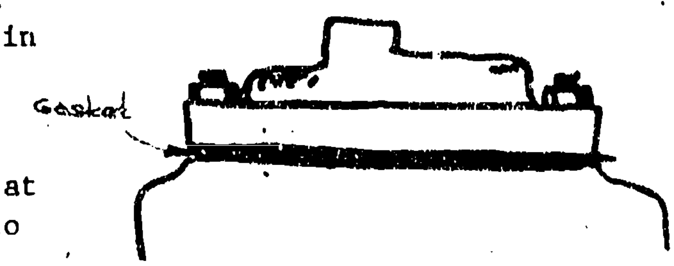
STATIC SEALS

Static seals is another name for gaskets and fluid sealants.

GASKETS

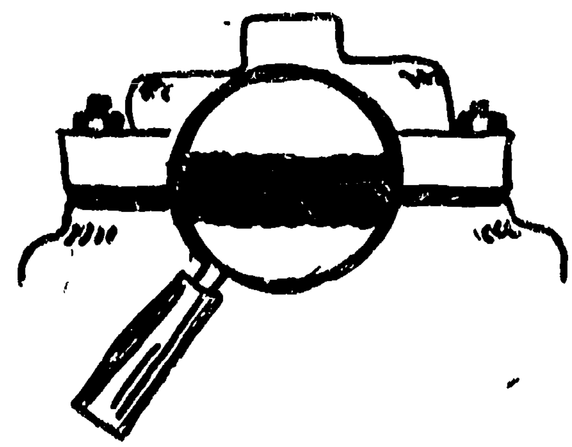
A gasket is any device that provides a barrier against transfer of fluids across the mating surfaces of a mechanical assembly when those surfaces do not move relative to each other.

Gaskets may be made of metal or other materials. All gasket materials must be softer than the assembly being sealed. Often cork, rubber, composition, plastic, and other materials are used. The requirement for softness permits the gasket to take on the shape of the surface being sealed. Metal gaskets are often used where high heat and pressure could break material of less strength. A prime example of this is the head gasket in any internal combustion engine.



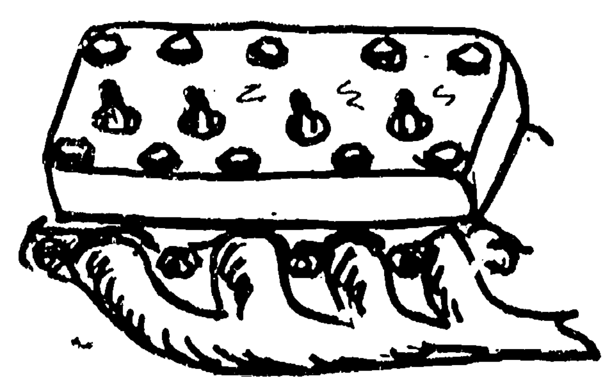
Gaskets must always be placed on a clean, dry, smooth surface. Always exercise great care in installation of gaskets so they do not get torn, bent, or damaged before or during installation. A damaged gasket will fail at the point of damage and cause the repair job to be repeated much earlier than otherwise required.

Bolt holes which have been previously used may have particles of carbon or other material in them. For this reason, they should be re-tapped and oiled to reduce friction while they are being torqued.



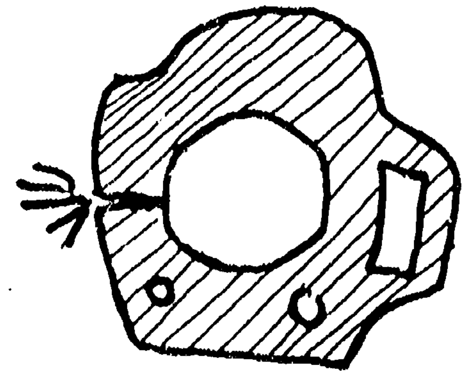
Be certain that the mating surfaces are clean, flat, and not warped in any direction.

Put all bolts into place and hand tighten. Bolts should turn freely if they are to be accurately torqued.



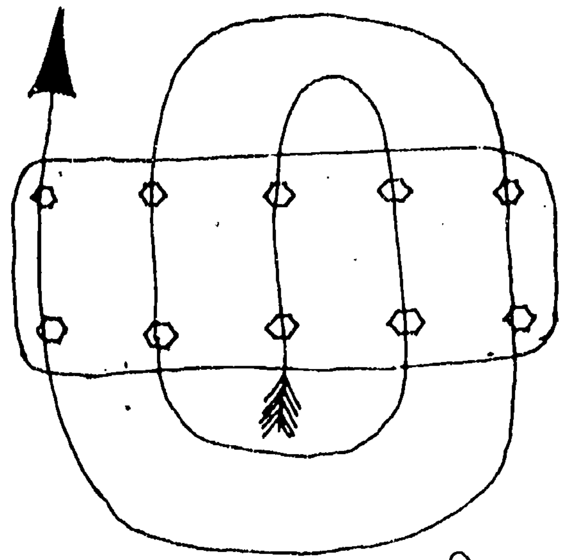
When tightening bolts that hold a large assembly together over a gasket, care must be exercised to tighten bolts in a proper sequence and to a proper tension (use torque wrench). In some gaskets, such as cylinder head gaskets, that sequence should be repeated several times until consistent readings are kept.

After the device has been used for a short period of time to permit a heating and cooling sequence, all bolts and other linkages must again be re-torqued to their proper tensions and clearances. The gasket has taken on the shape of the surrounding materials and has compressed. For this reason, all settings have changed. Sequence of tightening is important to keep the gasket for "kinking" by tightening the outer edges first.



SEALANTS

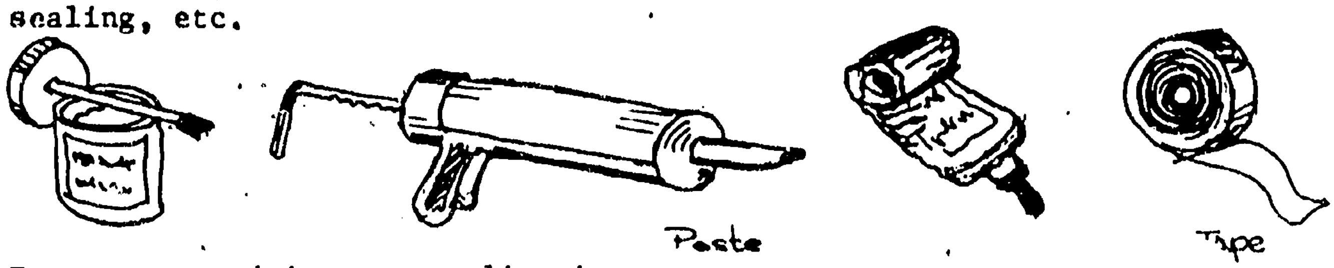
Sealants include liquids, pastes, and tapes that are used for sealing. These have the same use as gaskets but are not cut to shape.



Tightening Sequence for Torquing head bolts

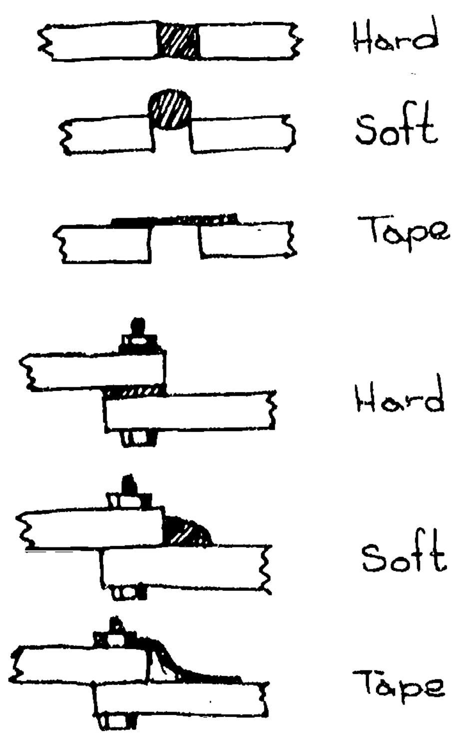
Sealants in liquid form can be the type that hardens. These may harden as a rigid material that cracks if bent or as a flexible gasket that will change shape as required. Some such as epoxies, also act as a glue or joining material.

Other liquid sealants are the non-hardening types. These materials will always remain in a soft "mastic type" condition. These sealants are used in caulking, window placement, bathtub sealing, etc.



Tapes are used in many applications to form a seal between surfaces.

Joints should be carefully prepared. This requires a clean and dry surface and secured parts. Some joints use a soft sealant to expansion of metals.



CAUTION: Don't get sealant into the flow area or it may damage moving parts or clog passageways. For example, if a sealer is used on a heater hose seal around the metal, do not push sealer applicator into the hose. Excess sealer in the hose may come off and plug radiator openings.

SELF-TEST

Complete the sentences.

1. Static seals include __________, __________ and __________.

2. Static seals are used where mated surfaces _____ _____ __________.

3. The sealing material must be __________ than surrounding material.

4. List 4 materials of which gaskets are made.

5. The gasket must conform to the __________ of the material being sealed.

6. Metal gaskets are used where __________ and __________ are intense.

7. Gaskets must not be __________ or __________.

8. The surface where the gasket is to be placed must be __________, __________ and __________.

9. All ________ must be cleaned and oiled for smooth tensioning.

10. Large machines should be tensioned with a __________ __________.

11. Sequence of tensioning is from the _______ to the _______.

12. Sealants come in 2 forms, those that _______ and those that _______.

SELF-TEST KEY

1. gaskets, sealants, tape
2. do not move
3. softer
4. metal, cork, rubber, plastic, composition
5. shape
6. heat pressure
7. bent, damaged, torn
8. clean smooth
9. bolts
10. torque wrench
11. inside - outside
12. harden - stay soft

POST-TEST KEY

Package No. 107-D

STATIC SEALS

1. clean, smooth, dry
2. T
3. expansion, contraction
4. transfer of fluid
5. shape
6. bent, torn
7. metal
8. T
9. tension
10. re-tapped

POST—TEST

Package Number 107-D

Name ____________ Date ____________

STATIC SEALS

INSTRUCTIONS: Complete the sentence or circle the most correct answer.

1. Surfaces or joints being prepared for a static seal should be __________, __________, & __________.

2. Tapes may be used to seal some areas. T F

3. Some sealants never harden. They are used where __________ & __________ take place.

4. A gasket is any device that provides a barrier against the __________ across the mating surfaces of a mechanical assembly.

5. Gaskets must conform to the __________ of the mated materials.

6. Gaskets are damaged beyond repair if __________.

7. __________ gaskets are used where heat and pressure are great.

8. Gaskets and sealants may be used at the same time and place. T F

9. Proper __________ on the bolts is a requirement if the gasket is to last.

10. Bolt holes should be __________ to remove dirt, carbon, and other materials.

Industrial Mechanics

107-E EXCLUSION SEAL INTRODUCTION AND FELT AND COMPRESSION PACKINGS

PURPOSE

Exclusion seals keep foreign material (dirt, dust, fluids) out of a lubricating area. Two common types of exclusion seals are felt packings and compression packings. This learning package provides material to permit the student to work with these packings.

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OBJECTIVES

Upon successful completion of this course, you will be able to:

1. Describe the purpose of exclusion seals.
2. List 5 types of exclusion seals.
3. List 5 advantages of felt packings.
4. Install felt and compression packings.
5. Maintain compression packings.

DEVELOPED WITH THE COOPERATION OF ...... State of Oregon Department of Education
Lane Intermediate Education District
Lane Community College
Educational Coordinating Council

PROJECT DIRECTOR: Dick Earl

WRITERS:

Frank Bishop

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John Anderson

Warren White

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LEARNING ACTIVITIES

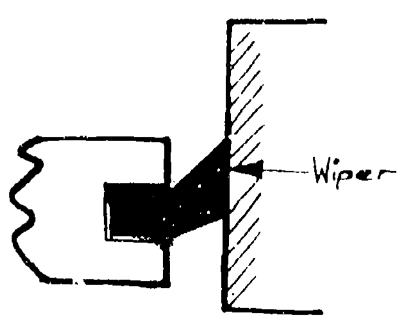
ACTIVITIES	PURPOSE
Read: Information Sheet Read: John Deere, Fundamentals of Service, Bearings and Seals.	Added text reading widens the appreciation of the problems and their solutions when working with this type of seal.
Do: Given a working model by the instructor, do the following: Replace a felt packing, using bulk material Replace a compression packing and tension properly.	Practice gained in this manner enables student to function in a working environment.

INFORMATION SHEET

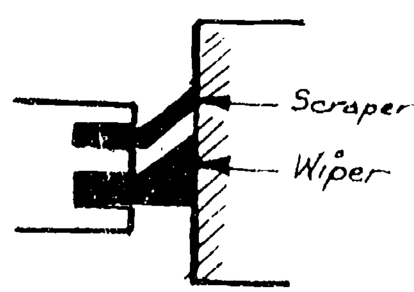
EXCLUSION SEALS

Inclusion seals use the slight film of fluid that passes the sealing edges as the sealing agent.

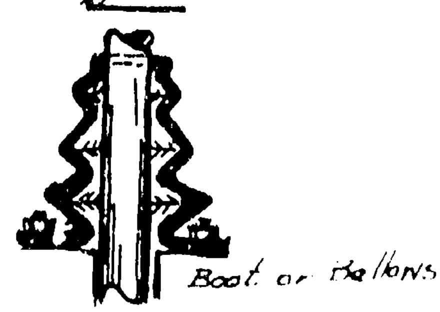
An exclusion seal must stop all the material at the sealing edge because the material being excluded is abrasive and does not lubricate.



Lip design is used in both inclusion and exclusion seal design. In exclusion seals, if the lips are made of leather or an elastic type of material, the seal is generally called a wiper (when used on a reciprocating shaft). The lip must be sturdy and remain in contact with the shaft.



Heavy duty seals on reciprocating shafts sometimes use metal lips. This type of seal is known as a scraper. Usually, because the scraper has less flexibility, it is followed by a wiper on the shaft.



A boot does not permit frictional contact between the shaft and the seal. It is [illegible] to both and absorbs the [illegible] action.

INFORMATION SHEET

MAINTENANCE OF EXCLUSION SEALS

LUBRICATION

Lubrication for the exclusion seal is often very sparse. Reciprocating shafts will have a slight film of oil from the inclusion seal.

In a rotary application, some seepage from the internal seal is required to lubricate the exclusion seal.

SHAFT CONDITION

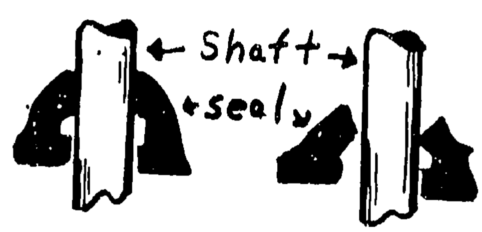
A proper seal finish on the shaft will permit oil to seep through the inclusion seal to lubricate the exclusion seal. Too smooth a finish will stop the oil at the internal seal. Obviously, a rough shaft surface finish will cause the exclusion seal to fail because of abrasive action.

TEMPERATURE

Usually, temperature is well within seal limits, unless something has caused an unexpectedly high temperature. Damage to seals because of overheating is unusual.

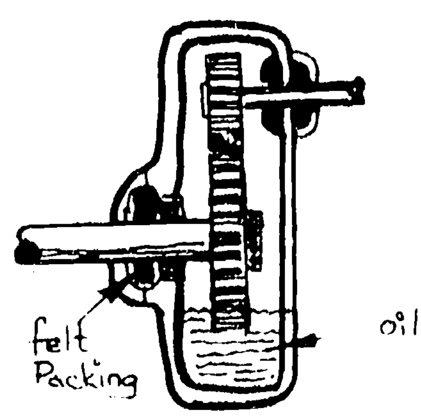
LIP CONDITION

If lips start to separate from the shaft, foreign matter can get into the seal area to scratch the shaft and further damage the seal.



FELT RADIAL PACKINGS

Radial packings of felt that are soaked in lubricant that has a greater viscosity than that of the reservoir are often used as dust seals in farm equipment. They will not hold oil pressure but often will be used to seal dust out of an area where an oil bath gear system is used.



Felt packings have several advantages:

1. Assure oiling will be present after long idle periods.

2. 3/4 of the wick volume stores oil.

3. Even when dry, felt polishes.

4. Felt seals are resilient. They do not wear from minor shaft damage.

5. Felt filters out dust.

NEW INSTALLATION OF FELT PACKINGS

Packings usually are purchased as precision cut felt washers that are sold pre-saturated with lubricant.

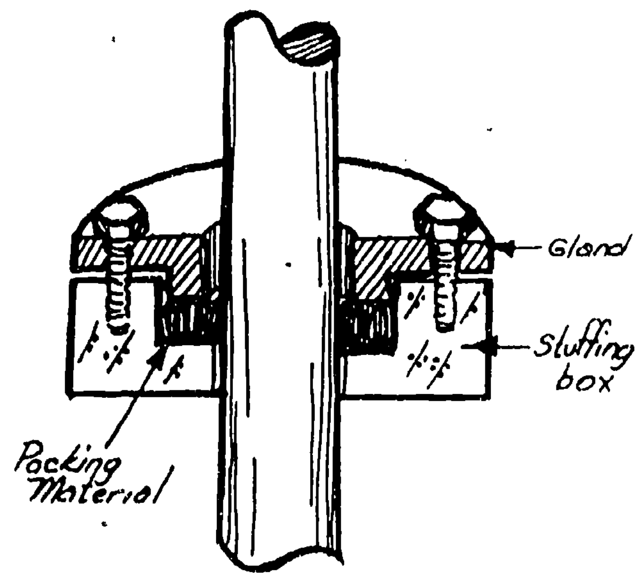
Packings may be made from strips of felt by measuring the old strip, cutting to the same size, then, after placing the strips in the holders, filling them with oil until the felt is saturated.

COMPRESSION PACKINGS

Compression packings create a seal when squeezed between the throat of a stuffing box and its gland.

Under pressure, these materials will expand against the sidewalls of the box and then against the shaft to form a seal. The gland must be tightened regularly to compensate for wear on the packing material.

Packings usually consist of a square or rectangular cross section of fabric, metallic, or plastic material.



INSTALLATION

Installation practice recommends lubrication prior to installation and care not to twist the packing during installation. Tighten gland loosely to permit further tightening during use.

Installation of new packings is recommended anytime a packing is disturbed by repair.

MAINTENANCE

Packings must have lubrication to properly seal. If they are tightened too tight, the packing will run dry and create frictional heat.

In high pressure or temperature application, external lubrication or cooling may be necessary.

SELF-TEST

Complete the sentence or circle the most correct answer.

1. Inclusion seals actually seal with a film of __________.

2. Exclusion seals are designed to keep all material out. T F.

3. Exclusion seals usually are working in an ______________ material that does not lubricate.

4. Exclusion seals on a reciprocating shaft are usually of a __________ design.

5. An all metal seal is called a ____________.

6. A leather or plastic seal is usually known as a ______________.

7. A seal that does not provide frictional contact with a reciprocating shaft is a ______________.

8. Lubrication on an exclusion seal is usually (heavy, light).

9. A ___________ finish on a shaft permits oil to seep out to lubricate an exclusion seal.

10. When lips separate from the shaft, the seal should be _________.

11. Felt packings may be purchased __________ or in bulk.

12. Felt packings are usually lubricated in __________ viscosity oil than that of the reservoir.

13. Felt packings are generally used to seal out ___________.

14. ___________ of the volume of a felt packing stores oil.

15. The gland of a compression packing must be ____________ regularly.

16. Packings should be ___________ before installing.

17. Proper installation requires __________ tension on the gland.

18. In high pressure or temperature application, __________ lubrication or cooling may be necessary.

19. New compression packings should be installed whenever the old are ____________.

SELF-TEST KEY

Package No. 107-E

1. oil
2. T
3. abrasive
4. lip
5. scraper
6. wiper
7. boot
8. light
9. medium
10. replaced
11. pre-cut
12. heavier
13. dust
14. 3/4
15. tightened
16. lubricated
17. loose
18. external
19. disturbed

POST TEST KEY Package No. 107-E

1. - scraper
2. - light
3. - pre-cut
4. - lubricated
5. - loose
6. - oil

POST—TEST

Package Number 107-E

Name ______ Date ______

Complete the sentences.

1. An all metal seal is called a ____________________.
2. Lubrication on an exclusion seal is usually (heavy, light).
3. Felt packings may be purchased ______________ or in bulk.
4. Packings should be ____________________ before installing.
5. Proper installation requires __________________ tension on the gland.
6. Inclusions seals actually seal with a film of ____________________.

Industrial Mechanics

Introduction and Radial Lip Seals

907-[illegible] INTRODUCTION [illegible]

Seals play a vital role in keeping [illegible] oils and other fluids contained in [illegible] their proper place in modern equipment. This learning package [illegible] veloped to provide an opportunity [illegible] to learn the principles of how seals work, how to install them, and how to diagnose the reasons they fail [illegible]

OREGON BOARD OF EDUCATION

OBJECTIVES

Upon successful completion of this learning package you [illegible]

1. State in your own words definitions of technical terms for seals.

2. Describe a seal and considerations of why they seal.

3. Discuss reasons why seals fail.

4. Using the 12 steps for proper installation, install a radial lip seal.

DEVELOPED WITH THE COOPERATION OF:

State of Oregon Department of Education
Lane Intermediate Education District
Lane Community College
Educational Coordinating Council

PROJECT DIRECTOR: Dick Earl

WRITERS:

Frank Bishop

Steve Brous

John Anderson

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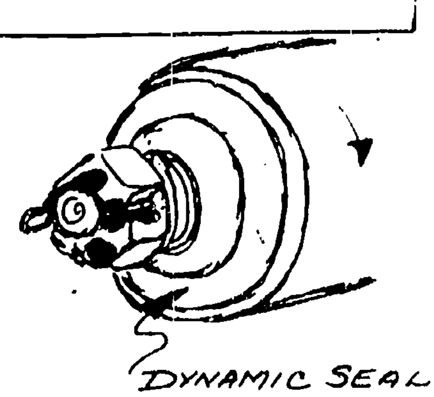
LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet	Added material expands the knowledge presented in the information sheets of this learning package.
Crouse: Automotive Mechanics, McGraw Hill Book Company	
Stockel: Auto Service & Repair - Goodheart-Willcox Co., Inc.	
Do: Obtain shafts from instructor and inspect for reasons causing seal failure. Sketch the shaft on paper showing the flaws found on the shaft and report all flaws to your instructor.	Practical experience will add to the knowledge provided by paper work.
Do: Install seal on shaft provided for this purpose. Install shaft and test for leaks.	

DEFINITION OF TERMS

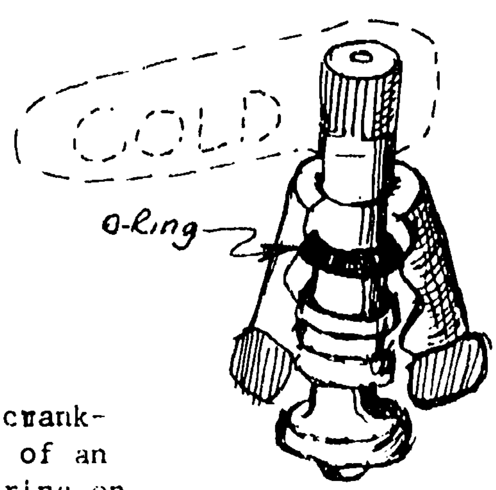
SEAL

A device that limits the flow of a liquid or gas to a given area. This learning unit on seals will discuss oil seals, dust seals, packings, etc



DYNAMIC SEAL

Allows motion on one of the parts being sealed. For example, an oil seal on an automotive axle.



STATIC SEAL

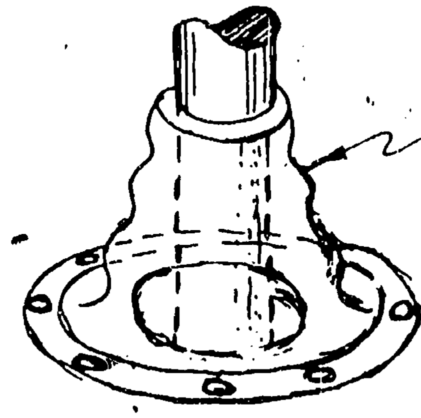
A seal used to secure an enclosed area. An example is a gasket or a sealant.

INCLUSION SEAL

A seal that keeps a fluid inside a chamber. A crankshaft seal on a four-cycle engine is an example of an inclusion seal. Another example would be an O-ring on a water faucet shaft.

EXCLUSION SEAL

A seal that is used to prevent entry of foreign matter. A dust seal, wiper, a scraper or a "boot" are examples of exclusion seals.



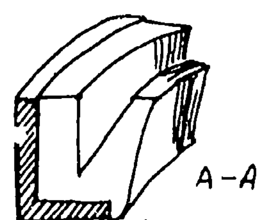
INTRODUCTION

A perfect inclusion seal would keep all of the fluid from leaking out of the system. This is not always necessary or desirable. Inclusion seals usually use a film of the fluid to do the actual sealing. Some are designed to permit an amount of fluid to leak through to lubricate equipment on the other side of the seal.

Even though seals look simple, they are really complex, precision parts and must be handled with care to prevent damage to the seal. A damaged seal will not perform its intended purpose properly.

