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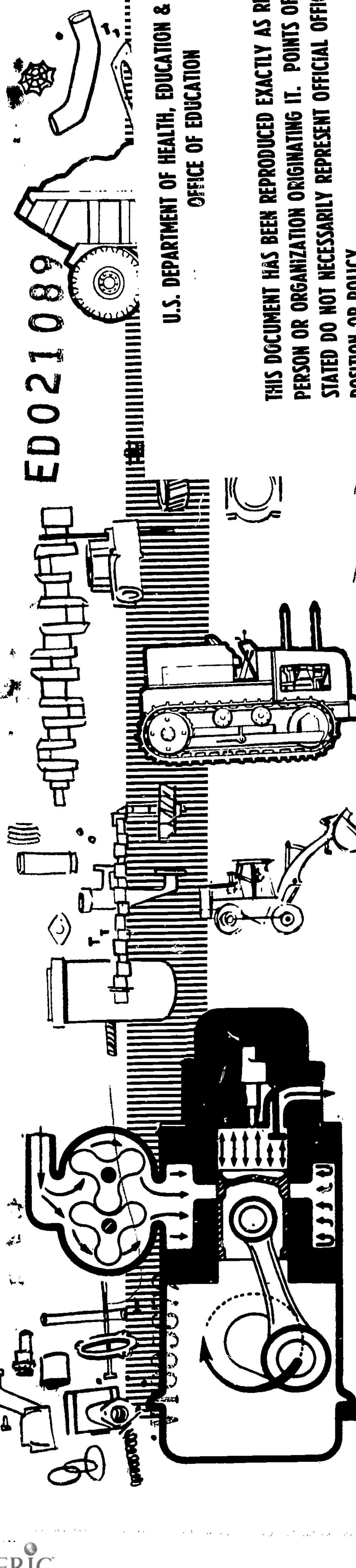
AUTOMOTIVE DIESEL MAINTENANCE 1. UNIT XVIII, I--UNDERSTAND ENGINE GEARS AND GEARING PRINCIPLES, II--MACK INTER-AXLE POWER DIVIDER.

HUMAN ENGINEERING INSTITUTE, CLEVELAND, OHIO
REPORT NUMBER AM-1-18 PUB DATE 16 JUN 66
MINNESOTA STATE DEPT. OF EDUCATION, ST. PAUL
EDRS PRICE MF-$0.25 HC-$2.00 48P.

DESCRIPTORS- *STUDY GUIDES, *TEACHING GUIDES, *TRADE AND INDUSTRIAL EDUCATION, *AUTO MECHANICS (OCCUPATION), *DIESEL ENGINES, ADULT VOCATIONAL EDUCATION, TRANSPARENCIES, PROGRAMED MATERIALS, INDIVIDUAL INSTRUCTION, INSTRUCTIONAL FILMS, PROGRAMED INSTRUCTION, MOTOR VEHICLES, EQUIPMENT MAINTENANCE, KINETICS,

THIS MODULE OF A 30-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF DIESEL ENGINE GEARS AND GEARING PRINCIPLES AND THE OPERATING PRINCIPLES AND MAINTENANCE OF POWER DIVIDERS (GEAR BOXES) USED IN DIESEL ENGINE POWER TRANSMISSION. TOPICS ARE (1) THE PURPOSE OF THE ENGINE GEARS, (2) INSPECTING FOR GEAR FAILURES, (3) INSPECTING FOR SHAFT FAILURES, (4) USING SNAP RINGS TO POSITION GEARS OR BEARINGS, (5) OPERATING PRINCIPLES (POWER DIVIDER), AND (6) REPAIRING THE MACK POWER DIVIDER. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL BRANCH PROGRAMED TRAINING FILM "UNDERSTANDING GEARS AND GEAR RATIOS" AND OTHER MATERIALS. SEE VT 005 655 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 655 - VT 005 684. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 2" ARE AVAILABLE AS VT 005 685 - VT 005 709. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE TEXT MATERIAL, TRANSPARENCIES, PROGRAMED TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEADQUARTERS AND DEVELOPMENT CENTER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)



STUDY AND READING MATERIALS

AUTOMOTIVE DIESEL MAINTENANCE 1

I - UNDERSTAND ENGINE GEARS AND GEARING PRINCIPLES

II - MACK INTER-AXLE POWER DIVIDER

UNIT XVIII

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AM 1-18
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Human Engineering Institute - Minn. State Dept. of Ed. Vocational Education

HUMAN ENGINEERING INSTITUTE

This Unit is separated into two parts. The first half covers the theory behind engine gears, shafts, pulleys and bearings. The second half covers a brief description of the Mack inter-axle power-divider.

I -- UNDERSTANDING ENGINE GEARS AND GEARING PRINCIPLES

SECTION A -- THE PURPOSE OF ENGINE GEARS

Most diesel mechanics working on heavy off-highway equipment are quite aware of why engine manufacturers use gearing for the auxiliary drive mechanisms. As a review, let's discuss briefly the theory behind it.

Auxiliary drive mechanisms are used in internal combustion engines to maintain a fixed and definite relationship between the rotation of the crankshaft and the camshaft. Proper engine performance cannot allow this rotation to be changed even a little bit. The engine must have a correct sequence of events happening at the proper instant for smooth running and proper efficiency. Also, the rotating auxiliary drives such as (blowers, governors, fuel pumps, oil pumps, water pumps, etc.) must turn at the designed speed in order for all components to run in unison.

In order to reach and maintain a precise transfer of rotation, most engine manufacturers use gears; there are a few who use sproket and chain arrangements and on some small engines belts are sometimes utilized. However, chain arrangements are noisy, and belts will stretch after prolonged use.

Figure 1 shows a typical gear train arrangement found on diesel engines today. Most gear trains use a single helical spur type gear, while governor drives are usually of the bevel type; you will recall in our Units covering the Cummins PT pump, that the tachometer drive was driven by a worm gear. Most types of gears will be found in one form or another in use on off-highway equipment.

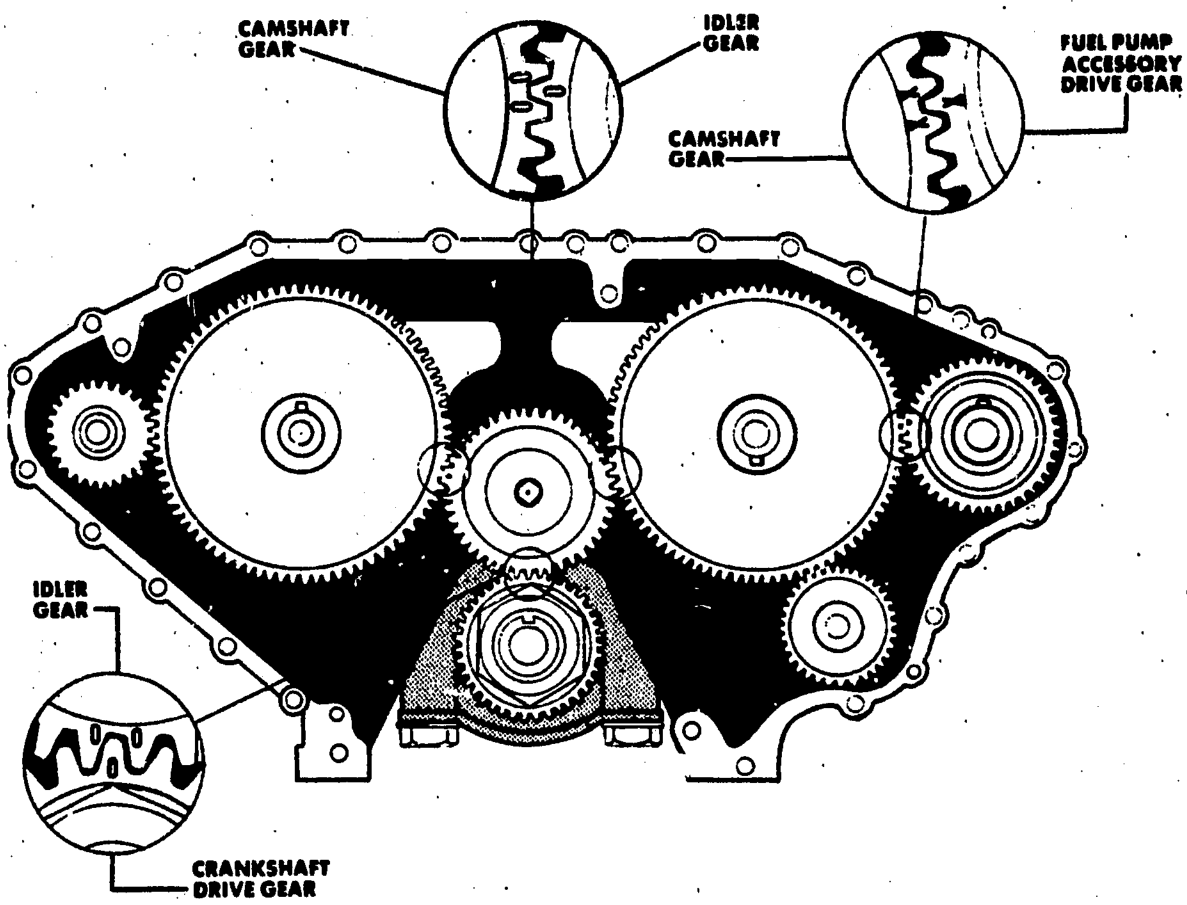


Fig. 1 Typical engine gear train.

SECTION B -- INSPECTING FOR GEAR FAILURES

Usually an indication that gears or gear components are failing will be evident to the mechanic by noise or vibration in the engine. There are eight common causes of noise and vibration in gearing. Let's see what they are:

DISTORTION - To check for a distorted pinion or gear:

1. Clean all tooth surfaces thoroughly.
2. Coat the teeth with Prussian blue or red lead.
3. Turn the gears slowly.

If no distortion is present, the tooth markings made by the marking compound will show across the entire width of the tooth.

NOISY BEARINGS - Noise from a gear may be misleading. Figure 2 shows how the noise caused by a faulty bearing may seem to originate in the gears. Replacing a bad bearing is critical to the life of a gear. Because a worn or loose bearing will run a long time before a complete failure occurs, bad bearings are sometimes allowed to continue in operation under the illusion that bearing cost is being reduced. But while the bearing is being used up, an expensive set of gears is being ruined. Check the bearings before blaming the gears.

MISALIGNMENT - If gear and pinion shafts are not parallel, misalignment occurs and full contact across gear teeth will not be made. See Figure 3. Bearing caps, bearings, and drives should be checked for tightness since looseness of any of these parts will affect alignment of the gears. Another cause of misalignment will occur if the gear is pressed against an over-sized key or against an off-square shoulder.

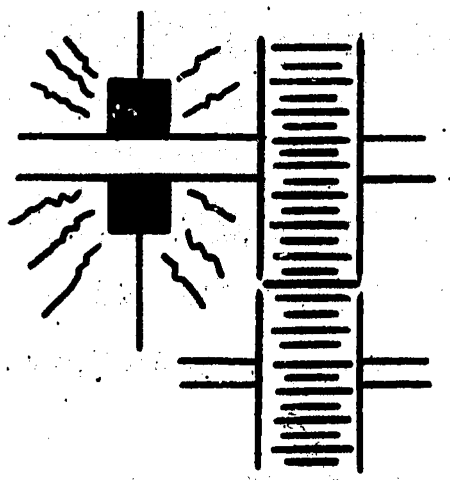


Fig. 2 Noisy bearing.

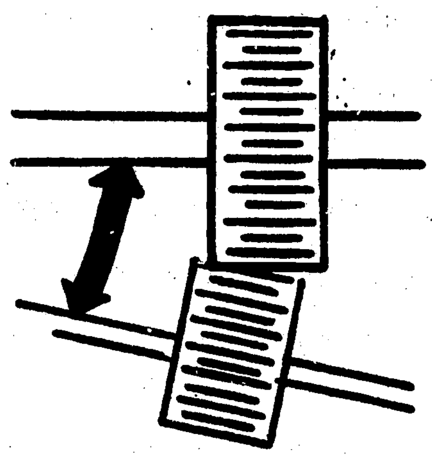


Fig. 3 Misalignment.

CENTER DISTANCE - Backlash is the amount by which the width of a tooth space exceeds the thickness of the engaging tooth on the pitch circles. It increases when gears move farther apart from each other, and decreases as they are brought together. See Figure 4.

The general purpose of backlash is to prevent gears from jamming together and making contact on both sides of their teeth simultaneously. Lack of backlash may cause noise, overloading, overheating of the gears and bearings, and even seizing and failure.

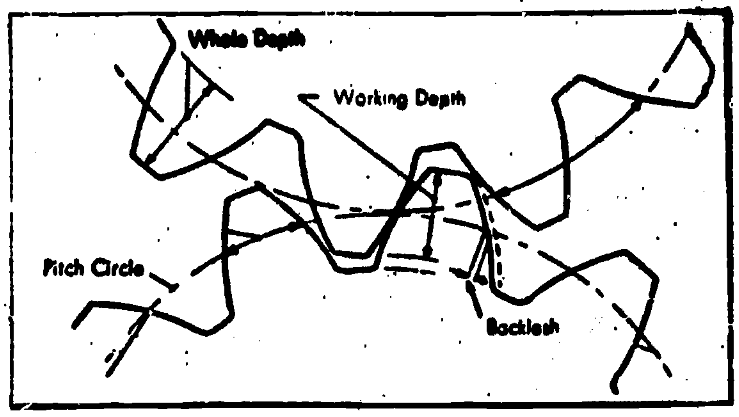


Fig. 4 Backlash.

Excessive backlash is objectionable, especially if the drive is frequently reversing, or if there is an overrunning load as in cam drives. On the other hand, a requirement of an unnecessarily small amount of backlash allowance will increase the costs of gears, because errors in runout and mounting must be held correspondingly smaller.

Too much backlash produces a rumbling sound. A "whining" sound is heard if the center distance is too little. This may cause the gears to bind because the temperature of the gear set increases while in operation.

CONTROL OF BACKLASH IN ASSEMBLIES - Provision often is made for adjusting one gear relative to the other, thereby affording complete control over backlash at initial assembly and throughout the life of the gears. This practice is most common in bevel gearing. It is fairly common in spur and helical gearing when the application permits slight changes between shaft centers. It is practical in worm gearing only for single thread worms with low lead angles. Otherwise, faulty contact results.

TOOTH DAMAGE - A damaged tooth on a gear or pinion may cause a recurring "click". See Figure 5. This "click" may disappear as the gear wears in, if the damage is not great. If this condition does not correct itself, the gear set should be dismantled and the damaged gear or gears replaced or repaired.

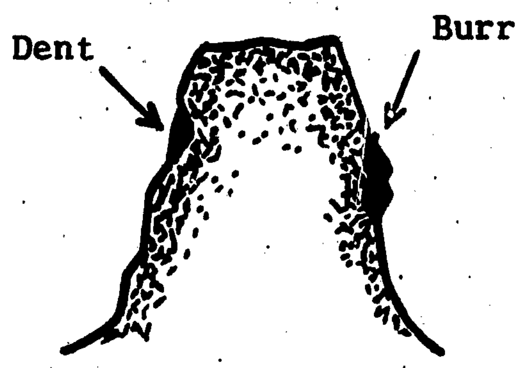


Fig. 5 Tooth damage.

LUBRICATION - Noise can arise from inadequate or improper lubrication. See Figure 6. The lubricant may not be getting to the contact areas. Oil viscosity may be too low for the operating temperature. Be sure the proper kind and amount of lubricant is being used.

IMPURITIES - As Figure 7 shows, the lubricant often is blamed for faulty operation when the real cause may be improper maintenance. A case in point would be where chips or other abrasives are allowed to accumulate in the lubrication system. Always keep the oil in top condition.

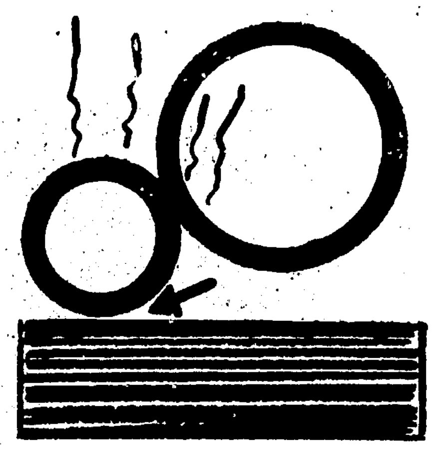


Fig. 6 Lubrication

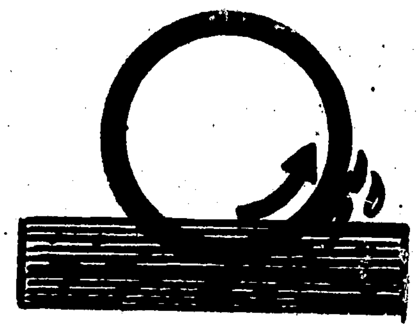


Fig. 7 Oil carrying impurities to gear surface.

OVERLOADING - Excessive overloading may cause noise. See Figure 8. This noise usually is not present at the beginning of the overload, but develops later. Overheating that results from overload will lower oil viscosity. It will also speed oil oxidation. The gear teeth will eventually be damaged if excess overloads are not removed.

Fig. 8 Overloading.

Let's look at some of these failures more closely.

SURFACE DETERIORATION - Any time the gears in an engine, or engine components are exposed for any reason, the gear teeth should be inspected for signs of surface deterioration. Surface changes on great teeth may range from a mild smoothing under normal operating conditions to complete destruction of the tooth shape. This deterioration can result from causes classified as wear, plastic yielding, welding, surface fatigue and miscellaneous deterioration.

