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AUTOMOTIVE DIESEL MAINTENANCE 2. UNIT I, UNDERSTANDING MECHANICAL CLUTCHES.

HUMAN ENGINEERING INSTITUTE, CLEVELAND, OHIO

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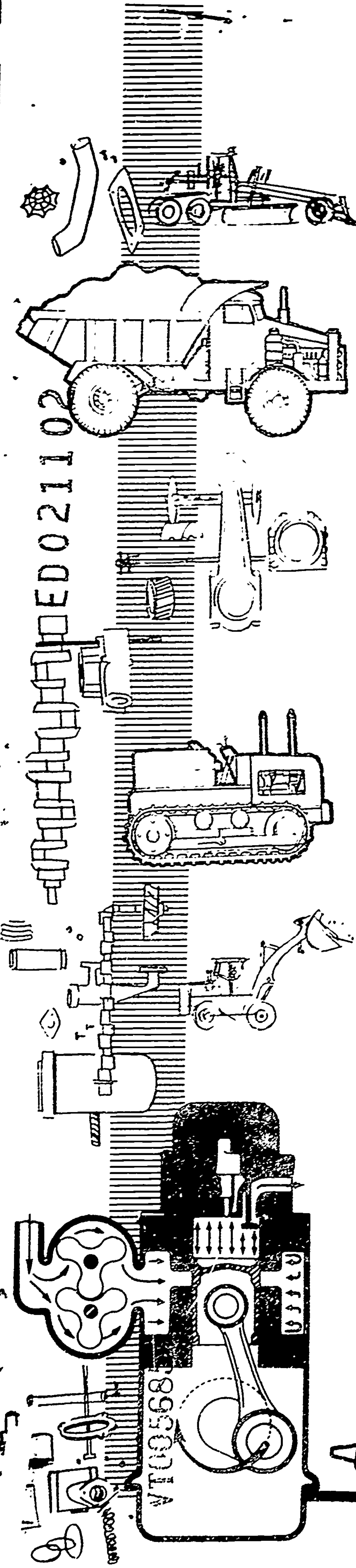
ONE OF A 25-MODULE COURSE DESIGNED TO UPGRADE THE JOB SKILLS AND TECHNICAL KNOWLEDGE OF DIESEL MAINENANCE MECHANICS THIS MATERIAL WAS DEVELOPED BY INDUSTRIAL TRAINING AND SUBJECT-MATTER SPECIALISTS AND TESTED IN INDUSTRIAL TRAINING SITUATIONS. THE PURPOSE OF THIS FIRST UNIT IS TO DEVELOP AN UNDERSTANDING OF COMPONENTS, OPERATION, AND ADJUSTMENTS OF THE DIFFERENT TYPES OF MECHANICAL CLUTCHES USED ON DIESEL POWERED VEHICLES. THE MODULE CONSISTS OF AN INSTRUCTOR'S GUIDE, TRANSPARENCIES, AND A LIST OF SUGGESTED SUPPLEMENTARY MATERIALS FOR 2 HOURS OF GROUP INSTRUCTION, TRAINEE TEXT MATERIAL, AND A SELF-INSTRUCTIONAL BRANCH PROGRAMED TRAINING FILM "LEARNING ABOUT MECHANICAL CLUTCHES" FOR SELF-PACED INDIVIDUAL INSTRUCTION USING AN ELECTRONIC TUTOR. A REPRODUCTION OF THE TRAINING FILM WITH PROGRAM BRANCHING INFORMATION IS INCLUDED SO THAT IT MAY BE DEVELOPED AS PRINTED MATERIAL FOR USE WITHOUT THE ELECTRONIC TUTOR. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 685 - VT 005 709. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 1" ARE AVAILABLE AS VT 005 655 - VT 005 684. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILALBE 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 2

UNDERSTANDING MECHANICAL CLUTCHES

UNIT I

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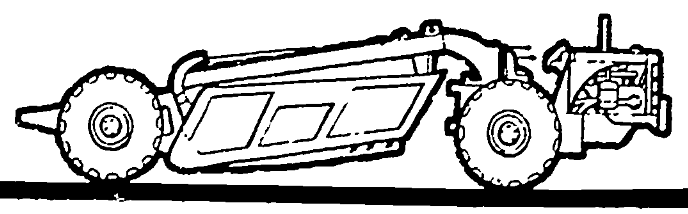


HUMAN ENGINEERING INSTITUTE

SECTION A -- POWER FROM THE ENGINE -- THEN WHAT?

In some applications of combustion engines, there are no problems encountered when the engine is connected directly to the load. This applies, for instance, when the engine drives a propeller (either marine or air), a blower, or a centrifugal pump. But in road and off-highway equipment the torque load usually is quite high when starting from rest, and some means must be provided to gradually accelerate; otherwise the engine would stall. Furthermore, it would be difficult, if not impossible, to start the engine before torque is required.

CLUTCH -- In order to satisfy the requirement mentioned above, vehicles must be equipped with some type of clutch. Usually it is a friction clutch which allows the operator to disconnect the power of the engine from the driving wheels while shifting gears, or while idling the engine. Also, the clutch allows the engine to take up the load of driving the vehicle gradually without shock.

LOCATION -- The clutch is located between the engine flywheel and the transmission (non-automatic) on most applications as shown in Figure 1.

CLUTCH POSITIONS -- When the clutch is in the coupling (or normal running) position, power flows through it from the engine to the transmission. If the transmission is in gear, then power flows on through to the wheels of the vehicle. Essentially, then, the clutch has the job of permitting the operator to uncouple the engine temporarily so that the gears can be shifted from one forward gear position to another (or into reverse or neutral). It is necessary to interrupt the flow of power (by uncoupling) before gears are shifted. Otherwise, gear shifting would be extremely difficult, if not impossible.

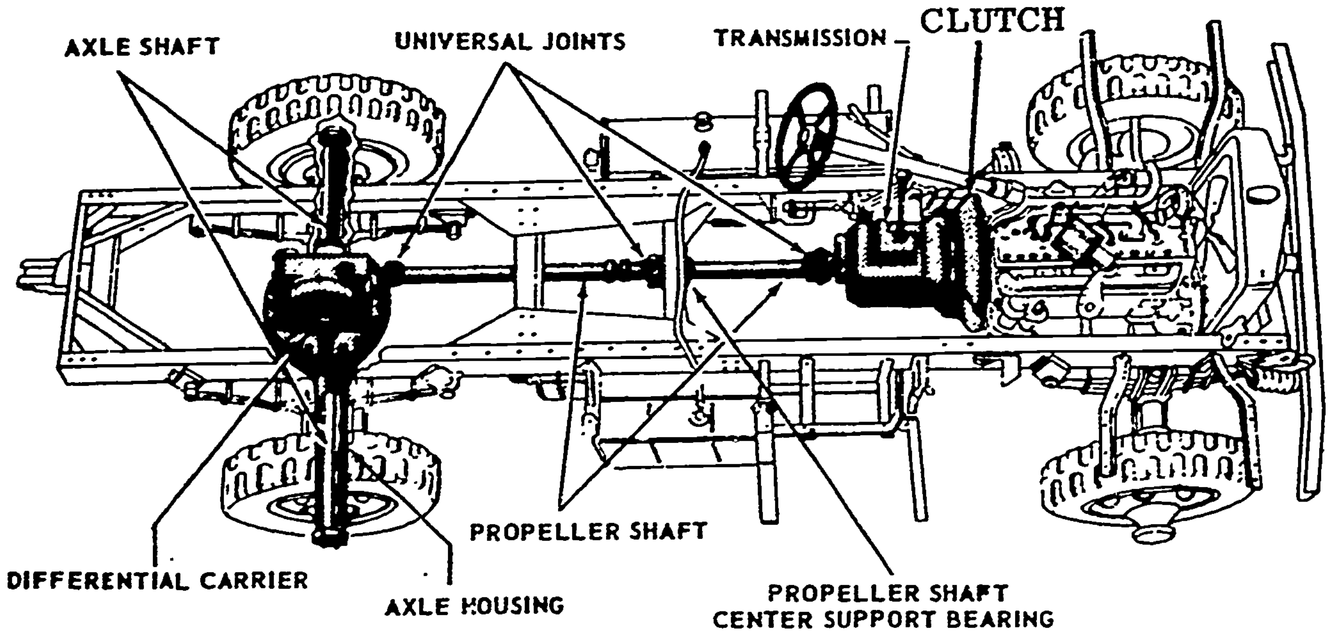


Fig. 1 Clutch location in the power train

OPERATION AND TERMINOLOGY -- There are many types of clutches used with manual transmissions, but basically they all operate in the same manner. The friction clutch consists of one plate squeezed tightly between two other plates. The plate in the middle is the DRIVEN plate; it is the one splined to the shaft leading to the transmission and is not connected to the flywheel. The other two plates are the DRIVING plates, both of which are connected to the engine, see Figure 2.

A strong spring (or springs) forces the two driving members together. This tightens their grip on the middle plate until they are all turning together as one unit.

The engine flywheel is used for the first driving member (plate). Its surface is smooth where the driven plate pushes up against it. The other driving member is called the PRESSURE plate, see Figure 2. This plate is a heavy ring of cast iron, smooth on one side. It is fastened to the cover, which is bolted to the flywheel. It is fastened in such a way that

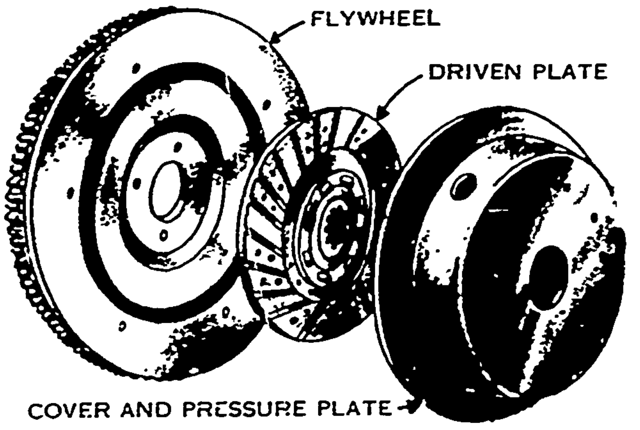


Fig. 2 Clutch nomenclature

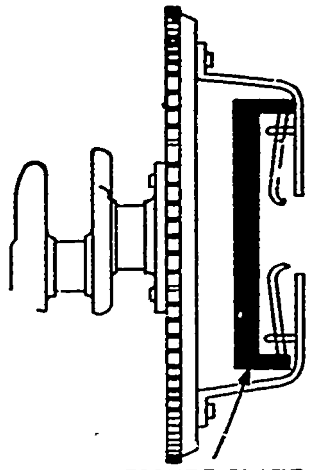


Fig. 3 Pressure plate

it can slide back and forth; see Figure 3. The driven plate is a flat disk of steel with friction facing fastened to each side. As mentioned earlier, this disk is splined to the shaft leading to the transmission; see Figure 4.

A series of coil springs, or sometimes one large flat spring, act between the clutch cover and the pressure plate. They push the pressure plate toward the flywheel, squeezing the driven plate between the two. The springs are always trying to engage the clutch, and they are strong enough to keep it from slipping under any ordinary circumstances; see Figure 5.

To disengage the clutch, the operator depresses the pedal which, through mechanical advantage principles, forces the pressure plate away from the driven plate, leaving it free between the two outer plates; see Figure 6.

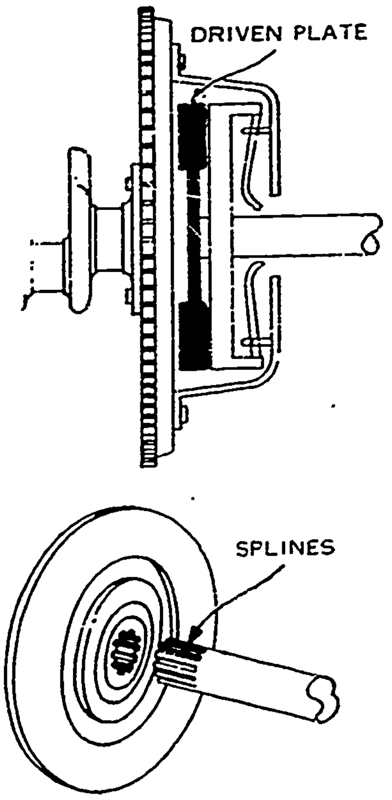


Fig. 4 Driven plate

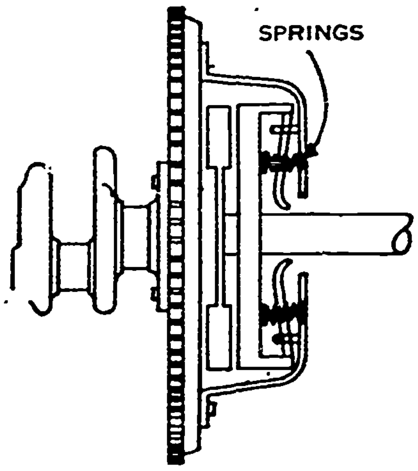
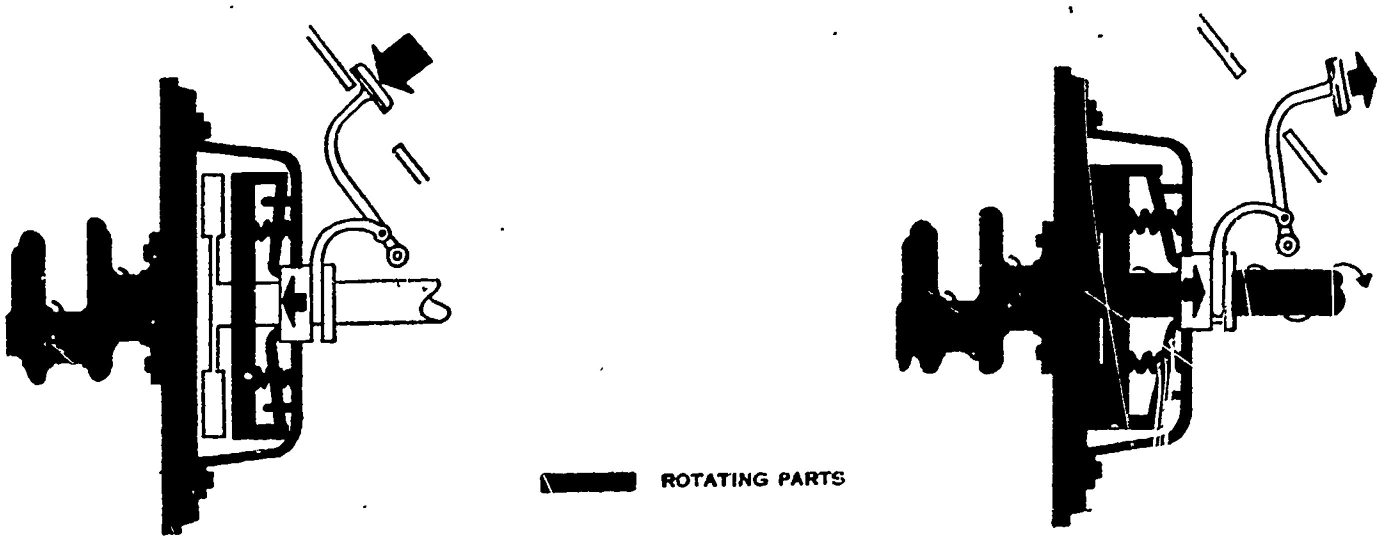


Fig. 5 Clutch springs



(a) clutch released

(b) clutch engaged

Fig. 6 Clutch action

SECTION B -- TYPES OF CLUTCHES

SINGLE DISK CLUTCH -- The single disk clutch is essentially the type discussed in the previous paragraphs. The driving members of this clutch consist of the flywheel and the driving (pressure) plate. It has one driven member, faced on both sides with friction material, and is splined to the transmission shaft.