RADIAL LIP SEALS

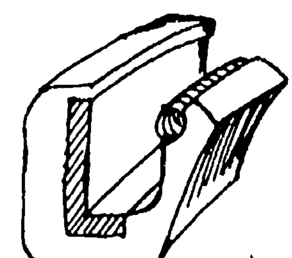
These are also called oil seals or shaft seals and are probably the most common type of dynamic seal in use. They fit into small spaces, are low in cost, easy to install and generally can accomodate wider tolerances of temperature, pressures, alignment, ets., than other types of seals.



Single Lip

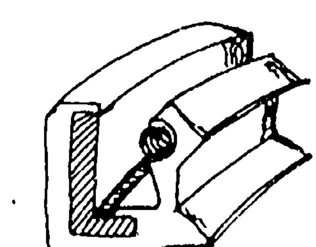
These seals are molded to shape and must often have a metal case. Most are spring-loaded to add rigidity and longer life to the seal.

The basic material for contruction is rubber, plastic, synthetic compositions or leather. The choice of material to be used depends upon cost, quality, and the working requirements for the seal.



Spring Loaded Single Lip

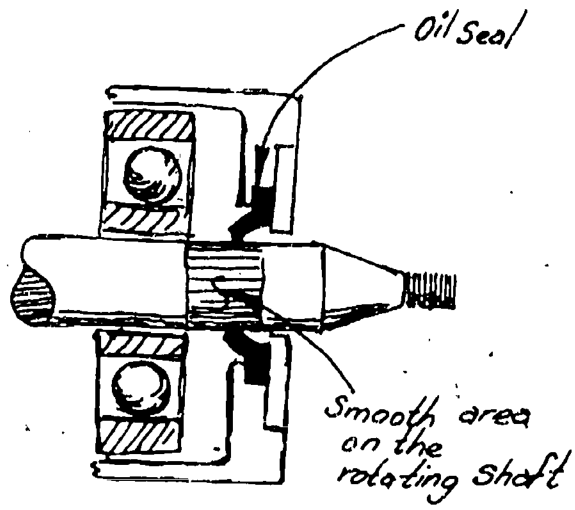
A turning shaft must have lubrication on its bearings. Normally, that lubricant must stay within the bearing area. Many types of seals have been designed to handle different oil, grease viscosity, heat requirements and shaft speeds. Some (such as the double lip) are designed to do two functions at once. These functions might be to contain one fluid within a chamber and to keep another fluid out of the chamber.



Double lip Seal
One side Spring loaded

In order to keep the oil in a chamber, the seal has been designed to ride on the rotating or reciprocating shaft with the lip pointing toward the oil reservoir. In this position, the mechanical pressure of the seal can control the sealing of the fluid.

The sealing capability of a seal is a consideration of:



- shaft finish
- revolutions per minute (RPM)
- atmospheric conditions
  - dust
  - moisture
  - chemicals
- pressure of fluid against the seal
- seal design
  - designed to leak
  - designed to leak completely

A seal is effective on a given shaft depending upon the area of contact of the seal to the shaft, the pressure exerted by the seal against the shaft, and the material from which the shaft is made.

There are various cross section shapes to lip seals depending upon the function of the seal and its manufacturer.

Actually, the film of oil between the seal and the shaft does the sealing. If it becomes too thick, the seal leaks. If it becomes too thin, the lip of the seal wears and friction and heat result, causing the seal to deteriorate rapidly.

LIP SEAL FAILURES

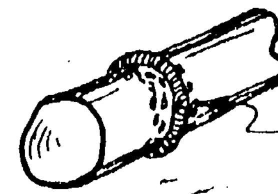
Since, under ideal circumstances, the seal does not contact the shaft, a seal should never wear out. Seal failures become evident when a leak occurs.

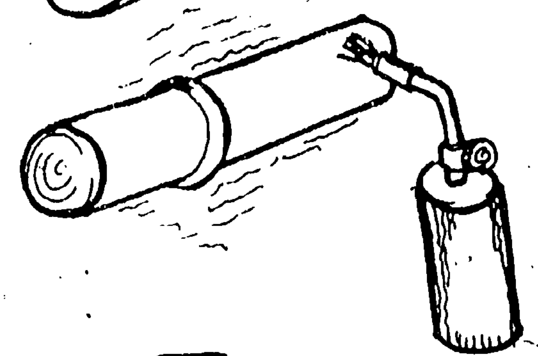
Most failures are caused by other factors.

- Installation damage over sharp splines, keys or threads may damage seals. When seals are not properly seated, they may not ride in the prepared place on the shaft and may allow dirt, etc. into the sealing area.

- Rust or scale on the shaft will rub on the seal, causing it to fail.

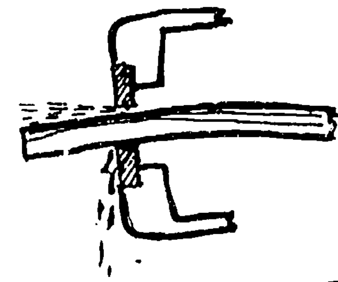
- Excessive heat from some outside source will cause the oil film to thin and cause the seal to fail. Check anything that might cause unusual heat near the seal.



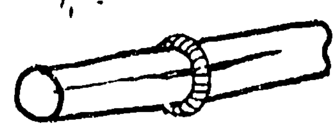


- Improper fluid in the sealed area may cause damage. Some chemical additives to oils deteriorate the rubber or composition from which the seal is made, causing it to swell out of shape. Be certain to use equipment manufacturer recommended seals and lubricants.

- A bent shaft or cocked seal causes the seal to have an unnatural fit and therefore, it can no longer seal in the lubricant.



- Grooves or sharp edges on the shaft will tear the seal if contact is allowed.



PROPER LIP SEAL INSTALLATION TECHNIQUES

Always replace any seals that have been disturbed during repair. Never re-install an old seal.

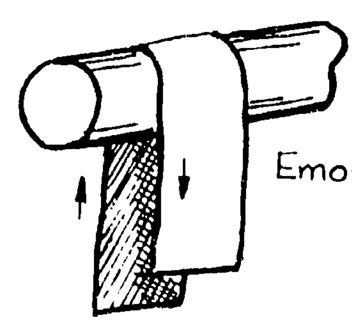
1. <u>USE ONLY MANUFACTURER RECOMMENDED SEALS</u>

2. <u>USE ONLY MANUFACTURER RECOMMENDED FLUIDS</u>

3. Keep seals and fluids free from dirt.

4. Inspect shaft and bore area for damage. If damage is found, file away larger burrs or nicks and polish with fine emory cloth (400 to 600 grit).

CAUTION: Do not file shaft out-of-round.



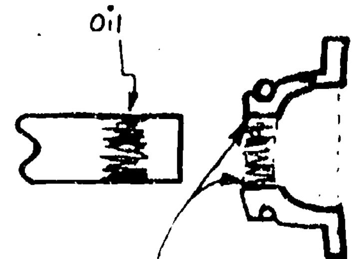
<u>NOTE</u>: Shaft areas that move under a seal should have a smooth finish.

5. The lip side of the seal always faces toward the lubricant.

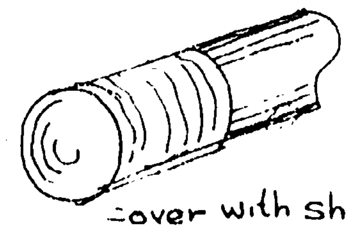
6. Oil the seal and the shaft with the <u>system</u> lubricant.

7. On metal cased seals, use gasket cement to prevent leaks in the bore area.

CAUTION: Do not let cement get on the lip surface.



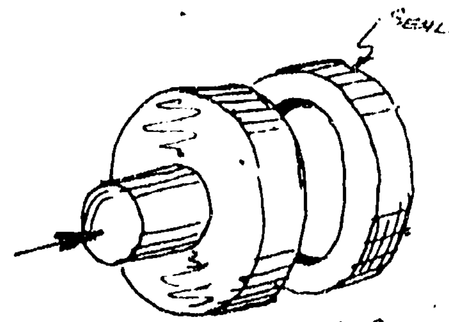
8. Use great care in slipping the seal over the shaft to protect the lip from contact with sharp threads, keyways, splines or rough shaft surface. Always protect it with a tool, shim stock, or take other protective measures.



Cover with shim stock

Press the seal with a circular tool near the outer diameter of the seal case. If available in the shop, use an approved seal driving too.

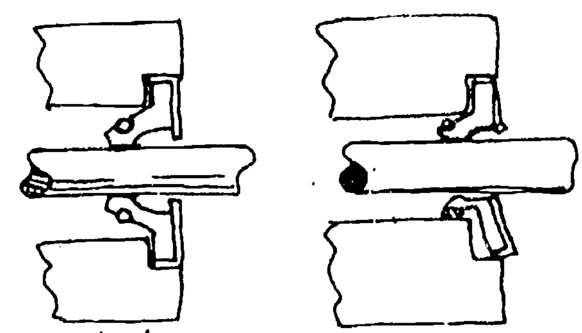
CAUTION: Never press on the seal lip. Never use sharp tools.



Use tool that fits outer edge

9. Be certain seal is properly seated to obtain correct lip pressure on the shaft. Do not force seal beyond its intended location. Do not distort seal by bending or "dishing" the metal case.

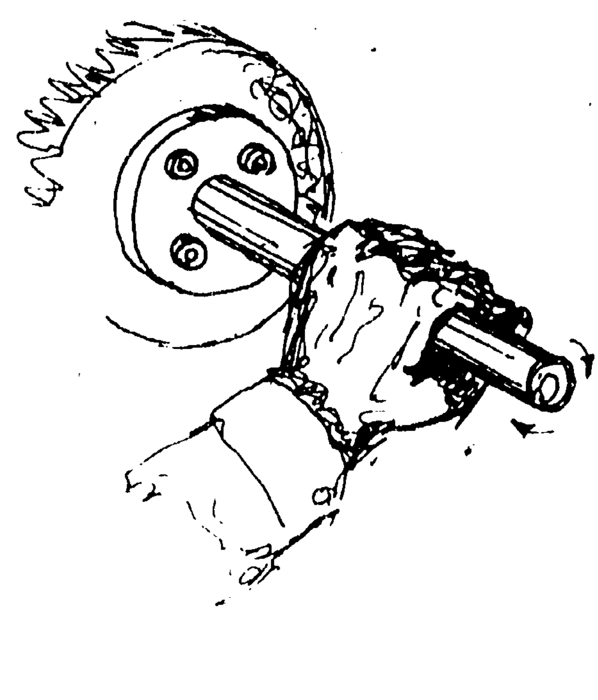
10. Be certain seal area is free from dirt, as this can quickly damage the seal and shaft.



Right Wrong

11. Turn the mechanism by hand to check for freedom of operation before operating under power.

12. Allow a slight amount of leakage in the first few hours of operation as the seal wears off its sharp edge and seals to the shaft.



SELF-TEST

Complete the sentence or circle the most correct answer.

1. A seal that operates against moving parts is called a __________ seal.
2. A seal joining non-moving parts is called a ____________ seal.
3. An exclusion seal is used to keep material from (entering, or exiting.)
4. An inclusion seal is used to keep material from (entering, or exiting).
5. Seals are usually a simple, uncomplicated device. T or F.
6. An oil seal is usually a _________ _________-seal.
7. Many seals have metal cases. T or F.
8. Seals may perform 2 functions at once. T or F.
9. The lip faces (toward, away from) the fluid reservoir.
10. Friction of the lip rubbing the shaft does the sealing. T or F.
11. List 4 reasons why seals fail.

12. Effectiveness of a seal depends on ________ of the lip in contact with the shaft, the _________ exerted by the seal against the shaft and the condition of the __________ of the shaft.
13. In a functioning seal, a _________ ____ _________ does the sealing.
14. Always replace seals that have been __________ by a repair.
15. Lubricate the seal and the shaft with ______________ oil.

SELF-TEST KEY

1. dynamic
2. static
3. entering
4. exiting
5. F
6. radial lip
7. T
8. T
9. toward
10. F
11. rust or scale, excessive heat, wrong fluid, bent shaft, grooved shaft, installation damage
12. area, pressure, surface
13. film of oil
14. disturbed
15. system

POST-TEST KEY

Package No. 107-F

INTRODUCTION AND RADIAL LIP SEALS

1. F
2. F
3. T
4. lubricate
5. F
6. F
7. F
8. lip
9. by hand
10. T
11. exclusion
12. static
13. fluid
14. heat, wear
15. shaft
16. installation

POST—TEST

Package Number 107-F

Name ______________ Date ______________

INTRODUCTION AND RADIAL LIP SEALS

INSTRUCTIONS: Complete the sentence or circle the most correct answer.

1. Any seal may be used to replace another if it is the same size and shape. T F
2. Manufacturer's recommended fluids are best but you may substitute if it is more convenient. T F
3. Shafts may be smoothed with a file, if nicked. T F
4. Always ________________ the shaft and seal before installing.
5. Metal cased seals may be struck directly with hammer if care is used. T F
6. Gasket cement is used on metal covered seals. T F
7. Seals may be slipped over unprotected splines if care is used. T F
8. Seals must be properly seated to provide correct ________________ pressure.
9. Mechanism should be cycled ________________ before power is applied.
10. New seals will leak during the run-in period. T F
11. A seal that keeps fluid out is an ________________ seal.
12. A seal between unmoving parts is a ________________ seal.
13. Wrong ________________ in the sealed area may cause the seal to fail.
14. Excessive ________________ will cause a seal to fail.
15. A bent ________________ will cause seal failure.
16. Careless ________________ will cause seal failure.

10.4

MACHINE COMPONENTS -- CHAIN DRIVES

Goal:

The apprentice will be able to describe chain drives and their use in machine applications.

Performance Indicators:

1. Describe types and uses of chain drives.
2. Describe operation and safety of chain drives.
3. Describe procedures for storing, cleaning and lubricating chains.
4. Describe adjustment of chain slack.
5. Describe alignment of sprockets.
6. Describe troubleshooting procedures in chain drives.

102-A CHAIN DRIVE INTRODUCTION

This learning package material is designed to teach the student the basic terminology, principles, and types of chain drives. The student should continue into additional learning packages for maintenance and design information.

Having successfully completed this learning package, the student will be able to:

1. State the 3 basic uses of chain drives.
2. Give 5 advantages and 3 disadvantages of chain drives.
3. Describe how a chain drive works.
4. State 12 principles of chain drives.
5. Name 10 types of chains.
6. Describe 3 types of chains in common use.

LEARNING ACTIVITIES

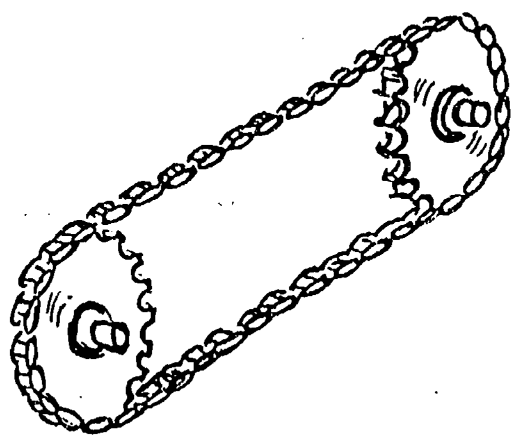
ACTIVITIES	PURPOSE
Read: Information Sheet	Contains basic introductory information on chain drives.
Read: John Deere, Fundamentals of Service - Power Trains, Belts & Chains	Contains information on chain drive advantages and types.
Do: Using the chain-board available in the shop, identify all of the chains and their uses.	Provides a practical tool to permit the student to recognize different chain types

INFORMATION SHEET

CAHIN DRIVE INTRODUCTION

A chain drive is similar to a belt drive except it is:

- less flexible
- more powerful
- eliminates slip



It consists of an endless chain and toothed sprockets.

USES OF CHAIN DRIVES

Chain drives have three main uses:

TRANSMIT POWER

Chain drives are used to turn shafts, much in same manner as belt drive systems. A chain works well in running several shafts from a main power shaft. A chain drive is sometimes referred to as a "flexible gearing" system.

TIMING

Chains are used in timing because they do not slip or creep on the sprockets as belts do on pulleys. This accuracy is necessary in timing applications. Most automobile engines use timing chains.

CONVEYING

Conveying implies pushing, pulling, sliding or carrying material. Often conveyors are required to work at very low speed carrying heavy loads. The belt may be used to hold the material but often a plain link chain is used to drive the belt system rather than using the belt friction on the pulley to carry the load.

ADVANTAGES OF CHAIN DRIVES

STURDIER

Chains are sturdier than belts. Not only can a chain of equal size to a belt carry a heavier load, but heat, sun, age, oil and grease do not affect its life.

COMPACT

The load carrying capacity is greater for a chain than a belt of equal size. This means that for an equal load, the chain drive can be much smaller than a belt drive.

NO SLIPPAGE

Belts depend upon friction caused by tension for their load carrying capacity. There are times when the stretching of a belt may cause it to slip. Belts may also have a tendency to creep, even if tension is properly applied. Chain drives operate by pulling against teeth on sprockets and, therefore, eliminate both slip and creep.

LONGER LIVED

Chains last longer than belts because they are not affected by elements and conditions which are detrimental to belts.

LOW SPEED

Low speed applications work better with chains because they pull against toothed sprockets rather than rely on friction for their power.

OPERATE AT HIGHER AND LOWER TEMPERATURE

Chains can operate in environments that would completely destroy belts.

DISADVANTAGES OF CHAIN DRIVES

NOISE

Chains are generally noisier than belts. Where several are used in an application, the noise level may be excessively high.

LUBRICATION

Chains require lubrication on a regular basis.

NO SLIPPAGE

Some applications require a slipping power transfer such as used in a belt drive clutch. Chain drives cannot supply this without special modification.

DIRT AND FOREIGN PARTICLES

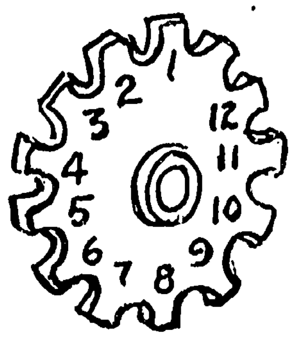
Chains accumulate and can be damaged by dirt and foreign materials.

MAINTENANCE

Requires regular maintenance.

PRINCIPLES OF CHAIN DRIVES

TEN TEETH



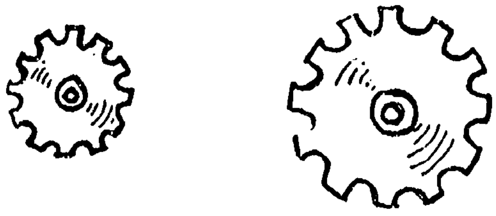
Generally, sprockets require in excess of twelve teeth to be large enough for power transfer without excessive wear on the chain.

CHAIN LINKS AND SPROCKET TEETH SHOULD CHANGE EACH REVOLUTION

If chains have an even number of links, sprockets should have an odd number of teeth. This permits the links to change teeth each revolution and not permit one link to wear on a specific tooth, regularly.

SMALL SPROCKETS CAUSE GREATER WEAR THAN LARGE

Because the small sprocket causes the chain to bend more than a large sprocket, the pins and joints will have greater wear.

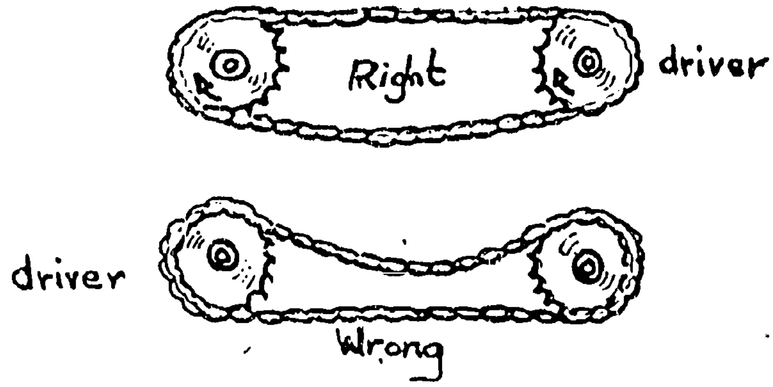


SHORT LINKS BEND LESS THAN LONG LINKS

The shorter the bend between links, the less the wear. Therefore, short links work better on small sprockets than long links.

HORIZONTAL DRIVES SHOULD HAVE SLACK ON THE BOTTOM

If slack is on the top of a horizontal drive, there is danger of the slack falling into the taut side of a chain, causing unnecessary wear.

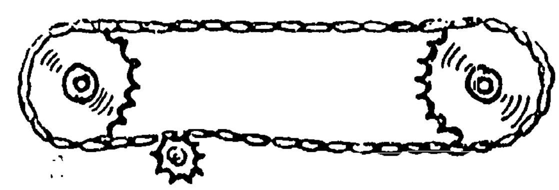


CHAIN SLACK MUST BE CHECKED REGULARLY

Chain slack can grow due to wear on the sprocket teeth and the chain links. Slack should be checked and adjusted regularly.

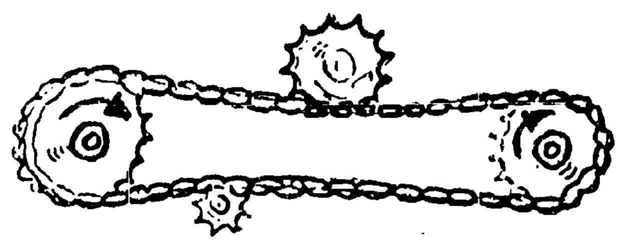
TIGHTENERS SHOULD BE INSTALLED ON SLACK SIDE

Chain tighteners are required to take up the slack of a chain drive, not to apply tension on the chain. For this reason, they are to be used on the slack side.



SPROCKET DIRECTION DEPENDS ON LOCATION

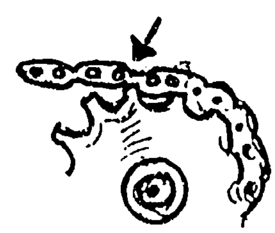
Sprockets located on the same side of the chain rotate the same direction. If they are located on the opposite side of the chain, they rotate in the opposite direction.



WORN SPROCKETS WILL CAUSE THE CHAIN TO CLIMB

As the sprocket wears, the distance between the teeth increases so that the chain links will no longer fit.

This wear will cause the link rollers to strike the sprocket tooth toward the point of the sprocket tooth, causing the chain to climb.



CHAIN DRIVE TYPES

There are a large number of chain drive types available today. Some of the types are listed below:

Common Use	Special Purpose
roller	bushing
rollerless	straight sidebar
silent	leaf
plain (detachable)	side bow
pintle	plate top
block	flexible
	saw

For the purpose of this lesson series, we will address the three most commonly used chain drive types.

ROLLER

Roller chains are used for moderate speed, heavy load applications. They may be used to run in either direction.

Some terms of interest are;

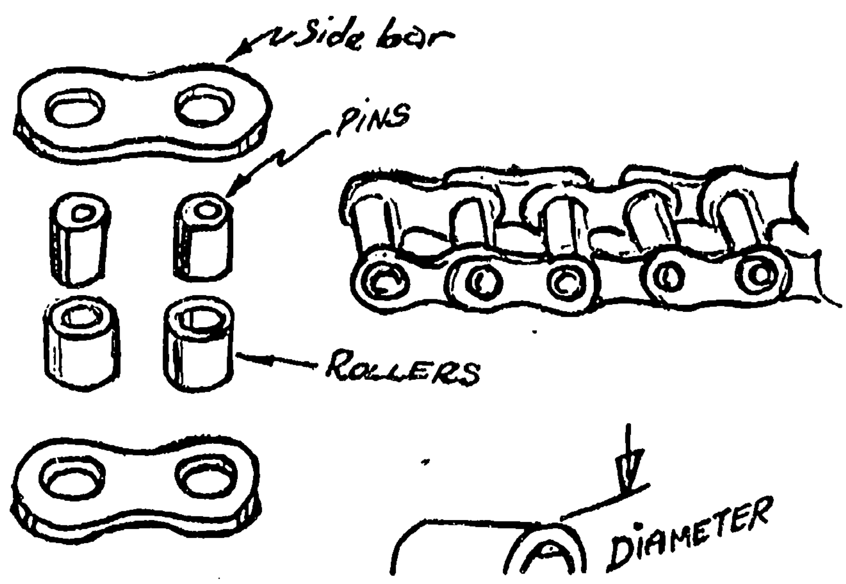
pitch - distance between roller centers

width - distance between side bars

single pitch - one roller per sprocket tooth

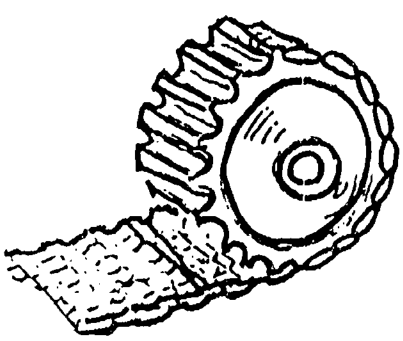
double pitch - one roller per two sprocket teeth

roller diameter - distance across the roller



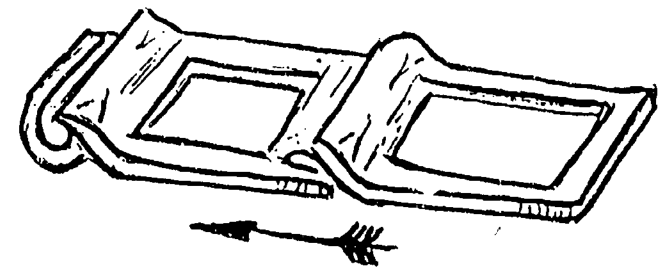
SILENT

Silent chains are used for high speed, quiet operation in either direction. Silent chains usually have teeth on one side that run in a gear-like sprocket.