WEAR is a general term to cover the sliding of metal against metal, or abrasion by lapping or scratching. See Figure 9. Normal wear is the loss of metal from the surface of a gear tooth. It is a result of unavoidable abrasion and occurs at a rate and degree that will not prevent the gear from performing satisfactorily during its expected life.

Fig. 9 Wear.

Maintenance procedure - A certain amount of smoothing and polishing is expected during "running-in" of new gear sets. This type of wear is less noticeable where gears have been shaved or ground-finished during manufacture.

Before gears are put in operation, they should be checked for proper installation and loading to assure that the manufacturer's requirements are met. Ths use of recommended lubricants and filters should eliminate excessive tooth wear during the "running-in" period.

ABRASIVE WEAR is surface injury caused by fine particles carried in the lubricant or buried in the tooth surfaces. The particles may be metal detached from gear teeth or bearings, abrasives not completely removed before assembling, dust and dirt, or other impurities in the oil. See Figure 10.

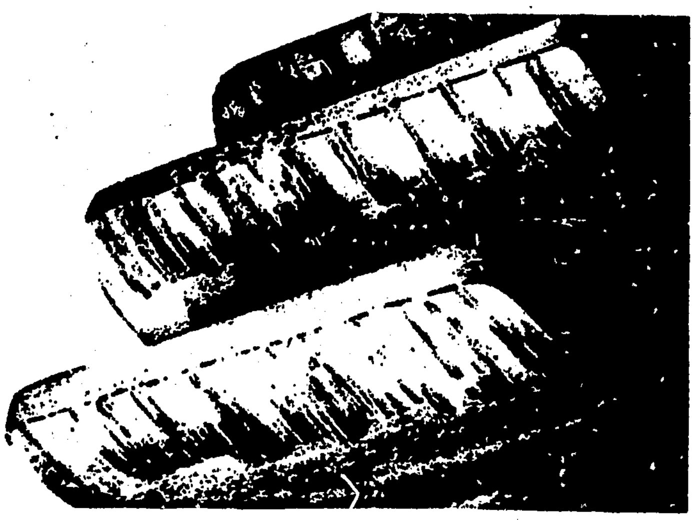


Fig. 10 Abrasive wear.

Maintenance procedure - Whenever abrasive wear is detected the condition should be remedied as follows:

1. The oil should be drained.
2. Remove oil pan and clean.
3. The inside of the housing, gear teeth, and oil passages. should be cleaned, flushed and wiped down.
4. A light flushing oil should be used for a short time, then drained before refilling the reservoir.
5. Check the air system for dirty filters, leaking hoses, etc.; change if required.

6. Check the oil filtering system for proper operation; change filter if required.

SCRATCHING is a form of wear characterized by deep scratches in the direction of surface sliding. It is caused by particles that are larger than those associated with abrasive wear. See Figure 11. Maintenance procedure calls for the same steps that are used for abrasive wear.

OVERLOAD WEAR is a form of wear experienced under conditions of heavy load and low speed. It occurs in both hardened and unhardened gears. Metal seems to be removed progressively in thin layers or flakes, leaving surfaces that appear somewhat as if etched. See Figure 12.

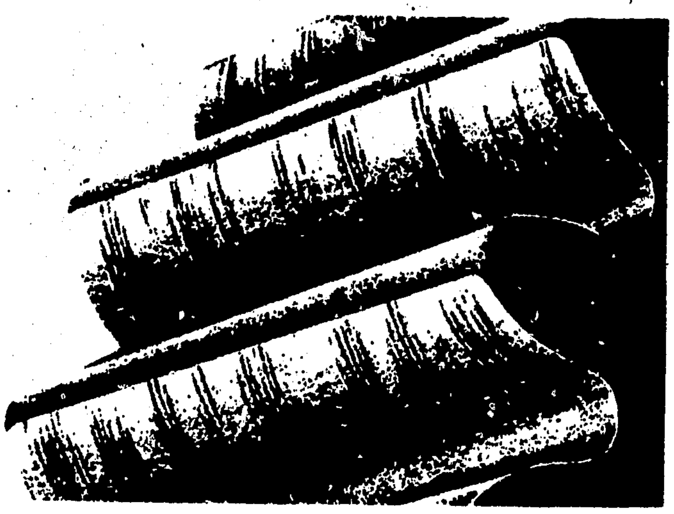


Fig. 11 Scratching.

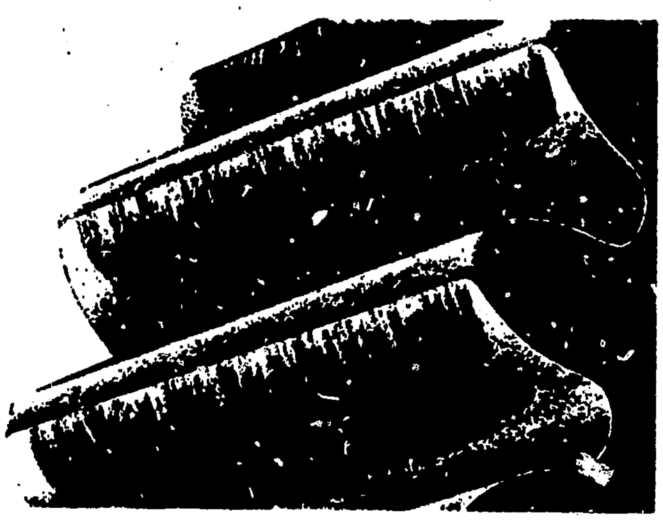


Fig. 12 Overload wear.

Maintenance Procedure - The only permanent remedy for overload wear is to reduce unit loading to the rated capacity of the gears. In some cases, extreme-pressure lubricants may be used to reduce the rate of wear. Care should be exercised to select a lubricant that is free from corrosive substances.

RIDGING is a particular form of scratching wear that usually occurs on case hardened surfaces of hypoid pinions under heavy load. It appears as closely spaced grooves in the direction of surface sliding. See Figure 13.

Maintenance Procedure - Since ridging usually results from localized loading, wherever possible gears should be adjusted to distribute the load more evenly over the full tooth surface. In some cases the use of an extreme-pressure lubricant may help to reduce the rate of tooth-surface deterioration. With bevel gears, backlash should be altered to reduce impact loading.

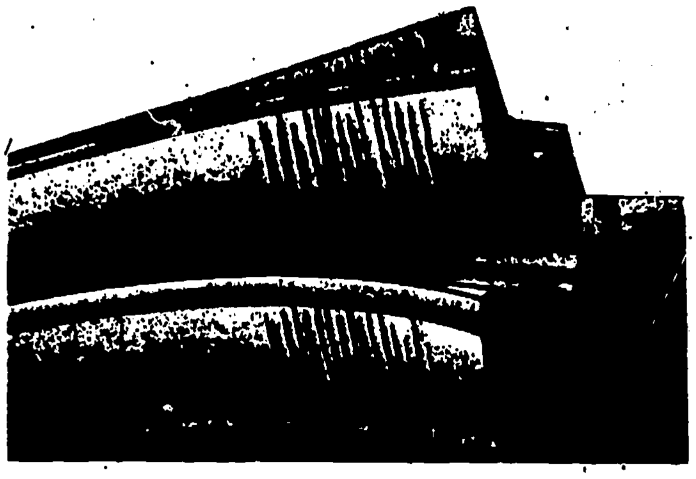


Fig. 13 Ridging.

PLASTIC YIELDING is a deterioration of tooth surfaces resulting from heavy loads, characterized by fins on the tip edges or ends of teeth (not to be confused with burrs from shaving the teeth in manufacture) and an occasional ridge and matching groove on the mate at the pitch line. It is usually associated with ductile materials but actually occurs with hardened steel as well.

Rolling is a form of plastic yielding resulting from heavy, even loads and sliding. See Figure 14.

Peening is a form of plastic yielding caused by uneven heavy or shock loads. The effect is that of a series of "hammer blows" resulting in flattening of tooth surfaces at irregular intervals.

WELDING is a general kind of surface deterioration. It occurs when pressure, sliding, and temperature rise combine and cause the lubricating film to be forced out from between the teeth. This action allows metallic surfaces to rub directly against each other to the extent that molecular adhesion, or welding, occurs - followed by immediate tearing apart. It is usually the result of excessive loading and inadequate lubrication or relatively soft gear sets.

SLIGHT SCORING or GALLING, as shown in Figure 15, is a minor impariment showing slight tear and scratches in the direction of sliding. It usually starts at a surface area where there is a combination of high surface stress and sliding velocity -- generally occurs at or near the tooth tip.

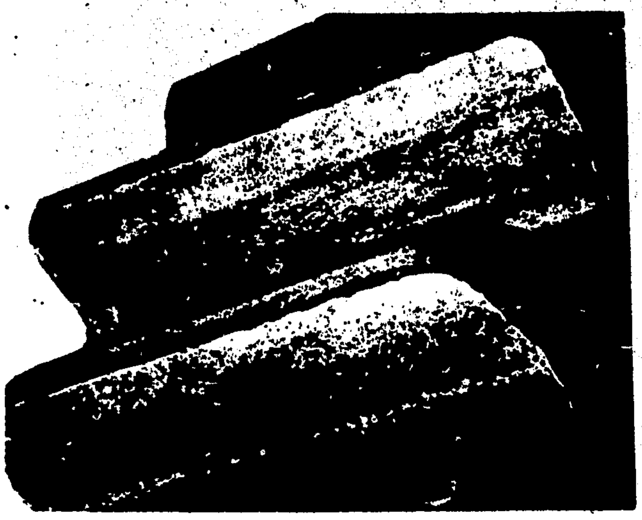


Fig. 14 Rolling

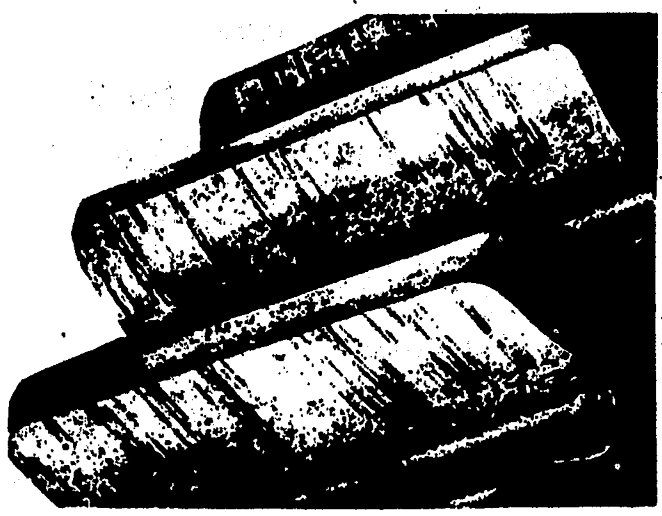


Fig. 15 Slight scoring and galling.

Maintenance Procedure - Slight scoring or galling may be resulting from the use of an incorrect lubricating oil. Check the maintenance manual for the proper oil.

SEVERE SCORING, or GALLING, as shown in Figure 16, is a more advanced degree of welding, showing deep scratches and adhesions leading to rapid deterioration. Maintenance procedure is the same as for slight scoring.

TOOTH CRACKING or actual breakage is the end result of gear tooth deterioration. These conditions are shown here for identification purposes only. When the teeth are found to be in this condition, no amount of preventive maintenance will correct them. The usual procedure is to replace the gear and eliminate the cause of the conditions. Cracking, as shown in Figure 16, results from stresses that develop from too soft a core or some other form of improper heat treatment.

FATIGUE BREAKAGE results from a large number of repititions of a load. See Figure 17. The break starts as a short crack which continues to extend until a portion, or a whole tooth, breaks away. Discoloration and rubbing on the fractured surfaces are indications of fatigue breakage.

Fig. 16 Cracking

Fig. 17 Fatigue breakage.

We have so far discussed each of the failures listed above as occuring separately. This is not always the case in practice. Two or more failures may occur during the same period. One condition may be the cause of another condition developing.

SECTION C -- INSPECTING FOR SHAFT FAILURES

SHAFT FAILURES -- An extensive discussion of engine crank shaft failures has already been covered in Unit AM 1-9. As you recall, shaft failures are largely due from operating the engine at critical or torsional speeds and from fatigue failure. Other reasons for shaft failure are:

1. Journal bearing failure, resulting from lube oil breakdown or dirt.
2. Excessive bearing clearances.
3. Improper functioning of the torsional vibration damper.
4. Overtightening belts (especially on GM engines)

SECTION D -- USING SNAP RINGS TO POSITION GEARS OR BEARINGS

SNAP RINGS, or lock rings as they are sometimes called, are generally used for economy reasons. Their use as "artifical shoulders" eliminates additional machining of shafts. Also it is a quick way of mounting bearings, gears, and pulleys. Figure 18 shows the components used in mounting the belt-driven accessory to a drive shaft.

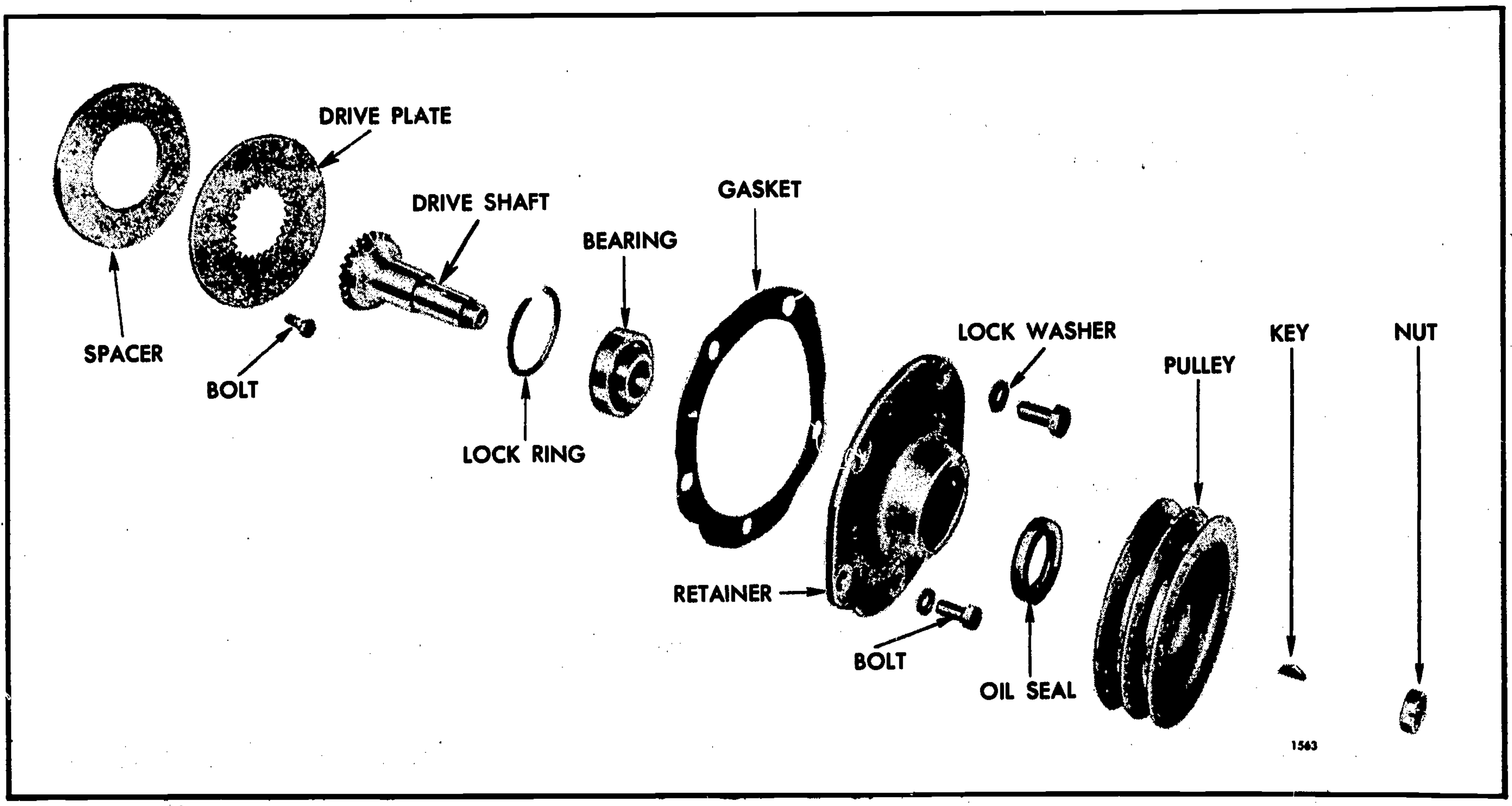
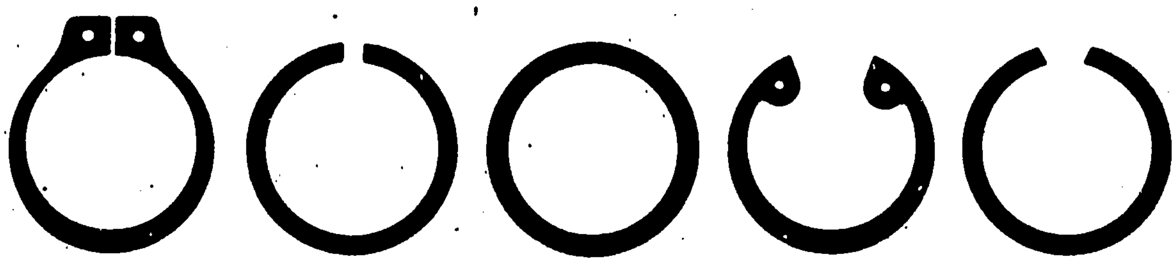


Fig. 18 Components of accessory drive mounting.

Snap rings are used only where radial load is a factor and thrust load is normal.