DOUBLE DISK CLUTCH -- The double disk clutch is essentially the same type except it has another driven disk and an intermediate driving plate; see Figure 7.

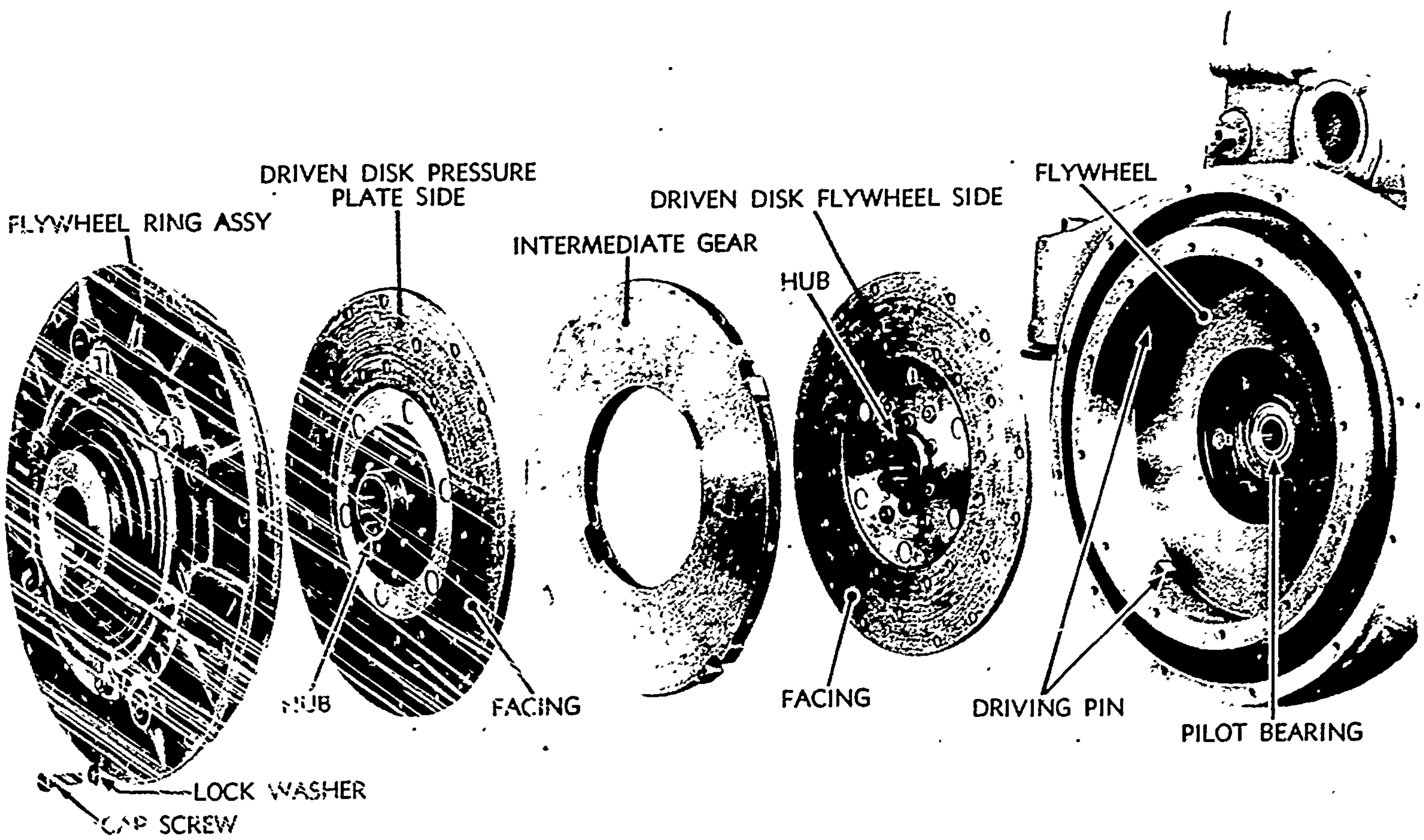


Fig. 7 Double disk clutch

MULTIPLE DISK CLUTCH -- This type clutch has more than three plates or disks. Some have as many as eleven driving plates and ten driven disks. Because the multiple disk type has a greater frictional area than a plate clutch, it is best suited as a steering clutch on crawler tractors. Also, it sometimes is used on heavy trucks. In operation, it is very much like the plate clutch and has the same release mechanism. The facings, however, usually are attached to the driving plates rather than to the driven disks. This reduces the weight of the driven disks and keeps them from spinning after the clutch is released.

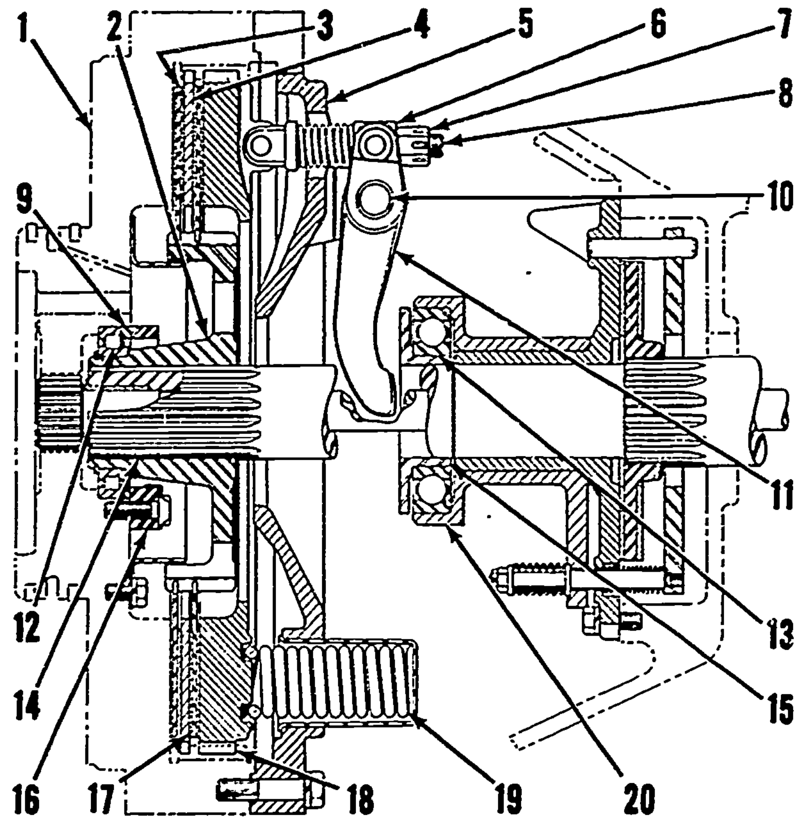
HEAVY DUTY CLUTCHES -- Most heavy duty vehicles today use automatic transmissions which call for a different clutch arrangement than has been discussed so far. In units to follow we will cover automatic transmissions and what is sometimes called the hydraulic coupling, or fluid flywheel type of clutch.

Heavy duty clutches used with mechanical transmissions are somewhat different then we normally think of a clutch in an automobile. Naturally, they are designed to handle more torque and all parts are readily replaceable. One such clutch is the FLYWHEEL CLUTCH shown in Figure 8.

This clutch is used on the No. 12 CAT motor grader. All other vehicles (CAT), including the No. 14 motor grader, use the power shift (automatic) transmission and clutch arrangement which will be discussed later.

NOTE: For items mentioned in the following paragraphs, refer to Figure 8.

The oil type flywheel clutch is mounted to the engine flywheel (1) and transmits engine power to the transmission when it is engaged. The clutch is located in the clutch and transmission housing, which is bolted to the flywheel housing. The clutch contains two driven disks (3) and (17), one driving disk (4), and a driving plate (18).



1–Flywheel. 2–Hub. 3–Driven disc. 4–Driving disc. 5–Cover plate. 6–Retainer. 7–Adjusting nut. 8–Adjusting screw. 9–Retaining ring. 10–Pivot pin. 11–Lever. 12–Bearing. 13–Bearing. 14–Shaft. 15–Thrust ring. 16–Ret
17–Driven disc. 18–Driving plate. 19–Spring. 20–P

Fig. 8 Flywheel clutch

The driving disk and the driving plate have external teeth which mate with the internal teeth of the flywheel.

The driven disks are cork faced and have internal teeth which mate with the external teeth of the hub (2), which is splined to the dual ratio upper shaft (14).

The clutch end of the dual ratio upper shaft is piloted in the splined bore of the hub, which is piloted in the flywheel by the bearing (12). The bearing is held in place by a retaining ring (9) which, in turn, is held in place by a retainer (16) and bolts.

The transmission end of the dual ratio upper shaft is supported by a bearing located in the transmission housing. A double lip seal is used between the clutch housing and the transmission housing to prevent exchange of oil between the two.

Springs (19), which are located between the clutch cover plate (5) and the driving plate (18), hold the clutch in the engaged position by clamping the driven disks tightly between the driving disk and the flywheel. Depressing the clutch pedal disengages the clutch by acting through linkage to move the release bearing cage (20) toward the levers (11). The thrust ring (15), each one to pivot at its pivot pin (10), which is anchored to the clutch cover plate. Retainers (6), and adjusting screws (8), held in place by adjusting nuts (7), move, compressing the springs between the clutch cover and the driving plate, which releases the pressure on the driven disks.

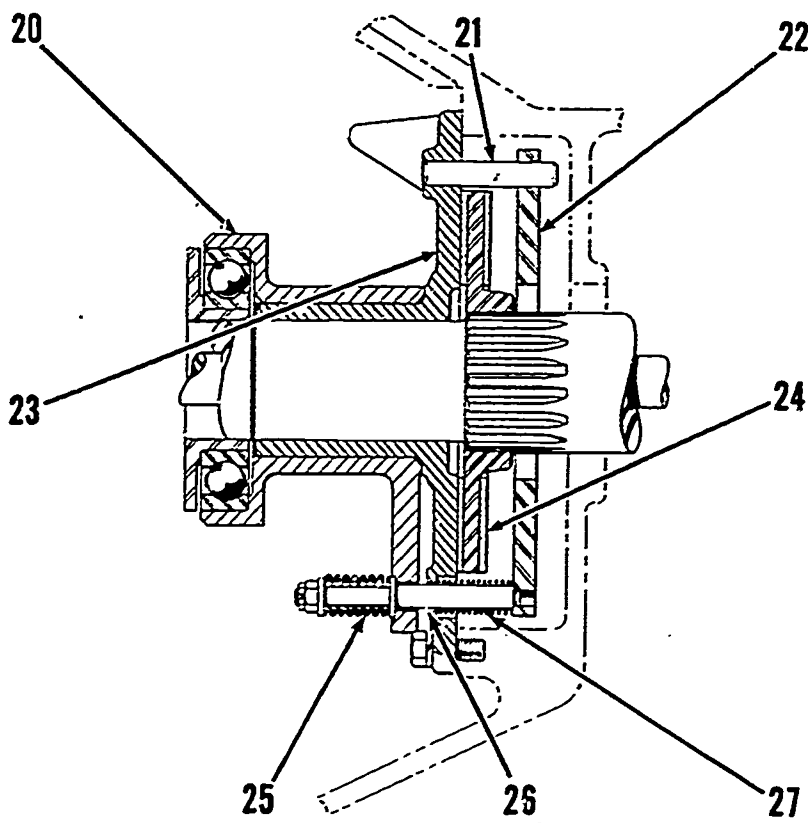
When the clutch is disengaged, the driving disk, driving plate, clutch cover plate, release levers, thrust ring and the bearing (13) continue to rotate with the flywheel.

The clutch brake is actuated by the clutch pedal. The farther the pedal is depressed, after the clutch is fully released, the more the brake is applied.

NOTE: For items mentioned in the following paragraphs, refer to Figure 9.

As the release bearing cage (20) moves toward the flywheel, it draws the brake plate (22) toward the flywheel by means of two spring-loaded studs (26). The brake plate moves toward the flywheel on locating pins (21), partially compressing the springs (27) and clamping the brake hub (24) between the brake plate and the bearing cage support (23).

As the brake plate contacts the brake hub, further depressing of the clutch pedal will compress the spring (25), thus exerting pressure against the brake hub. Since the brake hub is splined to the dual ratio upper shaft, the shaft and also the transmission gears are slowed down accordingly, or stopped entirely to allow gear shifting. Braking effort is limited by the spring load.