PLAIN

Plain chains are generally used in low speed, heavy duty applications such as conveyors, etc. They run in only one direction with the link end first.



WORKSHEET

Pick another type of chain drive

Research it

Describe its use

Give its advantages and disadvantages.

SELF TEST

1. Chain drivers are used in some automobile engines for ____________________.
2. Two disadvantages the chain drives have in comparison to belt drives are ____________________.
3. When buckets are attached to the chain on a chain drive, the system is commonly referred to as a ____________________.
4. Chains are ____________________ than belts, of the same diameter.
5. 5 common types of chains are ____________, ____________, ____________, ____________, ____________.

SELF TEST ANSWERS

1. timing
2. noisy, need lubrication, and no slippage
3. conveyor
4. stronger
5. roller silent, plain (detachable), pintle, block, and rollerless

CHAIN DRIVE INTRODUCTION

1. transmit power
   timing
   conveying

2. sturdier
   compact
   do not slip
   long level
   low speed
   operate at high or low temperature

3. roller
   rollerless
   plain (detachable)
   silent
   pintle
   block

4. climb

5. cleaned, oiled, adjusted

6. temperatures

7. slip or stretch

8. There is no give to a chain so the chain cuts into anything caught in the chain drive.

POST—TEST

Package Number 102-A

Name ____________ Date ____________

CHAIN DRIVE INTRODUCTION

INSTRUCTIONS: Complete the following sentences.

1. 3 basic uses of chain drives are ____________, ____________, and ____________.

2. 5 advantages of chain drives are:

3. 5 types of chains in common use are:

4. Worn sprockets will cause the chain to ____________.

5. Name 3 maintenance services that are done to chains to keep them in good working condition.

6. Chains can be used where ____________ are very extreme.

7. Chain drives are dangerous to fingers because they do not ____________.

8. Hands and feet can be damaged severly if caught in a chain drive. Explain in your own words.

102-D CHAIN SLACK AND SPROCK ALIGNMENT

The purpose of this learning package is to teach proper tensioning of chain drives. These drives must have the correct amount of slack or they will wear rapidly.

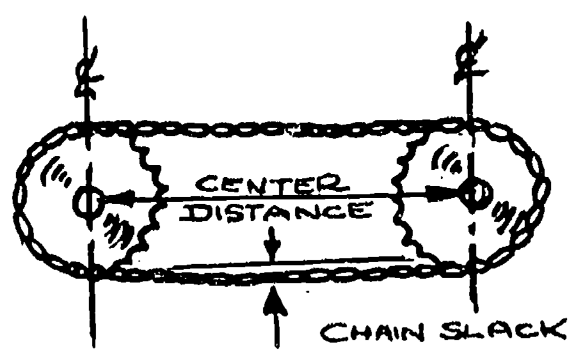
LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet	Contains the basic general information required for proper setting of chain slack.
Read: John Deere, Fundamentals of Service - Power Trains, page 10-10, Belts & Chains, page 40	Provides more information on the setting of chain slack.
Do: Set proper tension on the shop chain drive systems to your instructor's satisfaction.	Practical experience will provide best learning tool in setting chain slack
Do: Align the sprockets on a: - bicycle - motorcycle	

INFORMATION SHEET

CHAIN SLACK - GENERAL

Chains do not have initial tension as do belts. Chains do not have an initial stretch after installation. For best result, about 2% of center distance should be allowed when setting slack (see Adjusting Slack).



TOO TIGHT

When chains are adjusted without any slack, the chain will bind as it rides over the teeth on the sprocket. This binding action creates an artificially heavy load and causes rapid chain wear.

TOO LOOSE

If chains are adjusted with too much slack, they are likely to vibrate and whip. They might whip sufficiently to come off a sprocket. In any event, the added shock and wear action on the chain will greatly reduce its life.

CHAIN STRETCH

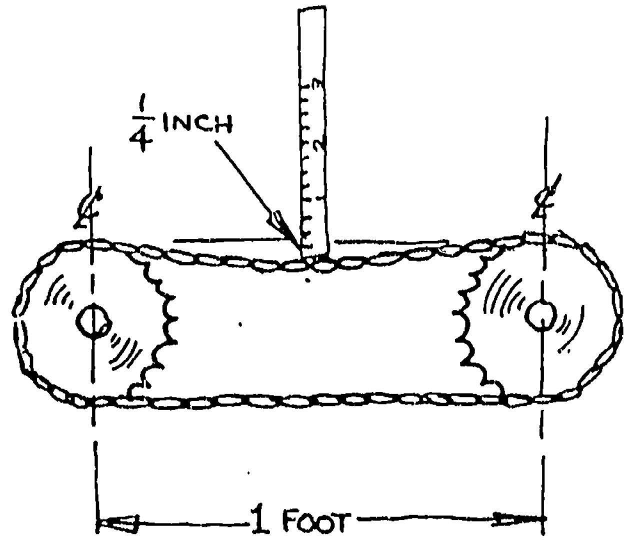
As stated above, chains do not have an initial stretch as belts do. However, wear on pins and the pin bushing surface will cause chains to stretch.

When they stretch to where they try to climb a sprocket, the chain is no longer useful.

ADJUSTING SLACK

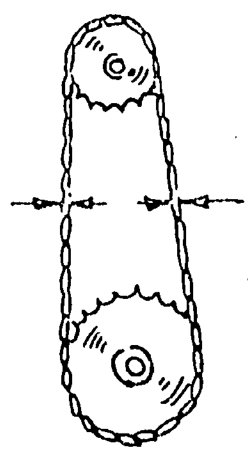
HORIZONTAL DRIVES

An easy rule of thumb to use in adjusting slack is to allow about 1/4" per foot between centers on horizontal drives. This may be measured by taking all the slack out of the system by laying a straight edge on the sprockets and pressing against the chain with a rule.



VERTICAL DRIVES

Vertical drives and those that run in a reverse direction or are subject to shock loadings require that both chain spans are almost tight. Too much slack increases the impact of shock loads.

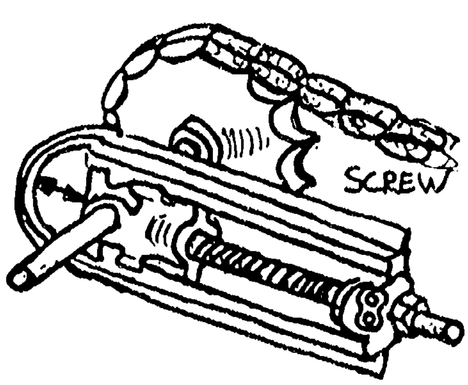


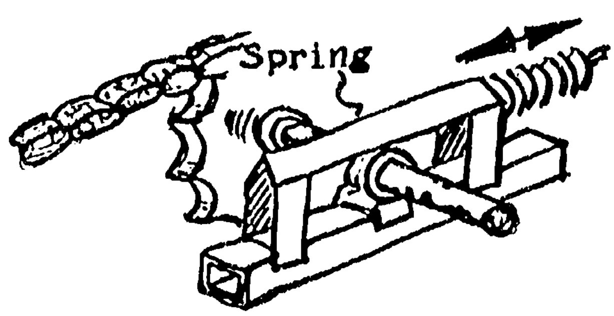
NOTE: Sprockets may be out of round. Be sure to turn the chain drive system and test slack in several positions.

CAUTION: Never adjust chains in motion.

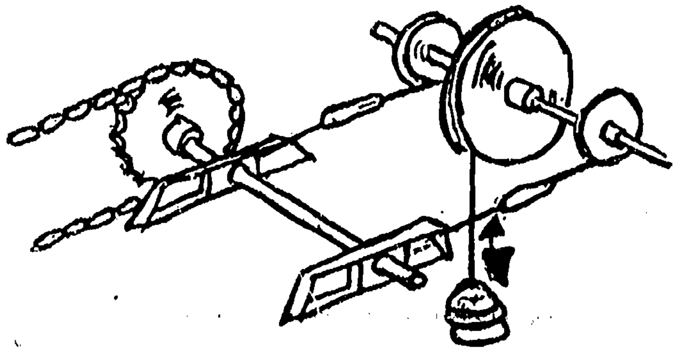
TIGHTENERS

Generally, there are five types of chain tighteners. Four types are means of moving shafts to adjust for the chain lengths. The fifth is a chain idler similar to a belt system idler.

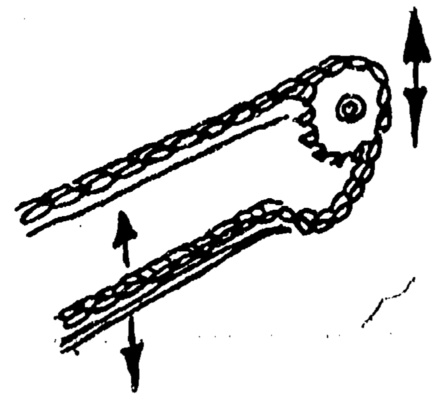




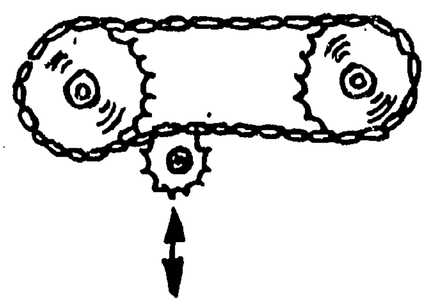
Gravity



Catenary



Chain Tighteners
(idler)



SAFETY

Lock out drive system to prevent inadvertent rotation of sprocket which could pinch or cut off fingers.

Chain drives are particularly hazardous devices when safety guards are removed for drive servicing.

Be sure to restrict loose clothing such as neckties, open sleeves, open jackets or coats, straps or clothing flaps that could get caught in the chains.

Keep fingers, feet and hair away from operating chain drives. The draft established by some configurations will pull loose clothing or hair into chains and sprockets. Obviously, this can be extremely dangerous.

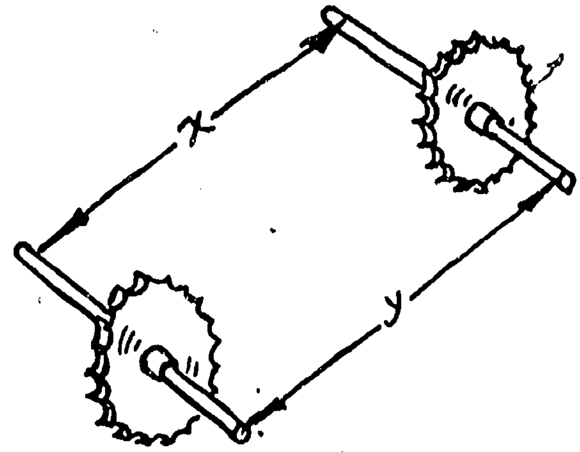
Extreme caution should be used around chain drives. Fingers and other appendages have been cut off when caught in a moving chain drive system. There is no stretch or slippage in chain drives as there is in belts. Keep safety guard on chain drives at all times unless it is being attended for servicing.

SPROCKET ALIGNMENT

A part of setting proper tension on a chain drive is to adjust the alignment. If the alignment of shafts and sprockets is not properly done, chains will have side wear and their life span will be greatly reduced.

ALIGN THE SHAFTS

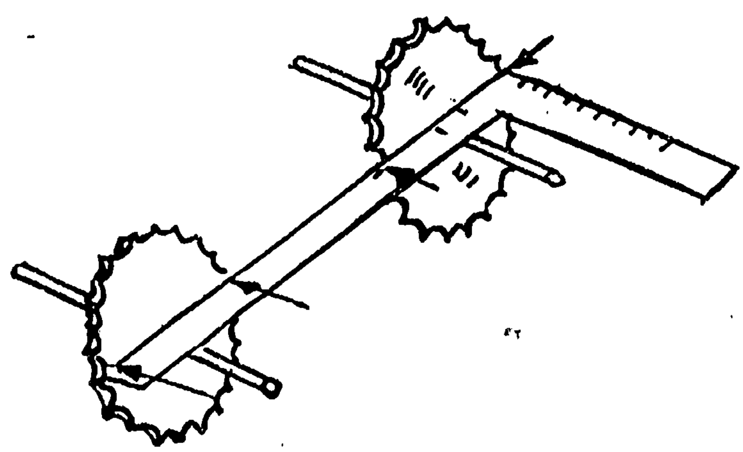
If shafts are not in line, the sprockets cannot be in line. Be sure the shafts are parallel to each other. In the illustration, distance x must be the same as distance y. If on a stationary machine, the shafts can be adjusted to a horizontally level position, side wear will be reduced.



ALIGN THE SPROCKETS

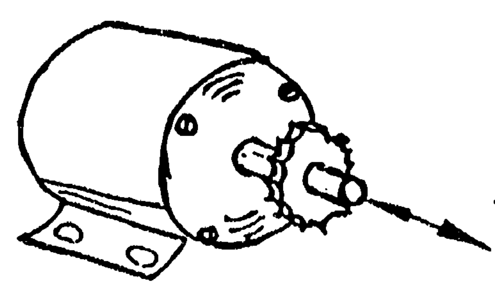
Sprockets should be checked for damage before attempting to align them. A pointer may be placed close to one side of the sprocket and rested on a separate support. As the sprocket shaft is slowly rotated by hand, the distance between the pointer and the edge of the sprocket should show very little change. If sprockets are damaged, they should be replaced.

Axial alignment of the sprockets means to place the sprockets in line with each other on parallel shafts. This may be done by placing a straight edge on the smooth side of the sprocket that is in the correct position and adjusting the other sprocket until it, too, touches the straight edge.



<u>NOTE</u>: Be sure the straight edge lies along the sprocket sides or touches them firmly at each edge.

If shafts have end play, find the normal position of the critical shaft (such as an electric motor) by noting the running position and marking on an identifying surface. Then, align to that position.



SELF-TEST

1. Bicycle chain drives are adjusted almost tight because of the ____________ load that is applied when braking.

2. Sprockets must be aligned to prevent ____________________ pressure on the chain.

3. 3 types of chain tighteners are:
________________________, ________________________, ________________________.

4. Shafts that hold sprockets should run _________________________ to each other.

5. Proper chain slack is approximately 1/4" per foot, measured between sprocket ________________________.

SELF-TEST KEY

1. shock
2. side
3. screw, gravity, spring, catenary, idler
4. parallel
5. centers

POST-TEST KEY

Package No. 102-D

CHAIN SLACK & SPROCKET ALIGNMENT

1. climb
2. whip
3. 1/4"
4. sprockets
5. motion

POST—TEST

Package Number 102-D

Name ____________ Date ____________

CHAIN SLACK AND SPROCKET ALIGNMENT

INSTRUCTIONS: Complete the following sentences.

1. Worn chain pins and bushings allow the chain to stretch which will cause the roller to ________________ the sprocket teeth,

2. Chains that have too much slack may ________________ and break, or come off its sprockets.

3. Proper chain slack is usually about ________ per foot, measured between sprocket centers.

4. A straight edge should be used to align the ____________________________.

5. Never adjust chains that are in ____________________________.

102-E TROUBLESHOOTING CHAIN DRIVES

The purpose of this learning package is to prepare the student to recognize various problems that cause improper chain wear and to know the causes of that wear.

When this learning package is successfully concluded the student, given eleven types of chain problems, will be able to:

1. Recognize possible causes and take corrective action.

LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet	A basic chart of failures and corrective action is provided.
Read: John Deere, <u>Fundamentals of Service, Power Trains - Belt & Chains</u>	Provides information on chain wear damage.
Do: Using the shop chain-board, identify the problem and probable cause of the damage on each chain segment.	To be able to determine if a chain is in operable condition.
Do: Check sprockets for chain wear	
Do: Check chain length of a worn chain in relation to a matching new chain.	

INFORMATION SHEET

<u>SAFETY</u>

Chain drives are particularly hazardous devices when safety guards are removed for drive servicing.

Be sure to restrict loose clothing such as neckties, open sleeves, open jackets or coats, straps, or clothing flaps that could get caught in the chains.

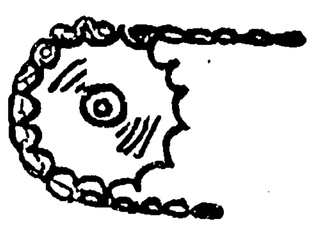
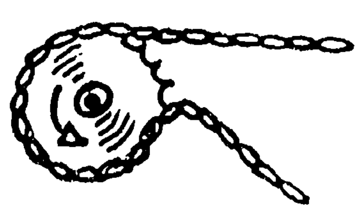
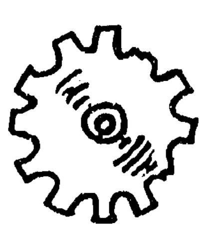
Keep fingers, feet and hair away from operating chain drives. The draft established by some configurations will pull loose clothing or hair into chains and sprockets. Obviously, this can be extremely dangerous.

Extreme caution should be used around chain drives. Fingers and other appendages have been cut off when caught in a moving chain drive system. There is no stretch or slippage in chain drives as there is in belts.

Keep safety guards on chain drives at all times unless it is being attended for servicing.

Lock out drive system to prevent inadvertent rotation of sprocket which could pinch or cut off fingers.

TROUBLE SHOOTING CHART

PROBLEM	POSSIBLE CAUSE	WHAT TO DO
1. TOO MUCH NOISE	- sprocket misaligned	- align
	- wrong slack	- adjust slack
	- wrong chain size	- check charts for correct chain
	- no lubrication	- lubricate & set a regular maintenance schedule
2. WEAR ON CHAIN SIDE BARS OR LINK PLATES & SIDES OF SPROCKET TEETH	- misalignment	- align
3. CHAIN CLIMBS SPROCKET	- chain or sprocket worn out	- replace defective parts
	- poor fitting of chains on sprockets	- check if sprocket is worn. If so, replace
	- excessive slack	- adjust slack
	- material build-up in teeth	- remove material & protect chain running area
	- lack of chain wrap	- revise drive to put more teeth in contact with chain. Add an idler.
4. CHAIN CLINGS TO SPROCKETS	- wrong chain	- replace with correct chain
	- worn sprocket pockets	- replace or reverse sprocket
	- heavy lubricant	- clean & use correct lubricant
	- material build-up	- remove material & protect chain running area
5. BROKEN SPROCKET TEETH	- obstructions in chain guards	- check chain & sprocket guard clearances
	- excessive shock loads	- reduce shock or install stronger sprockets
	- chain climbing sprocket teeth	- see 3.

PROBLEM	POSSIBLE CAUSE	WHAT TO DO
6. BROKEN PINS, BUSHINGS OR ROLLERS	- uneven chain wear	- use chain with higher limits
	- lack of lubrication	- lubricate & set lubrication schedule
	- heavy shock loading	- reduce shock loads or use heavier chain
	- material buildup	- remove material & protect chain running area
	- corrosion	- protect from corrosion
	- badly worn or wrong sprockets	- check for correct sprocket size & specifications
7. CHAIN WHIPS	- uneven chain wear	- replace chain
	- one or more stiff joints	- remove stiff joints - see 9
	- high pulsating loads	- reduce loads or use stronger chains
	- excess chain slack	- adjust slack
8. CHAIN SURGING (Conveyor belts)	- chain too tight or too loose	- adjust to proper slack
	- chain tighteners in wrong locations	- relocate tighteners
	- mechanical interference	- remove interference
	- sprockets too small	- replace with larger sprockets
	- chain track worn	- replace track
	- lack of lubrication	- lubricate & set regular lubrication schedule
	- stiff chain joints	- free up or replace links - see 9
	- concentrated loads	- even out loading
9. CHAIN STIFFENS	- lack of lubrication	- remove, clean & lubricate
	- corrosion	- protect chain from corrosion
	- excessive overloads	- reduce overloads or use heavier chain
	- material buildup	- protect chain with guard-clean & lubricate more often
	- peening of side plate edges	- check for chain interference & correct
	- misalignment	- check sprocket & shaft alignment

PROBLEMS	POSSIBLE CAUSE	WHAT TO DO
10. CHAIN FASTENERS FALL	- vibration	- check for cause of vibration & reduce it
	- obstructions strike cotter pins	- eliminate obstructions or change to another type of chain
	- cotter pins not correctly installed	- install cotter pins tightly & close to the chain side bar
11. CHAIN DRIVE RUNS TOO HOT	- operating faster than recommended	- check for maximum speed
	- lack of lubrication	- increase volume of oil
	- chain operating faster than oiler capacity	- use oil stream lubrication system
	- chain rubbing on obstruction	- remove obstructions to chain drive

DON'TS FOR ROLLER CHAINS

DON'T put a new link in a worn chain. The bite is different and shock will quickly destroy the chain.

DON'T install a new chain on badly worn sprockets. A few hours operation will do more damage than years of regular use.

DON'T run chains too tight or too loose. Either will cause rapid wear.

SELF TEST

Complete the sentences.

1. When replacing badly worn chain, also replace __________________ of the sprockets.
2. Don't put a ________________ link in a worn chain.
3. Too little ________________ will cause a chain to heat.
4. Broken sprocket teeth are usually caused by ____________ ____________ ______________.
5. Misalignment may cause the chain to ________________.
6. Chains clinging to sprockets is caused by too ________________ a lubricant.

ANSWERS TO SELF-TEST

1. both
2. new
3. lubrication
4. excessive shock load
5. stiffen
6. heavy

POST–TEST

Package Number 102-E

Name ____________ Date ____________

Obtain a chain and a sprocket from instructor.

1. Identify causes for chain wear

2. Identify sprockets, determine causes for wear.

102-C STORING, CLEANING AND LUBRICATING CHAINS

The purpose of this learning package is to teach basic storing, cleaning and lubrication practices for chains. It is intended for the person who will need this information in the maintenance of chains and chain drives. A chain drive maintenance person should understand the information contained in learning packages 102-A and 102-B.

Upon successful completion of this package, the student will be able to:

1. State and demonstrate the three proper steps to store used chains.

2. State the 5 steps to properly clean chains.

3. Describe the 4 reasons why lubricating chains is a requirement.

4. State the 6 rules of lubrication.

5. Discuss 3 methods of lubrication.

LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet	Basic lubrication techniques and practices are stated in the Information Sheet.
Read: **Fundamentals of Service Power Trains, Belts and Chains, John Deere**	Provides information in lubrication, cleaning & storing of chains.
Do: Remove, clean, lubricate, install, align and tension a bicycle chain.	Practical experience in these processes is more beneficial to learning than reading.
Do: Remove, clean, lubricate, install, align, and tension a motorcycle chain.	

INFORMATION SHEET

STORING CHAINS

NEW CHAINS

When new chains are received from the manufacturer that are not to be placed in use immediately, caution the receiver to inspect the purchase without disturbing the manufacturer's original lubrication. Do not remove the new chain's special break-in lubricant.

These chains should be stored in the manufacturer's box and wrapping paper. They should be stored indoors away from dirt, heat, and moisture.

If the lubrication has been removed (or partially removed), run the chain through the storing procedure for old chains.

OLD CHAINS

Old chains to be stored for a long period of time should be removed from the equipment, washed (as discussed in the next topic), and completely coated with heavy grease. They should then be wrapped in heavy, grease resistant paper and properly identified before storing indoors away from dirt, heat and moisture. All sprocket teeth on which the chain runs should also be cleaned with solvent and coated with heavy grease.

NOTE: Both old and new chains with a preservative should be cleaned and lubricated when they are put into service. (Don't foget to clean the sprockets if they have been grease-coated!)

CLEANING

When chains become dirty they must be cleaned or they will wear out rapidly. The cleaning process is generally as follows:

- Remove chain from equipment. This is necessary to permit a thorough washing of the chain.

- Immerse and wash in cleaning solvent to remove grit and abrasives.

NOTE: Cleaning solvent has a lower flash point than kerosene or diesel fuels and, therefore, is much safer to use in the shop.

- Dry chain by accepted methods.

- Hang chain over solvent bath to drain solvent. Solvents will dilute oil bath if this step is omitted.

- Soak cha'n in lubricating oil to permit oil to soak into the pins and bushings.

- Hand chain over oil bath to drain off the excess oil before re-installing on the equipment. If reinstalled without draining, oil will spray over the equipment causing a housekeeping problem. Hang in a dust free place.

LUBRICATING

WHY LUBRICATE

Even though it seems obvious, we must state that lubrication of chains must be done on a regularly scheduled basis. Proper lubrication will:

- Prevent rust.

- Prevent seizing of the pins.

- Reduce wear.

- Cushion shock loads.

LUBRICATION RULES

The following rules will help in developing lubricating procedures:

- Lubricate at regular intervals.

- Remove excess dirt before lubricating.

- Protect chains from contaminants where possible.

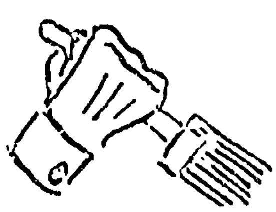
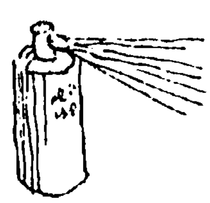
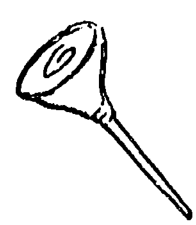
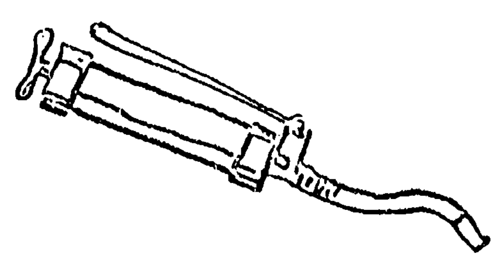
- Follow equipment manufacturer's instructions.