WHAT IS A WELL DESIGNED SNAP RING? The characteristics of a well designed snap ring are: (1) the ring should have no tendency to spring out of its groove under severest conditions of operation; (2) the ring should be elastic enough to snap back fully into the groove; (3) dimensions and tolerances should have sufficient looseness for facility in assembly, and on the other hand should not permit an axial movement of the shaft; (4) the ring should be easily removable with ordinary tools. The widest opening of the ring should not result in fiber stresses over 200,000 pounds per square inch. All rings are made from a spring steel of proper analysis.

Snap rings are of two kinds: external for use on shafts; and internal for use in housing. The chief difference between the two kinds is the gap which provides for easy assembly and disassembly on the shaft or in the housing. Figure 19 (a) and (b) show commonly used external designs. Type (b) is the one pictured in Figure 18. Figure 19 (c) shows a design for both internal and external use; (d) and (e) show internal types.



(a) (b) (c) (d) (e)

Fig. 19 Snap or lock rings.

Snap rings also differ in design of cross section. The external snap rings in general have square corners, and the internal snap rings have round corners. Also, external snap rings generally have a heavier cross section.

HINTS ON HANDLING OF SNAP RINGS -- The mechanic should exercise care in the handling of snap rings since they may be damaged or broken in the assembly or disassembly operation. The tools most frequently used are screwdrivers and pliers. Some maintenance men make their own snap ring tools, or buy special tools especially designed for assembling and disassembling snap rings.

POINTS TO REMEMBER in using snap rings:

1. Do not twist ring out of shape.
2. Do not mar corners of ring or ring groove.
3. Do not yank ring open in spreading.
4. Do not tap OD of ring after shaft assembly.
5. Do not jam screwdriver into the bearing.
6. When assembling, maintain a clearance between the ring and shaft.
7. Keep tools and hands clean.

II -- MACK INTER-AXLE POWER DIVIDER

SECTION A -- OPERATING PRINCIPLES

The purpose of the MACK Inter-Axle Power divider is to divide the driving power from the input shaft equally between the front and rear axles on a four wheel drive bogie. The same result is obtained on units using the Euclid power divider, with the exception that the latter has to be operated manually from the cab, whereas the Mack unit is automatic.

When operating the truck under normal conditions, the power divider acts in the same way as the familiar bevel-gear differential, maintaining equal torque on both axles while permitting differences in speed between the two axles at a constant average speed. However, when traction on one axle is lost, its wheels will not spin. Most of the torque is delivered to the axle that still has traction, so the vehicle continues in motion. There is an exception to this, which we will cover later after examining the internal parts of the divider.

As used in the inter-axle location, the power divider is located just ahead of the forward bogie axle pinion housing; see Figure 20 and Figure 21.

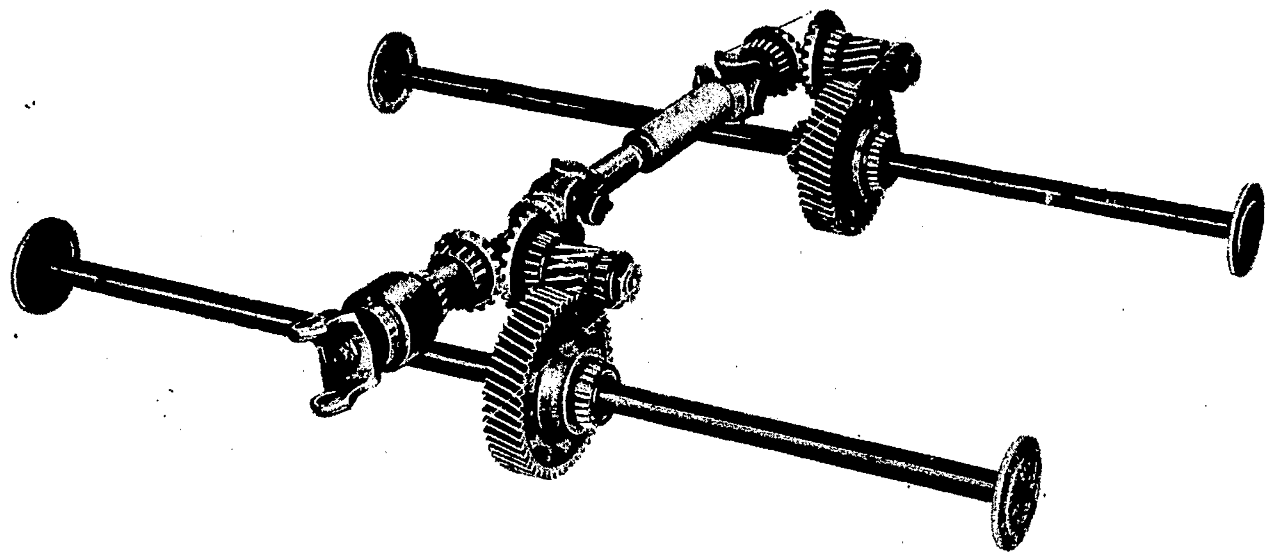


Fig. 20 Cutaway of the power divider set-up.

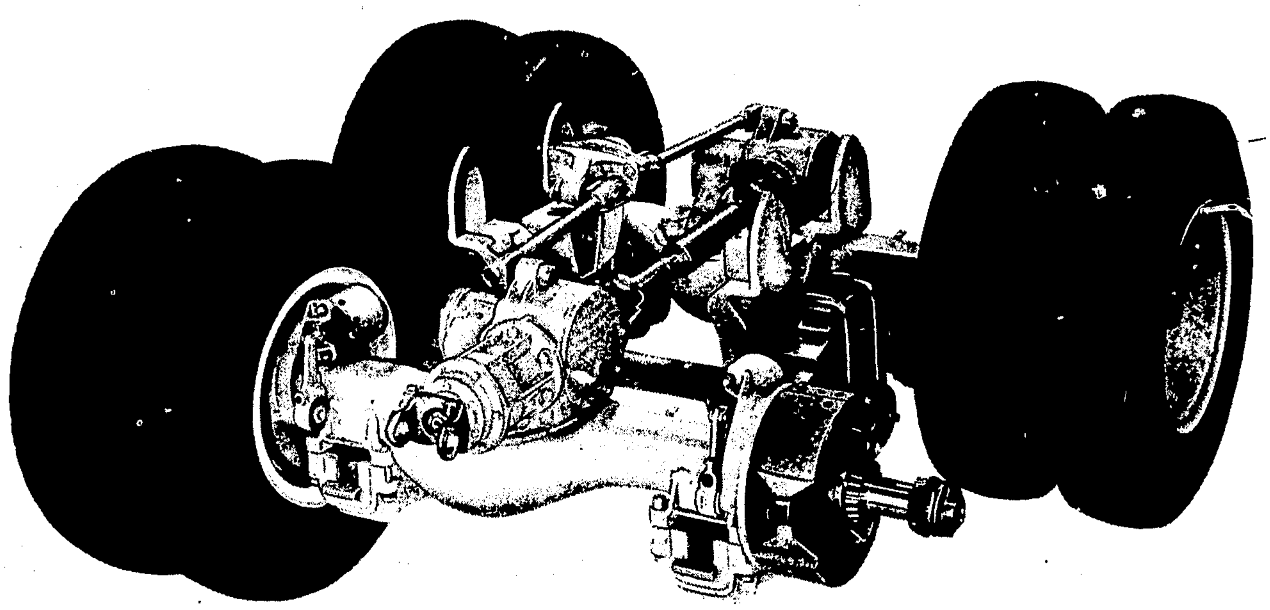


Fig. 21 Four wheel bogie with a power divider.

Three main elements make up the power divider: A driving member and two driven members. The driving member is a wide ring or cage carrying twenty four short radial plungers (dogs) in two rows,which are free to slide in a short distance inward or outward as in Figure 22. It is important to remember that the cage rotates whenever the driveshaft from the transmission is rotating. Again, this part of the divider is the driving member.

The driven members are an inner cam and an outer cam; see Figure 23. Each cam (inner and outer) has its own driving shaft which can rotate independently. The inner cam and shaft drive and near axle, while the outer cam and shaft drive the front axle; see Figure 20.

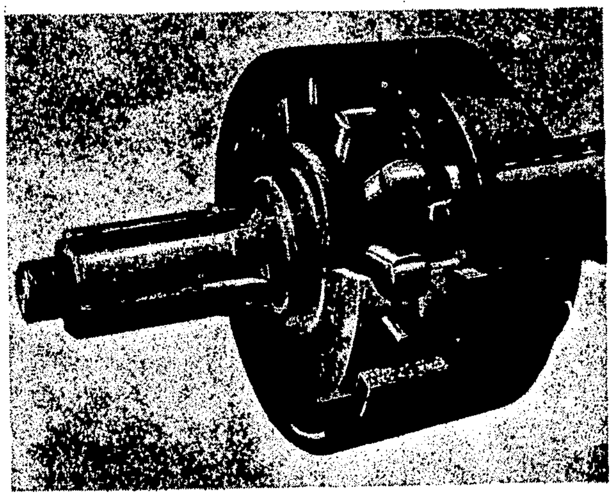


Fig. 22 Cage and plungers of the power divider.

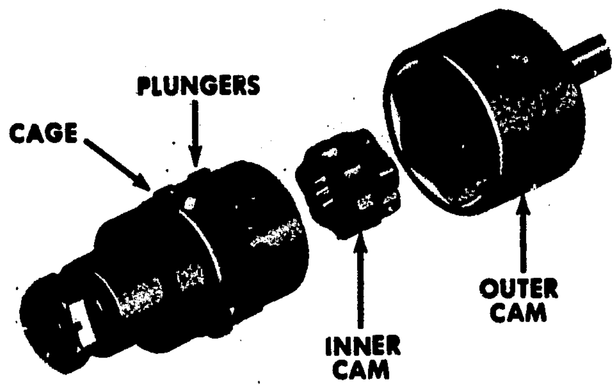


Fig. 23 Parts of the power divider.

Assembled, the inner cam is placed within the ring of plungers, and the outer cam surrounds them; see Figure 23.

OPERATION -- As the drive shaft turns the cage, the twenty four chisel nosed plungers turn also. These plungers are always in contact with both the inner and outer cams. Because of their angles of contact, they cause the two cams to be carried around with the cage, the whole assembly normally rotating as a unit, driving the two axles at the same speed.

As the driving cage containing the plungers rotates, the hills and valleys of the inner and outer cams cause the plungers to move in and out.

However, the lobes of the inner cam are arranged alternately, or staggered; see Figure 24 (a). Therefore, the inward motion of a plunger - as it surmounts the crest of one lobe - causes outward motion at the other, so that it forces the other cam to turn in the opposite direction.

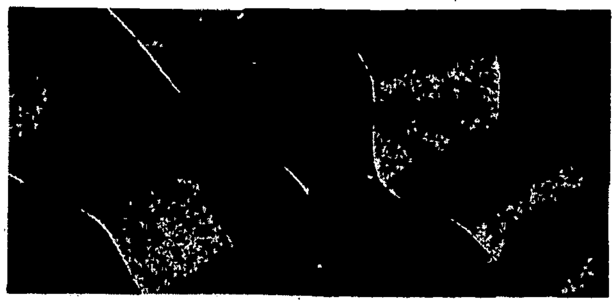


Fig. 24 Staggered hills and valleys of the cams.

RESISTANCE -- When more resistance is offered by one set of wheels than the other set, such as a vehicle moving over a curb, the action of the power divider is set in motion. One cam will overrun the speed of the cage while the other lages behind. The cut or taper of the plungers are designed to establish a torque bias of 3 to 1. This means that when one axle offers less resistance to forward motion than the other (in this case it would be the one not trying to climb the curb) the torque delivered to the other is three times greater. Therefore, it is possible to get 3 to 1 ratio of torque differential between the two axles.

ZERO RESISTANCE -- As long as there is some resistance on one of the bogies, the truck will move. However, as we mentioned earlier, there is one exception to this movement. Suppose we had no resistance on one of the bogies. Say one set of wheels were off the ground (jacked up), or one axle were broken. Then we can see that the ratio would be: 3 x 0 = 0. The cage and plungers are still rotating, but the plungers are situated in such a position that they slide over both the inner and outer cam lobes, failing to trun either shaft. How, then, could we move the truck from the jack? Right - gently depress the brakes. This gives enough resistance to the wheels off the ground to enable a ratio to again be present. The truck would then move off the jacks.

On rare occasions this situation occurs on ice. By applying the same driving techniques as above, the vehicle may be moved with a broken axle, the broken shaft or axle has to be chained up to permit moving the vehicle.

SECTION B -- REPARING THE MACK POWER DIVIDER

IN PLACE -- All maintenance on Mack power dividers is done in place on the vehicle. On occasion it may be necessary to remove the unit for purposese of gear changing, bearing removal, etc., but generally this also can be accomplished in place.

PART FAILURES -- Usually the input shaft support bearing will fail, or the wedges (plungers) become worn. The inner axle sometimes fails, as well as the outer axle. As usual, when any one part fails, the entire unit is checked for wear while the truck is in the shop and the unit is open.

This has been a brief discussion on the Mack power divider. The next time one is open and available for your inspection, try to visualize in your mind how and why this unit works the way it does.

DIDACTOR PLATES FOR AM 1-18D

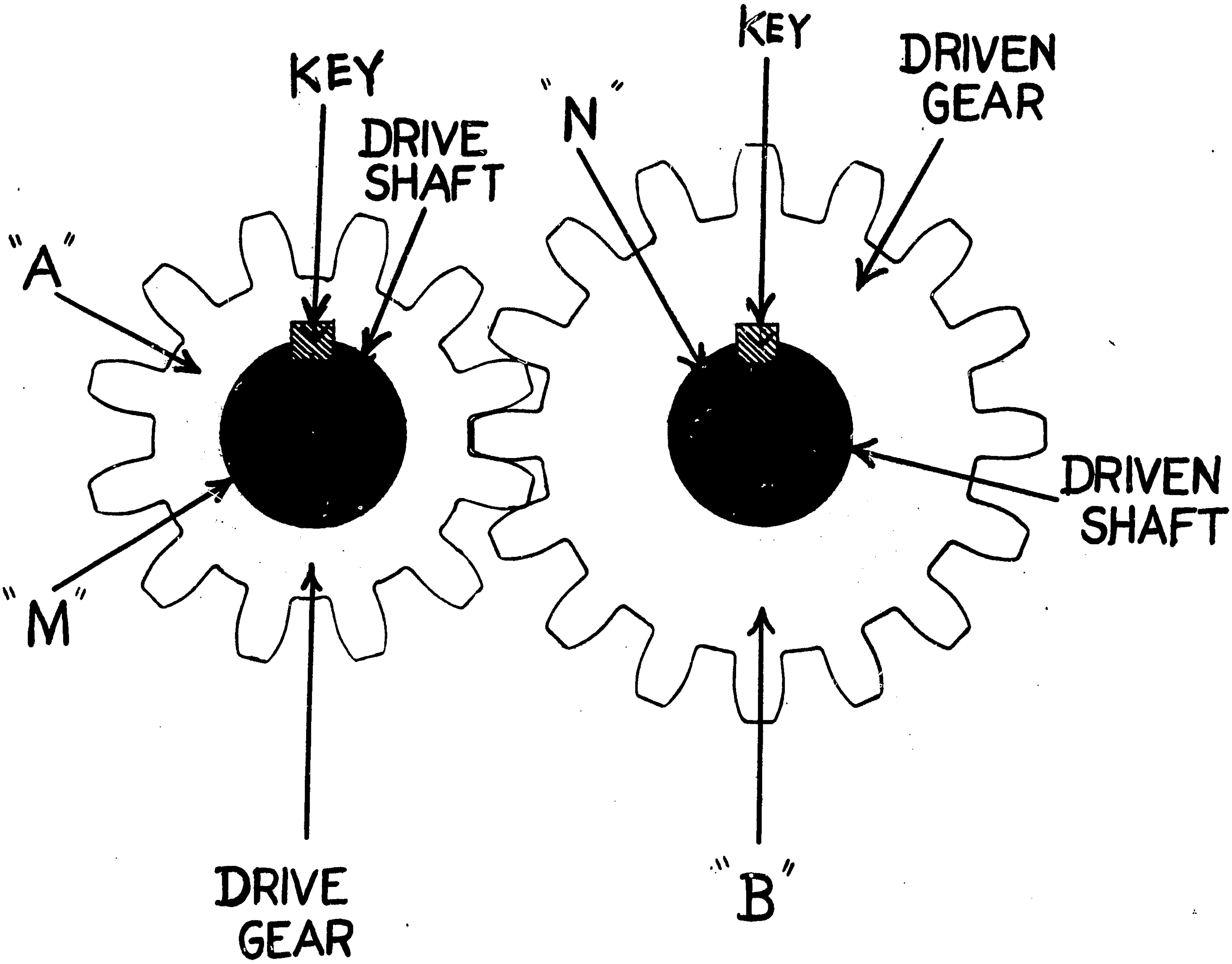


Plate I Drive and driven gears and shafts.

