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AUTOMOTIVE DIESEL MAINTENANCE 2. UNIT V, AUTOMATIC TRANSMISSIONS--TORQUE CONVERTER.

HUMAN ENGINEERING INSTITUTE, CLEVELAND, OHIO

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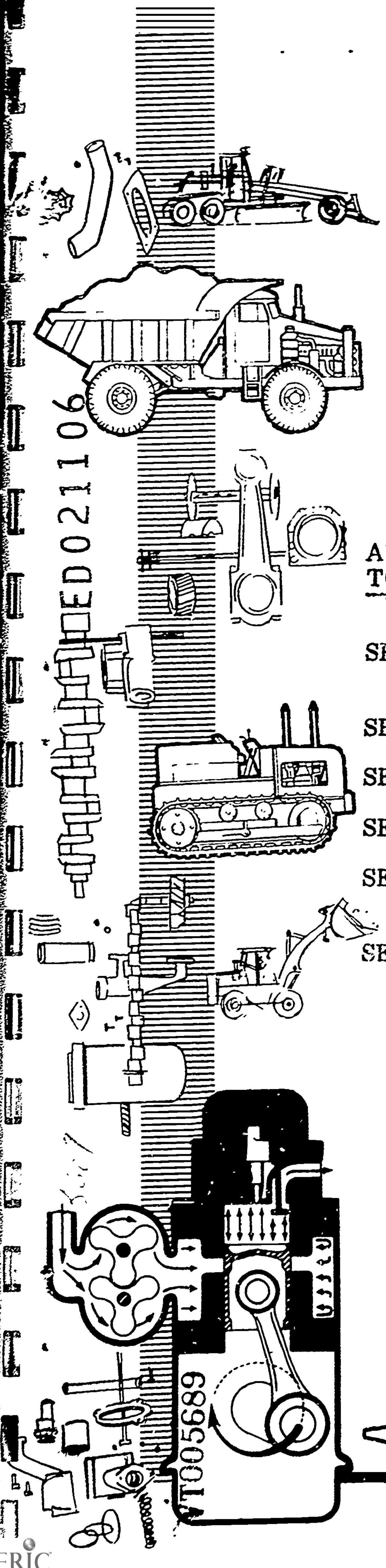
THIS MODULE OF A 25-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF THE OPERATION AND MAINTENANCE OF TORQUE CONVERTERS USED ON DIESEL POWERED VEHICLES. TOPICS ARE (1) FLUID COUPLINGS (LOCATION AND PURPOSE), (2) PRINCIPLES OF OPERATION, (3) TORQUE CONVERRS, (4) TORQMATIC CONVERTER, (5) THREE STAGE, THREE ELEMENT TORQUE CONVERTER, AND (6) TORQUE CONVERTER MAINTENANCE AND TROUBLESHOOTING. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL PROGRAM TRAINING FILM "LEARNING ABOUT TORQUE CONVERTERS" AND OTHER MATERIALS. SEE VT 005 685 FOR FURTHER INFORMATION. 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 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 CETER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)

STUDY AND READING MATERIALS



AUTOMOTIVE DIESEL 2 MAINTENANCE

AUTOMATIC TRANSMISSIONS - TORQUE CONVERTER — UNIT V

SECTION A	FLUID COUPLINGS (LOCATION AND PURPOSE)
SECTION B	PRINCIPLE OF OPERATION
SECTION C	TORQUE CONVERTERS
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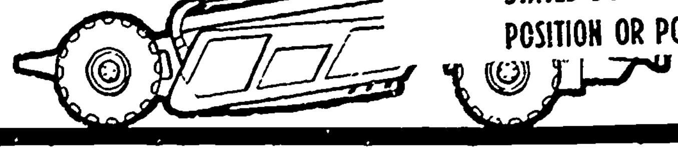

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This Unit is a discussion of the fluid coupling, also referred to as a torque converter, a hydraulic coupling or a fluid flywheel. This device replaces the friction clutch, discussed earlier, and is used with automatic transmissions.

SECTION A -- FLUID COUPLINGS (LOCATION AND PURPOSE)

The simplest means of transmitting torque hydraulically is through a fluid coupling. Fluid couplings can be used with standard transmissions as well as with automatic transmissions. Figure 1 is a cross sectional view of a fluid coupling, showing the parts involved.

As you can see, power flows from the flywheel through the fluid, to the transmission shaft.

A simple fluid coupling could be made with two electric fans. If the fans were placed a few inches apart and facing each other, and if one fan were plugged in so that it ran, the current of air from it would cause the blades of the other fan to turn. See Figure 2.

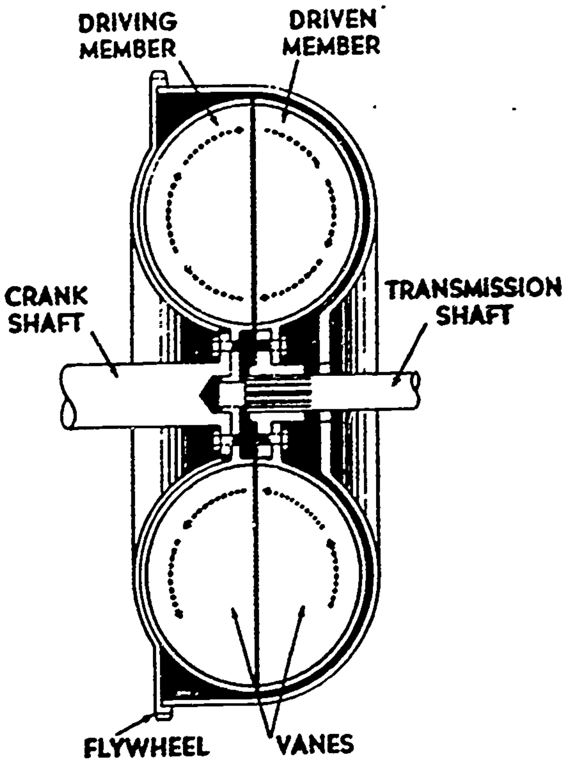


Fig. 1 Cross sectional view of a fluid coupling

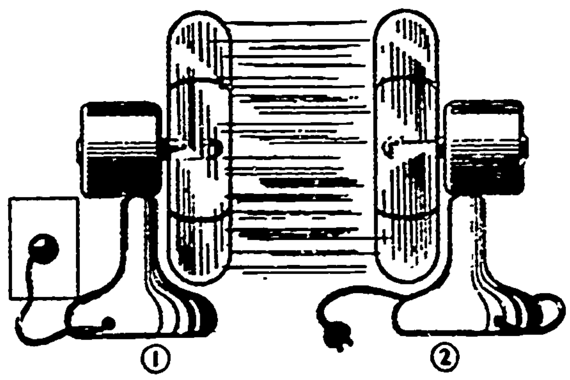


Fig. 2 Simple fluid coupling (air serving as fluid)

SECTION B -- PRINCIPLE OF OPERATION

In the example of a simple fluid coupling, Figure 2, the air is the fluid. But, since the two fans are not enclosed nor closely coupled, this sort of fluid coupling is not very efficient.

The working parts of a fluid flywheel look very much like a doughnut. But, since the doughnut is sliced down the middle, there is no connection between the two halves.

A fluid coupling consists of two main parts, the driving member of the unit and the driven member.

The driving member may be called the pump or impeller, while the driven member is sometimes called the turbine or runner.

When a fluid is used with a hydramatic transmission, the driving member is called the drive torus and the driven member is called the driven torus. (A torus is any doughnut shaped object.) It is important that you become familiar with all these terms so that you can understand the manufacturer's instruction manuals.

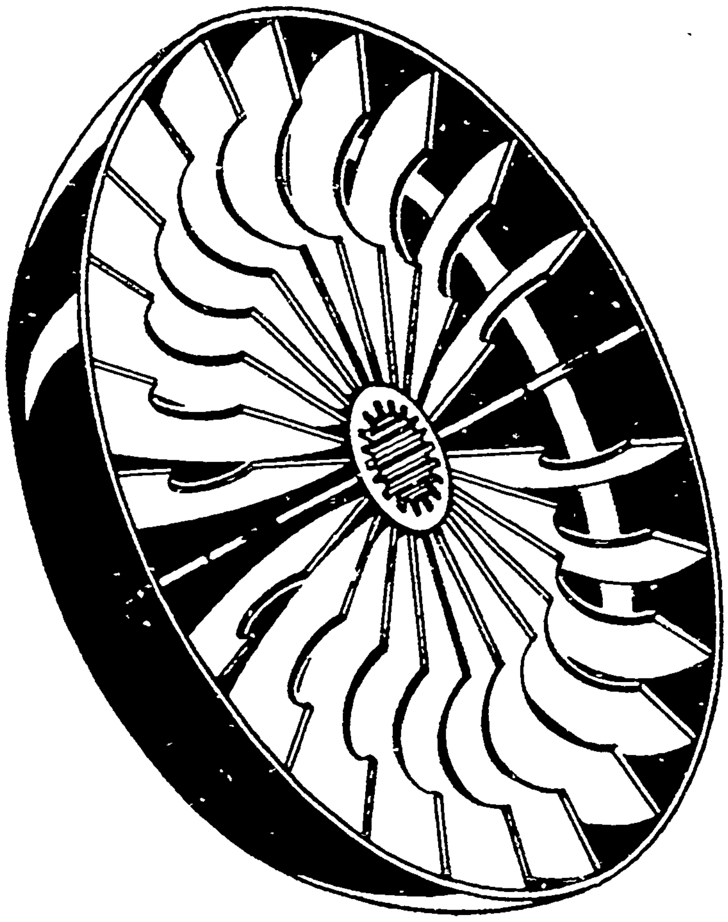


Fig. 3 Fluid coupling pump

The pump of the fluid coupling is connected to the engine and is rotated in the same manner that a crankshaft rotates a flywheel. Usually, the pump is bolted directly to the flywheel. The pump is a torus shaped object that has fins extending radially from its center; see Figure 3.

The turbine is much like the pump, but is connected to the transmission input shaft. The two members of the coupling face each other within a housing that is filled under pressure with the driving fluid (generally oil).

When the pump goes into motion, oil is forced outward by centrifugal force around the entire circumference of the pump, and is hurled against the blades of the turbine. A continuous flow of oil against the turbine blades is necessary to transfer sufficient kinetic energy to keep a vehicle in motion.

At this point, let us look at the definition of ENERGY and also look at the two types of energy, potential energy and kinetic energy.

ENERGY is the ability to do work or overcome resistance. Energy can be stored (potential) or it can be active (kinetic).

POTENTIAL ENERGY of a particle or body is energy that is stored and is ready for use but is in an inactive state. A sleeping bear would serve as a rough illustration of this condition, because the bear has the capacity for doing work, but he is presently in a dormant state. Other examples are:

A compressed spring
A charged storage battery
An unlit firecracker
(energy stored in the powder)

KINETIC ENERGY is energy that is active or being expended. It is associated with motion as illustrated by the bear chasing the Indian. The Indian aroused the bear and this action changed the bear from its dormant state (potential energy) to an active state (kinetic energy). Other examples of this type of energy are:

A falling object
The flow of electric current
The flow of fluid within a torque converter or fluid coupling

This conversion of potential energy to kinetic energy is illustrated in Figure 4.

The centrifugal force of the oil as it leaves the pump gives the oil the velocity it needs. The faster the pump operates, the more velocity the oil will have as it leaves the pump.

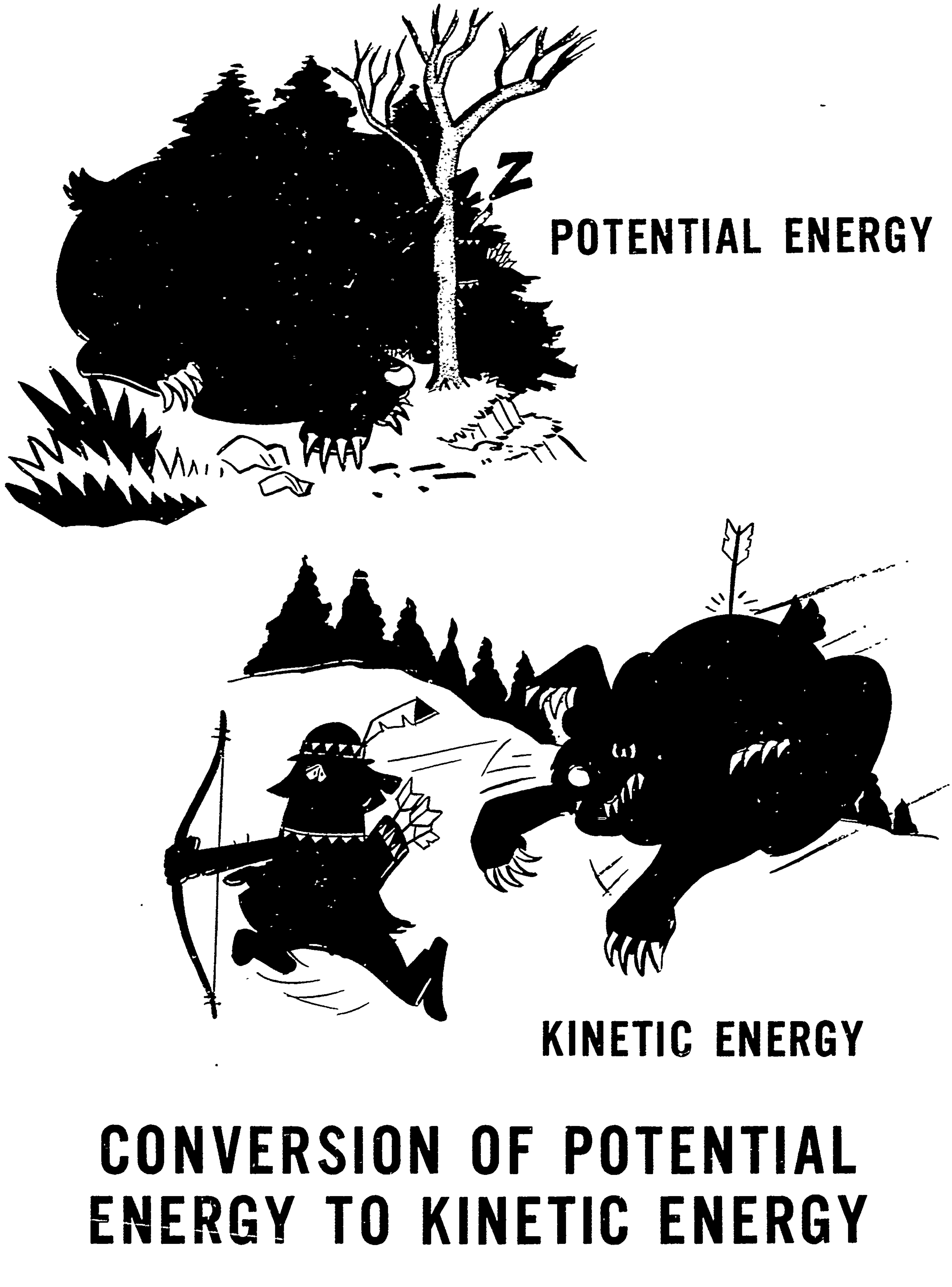


Fig. 4 Conversion of potential energy to kinetic energy

The design of the coupling permits the oil to return to the pump as soon as it has delivered its energy to the turbine. This path of oil is called a vortex and is the path of the stream of oil which drives the turbine.

This action can be compared to a shallow round bowl placed on a spinning turntable. If water is poured into the center of the bowl, it will go outward to the edge and fly up and out of the bowl, due to the action of centrifugal force.

Now if we invert another identical bowl over the first one, the water will enter the upper bowl, will be guided toward the center and will drop back into the lower bowl.