- Lubricant must penetrate the chain joints.

- The higher the speed - the greater the need for lubricants.

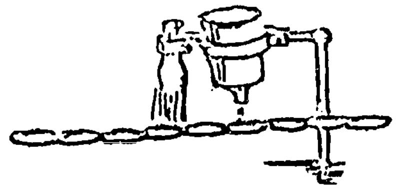
LUBRICATION METHODS

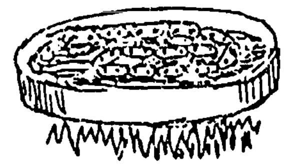
Manual: brush aerosol can oil can pressure gun

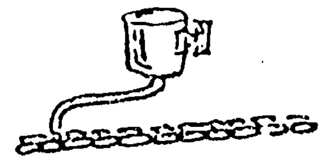





Manual lubrication should be scheduled at least every 8 hours of machine operation.

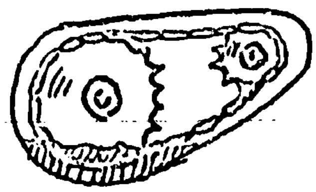
Semi-automatic: contact brush hot soak drip oiler

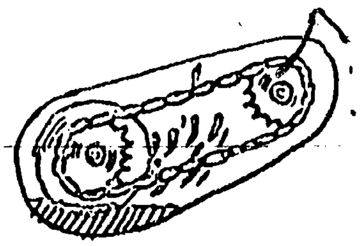


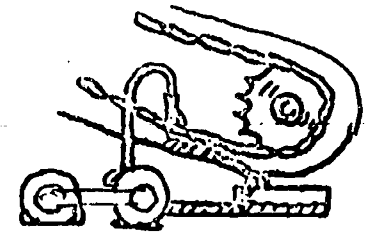




Automatic: oil bath oil disk oil stream







SAFETY

Chain drives are particularly hazardous devices when safety guards are removed for drive servicing.

Be sure to restrict loose clothing such as neckties, open sleeves, open jackets or coats, straps or clothing flaps that could get caught in the chains.

Keep fingers, feet and hair away from operating chain drives. The draft established by some configurations will pull loose clothing or hair into chains and sprockets. Obviously, this can be extremely dangerous.

Extreme caution should be used around chain drives. Fingers and other appendages have been cut off when caught in a moving chain drive system. There is in belts. Keep safety guard on chain drives at all times unless it is being attended for servicing.

NOTE: Use only cleaning solvents rather than kerosene or diesel fuel, if possible. The flash point in solvents is lower and, therefore, will not create as great a fire hazard.

CAUTION: Do not use gasoline.

Lock out drive system to prevent inadvertent rotation of sprocket which could pinch or cut off fingers.

SELF-TEST

1. Chains should be ____________ and ____________ periodically to add to their life.

2. Excessive cleaning solvents should be dried from chain before lubricant is applied because solvent will ______________ the lubricant.

3. Chains on bicycles can be oiled in place most easily with a ____________.

4. Used chains should _________________ and _______________ before wrapping, numbering and marking for storage.

SELF-TEST ANSWERS:
1. cleaned, oiled
2. thin
3. brush or spray
4. cleaned, greased

STORING, CLEANING, AND LUBRICATING CHAINS

1. lubrication

2. solvent

3. they create more heat

4. dirt

5. manual
   semi-automatic
   automatic

POST—TEST

Package Number 102-C

STORING, CLEANING, AND LUBRICATING CHAINS

Name ______________ Date ______________

INSTRUCTIONS: Complete the sentences.

1. In order to prevent the rollers and pins from seizing, proper ___________ should be applied regularly.

2. Chains should be removed and soaked in ____________________ to clean.

3. High speed chains require more lubrication than low speed chains. Explain.

4. Excess _______________ should always be removed from the chain with cleaning solvent before lubricating.

5. Name 3 kinds of lubrication systems.

After successful completion of this learning package, the student will be able to:

1. State the results of too much tension on chain drives.

2. State the effects of too loose tension on chain drives.

3. Describe and set proper tension
   - on horizontal drives
   - on vertical drives

4. Describe 5 types of tension setting devices.

5. Define axial alignment.

6. Align shafts and sprockets.

Industrial Mechanics

102-B CHAIN DRIVE IN USE

The purpose of this lesson is to provide information on drive arrangements and proper techniques for start-up and shut-down of a chain drive system.

CHAIN DRIVES

Coordinated by Jerry Ludlow for
OREGON BOARD OF EDUCATION
942 LANCASTER DRIVE NE
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DALE PARNELL
SUPERINTENDENT OF PUBLIC INSTRUCTION

OBJECTIVES

Upon successful completion of this learning package, the student will be able to:

1. State which configurations of chain drives are most commonly used and describe best design criteria.
2. Describe where chain slack should be located on various configurations.
3. State 3 general rules for start-up of chain drives.
4. Discuss 5 rules of operation of conveyor type systems.

NOTE: Chain Drive Introduction 102-A provides background material for this lesson.

DEVELOPED WITH THE COOPERATION OF . . . . . State of Oregon Department of Education
Lane Intermediate Education District
Lane Community College
Educational Coordinating Council

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CONTINUING EDUCATION PUBLICATIONS
EXTENSION HALL ANNEX, CORVALLIS, OREGON [illegible]

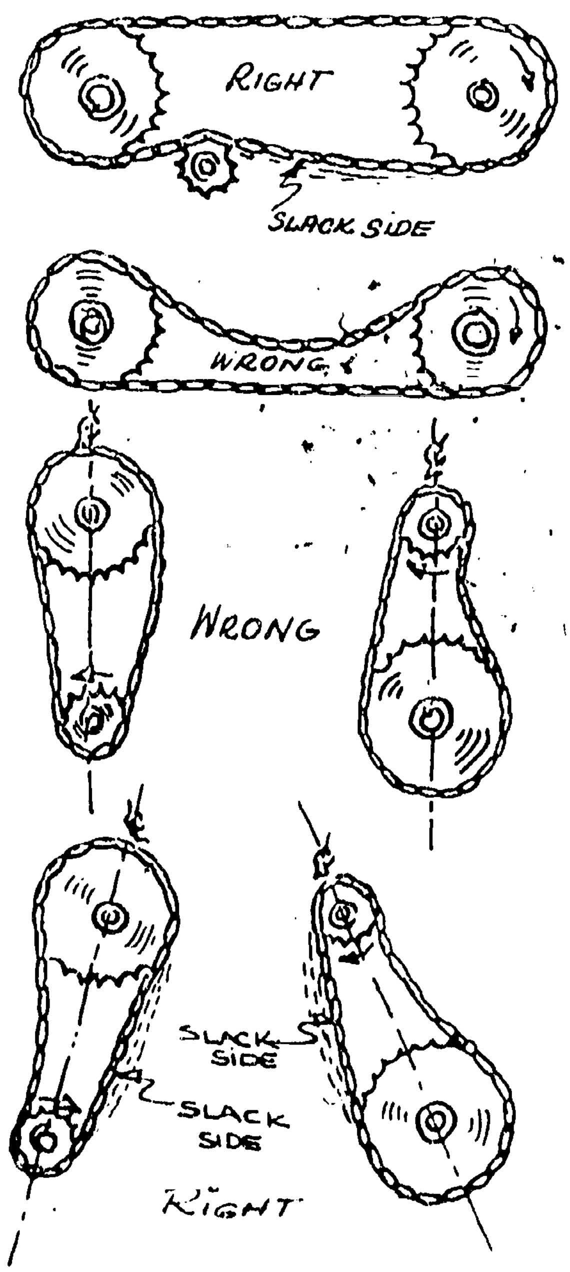
LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet	Provides basic information on arrangements and operating procedures.
Read: John Deere, Fundamentals of Service - Belts & Chains	

INFORMATION SHEET

CHAIN DRIVES IN USE

ARRANGEMENTS



Generally speaking, chain drives are used in an open configuration. Most chains are not flexible enough for other types of drive arrangements.

In horizontal arrangements, be sure the slack side of the chain is on the lower side.

Vertical arrangements of sprockets should be offset so the shafts are not directly above one another. When they are positioned in this manner, chain slack can cause unnecessary wear.

Offset shafts permit chain slack to be on the lower side.

NOTE: If it is not possible to keep slack on lower side because chain goes both directions, see learning package Chain Slack 102-D.

CHAIN DRIVE STARTING & STOPPING PROCEDURES

Generally:

- start the system unloaded.
- begin to run a chain drive system slowly to assure that all links are moving freely, proper lubrication is taking place, and no obstructions are hindering the operation.
- gradually bring up to operating speed and add load.

Conveyors, elevators and similar systems require more care than other systems:

- they should be unloaded before they are stopped. If they carry materials such as concrete that may harden, they should be properly cleaned immediately after shut down or on a regular basis.
- routine inspection of the entire system should be made to discover obstructions that could cause overloading to the system.
- start up before loading. This will prevent an unnecessary strain on all of the starting mechanisms. Many equipment manufacturers recommend hand cycling when possible.
- the system should be run occasionally during extended shut-down periods to prevent the chain links from freezing in position.
- when a chain drive is run under a condition of excessive heat, it should be run at normal temperatures for a period before shutting it down, if possible.

SAFETY

Chain drives are particularly hazardous devices when safety guards are removed for drive servicing.

Be sure to restrict loose clothing such as neckties, open sleeves, open jackets or coats, straps or clothing flaps that could get caught in the chains.

Keep fingers, feet and hair away from operating chain drives. The draft established by some configurations will pull loose clothing or hair into chains and sprockets. Obviously, this can be extremely dangerous.

Extreme caution should be used around chain drives.

Fingers and other appendages have been cut off when caught in a moving chain drive system. There is no stretch or slippage in chain drives as there is in belts.

Keep safety guards on chain drives at all times unless it is being attended for servicing.

Lock out drive system to prevent inadvertent rotation of sprocket which could pinch or cut off fingers.

SELF-TEST

1. A bicycle has an ______________________ chain drive.

2. In a horizontal chain drive, chain slack should be on the ______________ side.

3. Three general rules for starting chain drives are:

4. Give 5 rules for operating conveyor systems.

SELF-TEST KEY

1. open

2. lower

3. - start the system unloaded
   - turn slowly or hand cycle once
   - gradually bring up to speed and then load

4. - routine safety inspection
   - start up before loading
   - run systems occasionally in period of shutdown
   - allow system that is run through excessive heat to cool down before stopping.
   - unload before stopping.

POST-TEST KEY

Package No. 102-B

CHAIN DRIVES IN USE

1. offset
2. lower
3. unloaded
4. slow
5. chains are quick to pick up foreign materials and are hard to stop.

POST-TEST

Package Number 102-B

CHAIN DRIVES IN USE

Name ____________ Date ____________

INSTRUCTIONS: Complete the sentences.

1. Vertical arrangement of sprockets should be ______________________.

2. Chain slack should be on the ______________ side of a horizontal chain drive.

3. Generally, conveyors should be ______________ before they are stopped.

4. Chain drives should be run at a ______________ speed through their cycle before full power is applied.

5. Clothing, hair, hands, and feet must be kept away from chain drives. Explain in your own words.

INSTRUCTIONAL LEARNING SYSTEMS

10.5

MACHINE COMPONENTS -- BELTS AND PULLEYS

Goal:

The apprentice will be able to describe belts and pulleys.

Performance Indicators:

1. Describe advantages and disadvantages of belt and pulley systems.
2. Describe adjustment of belt drives.
3. Describe flat belt systems.
4. Describe specialized belt types.
5. Describe v-belt systems.
6. Describe pulley alignment.
7. Describe variable speed pulleys.
8. Describe belt clutches.

101-A BELT AND PULLEYS

Belt drive systems are very common for good reasons. Among their advantages are: low cost, simplicity, easy care, and quiet running. Their disadvantages are relatively minor.

Maintenance of belt drives involves setting the proper tension, aligning the pulleys, and replacing the belt when it shows excessive wear.

Pulleys must never be worked on when the machinery is running. They can be dangerous.

After completing this package:

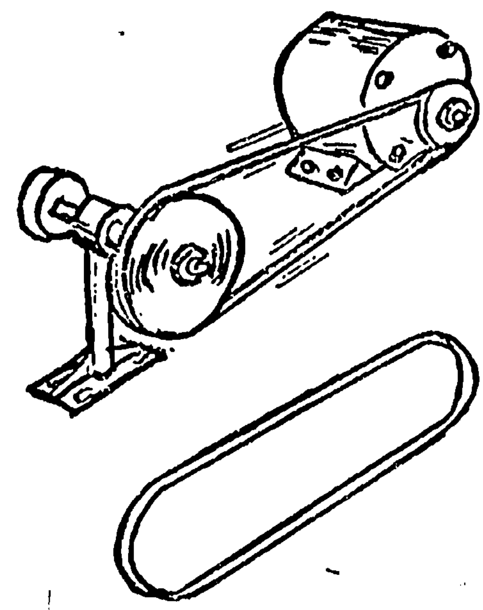
1. You will be able to list three common types of belts.
   A. Optional - Given samples of three common types of belts, you will be able to name them and tell where they might be used.
2. You will be able to state the advantages and disadvantages of belt drive systems.
3. Given a belt drive system, you will be able to identify its parts.
4. Given a belt drive, you will be able to:
   - safely change the belt
   - align the belt
   - adjust tension, keeping it so that the bearings are not damaged
   - point out what to look for in examining a belt for wear

LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
READ: Information Sheet #1	This provides definitions of the types of belt drives, the parts of a belt drive system, and the advantages and disadvantages of belt drives.
READ: Information Sheet #2	This tells you how to safely adjust belt drives.

INFORMATION SHEET #1

DEFINITIONS OF TERMS:

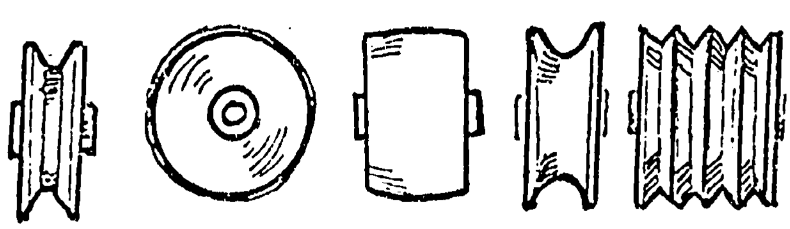


Belt Drive:
A belt drive is a drive system in which power is transmitted between two or more shafts by the friction between the belt and the pulleys on the shafts. The amount of friction available depends upon tension, speed, belt types, and amount of belt-pulley contact surface around the pulley.

Belt:
A belt is a closed, flexible loop of leather, rubber, fabric, rope wire, or a combination of any of these natural or synthetic materials.

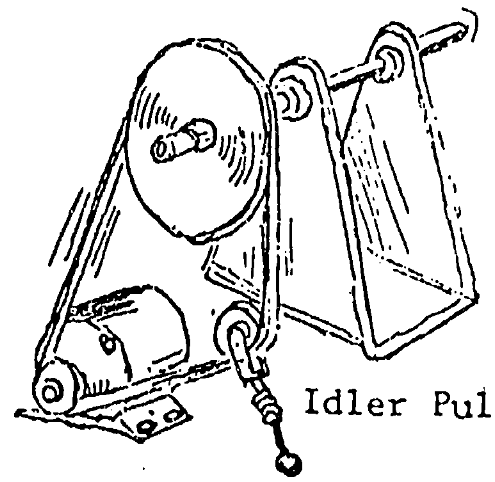
Belt Types:
There are three belt types in common use. These differ because of shape and function. They are (1) flat, (2) round, (3) V-belts. Ask your instructor for examples of systems using these belts.

Pulleys:
Pulleys are the wheels on which belts run. Their shape depends upon the type of belt for which they are to be used.



Idlers:

Idlers take up the slack in some belt drive systems to permit proper belt tension adjustments. Sometimes a piece of equipment acts as an idler. An example of this is an alternator on an automobile.



The Power and Slack Side of a Belt:

Fig. 1

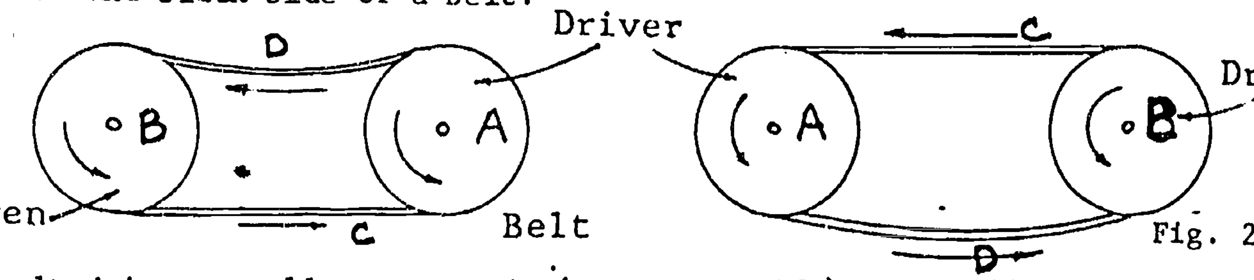


Fig. 2

As a belt drives a pulley, one side (the power side) will pull against the driven wheel and the other side will remain slack or loose. In both Figure 1 and 2, A is pulling B with C the power side of the system and d the slack side. The pulley arrangement in Figure 1 is better than that in Figure 2 because it is less likely to slip. This is because more of the belt is in contact with the pulleys in Figure 1.

ADVANTAGES OF BELT DRIVE SYSTEMS:

Easy To Design:

A belt system is usually the simplest way to transmit power from a motor or an engine to a work application. A single belt may drive several accessories.

Inexpensive:

A wide range of belt designs are available on the mass-produced market. Therefore, chances are tnat an existing belt will fit your new application. Belts are usually much less expensive than chains or gears that will do the same function. They require no lubrication.

Absorb Shock:

Belts are made of flexible materials. When gears and chains absorb shock, they are likely to break while belts do not.

LESS NOISE THAN CHAIN DRIVES:

Easy To Service:

Belt flexibility again permits them to be rolled or stretched during installation or removal (depending on the type of belt). They do not have to be taken apart for removal or lubricated, as do chains.

May Be Used As A Clutch:

Belts (other than toothed belts) may be used as a clutch because, by removing the tension on the belt, it will slip on the drive pulley.

DISADVANTAGES OF BELT DRIVE SYSTEMS:

Shorter Life Expectancy:
Belts are continuously flexing. This bending causes the material to weaken. Therefore, the life of a belt is shorter than for chains or gears.

Will Not Carry As Heavy A Load:
Belts work best under light load. Too much load will cause pre-mature wear or else the belt just will not have sufficient friction to turn the shaft.

Not Useable For Timing:
Generally, belts cannot be used for exact timing. Belts (other than toothed belts) will develop a small amount of creep in use and, therefore, cannot be relied upon to provide timing accuracy, even though care is used in the original setup.

INFORMATION SHEET #2

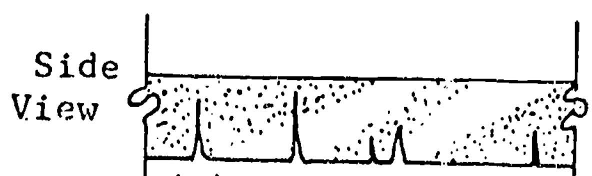
I. SAFETY

Belt drives are particulary hazardous devices when safety guards are removed for drive servicing. Be sure to restrict loose clothing such as neckties, open sleeves, open jackets or coats, straps, or clothing that flaps, as they could get caught in the belt. Keep fingers, feet and hair away from operating belt drives. The draft established by some configurations will pull loose clothing or hair into belts and pulleys. Obviously, this can be extremely dangerous. Fingers have been cut off by trying to put a belt onto a moving pulley. Keep safety guards on a belt drive at all times unless it is attended for servicing.

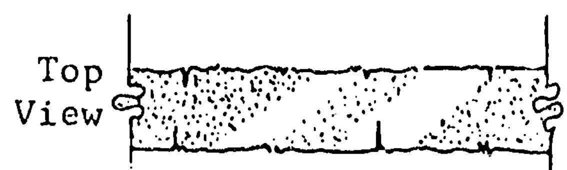
II. SIGNS THAT THE SYSTEM NEEDS ADJUSTMENT

A. The driven pulley appears to be slipping. This is a sign that the tension needs adjusting; in this case tightening.
B. If the drive motor overheats or the bearings sound noisy, the tension may be too great or the bearings may need lubrication.
C. When a black "dust" is found under or near a belt drive, the belt may be wearing too much. This dust is fine rubber particles worn off of the rubber belt. Check the tension and alignment of the belt.
D. As rubber belts get older, they begin to crack and fray. Always replace these belts. The actual life of a belt varies with the quality, operating temperature, and maintenance. Never allow grease or oil to get on a belt. This will make it slip and cause the rubber to crack.

Here is what to look for on a worn belt.



(1) Cracks Underneath

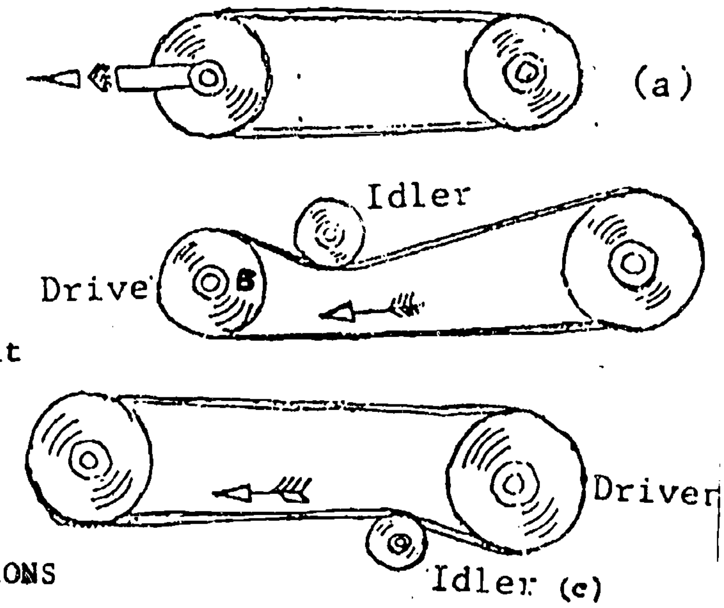


(2) Fraying or cracks on top

(3) Shiny sides may indicate slipping.

Belt tension is one of the elements that provides proper friction to the belt drive. Some belts are made of spring wire or flexible rubber and are stretched onto the pulleys. They set their own tension. Normally, belt tension is applied to belts that do not stretch in two ways.

The ideal system - one pulley in the system is moveable to adjust the tension. (a)



Adding an idler system:

Preferred - on the slack side of belt near drive pulley (b)

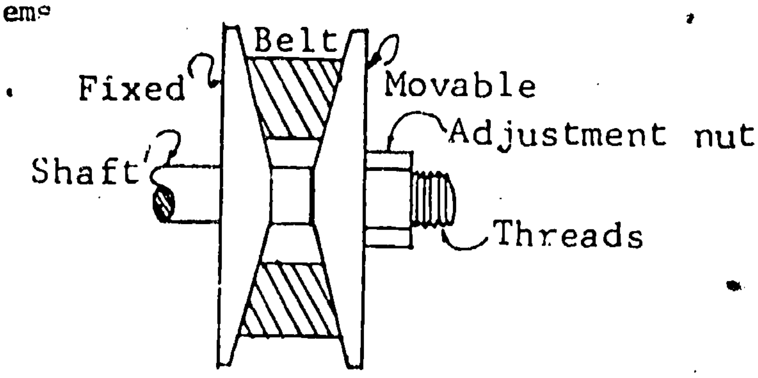
- on power (tight) side of belt near driven pulley (c)

Rule - Have enough tension to prevent slip and no more.

III. OTHER BELT AND PULLEY CONSIDERATIONS

A. Speed

While most pulley and belt systems have no speed adjustment, a few have special adjustable sheaves. These look like this:

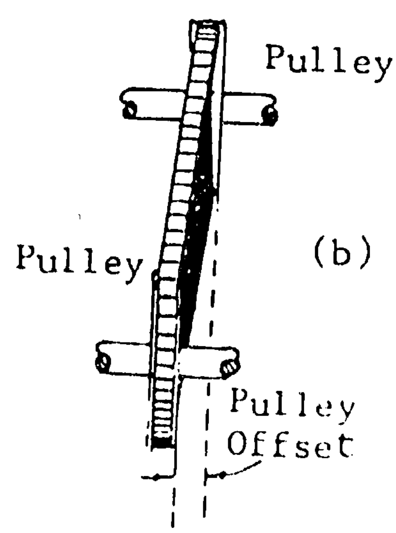


As the adjustment nut is turned in or out, the belt will run farther out or in thus controlling the effective size of the pulley hence the speed of the system. Some pulleys have this adjustment made automatically or by remote control.