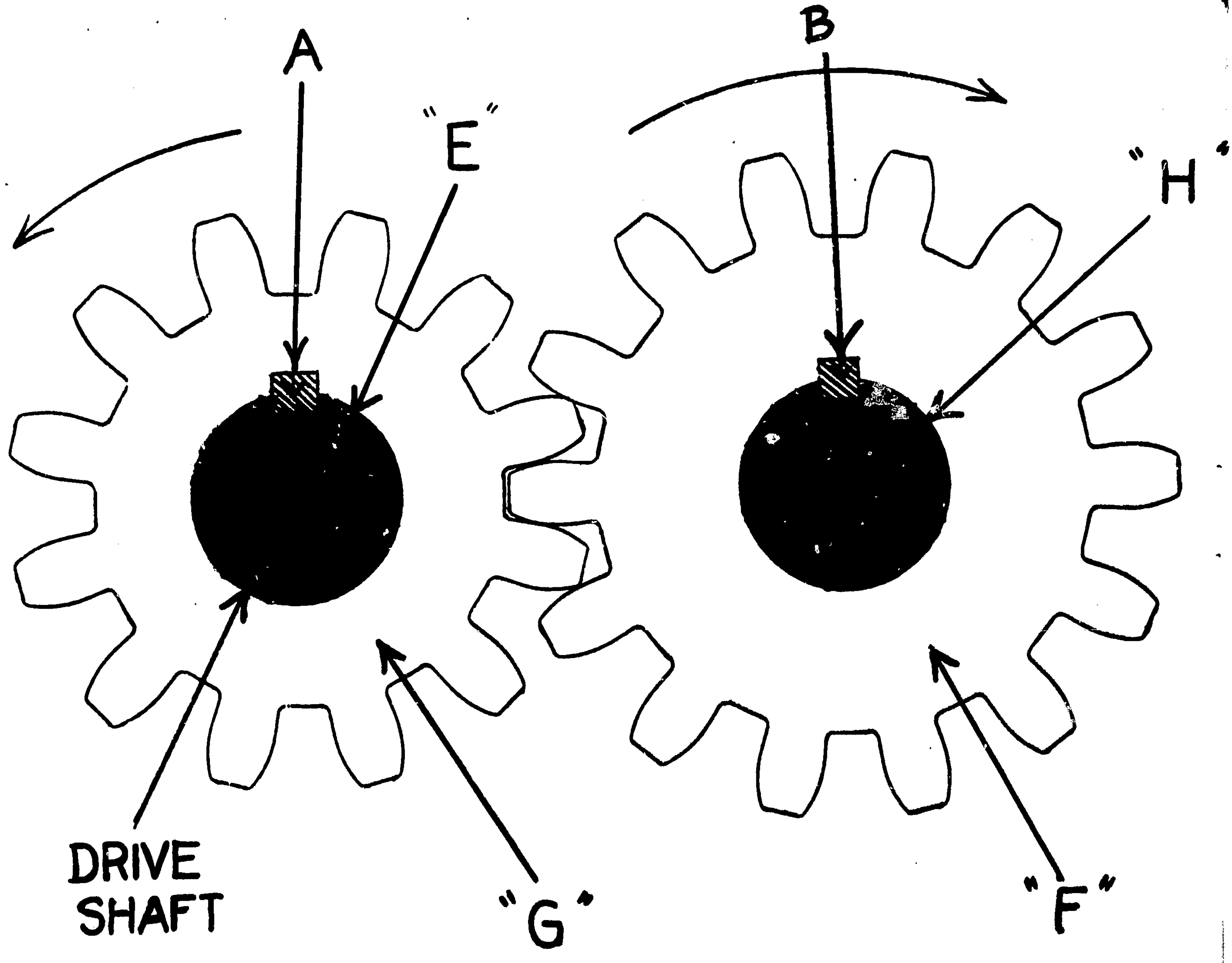


Plate II Rotation of gears and shafts.

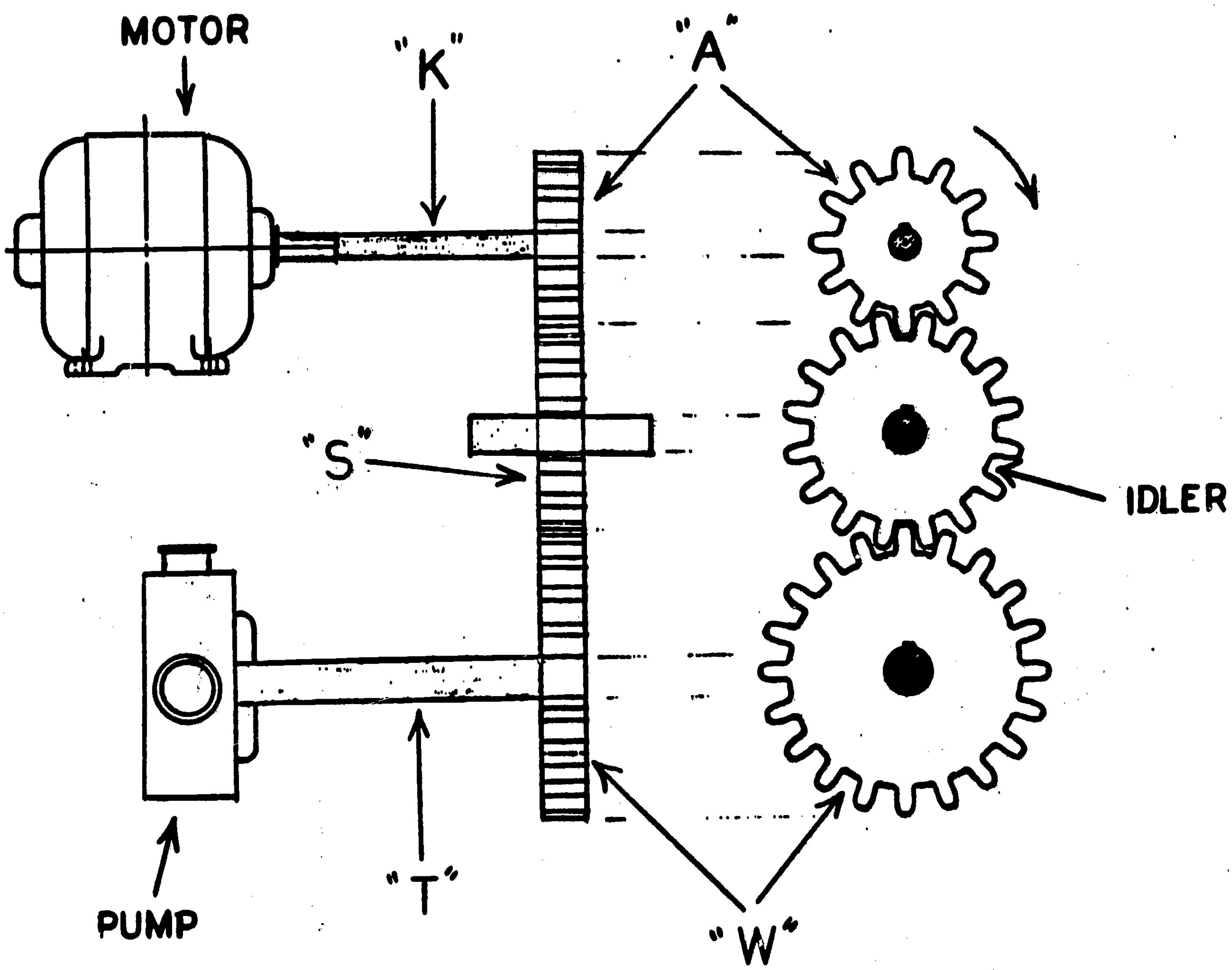


Plate III Idler gear.

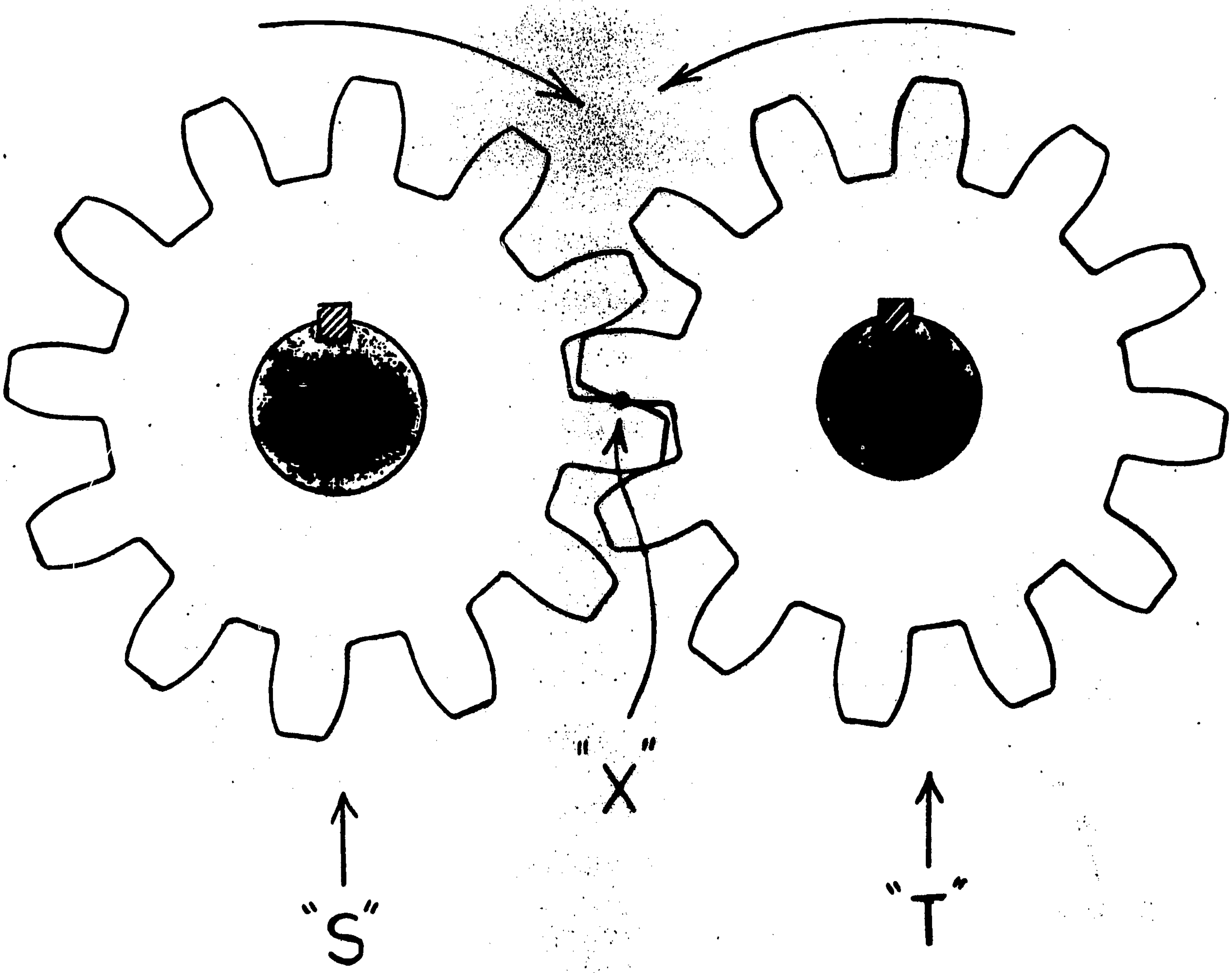


Plate IV Gear ratios.

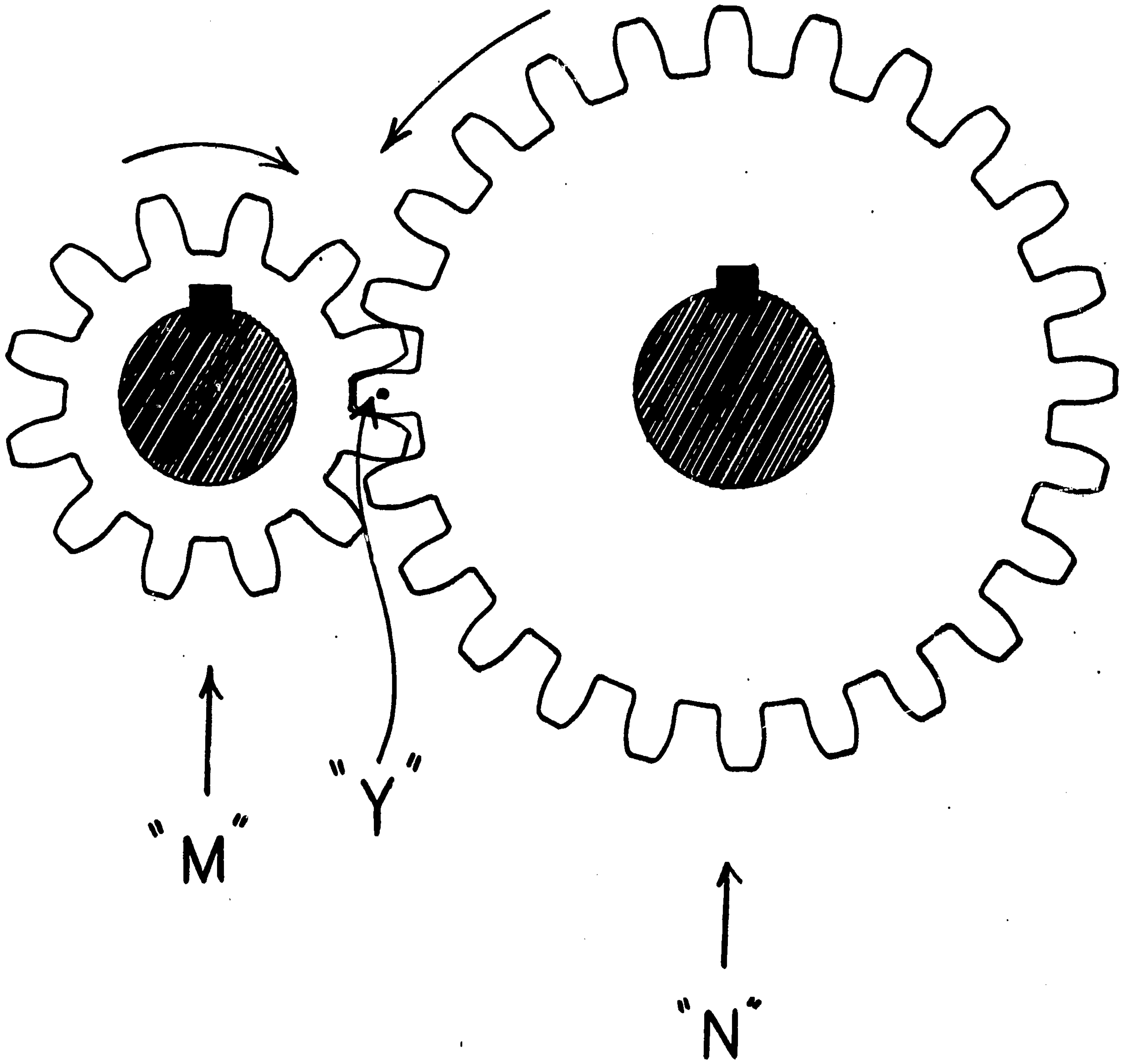


Plate V Gear ratios.

0

AM 1-18D
5/20/66

UNDERSTANDING GEARS AND GEAR RATIOS

Human Engineering Institute

Press A — 1 Check to see that timer is OFF

1

1

In the class session we talked of engine gear trains, their purpose, how auxiliary drives function, and what to look for when gears fail.

In this film we shall discuss principles of drive and driven gears, shafts, the direction of rotation, idle gears, gear ratio, gear speed, and speed ratio.

Read carefully and take your time in answering the questions.

Press A — 2

1

2

Turn to Plate I in Unit AM 1-18. This is a sketch of two spur gears, showing a drive gear, drive shaft, driven gear, and a driven shaft.

Identify them. Take a good look.

Are these gears in mesh? (The film will move only when you answer this question correctly).

A. No — 4
B. Yes — 3

1

3

OK. The SPUR GEARS in Plate I are in mesh.

What part of the gear train does the letter "A" point to?

A. The key and the keyway. — 4
B. The driven gear. — 5
C. The drive gear. — 6

1

4

No. You were sharp to notice the key in Plate I: however, the arrow "A" does not point to either the key or the keyway.

The letter "A" points to the DRIVE GEAR. Look and see.

Press A — 6

1

5

No.

There are two gears shown in Plate I. The arrow from letter "A" points to the DRIVE GEAR, the smaller of the two gears.

Take a good look.

Press A — 6

1

6

O.K. The letter "A" points to the smaller of the two gears shown in Plate I, the DRIVE GEAR.

To what does the arrow from the letter "M" point?

A. The drive gear. — 7
B. The drive shaft. — 9
C. The driven gear. — 8

1

7

Your answer is incorrect.

Look at Plate I carefully. The arrow from letter "M" points to the DRIVE SHAFT. The drive gear is on the drive shaft.

Press A — 9

1

8

Your answer is incorrect.

Look at Plate I again. Now, look at the letter "M" and the arrow carefully.

Letter "M" points to the DRIVE SHAFT. Notice that the drive shaft is within the smaller of the two gears, the drive gear.

Press A — 9

1

9

O. K. The letter "M" points to the DRIVE SHAFT.

The film will move only when you complete the sentence below correctly.

The drive gear ______________________ the drive shaft.

A. is loose on —|
B. is fastened to. — 10

1

10

OK. The drive gear is fastened to the drive shaft.

How is the drive gear fastened to the drive shaft? (Look at Plate I).

A. With a spot weld.
B. It is pressed on. > 11
C. With a key. — 12

1

11

No. Where gears are subject to stress and vibration under load as in a diesel engine, a press fit or spot weld would hold for only a short time.

In Plate I, the drive gear is fastened to the drive shaft with a KEY.

Look at the arrow pointing to the KEY.

Press A — 12

1

12

O. K. The drive gear is fastened to the drive shaft with a KEY.

What will the drive gear do when the drive shaft rotates? (The film will move only when you press the correct answer.)

A. The drive gear will rotate with the shaft. — 13
B. The drive gear [illegible]ll remain motionless. —|

1

13

Right. The drive gear will rotate when the drive shaft rotates because the drive gear is fastened to the drive shaft with a key.

Look at Plate I again.

What part of our gear train does the letter "B" point to?

A. The drive gear.
B. The drive shaft. > 14
C. The driven gear. — 15

1

14

No. The arrow from the letter "B" points to the DRIVEN gear.

Look at Plate I carefully so that you can be sure "A" points out the drive gear.

Press A — 15

1

15

O. K., the arrow from the letter "B" points to the DRIVEN gear.

Note that the DRIVEN gear is larger than the drive gear in Plate I. To what part of the gear train does the letter "N" point?