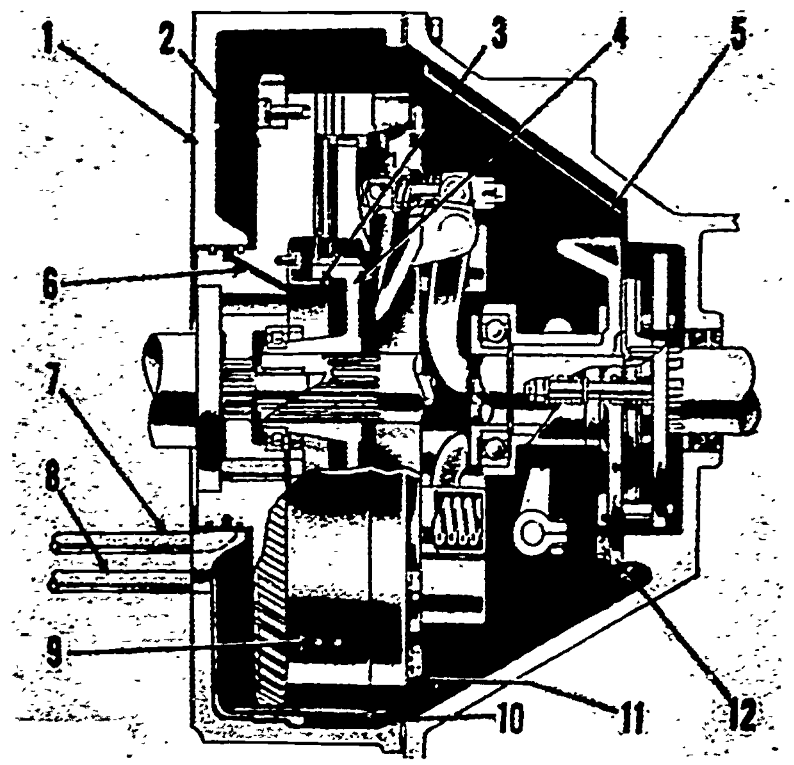
20–Bearing cage. 21–Locating pin. 22–Plate. 23–Bearing cage support. 24–Hub. 25–Spring. 26–Stud. 27–Spring.

Fig. 9 Clutch brake (cross section)

NOTE: For items in the following paragraphs, refer to Figure 10.

LUBRICATION IN THE FLYWHEEL CLUTCH -- Oil from the engine lubricating system is supplied to the flywheel clutch through the line (7) from the lower section of the diesel engine oil pump. The oil travels through a passage in the flywheel housing (1) and enters the flywheel (2) through an annular groove which is cut into the outer diameter of the flywheel hub. Drilled passages (6) carry the oil through the flywheel. An oil thrower (3) on the clutch side of the flywheel directs the oil to the inner diameter of the clutch hub (4).

Slots in the hub direct the oil flow radially across the clutch friction surfaces. Holes (9) in the outer edge of the flywheel and cutouts in the clutch



1-Flywheel housing. 2-Flywheel. 3-Oil thrower. 4-Hub. 5-Cup. 6-Drilled passage. 7-Oil supply line. 8-Oil return line. 9-Holes. 10-Opening. 11-Clutch cover plate. 12-Brake support plate.

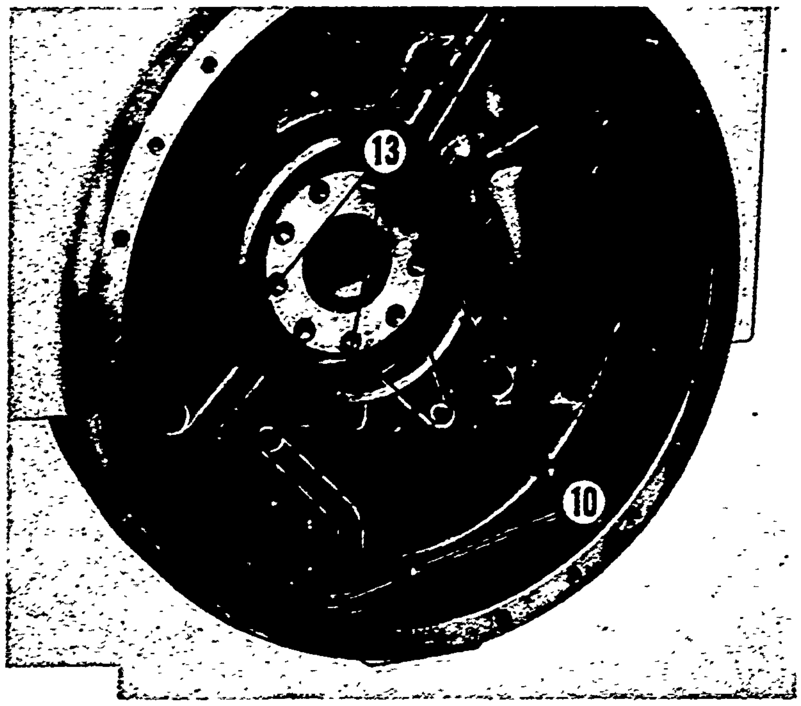
Fig. 10 Flywheel oil clutch lubrication

cover plate (11) allow oil to be thrown against the walls of the flywheel housing. The flywheel acts as a slinger and directs oil toward the opening (1) in the bottom of the flywheel housing. Oil from the bottom of the housing is carried through a passage in the flywheel housing to the line (8). The oil flows through the line to the scavenger pump section of the diesel engine oil pump, where it is returned to the diesel engine crankcase.

Part of the oil thrown onto the inside of the clutch housing is directed down to the clutch brake by two ribs which are cast into the top inside surface of the clutch housing. The oil drains into a cup (5) which is cast into the top of the brake support (12). The cup acts as a catch basin and delivers oil to all parts of the clutch brake. After lubricating the brake, the oil then drains to the bottom of the flywheel housing, where it is picked up and returned to the engine oil sump.

Holes (see Figure 11 (13) in the flywheel housing permit oil to travel between the flywheel housing and diesel engine crankcase.

Because all parts of the flywheel clutch are splash lubricated, no external lubrication of the release bearing or pilot bearing is required.



10–Opening. 13–Holes.

Fig. 11 Flywheel housing openings

SECTION C -- COMPONENT PARTS OF THE CLUTCH

FRICTION DISK -- The friction disk (see Figure 12) consists of a hub and plate assembly, to which is attached a series of facings. The disk usually includes a cushioning device as well as a dampening device. The cushioning device provides a cushioning effect as the clutch is engaged, so that smoother engagement results. The cushion springs, to which the facings are mounted, (see Figure 12) provides this effect by compressing slightly as the clutch engages, thus preventing a shock to the power train.

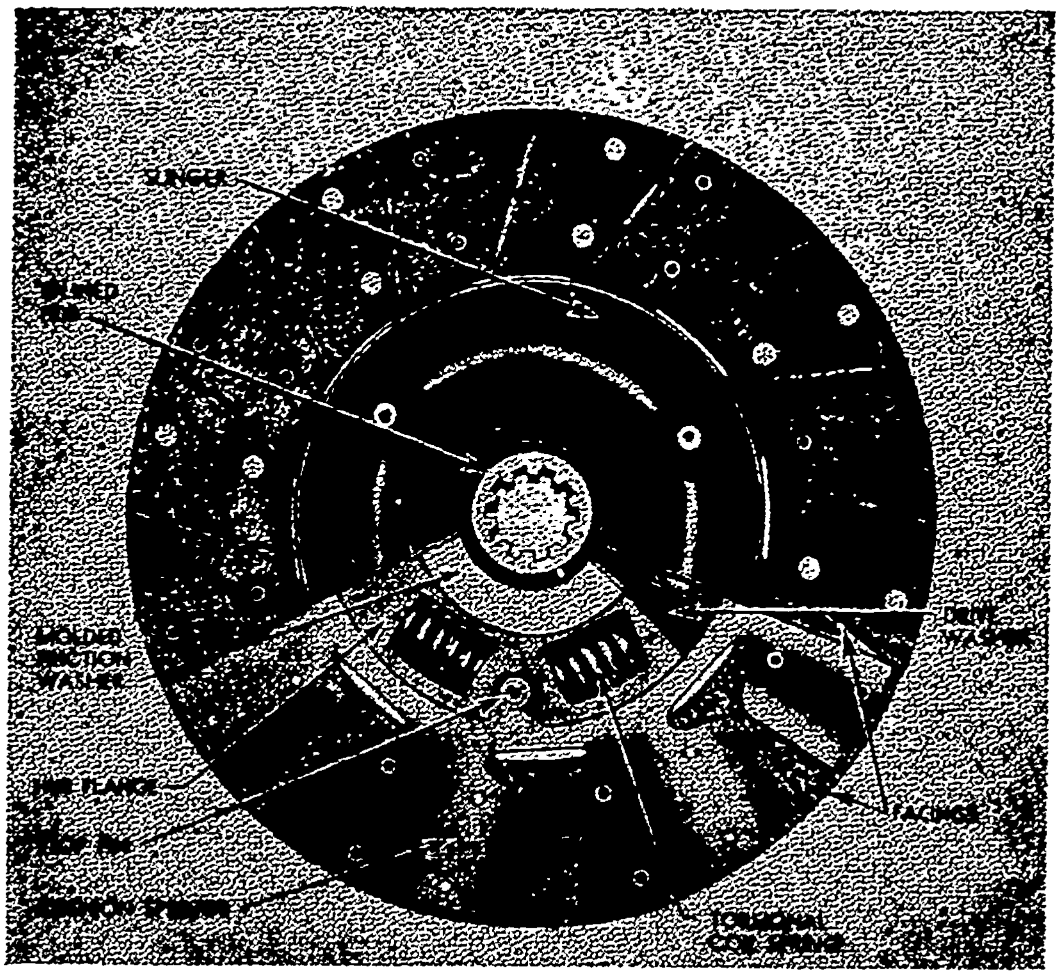


Fig. 12 Friction disk or driven plate

The dampening device uses a series of torsional coil springs placed between the drive washers and riveted to the cushion springs and hub flange. The disk hub is thus driven through the springs, and they absorb a certain amount of torsional vibration. Stop pins limit the relative motion between the hub flange and the drive washers. A molded friction ring, compressed between the hub flange and the drive washers, provides frictional dampening that prevents oscillation between the hub flange and the drive washers.

CLUTCH BEARINGS -- The friction clutch requires two bearings, one to support the clutch shaft in the flywheel web or the end of the crankshaft, the other for the throw-out collar. The bearing at the front end of the clutch shaft, which carries comparatively little load, is frequently an annular ball bearing; but sometimes cylindrical roller bearings also are used, and some use plain oilless bushings. The bearing is pressed into a counterbore in the end of the crankshaft (or the bore of the flywheel web), and the inner race slips over the clutch shaft without being fixed axially, as any end thrust on the shaft is taken up on the bearing at its opposite end, which is secured to the wall of the transmission housing. The bearing at the forward end of the clutch shaft is usually packed in grease. It can also be lubricated from the engine lubricating system through drill holes in the crankshaft. In any case, provision must be made so that none of the lubricant supplied to this bearing gets to the friction surfaces of the clutch.

To counteract oil getting to the clutch facings, the flywheel has a groove with a drain hole which catches any oil which has dripped or has been thrown by centrifugal force from the rotating parts. In addition, an oil slinger may be provided on the clutch driven member. This consists of a pan-shaped stamping with a hole in the center, which is secured with its "bottom" to the hub of the driven disk, and is so proportioned that any oil thrown from its edge is caught in the oil groove in the flywheel rim.

Occasionally, a radial ball bearing is used for the clutch throw-out collar, but as the load is a straight thrust load and radial bearings have relatively little thrust capacity, it must be made comparatively large. The one thing in favor of radial bearings for this application is that they are less sensitive to centrifugal force on the balls than other types. Special designs of angular-contact and thrust ball bearings have been developed for this purpose. The bearing on the clutch throw-out collar shown in Figure 13 (a), is a New Departure product. It is provided with a heavy inwardly-turned flange on the outer race, against which the clutch levers may bear, and with a steel shell forming a lubricant reservoir which is permanently fixed to the outer ring. The shell is made to hug either the projecting portion of the inner race or the throw-out collar. For use with clutches in which the levers are in the form of flat steel springs, the flange on the outer race with which the levers contact is made convex. Other clutch throw-out

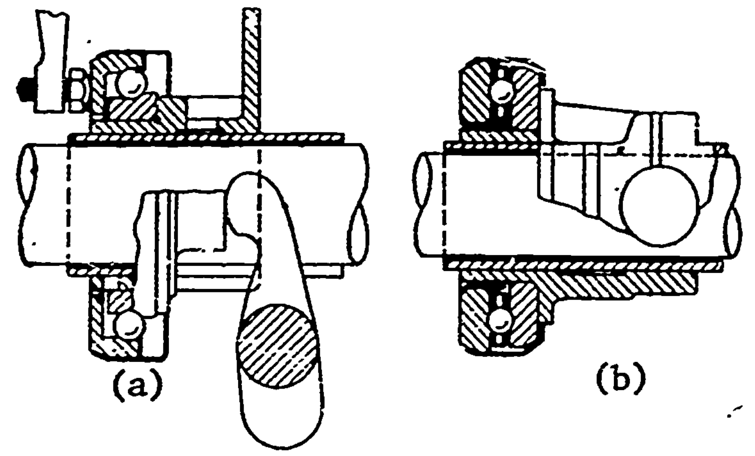


Fig. 13 Types of bearings

bearings of the angular-contact type are made with a radial flange on the inner race, to suit special mounting conditions.

The BCA throw-out bearing, on the throw-out collar illustrated in Figure 13 (b), is of the angular-contact thrust type, the line of contact making a small angle with the axis of the bearing. A steel sheel is secured to the outside of one race and cupped over the other. This latter race is located against a shoulder on the throw-out collar, while the outer face of the outer race will contact the clutch levers.

THROW-OUT COLLAR -- The clutch throw-out collar can be arranged to slide either directly on the clutch shaft, on a flanged tube extending forward from the transmission housing and surrounding the clutch shaft, or in a hub formed on or secured to the clutch cover plate. Having the collar slide directly on the clutch shaft is open to the objection that with this arrangement there is high velocity sliding motion between the parts whenever the engine is running and the clutch is engaged, which necessitates thorough provisions for lubrication and entails wear on the bearing surfaces.