Thus we have established a system of circulation for the fluid. This is the action that takes place in a fluid coupling; see Figure 5.

At high speed the fluid coupling is very effective. The loss of speed between the two torus members is not more than 2 percent. However, at low speeds there is considerable slippage. At idle speed there is 100 percent slippage.

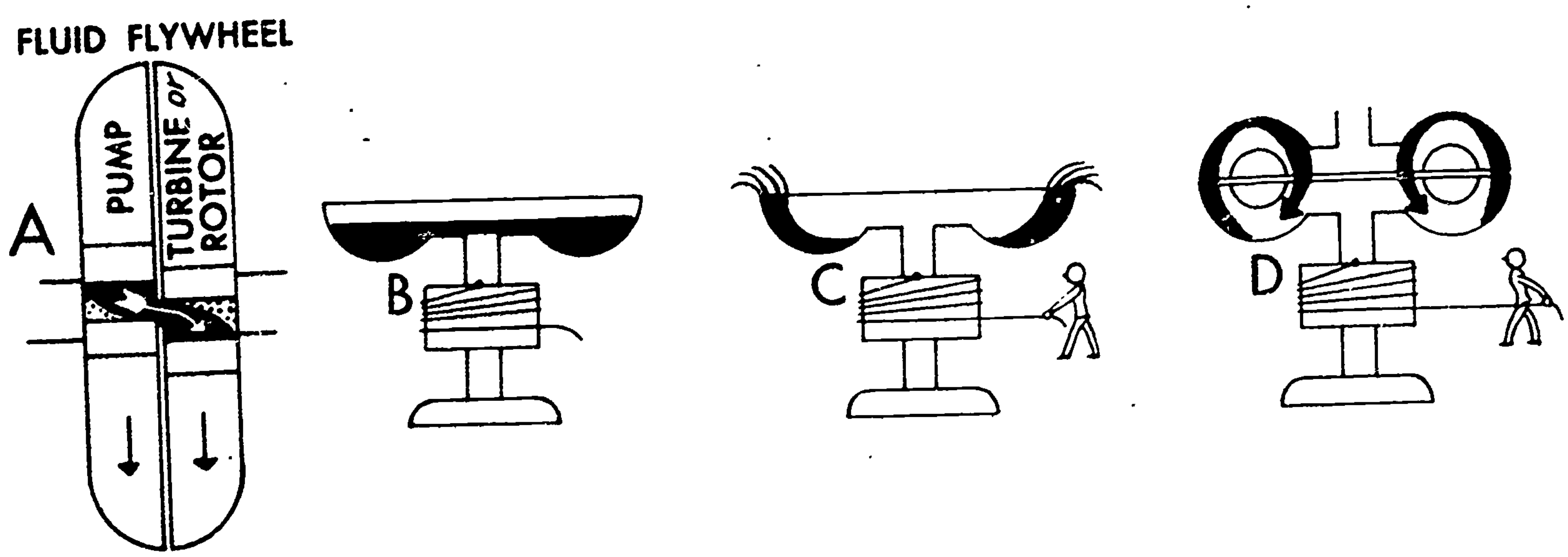


Fig. 5 Fluid flywheel

However, while the engine is idling, there is some energy transmitted, and under some conditions the car or truck may creep slowly since there is no clutch to disengage the idling engine.

To correct this condition, vehicles using a hydramatic design have the torus members reversed. The driven torus is in front of the driving torus instead of behind it, and the engine power must go through a planetary unit attached to the driving torus. This will give a gear reduction and will allow the fluid coupling to turn slower than the flywheel.

See Figure 5 to better understand the location of the units in a hydramatic fluid coupling.

Notice in Figure 6 that the power must go through the planetary unit and then return to the drive torus.

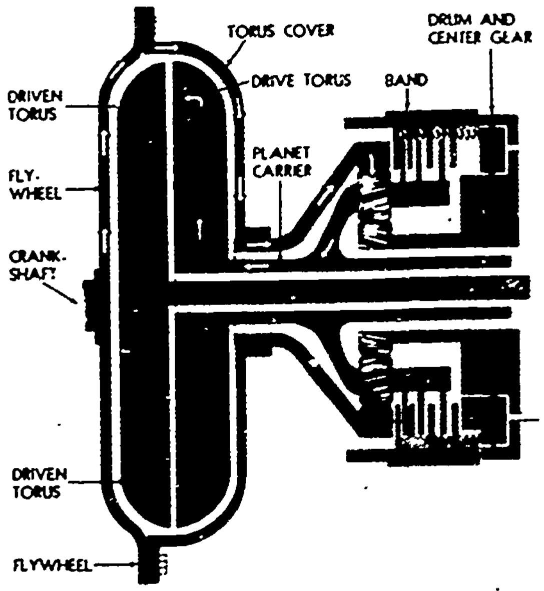


Fig. 6 Hydramatic fluid coupling design

The fluid flywheel should not be confused with the hydraulic torque converter used in many types of automatic transmissions. Both of the units have vanes in them and are operated by oil, but the fluid flywheel we are now considering cannot increase or diminish torque.

However, fluid flywheels can be so constructed that they will increase torque.

SECTION C -- TORQUE CONVERTERS

Torque converters of the hydraulic type for off-highway equipment have a similar outward appearance and some inner similarity to fluid flywheels, or fluid couplings, which we have already studied.

The operation is NOT the same. The conventional fluid coupling simply transmits the same amount of torque that is applied to it. A torque converter increases the amount of torque applied to it. This torque increase is accomplished hydraulically within the unit itself. Many kinds of torque converters are used in vehicles.

One type of torque converter is shown in Figure 7. This type is called three member torque converter. The three basic parts are:

1. Driving member (sometimes called the pump or impeller).
2. Driven member (called the turbine).
3. Reaction member (called the stator).

Another type of torque converter is shown in Figure 8.

This is called a four member type torque converter. The main difference between this type and the three member unit is the addition of a second turbine.

Still another form of torque converter is the five member type illustrated in Figure 9. This type uses the following parts:

1. Primary pump
2. Turbine
3. Secondary stator
4. Primary stator
5. Secondary pump

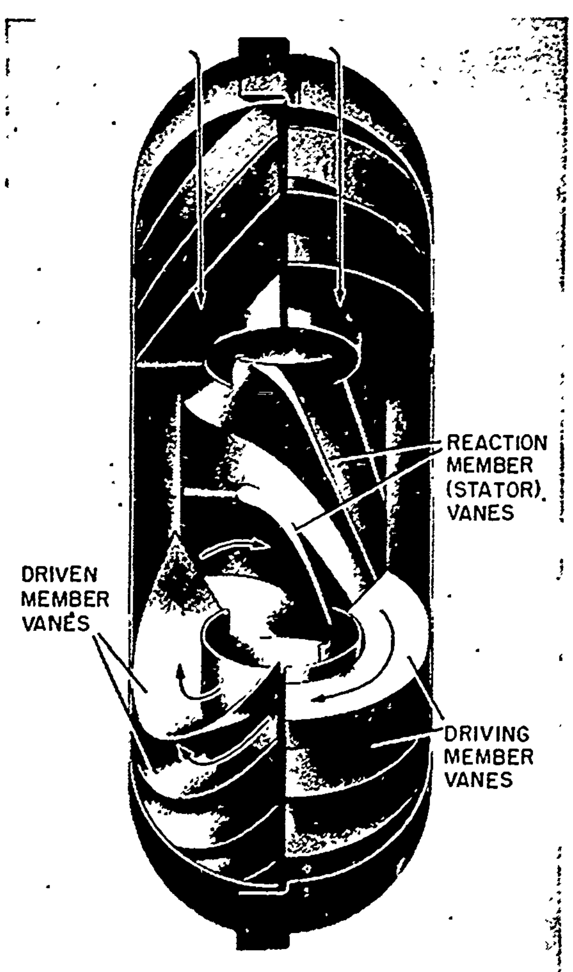
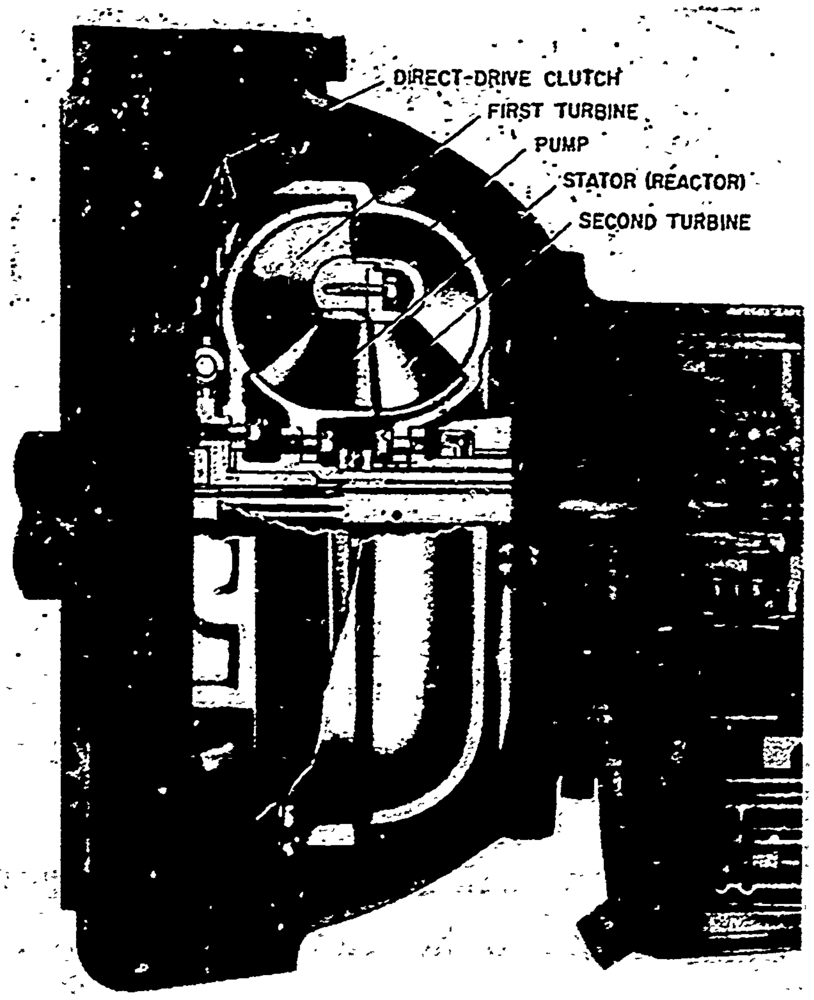


Fig. 7 Cutaway view of torque converter (three member unit)



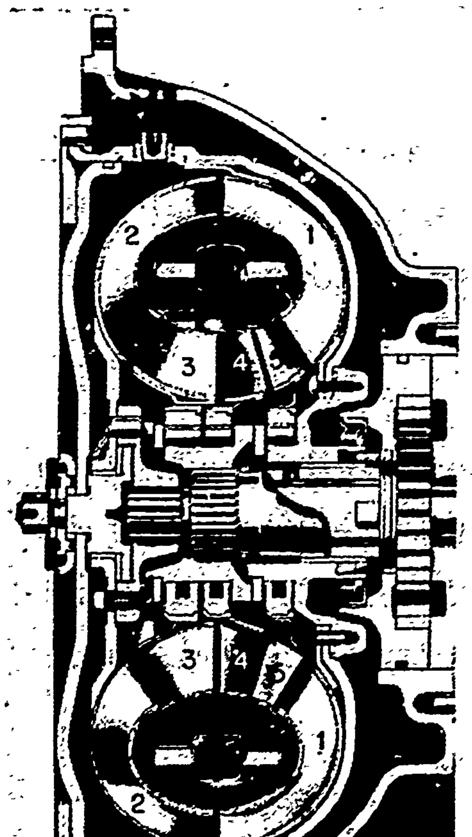


Fig. 8 Sectional view of a four member torque converter

Fig. 9 Sectional view of a torque converter using five members

TORQUE CONVERTER ACTION -- The torque converter acts, in a sense, like a gear transmission with a large number of gear shift positions. That is, it can transmit torque at a 1:1 ratio, or under certain conditions, it can increase or multiply this torque so that more torque is delivered than is applied.

This compares with a transmission in low gear. In low gear, the speed through the transmission is reduced; this increases the torque.

Remember, that torque means turning effect or twisting. When torque is increased, speed is decreased. Conversely, when torque is decreased the speed is increased.

In operation, all torque converters use the engine to drive the pump or impeller. This unit usually is welded into the converter housing and the housing is bolted directly to the flywheel.

The pump will then impel fluid against the vanes of a turbine or turbines connected to the transmission input shaft.

In the torque converter, the driving member usually is referred to as the pump, also called the impeller, while the driven member is called the turbine. There is no mechanical connection between the driving and driven members.

As shown in Figure 10, the driving member is welded to the housing and is driven by the engine flywheel. The pump will throw the fluid into the turbine vanes. The turbine or driven member is similar to the impeller except that it has blades curved in the opposite direction to the impeller blades.

In Figure 11, you will see that there are two types of oil circulation in a converter. Fluid from the impeller strikes the turbine blades and causes the turbine and turbine shaft to rotate in the same direction as the impeller.

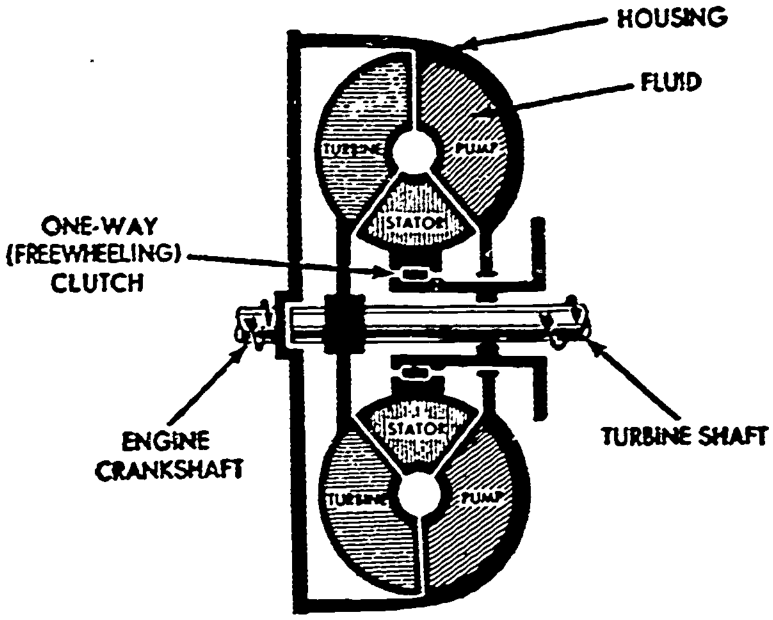


Fig. 10 Simplified drawing of a torque converter

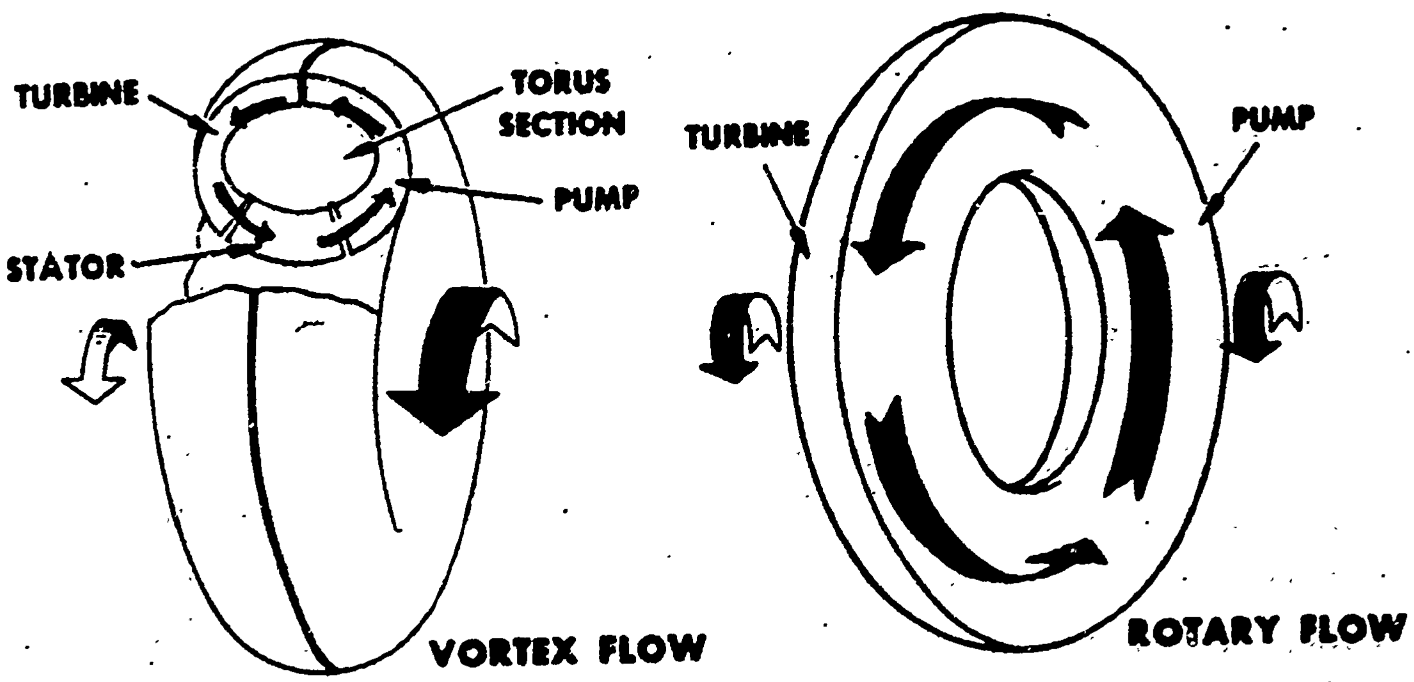


Fig. 11 Oil flow within a converter

The torque applied to the turbine is proportional to the velocity of the fluid flowing through it.