A. The driven shaft. — 17
B. The drive gear.
C. The drive shaft. > 16

1

16

Your answer is incorrect. Look carefully at Plate I and at the letter "N".

Letter "N" points to the DRIVEN shaft.

Did you see that the driven gear (B) is larger than the drive gear (A)?

Press A — 17

1

17

O.K., the letter "N" points to the DRIVEN shaft. And the driven gear is larger than the drive gear.

Note also that the driven gear is fastened to the driven shaft with a key.

When the drive gear rotates, what will happen to the driven gear?

A. The driven gear will remain stationary. — 18
B. The driven gear will rotate in the opposite direction. — 19
C. The driven gear will rotate in the same direction. — 18

1

18

No. The drive gear and the driven gear are in mesh. Therefore, when one rotates the other must rotate.

The drive gear and driven gear in Plate I rotate in opposite directions. Try to imagine how they would look in motion as they turn, in actual operation.

Press A — 19

1

19

O.K. When the drive gear rotates, the driven gear must rotate.

Rotation of the drive and driven gears in Plate I is in opposite directions.

When the driven gear rotates, what will happen to the driven shaft?

A. The driven shaft will rotate. — 21
B. The driven shaft will remain motionless.
C. The driven shaft will rotate in the opposite direction from the driven gear. 20

1

20

Your answer is incorrect. When the driven gear rotates, the driven shaft will rotate, because the driven gear and shaft are fastened together with a key.

The driven shaft and gear will rotate in the same direction also because they are fastened together with a key.

Go back and select the correct answer.

Press A — 19

1

21

Correct. When the driven gear rotates, the driven shaft will rotate because the driven gear and shaft are fastened together with a key.

The film will move when you answer the question below correctly.

When a drive shaft rotates, what parts below will rotate also?

A. The drive gear.
B. The driven gear.
C. The driven shaft.
D. All of them. — 22

1

22

You are correct.

We have started to review drive gear and shaft, driven gear and shaft, and keys.

Because you have made one or more errors, we'll go back and review this section again.

Press A — 2

1

23

You are correct.

We have started to review drive gear and shaft, driven gear and shaft, and keys. We know that the drive gear and shaft are fastened together with a key. Therefore when the drive shaft turns, the drive gear turns and they rotate in the same direction.

We also know that when the drive gear turns the driven gear also must turn if the drive and driven gear are in mesh.

Now look at Plate II.

Press A — 24

2

24

Plate II is like Plate I except that Plate II has arrows to indicate which way the parts are rotating.

Note that Plate II has a drive and a driven shaft, a drive and a driven gear, and keys.

Which part does the arrow from the letter "E" point to?

A. Drive gear. - 25
B. Drive shaft. - 26
C. Driven shaft. - 25

2

25

No.

Look at Plate II again.

In this sketch of two gears, the arrow from the letter "E" points to the drive shaft.

Press A - 26

2

26

O. K., the letter "E" points to the drive shaft in Plate II.

To what part of the gear train does the letter "G" point?

A. The drive gear. - 28
B. The drive shaft. } 27
C. The driven shaft. } 27

2

27

Your answer is incorrect.

Look at Plate II again.

The arrow from the letter "G" points to the DRIVE gear.

Press A - 28

2

28

O.K., the letter "G" points to the drive gear. There are two ways to tell that "G" is the drive gear: note that "E" is the drive shaft (if "E" is the drive shaft, "G" must be the drive gear). Also note that "G" is the smaller of the two gears (in Plate I, the smaller of the two gears is the drive gear).

What does the letter "F" point to in Plate II?

A. The keys. } 29
B. The drive gear. } 29
C. The driven gear. - 30

2

29

The letter "F" points to the driven gear.

We know that "F" is the driven gear because "G" is the drive gear. "G" is the drive gear; therefore. "F" has to be the driven gear.

Press A - 30

2

30

O.K., the letter "F" points to the driven gear.

To what part does the letter "H" point?

A. The drive gear. - 31
B. The driven shaft. - 32
C. The driven gear. - 31

2

31

Your answer is wrong. The letter "H" points to the driven shaft.

We know that "H" is the driven shaft because "F" is the driven gear; and we know that "F" is the driven gear because "G" is the drive gear.

Press A - 32

2

DIDACTOR

32

O.K., the letter "H" points to the driven shaft.

The curved arrows on this sketch indicate that parts are rotating.

Name the parts below that are rotating.
(The film will not move unless you answer the question below correctly.)

A. The drive shaft.
B. The drive gear.
C. The driven shaft.

E. The drive shaft, the drive gear, the driven gear, and the driven shaft are all rotating. - 33

2

33

Your answer is right. The drive shaft, the drive gear, the driven gear, and the driven shaft are all turning in the sketch in Plate II.

Gears TRANSMIT motion (torque or speed) from one shaft to another.

What parts do the arrows from "A" and "B" point to and what do those parts do?

A. The arrows from "A" and "B" point to keys. They fasten the gear to the shaft. - 36
B. The arrows from "A" and "B" point to gears. They transmit motion from one shaft to another. — 35
C. The arrows from "A" and "B" point to shafts. They transmit motion from one gear to another. - 35

2

34

You did not answer the question correctly. Look at Plate II again.

The arrows from "A" and "B" point to keys. The keys fasten the gears to the shafts.

Gears do transmit motion from one shaft to another, but "A" and "B" do not point to them.

Press A - 36

2

35

Your answer was wrong. Look at Plate II again.

The arrows from "A" and "B" point to keys. The keys fasten the gears to the shafts.

The second statement about shafts was also wrong since all that a shaft usually does is support the gear.

Press A - 36

2

36

O.K., "A" and "B" point to the keys; the keys fasten the gears to the shafts.

What are gears used for?

A. Gears are used to support the shafts of a gear reducer. - 37
B. Gears are used to transmit motion (speed or torque) from one shaft to another. — 38
C. Gears are used to hold the shafts in place. — 37

2

37

Your answer could have been better. Gears are used mainly to transmit motion (speed or torque) from one shaft to another.

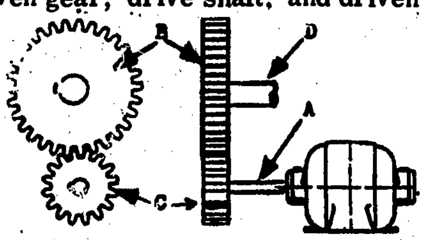
Press A — 38

2

38

O.K., gears are used to transmit motion (speed or torque) from one shaft to another.

In this two view sketch, identify (by letter) the drive gear, driven gear, drive shaft, and driven shaft.



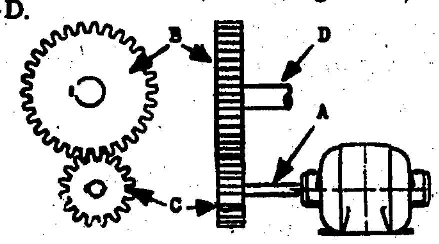
A. Drive shaft-D, drive gear-B, driven gear-C, driven shaft-A.
B. Drive shaft-D, drive gear-A, driven gear-C, driven shaft-B.
> 39
C. Drive shaft-A, drive gear-C, driven gear-B — 40
driven shaft-D.

2

39

Your answer is incorrect. Look again. Now identify the parts and follow the action, starting from the motor:

Drive shaft-A, drive gear-C, driven gear-B, driven shaft-D.



Now go back and pick the right answer.

Press A - 38

2

40

Very good, your answer is correct.

Now, what are gears used for?

A. To transmit motion (speed or torque) from one shaft to another. — 42

B. ~~To transmit force from one shaft to another.~~

C. To transmit speed from one shaft to another. > 41

2

41

Your answer is partly right. Gears are used to TRANMSIT MOTION (speed or torque) from one shaft to another.

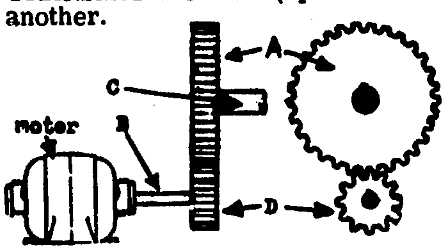
Press A — 42

2

42

O. K., gears are used to TRANSMIT MOTION (speed or torque) from one shaft to another.

Now, in this two view sketch, identify parts A, B, C, D.



44 A. driven gear-A, drive shaft-B, driven shaft-C, drive gear-D.

43 B. drive gear-A, driven shaft-B, drive shaft-C, driven gear-D.

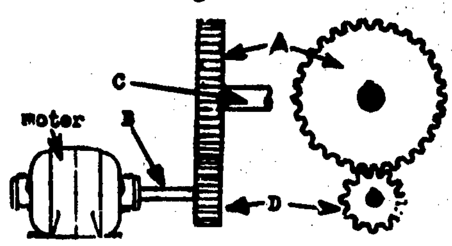
C. driven gear-A, driven shaft-B, drive shaft-C, drive gear-D

2

43

Your answer is incorrect. You're having a little trouble identifying these parts.

Maybe this will help you: The drive shaft is the shaft coming off the electric motor; so B is the drive shaft. The drive gear is the gear on the drive shaft; so D is the drive gear. The driven gear meshes with the drive gear; so A is the driven gear. The driven shaft comes off the driven gear; so, C is the driven shaft.



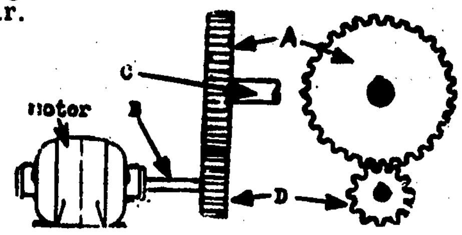
Try again.

Press A — 42

2

44

Very good, your answer is correct. The drive shaft (B) is connected to the motor. The drive gear (D) is on the drive shaft. The driven gear (A) meshes with the drive gear. The driven shaft (C) comes off the driven gear.



Note in this speed reduction gear train that the driven gear is larger than the drive gear.

In the next section we will review the direction of rotation and idler gears.

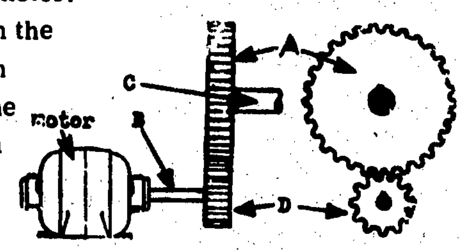
Press A — 46

✓ (c) → 45

2

45

Very good, your answer is correct. The drive shaft (B) is connected to the motor. The drive gear (D) is on the drive shaft. The driven gear (A) meshes with the drive gear. The driven shaft (C) comes off the driven gear.



The identification of the drive shaft and gear, and the driven shaft and gear is important, so we will review.

Press A → 24

2

46

Look at Plate II again.

In this sketch, the curved arrow above the drive gear shows that the drive gear is rotating in a counter-clockwise direction.

In what direction is the driven gear rotating?

The film will advance only when you select the correct answer.

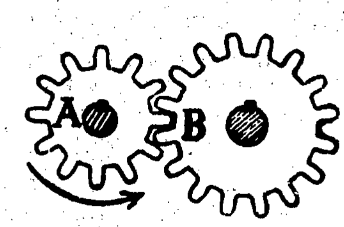
A. Counterclockwise. —|

B. Clockwise. — 47

3

47

Two gears mesh, rotate in opposite directions. Gear "A" is rotating in a counter-clockwise direction.



The direction of rotation of gear "B" is ___________.

A. The same direction of rotation as gear "A". — 48

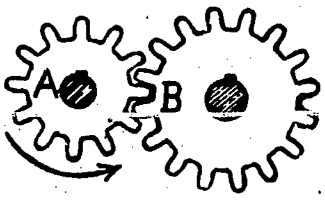
B. Clockwise. — 49

C. Counterclockwise. — 48

3

48

Your answer is incorrect. Two gears in mesh rotate in opposite directions. Therefore, if gear "A" is rotating in a counterclockwise direction, gear "B" is rotating in a clockwise direction.



Press A — 49

3

49

O.K.

Now if a drive gear rotates clockwise, what will the driven gear do?

A. It will rotate in the same direction as the drive gear.
B. It will rotate clockwise.
C. It will rotate counterclockwise. — 51

3

50

No. If the drive gear and the driven gear are in mesh, they will rotate in opposite directions.

This means that if a drive gear and a driven gear are in mesh and if the drive gear rotates clockwise, the driven gear will rotate counterclockwise or in the opposite direction.

Press A — 51

3

51

O.K.

Now, when two gears are transmitting motion (speed or torque) from one shaft to another, the direction of rotation of the driven shaft is __________ the direction of rotation of the drive shaft.

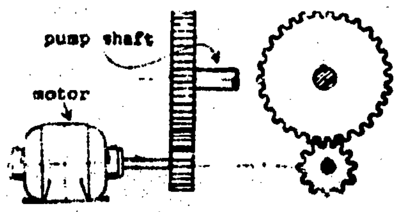
A. the same as — 1
B. the reverse of — 52

(The film will move only when the right answer is pressed.)

3

52

The motor shown here rotates in a clockwise direction.



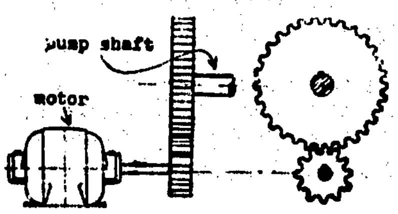
What is the direction of the rotation of the pump shaft?

A. The same direction as the motor. — 53
B. It will rotate in a counterclockwise direction. — 54
C. It will rotate in a clockwise direction. — 53

3

53

You have made an error. Since the drive gear and the driven gear are in mesh, they will rotate in opposite directions.



This means that if the motor is rotating in a clockwise direction, then the pump shaft is rotating in a counterclockwise direction.

Press A — 54

3

54

O.K.

Now look at Plate III.

This is a two view sketch of a motor and pump assembly.

The letter "K" points to the _____(1)_____.

The letter "A" points to the _____(2)_____.

A. (1) drive shaft (2) drive gear. — 56
B. (1) drive shaft (2) driven gear. — 55
C. (1) driven shaft (2) driven gear. — 55

3

55

Your answer is incorrect. It is the drive shaft that comes off the motor. The gear on the drive shaft is the drive gear.

Now look at the motor and pump assembly on Plate III again.

The letter "K" points to the drive shaft and the letter "A" points to the drive gear.

Press A — 56

3

56

O. K.

Look at Plate III again and complete these sentences.

The letter "T" points to the ______(1)______.

The letter "W" point to the ______(2)______.

A. (1) drive shaft (2) drive gear. >57
B. (1) drive shaft (2) driven gear. >57
C. (1) driven shaft (2) driven gear. — 58

3

57

No. The driven shaft is the output shaft and the driven gear is the output gear.

Since "T" goes out to the pump, it is the output shaft or the driven shaft.

Since "W" is the output gear, it is the driven gear.

Press A — 58

3

58

O. K.. the driven shaft ("T") is the output shaft and the driven gear ("W") is the output gear.

Now. look at Plate III again.

The letter "S" points to the idler.

The idler (idler gear) is between the ____(1)____ and the ____(2)____.

A. (1) drive shaft (2) drive gear — 59
B. (1) drive gear (2) driven gear — 60
C. (1) driven shaft (2) driven gear — 59

3

59

Your answer is wrong.

Look at Plate III again.

The idler (idler gear) is the gear between the drive gear and the driven gear.

Press A — 60

3

60

O. K.. the idler is the gear between the drive gear and the driven gear. Note that the drive gear in the sketch is smaller than the driven gear.

In machinery where the drive gear and driven gear are too far apart to mesh, one or more idlers are used to "bridge the gap". Idlers are also used to control the direction of rotation of the driven gear.

What does the letter "S" point to in the sketch in Plate III ?

A. The drive gea >61
B. The driven gear. >61
C. The idler. — 62

3

61

No. The letter "S" points to the idler.

In machinery, when the drive gear and driven gear are too far apart to mesh, idlers are used to "bridge the gap". Idlers are also used to control the direction of rotation of the driven gear.

Press A — 62

3

62

O. K.

If the shaft on a ventilating fan and the shaft on its driving motor are not close enough for their gears to mesh, what could we use to bridge the gap between the gears?

A. The idler. — 64
B. The driven gear. >63
C. The drive gear. >63

3

63

Your answer is incorrect. We would use an idler.

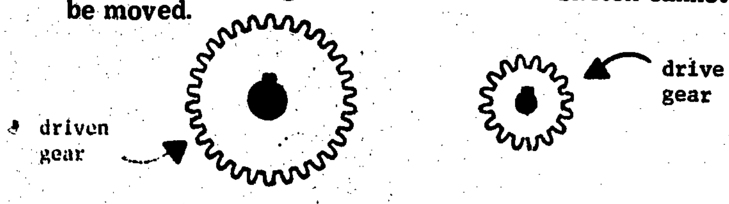
In machinery, when the drive gear and driven gear are too far apart to mesh, one or more idlers are used to "bridge the gap". On Plate III, one idler gear is being used to bridge the gap between the drive and driven gears.

Press A — 64

3

64

OK. The driven gear and shaft in this sketch cannot be moved.



In order for the drive gear to drive the driven gear, we must use one or more idlers (idler gears) to ________________ between them.

A. stop the rotation
B. keep the teeth from being broken > 65
C. bridge the gap. — 66

3

65

No.

In machinery, when the drive gear and the driven gear are too far apart to mesh, idlers are used to "bridge the gap." On Plate III, one idler gear is being used to bridge the gap between the drive and driven gears.

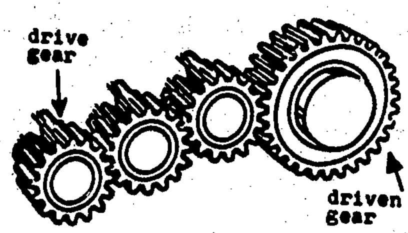
Press A — 66

3

66

O.K.