When the collar slides on a tube secured either to the transmission housing or to the clutch cover plate, the only sliding motion between contacting parts is that due to clutch engagement or disengagement. The clutch collar is generally provided with an oil pocket, from which an oil hole extends to its bearing surface, and it is chambered out at the middle of its length to provide an oil reservoir. Oiling generally is effected through a tube protruding through the wall of the clutch housing and having a lubricator fitting at its end, the inner end of the tube being located over the oil pocket. Where no such provision is made, the clutch collar can be lubricated by removing the cover on the clutch housing. To prevent rattling, a spring is provided which draws the clutch collar against the throw-out yoke.

CLUTCH FACINGS (HEAVY DUTY) -- Clutches used in heavy duty vehicles have facings of spirally-wound asbestos yarn and brass wire, impregnated with compound, with a layer of copper-asbestos compound (molded to it). The copper-asbestos is the friction surface and constitutes about one-half the total thickness. The surface of this lining is of copper color, while the back is covered with an aluminum compound to improve the heat-radiating qualities. These facings are much lighter than metallic facings, and can be riveted to the disk in the same manner as ordinary "woven" facings.

Metallic facings are used to a certain extent in heavy duty service. The high heat conductivity of such facings tends to prevent excessive temperatures in multiple-disk clutches; their frictional properties are practically unaffected by high temperatures; and their rate of wear is said to be relatively low.

PEDALS AND PEDAL LINKAGE -- Clutch pedals vary in height from 14 to 18 inches, while the yoke arms on the pedal shaft, which press against the clutch throw-out collar, measure from 1 1/4 to 2 1/2 inches. In the case of clutches of comparatively low torque capacity, the clutch pedal often is mounted directly on the shaft of the clutch throw-out yoke which extends through the wall of the clutch housing. Large clutches are not built this way because it is difficult to obtain enough leverage to bring the required clutch pressure within the desired range of 20 to 30 lbs. One remedy to this is using compound clutch levers as shown in Figure 14. Another method is to use a hydraulically operated clutch; this type will be discussed in AM 2-1D film.

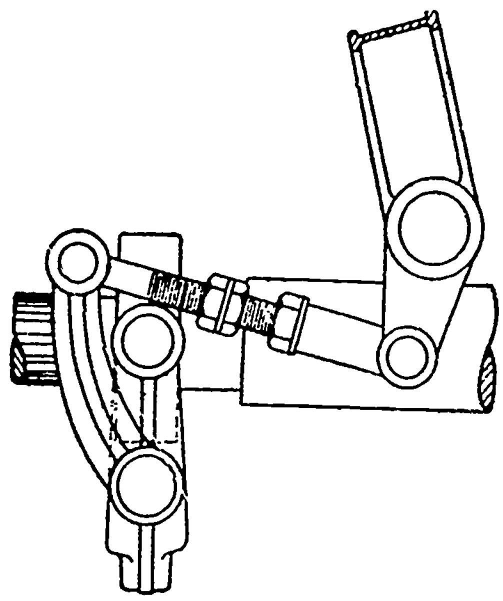


Fig. 14 Compound clutch lever

SECTION D -- CLUTCH ADJUSTMENT AND TROUBLESHOOTING

CATEGORIES -- Clutch troubles usually are fairly obvious to the mechanic and fall into one of the following categories: slipping, chattering or grabbing when engaging, spinning or dragging when disengaged, clutch noises, clutch-pedal pulsations and rapid friction disk facing wear.

SLIPPING of the clutch while it is engaged is extremely hard on the clutch facings. The facings wear and burn badly; so a slipping clutch may soon become completely inoperative.

Clutch slippage is particularly noticeable during acceleration, especially from a standing start or in low gear. A rough test for clutch slippage can be made by starting the engine, setting the hand brake, shifting into high gear, and then slowly releasing the clutch pedal while accelerating the engine slowly. If the clutch is in good condition, it should hold so that the engine stalls immediately after clutch engagement is completed.

Several conditions can cause clutch slippage. The clutch linkage may not be properly adjusted. With an incorrect adjustment that reduces pedal lash too much, the throw-out bearing will still press against the release levers, even with a fully released clutch pedal. This takes up part of the spring pressure; the pressure plate will not exert sufficient pressure to hold the friction disk tightly enough against the flywheel. As a result, there is slippage between the surfaces. The correction here is to re-adjust the linkage.

If the clutch-release linkage binds, it may not return to the fully engaged position when the clutch pedal is released. This, of course, causes clutch slippage. Binding can be eliminated by lubricating all points of friction in the linkage and realigning and readjusting the linkage if necessary. If readjusting, lubricating, and freeing the linkage do not eliminate the slippage, then the trouble is probably inside the clutch itself, and this requires removal of the clutch from the vehicle so that it can be disassembled for service. Conditions in the clutch itself that could cause slippage include the following.

Weak or broken pressure springs (or diaphragm spring) will not exert sufficient pressure; new springs should be installed. Worn friction-disk facings or grease or oil on the disk facings will permit slippage; the facings or the complete disk should be replaced if this is the case.

Incorrectly adjusted release levers (adjustable type) may act in the same manner as an incorrectly adjusted clutch linkage or a binding clutch-release linkage. That is, they may prevent full spring pressure on the pressure plate, with a resulting clutch slippage. Release levers must be adjusted as explained in the applicable manufacturer's shop manual.

CLUTCH CHATTERS OR GRABS WHEN ENGAGING -- As a rule, this trouble is inside the clutch itself, and the clutch will have to be removed. Before this is done, however, the clutch linkage should be carefully checked to make sure it is not binding; if it binds, it may release suddenly to throw the clutch into quick engagement, with a resulting heavy jerk.

In the clutch, the trouble could be due to oil or grease on the disk facings or to glazed or loose facings. Also, binding of the friction-disk hub on the clutch shaft could prevent smooth engagement of the clutch; this condition requires cleaning up of the splines in the hub and on the shaft and lubrication of the splines. Broken parts in the clutch, such as broken disk facings, broken cushion or coil springs in the friction disk, or a broken pressure plate, could cause poor clutching action and grabbing.

CLUTCH SPINS OR DRAGS WHEN DISENGAGED -- The clutch friction disk spins briefly after disengagement when the transmission is in neutral. It takes a moment for the friction disk to come to rest. This normal spinning should not be confused with a dragging clutch. When the clutch drags, the friction disk is not being fully released from the flywheel or pressure plate as the clutch pedal is depressed; the friction disk continues to rotate with or to rub against the flywheel or pressure plate.

The first thing to check with this condition is the pedal-linkage adjustment. If there is excessive pedal lash, or "free" travel, even full movement of the pedal to the floorboard will not force the throw-out bearing in against the release levers (or diaphragm spring) far enough to release the clutch fully. If adjustment of the linkage to reduce pedal lash, or free travel, does not correct the trouble, the trouble is in the clutch, and the clutch must be removed for disassembly and service.

In the clutch, the trouble could be due to a warped friction disk or pressure plate, or to a loose friction-disk facing. On the type of clutch with adjustable release levers, improper adjustment would prevent full disengagement, so that the clutch would drag. The friction-disk hub may bind on the clutch shaft so that it does not move back and forth freely. The result is that the friction disk rubs against the flywheel when the clutch is released. Binding may be relieved by cleaning up the splines on the shaft and in the hub and lubricating the splines.

CLUTCH NOISES -- Clutch noises usually are most noticeable when the engine is idling. To diagnose clutch noises, first note whether it is heard when the clutch is engaged or when the clutch is disengaged.

Noises that come from the clutch when the clutch is engaged could be due to a friction-disk hub that is loose on the clutch shaft. This would require replacement of the disk or clutch shaft, or perhaps both if both are excessively worn. Friction-disk dampener springs that are broken or weak will cause noise, and this requires replacement of the complete disk. Misalignment of the engine and transmission will cause a backward-and-forward movement of the friction disk on the clutch shaft; alignment must be corrected.

Noises that come from the clutch when it is disengaged could be due to a clutch throw-out bearing that is worn, is binding, or has lost its lubricant. Such a bearing squeals when the clutch pedal is depressed and the bearing comes into operation. The bearing should be relubricated or replaced. If the release levers are not properly adjusted, they will rub against the friction-disk hub when the clutch pedal is depressed. The release levers should be readjusted. If the pilot bearing in the crankshaft is worn or lacks lubricant, it will produce a high-pitched whine when the transmission is in gear, the clutch is disengaged, and the vehicle is stationary. Under these conditions, the clutch shaft, which is piloted in the bearing in the crankshaft, is stationary, but the crankshaft and bearing are turning. The bearing should be lubricated or replaced.

CLUTCH-PEDAL PULSATION -- Clutch-pedal pulsation, sometimes called a nervous pedal, is noticeable when a slight pressure is applied to the clutch pedal with the engine running. The pulsations can be felt by the foot as a series of slight pedal movements. As the pedal pressure is increased, the pulsations cease. This condition is often an indication of trouble that must be corrected before serious damage to the clutch results. One possible cause of the condition is misalignment of the engine and transmission. If the two are not in line, the friction disk or other clutch parts will move back and forth with every revolution. The result is rapid wear of clutch parts. Correction is to detach the transmission, remove the clutch, and then check the housing alignment with the engine and crankshaft. At the same time, the flywheel that is not seated on the crankshaft flange, will also produce clutch-pedal pulsations. A flywheel that is not seated on the crankshaft flange should be removed and remounted to make sure that it does seat evenly. If the flange itself is bent, then a new flange, or crankshaft, is required.

If the clutch housing is distorted or shifted so that alignment between the engine and transmission has been lost, it sometimes is possible to restore alignment by installing shims between the housing and engine block and between the housing and transmission case. Otherwise, a new clutch housing will be required.

Other causes of clutch-pedal pulsations include uneven release-lever adjustments (so that release levers do not meet the throw-out bearing and pressure plate together) and a warped friction disk or pressure plate. Release levers (adjustable type) should be readjusted. A warped friction disk usually must be replaced. If the pressure plate is out of line because of a distorted clutch cover, then the cover sometimes can be straightened to restore alignment.

RAPID FRICTION-DISK-FACING WEAR -- Rapid wear of the friction-disk facings will be caused by any condition that permits slippage between the facings and the flywheel or pressure plate. Thus, if the driver has the habit of "riding" the clutch (that is, if he keeps his foot resting on the clutch) part of the pressure-plate spring pressure will be taken up so that slipping may take place. Likewise, frequent use of the clutch or excessively slow releasing of the clutch after declutching will increase clutch-facing wear. The remedy here is for the driver to use the clutch properly and only when necessary.

Several conditions in the clutch itself can cause this trouble. For example, weak or broken pressure springs will cause slippage and facing wear. In this case, the springs must be replaced. If the pressure plate or friction disk is warped or out of line, it must be replaced or realignment must be reestablished. In addition to these conditions in the clutch, improper pedal-linkage adjustment or binding of the linkage may prevent full spring pressure from being applied to the friction disk. With less than full spring pressure, slippage and wear are apt to take place. The linkage must be readjusted and lubricated at all points of friction.

CLUTCH PEDAL STIFF -- A stiff clutch pedal, or a pedal that is hard to depress, is likely to result from lack of lubricant in the clutch linkage, from binding of the clutch-pedal shaft in the floorboard seal, or from misaligned linkage parts that are binding. In addition, the overcenter spring (on vehicles so equipped) may be out of adjustment. Also, if the clutch-pedal has been bent so that it rubs on the floorboard, it may not operate easily. The remedy in each of these cases is obvious: parts must be realigned, lubricated, or readjusted as necessary.

CLUTCH-PEDAL ADJUSTMENT -- Clutch-pedal-linkage adjustment may be required from time to time to compensate for friction-disk-facing wear. Also, the linkage requires periodic lubrication. The adjustment must provide the proper amount of free clutch pedal travel (also called pedal lash). The free travel is the pedal movement before the throw-out bearing comes up against the clutch release levers. After this occurs, there is a definite increase in the amount of pressure required to actuate the release levers and disengage the clutch. If the pedal lash is too great, the clutch may not release fully, and this could cause clutch spinning during disengagement. If the pedal lash is too small, the clutch may not be able to engage fully, and this could cause rapid friction-disk-facing wear. Methods of making the adjustment vary in differentvehicles. Refer to the manufacturer's shop manual for details and specifications.

INSPECTING AND SERVICING CLUTCH PARTS -- The various clutch parts can be checked as follows when they are removed from the clutch:

1. Clutch pressure springs -- If the pressure springs have overheated, the paint will burn off or the springs will turn blue. Overheated springs should be replaced, since they may have lost tension and will not operate satisfactorily. Spring pressure can be tested with a spring-tension tester.

2. Pressure plate -- A warped or badly scored pressure plate should be replaced. Slight scores or scratches can be cleaned off with fine emery cloth. All traces of emery should be removed.

3. Friction disk -- The friction disk should be carefully inspected to make sure that it is in good condition. Several points should be considered.

CAUTION: Do not get any trace of oil or grease on the friction-disk facings. Even small traces may cause clutch grabbing or slipping.

FACINGS -- If the facings are worn down nearly to the heads of the rivets, then the facings or friction disk should be replaced. Many manufacturers recommend replacement of the complete disk; some supply facing-replacement data along with strong cautions to be extremely careful if installation of new facings on the disk is attempted.

CUSHION SPRINGS -- If the cushion springs under the facings appear to be cracked or weak, the friction disk should be replaced.

TORSIONAL SPRINGS -- Torsional springs that are loose, and seem to have lost tension, require replacement of the complete friction disk.

HUB SPLINES -- The fit of the hub to the clutch shaft should be tested. It should slide without difficulty and should not have any noticeable rotary play. Excessive play means worn splines, and either the shaft or the disk should be replaced (or both).