The fluid leaving the turbine returns to the impeller by a third set of blades known as the stator.

The stator is attached to the stator support on the transmission case by a one way clutch which permits the stator to rotate only in the same direction as the impeller. The clutch locks the stator to the fixed stator support to prevent counterclockwise rotation.

Stator one-way clutches may use sprags, or springs and ramps, as locking and unlocking devices.

Sprags are wedge shaped devices, used to lock the outer race to the inner race. The roller type clutch uses springs and ramps to accomplish the same purpose. The roller type overrunning clutch used to support a stator in a torque converter is illustrated in Figure 12.

The sprag type stator clutch uses a slightly different device. A machined sprag is used, to cause a wedging action between the inner and outer race. A typical sprag is shown in Figure 13. The sprags are machined so that the wedging dimension is larger than the coasting dimension.

Torque converter operation is composed of two phases -- torque multiplication and fluid coupling.

PHASE I - TORQUE MULTIPLICATION -- The impeller or driving member is being turned by the converter housing. The fluid is forced to the outside of the curved impeller vanes and is thrown into the turbine vanes, which are curved in the opposite direction. The fluid is then forced to the center of the turbine blades and into the stator (reaction member) blades; see Figure 14.

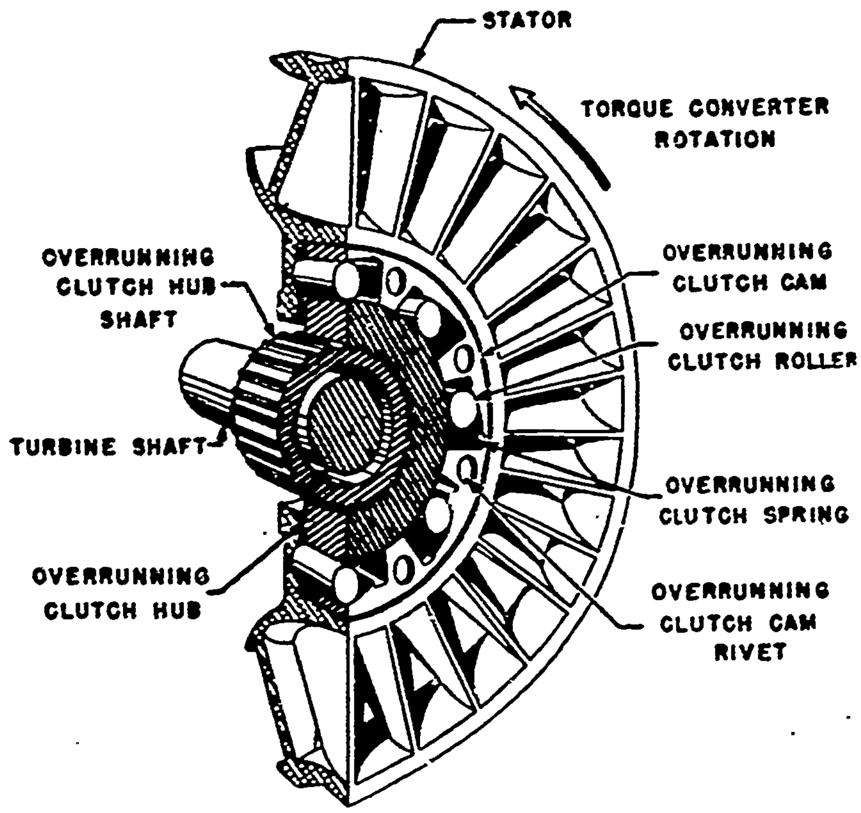


Fig. 12 Roller type stator

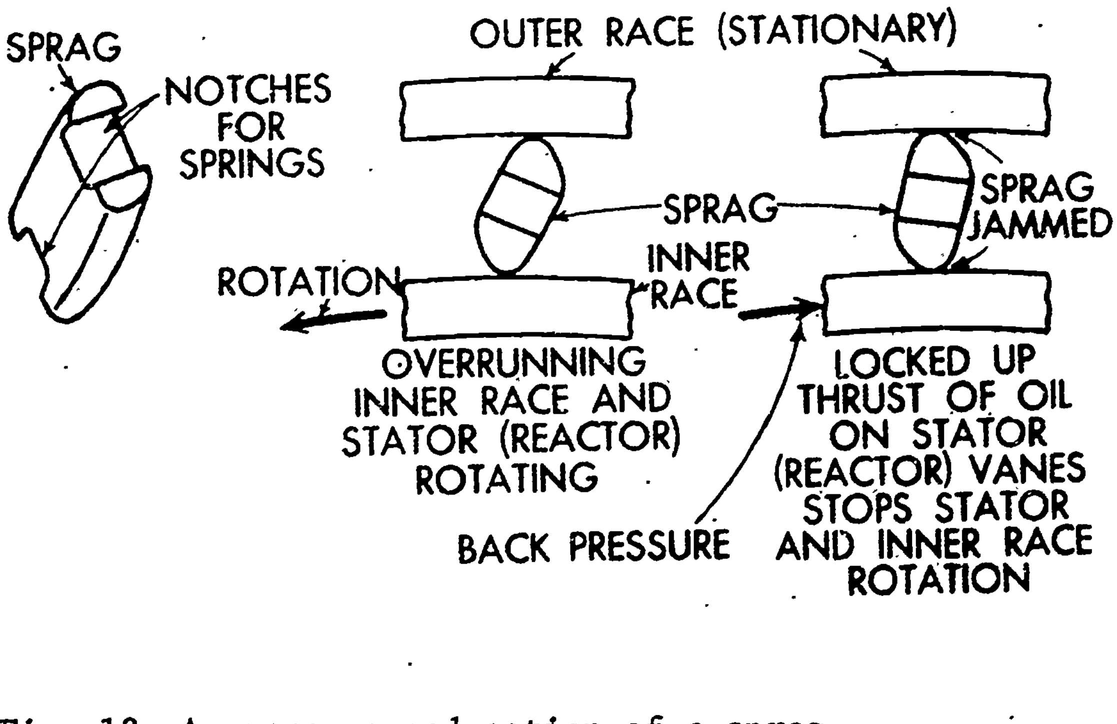


Fig. 13 Appearance and action of a sprag

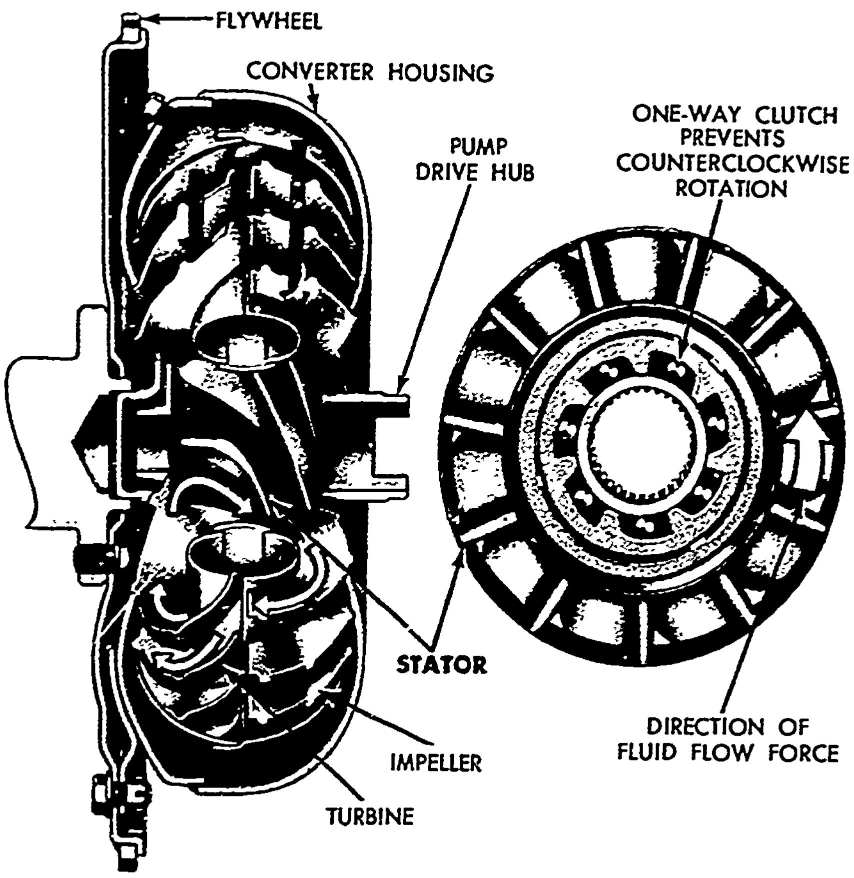


Fig. 14 Converter in torque multiplication phase

Once again, the blades are curved in the opposite direction. The fluid from the turbine strikes the underside of the curved stator blade. This force of the fluid locks the stator (it cannot rotate counterclockwise) and the fluid is redirected to the impeller, to assist it to turn and thus multiply the torque.

PHASE II -- FLUID COUPLING PHASE -- As the vehicle picks up speed and no longer requires the great amount of torque to set it in motion, the direction and speed of the fluid change.

As the fluid leaves the turbine blades, it is moving more rapidly, and the vortex flow within the converter will hit the back of the stator blades. (See Figure 11 for review of oil flow.) When the oil hits the back of the stator blade, it will unlock the stator and cause it to free-wheel clockwise.

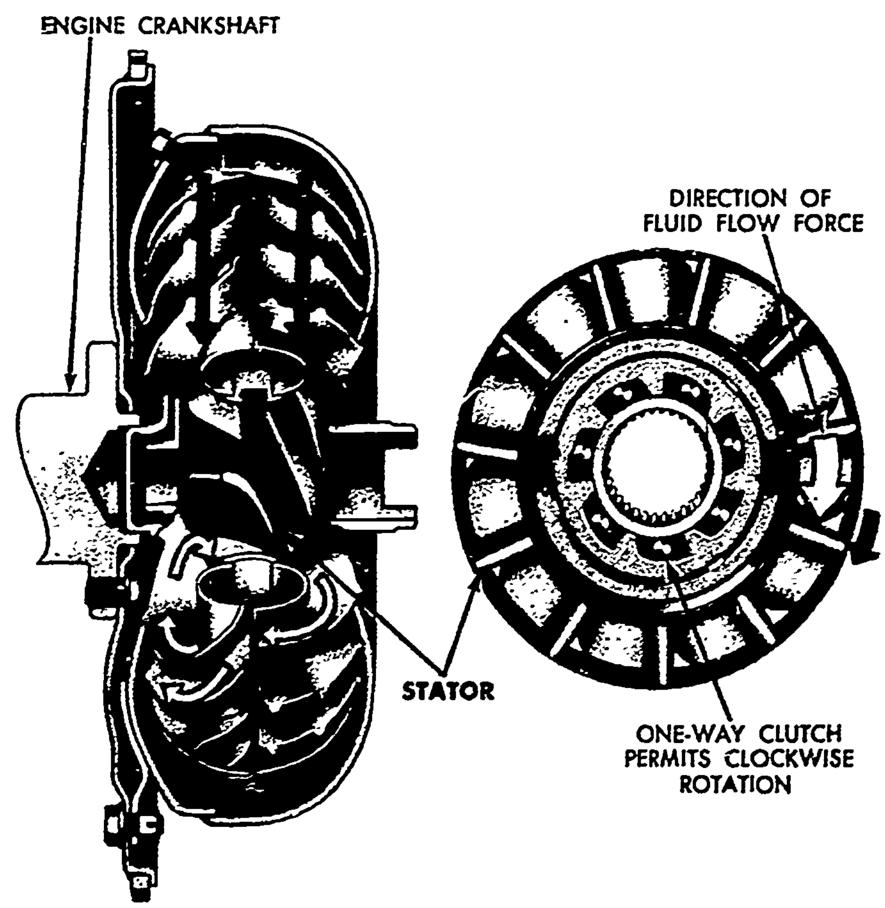


Fig. 15 Converter in fluid coupling phase

At this time, the impeller, the turbine, the stator and the fluid are all moving together to form a fluid coupling; see Figure 15. This fluid coupling phase will take place whenever the turbine turns at ninety percent of the speed of the impeller.

SECTION D -- TORQMATIC CONVERTER

Torqmatic converters are either the four element or three element type. We have just discussed the standard three element type. We will now look at the four element type, which is used in many heavy duty trucks and construction equipment.