Now, how many idlers are in this "train" of gears?



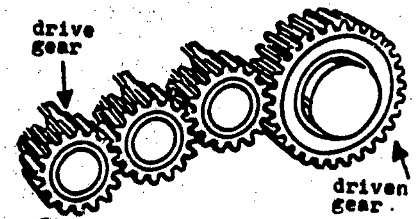
67 A. Four.
68 B. Two.
67 C. Three.

3

67

Your answer is wrong. There are two idlers in this gear train.

The two gears being used to bridge the gap between the drive gear and the driven gear are both idlers.



Press A — 68

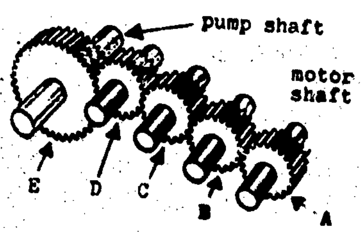
3

68

O.K.

In this gear train, gear "A" is the drive gear.

Identify each of the other four gears.



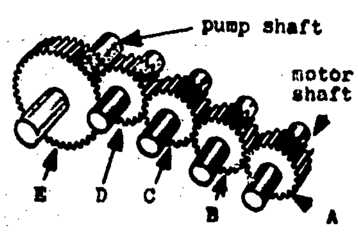
A. "B" drive gear, "C" drive gear, "D" drive gear "E" driven gear.
B. "B" idler, "C" driven gear, "D" driven gear, "E" driven gear. > 69
C. "B" idler, "C" idler, "D" idler, "E" driven gear. — 70

3

69

No. If gear "A" is the drive gear then:

"B"=idler (gear)
"C"=idler (gear)
"D"=idler (gear)
"E"=driven (gear)



Press A — 70

3

70

OK. Remember, idlers are used to bridge the gap between drive and driven gears.

Now, look at Plate III. In this pump and motor assembly, the curved arrow indicates that the drive gear is rotating in a clockwise direction.

What is the direction of rotation of the idler?

A. The same direction as the drive gear. — 71
B. The opposite direction from the drive gear. — 72
C. Clockwise. — 71

3

71

Your answer is incorrect. The idler is rotating counter-clockwise, or the opposite direction from the drive gear.

Two gears in mesh rotate in opposite directions. The drive gear is rotating clockwise. Therefore the idler must rotate in the opposite direction or in a counter-clockwise direction.

Press A — 72

3

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72

O.K., the idler is rotating counterclockwise.

Now, look at Plate III and complete these sentences:

The pump shaft is turning in a ____(1)____ direction. It is turning in the ___(2)___ direction as the motor shaft.

A. (1) clockwise (2) same — 74
B. (1) counterclockwise (2) same
C. (1) clockwise (2) opposite > 73

3

73

No, you have made an error. The pump shaft is turning in a clockwise direction. It is turning in the same direction as the motor shaft.

This is why: Two gears in mesh turn in opposite directions. Since the drive gear is rotating clockwise, the idler is rotating in a counterclockwise direction.

Since the idler gear is turning in a counterclockwise direction, the driven gear is turning in a clockwise direction.

Therefore, the drive gear and the driven gear are turning in the same direction because they are both turning clockwise.

Press A — 74

3

74

O.K. The pump shaft is turning in a clockwise direction, the same direction as the motor shaft.

Now, use Plate III to help you complete these sentences:

If there were no idlers and the drive and driven gears were in mesh, they would rotate in the ____(1)____.

The use of two idlers would cause the drive and driven gears to have ____(2)____ of rotation.

A. (1) opposite direction (2) the same direction — 75
B. (1) opposite direction (2) opposite direction — 76
C. (1) same direction (2) opposite direction — 75

3

75

No. If there were no idlers and the drive and driven gears were in mesh, they would rotate in opposite directions because gears in mesh rotate in opposite directions.

One idler causes drive and driven gears to rotate in the same direction.

The use of two idlers would cause the drive and driven gears to have opposite directions of rotation, again.

Press A — 76

3

76

O.K. Now complete these sentences:

In a gear "train", an odd number of idlers cause the drive and driven gears to rotate in ____(1)____.

An even number of idlers cause the drive and driven gears to rotate in ____(2)____.

A. (1) the same direction. (2) opposite directions. — 78
B. (1) opposite directions. (2) opposite directions.
C. (1) the same direction. (2) the same direction. > 77

3

77

Your answer is incorrect. In a gear "train", an odd number of idlers cause the drive and driven gears to rotate in the same direction.

However, an even number of idlers cause the drive and driven gears to rotate in opposite directions.

Draw for yourself a set of gears with one idler and another with two idlers and follow through each for directions of rotation.

Press A — 78

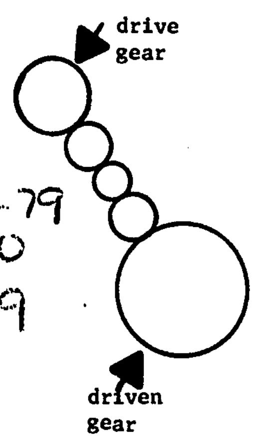
3

78

O.K.

If the drive gear in this train is rotating clockwise, the driven gear is rotating____.

A. in the opposite direction. — 79
B. clockwise — 80
C. counterclockwise. — 79

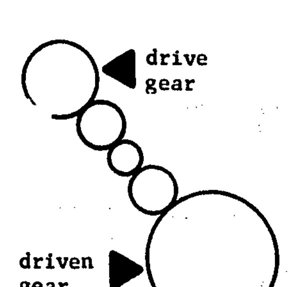


3

79

Your answer is incorrect. If the drive gear in this train is rotating clockwise, the driven gear is also rotating clockwise.

Why? In a gear train, an odd number of idlers will cause the drive and driven gears to rotate in the same direction.



However, an even number of idlers will cause the drive and driven gears to rotate in opposite directions.

Press A — 80

3

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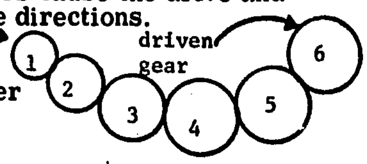
80

O.K. Remember, in a gear train, an odd number of idlers cause the drive and driven gears to rotate in the same direction.

However, an even number of idlers cause the drive and driven gears to rotate in opposite directions.



In this sketch, the drive gear is rotating clockwise. Which answer below shows the direction of rotation of gears 4, 5 and 6?

71 < A. (4) clockwise, (5) counterclockwise, (6) clockwise

B. (4) counterclockwise, (5) counterclockwise, (6) clockwise

82 — C. (4) counterclockwise, (5) clockwise, (6) counter-clockwise.

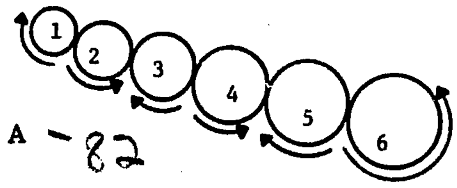
3

81

No. If the drive gear is rotating clockwise, then:

(2) rotates counterclockwise
(3) rotates clockwise
(4) rotates counterclockwise
(5) rotates clockwise
(6) rotates counterclockwise.

This sketch illustrates the rotation of each gear.



Press A — 82

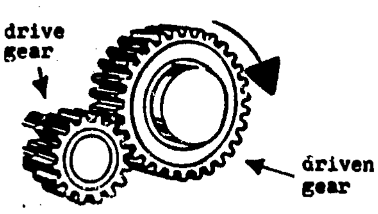
3

82

O.K.

Now, complete this sentence:

The driven gear is rotating clockwise. If we wanted to reverse the direction of rotation of the driven gear we could install one ______.

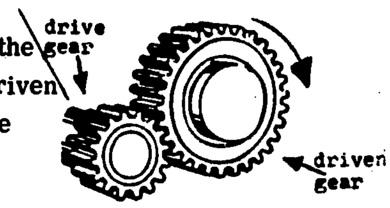


A. idler. — 84
B. gear shaft.
C. driven gear shaft. > 83

3

83

No. If we wanted to reverse the direction of rotation of this driven gear, we could just install one idler.



This would cause the drive gear and the driven gear to rotate in the same direction because an odd number of idlers cause the drive and driven gears to rotate in the same direction.

Press A — 84

3

84

O.K.

We have learned that idlers are used for two purposes. What are they?

A. To support the shafts and to support the inside of the gear reducer.
B. To support the gears and to stop the motion of the gear reducer. > 85
C. To bridge the gap between the drive and driven gears; and to control the direction of rotation of the driven gear. — 86

3

85

No, your answer is incorrect. Idlers are used for two purposes: (1) to bridge the gap between the drive and driven gears and (2) to control the direction of rotation of the driven gear.

Go back and pick the correct answer this time.

Press A — 84

3

86

Very good, your answer is correct. You have completed the section on idlers and direction of rotation.

Now you will review gear ratio, gear speed, and speed ratio.

Turn to Plate IV. This is a sketch of a pair of spur gears. Complete the statement below. (The film will move only when the correct answer is pressed.)

Gear "S" is the drive gear and is rotating in a clockwise direction. Gear "T" is the ____(1)____ gear and is rotating in a ____(2)____ direction.

A. (1) drive (2) counterclockwise

B. (1) driven (2) counterclockwise — 88

X(C) → 77.

3

87

Very good, your answer is correct.

The two purposes of idlers are: (1) to bridge the gap between the drive and driven gears and (2) to control the direction of rotation of the driven gear.

Understanding the function of the idler is important. We will now review some of this material. Get all the answers ~~right and~~ we will go on to gear and speed ratios.

Press A → 46

3

88

Correct. If gear "S" is the drive gear rotating in a clockwise direction, then "T" is the driven gear rotating in a counterclockwise direction.

Answer the questions below. The film will move only if they are answered correctly.

(1) How many teeth does gear "S" have?
(2) How many teeth does gear "T" have?

A. (1) 12 (2) 12 — 89
B. (1) 10 (2) 12
C. (1) 10 (2) 10

4

89

Right. Each gear has 12 teeth.

Gear "S" and gear "T" are in mesh. Therefore when gear "S" makes one complete turn, gear "T" will make one complete turn.

Turn to Plate V and complete these statements:

In this pair of spur gears, how many teeth does gear "M", the drive gear, have? (1)______

Gear "N" is the __(2)__ gear. How many teeth does gear "N" have? (3)______

A. (1) 24 (2) driven (3) 12
B. (1) 12 (2) drive (3) 24 — 90
C. (1) 12 (2) driven (3) 24 — 91

4

90

Your answer is incorrect. Take another look at the sketch in Plate V. We said that "M" is the drive gear.

In this pair of spur gears, the drive gear "M", has 12 teeth. Gear "N" is the driven gear. It has 24 teeth.

Press A — 91

4

91

O.K., the drive gear, "M", has 12 teeth. Gear "N" is the driven gear and it has 24 teeth.

When the 12 teeth on gear "M" have made a complete turn, how many teeth on gear "N" have meshed (1)____.
How many teeth on gear "N" have not meshed (2)______.

A. (1) 12 (2) 24. — 92
B. (1) 12 (2) 12. — 93
C. (1) 24 (2) 12. — 92

4

92

No.

The drive gear, "M", has 12 teeth. Gear "N" is the driven gear and it has 24 teeth.

Therefore when the 12 teeth on gear "M" have made a complete turn, 12 teeth on gear "N" will have meshed and 12 teeth will not have meshed.

Press A — 93

4

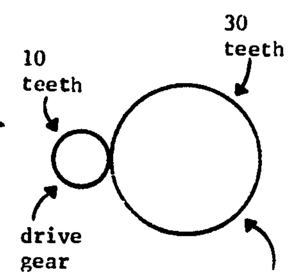
93

O.K., 12 teeth will have meshed and 12 will not have meshed.

In other words, "M" must make two complete turns before "N" makes one. The number of turns of the drive gear for each turn of the driven gear is called the Gear Ratio.

This set of gears has a Gear Ratio of 3.0 because the drive gear turns __(1)__ times for each single turn of the __(2)__ gear.

A. (1) 3 (2) driven — 95
B. (1) one-half (2) drive — 94
C. (1) $3\frac{1}{2}$ (2) drive — 94



4

94

No. your answer is wrong. Since this set of gears has a Gear Ratio of 3.0, the drive gear turns 3 times for each one turn of the driven gear.

Press A — 95

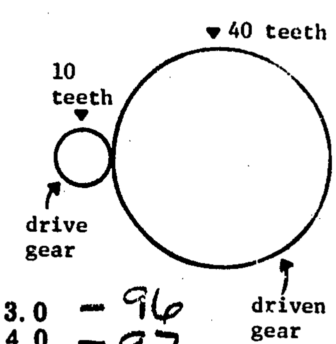
4

95

O.K., the drive gear turns 3 times for each turn of the driven gear because this set of gears has a gear ratio of 3.0.

1) How many times must the drive gear turn for each turn of the driven gear in this sketch? (1)___.

2) What is the gear ratio? __(2)__.



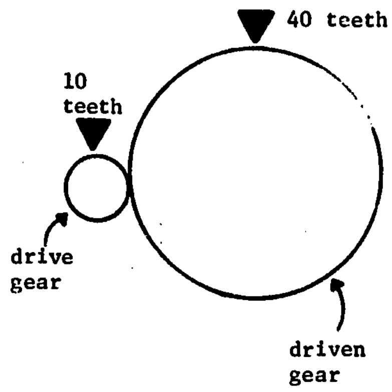
A. (1) 3 times (2) 3.0 — 96
B. (1) 4 times (2) 4.0 — 97
C. (1) $\frac{1}{4}$ times (2) 4.0 — 96

4

96

Your answer is incorrect. The drive gear must turn 4 times for each turn of the driven gear. Thus, the gear ratio is 4.0.

Press A — 97



4

97

O.K. The drive gear must turn 4 times for each turn of the driven gear. Therefore, the gear ratio is 4.0.

The Gear Ratio is found by dividing the number of teeth in the driven gear by the number of teeth in the drive gear.

What is the Gear Ratio of the set of gears shown on Plate V?

A. .50. — 98
B. 4.0. —
C. 2 0. — 99

4

98

Your answer is incorrect. The Gear Ratio of the set of gears shown on Plate V is 2.0.

The Gear Ratio is found by dividing the number of teeth in the driven gear by the number of teeth in the drive gear.

Here's the calculation: $\frac{\text{24 teeth (driven gear)}}{\text{12 teeth (drive gear)}} = 2.0.$

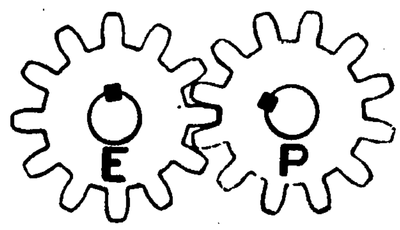
Press A — 99

4

99

O.K., the gear ratio of the set of gears on Plate V is 2.0. This formula: $\frac{\text{number of teeth in the driven gear}}{\text{number of teeth in the drive gear}}$ is called the gear ratio of the set of gears.

Gear "E" is the drive gear in this set of gears.



What is the gear ratio?
A. 3.0 — 100
B. 1.0 — 101
C. 4.0 — 100

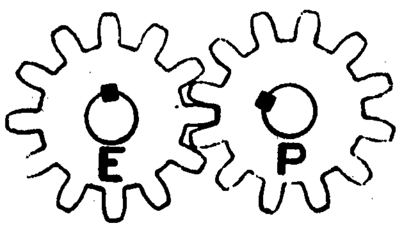
4

100

No. To find the gear ratio, we must first count the number of teeth in each gear. Then use the gear ratio formula: $\frac{\text{number of teeth in the driven gear}}{\text{number of teeth in the drive gear}}$

THUS: $\frac{\text{12 teeth}}{\text{12 teeth}} = 1$

Therefore, the gear ratio of this set of gears is 1.



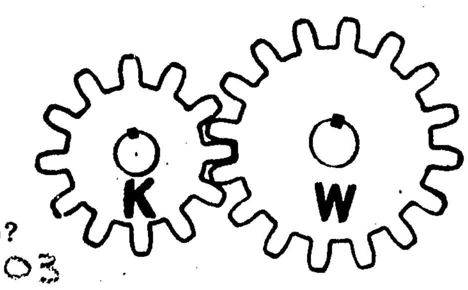
Press A — 101

4

101

O.K., the gear ratio of that set of gears was: $\frac{\text{12 teeth}}{\text{12 teeth}} = 1.$

In this set of gears, "W" is the driven gear.



What is the gear ratio?
A. 1.333. — 103
B. 3.0. — 102
C. 1.0. — 102

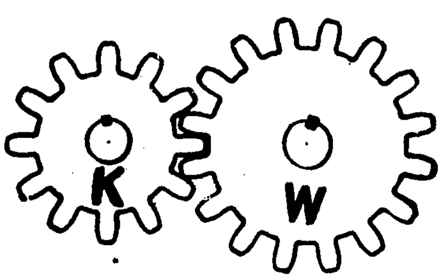
4

102

Your answer is incorrect. The gear ratio in this set of gears is found:

$\frac{\text{16 teeth}}{\text{12 teeth}} = 1.333.$

Press A — 103



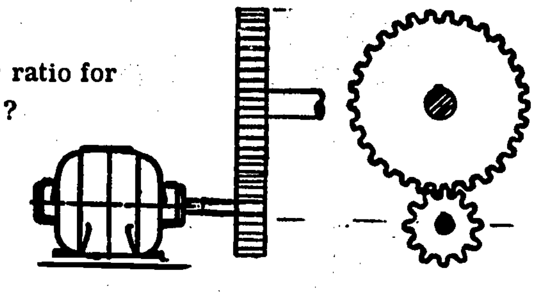
4

103

O.K., that gear ratio was 1.333.