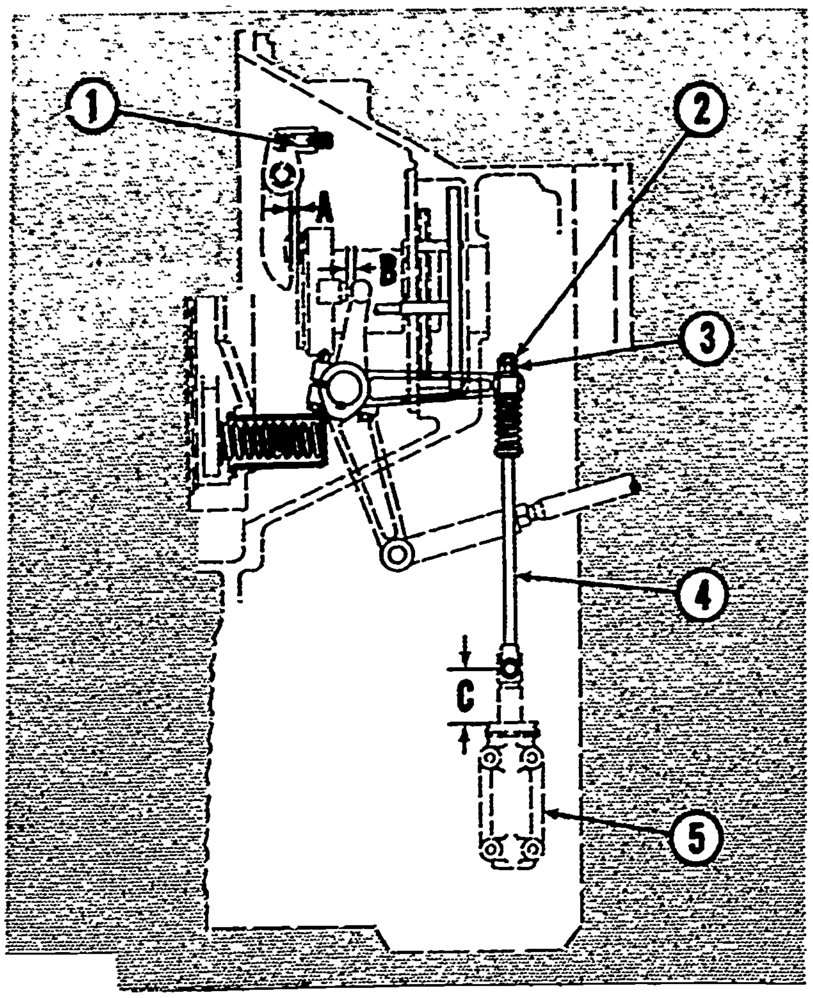
THROW-OUT BEARING -- The throw-out, or release, bearing should never be cleaned in any cleaning solvent or degreasing compound, since this would remove the lubricant that is placed in the bearing on orignial assembly and would thereby ruin the bearing. If the bearing runs roughly or seems loose or noisy, it should be replaced.

HOUSING ALIGNMENT -- Normally, there need be no concern about the clutch-housing alignment, since it was correct on original assembly, and alignment should not be lost even if the transmission has been removed and replaced. However, if clutch-pedal pulsations are noticed or if gear shifting is hard and gears jump out of mesh, then alignment should be checked. This requires a special alignment arbor and dial indicator.

PILOT BEARING IN CRANKSHAFT -- The pilot bearing in the cranksahft usually is either a bushing or a ball bearing. The old bushing can be removed and a new one installed with a special tool. A small amount of short-fiber grease should then be placed in the bushing. Do not put any kind of grease on the end of the clutch shaft.

HEAVY-DUTY FLYWHEEL CLUTCH ADJUSTMENT -- Figure 15 shows points of adjustments on the CAT No. 12 Grader flywheel clutch. Upon installation of this clutch, turn adjusting nuts (1) until there is a 1/8" clearance at (A) between the clutch release levers and the face of the thrust ring. Install a cotter pin in each adjusting screw to lock the nut.

With no pressure on the clutch pedal, adjust the linkage between the clutch pedal and the clutch until there is .010" to .015" clearance at (B) between the release yoke arms and the buttons on the bearing cage assembly.



1-Adjusting nut. 2-Locknut. 3-Adjusting nut. 4-Interlock control rod. 5-Interlock housing. A-1/8" clearance at this point. B-.010" - .015" clearance at this point. C-2 1/16" dimension earlier machines or 1.81" dimension later machines.

Fig. 15 Flywheel clutch assembly

After the clearances are obtained at (A) and (B) and with the clutch engaged, loosen the locknut (2) and turn the adjusting nut (3) as required to obtain the measurement (C), between the center of the lower pin of the interlock control rod (4) and the top of the interlock housing (5). Tighten the locknut securely after the adjustment is completed.

DIDACTOR PLATES FOR AM 2-1D

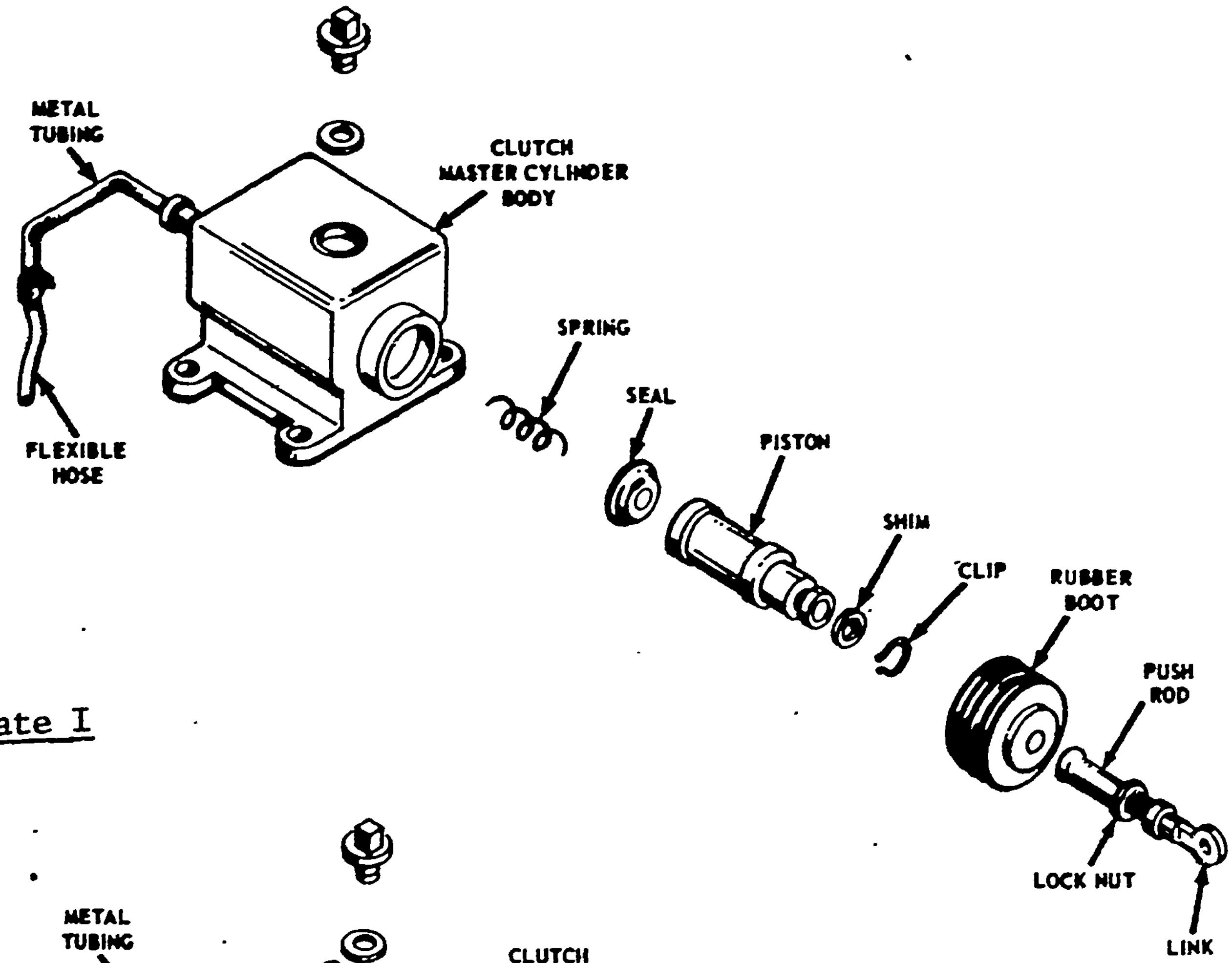


Plate I

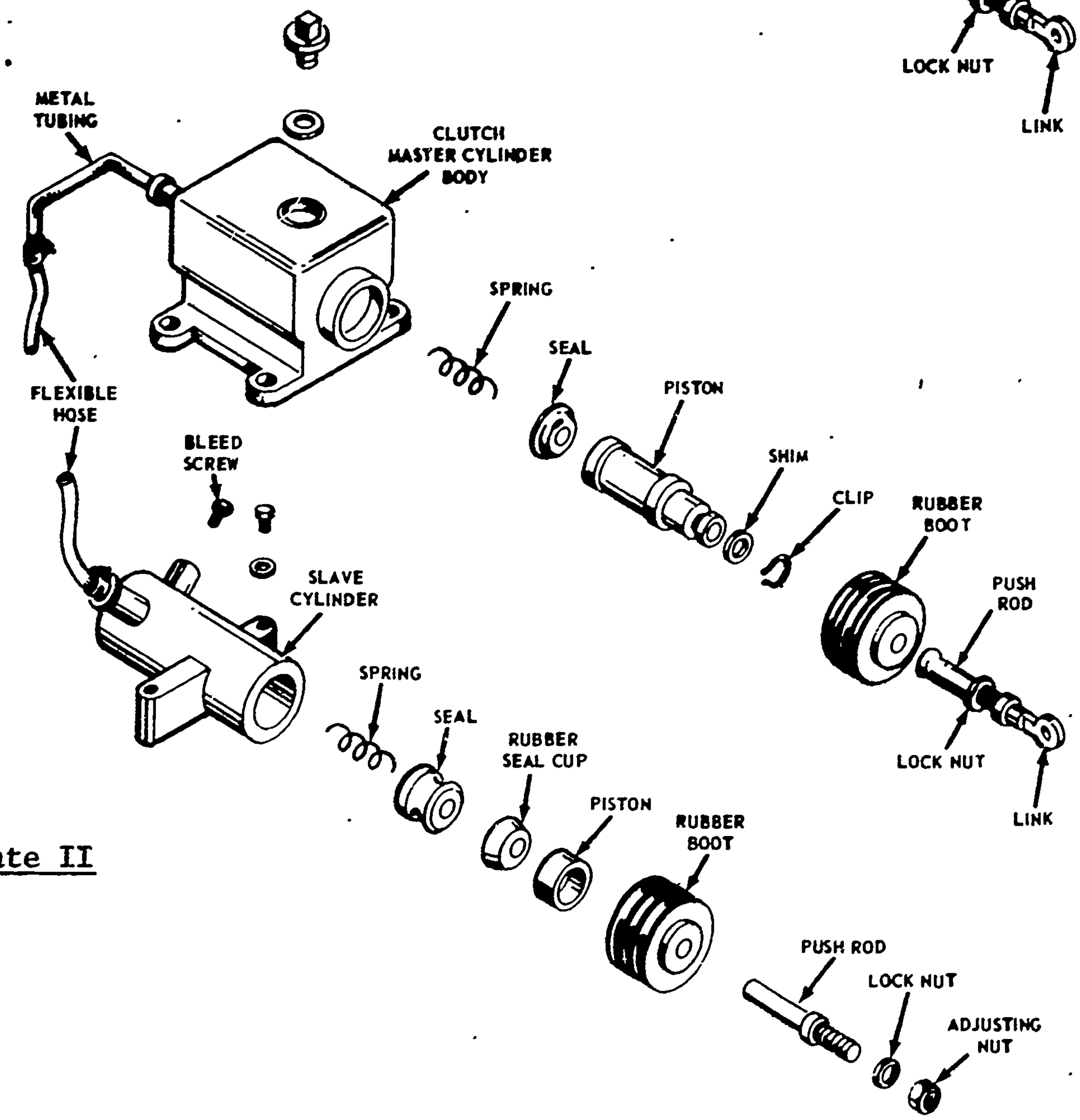
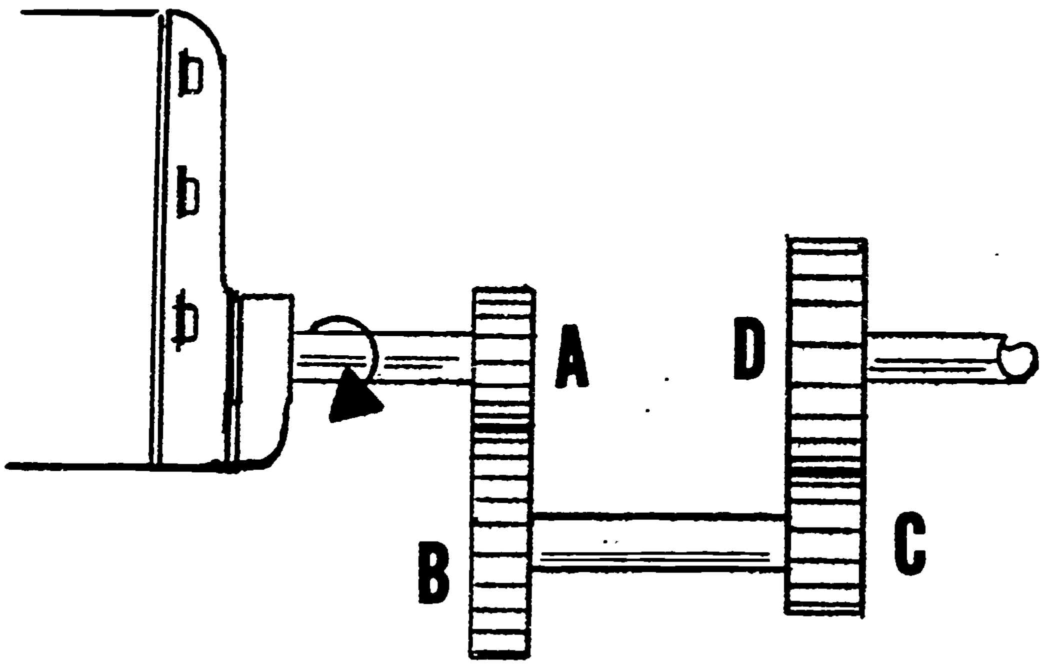


Plate II



Gears A and C have 12 teeth
gears B and D have 24 teeth
(gear A is turning as indicated).