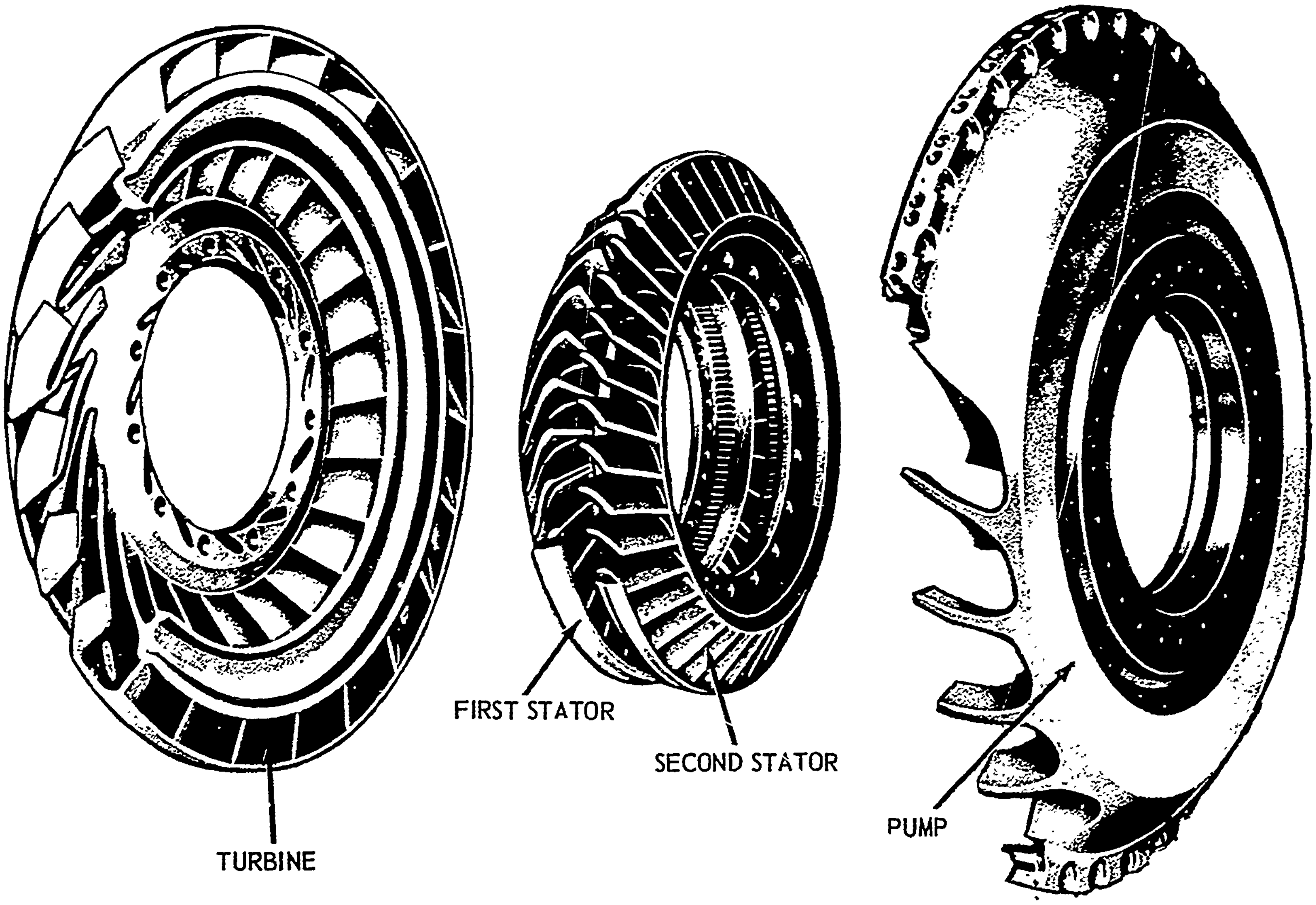


Fig. 16 Four element torqmatic converter

The basic difference is the addition of a stator unit, illustrated in Figure 16. This type uses a primary stator and a secondary stator. The other elements in this converter are the same as in the standard three element type.

OPERATION -- The stators are designed so that they can free wheel, or automatically lock up, to provide the necessary reaction for torque multiplication. During the first phase (torque multiplication), both stators are being held stationary by the force of the fluid and the greatest amount of torque multiplication is being accomplished.

The second phase (also torque multiplication) means that the first or primary stator is now free-wheeling. The first stator starts to free-wheel as soon as the load demand for output torque is reduced.

The next converter phase is the fluid coupling phase. This is the same phase that we discussed in the three element type converter. The difference is that both stators are free-wheeling in the torqmatic converter during the fluid coupling phase.

The input torque and output torque are approaching a one-to-one ratio. The vortex oil flow has practically stopped and the oil resumes a rotary motion within the converter.

As the load resistance increases, the vortex flow of the oil will increase and the converter will go back into a torque multiplication phase.

Figure 17 shows the three phases of torqmatic operation with a two stage stator.

REVIEW OF OPERATION:

A - 1st and 2nd stator locked - maximum torque multiplication

B - 1st stator free wheeling - 2nd stator locked - reduced torque multiplication

C - 1st and 2nd stators free-wheeling - no torque multiplication

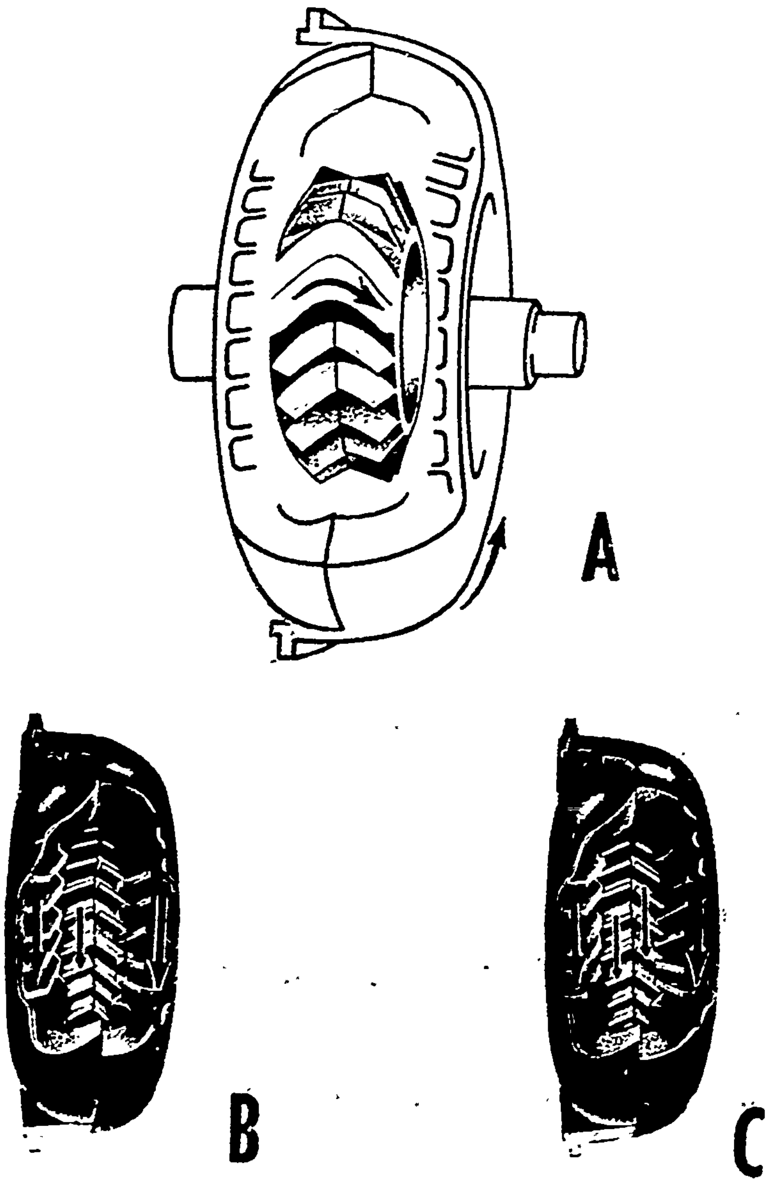


Fig. 17 Torqmatic converter operation

SECTION E -- THREE STAGE, THREE ELEMENT TORQUE CONVERTER

This type of converter generally is used in heavy construction equipment. A three stage torque converter multiplies engine torque output, to exert the correct torque ratio demanded by the load. Figure 18 shows the operation of a three stage unit.

The twin dish torque converter shown in Figure 17 has three basic parts. Part (A), the impeller or pump, is driven by the engine shaft and has a ring of metal blades which turn in the fluid with which the converter is

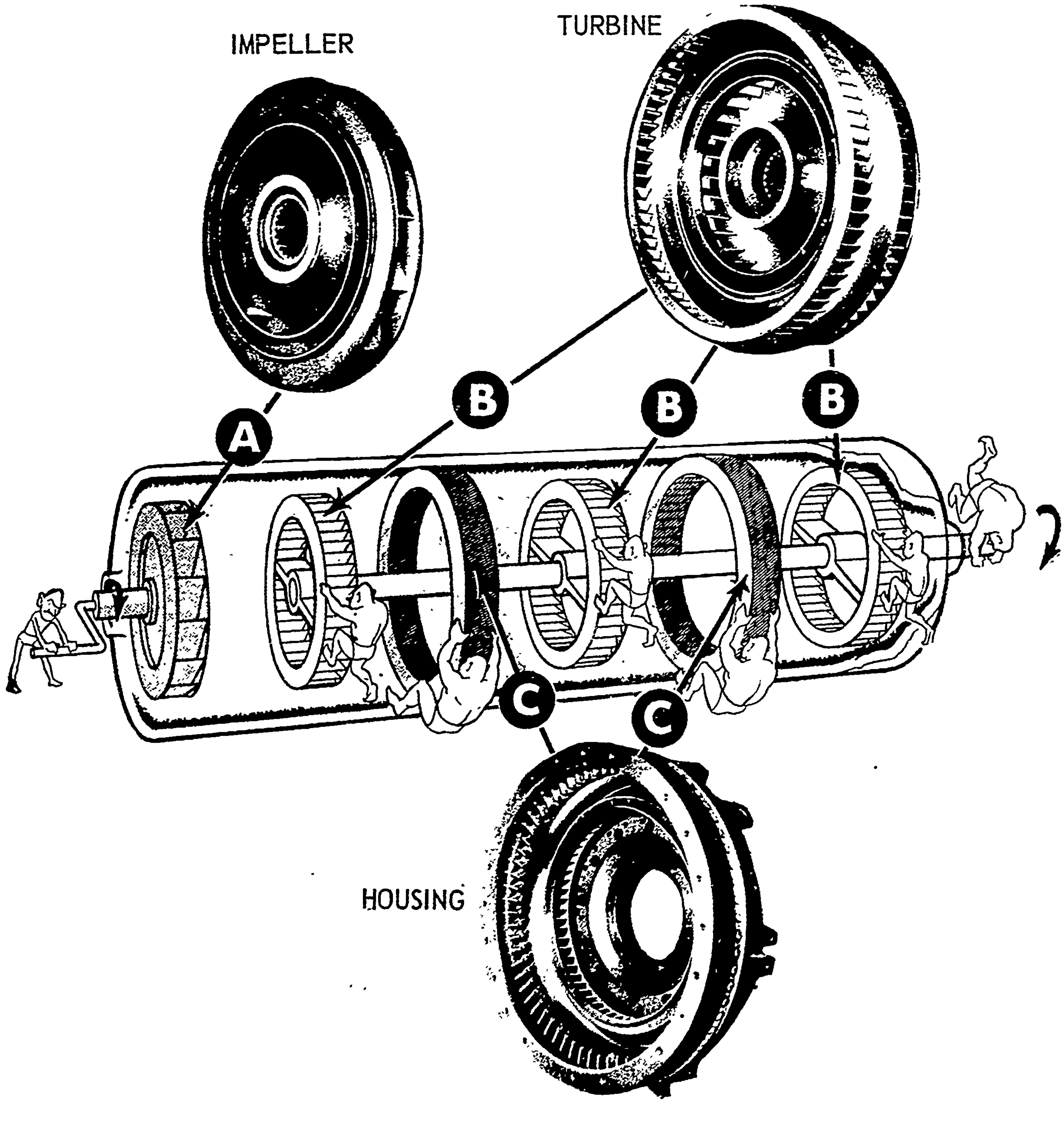


Fig. 18 Operation of a three stage torque converter

filled. Part (B), the turbine, is made up of three rings of blades and is connected to the shaft of the load. Part (C), is the stator, containing two stationary sets of blades.

As the pump is driven by the engine, the pump blades force the fluid outward, striking the first ring of blades in the turbine. The fluid, having given initial rotation to the turbine, is then redirected by the first set of reaction blades in the stator, thereby hitting against the second ring of turbine blades. Thus, the fluid is directed and redirected through all three sets of turbine blades.

Under normal running conditions, the oil from the pump strikes the blades of the turbine at a very slight angle, allowing the fluid to pass through the converter quickly and easily. When a load is encountered, and the turbine slows down, the fluid strikes the turbine at a sharper angle. As the force of the fluid is relayed from the first to the second to the third ring of the turbine blades, the output torque accumulates, until it is increased to as much as six times the input torque.

SECTION F -- TORQUE CONVERTER MAINTENANCE AND TROUBLESHOOTING

Because of the varied uses and designs of hydraulic torque converters, it is impossible to cover all the maintenance problems that you will encounter in the field. Maintenance of a general nature is covered in this section. Be sure to refer to the proper manual or maintenance guide put out by the manufacturer of your specific equipment.

Torque converters generally are used with a planetary transmission and they can be serviced as a unit.

GENERAL MAINTENANCE INFORMATION:

1. Check the fluid level daily according to the method recommended by the manufacturer.

   NOTE: Do not overfill. Oil level must be maintained between the "FULL" and "ADD" levels. Overfilling causes heat and aeration.

   a. Check for a burnt odor (indicating clutches are worn out or have been overheated).

   b. Check for a milky appearance (indicating water has leaked into the transmission).

   c. Check screen if these two conditions are found.

2. Inspect the following if a loss of fluid in the converter is indicated:

   a. Excessive leakage past converter seals

   b. Loose connections at oil lines to cooler

   c. All gasket connections and torque

TORQUE CONVERTER MAINTENANCE AND TROUBLESHOOTING:

3. Overheating of torque converter may be caused by:

   a. Air in the converter (low on fluid)

   b. Operating in a low-efficiency range for too long a period of time

   c. High fluid level

   d. Clogged oil cooler

   NOTE: It is better to be low on fluid than high; if too low, transmission and converter will not move.

   (Correct the conditions that are causing overheating).