What is the gear ratio for this set of gears?

A. .40. — 104
B. 1.333. — 104
C. 2.5. — 105



4

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104

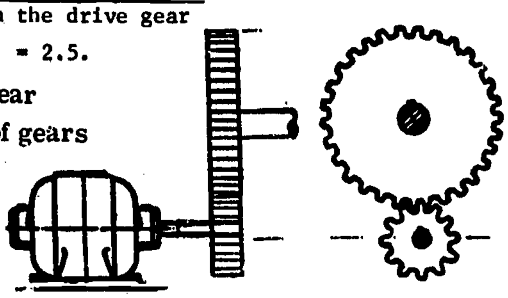
No. To find the gear ratio, we must count the number of teeth in each gear and use the gear ratio formula:

$\frac{\text{number of teeth in the driven gear}}{\text{number of teeth in the drive gear}}$

Thus: $\frac{30 \text{ teeth}}{12 \text{ teeth}} = 2.5.$

Therefore, the gear ratio of this set of gears is 2.5.

Press A -105

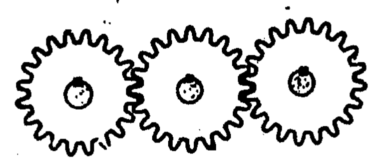


4

105

O.K., the gear ratio of that set of gears was 2.5.

The number and size of idlers have no effect on the gear ratio of drive and driven gears.



What is the gear ratio of this set of gears? ___(1)___.

If there were no idler, would the gear ratio change? ___(2)___.

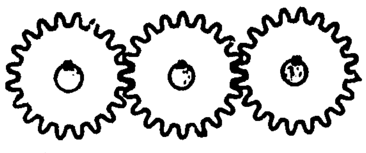
A. (1) 1.0 (2) No. — 107
B. (1) 2.5 (2) Yes. > 106
C. (1) 1.333 (2) No.

4

106

Your answer is incorrect. The correct gear ratio of this set of gears is figured:

$\frac{20 \text{ teeth}}{20 \text{ teeth}} = 1.0.$



Remember, the number and size of idlers have no effect on the gear ratio.

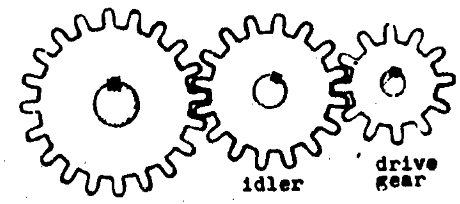
Press A — 107

4

107

O.K., the gear ratio of that set of gears was $\frac{20 \text{ teeth}}{20 \text{ teeth}} = 1.0.$

Remember the number and size of the idlers have no effect on the gear ratio of the drive and driven gears.



What is the gear ratio of this train of gears? ___(1)___ Does the idler affect the gear ratio ___(2)___

A. (1) 1.333 (2) No. > 108
B. (1) 1.25 (2) Yes.
C. (1) 1.667 (2) No. — 109

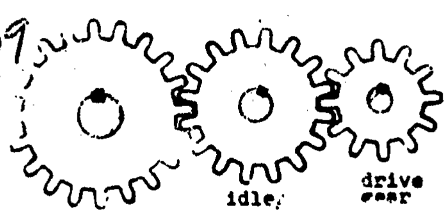
4

108

No. The gear ratio of this set of gears is $\frac{20 \text{ teeth}}{12 \text{ teeth}} = 1.667.$

As we see above, the idler does not affect the gear ratio of the drive and driven gears.

Press A - 109



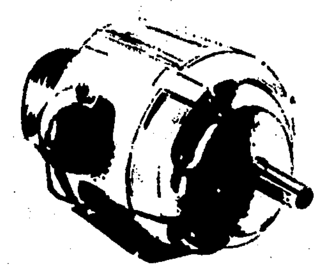
4

109

O.K., the gear ratio of that set was 1.667. The gear ratio of the drive and driven gears is not affected by the size or number of idlers.

Now, the speed of a rotating part is measured in revolutions per minute (rpm).

Complete the statement below. (The film will move when you answer it correctly.)



Since this motor shaft rotates 860 times in one minute, it is said to have a speed of ______.

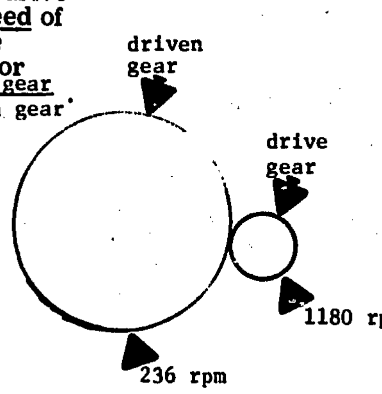
A. 860 turns. —|
B. 860 rpm. — 110

4

110

Right.

In gearing, the speed of the drive gear as compared to the speed of the driven gear is called the Speed Ratio. The formula for Speed Ratio is: $\frac{\text{rpm of drive gear}}{\text{rpm of driven gear}}$



What is the Speed Ratio of this set of gears?

A. 5.0 — 112
B. .20 > 111
C. 1.667

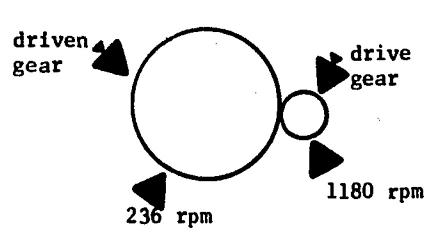
4

111

You made a mistake. The Speed Ratio of this set of gears is 5.0.

The Speed Ratio formula is:

$\frac{\text{rpm of drive gear}}{\text{rpm of driven gear}}$ THUS: $\frac{1180 \text{ rpm}}{236 \text{ rpm}} = 5.0$



4

So, the Speed Ratio of this set of gears is 5.0.

Press A — 112

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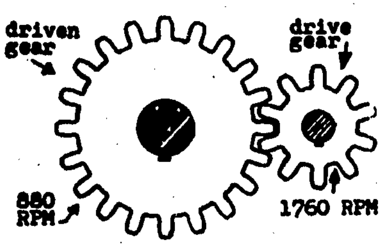
112

O. K., the speed ratio of that set of gears was 5.0

What is the speed ratio of this set of gears? (1)

What is the gear ratio? (2)



114 A. (1) 2.0 (2) 2.0

13 B. (1) 5.0 (2) .20

C. (1) .20 (2) 5.0

4

113

Your answer is incorrect. The formula for speed ratio is:

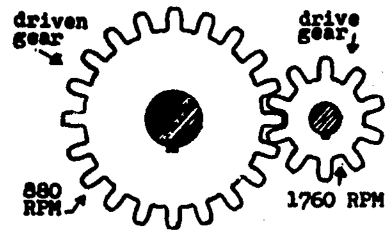
$\frac{\text{rpm of drive gear}}{\text{rpm of driven gear}}$ or $\frac{1760 \text{ rpm}}{880 \text{ rpm}} = 2.0$

The formula for gear ratio is:

$\frac{\text{number of teeth in the driven gear}}{\text{number of teeth in the drive gear}}$ or $\frac{20 \text{ teeth}}{10 \text{ teeth}} = 2.0$

Are the speed ratio and gear ratio equal?

Press A - 114



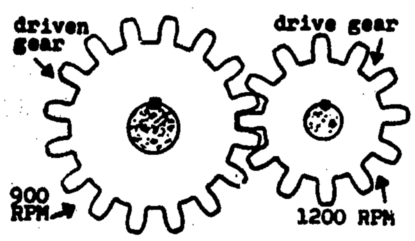
4

114

O. K., that gear ratio and speed ratio both equaled 2.0.

1) What is the gear ratio of this set? (1).

2) What is the speed ratio of this set? (2).



115 A. (1) .333 (2) 1.333.

16 B. (1) 1.333 (2) 1.333.

15 C. (1) .333 (2) .333.

4

115

Your answer is incorrect. The gear ratio is:

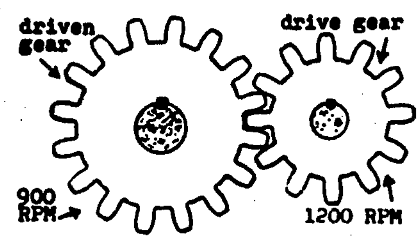
$\frac{16 \text{ teeth}}{12 \text{ teeth}} = 1.333.$

The speed ratio is

$\frac{12000 \text{ rpm}}{900 \text{ rpm}} = 1.333.$

Are the speed ratio and gear ratio equal?

Press A - 116



4

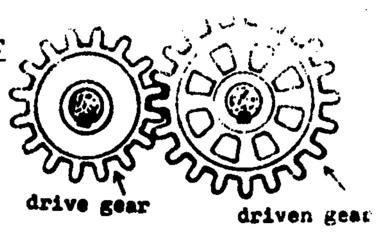
116

O. K., that gear and speed ratio were 1.333.

In a set of gears, the speed ratio is the same as the gear ratio.

1) What is the gear ratio of this set of gears? (1).

2) What is the speed ratio? (2).



A. (1) 1.27 (2) 1.27. > 117

B. (1) 1.56 (2) 1.56.

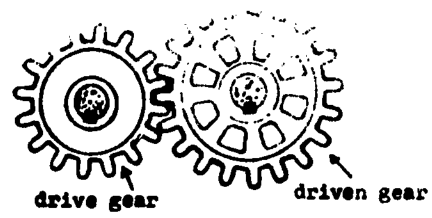
C. (1) 1.25 (2) 1.25. — 118

4

117

No. The gear ratio = $\frac{20 \text{ teeth}}{16 \text{ teeth}} = 1.25.$

Because the speed ratio is the same as the gear ratio in a set of gears, the speed ratio = gear ratio. They each equal 1.25.



Press A — 118

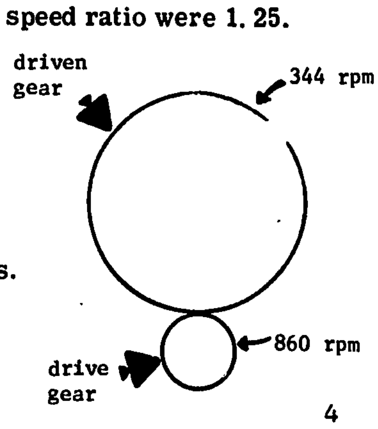
4

118

O. K., both the gear ratio and speed ratio were 1.25.

Thus, we can calculate one and automatically know what the other is.

Calculate the gear ratio and speed ratio of this set of gears.



A. 2.5 — 120

B. .20 > 119

C. 2.333

4

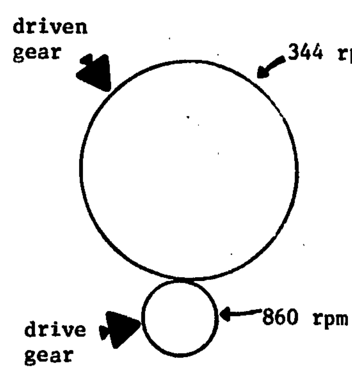
119

Your answer is incorrect. We can only figure speed ratio here so:

$\frac{860 \text{ rpm}}{344 \text{ rpm}} = 2.5.$

We know that the gear ratio must be the same. So, both the gear ratio and the speed ratio = 2.5.

Press A — 120

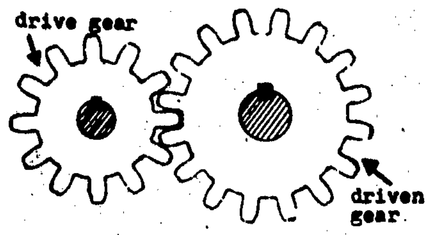


4

120

O.K. Both the speed and gear ratios were 2.5.

Now, although we don't know the speeds of these gears, we can figure out the speed ratio.



What is the speed ratio?

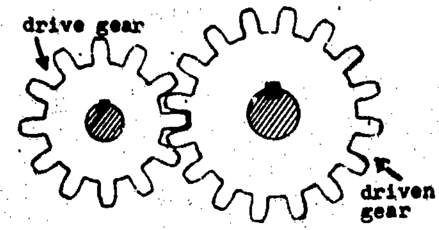
A. 1.667 — 121
B. 1.333 — 122
C. .333 — 121

4

121

Your answer is incorrect. The speed ratio is 1.333. This is true because the speed ratio is the same as the gear ratio.

We can figure the gear ratio by counting the teeth on each gear.



Thus: $\frac{16 \text{ teeth}}{12 \text{ teeth}}$.

Now choose the correct answer.

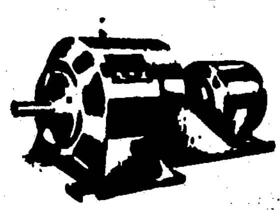
Press A — 120

4

122

Your answer is correct. That gear ratio and speed ratio were each 1.333.

Now, the nameplate on this motor-gear unit says the speed ratio is 4.75. We know the gear ratio is also 4.75 because the gear ratio is the same as the speed ratio.



You have completed this tape. Please rewind the film and turn the machine off.

x (c) → 123

4

123

Your answer is correct. That gear ratio and speed ratio were each 1.333. Now, the nameplate on this motor-gear unit says the speed ratio is 4.75.

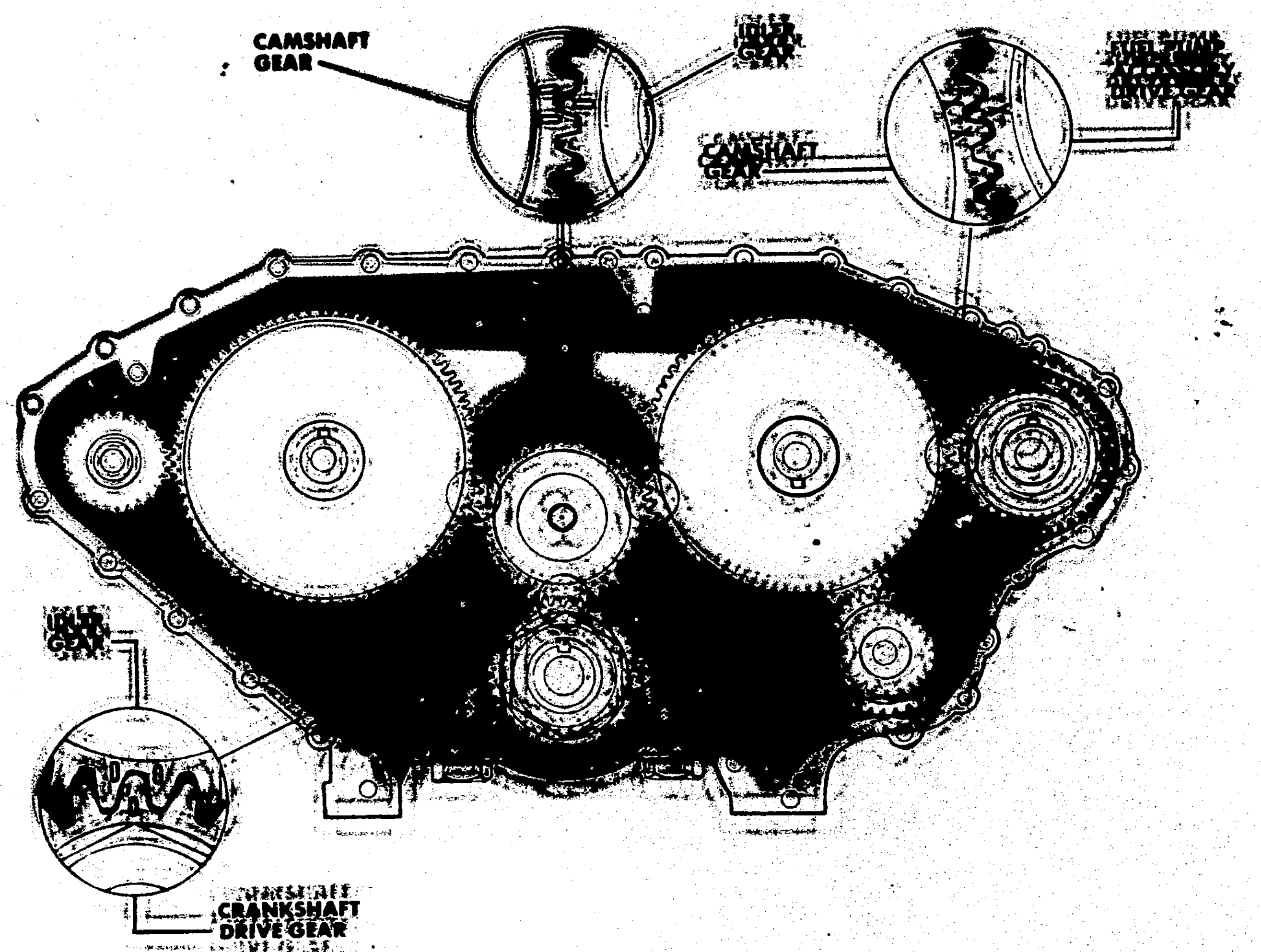
We know the gear ratio is also 4.75, because the gear ratio and the speed ratio are the same.

Because this material ~~is~~ important, we will review gear and speed ratios. ~~They~~ really are not bad - just follow each statement and each question very carefully.