Plate III Gear problem

0

AM 2-1D
1/5/67

LEARNING ABOUT MECHANICAL CLUTCHES

Human Engineering Institute

Minn. State Dept. of Ed. Vocational Education

Press A 1 Check to see that timer is OFF

1-1

1

This film lesson is designed to supplement class text AM 2-1 by reviewing some basic knowledge behind the mechanical aspects of the CLUTCH. In addition, an introduction to transmissions will be presented by reviewing GEARING principles. As you proceed through this lesson read each frame carefully and think before answering the questions.

Press A 2

1-2

2

As we have learned, mechanical clutches are used with mechanical transmissions. In a transmission of this type the operator must shift the gears manually. The mechanical clutch in this type of power train enables the operator to ______________.

3 A. increase or decrease the engine torque output
5 B. gradually allow engine torque to be applied to the load
4 C. delay torque until engine builds up rpm

1-3

3

No. You are incorrect. Engine torque cannot be changed by the clutch. Torque is designed into the engine (i.e, small engines have low torque, large engines have high torque etc.)

The operator can use the clutch as a means to change into various gears: this is one reason for the clutch, but not the answer we want here. Try this question again.

Press A 2

1-4

4

No. Delaying torque until a certain rpm is reached is not the purpose of the clutch. It can be used in this manner but it is definitely not recommended. Try this question again.

Press B 2

1-5

5

OK. The clutch is a mechanism that allows the engine to take up the load gradually and without shock. The clutch also provides a means for disconnecting power (torque) from the load, for gear shifting purposes. In a simple one disc clutch arrangement, the engine flywheel serves as a ______________ plate.

8 A. driving
6 B. driven
7 C. pressure

1-6

6

No. The flywheel is called one of the driving plates in this type of clutch. The flywheel is attached to the engine crankshaft.

The other driving plate is attached to the flywheel. Hence, when the crankshaft rotates, both driving plates rotate.

Press A 7

1-7

7

No. The pressure plate is the other driving plate. Strong springs force the two driving plates together, squeezing the driven plate until all plates are turning as a unit.

Press B 8

1-8

8

OK. The flywheel serves as one of the driving plates. The other driving plate is fastened to the flywheel. Both are attached to the engine crankshaft. This statement is________.

9 A. True
4 B. False

(NOTE: You must select the correct answer before the next frame will appear).

1-9

9

OK. The engaging and disengaging of the clutch is controlled by two factors: the series of springs constantly trying to engage the clutch, and the pedal-operator combination disengaging the clutch. As the operator depresses the pedal, the spring tension is overcome and the clutch is allowed to slip. When the pedal is depressed all the way, the driving and driven plates are separated entirely.

Press A 9.1

1-10

9.1

When the pedal is completely let out (no foot pressure), the spring pressure is at maximum, the speeds of the driving plates and the driven disks are the same, and all slipping stops. At this time there is a direct connection between the driving and driven shafts.

Press A 10

1-11

10

In most clutches, there is a direct mechanical linkage between the clutch pedal and the clutch release yoke lever.

On some heavy clutch installations, where a great amount of pressure is required, a hydraulic clutch release system is used; see Plate I. A master cylinder, similar to a brake master cylinder, is attached to the clutch pedal.

Press B 11

1-12

11

A cylinder, similar to a single acting brake wheel cylinder, is connected to the master cylinder by pressure hose or metal tubing; see Plate II. The slave cylinder is connected to the clutch release yoke lever. Movement of the clutch pedal actuates the clutch master cylinder. This movement is transferred by hydraulic pressure to the slave cylinder, which in turn actuates the clutch release yoke lever.

Press A 12

1-13

12

Just as in a hydraulic brake system, a hydraulic clutch system uses________________ as a means of depressing the clutch springs.

13 A. mechanical advantage
13 B. leverage principle
14 C. hydraulic power assist plus A and B

1-14

13

No. Your answer is only partially correct. The hydraulic clutch, just as the hydraulic brake, uses these mechanical advantage and leverage principles. But, in addition, there is a hydraulic power assist that makes it easier to depress the clutch pedal.

Press A 14

1-15

14

OK. Where there is a hydraulic system of any type, there must be a pump. Look at Plates I and II carefully. The pump in this arrangement is the ____(1)____ which is actuated by the ____(2)____ action.

15 A. (1) slave cylinder (2) master cylinder
16 B. (1) master cylinder (2) pedal
15 C. Both A and B are wrong

1-16

15

No. The correct answer is: the master cylinder is the pump which is actuated by the pedal.

When the pedal is depressed, it forces the master cylinder piston to move so as to compress oil in the cylinder. This action forces oil under pressure through tubing to the slave cylinder, which in turn actuates the clutch release yoke lever.

Press A 16

1-17

16

OK. When the pedal is depressed, oil is compressed by the master cylinder piston and pressurized oil moves the slave cylinder push rod, which in turn moves the clutch release yoke lever.

We have discussed the multiple disk clutch. Facings on frictional surfaces in these clutches usually are attached to the driving plates rather than the driven plates. The main reason for this is to________________.

18 A. gain more friction, greater heat dissipation, and a more positive contact

19 B. reduce the weight of the driven disks so spinning can be held to a minimum after the clutch is released

[redacted] x (C) 17

2-1

17

You have answered one or more of the questions in this sequence incorrectly. Before going on to new material, read this section again. Take your time in answering the questions.

Press A 2

2-2

18

No. You are incorrect. The fact that frictional surfaces are attached to the driving plates will not afford more frictional surface nor have any higher heat dissipation capabilities.

The correct answer is: to reduce the weight of the driven disks, to keep them from spinning after clutch release.

Press A 19

2-3

19

OK. It is desirable to hold spinning of the driven plates to a minimum after clutch release to________________.

20 A. reduce wear on the drive shaft bearings

21 B. allow easier shifting of gears

20 C. Both A and B are incorrect

2-4

20

No. To allow easier shifting of the gears, is the correct answer. This also reduces wear on the gears in the transmission. You will recall, in our discussion of the CAT mechanical clutch arrangement, where a brake mechanism stopped the rotating shaft only for the purpose of shifting gears.

Press A 21

2-5

21

OK. You will recall we mentioned that the CAT. No. 12 Grader clutch had a brake arrangement to slow down, and even stop, the drive shaft to facilitate shifting the gears.

The cushioning device that most friction clutches have consists of________________.

22 A. a series of coil springs riveted to the pressure plate

23 B. a throw-out bearing mounted to the drive shaft

24 C. waved cushion springs mounted in the driven disc

2-6

22

No. These springs are not for dampening. The cushioning device consists of waved cushion springs to which the friction faces are attached. These springs compress slightly as clutch engagement occurs.

Press A 24

2-7

23

No. The throw-out bearing moves up and down the shaft for another purpose.

The correct answer is: the cushioning device built into the friction plate consists of waved springs that compress slightly when clutch engagement occurs.

Press A 24

2-8

24

OK. The waved springs on which the friction facings are attached compress a little when clutch engagement occurs.

The dampening effect comes from a series of coil springs (also mounted in the friction disk) placed between the drive washers and riveted to the cushion springs and hub flange.

There normally are (1) bearings in a friction clutch, one to support the (2) and the other for the (3).

25 A. (1) two (2) friction disk (3) pedal movement
26 B. (1) two (2) clutch shaft (3) throw-out collar
25 C. Answers A and B are both wrong.

2-9

25

No. You have chosen a wrong answer. Two bearings are used, but one is to support the clutch shaft, and the other is used for the throw-out collar.

Press A for another look at this one. 24

2-10

26

OK. The bearing at the front of the clutch shaft must carry a heavy radial load, due to the torsional vibration and the weight of the crankshaft and clutch shaft. This statement is__________.

27 A. True
28 B. False

2-11

27

No. You are incorrect. This bearing frequently is an annular ball bearing which will take comparatively little radial load. Some clutch manufacturers use a cylindrical roller bearing for this application, and still others use an oilless bushing.

Press A 28

2-12

28

False is correct. This bearing is required to take a comparatively light radial load. The bearing is pressed into a counterbore in the end of the crankshaft (or the bore of the flywheel web), and the inner race slips over the clutch shaft. Any end thrust on the shaft is taken up on the bearings at the opposite end, which is secured in the wall of the transmission housing.

The clutch throwout bearing is subject to a straight thrust load as inflicted by the yoke. Since centrifugal force is a factor here, most throw-out bearings are of the __________ type.

30 A. angular contact
29 B. radial load
29 C. vertical load

2-13

29

No. Radial load and vertical load are very similar and here we need a thrust load type bearing. Remember, there are two types of force that act on bearings, radial and thrust. In some cases, there is a need for a combination of both radial and thrust.

In this case, there is no radial force on the throw-out bearing, but -- due to the centrifugal force factor -- we need a bearing that will accept angular contact.

Press A 30

2-14

30

OK. Special designs of angular contact and thrust ball bearings have been developed for this purpose.

Clutch adjustment and troubleshooting -- As we learned earlier, clutch problems usually are obvious to the mechanic. Let's review a few problems that frequently occur with mechanical clutches.

Press A 32

X(C) 31

3-1

31

You have missed one or more of the questions in this sequence of material. Before going on, review the last few frames. Take your time in answering the questions.

Press A 16

3-2

32

Clutch slipping frequently is a complaint when mechanical transmissions and friction clutches are installed on a vehicle. Suppose we take one that was slipping badly. Probably the first thing to do would be________.

33 A. remove the clutch and check the return springs
33 B. check for misalignment of the engine and transmission
34 C. to check pedal linkage and readjust if necessary

3-3

33

No. To check the return springs or misalignment of the engine and transmission would require a complete teardown of the unit. Remember, as has been mentioned many times before, check for simple things first. In this case it may be pedal linkage.

Press A 34

3-4

34

OK. If readjusting, lubricating and freeing the linkage does not remedy the situation, then the only thing left to do is pull the clutch and check the internal workings.

One condition inside the clutch that could cause slipping is________.

35 A. a loose friction disk hub
35 B. a worn out clutch throw-out bearing
36 C. Both A and B are wrong answers

3-5

35

No. You are incorrect. A loose friction disk hub or a worn out clutch throw-out bearing would not cause a clutch to slip.

If these two components were bad, there would be a lot of clutch noise.

Press A 36

3-6

36

OK. These two conditions would not cause clutch slipping. One thing that may cause excessive slipping is weak or broken pressure springs.

Another would be________.

37 A. the operator riding the clutch
39 B. worn friction disks
38 C. warped friction plate

3-7

37

No. The mechanic can only guess whether the clutch has been ridden excessively or not. Usually, if the clutch has been treated in this manner, it will be shown by badly worn friction disks through overheating.

The answer we want here is: worn friction disks. Sometimes they are worn so badly that the rivets rub the driving plates.

3-8

Press A 39

38

No. Unless the friction disks are worn, or there has been grease or oil on the disks, there will be little slipping of the clutch.

An excessively warped disk should be replaced immediately.

Press A 39

3-9

39

OK. Worn friction disks are common in the mechanical clutch. Some get so bad the rivets that hold the friction material are rubbing the driving plates, just as brake lining rivets rub the drums when they get worn.

Either a binding clutch linkage or a sticking release mechanism very often causes clutch problems. If the linkage binds, then releases suddenly, clutch chattering or grabbing will occur. This is caused by the driven disk being squeezed too quickly.

Press A 40

3-10

40

There is little clearance between the driven (friction) disk and the driving plates. Hence, when the clutch is released, by pushing in the pedal, all internal parts of the clutch must be in good shape. For instance, if the driven disk is warped, or has loose friction facings, you will get a condition of________________.

41 A. clutch noises, commonly called squealing
42 B. rapid wear on the friction facing
43 C. clutch dragging when disengaged

3-11

41

No. Noises heard when the clutch is disengaged usually are caused by the throw-out bearing being worn. Many times the bearing is binding and it has lost all lubricant. Try this question again.

Press A 40

3-12

42

No. Rapid wear on the friction plates is usually caused by excessive slipping. an indication that the operator is "riding" the clutch or abusing it in some other manner. Try this question again.

Press A 40

3-13

43

OK. The driven disk will spin a little (due to centrifugal force) after disengagement. However, clutch spinning in this sense is not clutch dragging. Clutch dragging occurs when the friction plate "hangs up" against the driving plates and will not release completely. In troubleshooting this condition, a smart mechanic would first check________________.

44 A. for weak cushion springs in the friction plate
46 B. pedal linkage adjustment
45 C. for a warped pressure plate

3-14

44

No. Weak cushion springs in the friction plate would not cause clutch dragging.

If these springs are worn or broken, the result will be clutch grabbing, or heavy jerking when the clutch is engaged.

Try this question again.

Press B 43

3-15

45

No. To check for a warped pressure plate would mean removal of the clutch housing and disassembly.

Here again: check for simple things first. Much time and money can be saved by using the methodical approach to troubleshooting.

Try this one again.

Press A 43

3-16

46

OK. The first thing to check with this condition is the pedal linkage adjustment. If there is excessive pedal lash, or free travel, even full movement of the pedal to the floor board will not force the throw-out bearing in against the release levers (or diaphragm spring) far enough to release the clutch fully; hence we get dragging.

Press B 47

3-17

47

Let's talk about clutch noises, which are common complaints with mechanical clutches. When trouble-shooting for clutch noise, the first step is to start the engine ______________.

48 A. and rapidly release the pedal with the transmission in low gear

49 B. depress the clutch fully, and shift into all gears, noting any mesh noise

50 C. and note whether the noise is heard when the clutch is engaged or disengaged

3-18

48

No. The proper procedure to test clutch noise is to first determine whether the noise is heard when the clutch is engaged or disengaged with the engine idling. To rapidly release the pedal when the transmission is in low gear would only stall the engine.

Press A 50

3-19

49

No. Shifting from one gear to another with the clutch engaged would only be a partial test indicating if noise was present when the clutch is engaged (shifting the gears at this time is not necessary).

The answer we want here is: to leave the engine at idle and determine whether the clutch noise is present when the pedal is out,or fully depressed.

Press A 50

3-20

50

OK. There are several conditions that could cause a noisy clutch when the cluch is engaged. One of these could be due to a friction-disk hub that is loose on the clutch shaft. Another condition is broken or weak dampener springs on the friction disk. To repair this would require______________.