4. Check the following as outlined in your maintenance manual: (unit must be disassembled)

   a. Turbine to stator interference

   b. Impeller to stator interference

   c. Stator one way clutch lock-up torque

5. Troubleshooting with unit in place:

   a. Oil level

   b. Output speed (stall)

   c. Charging pump pressure

   d. Clutch pressure

   e. Leakage

   f. Screen for metal particles

DIDACTOR PLATES FOR AM 2-5D

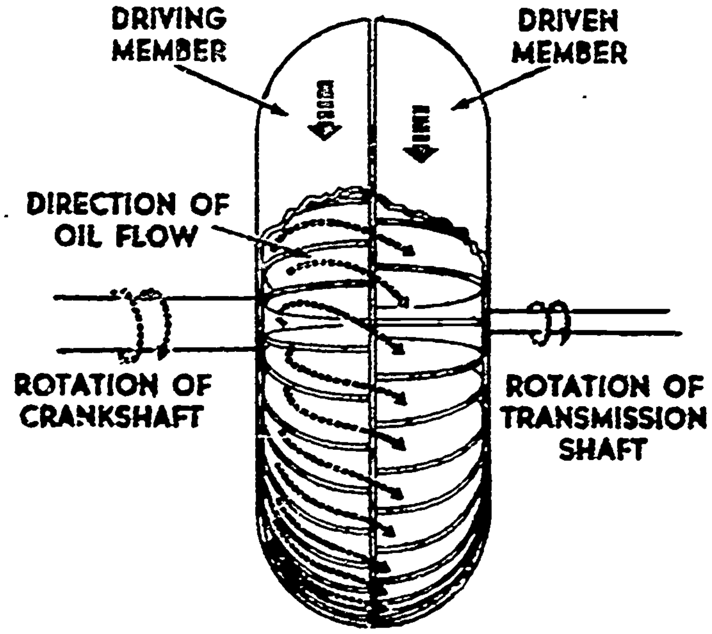


Plate I Fluid coupling in action

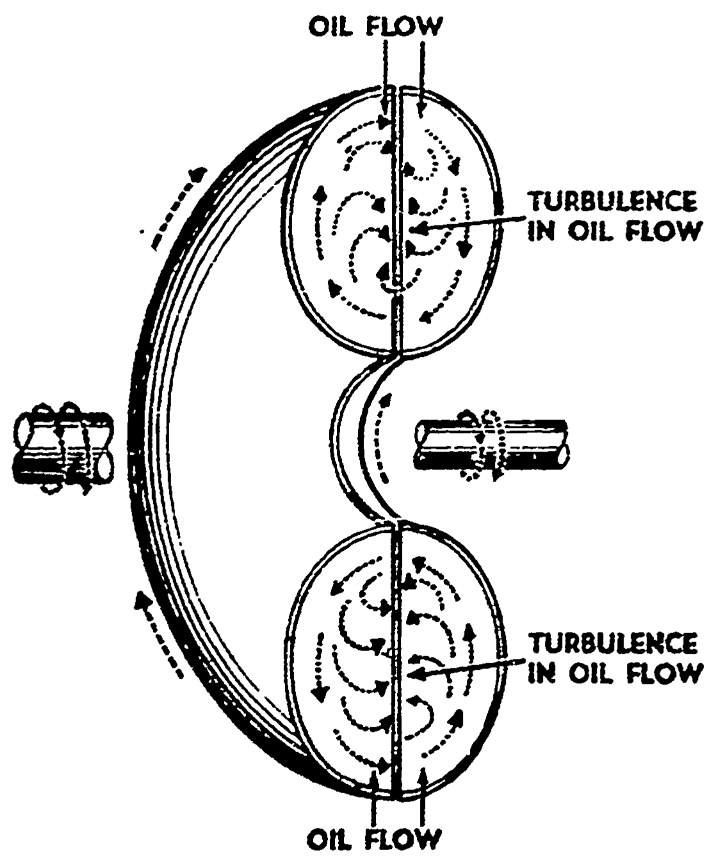


Plate II Turbulence in oil flow within the fluid coupling

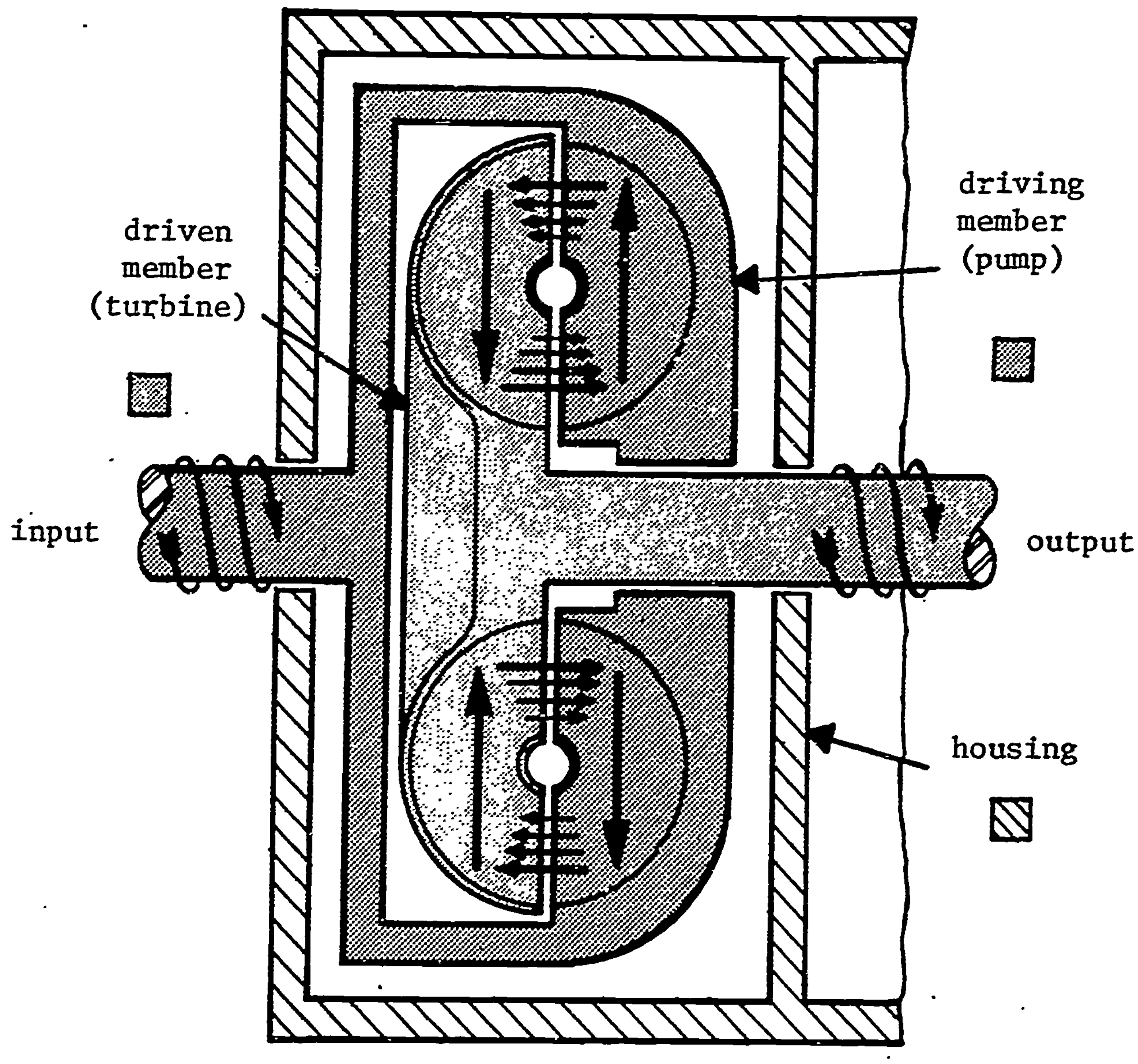


Plate III Fluid coupling schematic

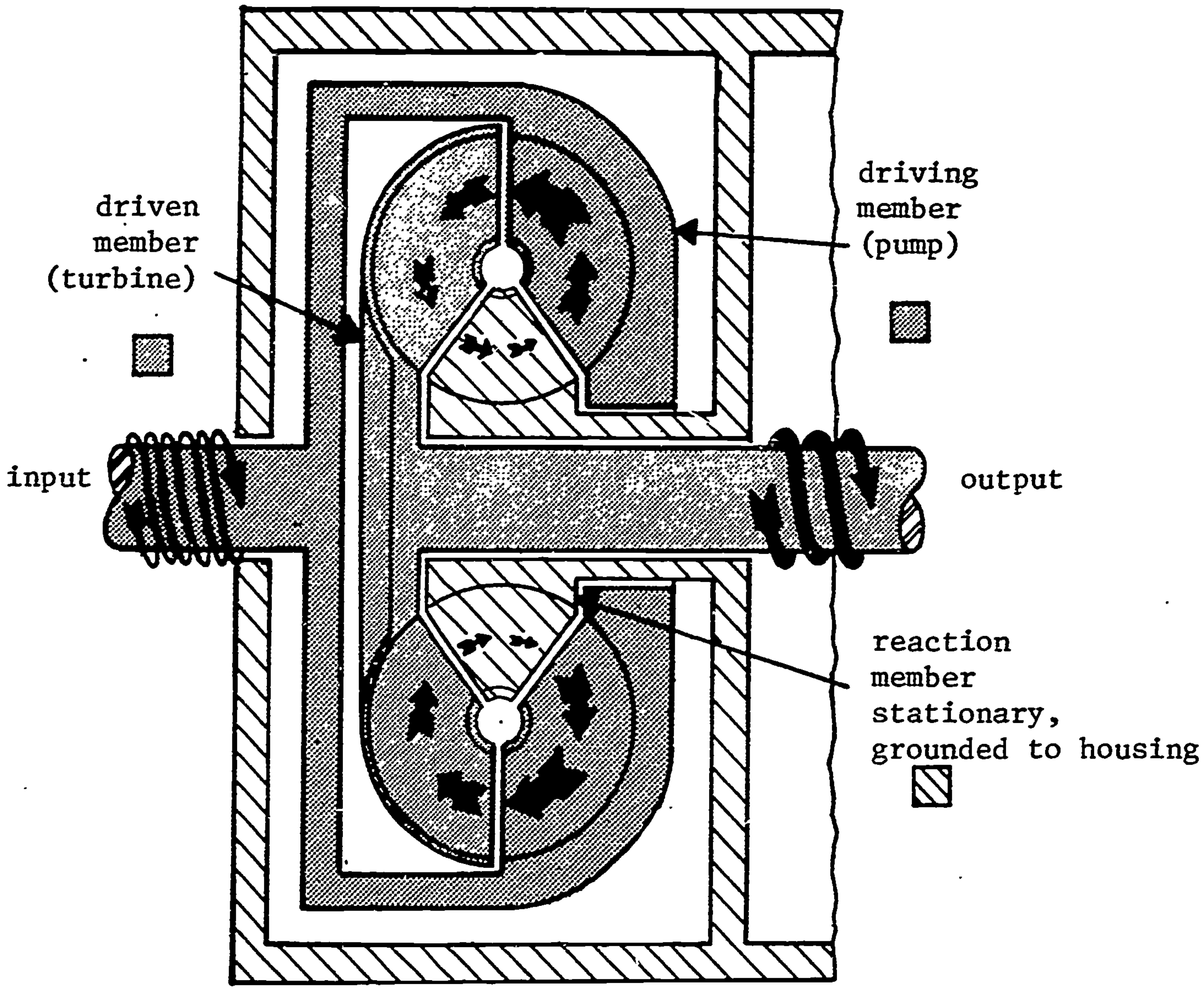


Plate IV Torque converter schematic

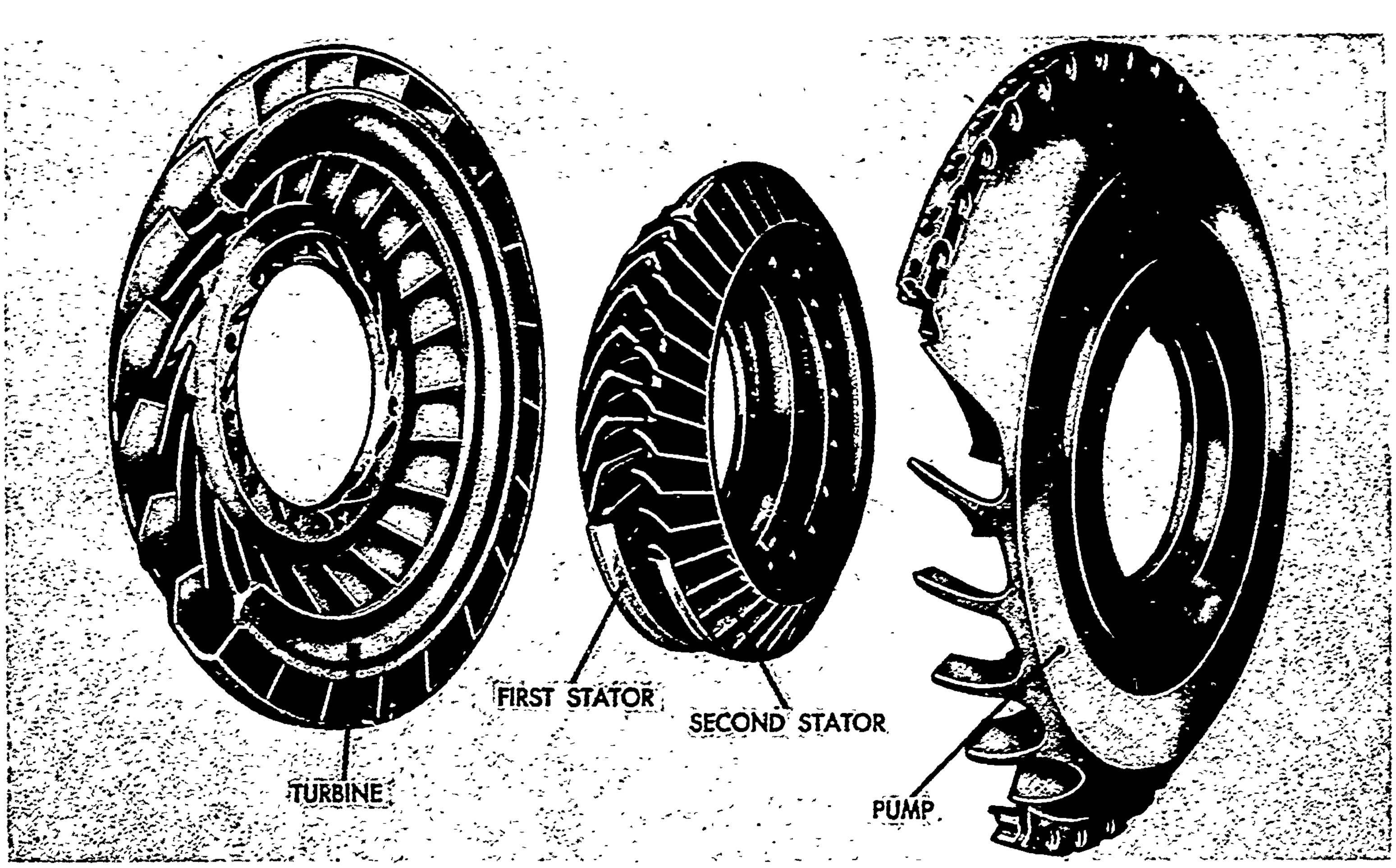


Plate V Curved blades of the torque converter

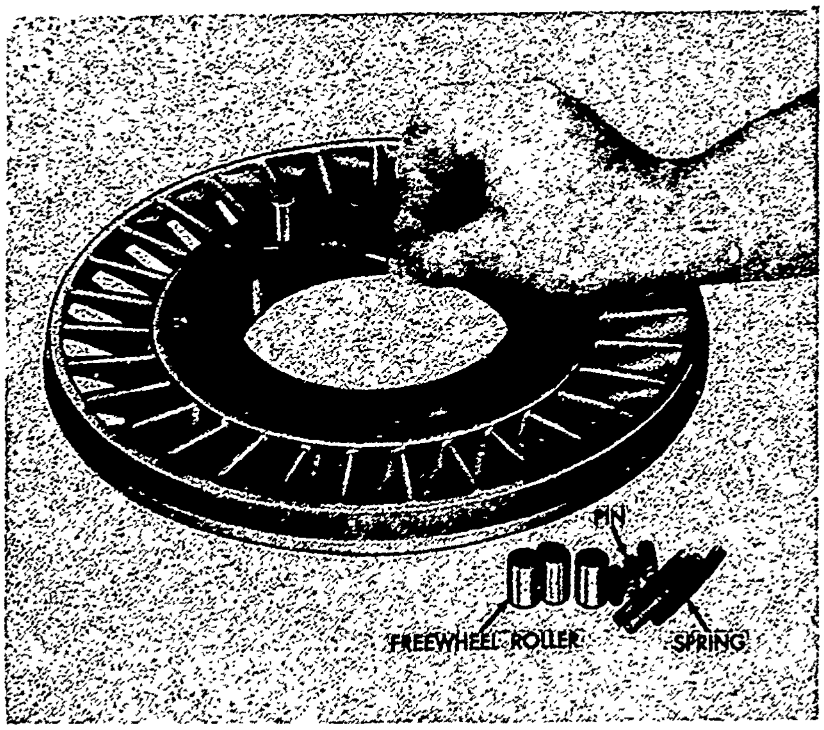


Plate VI Lockup mechanism in stators

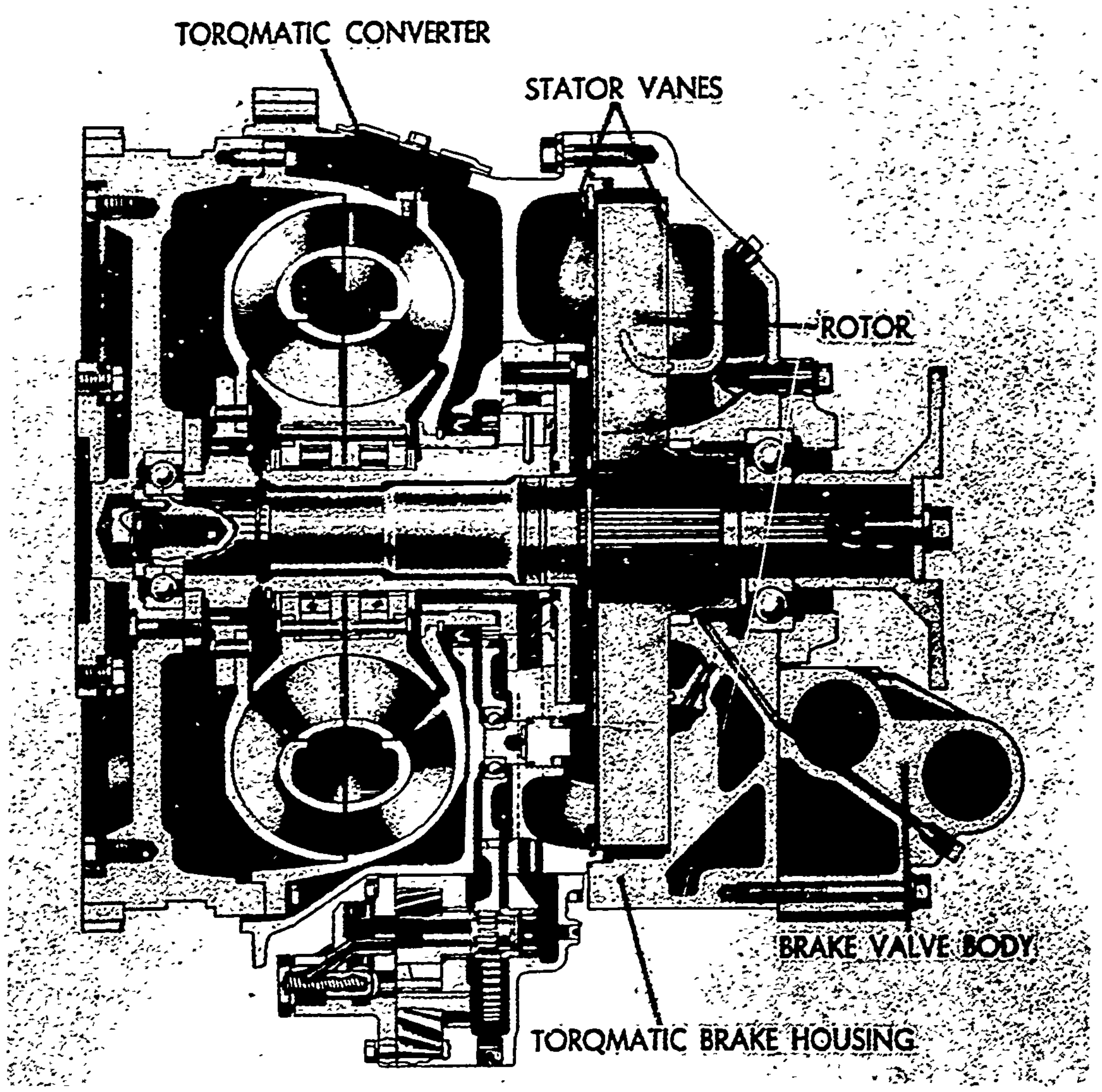


Plate VII Torqmatic converter and retarder cross-sectional view

1

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LEARNING ABOUT TORQUE CONVERTERS

Human Engineering Institute — Minn. State Dept. of Ed. Vocational Education

Press A 2 Check to see that timer is OFF.

2

This film is designed to supplement class text Unit # AM 2-5, Automatic Transmissions--Torque Converter. In some instances, you will recognize material taken directly from the text, on which there will be questions. Also there will be questions on other material which is not in the text, but which you should be familiar with. In both cases, the correct answer will be given, if you choose the incorrect answer. Read carefully and think before answering the questions.

Press A 3

1-1

3

When using a fluid coupling in a power train, we can say that power from the engine flywheel is transmitted to the rear wheels ________________.

A. mechanically 4
B. hydraulically 5
C. neither A or B is correct 4

1-2

4

No. You are incorrect. Power is transmitted through the transmission hydraulically.

Let's see why this is true.

Press A 5

1-3

5

Correct. Power flows through a fluid (instead of through a mechanical device like a clutch). An advantage of using this arrangement is that torsional vibration from the engine, as well as roughness resulting from changing gears, is smoothed out.

In the text, an example of two fans facing each other was given to illustrate a simple coupling. This type is not effective because ________________________.

A. a fluid of some type is not used 6
B. the speed of the driven fan cannot be controlled 6
C. there is too much loss of power 7

1-4

6

No. If you said that "a fluid of some type is not used", or "the speed of the driven fan cannot be controlled", you are incorrect. The correct answer is "there is too much loss of power". Let's see why.

Press A 7

1-5

7

Correct. This arrangement (fans) is very ineffective because the fans are not enclosed in a casing, nor are they closely coupled together.

In a fluid coupling, the pump portion is ____________ __________.

A. connected to the transmission shaft 8
B. connected to the engine crankshaft 10
C. free floating within two outer members 9

1-6

8

No. The driving member of the two part fluid coupling is the pump. Think about this arrangement and try this question again.

Press A 7

1-7

9

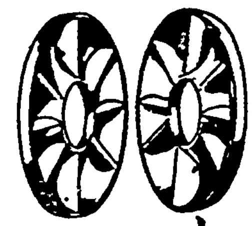
No. The fluid coupling, sometimes called the fluid flywheel, has only two members. One is the driving member, the other is the driven member. Think, and then try this question again.

Press A 7

1-8

10

Correct. The pump, or impeller, looks like a half of a doughnut and contains fins as shown here. This portion is connected directly to the engine crankshaft.



The other half of the doughnut (also containing fins) is the driven member, which is fastened to the transmission shaft. These two halves are connected. This is a ____________ statement.

A. true XX B. false 11

1-9

11

As the engine is started, the rotation of the pump half starts moving the oil between the two halves. The vanes in the driving member (pump) force the oil around in one direction. As the oil is spun around, it is thrown in an outward direction by centrifugal force. The flow of this oil can be seen in Plate I. As the oil leaves the pump, it strikes the fins of the driven member (referred to as the turbine) at an angle.

Press A 12

1-10

12

A continuous flow of oil against the turbine blades is required to transfer sufficient energy to keep a vehicle in motion.

A continuous circulation of the fluid in the fluid flywheel is accomplished by ________________________.

A. continuously replenishing new oil to the pump half 13
B. the action of the turbine 14
C. neither A or B is correct 13

1-11

13

No. The correct answer is " the action of the turbine". As the turbine is forced to turn through action of the oil, and since it is dished out like the pump half (only facing the pump), oil is thrown back out through centrifugal force. The oil is reused.

Press A 14

1-12

14

Correct. A continuous flow of oil is produced by action of the turbine. No continuous replenishing of the oil is required; this is a closed system. Oil pressure is maintained within the coupling through an outside pump. For a look at the oil flow within a coupling, see Plate II.

In a fluid flywheel coupling, the loss of power incurred through torque transfer is ____________________.

A. less at high speed 17
B. less at low speed 15
C. there is no loss at any speed 16

1-13

15

No. There is almost 100 percent loss of power at idle speed. At idle speed a vehicle will creep slightly if left in gear. This indicates that some energy is being transferred through the coupling.

Press A 17

1-14

16

No. There is definitely a loss of power at lower engine speeds. In fact, at idle there is practically a 100% loss. An indication that some torque is being transferred at idle is the fact that the vehicle will creep slightly at idle while in gear.

Press A 17

1-15

17

Correct. At full throttle, the loss incurred in the fluid flywheel is not more than 2 percent.

The fluid flywheel is not to be confused with the hydraulic torque converter. Both of these units have vanes in them and are operated by oil, but the fluid flywheel cannot increase or diminish torque.

Press A 18 1-16

18

TORQUE CONVERTER -- There are various types of torque converters (i.e. three member, four member and five member). The three member unit consists of the following:

1. Driving member (sometimes called a pump or impeller)
2. Driven member (called the turbine)
3. Reaction member (called the stator)

Some torque converters have more than one stator and more than one pump, but let's see how the three member unit functions and why.

Press A 20 X(C)-19 2-1

19

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

Press A 3 1-17

20

FLUID COUPLING VS. TORQUE CONVERTER -- As mentioned earlier, oil is thrown from the pump to the turbine in both the fluid coupling and the converter. However, when the driving member turns faster than the driven member, the efficiency with which torque is delivered to the driven member is lowered. This is the reason for adding the third member (stator) in a torque converter.

Without the stator, oil splashes back from the turbine into the pump, which causes the oil to work against itself.

Press A 21 2-2

21

Hence, when there is a big difference in driving and driven speeds, a large part of the torque is used to overcome this counteracting effect, greatly reducing the efficiency of the fluid coupling.

In the torque converter, varying drive ratios are provided between the driving and driven members, providing varying amounts of torque increase. This is possible by means of curved vanes in the driving and driven members and by the use of one or more members between the two outer members.