B. Alignment

Belt pulleys must be properly aligned to permit belts to run correctly and give longest service. (a)

When belts are out of alignment, some will turn over, others will jump off the pulley, and still others will show excessive wear. (b)



C. Belt Removal and Replacement Procec

1. Remove belt tension

2. Remove loose belt

3. Check condition of all:

   a. idlers

   b. pulleys

   c. belts

   NOTE: See lesson on your type of belt for ir[illegible]ction

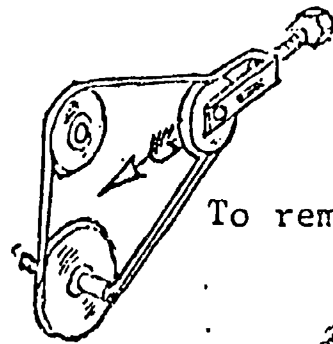
4. Remove pulley

5. Replace pulley

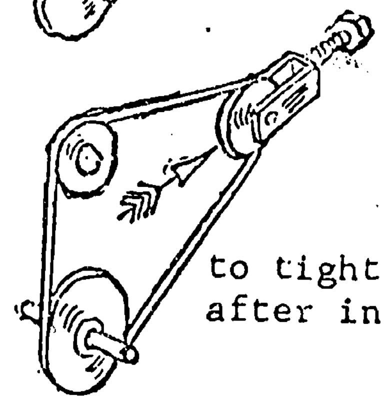
6. Install good belt

7. Set tension

   CAUTION: Although some circumstances may require rotating the belt drive during installation - NEVER START THE BELT DRIVE UNDER MOTOR POWER with fingers, hands, other parts of the body, or tools near belt and pulley.



To remove



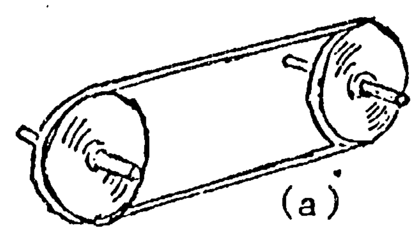
to tighten after installation.

D. How Pulley Sizes Affect the Load Carrying Capacity

One of the factors that determines the amount of friction between the belt and the pulley is the amount of the pulley arc that is in contact with the belt. (This is sometimes called "wrap.")

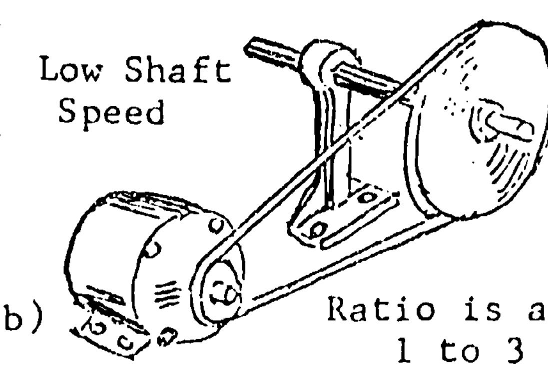
An ideal drive has pulleys of the same size driving shafts. (a)

However, pulley size is often one factor in determining the speed of the shafts when a high speed motor drives a low speed device or vice versa. (b)



(a)

Ratio is 1 to 1

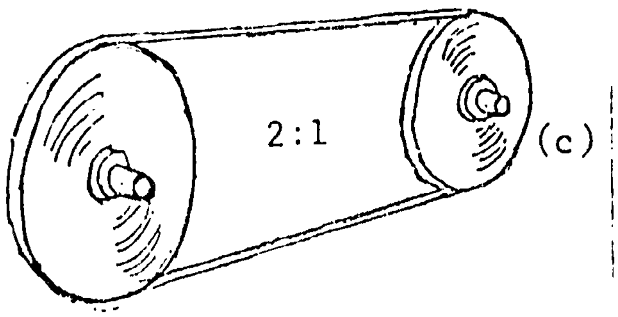


(b)

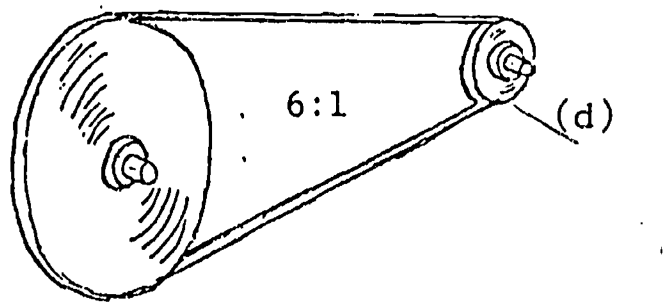
Ratio is about 1 to 3

For full amounts of power on a belt, the designer should not exceed a ratio of 3 to 1 in pulley circumference.

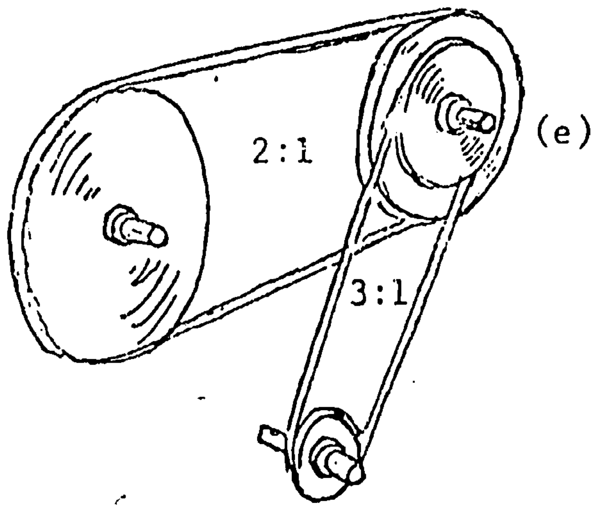
Good Drive (c)



Poor Drive for Heavy Loads (d)
(not enough wrap on the small pulley)



If a greater reduction is necessary, a secondary drive can reduce the drive. (e)



There is a practical minimum pulley diameter for load carrying. When the pulley diameter approaches 2" for a ½" V-belt for example, the great flexing necessary as the belt "rounds the corner" will cause rapid wear on the belt and cracking will show up relatively soon. Do not overload the belt system when using a small diameter pulley.

EXPERIMENT

With whatever belt drive system(s) available, perform the following:

1. Examine the belt for wear - does it need replacing?

2. Practice replacing the belt.

3. Practice adjusting the tension and aligning the pulleys.

SELF-TEST

Do the following:

1. What are the three most common types of belts?

2. What are the advantages and disadvantages of belt drives?

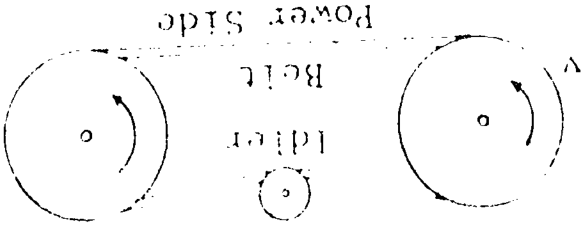
3. Sketch a belt drive system and identify the parts.

4. Give at least three warning signs that a belt system needs maintenance.

SELF-TEST ANSWERS

1. Flat, round, V-belt
2. Advantages
   - easy to design
   - low cost
   - absorbs shock
   - quiet
   - easy to service
   - may be used as a clutch

   Disadvantages
   - comparatively short life expectancy
   - limited load capacity
   - has some slippage so can't be used for timing
3.



4. Warning signs - black dust belt, slipping belt, noisy ings, hot motor, cracked or shiny belt

BELTS AND PULLEYS

1. flat, round, v-belts

2. a. easy to design
   b. inexpensive
   c. absorb shock

3. a. shorter life expectancy
   b. will not carry heavy load

4. a. do not remove safety guards
   b. do not wear loose clothing
   c. keep all body parts away from moving parts
   d. be careful when installing a belt, make sure all fingers are out of the way

5. a. drive pulley slipping
   b. motor overheats-loud bearings
   c. black dust under or near drive belt
   d. check for cracks and frays

POST—TEST Package Number 101-A

Name ________ Date ________

BELTS AND PULLEYS

1. List three common types of belts.

2. List 3 advantages of belt drive systems.

 a.
 b.
 c.

3. List 2 disadvantages of belt drive systems.

 a.
 b.

4. List 4 safety rules that must be adhered to when working with belt drives.

 a.
 b.
 c.
 d.

5. Name 4 signs that the system needs adjustment.

 a.
 b.
 c.
 d.

101-E PULLEY ALIGNMENT

Proper alignment is necessary to gain the most power and belt life in a belt drive system. A person working in belt drives should know the symptoms of misaligned belt drives and how to properly align a belt drive.

Upon successful completion of this learning package, the trainee will be able to:

1. State how belts react to misaligned or damaged pulleys.

2. State 6 belt failures caused by misalignment.

3. Describe the requirements of turned-drive components.

4. Align parallel shaft drives.

LEARNING ACTIVITIES

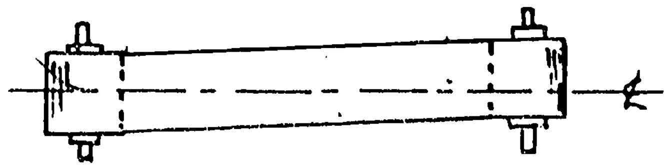
ACTIVITIES	PURPOSE
Read: Information Sheet	Provides basic information on belt drive alignment.
Read: John Deere, Fundamentals of Service - Belts & Chains, Power Trains	Provides added information on belt alignment.
Read: Material from any belt manufacturer on belt alignment.	Belt manufacturer's information will supplement learning package, VIP 101-A.
Do: Identify belt damage types on the shop belt-board.	Provides practical experience in recognizing the causes of certain types of belt damage.
Do: Align a sample belt drive that has been set up by your instructor	Provides experience in alignment.
Do: Make up and align a quarter-turned drive. Turn the drive in both directions.	Practical experience in understanding the principles of quarter-turned alignment.

INFORMATION SHEET

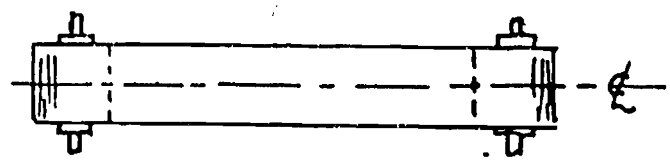
ALIGNMENT DEFINITION

Proper pulley alignment is achieved when pulley mountings are adjusted to bring the belt and pulley surfaces in line with one another. When belts and pulleys are aligned, there is little or no side pressure exerted by a pulley on the belt.

out of line



properly aligned

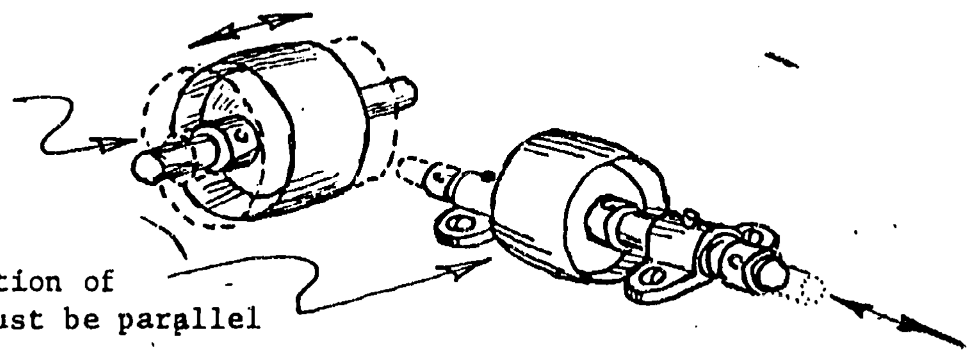


Poorly aligned drives will reduce the life of the belts. It is to the advantage of the user to obtain proper alignment when servicing belts.

Proper alignment is secured by adjusting the position of the pulleys on shafts

or

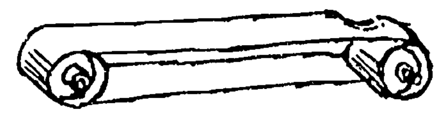
by adjusting the position of the shafts. Shafts must be parallel to each other.



Since each pulley mount varies, the particular drive must be studied for the proper technique to bring it into alignment.

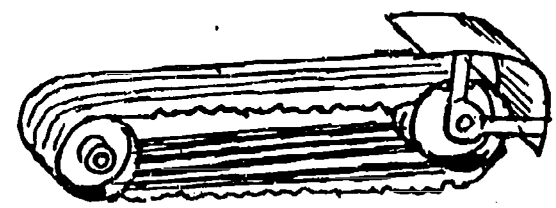
HOW BELTS REACT TO MISALIGNED PULLEYS

All belts have their life span reduced if used on misaligned drives. Belts react to misalignment, depending upon belt type, amount of tension, and condition around the pulley. Generally, however, failures fall into categories depending on belt types.



FLAT BELTS - RIBBED BELTS - TOOTHED BELTS

- Tend to run off the pulley.
- Tear on the edges if safety guards or other equipment is installed.



V-BELTS - LINKED BELTS

- Roll over in the groove.
- Cords stretch and/or break from pulling loads in "rolled over" positions.
- Belts come off system if continued to run in the above conditions.

BANDED BELTS

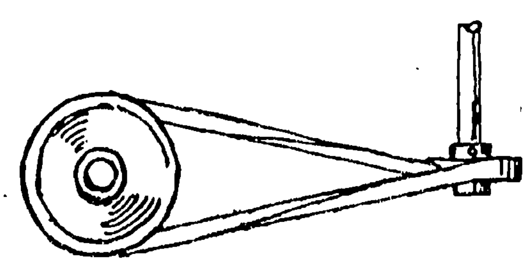
- One or two parts of the banded belt will work out of their pulley grooves. This will cause them to split and tear.

ROUND BELTS

- Fabric belts will fray if too much side pressure is exerted by misalignment. Rubber belts will begin to "sliver" or chip.

SPECIAL DRIVES

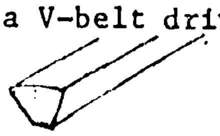
Sometimes, belt drives are chosen because of their ability to be used in an "out-of-alignment" position. These applications use quarter-turned drives or sometimes deliberate use of misaligned parallel drives is used.



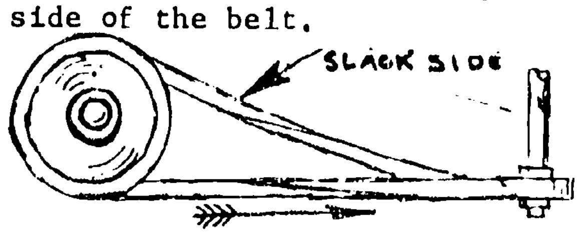
If this type of application is under design, do not expect to be able to obtain the full power from the belt drive used.

There are several requirements for using these types of systems, as follows:

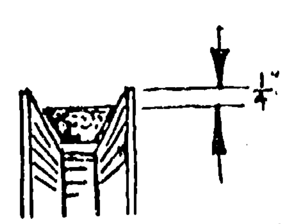
- Use a V-belt drive



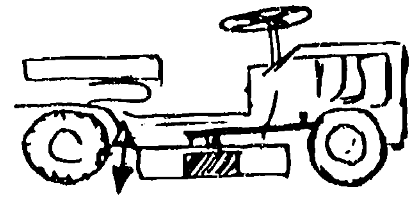
- Where possible, align the power side of the belt.



- Use a deep V-pulley. The belt will ride approximately ¼" from the top of the sheave groove.



Application of this type of usage is found in lawn equipment such as a riding lawn mower in the adjustment of the height of the blade in the mower. Deliberate use is made of pulleys where misalignment is present.



SAFETY

Belt drives are particularly hazardous devices when safety guards are removed for drive servicing.

Be sure to restrict loose clothing such as neckties, open sleeves, open jackets or coats, straps or clothing flaps that could get caught in the belt.

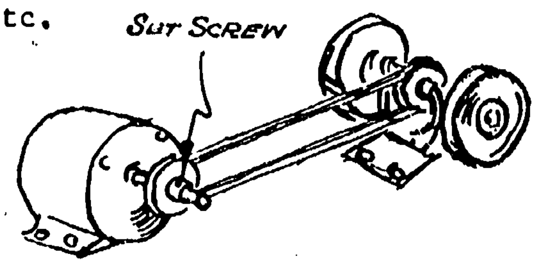
Keep fingers, feet and hair away from operating belt drives. The draft established by some configurations will pull loose clothing or hair into belts and pulleys. Obviously, this can be extremely dangerous.

Lock out drive system to prevent inadvertent rotation of pulley which could pinch or cut off fingers.

Keep safety guards on a belt drive at all times unless it is intended for servicing.

ALIGN BELT DRIVES (Parallel Shaft Applications)

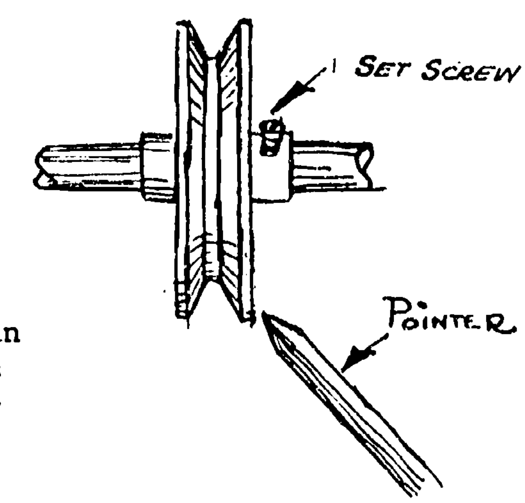
Home shop applications often have a motor on a shaft that drives one or more shop appliances such as, a grinder, a saw or etc. This type of drive usually has an adjustable pulley. The pulley's position on the shaft is established by the setting of a locknut.



Alignment procedures may vary in the other parallel shaft systems but the basic requirements remain the same.

1. First, be certain that both pulleys are true. This can be done by placing a pointer that is supported from the bench or floor near the edge of the groove and rotating the pulley. Distance between the pulley and the pointer should not change.

   If the distance varies, check if it can be corrected by adjusting the pulley's position on the shaft or if the pulley is bent. If it is bent, replace the pulley.



2. With belt removed, place straight edge against side of one of the pulleys so it touches the pulley in two places. (a & b)

NOTE: If second pulley keeps straightedge from touching pulley in two places, loosen lock-nut and move it out of the way.

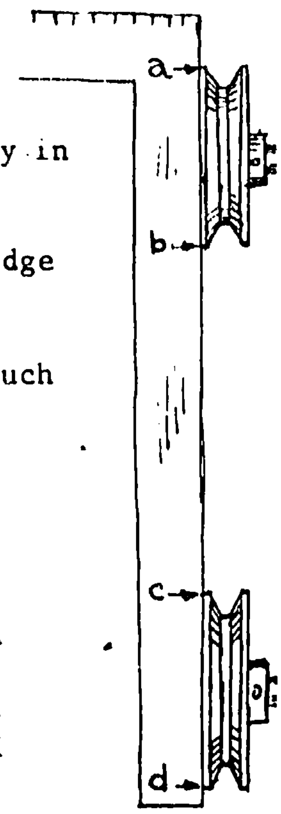
3. Adjust second pulley so that it will also touch straight edge in two places (c & d). Tighten adjusting lock-nuts.

4. Turn each pulley and be certain the pulleys continue to touch the straight edge at all times.

5. Adjust for maximum effectiveness for all positions.

6. Install belt.

NOTE: This procedure works for simple alignment of same width pulleys on parallel shafts. If shafts have end play, find the normal position of the critical shaft (such as an electrical motor) by noting the running position and marking on an identifying surface. Then, align to that position.



WORKSHEET

Research special alignment techniques for alignment of turned drives or parallel drives with multiple types of pulleys.

Example:
Given an automobile cooling system fan drive, check alignment of the water pump pulley to the power pulley on the crank shaft. These are press-fit to the shaft and are sometimes misaligned by collision accidents (or parts substitutions). Be sure the belt drive is in alignment.

SELF-TEST

1. Proper alignment of pulleys will add ______________ to a belt.

2. Give 6 types of belt damage caused by alignment problem.

3. Quarter-turn drives require ________________ grooved V-pulleys.

4. The ___________ side of the belt is aligned on a quarter turn drive.

5. Pulleys should be checked to see if they are ____________ before aligning.

SELF TEST ANSWERS:
1. life
2. edge tear, uneven stretch, rolling over, cord breakage, belt splitting, cover-fraying
3. deep
4. power
5. bent

POST-TEST KEY Package No. 101-E

PULLEY ALIGNMENT

1. shorten

2. flat

3. deep

4. edge tear
   uneven stretch
   rolling over
   cord breakage
   belt splitting
   cover fraying

5. replaced

6. straight edge

7. V- deep

POST–TEST

Package Number 101-E

PULLEY ALIGNMENT

INSTRUCTIONS: Complete the following sentences.

1. Misaligned pulleys will ______________________ belt life.

2. ____________________ belt drives requires proper alignment to keep belt on the pulleys.

3. Turned drives require ______________________ grooved pulleys.

4. List 6 belt failures caused by poorly aligned pulleys:

5. Bent pulleys should be ____________________ before trying to align any belt drive.

6. Pulleys are best aligned with a __________________________.

7. Quarter turned drives require _______________ belts and _________________ grooved pulleys.

Name ______________________ Date ________

Industrial Mechanics

101-B FLAT BELTS

This material describes flat belts, their uses, measuring requirements, maintenance of drive arrangements and inspection for damage. It is designed to assist the person with a need to use or service flat belt drives.

OBJECTIVES

Upon successful completion of this learning package, you will be able to:

1. State why applications use flat belts.
2. Give three uses of a flat belt drive.
3. Describe the working parts of a flat belt drive.

Given a flat belt drive, you will be able to:

1. Align the pulleys and recognize the effects of misalignment.
2. Measure for proper tension to the belt drive.
3. Apply proper tension to the belt drive.
4. Recognize damaged belts and the cause of such damage.
5. Recognize three pulley configurations of flat belt systems.

DEVELOPED WITH THE
COOPERATION OF ...... State of Oregon Department of Education
Lane Intermediate Education District
Lane Community College
Educational Coordinating Council

PROJECT DIRECTOR: Dick Earl

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John Anderson

[illegible] White

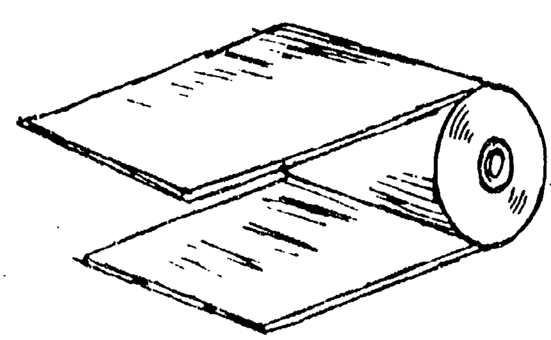
LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet	Provides the basics of measuring, adjusting and service.
Read: John Deere, Fundamentals of Service Manual -Power Trains -General	Provides belt drive background.
Do: Assemble a flat belt drive Suggested belt systems: -electric typewriter -band saw -flat belt driven machine -shop equipment (K.O. Lee grinders) -collators -printing machines (blue print) -Xerox machines -belt grinders	This activity will familiarize the student with drive components, tensioning, measuring, and belt splicing.

INFORMATION SHEET

FLAT BELTS

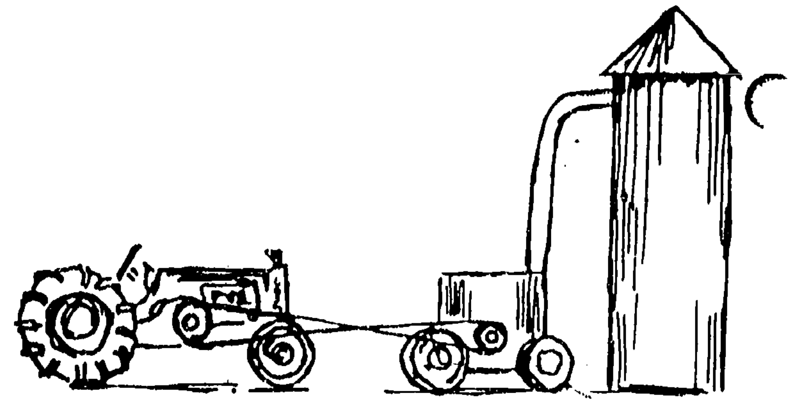
Flat belts have generally been used in applications that carry a heavy load. A flat belt can also be used on small pulleys for high speed utilization. They may be modified for specialized uses. Usage as heavy duty power drives in sawmills, machine shops, and factories are becoming less common because many units have their own power systems.



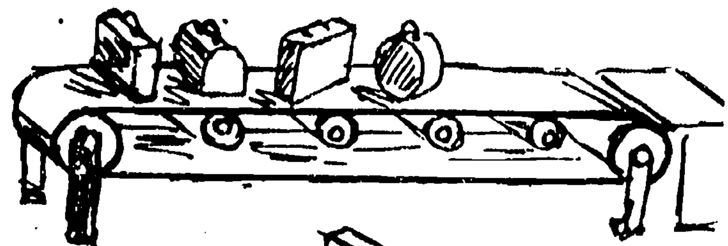
APPLICATIONS

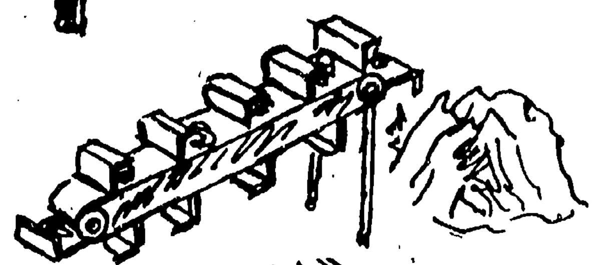
In current usage, flat belts serve:

- in driving stationary farm equipment. Hay choppers and silo filling equipment are often driven by the power take-off unit of the tractor using a flat belt.