51 A. tightening up of the friction disk hub

52 B. only replacing the springs in question

53 C. replacing the friction disk

3-21

51

No. This would not help a condition of weak or broken dampener springs. The answer we want here is that the entire disk should be replaced. It is not feasible to replace these dampener springs because, as we learned earlier, the friction face material is riveted to these springs.

Press B 53

3-22

52

No. It is not feasible to replace the weak or broken dampener springs because, as we learned earlier, the friction face material is riveted to these springs and the standard policy is to remove and replace the entire friction disk or disks.

Press A 53

3-23

53

That is correct. It is standard policy to replace the entire friction disk in most shops because of the riveted parts involved.

There is one condition where shims can be used to correct malfunctions in the clutch. This is when ______________.

54 A. the clutch pedal linkage is out of adjustment

56 B. there is misalignment of the engine and transmission

55 C. the friction disk hub is loose on the shaft

3-24

54

No. There are locknuts and other methods of pedal and linkage adjustments. The answer we want here is that shims can sometimes be used to correct a misalignment between the engine and transmission.

Press A 56

3-25

55

No. A loose disk hub would require the replacement of the friction disk or clutch shaft. The answer we wanted here is that shims can sometimes be used where there is a misalignment between the transmission and engine.

Press A 56

3-26

56

You are correct. Sometimes this situation can be corrected by shims. However, it may be other components that are causing this misalignment.

For example, the flywheel should be checked for wobble. This condition may be caused either by a bent crankshaft or the flywheel may not be seated correctly on the crankshaft flange. Shims would not help in this case. If there is a bent crankshaft, it must be replaced. The same holds true if the flange is bent.

Press A 58
X(C) 57

3-27

57

You have missed one or more of the questions in this sequence of material. Review this section, read carefully and take your time in answering.

Press A 32

3-28

58

Since the next nine text units will be covering mechanical and semi-automatic transmissions, let's discuss some definition of terms relative to transmission operation.

DEFINITION OF TORQUE -- Torque is "that which produces or tends to produce rotation or torsion". Torque often is referred to as a "twisting" action or that which tries to make something turn.

Torque is made up of two factors, a force measured in pounds and the length of a lever arm on which the force acts, which is usually expressed in feet.

Torque is equal to the product of these two factors, and is measured in foot-pounds.

Press A 59

4-1

59

Foot-pounds used to describe torque measurement is actually a false statement.

Engineers classify the foot-pound as a unit of work or energy. In other words a foot-pound is the amount of work done when a mass of one pound is raised one foot against gravity.

A pound-foot, on the other hand, is the action created when a force of one pound is applied to the end of a lever arm one foot long.

Press A 60

4-2

60

In our discussion of torque so far, terms used to describe its measurement and description can be classed as follows: (Choose one)

61 A. twist, mechanical advantage, foot pounds

61 B. force, pounds, multiplication, foot pounds

64 C. Neither A or B is correct

4-3

61

If you answered "foot-pounds" you are incorrect.

Remember, we said that this term is incorrectly used in reference to torque.

Also, "mechanical advantage" is wrong. In past units you learned that this term had to do with levers, fulcrums and pivot points, where an advantage is gained but the distance moved is short.

Press A 62

4-4

62

Correct. The term is pound-foot, instead of foot-pounds. when talking in terms of torque. We defined pound-foot as the ______________________.

63 A. amount of force it takes to raise one pound one foot from the ground

65 B. potential created when a force of one pound is applied to the end of a lever arm one foot long

64 C. length of lever required to raise a pound of material one foot from the ground

4-5

63

No. You are thinking of the amount of work that is done in raising one pound of mass one foot from the ground. Try this question again.

Press A 62

4-6

64

No. Pound-foot does not refer to length of levers. It refers to the potential created by a force (one-pound) applied to the end of a lever arm one-foot in length.

Press A 65

4-7

65

You are correct. Now let's see how engine torque is measured.

A dynamometer not only provides a means of determining engine torque, but also provides an excellent method of detecting misfiring injectors, improper tune-up, low compression, and other malfunctions.

Before checking an engine for torque, look at the applicable engine manual to determine what the basic engine is. Accessories, such as generators absorb power from the engine and may cause false engine performance ratings.

Press B 67

4-8

67

The function of a dynamometer is to absorb and measure engine output. It's basic components are a frame, engine mounts, the absorption unit, a heat exchanger, and a torque loading and measuring device.

The engine is connected through a universal coupling to the absorption unit. There are several types of absorption units on the market today. For example, there is a water brake type where fluid offers resistance to rotating motion. By controlling the volume of water in the unit, the load may be increased or decreased as required.

Press A 68

4-9

68

In the dynamometer, the purpose of the absorption unit is to________________________.

69 A. hold the engine speed to a specific rpm

70 B. determine engine rating and horsepower

71 C. regulate the load being placed on the engine

4-10

69

No. The throttle arrangement varies the engine rpm.

It is possible to increase or decrease the engine rpm by reducing the water level or increasing the water level in this type of dynamometer. but this is not the purpose of the absorption unit. Try this question again.

Press A 68

4-11

70

No. The rating of a given diesel engine is the amount of brake horsepower which the engine builder states the engine will produce. This rating is not always true, especially with an engine that has had considerable use. Try this question again.

Press A 68

4-12

71

You are correct. The absorption unit provides a means of placing a load on the engine; this is the only way that torque can be measured. The readings obtained on a dynamometer generally are measured in torque (pound-feet) on a suitable scale. This value for a given rpm will show the horsepower developed in the engine by the following formula:

$$\text{Engine HP} = \frac{\text{torque} \times \text{rpm}}{5250}$$

Press A 73

X (C) 72

4-13

72

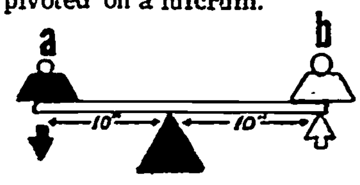
You have answered one or more of the questions in this sequence of material incorrectly. Review these last few frames. Please read carefully and take your time in answering the questions.

Press A 58

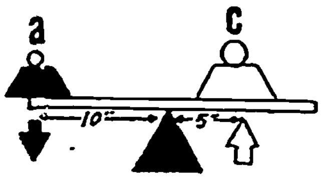
4-14

73

Now let's talk about levers, gears and torque. We have discussed types of gears such as spur, helical, herring-bone, spiral bevel, etc. But just what is the principle behind the use of gears? Actually, a gear is a spinning lever. Take an ordinary lever, 20 inches long, pivoted on a fulcrum.



A 100 pound force down at A exerts a 100 pound force up at B. 100 x 10 = 100 x 10



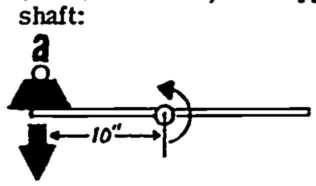
A 100 pound force down at A exerts a 200 pound force up at C. 100 x 10 = 200 x 5

Press A 74

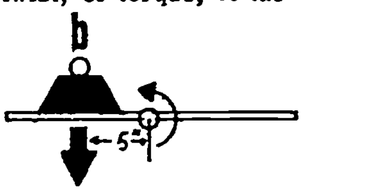
5-1

74

Now, let's change the fulcrum into a shaft fastened securely to the lever. If a force pushes down on one end of the lever, this applies a twist, or torque, to the shaft:



A force of 100 pounds at A causes a torque of 1000 pound-inches on the shaft. 100 x 10 = 1000



A force of 200 pounds at B also causes a torque of 1000 pound-inches on the shaft. 200 x 5 = 1000

5-2

Press A 75

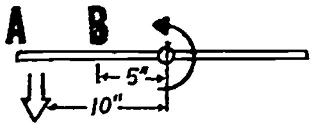
75

Now, suppose we make the shaft try to turn the lever. Instead of the force being applied to the lever, we apply a 1000 lb. torque (twist) to the shaft. This would create a force at (A) of __(1)__ lbs. and a force at (B) of __(2)__ lbs.

76 A. (1) 200 (2) 400

76 B. (1) 50 (2) 100

77 C. (1) 100 (2) 200



5-3

76

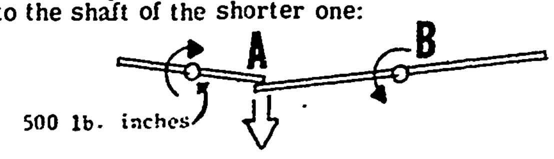
No. The force at points (A) and (B) will not change. The ratio remains the same. (A) has a 100 lb. force and (B) has a 200 lb. force with 1000 lb. torque on the shaft.

5-4

Press A 77

77

You are correct. Now let's take two of these levers, one 10 inches long and the other 20 inches long. Arrange them so one end of the short one is resting on one end of the long one. A torque of 500 pound-inches is applied to the shaft of the shorter one:



There will be a force of 100 lb. pushing down at (A), the end of the short lever. Also, the end of the long lever will have 100 lb. exerted against it. This will create a torque of 1000 lb. -inches at (B). In other words, we have doubled the torque.

5-5

Press A 78

78

Suppose that instead of using a 10 inch lever and a 20 inch lever, we substitute a 20 inch lever and a 40 inch lever, using the same lb. inches of torque (500) applied to the 20 inch lever.

If the same principle applies, the output torque on the longer lever, (40 inch), would be 1000 lb. inches.

This is a _______ statement.

79 A. true

80 B. false

5-6

79

No. The ratio of the levers remained in the same proportion as before, so the torque ratio remains the same. If the smaller lever was 10 inches long and the longer lever was 40 inches long, with the same torque applied to the small one, then the output torque would be 2000 lb. -inches.

Press A 80

5-7

80

That is correct. The torque is multiplied in the same ratio as the size of the levers.

So far we have only mentioned levers. Now let's put a group of levers together around two shafts as shown in(A). Fill them in and we have gears in (B).

Press A 81

5-8

81

The main thing to remember when we study torque (and, later on, transmissions) is that if we have a small gear fastened on one shaft driving a larger gear on another shaft, the torque on the second shaft will be increased. The second shaft will have more twisting force than the first shaft.

Press A 82

5-9

82

Suppose we had an engine driving a shaft, with a gear at the end having 12 teeth, (see Plate III). The engine is running at 1000 rpm; this makes gear (A) turn at 1000 rpm. Gear (B) is turning at ___(1)___ rpm and (B) is turning the ___(2)___ direction as (A).

83 A. (1) 250 (2) same
84 B. (1) 500 (2) opposite
83 C. (1) 750 (2) opposite

5-10

83

No. Remember, we have a gear of 12 teeth turning another gear of 24 teeth. This makes the larger gear turn at exactly half the speed of the smaller gear, or 500 rpm. Also it is turning in the opposite direction.

Press A 84

5-11

84

You are correct. Gear (B) is turning in the opposite direction of gear (A) and it is turning at half speed, or 500 rpm. We know that the shaft speed of gear (B) is cut in half, and that the torque of this shaft is reduced from the engine shaft. This is a_____ statement.

85 A. true
86 B. false

5-12

85

No. You are incorrect. The torque of gear (B) shaft is doubled. Remember, the speed is cut in half but the torque is doubled in this situation.

Press A 86

5-13

86

You are correct. The shaft torque of gear (B) is double that of the engine shaft. Remember, when speed is lost, torque is gained. This is also true in reverse: decrease torque, increase speed.

Now let's talk about gears (C) and (D), (Plate III). Here we have the same ratio, but this time the shaft of gear (C) is turning at 500 rpm. This would make the shaft of gear (D) turn at ___(1)___ rpm but have a torque ___(2)___ times ___(3)___ than the engine shaft torque.

87 A. (1) 750 (2) four (3) less
87 B. (1) 500 (2) two (3) more
88 C. (1) 250 (2) four (3) more

5-14

87

No. You are incorrect. We have a situation here where a double reduction gearing condition exists. Remember, we said as torque is increased, speed is reduced as it was on the engine and gear (B) shaft. Think this over and try the question again.

Press A 86

5-15

88

All right. That is correct: gear (D) shaft is turning at 250 rpm, but the torque has been increased by 4 times over the engine shaft.

Congratulations, you have completed this film on mechanical clutches.

Press REWIND

X(C) 89

5-16

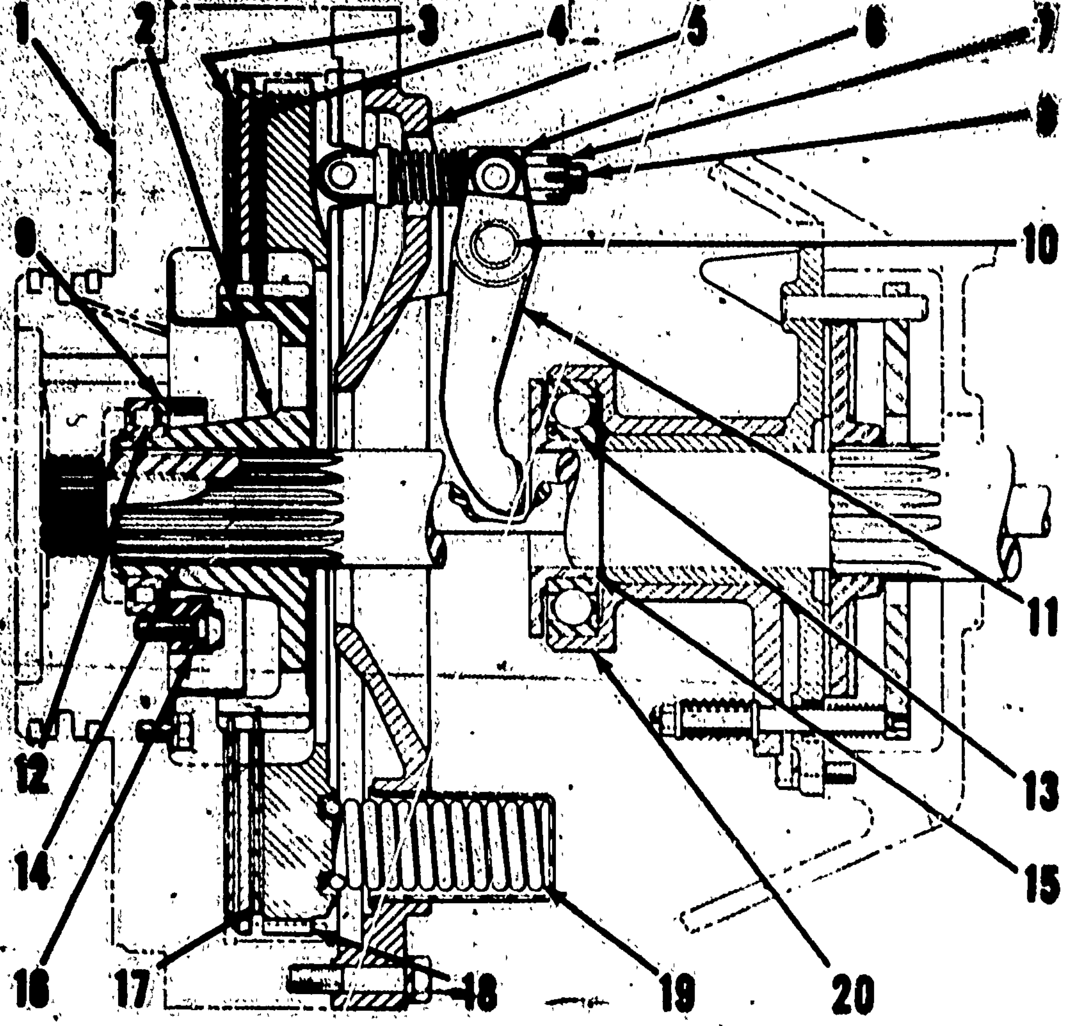
89

You have missed one or more of the questions in this sequence of material. Read the last few frames over again and think before answering the questions.