These members between are called ________________.

A. reaction pumps 22
B. stators 23
C. both A and B are incorrect 22

2-3

22

No. The correct answer is "stators", or reaction member. The stator does not serve as a pump. Again, the purpose of the stator is to counteract the back splash of oil from the turbine.

Press A 23 2-4

23

Correct.
Notice in Plate III the location of the components within the fluid coupling. In contrast, Plate IV shows the torque converter components. Both are similar in construction with the exception that the torque converter has a reaction member (stator). Notice in both that a cover is fastened to the pump so as to enclose the turbine completely.

Press A 24 2-5

24

BLADE DESIGN -- The oil circulates in the same manner in both units. But in the torque converter, the blades are curved in all the elements -- pump, turbine and stator, see Plate V.

CONVERTER OIL FLOW PATTERN -- The pump pushes the oil outward and in the direction the pump is turning. The oil strikes the blades; the oil is then directed inward toward the inner circumference of the turbine.

As the oil leaves the turbine it is moving in a direction opposite pump rotation. The stator, being held stationary, causes the oil to change direction and add its motion to the pump.

Press A 25 2-6

25

As oil leaves the pump and strikes the turbine, it causes the turbine to ____(1)____ and oil ____(2)____.

A. (1) rotate in the same direction as the pump (2) flows in an outward direction 26
B. (1) rotate in an opposite direction of the pump (2) flows inward toward the turbine center 26
C. (1) rotate in the same direction as the pump (2) flows inward toward the turbine center 27

2-7

26

No. Look at Plate IV and try to picture oil flow and turbine rotational movement, and then try this question again.

Press A 25

2-8

27

Correct. Oil striking the turbine blades forces the turbine to rotate in the same direction as the pump. Before movement of the turbine, oil is forced to rush to the center. As the turbine picks up speed, the oil leaves the turbine and is ________.

A. moving in an opposite direction of pump rotation 29
B. moving in the same direction as the pump 28
C. neither A or B is correct 28

2-9

28

No. The oil leaves the turbine and is moving in an opposite direction from pump rotation. Try to picture in your mind how the oil circulates.

Press A 29

2-10

29

Correct. Oil moves in the direction opposite to that of pump rotation as it leaves the turbine. As mentioned earlier, the stator, being held stationary, (in one direction) causes the oil to change direction and add its motion to the pump. Hence, the increase in torque.

NEW TERMS -- (1) Kinetic energy: oil in motion has kinetic energy, in fact anything in motion has kinetic energy. (2) Rotary flow: the flow of oil around the outer circumference in the converter is rotary flow. (3) Vortex flow: the flow of oil across the converter is vortex flow. Keep these terms in mind as we move on.

Press A 30

2-11

30

Kinetic Energy and the Stator -- Only a portion of the kinetic energy is removed from the oil as it strikes the turbine from the pump. The oil leaving the turbine has kinetic energy. The stator deflects this oil in motion, aiding the pump rather than hindering it.

The multiplication of input torque results from the velocity (kinetic energy) imparted to the oil by the pump plus the velocity (kinetic energy) entering the pump from the stator. The more the turbine resists turning (heavy load) the greater will be the velocity of the vortex flow of the oil circulating in the converter and the greater will be the torque multiplication.

Press A 31

2-12

31

The less the turbine resists turning (light load) the less will be the velocity of the vortex flow of the oil in the converter and the less will be the torque multiplication.

It could be said that velocity of vortex flow is directly proportional to ________.

A. curvature of the vanes 32
B. load requirement 32
C. neither A or B is correct 33

2-13

32

No. Load requirement is the correct answer. As the load increases or decreases, the velocity of vortex flow is increased or decreased respectively.

Press A 33

2-14

33

Correct.
As we learned earlier, the stators in a torque converter are designed to turn in ________________.

A. one direction 35
B. both directions 34
C. neither direction 34

2-15

34

No. The stators can turn in only one direction. If they were able to rotate both ways, the fluid leaving the turbine would work against the pump, rather than assist it.

Press A 35

2-16

35

Correct. Converters have what is called "free wheeling" stators. They rotate very easily in one direction, or "lock up" instantly when pressure is applied to turn them in the other direction. The roller type clutch prevents movement in one direction. See Plate VI.

TWO PHASE OPERATION -- Torque converter operation is composed of two phases. To illustrate what happens during these two phases, the two stator (four element) converter will be used as an example.

Press A 36

2-17

37

You have missed one or more of the questions in this sequence. Before going on to new material, let's review the past few frames. Read carefully and take your time in answering questions.

Press A 18

2-18

36

First Converter Phase - In the first converter phase, both stators are being held stationary, and the greatest torque multiplication of input torque is being accomplished. Both stators are held stationary in this phase because of the backward flow of the oil coming off the turbine.

Second Converter Phase - In this phase the first stator is free wheeling (no longer locked-up). This starts as soon as the load demand for output torque becomes less.

Press A 38 X (c) - 37

3-1

38

This means that the turbine is turning faster in relation to the pump. As the turbine speed increases, the oil leaving the turbine strikes the blades of the first stator in such a manner that it no longer locks up on the rollers, but starts turning with the turbine. When this happens ________________.

A. torque multiplication is increasing while turbine speed in decreasing and vortex flow is becoming less. 39
B. torque multiplication is decreasing while turbine speed is increasing and vortex flow is becoming less 40
C. neither A or B is correct 39

3-2

39

No. As the first stator starts revolving, we know that not as much torque is required as before; the turbine speed is increasing and the vortex flow is less.

Press A 40

3-3

40

Correct.

Fluid Coupling Phase - The torque converter acts as a fluid coupling when both stators are revolving. This means the turbine speed is approaching pump speed; input torque and output torque are approaching a one-to-one ratio. At this stage in the converter operation, there is practically no (1) flow and practically 100% (2) flow, see Plate VII.

A. (1) rotary (2) vortex XX
B. (1) vortex (2) rotary 41

NOTE: Only the correct selection will move the film.

3-4

41

The converter acts as a fluid coupling as long as there is no load variation. Even a slight load will slow the turbine down. When this happens first one stator, then the other will slow down to meet the required torque multiplication.

If a load is placed on the turbine, the stator next to the ___________ would slow down first.

A. pump 42
B. turbine 43

3-5

42

No. The stator next to the turbine would slow down first because the increased vortex flow of fluid will be attempting to force the stator in a reverse direction.

Press A 43

3-6

43

Correct. As the turbine slows down, the vortex flow of fluid increases; this in turn attempts to stop the first stator from moving.