Press A → 88

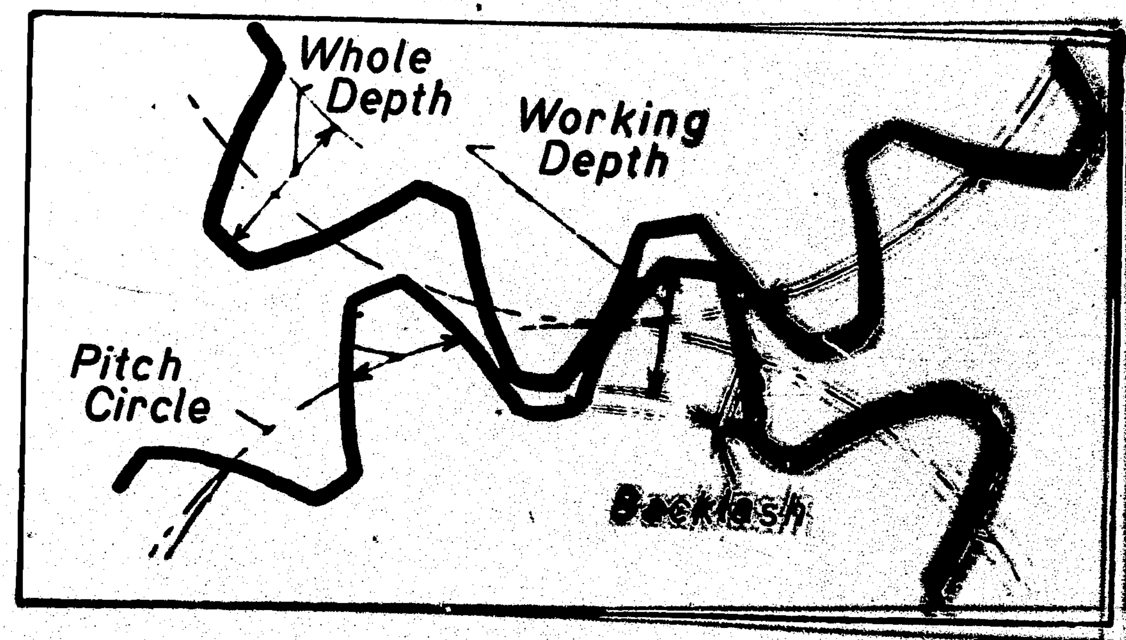
4

AM 1-16

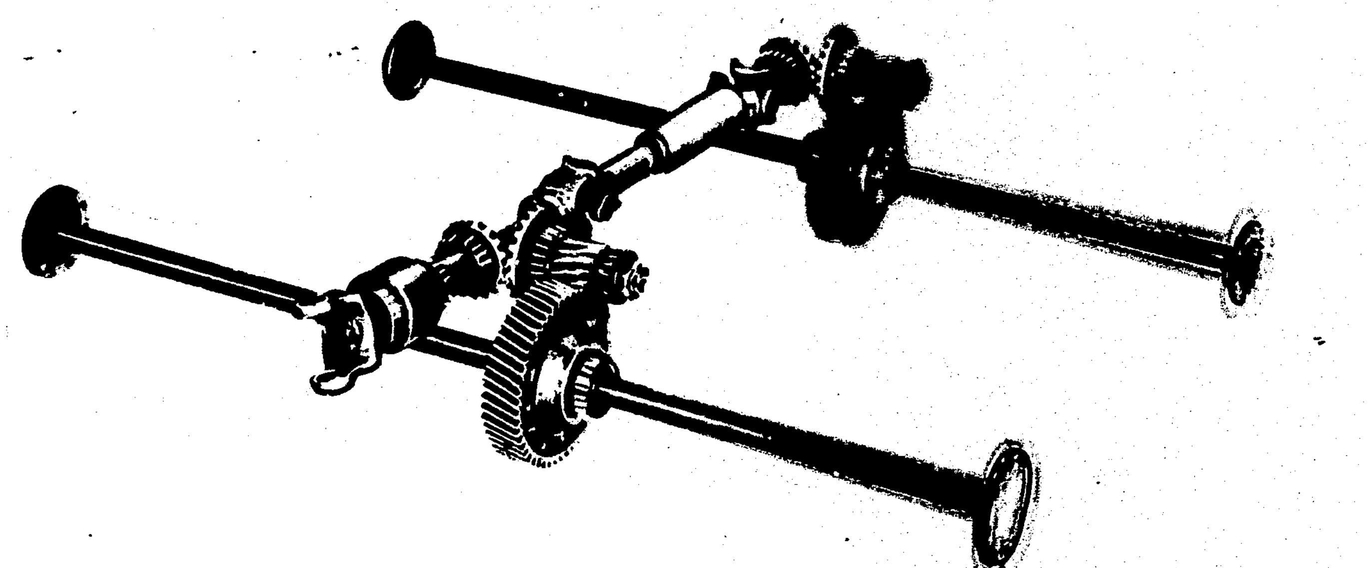


Typical engine gear train

AM 1-18

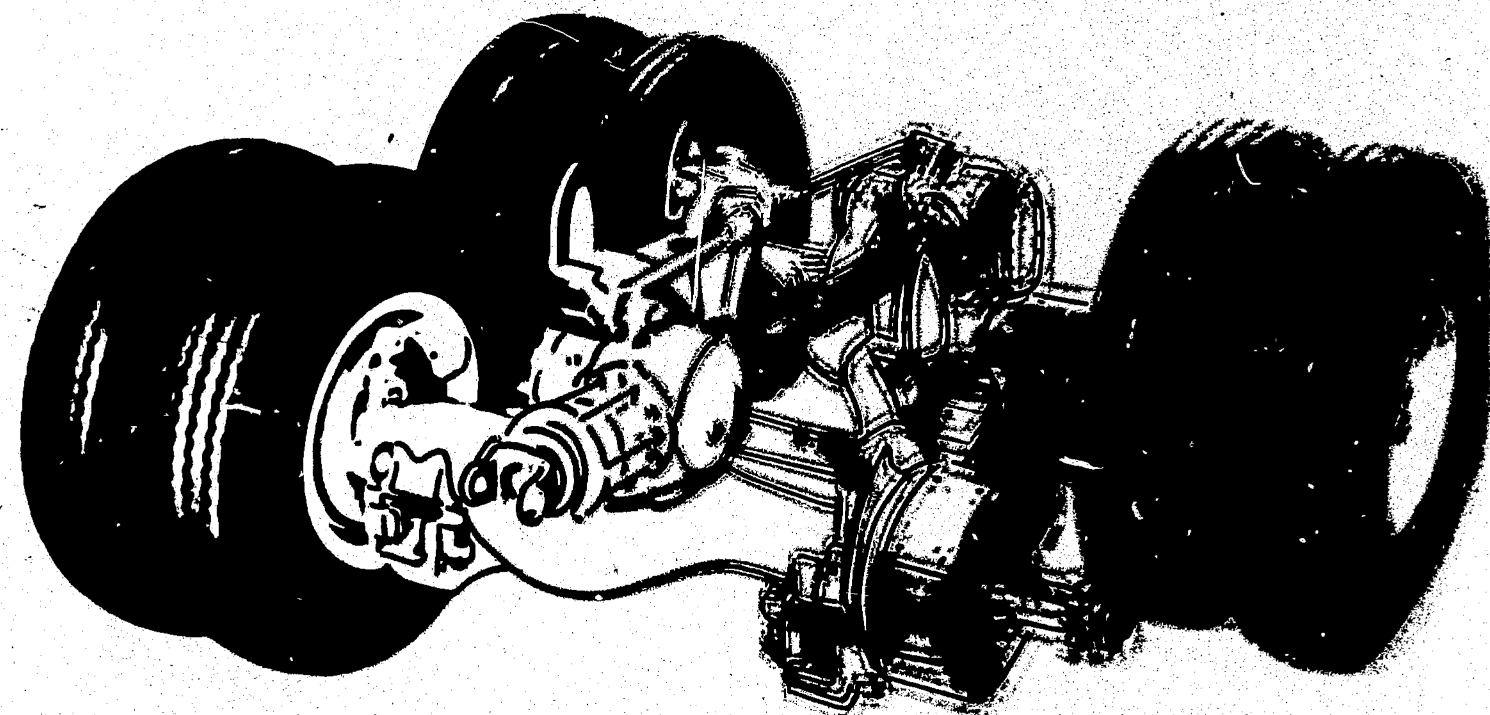


Gear backlash

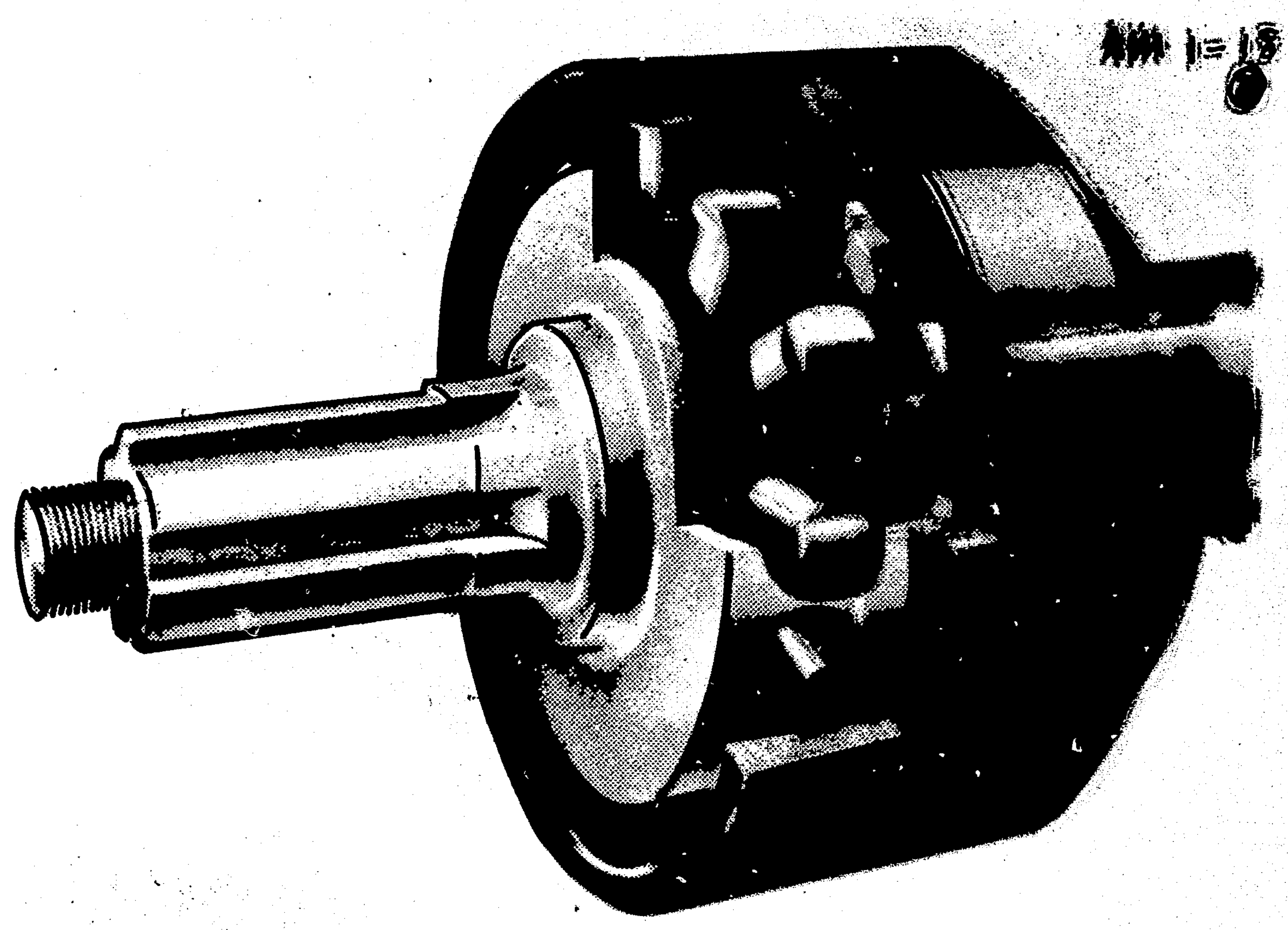


Cutaway of the power divider set-up

AM-1-78

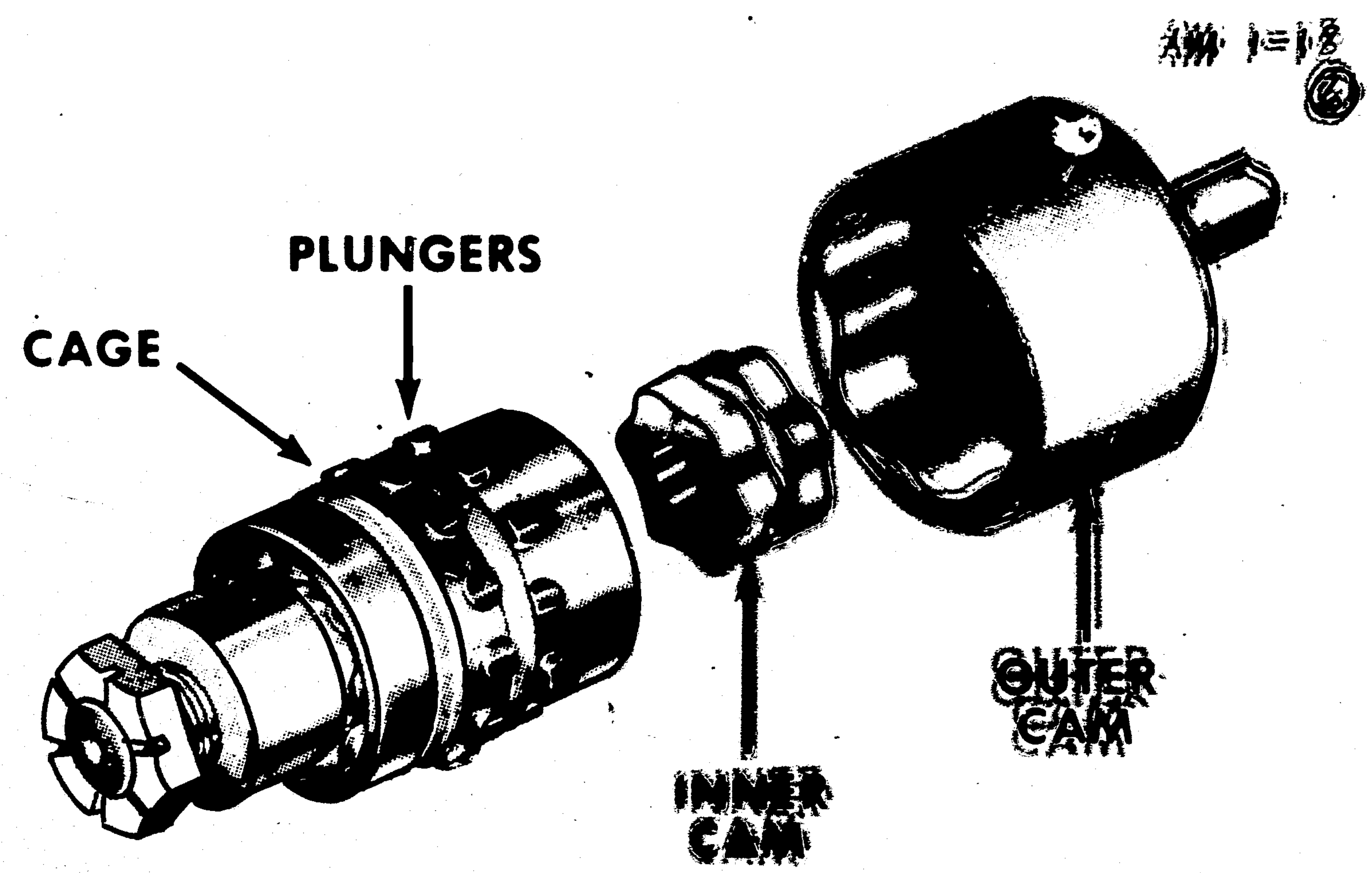


Four-wheel bogie with a power divider



Cage and plungers of the power divider

HUMAN
ENGINEERING
INSTITUTE



Parts of the [illegible]

INSTRUCTOR'S GUIDE

AM 1-18
6/16/66

Title of Unit: I - Understanding Engine Gears and Gearing Principles
II - Mack Inter-Axle Power Divider

FIRST: Be sure all questions have been answered that students might have on home study Units.

OBJECTIVES:

1. To give trainees an awareness of common failures to look for in mechanical power transmission equipment.
2. To give some groundwork in understanding what causes failures.
3. To learn how one failure can lead to another and eventually put a piece of equipment out of operation. (Stress need to correct before this happens).
4. To acquaint the student with the workings of the Mack Power Divider and how it behaves in different road situations. Also what components are most likely to fail.

LEARNING AIDS suggested:

VUE CELLS
AM 1-9 (3) (Engine gear train mounting)
AM 1-9 (4) (V-71 engine showing gear cutaway)
AM 1-18 (1) (Cummins V12 gear train)
AM 1-18 (2) (Gear backlash)
AM 1-18 (3) (Cutaway of the power divider set-up)
AM 1-18 (4) (Four-wheel bogie with a power divider)
AM 1-18 (5) (Cage and plungers of the power divider)
AM 1-18 (6) (Parts of the power divider)

MODELS: Any samples of gear failures that can be brought into class and discussed would be very helpful. Also, any parts of the Mack power divider that can be brought from the shop may help.

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

1. What is a backlash?
2. What are the results of too much or too litle backlash?
3. What is center distance?
4. How can our ears help us to detect failures?
5. Why is proper alignment of gears and shafts important?

6. Why are impurities dangerous to equipment?
7. Why is overloading dangerous to equipment?
8. What are the major classifications of gear-tooth surface deterioration?
9. Why is it important to recognize the causes of deterioration?
10. Can you name additional causes of gear-tooth failure?
11. In what ways can loose or damaged bearings affect gear or shaft life?
12. Why is it important that lubricating film be present on all surfaces?
13. How can snap-rings make better assemblies?
14. What is the purpose of the Mack Power Divider?
15. When does the power divider function as a straight shaft?
16. How many drive shafts does the power divider have?
17. What happens when no resistance is offered by one set of wheels? By one wheel?
18. What component is the driving member of the power divider?
19. What are the intermediate members between the driving member and the driven members?
20. What is the 3 to 1 ratio? When does it work?