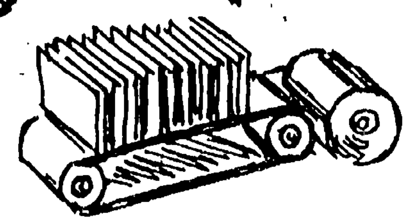


- as a conveyor belt. Conveyor belts are used to transport freight, baggage, or people at airline terminals; gravel and ore; and materials in factory or office. When modified by attaching buckets or other equipment, they convey loose materials such as grain. Even though they are modified, they are still flat belts.



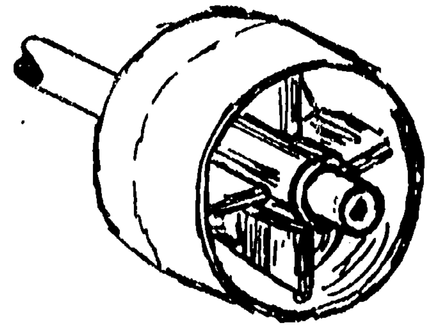


- as guides. Primarily, these will be found in handling paper in printing press applications and in stacking paper in folding machines, etc.

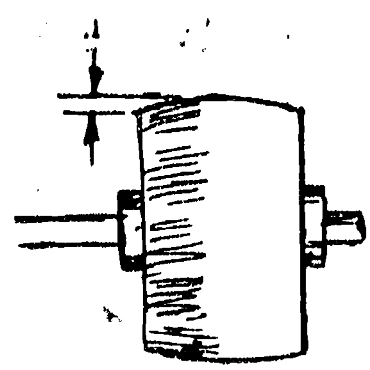


COMPONENTS

A flat belt drive system consists of a pulley that is equal in width to the belt (or slightly wider) constructed of cast iron, steel, wood, plastic or aluminum.



Its center is slightly crowned with the greater radius at the center of the pulley.



Flat belts will tend to creep toward the highest level of the pulley so the pulley's shape tends to keep the belt centered.

NOTE: Specialized applications may use different pulleys and configurations.

SAFETY

Belt drives are particularly hazardous devices when safety guards are removed for drive servicing.

Be sure to restrict loose clothing such as neckties, open sleeves, open jackets or coats, straps or clothing flaps that could get caught in the belt.

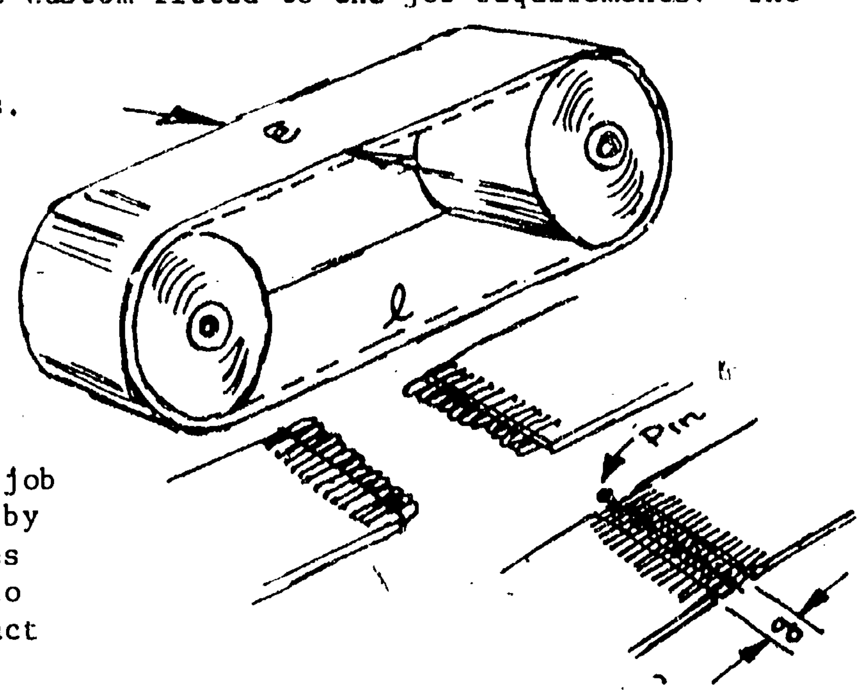
Keep fingers, feet and hair away from operating belt drives. The draft established by some configurations will pull loose clothing or hair into belts and pulleys. Obviously, this can be extremely dangerous.

Lock out drive system to prevent inadvertent rotation of pulley which could pinch or cut off fingers.

Keep safety guards on a belt drive at all times unless someone attends it for servicing.

MEASURING FLAT BELTS

Flat belts are generally made from flat strips of leather, rubber, flat fabric or flat cord. They can be custom fitted to the job requirements. The required length is determined by measuring around the path of the belt at the center of the pulleys. Be sure that adjustable pulleys are set near the minumum length to allow for the stretching of belt material. Remember the length (l) is the inside dimension (id) of your belt. Width (w) is equal to, or slightly less than, the narrowest pulley.



Leather belts constructed at the job site are usually joined together by inserting wire stitches, sometimes referred to as alligator clips, to each end and inserting a pin to act as a hinge.

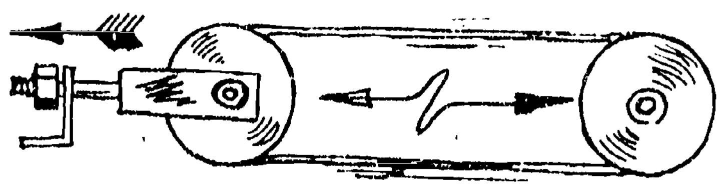
NOTE: Be sure to allow for the linking in your measuring or the gap (g) will add to the length of the belt.

NOTE: Some belts are fastened with a scarf joint (glue) process. The measured distance for overlap must be added to the loop requirements.

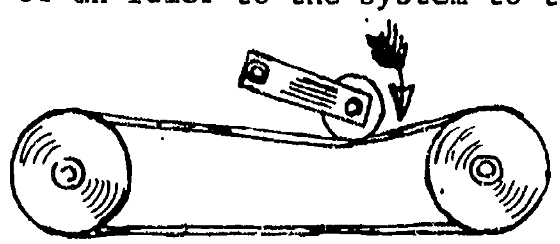
TENSIONING BELTS

Flat belts are tensioned in one or more of two ways:

- adjustment of the distance between the pulleys

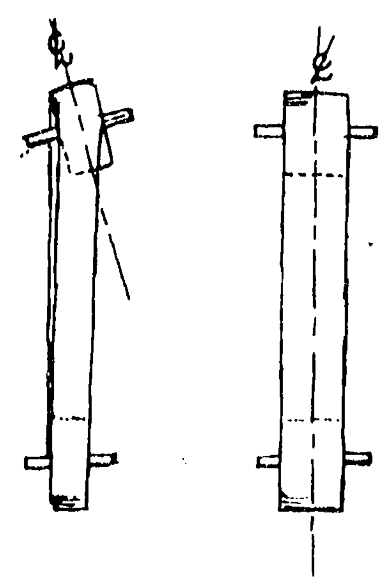


- addition of an idler to the system to take out slack



Tension must be sufficient to carry the load without slipping. In pounds, the flat belt normally requires more tension than a V-belt for a similar load. Excessive tension may cause premature belt failure, too much belt stretch and overloaded bearings.

ALIGNMENT



Pulleys must be in proper alignment for the flat belt drive to function properly.

An out-of-line system will cause the belt to leave the pulley. A properly aligned system will center the belt on the pulleys.

LUBRICATION OF PULLEYS

For lubrication information that applies to the appropriate system, see VIP Division Codes: 104 Bearings, and 108 Lubrication.

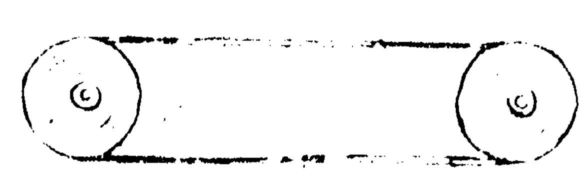
For most accurate lubricating information, see the equipment manufacturer's information on lubricating the device on which you are working.

DRIVE ARRANGEMENTS

Flat belts may be used on the following configurations:

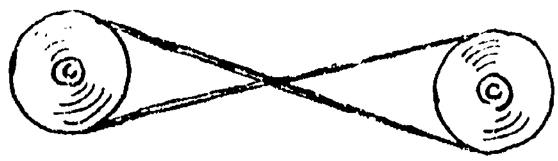
open -

To transmit power to another drive rotating in same direction



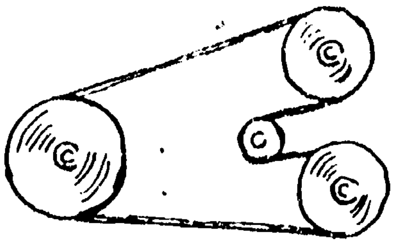
crossed -

to transmit power to another drive rotating in opposite direction



serpentine -

multiple power transfer



TROUBLE SHOOTING FLAT BELT DRIVE SYSTEMS

Because flat belt drives are used in high speed or heavy-duty applications, the components are much more durable.

PULLEYS:

Alignment of pulleys may be affected by defective bearings and shafts. Routine inspection may show damage to these parts and when the trouble is detected, they should be replaced. Se VIP Division Codes 103 and 104 for further information.

Pulley damage is very rare in flat belt systems. However, they should be checked during servicing for cracks and external damage. If such damage will affect the system, the pulley should be replaced.

BELTS:

Flat belts may tear if operated on poorly aligned pulleys as it will try to run off the pulley, but cannot because of brackets, etc. Burns and shiny spots may show if tension is too loose and the drive pulley is allowed to skid.

If it is fabric covered, the fabric will wear through exposing the sub-layers. If a leather or other solid material belt wears, damage will become noticeable because the belt will stretch unevenly and will cause the belt to warp. If this occurs, the belt will "wander" on the pulley. Leather belt stitching may also "pull out" where they are joined. In any of these situations, the belt should be repaired or replaced.

WORKSHEET #1

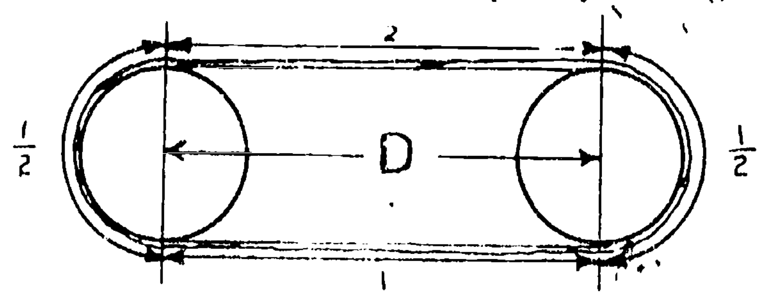
DRESSING FLAT BELTS

Some flat belts, usually leather or canvas, may be dressed with a commercially available belt dressing. This tacky material will increase friction between the belt and the pulley. The dressing will also prolong the belt life by adding a binder material to the belt.

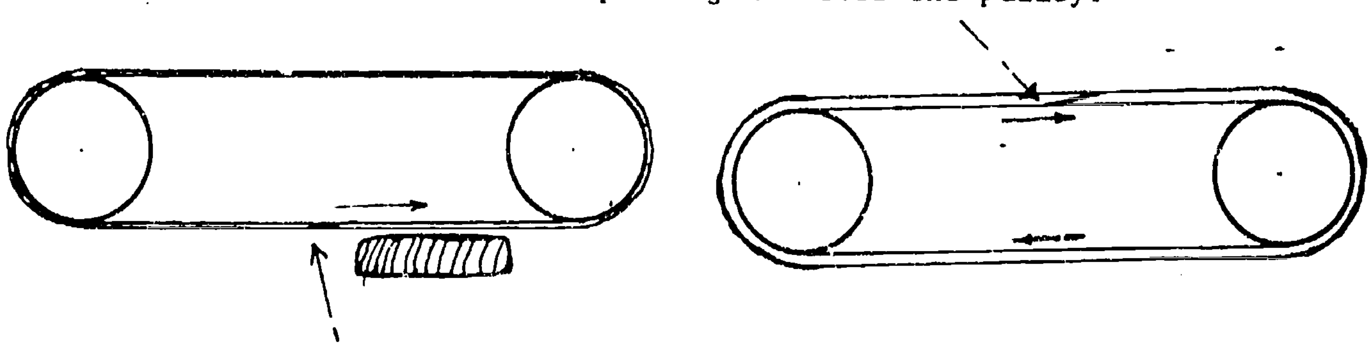
NOTE: Use dressing sparingly to avoid messy housekeeping problems, but be sure to use enough to coat the inner surface of the belt.

MEASURE A FLAT BELT DRIVE FOR A NEW BELT INSTALLATION

Formula: 2 X D + 1/2 circumference of each pulley = length of the belt.



Splice direction: Flat belts must be spliced to permit the toe of the scarf to follow the splice joint over the pulley.



Note: Sanding belts must be mounted in the opposite direction to keep the toe of the scarf joint from catching on the material being sanded.

SELF-TEST

INSTRUCTIONS: Complete the following questions by supplying the correct answers.

1. Flat belt pulleys are usually more (durable - fragile) than other drive systems. Explain your answer.

2. Name three things from which flat belts are made.

3. A flat belt measurement should be taken around the (edge - center) of the pulleys with the tension adjusted to (minimum - maximum) length.

4. Name two types of tension adjusting devices.

5. Flat belts generally require (more - less) tension than other belts.

6. Describe 5 types of common fatigue damage to flat belts.

SELF-TEST KEY

1. durable
2. leather, rubber, fabric, cord
3. center, minimum
4. adjustable or hinged pulleys - idlers
5. more
6. tears, burns, worn fabric, stretched belts, torn stitches or joint

1. drive stationary equipment
   drive conveyor assemblies
   drive guides

2. center slightly crowned with the greater radius at the center of the pulley

3. add an idler pulley
   adjust distance between pulleys

4. inside

5. leave

6. open and crossed

7. instructor's approval

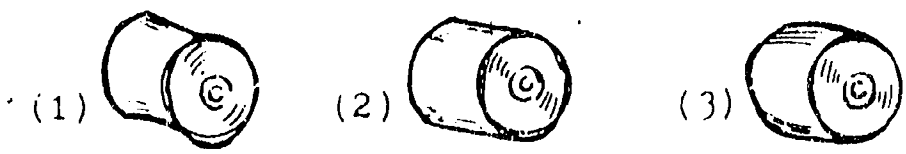
POST—TEST

Package Number 101-B

FLAT BELTS

1. Name three types of uses for flat belts.

2. Which is the correct shape for a flat belt pulley?



3. Name two ways to adjust the tension of a flat belt drive.

4. The length of a flat belt is measured as its inside or outside dimension?

5. If the pulleys are not in alignment, the belt will ________________ the pulley.

6. Name two configurations of flat belts.

7. The best source for lubrication information for flat belt drive pulley systems is the equipment manufacturer. Why? Explain in your own words.

Name ______________ Date ______________

Industrial Mechanics

101-C SPECIALIZED BELTS

Many devices have been created that require unusual characteristics in belt drives. This lesson will explain some belts of an unusual design, why that design was chosen, how to measure these belts, etc.

OBJECTIVES

Upon successful completion of this learning package, the student will be able to:

1. Describe five belt types.
2. State the uses of five belt types.
3. Adjust tension.
4. Describe five different belt configurations.
5. Recognize specific belt and pulley defects.
6. Change belts on a given specialized belt drive.
7. Measure a belt.

DEVELOPED WITH THE COOPERATION OF . . . . State of Oregon Department of Education
Lane Intermediate Education District
Lane Community College
Educational Coordinating Council

PROJECT DIRECTOR: Dick Earl

WRITERS:

Frank Bishop

Steve Brous

John Anderson

Warren White

LEARNING ACTIVITIES

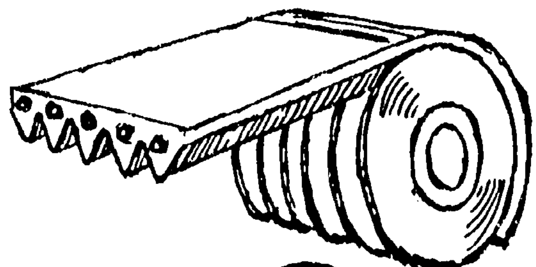
ACTIVITIES	PURPOSE
Read: Instruction Sheet	Provides information on belt types, pulleys, & trouble shooting.
Read: John Deere Fundamentals of Service Manual - Belts & Chains	Provides information on belt types, pulleys, & trouble shooting.
Read: Belt introductory pages in the NAPA catalog.	Provides information on belt types, pulleys, drive design information, etc.
Read: MOTOR MANUAL 1971 or later NOTE: Pinto or Vega engine section	Provides information on toothed belts for valve timing.
Do: Change a specialized belt that has fatigue damage on one or more of the following: - movie projector - blower - typewriter - Pinto, Vega or other with a specialized belt Describe damage and cause.	Provides practical experience in trouble shooting belt drive problems.

INFORMATION SHEET

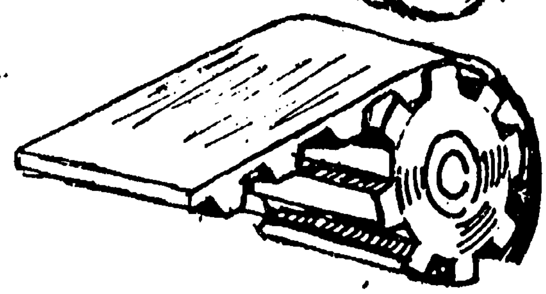
SPECIALIZED BELTS

There are many styles of specialized belts, even combinations of belt styles, but the most common are as follows:

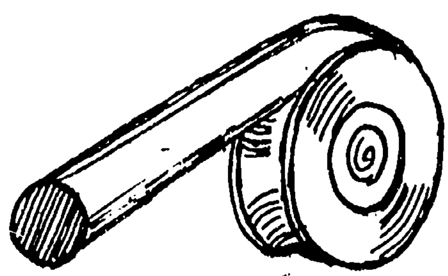
Ribbed belts



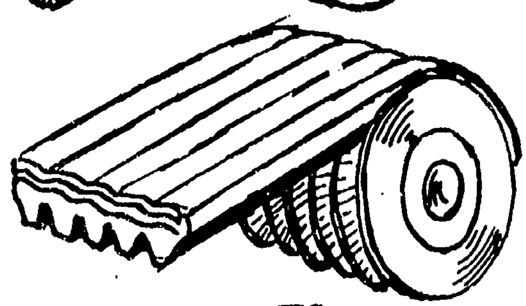
Toothed belts



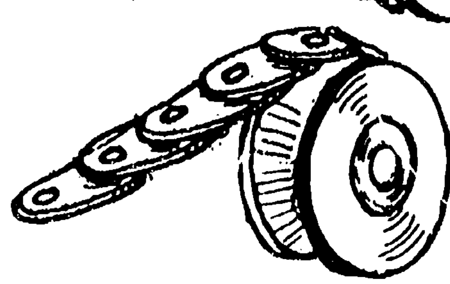
Round belts



Banded belts



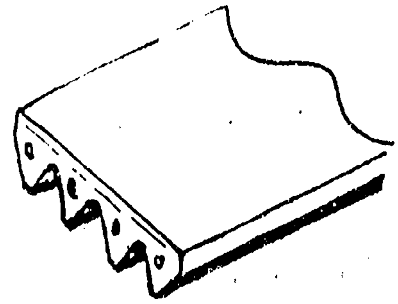
Linked belts



Most of the specialized belts are designed for unusual applications.

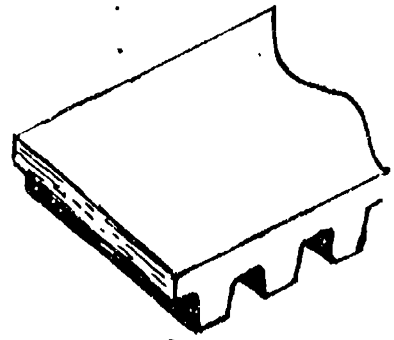
RIBBED BELTS

Ribbed belts are used to provide a flat belt function in an application where more friction is required than a flat belt of similar size will produce. Some clothes dryers are turned, using ribbed belts.



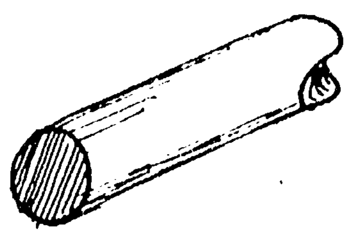
TOOTHED BELTS

Toothed belts are used when there are specific timing or registration requirements. Most belts will creep on a belt drive system. A toothed belt on a toothed pulley will not do this. Use example: are in presses to feed paper, and on some automobiles to time valves.



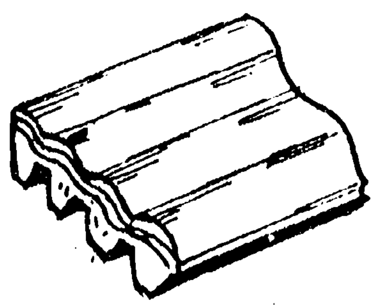
ROUND BELTS

Round belts are used in light duty applications with long reach and variable speed requirements. Their operation is not affected by conditions that may cause other belts to wear, through twisting. These are used in operating dentist drills, movie projectors, appliance blower fans, etc.



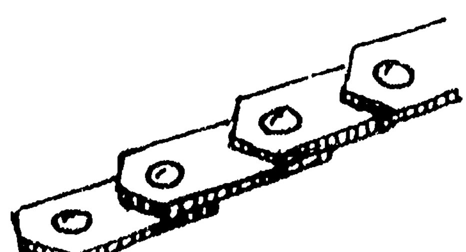
BANDED V-BELTS

Banded V-belts are V-belts that have been permanently tied together in the manufacturing process. They have a band that has been vulcanized to the top of a set of belts. The banded V-belt is used in multi-belt applications, especially those that have problems of belts that whip, turn over, or jump off the pulley.



LINKED BELTS

Linked belts consist of short pieces of V-belt material that have been held together with a series of metal studs. The belts are used where it is difficult to install a continuous loop belt. Link belts can be threaded and then closed at the job site. Links may be added or removed to meet the job requirements. Link belts are not recommended for high speed applications.



SAFETY

Belt drives are particularly hazardous devices when safety guards are removed for drive servicing.

Be sure to restrict loose clothing such as neckties, open sleeves, open jackets or coats, straps or clothing flaps that could get caught in the belt.

Keep fingers, feet and hair away from operating belt drives. The draft established by some configurations will pull loose clothing or hair into belts and pulleys. Obviously, this can be extremely dangerous.

Lock out drive system to prevent inadvertent rotation of pulley which could pinch or cut off fingers.

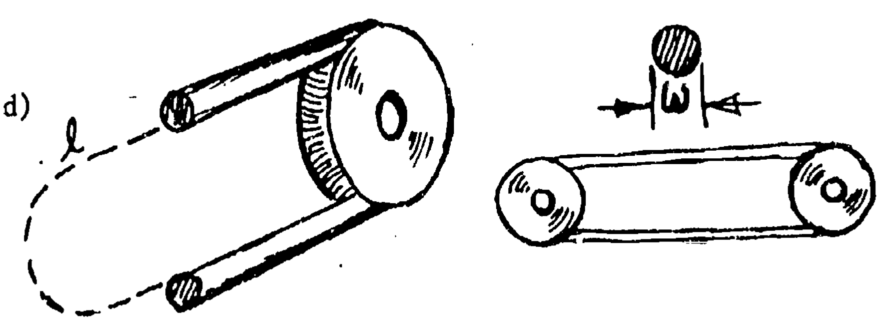
Keep safety guards on a belt drive at all times unless someone attends it for servicing.

HOW TO MEASURE

Measuring techniques will vary, depending upon the belt. Some examples are as follows:

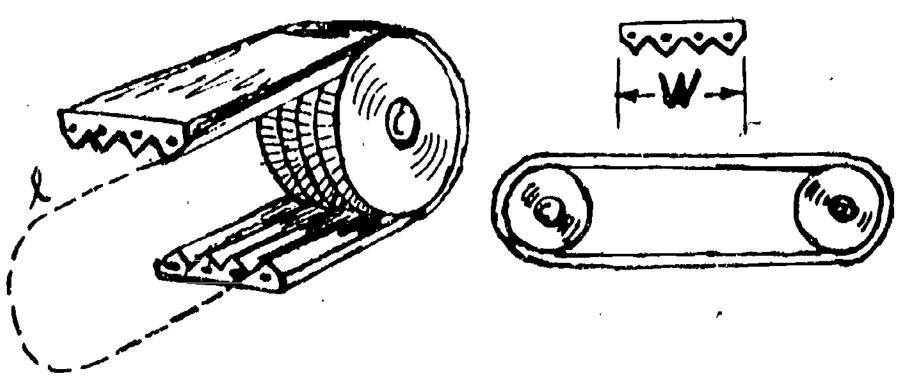
Round belts:

- l = inside dimension (id) of belt.
- w = diameter of belt.