Press B 73

5-17

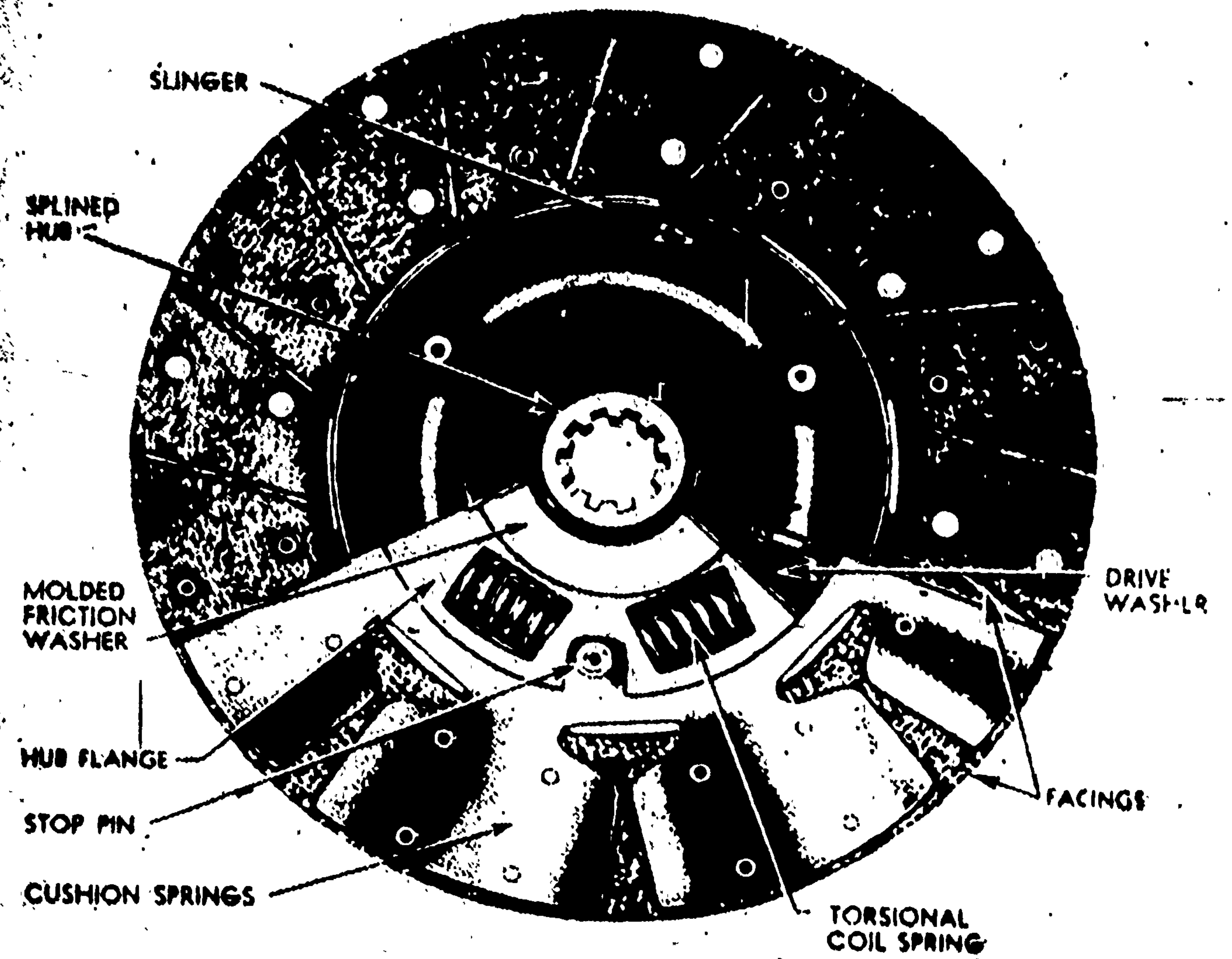
AM 2-1



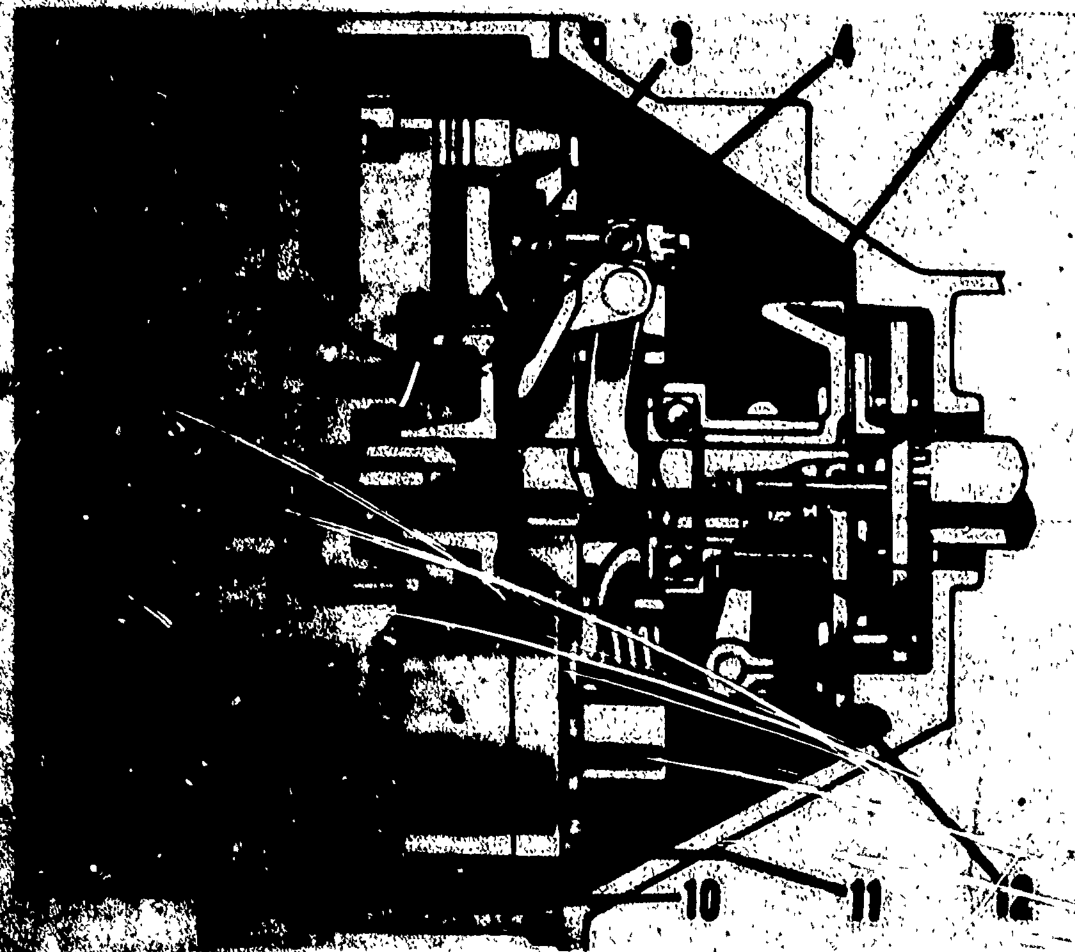
FLYWHEEL CLUTCH (CROSS SECTION)

1–Flywheel. 2–Hub. 3–Driven disc. 4–Driving disc. 5–Cover plate. 6–Retainer. 7–Adjusting nut. 8–Adjusting screw. 9–[illegible] ring. 10–Pivot pin. 11–Lever. 12–Bearing. 13–[illegible]. 14–Stud. 15–Thrust ring. 16–Retainer. 17–[illegible] disc. 18–[illegible] plate. 19–Spring. 20–Bearing cage.

AM 2-1


SLINGER
SPLINED HUB
MOLDED FRICTION WASHER
HUB FLANGE
STOP PIN
CUSHION SPRINGS
TORSIONAL COIL SPRING
FACINGS
DRIVE WASHER

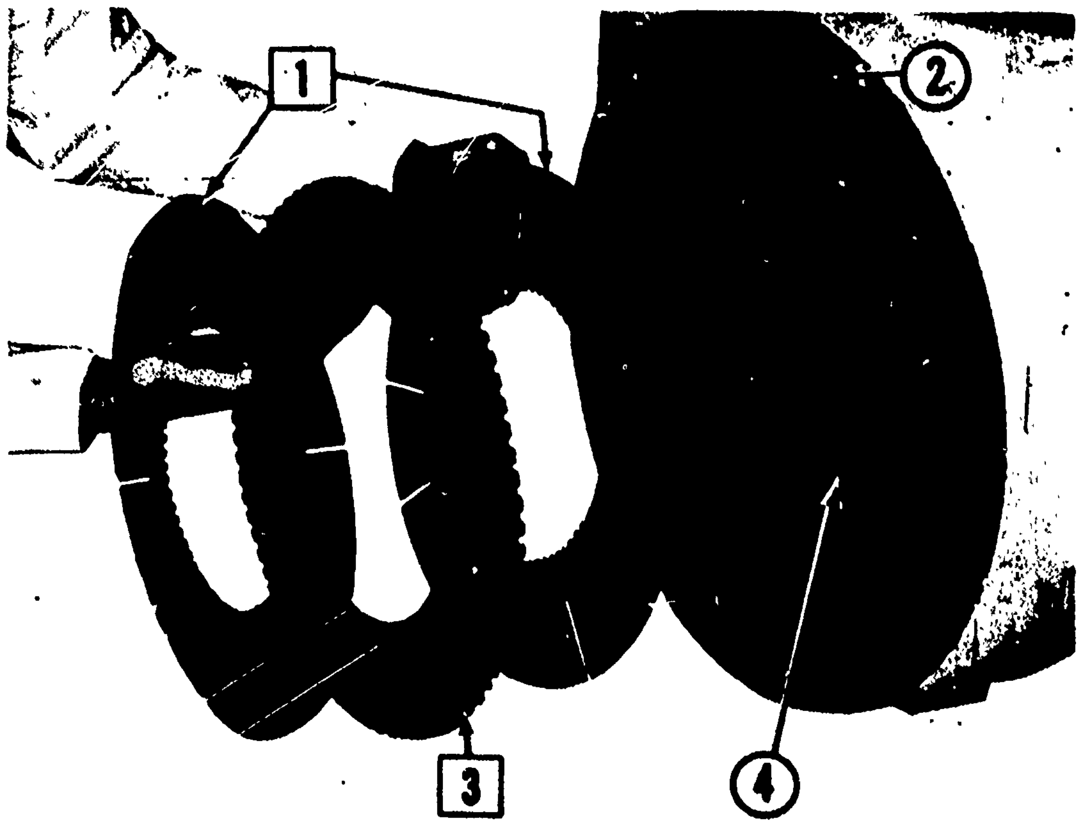
AM2-1 (5)



[illegible]YWHEEL OIL CLUTCH LUBRICATION

[illegible] housing. 2–Flywheel. 3–Oil thrower. 4–[illegible] [illegible] passage. 7–Oil supply line. 8–Oil [illegible] [illegible]. 10–Opening. 11–Clutch cover plate. 12–Brake support plate.

AM 2-1
(5)



REMOVING THE CLUTCH DISCS

☐ Remove

1–Clutch driven disc. 2–Flywheel. 3–Clutch driving disc. 4–Hub.

INSTRUCTOR'S GUIDE

Title of Unit: UNDERSTANDING MECHANICAL CLUTCHES

AM 2-1
12/7/66

OBJECTIVES:

1. To introduce mechanical clutches to the student, by covering what happens once power and torque leave the engine.

2. To show why clutches are a necessity on most power applications.

3. To explain the different types of mechanical clutches and how to troubleshoot them.

LEARNING AIDS suggested:

VU CELLS:
AM 2-1 (1) Flywheel clutch (cross section)
AM 2-1 (2) Clutch brake (cross section)
AM 2-1 (3) Flywheel oil clutch lubrication
AM 2-1 (4) Friction disk or driven plate
AM 2-1 (5) Removing the clutch disks

MODELS: Any parts of the clutch that can be brought into class will be helpful, especially worn parts such as flaked disks or burned disks due to a hot oil condition.

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

1. In what type of engine drive application would there be no need for a clutch?

2. What purposes does a clutch serve?

3. Where is the clutch located? What is it attached to?

4. What are the moving parts of a clutch?

5. What is the difference between the driven plate and the driving plate? Which plate is splined to the transmission shaft?

6. How does the friction plate come in contact with the plate attached to the flywheel?

7. Explain the difference between single, double and multiple disk clutches?

8. What is the purpose of the clutch brake on the CAT oil type flywheel clutch?

9. What is meant by the friction disk having a built in dampening and cushioning device?

10. How is the torsional vibration absorbed in the clutch?

11. How is the throw-out collar normally installed in a clutch?

12. What is an indication that oil has leaked into the clutch?