To summarize the operation of the torque converter, if the first and second stator are locked there is ______________________.

A. no torque multiplication 44
B. reduced torque multiplication 45
C. maximum torque multiplication 46

3-7

44

No. When the first and second stator are locked, there is maximum torque multiplication. The turbine is turning at a much slower rate than the pump, causing a back-splash of fluid which forces both stators to lock-up.

Press A 46

3-8

45

No. You are thinking of the situation where one stator is moving and one is locked. Think about what has been said and try this question again. Press A 43

3-9

46

Correct. When both stators are locked in place. there is maximum torque multiplication.

Now consider the fluid coupling stage, where both stators are rotating. We learned from the text that this stage occurs when the turbine is turning ________ of the speed of the pump.

A. 75% 47
B. 90% 48
C. 80% 47

3-10

47

No. When the turbine reaches 90% of the speed of the pump, both stators are revolving or "freewheeling".

Press A 48

3-11

48

Correct. The turbine needs to reach within 90% of pump speed before both stators are rotating.

TORQMATIC RETARDER (BRAKE) - In Plate VII there is a cross-sectional view of a torqmatic converter and retarder assembly. Notice the retarder has only one moving part--the rotor, sometimes referred to as "paddle wheel". This wheel can be compared to a "paddle wheel" on a river boat. The paddles work against the current, and help to slow the boat when rotation is reversed. In the same manner, the rotor attempts to reverse the forward motion of the vehicle.

Press A 49

3-12

49

The same oil in the converter used to drive the vehicle is used to retard it. The vehicle's own rolling force produces the braking energy in any speed range, subject only to the limitations of the drive system.

Operation - To brake the vehicle going downhill, the driver need only to open the control valve and let the oil enter the rotor cavity. Remember that the vehicle wheels are turning the rotor through the transmission, see Plate VII.

Press A 50

3-13

50

As the cavity fills with oil, the rotor sets the oil in motion. But the fixed stator vanes in the housing prevent the churning oil from going anywhere. Consequently, the oil makes it harder for the rotor to turn. Since the rotor is turning through rotation of the wheels through the transmission, the forward motion of the vehicle is affected, hence, the braking action.

Does filling the cavity with oil in the retarder mechanism affect the rpm of any of the components in the converter?

A. Yes 52
B. No 51
C. The pump will slow down 51

3-14

51

You have chosen the wrong answer if you said "No" or "the pump will slow down". Remember, we said the rotor is splined to the transmission shaft. The only component in the converter that is directly connected to this shaft is the turbine. Hence, when the rotor slows down, the turbine slows down.

Press A 52

3-15

52

Correct. The turbine is also splined to the transmission shaft and as the rotor slows down the turbine will slow down. We learned earlier that if the turbine slows down, so will the stators, etc.

While all this churning of the oil and resistance of the rotor from turning is happening, heat is being created. Most of the heat is absorbed by the oil. The same churning or pumping action of the rotor circulates the oil to a heat exchanger where the heat is dissipated. The cooled oil returns to the rotor cavity to repeat the cycle.

Press A 53

3-16

53

The operator of the vehicle controls the degree of braking by letting more or less oil into the cavity. When the valve is closed the oil is evacuated from the cavity.

Because of the heat dissipation by the churning action of the oil, the heated oil is routed to ____________. cooled, and returned.

A. the sump 54
B a cooler 55
C. the converter 54

3-17

54

No. If you said to "the sump" or back to "the converter" you are incorrect. Earlier we said the heated oil is routed to a heat exchanger (cooler) and returned to the cavity.

Press A 55

3-18

55

Correct. The heated oil is routed from the cavity to the heat exchanger (cooler), is cooled and returned to the cavity.

MAINTENANCE INTERVALS - The type of service and operating conditions will determine the maintenance intervals. However, it is well to check the oil system oil level daily, or at the end of each shift; also at the same time, check for oil leaks. Occasionally while equipment is operating, check the converter operating temperature. If equipment has been idle overnight or longer, the oil reservoir should be checked.

Remember, overfilling is worse than underfilling because it will produce churning by the gears, resulting in heat and air entrapment, both affecting the transmission operation.

Press A 6 r x (c) - 56

4-1

56

Correct. The heated oil is routed from the cavity to a heat exchanger (cooler), cooled and returned to the cavity.

You have missed one or more of the questions in this sequence. Before going on to preventive maintenance and troubleshooting, review the last few frames. Read carefully and think before answering the questions.

Press A 36

3-19

57

CHECKING OIL LEVEL -- As we learned earlier, there are several types of Allison Torque converters in use today in off-highway vehicles. Also, there are different ways to properly check the oil level. Be sure to check the maintenance manual procedure for the particular converter in use.

No matter what type of converter is involved the oil level should be check daily.

If the oil check indicates a burnt odor, the problem is that the converter has been ____________.

A. running with a low oil supply 58
B. running with water in the oil 59
C. neither A or B is correct 60

4-2

58

No. A low oil supply would hinder the movement of a vehicle by making the converter inoperative. Think about what has been said and try this question again.

Press A 57

4-3

59

No. If water has gotten into the transmission, there will be a milky appearance to the oil. Think about what has been said and try the question again.

Press A 57

4-4

60

Correct. Neither a low oil supply or water in the oil will give the oil a burnt odor. As mentioned earlier, this situation usually is caused by worn out clutches or by constantly overfilling the unit with oil.

Another condition that can cause overheating in a converter is ____________.

A. air in the converter XX
B. clogged oil cooler XX
C both A and B are correct 61

NOTE: The correct answer must be selected before moving to the next frame.

4-5

61

Oil Changing - Oil and converter filters should be changed every 500 hours of operation. This is under normal operating conditions. The oil in a system must be changed whenever oil shows traces of dirt, or when discoloration is evident, or as mentioned before, a burnt odor. If metal particles (brass or aluminum) are found in the screen, the entire system must be torn down, cleaned and rebuilt. Brass filings found in the screen would be an indication of ____________.

A. turbine to stator interference 62
B. pump to stator interference 62
C. neither A or B is correct 63

4-6

62

No. The brass filings would indicate a malfunction from the transmission, namely the piston clutches. All parts in the turbine are aluminum.

Press A 63

4-7

63

Correct. Aluminum particles in the screen would be from a turbine to stator, or stator to pump interference. Brass filings would indicate the piston clutches are wearing badly.

Another important thing that must be done when the oil is changed in a transmission is to ____________.

A. change the oil cooler 64
B. change the filters 65
C. do nothing, changing the oil is sufficient 64

4-8

64

No. If you said change the oil cooler, or just changing the oil is sufficient, you are incorrect. It is an established policy at most installations that every time the oil is changed, the filters must also be changed (under normal operating conditions).

Press A 65

4-9

65

Correct. Change the filters every time the oil is changed, approximately every 500 hours of operation.

TROUBLESHOOTING AS A UNIT - Although the transmission will be discussed in later units, the two (converter and transmission), must be considered as one when locating problems. Therefore, the remainder of this film lesson will be based on troubleshooting techniques treating the two components as one. Keep in mind that the unit has one oil supply sump, and one pump to supply both the transmission and converter.

Press A 66

4-10

66

When a low converter out pressure is found, the cause could be one of the following:

1. low oil level
2. oil line leakage
3. plugged oil strainer
4. defective oil pump
5. high oil temperature
6. foaming oil
7. converter pressure regulator stuck open

As mentioned earlier, a high oil temperature could be caused by ______________.

A. low engine output 67
B. stator installed backwards 68
C. neither A or B is correct 67

4-11

67

No. If you said "low engine output", or "neither A or B is correct", you are wrong. There may be nothing the matter with the unit (converter and transmission); the trouble may be low engine output. Hence, it would be well to check that initially. The correct answer here is a "stator may be installed backwards".

Press A 68

4-12

68

Correct. If a stator is installed backwards the violent churning and swirling of oil would definitely cause overheating.

Foaming oil also causes overheating. Overheating under these circumstances could be compared to ______________.

A. a loose fan belt 69
B. air in the engine coolant 70
C. a radiator without a pressure cap 69

4-13

69

No. If you said a loose fan belt, or a radiator without a pressure cap you are incorrect. Both of these conditions will cause overheating, but they cannot be compared to oil foaming. Air in the engine coolant is a closer comparison to oil foaming. Foaming oil prevents the proper heat dissipation needed in the converter because each bubble in the oil creates a type of "vacuum".

Press A 70

4-14

70

Correct. Air in the engine coolant is comparable to foamed oil. Both liquids contain air bubbles resulting from excessive churning, too low a liquid level or some condition which allows air to mix with the liquid.

High Engine Speed at Converter Stall - All of the following conditions will cause high engine speed at converter stall except one - choose the one that will not:

A. low oil level 71
B. low converter out pressure 71
C. high oil temperature 71
D. slipping clutch 71
E. stator installed without rollers 72

4-15

71

No. You have made the wrong choice. The one item out of the previous list that won't cause high engine speed at converter stall is "stator installed without rollers".

Press A 72

4-16

72

Correct. The stator being installed without rollers is the condition that would not cause high engine speed at converter stall. To have high engine speed at converter stall would mean there was little or no restriction being offered to the engine crankshaft. If the stator was allowed to "freewheel" in both directions, we know from previous study that the oil would work against itself coming out of the turbine, causing a low engine speed in place of a high engine speed.

This condition would cause the same results as if the stator were installed backwards. This is a ________ statement.

A. true 74
B. false 73

4-17

73

No. The stator installed backwards would create the same condition (low engine speed at converter stall). The reason for this is the turbulence of the oil, offering high resistance to engine output.

Press A 74

4-18

74

Correct. Low engine speed at converter stall can be caused by the following conditions:

1. low engine output torque
2. converter element interference
3. stator installed backwards
4. stator installed without rollers

Notice as you read further that some of the same conditions that cause one malfunction can also cause others.

Press A 75

4-19

75

Loss of Power - The following conditions can cause a loss of power:

1. stator installed backwards
2. stator installed without rollers
3. low converter charging pressure
4. low engine speed at converter stall
5. clutch plates slipping
6. range control valve inoperative
7. low clutch pressure
8. foaming oil

Of the three conditions listed below, (from those above), which of the following would make the unit completely inoperative?

A. clutch plates slipping 76
B. low converter charging pressure 76
C. range control valve inoperative 77

4-20

76

No. If the clutch plates were slipping, or if there was low converter charging pressure, there would still be movement and control, although reduced from normal operation. However, if the range control valve was inoperative, chances are there would be no control over the unit whatsoever.

Press A 77

4-21

77

Correct. Without movement of the range control valve. the unit would be useless. Chances are there would be no power transmitted in any range.

If it was determined that the clutch plates in the transmission were slipping, chances are there would be __________________.

A. a foaming oil condition 78
B. brass particles in the screen 79
C. neither A or B is correct 78

4-22

78

No. Remember, we said a foaming oil condition would cause a low converter out pressure. The correct answer here is that probably brass particles would be found in the screen, indicating clutch failure. More will be said about this later in the course.

Press A 79

4-23

79

Correct.
In summarizing the converter story, let's review some questions presented earlier in this film lesson.

The first converter phase means ________________.

A. both stators are freewheeling and torque multiplication is at a minimum 80
B. both stators are held stationary and torque multiplication is at a maximum 82
C. one stator is freewheeling and one is stationary 81

4-24

80

No. Remember, we said that if both stators are freewheeling the turbine is rotating at approximately the same rpm as the pump. Naturally, torque multiplication is at a minimum during this time.

Try the question again. Press A 79

4-25

81

No. When one stator is freewheeling and the other is stationary, the pump is turning faster than the turbine. When this is happening, the converter is multiplying the incoming torque. Try this question again. Press A 79

4-26

82

Correct. The first converter stage means that both stators are held stationary due to the backward flow of oil striking the stator blades from the turbine. Torque multiplication is at a maximum during this phase.

As mentioned earlier, we defined the second converter stage as a condition where ____________.

A. one stator is freewheeling (next to the pump) and the other stator is stationary (next to the turbine) 83
B. the load demand for output torque is becoming less (vehicle is increasing in speed) 85
C. pump and turbine are running at a one-to-one ratio 84

4-27

83

No. The second stage converter phase is defined as the condition where one stator is freewheeling and the other stator is stationary. The one freewheeling is next to the turbine; not the pump.

Press A 85

4-28

84

No. When the turbine and pump are running at a one-to-one ratio, both stators are freewheeling and torque multiplication is at a minimum.

Try this question again. Press A 82

4-29

85

Correct. The second converter stage occurs when the demand for torque is becoming less and less. One stator is freewheeling while the other is stationary.

The last or final converter phase is the fluid coupling phase. This is the time when all components of the converter are rotating at the same rpm.

Earlier we learned that the converter changes from the second stage into the converter stage when the turbine turns __________ of the rpm of the pump.

A. 75% 86
B. 90% 87
C. neither A or B is correct 86

4-30

86

No. The correct answer is: when the turbine turns 9/10 or 90% of the rpm that the pump is turning -- then the converter is a fluid coupling.

Press A 87

4-31

87

Correct. 90% or 9/10 of the speed that the pump is turning is correct.

Congratulations, this completes the film lesson on the converter.

Press REWIND.

4-32

X (c)-88

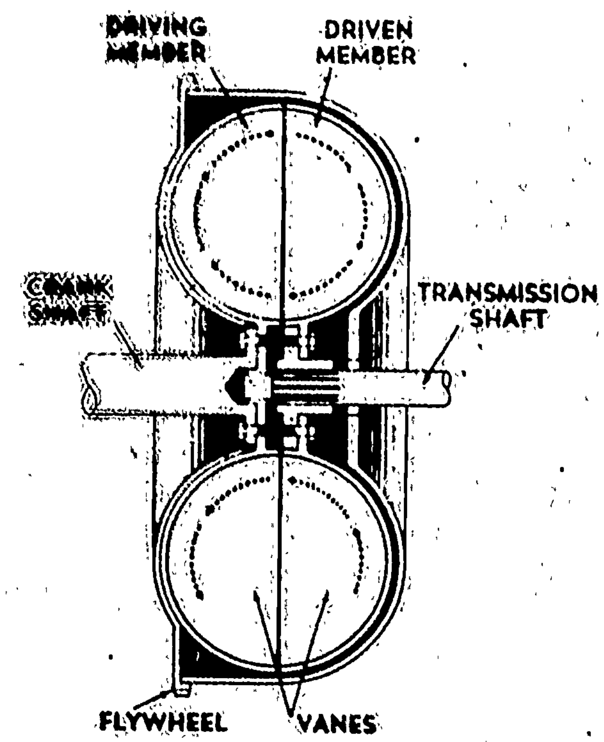
88

The correct answer to the last question is 90%. However, you have missed one or more questions in the last sequence. Review the last few frames carefully and take your time in answering the questions.