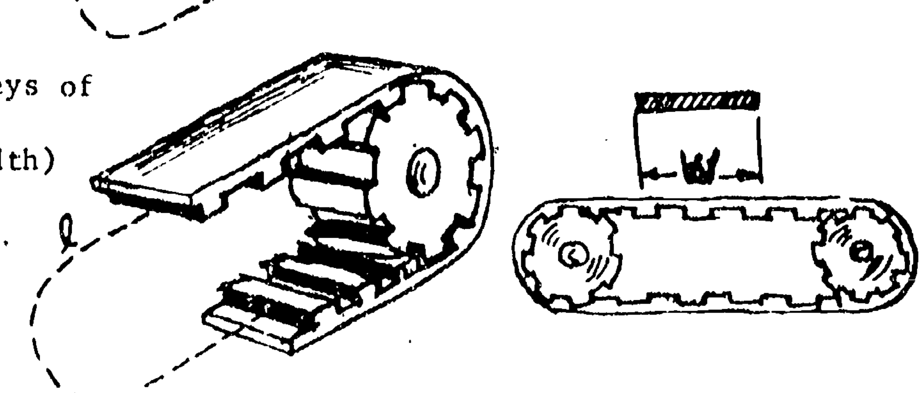
Ribbed belts:

- l = id of belt
- w = belt (pulley width)



Toothed belts:

- l = around the pulleys of the belt drive.
- w = belt (pulley width)

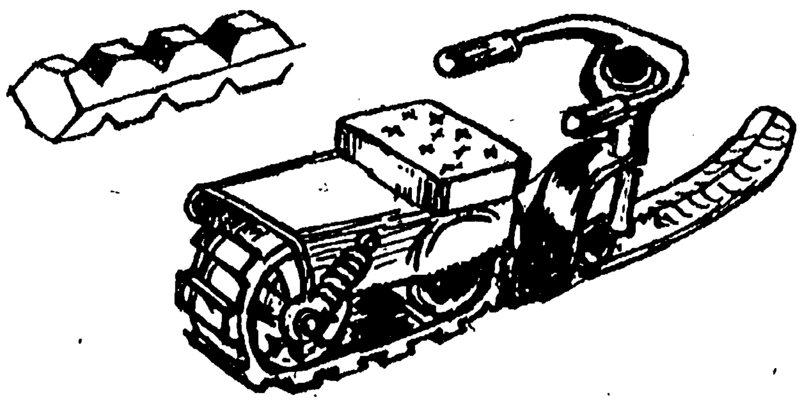


CAUTION: Measuring a used belt could give a false measuremet. It will have stretched and a replacement based on this measurement may not fit. Use specification number molded on the belt, if possible.

NOTE:

Many special applications today demand specialized drives. These will be variations and combinations on the above and flat and V-belt drives. Examples are:

- pin-setting machine drives garden and lawn equipment drives, snowmobile and recreational vehicle drives



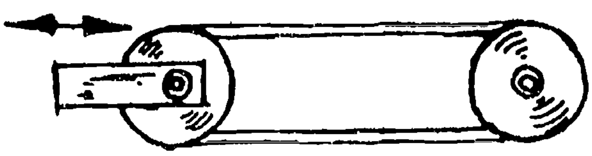
In each case, the belt design provides a flexible friction drive and employs the basic principles for choosing any of the belt styles previously discussed in this belt series.

TENSIONING BELTS

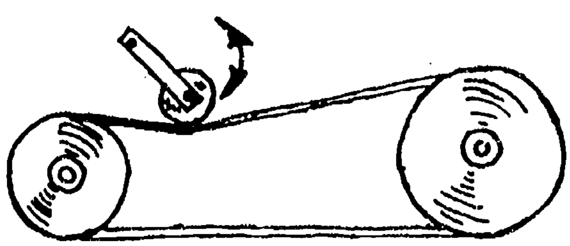
These belts are constructed normally of the usual combination of neoprene, cord and rubber, or materials without much "give". Some, such as projector belts, are stretched in installation and do not use idlers for tension adjustment. If they begin to slip, they should be replaced.

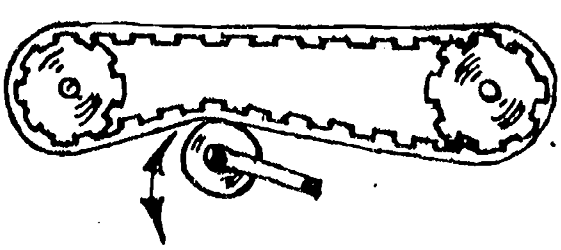
Other than the above, belt tensioning is accomplished by:

- adjusting the pulleys to the proper tension



- addition of an idler to the systems. The idler will take up the slack in the belt drive system. In the case of toothed belts, idlers must either be toothed or run on the back of a belt.





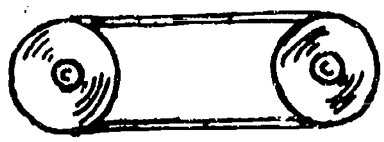
LUBRICATION OF PULLEYS

See Division Codes: 104 Bearings, and 108 Lubrication, or use the equipment manufacturers lubrication chart.

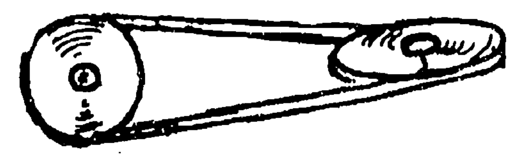
CONFIGURATIONS

Special applications may use any of the following:

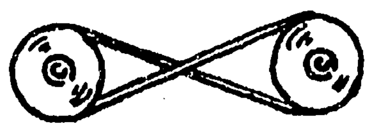
- open



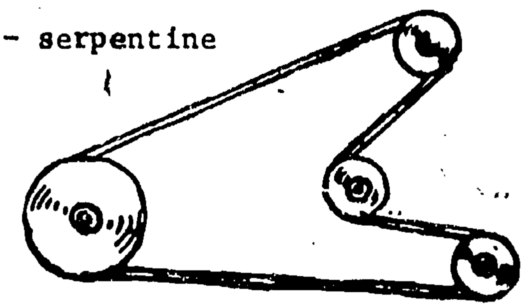
- turned



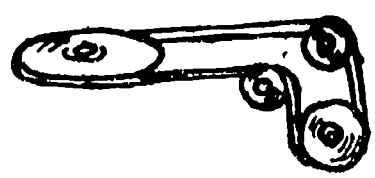
- crossed



- serpentine



- mule



NOTE: Always remember, in turned or mule configurations, that the power sides of the pulleys must be aligned.

TROUBLE SHOOTING SPECIALIZED BELTS

When do belt drives need their parts changed?

PULLEYS

Pulleys should be inspected for a condition on a periodic basis. They, or their parts, should be replaced when damage or wear will cause them to become a safety hazard or to damage the belts.

- If the shafts or bearings cannot be made to hold proper alignment, replace the defective part.

- If the sheave edges are damaged, it should be replaced before they can damage the belt.

- If the sides of the pulley are cracked, it should be replaced before it can fly apart and cause a safety hazard.

BELTS

Belts should also be routinely inspected. They should be replaced when their condition indicates fatigue. These condition indicators are:

- frayed fabric
- cracks in the inner side of the belt
- "dished out" spots in the belt (belt width not constant where it runs in the pulley)
- ruptured cords or stretched belts (the idler cannot be taken up, or the belt will no longer run true)
- oil and grease damage
- separation of belts and bands

SELF-TEST

1. A linked belt is used when ______________________________.
2. The only belt that is useful for timing is a ______________________ ____________.
3. List 3 ways to adjust belt tension.
4. List 5 belt arrangements (configurations).
5. Oil damage on a belt will cause it to ______________________________.
6. A slipping belt will cause what types of belt damage?
7. If a belt has ruptured cords, it will ______________________________.
8. A pulley with damaged shaft hole will ______________________________.
9. A cracked pulley that continues in use may ______________________ ____________.

SELF-TEST ANSWERS

1. A continuous belt is difficult to replace.

2. A toothed belt.

3. Adjustable pulley shaft, adjustable idler.

4. Open - crossed - mule - serpentined - turned.

5. Soften or deteriorate.

6. Burn or dish.

7. Stretch or break.

8. Wobble or slip on shaft.

9. Shatter

SPECIALIZED BELTS

1. ribbed
   banded
   round
   toothed
   linked

2. adjust pulley
   adjust idler
   install new "stretch" belt

3. open
   crossed
   mule
   turned
   serpentine

4. worn shaft holes
   bent pulley edges
   cracked around shaft hole

5. heat glaze and checks
   oil and grease damage
   slip burn
   ruptured cords
   belt and band separation
   frayed covers

POST–TEST

Package Number 101-C

SPECIALIZED BELTS

INSTRUCTIONS: Briefly respond to each of the following:

1. List 5 common styles of specialized belts.

2. List 2 methods to adjust tension.

3. List or draw 5 drive configurations.

4. List 3 kinds of pulley damage.

5. List 6 types of belt defects.

Name

Date

101-D V-Belts

Industrial Mechanics

101-D V-BELTS

PURPOSE

The most common belt style in use today is the V-belt. This learning package describes common uses, drive arrangements, inspection and service maintenance, and measuring requirements. If a trainee plans to work with V-belt drives, he should know the basic principles contained in this series.

MECHANICAL SYSTEM THEORY

OBJECTIVES

Upon completion of this unit, the trainee will be able to:

1. Describe V-belts and their correct operation.
2. State 6 uses for V-belts.
3. Measure and maintain V-belts and belt drives.
4. Describe and maintain a matched belt system.
5. State 4 types of belt damage and their causes.
6. Remove a V-belt, inspect the belt drive components, and replace defective parts.
7. Tension a belt.

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COOPERATION OF ...... State of Oregon Department of Education
Lane Intermediate Education District
Lane Community College
Educational Coordinating Council

PROJECT DIRECTOR: Dick Earl

WRITERS:

[illegible] Bishop

Steve Brown

John Anderson

[illegible]

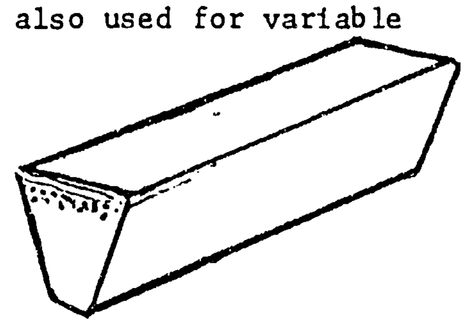
LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet	Provides the basic general material for this unit.
Read: Car Service, Check-Chart Corp., 1969, 222 W. Adams St., Chicago, Illinois 60606	Provides auto fan belt changing techniques.
Read: Modern Refrigeration & Air Conditioning 1968, Goodheart-Wilcox Co. Inc., Homewood, Illinois	Provides a discussion of pulleys & belt drives in refrigeration. - tensioning techniques for general belt applications. - tensioning automotive air conditioner belts.
Read: Belt Introductory pages in the NAPA catalog	Provides information on belts, pulleys, drive design information, etc.
Read: Stockel Auto Service & Repair 1969, Goodheart-Wilcox Co., Inc.	Provides information on automotive tensioning.
Read: Motor Services Automotive Encyclopedia 1965	Provides information on how to adjust a Volkswagon fan belt.
Read: John Deere Fundamentals of Service Manual	Provides general belt drive information.
Do: Idenfify all the belt defects on the shop belt-board.	Provides practical experience in identifying belts and pulleys and replacing damaged components.
Do: Change, inspect, and adjust belt and pulley components of a V-belt system, using proper equipment and procedure as specified by service manuals.	

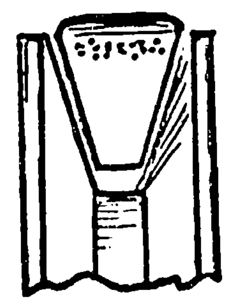
INFORMATION SHEET

V-BELTS

V-belts are the most commonly used belts. They provide a high friction drive for high speed short-coupled power transfer and are also used for variable speed pulleys and clutches.

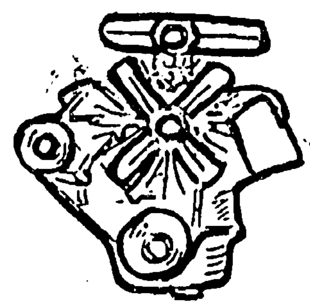


Higher amounts of friction are obtained with V-belts because they ride on their sides in the groove of the sheave (pulley). Tensioning the belt causes additional friction in the groove. Belts are often made with slightly concave sides, thus, when pressure is pulled against them, they tend to bulge in the center as they wedge into the pulley for greater friction. V-belts should never be permitted to run on the bottom of the pulley. If this is permitted, much of the wedging frictional advantage of the V-belt is lost.

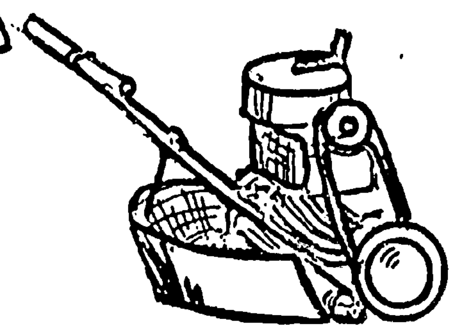


EXAMPLES OF V-BELT USES ARE:

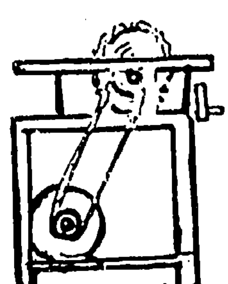
- automotive belts



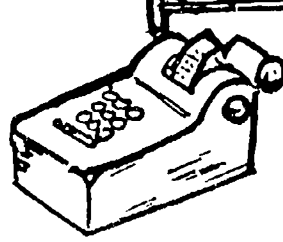
- lawn and garden equipment



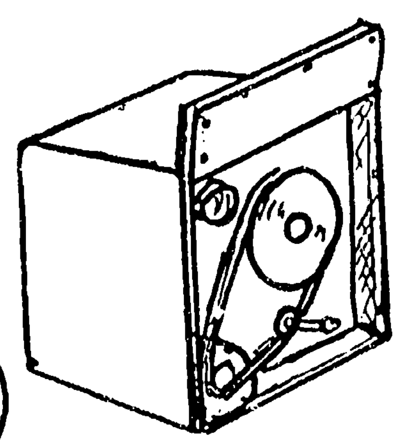
- shop tools



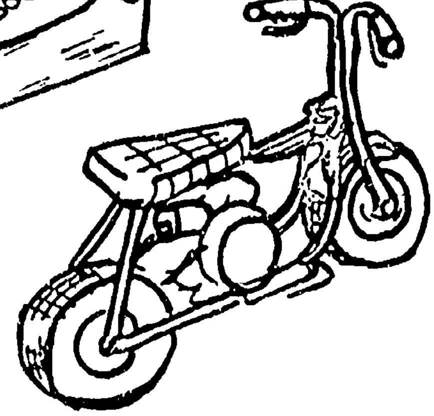
- office equipment

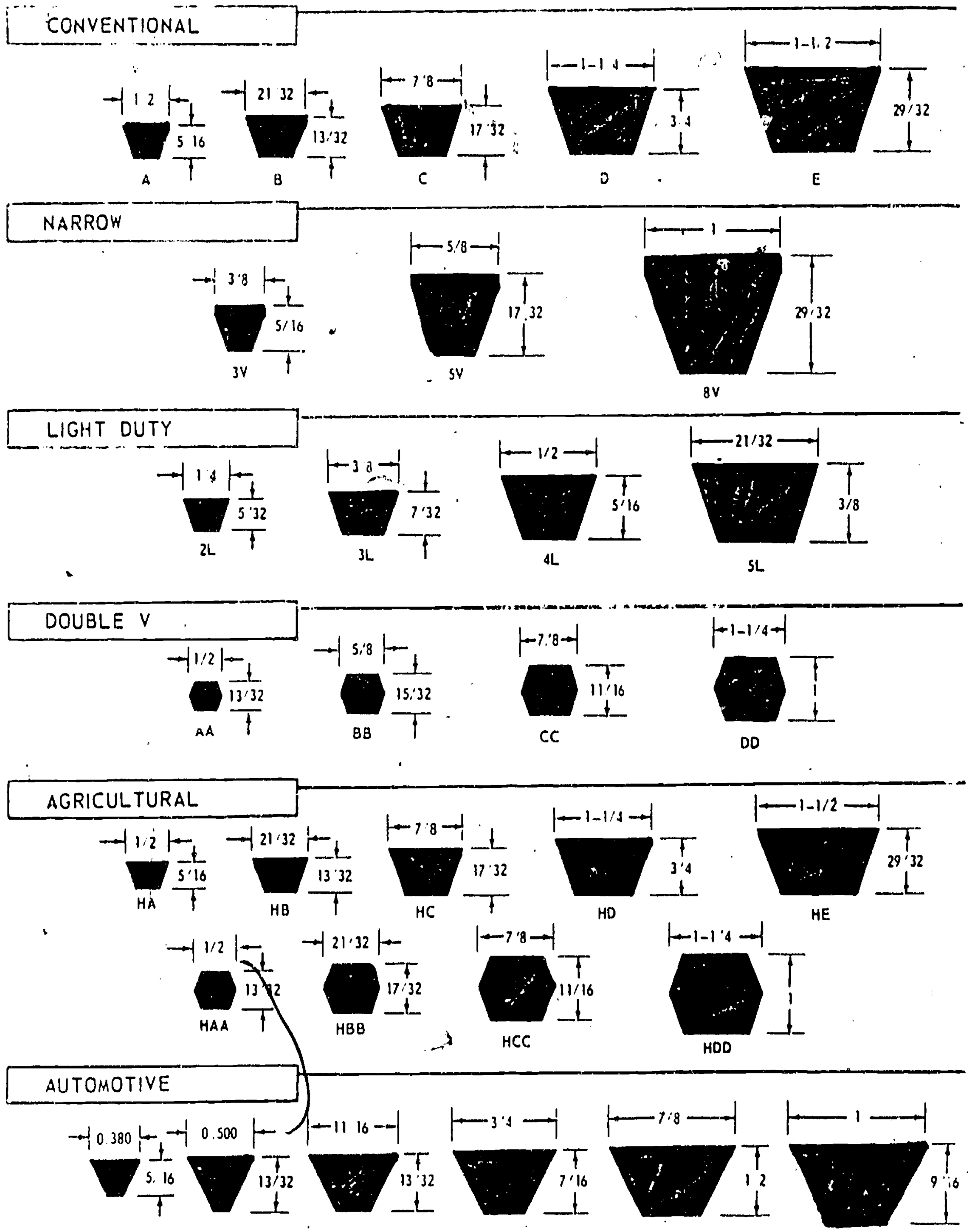


- home appliances



- recreational equipment



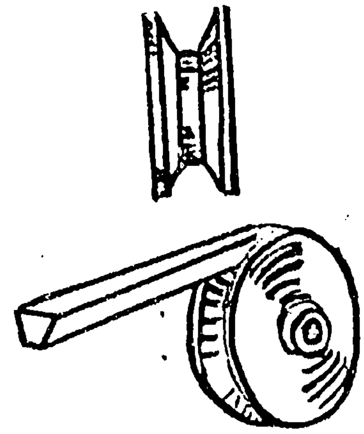


Types And Sizes Of V-Belts

COMPONENTS OF V-BELT DRIVES

A V-belt drive system consists of a pulley that is notched or grooved to nearly the same angle as the belt that drives it and a V-belt.

V-belts come in standard widths but may vary in length.

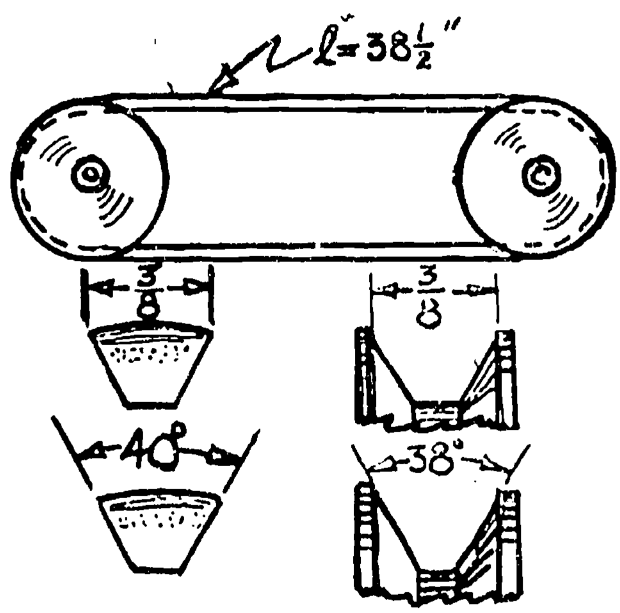


MEASUREMENTS

Belt sizes may be determined by the manufacturers part number or they may be indicated on the carton or molded into the belt.
For example: 38 1/2 x 3/8" x 38°.

The above measurements mean the belt is:

- 38 1/2" long, as measured around the outside of the pulley system.
- 3/8" wide as measured at the top of the V-belt on the sheaves.
- 38° sheave angle (the belt is usually of a slightly larger angle)



CAUTION: It is not advisable to measure a used belt. If it has been in use, it has been stretched and will not measure accurately. Belts usually have size information molded onto them and this information can be taken from used belt for new belt replacement.

NOTE: Newer automotive belts are made with 60° angles. They must have matching pulley grooves.

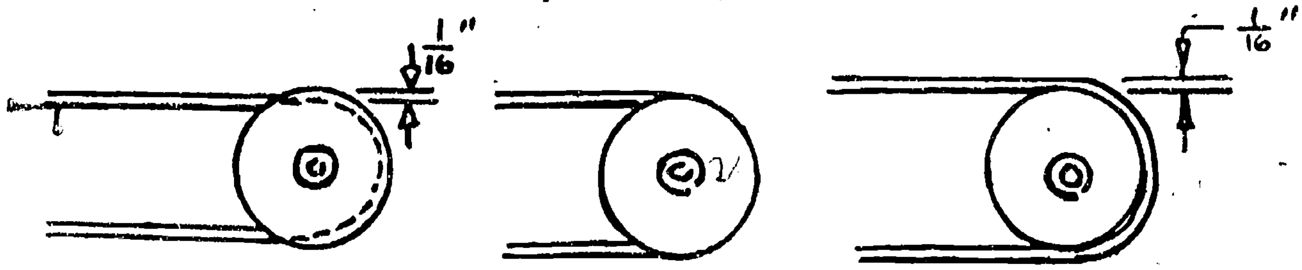
MATCHED BELTS

When a belt drive uses pulleys that have multiple grooves to accomodate more than one belt, the belts must be matched in length. When belts are manufactured, they all turn out to be slightly different in length. Belt manufacturers will than measure the belts and select those of the same length to within 1/10 of an inch and identify them as matched.

If one belt in a matched set breaks, then the complete set must be replaced. It is necessary because the complete set has stretched in use. Addition of one new belt will cause that belt to carry most of the load because it is new. This will cause the new belt to wear excessively.

PULLEYS

Pulleys for V-belts are designed to carry the load of the belts on the side of the groove and not on the bottom of the groove in the pulley. The top of the belt should ride + or - 1/16" to the outside edge of the pulley for best results. Check manufacturer's specifications.



Pulleys are made from a wide range of materials to fit a wide range of applications. Be sure to choose the correct pulley to handle the load.

Often, when multiple belts are needed to carry the load, a pulley with two or more grooves will be used. These applications require matched belts.

SAFETY

Belt drives are particularly hazardous devices when safety guards are removed for drive servicing.

Be sure to restrict loose clothing such as neckties, open sleeves, open jackets or coats, straps or clothing flaps that could get caught in the belt.

Keep fingers, feet and hair away from operating belt drives. The draft established by some configurations will pull loose clothing or hair into belts and pulleys. Obviously, this can be extremely dangerous.

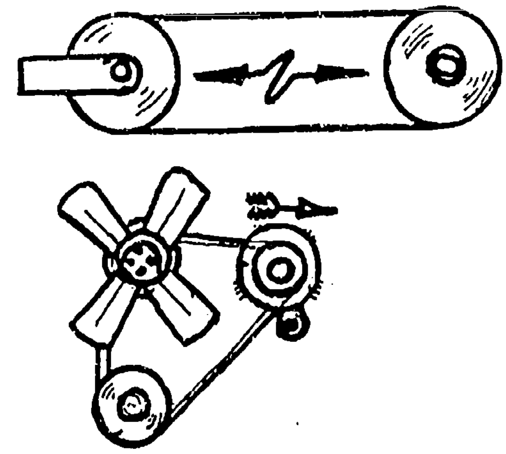
Lock out drive system to prevent inadvertent rotation of pulley which could pinch or cut off fingers.

Keep safety guards on a belt drive at all times unless someone attends it for servicing.

ALIGNMENT

Pulleys must be properly aligned for maximum belt life. See VIP lesson 101-E.

BELT TENSIONING



V-belts are normally tensioned by:

- adjusting one of the pulley and shafts

- adjusting an idler in the belt system to take up the slack. Often, as in the automobile alternator, the idler may be doing useful work.

Tension settings vary between applications. Use of the equipment manufacturers information and one of several tensioning devices is recommended to obtain proper belt settings.

LUBRICATION OF PULLEY SHAFTS

Pulleys should be inspected and their shafts lubricated on a regular basis. See 104 Bearings and/or 108 Lubrication, or the equipment manufacturers lubrication chart for particulars.

TROUBLE SHOOTING V-BELTS

A squeaking belt that is otherwise functioning properly may be silenced by lubricating the sides of the belt with soap or candle wax.

NOTE: Do not use oils or grease on belts. These products generally cause belt material to deteriorate rapidly.

BELTS

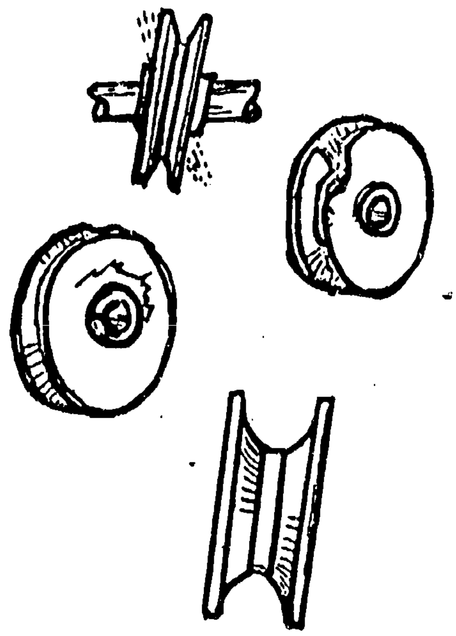
Belts should be inspected regularly to assure continued operating efficiency. Planned maintenance normally is preferred to breaking down.