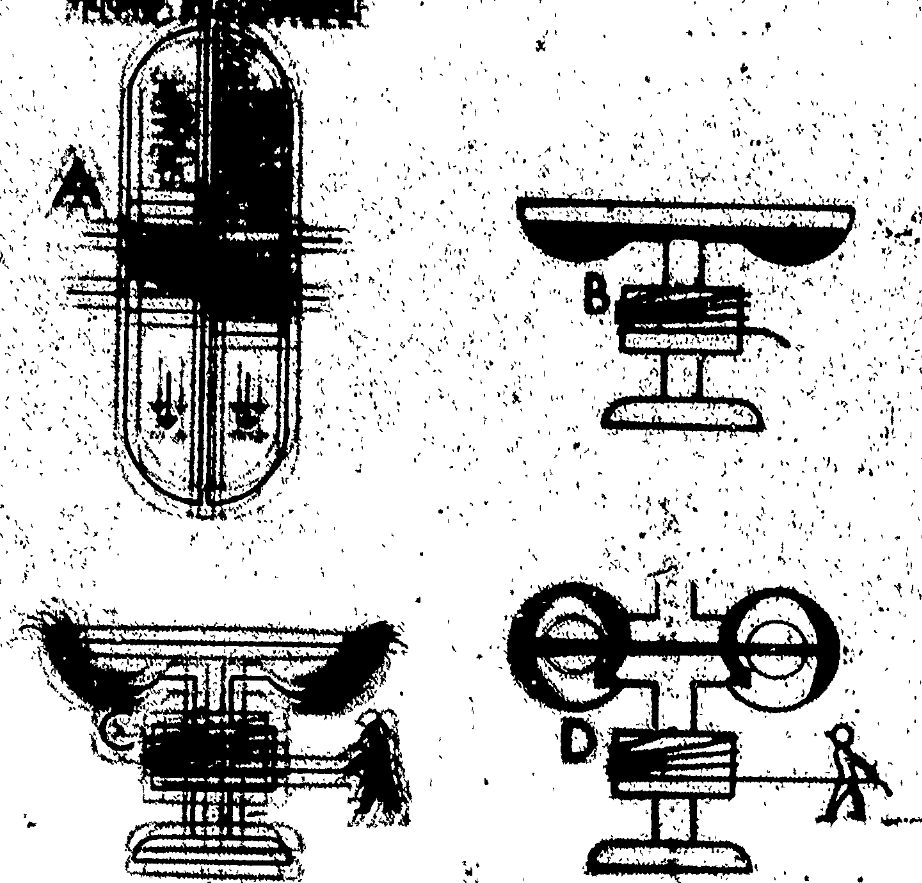
Press A 57

4-33

AM 2-5



Cross sectional view of a fluid coupling



Fluid Flywheel

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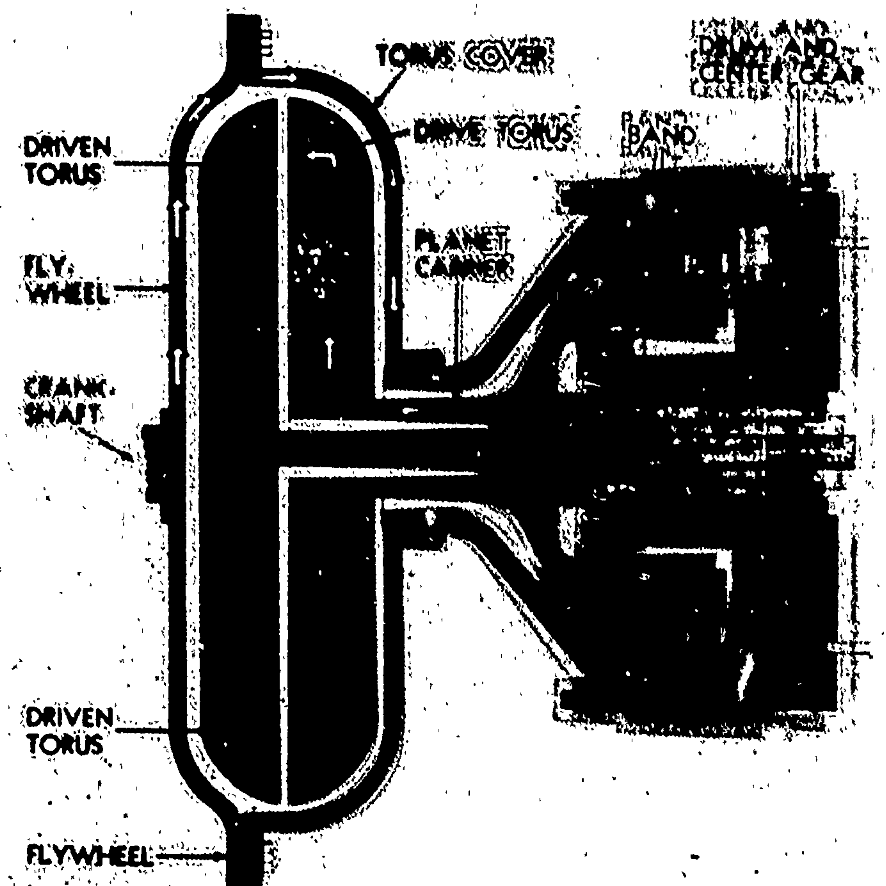
AM 2-5



Hydramatic fluid coupling design

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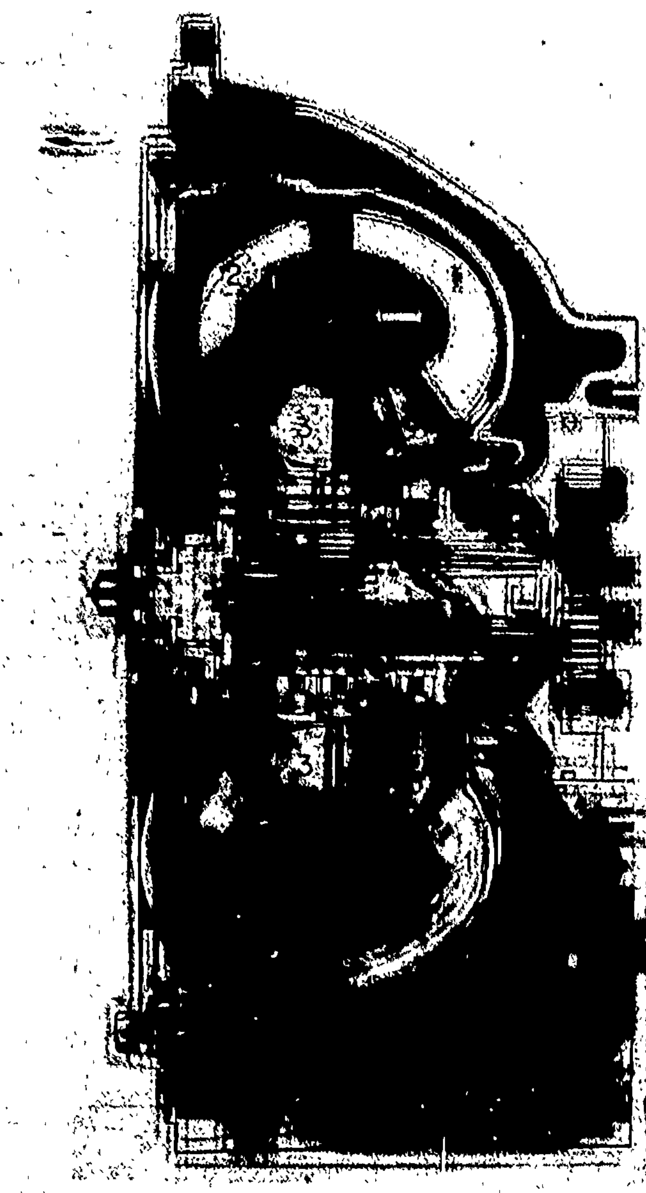
AM 2-5
(14)

Cutaway view of torque converter (three member unit)

AM-2-5 (5)



Sectional view of a torque converter using five members

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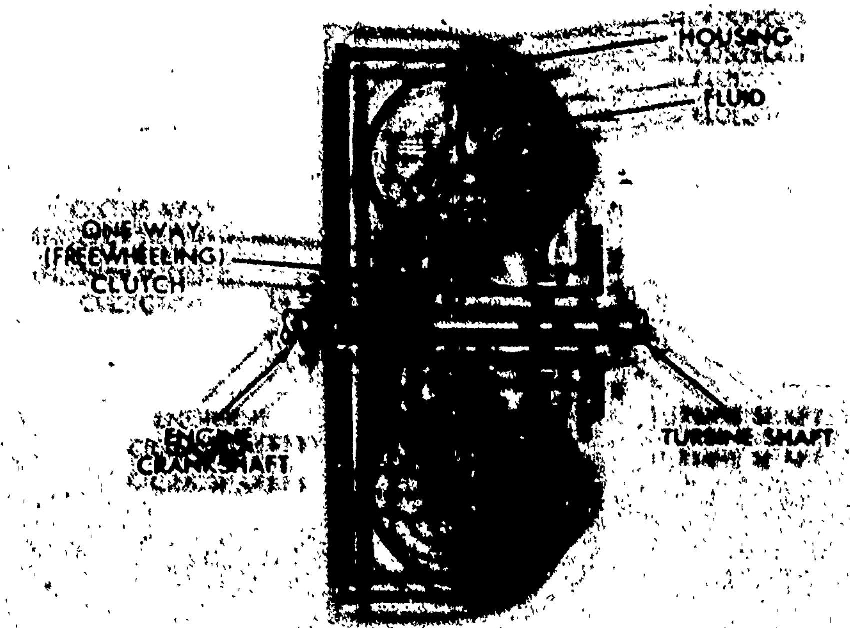
AM 3-7



Simplified drawing of a torque converter

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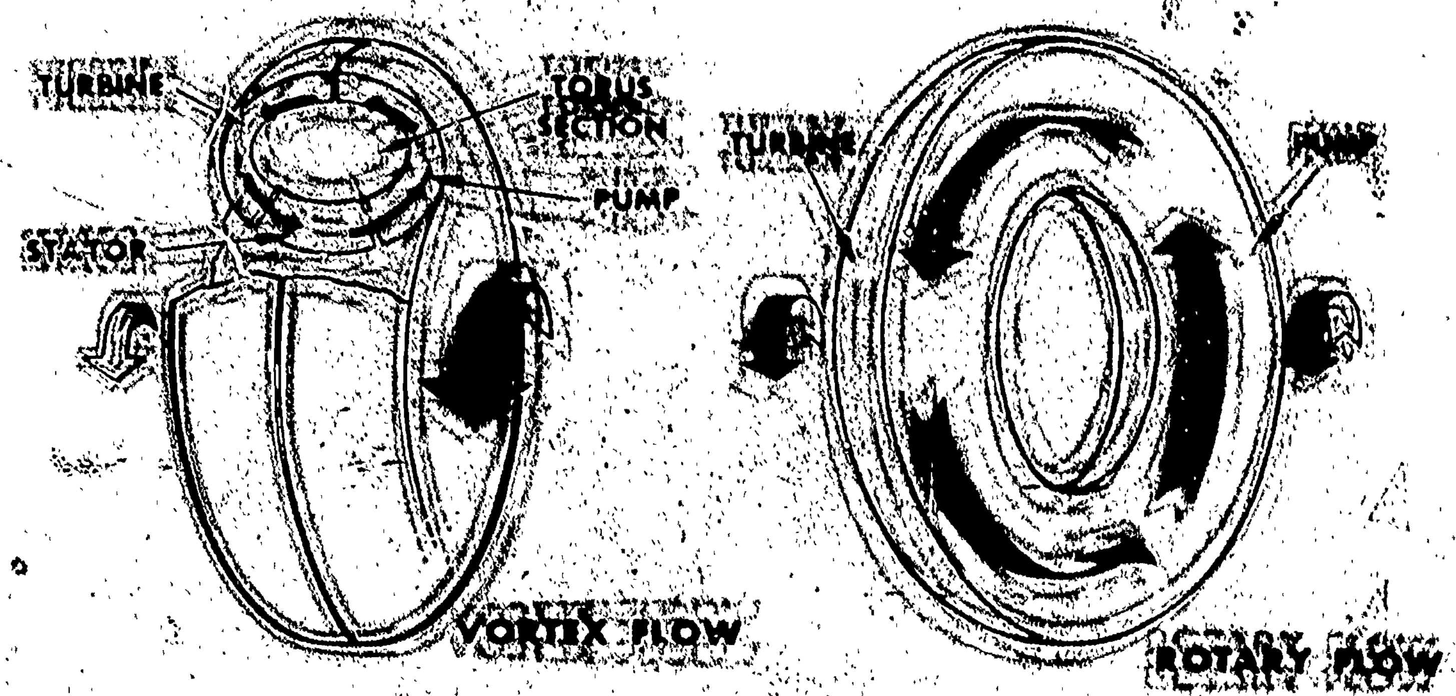
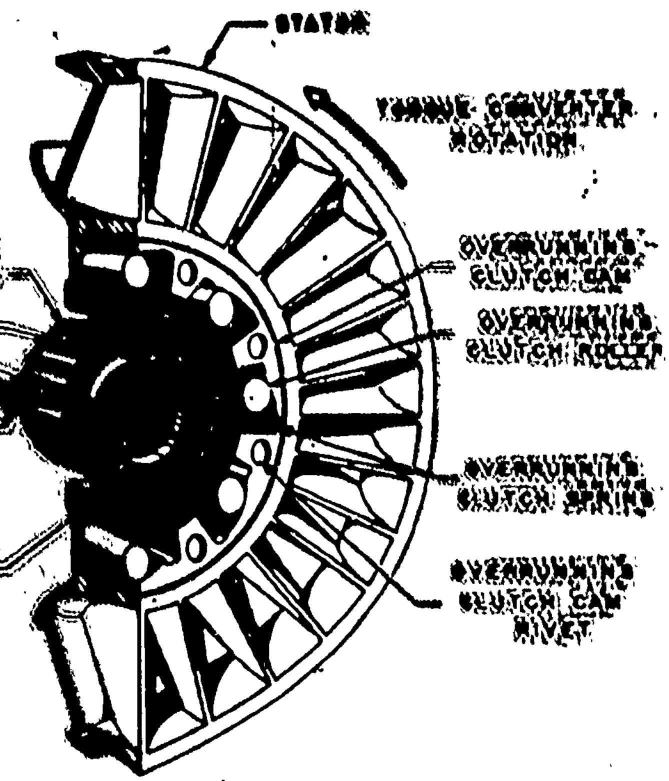
AM 2-6



Oil flow within a converter

HUMAN
ENGINEERING
INSTITUTE
Ohio 44115

AM 2-5



Roller type stator

HUMAN ENGINEERING INSTITUTE
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INSTRUCTOR'S GUIDE

Title of Unit: AUTOMATIC TRANSMISSIONS - TORQUE CONVERTER

AM 2-5
5/15/67

OBJECTIVES:

1. To introduce to the student a major part of the Allison transmission, the torque converter.
2. To show how oil flows through the converter, the role that stators play, how torque is multiplied, etc.
3. To present some maintenance and troubleshooting of the converter.

LEARNING AIDS suggested:

VU CELLS:

AM 2-5 (1)	Cross-sectional view of a fluid coupling
AM 2-5 (2)	Fluid flywheel
AM 2-5 (3)	Hydramatic fluid coupling design
AM 2-5 (4)	Cutaway view of a torque converter (three members)
AM 2-5 (5)	Sectional view of a torque converter using five members
AM 2-5 (6)	Simplified drawing of a torque converter
AM 2-5 (7)	Oil flow within a converter
AM 2-5 (8)	Roller type stator

MODELS:

Any parts of the converter that can be brought into class will be helpful.

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

1. What initiates movement of the torque converter?
2. What do two electric fans have to do with a fluid coupling?
3. What are the two parts of a fluid coupling?
4. What is meant by a "Torus"?

5. Which is connected to the engine flywheel, the driving member of the converter or the driven member?

6. What are some examples of "potential energy"?

7. What are some examples of "kinetic energy"?

8. What does centrifugal force have to do with the flow of oil in a converter?

9. Is there any loss incurred in a converter? Explain.

10. Does the loss mentioned in (9) above increase or decrease as the speed of the converter increases?

11. What is the main difference between a fluid flywheel and a torque converter?

12. How does the stator in a torque converter affect its operation?

13. What is the purpose of having the stator rotate in only one direction? How is this possible?

14. When do all of the components in a torque converter move as one unit?

15. Are there different types of torque converters?

16. Why would the oil in a torque converter be milky?