Belts should be removed for inspection in order to see the entire belt. Turn the belt inside out and check for fatigue by looking for:

- swelling and deterioration from oil soaking
- frayed fabric
- cracks on the inner side of the belt. If a belt is glazed from excessive heat, it may crack when handled. This belt should be replaced.
- stretched belts. This condition is caused by broken cords and will normally show up either as an idler that has no more capacity and/or a belt that "bottoms out" on the pulley.
- "dished out" belts. This is usually caused by a pulley turning in a stalled belt. The condition can be found by sliding the belt through your fingers. The width of the belt will be smaller in the "dished out" area.

PULLEYS

Pulley condition should be checked periodically. Parts should be replaced whenever wear or damage will cause a safety hazard or damage to belts. Defective parts should be replaced when:



- shafts and bearings will no longer holder proper alignment.
- pulley bearing is frozen and keeps pulley or idler from turning.
- sheave edges are damaged and may cause damage to the belt.
- sheaves are cracked around pulley shaft and may fly apart in service.
- sheaves are "dished out" by wear or the bottom of the groove area is shiny.
- dirt or foreign objects in the pulley groove.
- pulley bearing surface must be smooth and free of defects.

SELF-TEST

1. Two general angle sizes of belts are ______________________________.
2. Matched belts are the same size to within ______________________________.
3. Newer automotive design employs a ______________________________ angle.
4. V-belts ride on their ______________________.
5. A properly sized V-belt runs at the ____________________ of the pulley.
6. A belt with broken cords will ______________________________.
7. If a belt turns over in its pulleys, the ____________________ are out of line.
8. A belt will ride the bottom of the pulley if the wrong sized belt is used or the pulley is worn. Illustrate with a drawing.

ANSWERS TO SELF-TEST

1. 38° or 60°
2. 1/10"
3. 60°
4. sides
5. top
6. stretch
7. the pulleys are out of line
8. wrong sized belt, worn pulley or belt

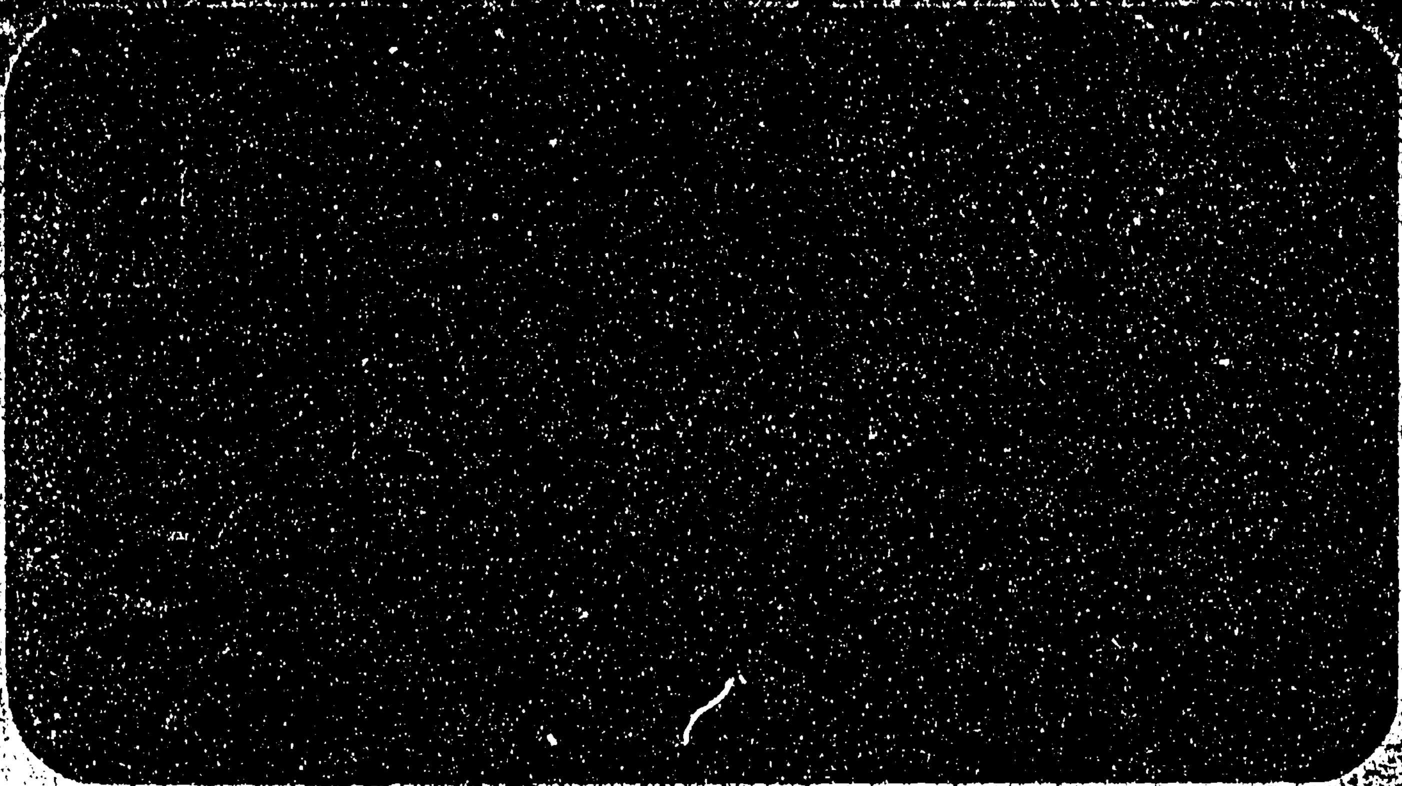
POST—TEST

Package Number 101-D

Name ____________ Date ____________

Using a system provided by your instructor:

- remove belt
- inspect the system
- identify all parts
- identify all damage
- identify damage causes
- replace with proper belt drive components
- tension properly



Industrial Mechanics

105-A BELT CLUTCHES

Many times a belt drive system will need some type of a device that will smoothly engage or disengage power from the drive. One method of doing this is to use the belt drive itself as a clutch. Two basic types of belt clutches are discussed in this unit.

OBJECTIVES

Upon successful completion of this learning package the student will be able to:

1. Identify and describe the components of a simple belt clutch.

2. Describe the operation of a simple belt clutch.

3. Describe the parts requirements of an automatic belt clutch controlled by a centrifugal actuator.

4. Be able to describe the operation of an automatic belt clutch.

DEVELOPED WITH THE COOPERATION OF ...... State of Oregon Department of Education
Lane Intermediate Education District
Lane Community College
Educational Coordinating Council

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[illegible]

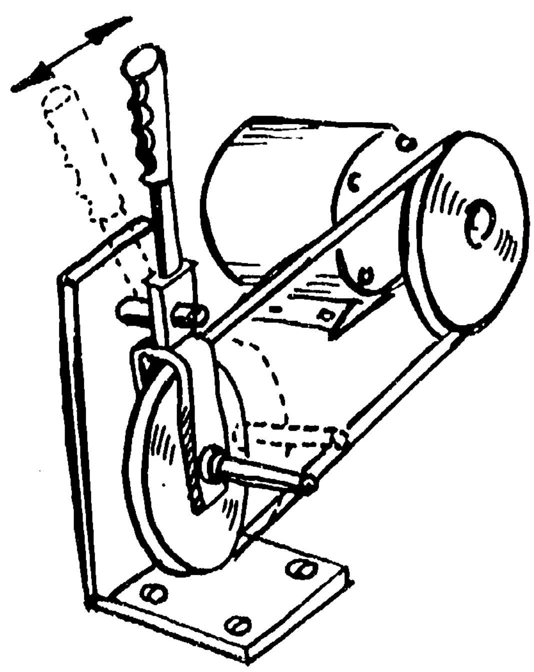
LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet	Provides basic principles of construction and operation of belt clutches.
Do: Construct a simple belt clutch from materials available in the shop.	This exercise will provide practical experience in selecting the correct components for a clutch system from available materials.
Do: Take an RPM indicator and have students check to see at which RPM the automatic belt clutch engages	This exercise will make the student aware of weights that actuate the automatic belt clutch.

INFORMATION SHEET

THE SIMPLE BELT CLUTCH

DESCRIPTION



A simple belt clutch is a modified belt drive with one shaft moveable under lever control. In the released position, the belt is loose around the pulleys. In the engaged position, the belt is tightened on the belt drive and the tension will cause enough friction to turn the equipment.

APPLICATION

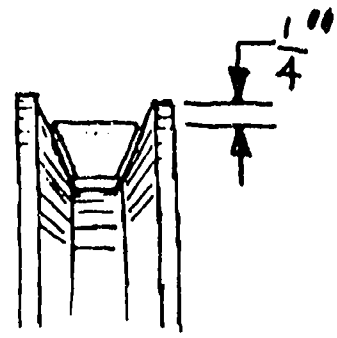
This type of clutch is used wherever an inexpensive drive line is used. It is frequently found in garden and lawn equipment, motorized recreational equipment, etc.

BELT LIFE

Belt life is reduced when the drive is held in a released or semi-released position, as the driving pulley will spin in the belt causing it to "dish out".

COMPONENTS

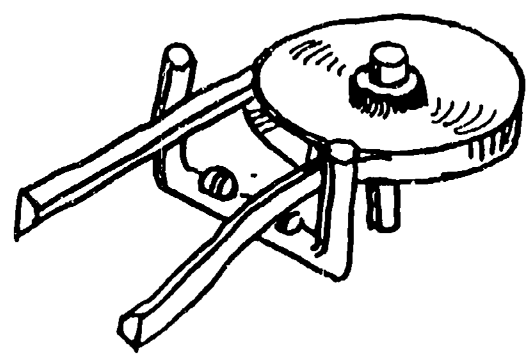
The belt drive requires some special components.



- This is usually a V belt application.

- A deep-grooved pulley helps to keep the drive from losing its belt. A deep-grooved pulley will permit the belt to ride approximately 1/4" down into the pulley.

- A belt guide. Some type of device is mounted near the drive pulley in many belt clutches to assure the belt remaining on the pulley when it is slack.



- One fixed and one moveable pulley shaft

- An actuating lever to tighten and loosen tension on the belt.

AUTOMATIC BELT CLUTCH (Centrifugal Actuator)

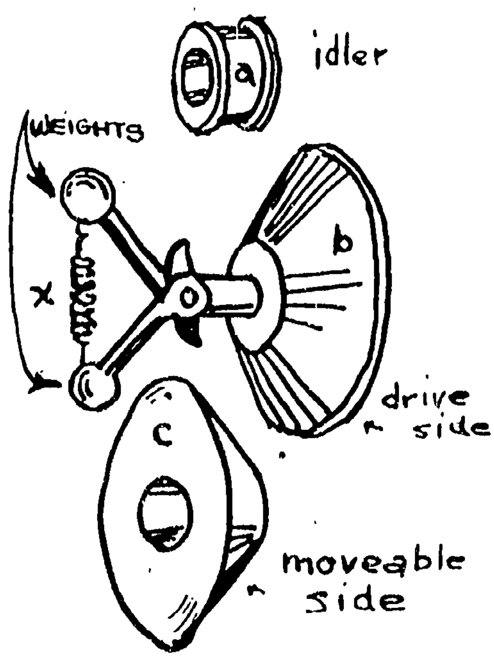
COMPONENTS

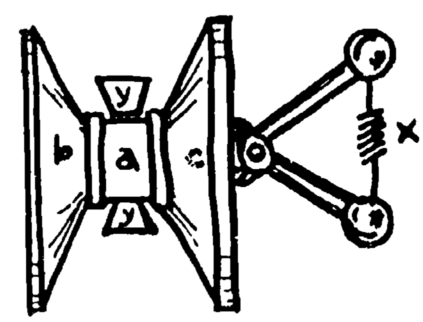
The automatic belt clutch normally requires a V-belt drive. The drive pulley is usually split into three parts.

- the idler. Rides freely on the shaft between the pulley sides.

- the drive side of the pulley. Includes the centrifugal actuator and is attached to the shaft.

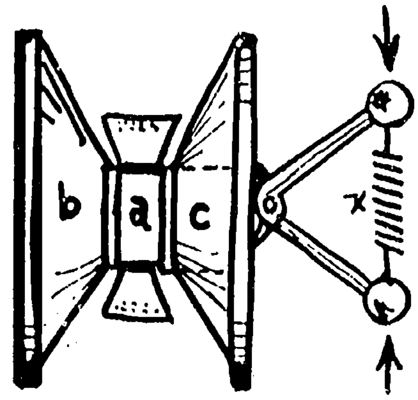
- the moveable side of the pulley. It will slide over the idler (a), up to the drive side of the pulley.



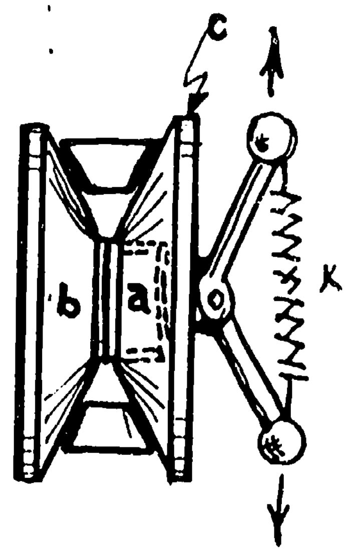


OPERATION

The drive side (b) of the drive pulley is attached to a power system, an engine, or a motor. When that motor is stopped, or running slowly, spring action will draw the centrifugal actuator to its released position, spreading the pulley sides (b & c) to maximum width. When the sides (b & c) are in this position, the belt (y) will rest loosely on the idler and no power is transmitted through the belt.



As the motor speed (RPM) is increased, centrifugal force will throw the weights on the actuator (attached to b) outward. The cam action of the weighted arms will then slide the moveable side of the pulley (c) closer to the drive side (b). Eventually, the sides of the pulley will encounter the belt and, as speed increases, the tension on the belt will increase to maximum.



SAFETY

Belt drives are particularly hazardous devices when safety guards are removed for drive servicing.

Be sure to restrict loose clothing such as neckties, open sleeves, open jackets or coats, straps or clothing flaps that could get caught in the belt.

Keep fingers, feet and hair away from operating belt drives. The draft established by some configurations will pull loose clothing or hair into belts and pulleys. This can be extremely dangerous.

Lock out drive system to prevent inadvertent rotation of pulley which could pinch or cut off fingers.

Keep safety guards on a belt drive at all times unless it is being serviced.

SELF-TEST

1. To make a simple belt clutch drive, four components are necessary. Name them.

2. The moveable pulley is moved ____________________ from the stationary pulley to engage a simple belt clutch drive.

3. Automatic belt clutch pulleys are engaged by centrifugal force which moves half the pulley ____________________ the other half as the revolutions per minute increases.

4. In an automatic clutch pulley, the moveable side of the pulley is controlled by centrifugal. ____________________.

SELF-TEST KEY

1. stationary pulley
   moveable pulley
   V-belt
   moveable pulley engaging lever
2. away
3. towards
4. weights.

POST-TEST KEY

Package No. 105-A

BELT CLUTCHES

1. moveable pulley
   stationary pulley
   operating lever
   V-belt

2. moveable pulley

3. moveable

4. side

POST–TEST

Package Number 105-A

Name ______________ Date ______________

BELT CLUTCHES

INSTRUCTIONS: Complete the following sentences:

1. A simple belt clutch consists of a ______________, ______________ ______________ & ______________.

2. The belt friction is increased in a simple belt clutch drive by moving the ______________ away from the stationary pulley.

3. Automatic belt clutches work by making one side of the pulley ______________ ______________.

4. Centrifugal weights force the moveable side of the pulley against the ______________ of the V-belt.

101-F VARIABLE SPEED PULLEYS

Some belt drive systems have a requirement to vary the speed and power applied to the load. This unit will discuss basic principles of varying the speed of the shafts by using variable speed pulleys.

When this learning package has been successfully completed, the student will be able to:

1. Describe the components of a variable speed split pulley.

2. Describe the theory and operation of a variable speed belt drive system.

3. Identify two types of driven shaft split pulleys.

LEARNING ACTIVITIES

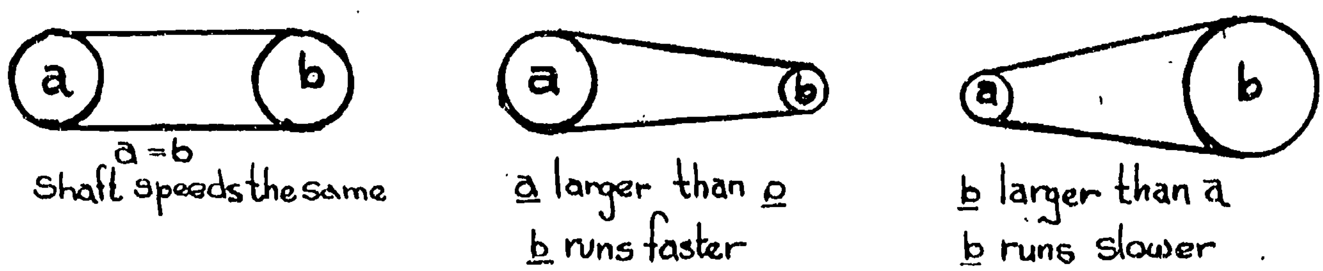
ACTIVITIES	PURPOSE
Read: Information Sheet	Provides the principles of operation of the variable speed belt drives. Differing types of split pulleys are explained.
Do: Assemble two different types of variable speed belt drives. - engine lathe - drill press - shaper	This activity provides practical experience in the theory and practice of using variable speed belt drives.

INFORMATION SHEET

VARIABLE SPEED DRIVES

THEORY

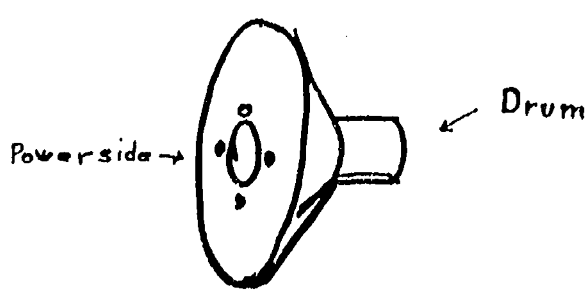
The speed of the driven shaft of a belt drive is determined by the size ratio of the pulleys on the drive. Assuming the drive pulley shaft turns at a constant speed (RPM), the RPM of the driven pulley varies as the pulley size changes.



THE SPLIT PULLEY

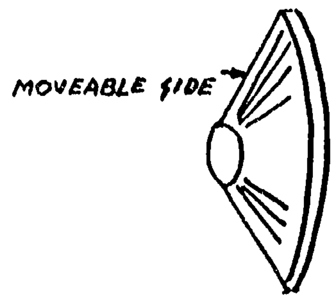
Split pulleys are usually made up of three pieces as follows:

- power side. This piece of the pulley is attached to the shaft.



- pulley drum. It is usually attached to the power side of the pulley.

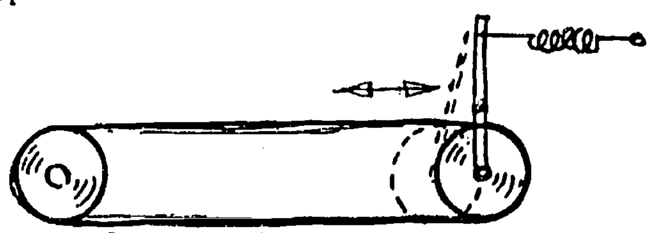
- moveable side. This side of the pulley slides on the pulley drum. Most moveable pulley sides are keyed or splined to match the drum or the shaft to give maximum belt drive friction to both pulley halves.



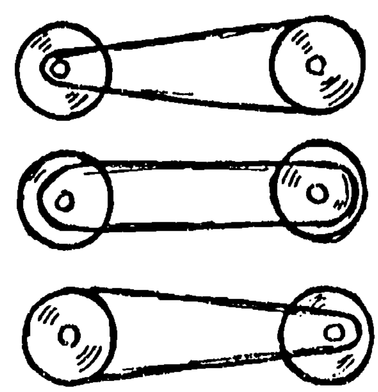
A big advantage of variable speed belt drive is its ability to vary the speed without steps between the minimum and the maximum speed.

The effective size of a V-Belt pulley may be changed by varying the V-belt riding position on the the pulley. In a split pulley, such as the one described in automatic clutches, the closer the belt rides to the outside edge of the drive pulley, the greater the speed of the driven pulley. In effect then, the drive pulley grows larger as speed increases and so, gives even greater speed advantage than that of the shaft alone.

The split drive pulley cannot be teamed with a fixed shaft, one piece pulley and still operate as described As the belt moves outward on the drive pulley, it requires more length. If nothing else provides slack, the belt merely tightens and the speed ratio remains constant.



There are several ways to counter this action. The least effective and least expensive way to counter the above problem is to provide a moveable shaft for one of the two pulleys. Then, when the belt tension reaches a certain point, the shaft can move to provide the belt slack to permit the belt to move out on the split pulley to maximum speed position.



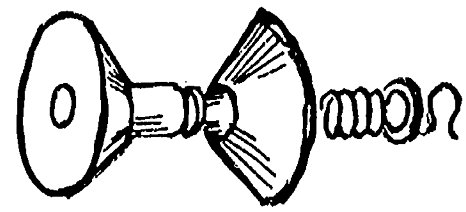
The best way to keep the belt length from becoming a problem is to change the effective size of the pulley on the drive and on the driven shafts at the same time. In this way, as one pulley gets larger, the other becomes smaller. This technique provides two major advantages:

- belt tension is always constant.

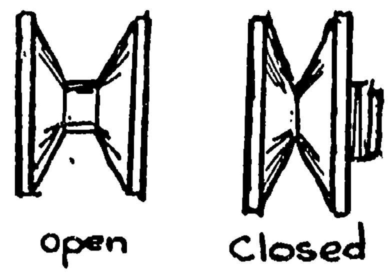
- speed changing occurs twice as fast as when only one pulley changes.

The driven shaft may be controlled by spring tension.

The driven pulley consists of two halves of a V-belt pulley that is spring-loaded into the closed position when tension is released on the belt drive.

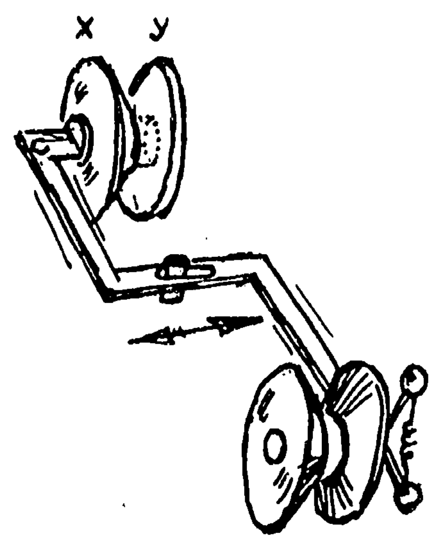


As shaft speed is increased, the belt will climb on the drive pulley. The increased tension will force the driven pulley apart and, as the belt moves between the parts of the split pulley, it will reduce the effective size of the driven pulley. As the shaft speed slows, the reverse will occur.



The most positive drive control is that in which the centrifugal actuator controls both the drive and the driven pulley. Thus, the belt tension requirements are not as severe as those of the spring-loaded system.

In the illustration at the right, the actuator will operate the y side of the drive pulley and the x side of the driven pulley. As one pulley opens, the other closes under direct control of the centrifugal actuator or a manual set lever.



SAFETY:

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Be sure to restrict loose clothing such as neckties, open sleeves, open jackets or coats, straps or clothing flaps that could get caught in the belt.

Keep fingers, feet and hair away from operating belt drives. The draft established by some configurations will pull loose clothing or hair into belts and pulleys. Obviously, this can be extremely dangerous.

Lock out drive system to prevent inadvertent rotation of pulley which could pinch or cut off fingers.

Keep safety guards on a belt drive at all times unless it is being attended for servicing.

SELF-TEST

1. The moveable side of the split variable speed pulley fits onto the ______________________________.

2. For maximum belt drive friction, the moveable side of the split pulley is ______________________________ to the drum.

3. If the driven pulley is a fixed size pulley and teamed with a variable speed pulley, the fixed size pulley shaft must ______________________________ in order to change speed.

4. If two split pulleys are used, as the belt moves outward on one pulley, it moves ______________________________ on the other.

SELF TEST ANSWERS

1. Drum
2. Splined or keyed
3. move
4. inward

POST—TEST

Package Number 101-F

VARIABLE SPEED PULLEYS

INSTRUCTIONS: Complete the following sentences:

1. List three components of a split variable speed pulley. ______________, ______________, ______________.

2. Drive speed is controlled by the belt ______________ on the variable speed pulley.

3. As the belt moves toward the outside of the split variable speed driving pulley, the belt speed ______________.

4. If the belt moves toward the outside of the split variable speed driving pulley, the fixed driven pulley must move _____ __________ the variable drive pulley.

5. Name two methods of controlling the moveable side of the driven shaft split pulley.

Name ______________ Date ______________

VARIABLE SPEED PULLEYS

1. moveable
2. speeds
3. decreases
4. moveable
5. increase