OTHER BOOKS BY WILLIAM H. CROUSE

Automotive Mechanics
and five accompanying study guides:
WORKBOOK FOR AUTOMOTIVE CHASSIS
WORKBOOK FOR AUTOMOTIVE ELECTRICITY
WORKBOOK FOR AUTOMOTIVE ENGINES
WORKBOOK FOR AUTOMOTIVE SERVICE AND TROUBLESHOOTING
WORKBOOK FOR AUTOMOTIVE TOOLS

Everyday Automobile Repairs
ABOUT THE AUTHOR

Behind William H. Crouse's clear technical writing is a background of sound mechanical engineering training as well as a variety of practical industrial experiences. He spent a year after finishing high school working in a tinplate mill, summers, while still in school, working in General Motors plants, and three years working in the Delco-Remy Division shops. Later he became Director of Field Education in the Delco-Remy Division of General Motors Corporation, which gave him an opportunity to develop and use his natural writing talent in the preparation of service bulletins and educational literature.

During the war years, he wrote a number of technical manuals for the Armed Forces. After the war, he became Editor of Technical Education Books or the McGraw-Hill Book Company. He has contributed numerous articles to automotive and engineering magazines and has written several outstanding books: Automotive Mechanics, Electrical Appliance Servicing, Everyday Automobile Repairs, Everyday Household Appliance Repairs, and Understanding Science.

William H. Crouse's outstanding work in the automotive field has earned for him membership in the Society of Automotive Engineers and in the American Society for Engineering Education.
How to study this book

This is one of a series of five books, called the McGraw-Hill Automotive Mechanics Series, which cover in detail the construction, operation, and maintenance of automobiles. The five books are designed to give you the complete background of information you need to become an automotive mechanic. Furthermore, every attempt has been made to give such thorough coverage of the subject that the books should be a valuable addition to the library of anyone interested in any phase of automobile engineering, manufacturing, sales, service, and operation.

Getting Practical Experience

Of course, these books alone will not make you an automotive mechanic, just as books alone do not make an airplane pilot or a dentist or an architect the expert he is. Practice also is required—practice in handling automotive parts and automotive tools and in following automotive servicing procedures. The books will give you the theoretical background you need, but you should seek out means of getting practice also. If you are taking a regular course in automotive mechanics, you will get practical experience in the school automotive shop. But if you are not taking a regular course in a school, you may still be able to make use of the facilities of any nearby school with an automotive shop. Perhaps you will meet others who are taking an automotive mechanics course and can talk over problems you have. This often clears up difficult points. A local garage or service station is a good source of practical information. If you can get acquainted with the automotive mechanics there, so much the better. Watch them as they work, notice how they do things. Then go home and think about it. Perhaps the mechanics will allow you to handle various parts and possibly even help with some of the servicing jobs.
How to Study This Book

SERVICE PUBLICATIONS

While you are in the service shop, try to get a chance to study the various publications they receive. Automobile manufacturers as well as suppliers of parts, accessories, and tools, publish shop manuals, service bulletins, and parts catalogues. All of these are designed to help service personnel do a better job. In addition, numerous automotive magazines are published which deal with the problems and methods of automotive service. All of these publications will be of great value to you; study them carefully.

These various activities will help you gain practical experience in automotive mechanics. Sooner or later this experience, plus the knowledge that you have gained in reading the five books in the McGraw-Hill Automotive Mechanics Series, will permit you to step into the automotive shop on a full-time basis. Or, if you are already in the shop, you will be equipped to step up to a better and a more responsible job.

CHECKING ON YOURSELF

Every few pages in the book you are given the chance to check the progress you are making by answering a series of questions. You will notice that there are two types of tests: progress quizzes and chapter checkups. Each progress quiz should be taken just after you have completed the pages preceding it. The quizzes allow you to quickly check yourself as you finish a "lesson." On the other hand, the chapter checkups may cover several "lessons" since they are review tests of entire chapters. Since they are review tests, you should review the entire chapter by rereading it or at least paging through it to check important points before trying the test. If any of the questions stumps you, reread the pages in the book that will give you the answer. This sort of review is very valuable and will help you to fix in your mind the essential information you will need when you go into the automotive shop. Do not write in the book. Instead, write down your answers in a notebook.

KEEPING A NOTEBOOK

Most of the questions require a written answer. It will be helpful for you to keep a notebook and to write the answers in the notebook. Also, you can write down in the notebook important facts that you pick up from reading the book or from working in the shop. As
How to Study This Book

you do this, you will find that the notebook will become a valuable source of information to which you can refer. Use a loose-leaf, ring-binder type of notebook so you can insert or remove pages and thereby add to and improve your notebook.

Glossary and Index

There is a list of automotive terms with their definitions in the back of the book. Whenever you have any doubt about the meaning of some term or the purpose of some automotive part, you can refer to this list, or glossary. Also, in the back of the book you will find an index. This index will help you to look up anything in the book that you are not sure about. For example, if you want to refresh your mind on how some component works, you can find it quickly by looking in the index to find what pages the information is on.

Automotive Tools and Components

In Automotive Engines (one of the five books in the McGraw-Hill Automotive Mechanics Series), there is a chapter on automotive tools. This chapter is an important one and should be studied along with any of the books in the McGraw-Hill Automotive Mechanics Series. In other words, the information in the chapter on tools applies to all service operations on the car, not just to engine service. Automotive Engines also has a chapter on automotive components that describes briefly the operation of all the mechanisms in the automobile. Reference should be made to this chapter if the reader desires a short explanation of any component.

And now, good luck to you. You are engaged in the study of a fascinating, complex, and admirable mechanism—the automobile. Your studies can lead you to success in the automotive field, a field where opportunities are great. For it is the man who knows—the man who can do things—who moves ahead. Let this man be you.

William H. Crouse
Preface to second edition

RAPID technological developments in the automotive field, as well as advancements in educational methods required to keep pace with these new developments, have made advisable a new edition of *Automotive Transmissions and Power Trains*. This revision includes material on the new automotive equipment introduced in the past three years and related servicing techniques. In so far as possible, this new material has not been appended to the old; instead, it has been integrated into the pattern of the text so that the student sees the new material as part of the complete presentation.

The comments and suggestions of teachers and students who have used the earlier edition have been carefully analyzed and acted upon where possible during the revision of the text. Reports of their experience in the actual use of the text for classroom and home study have been of paramount importance to the author in his efforts to make the book of maximum usefulness. Improvements that have been made in the present edition, therefore, should be credited to these users, and acknowledgment of their helpful suggestions is herewith gratefully extended.

William H. Crouse
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Acknowledgments

DURING the several years that the five books in the McGraw-Hill Automotive Mechanics Series (of which this is one) were in preparation, the author was given invaluable aid and inspiration by many, many people in the automotive industry and in the field of education. The author gratefully acknowledges his indebtedness and offers his sincere thanks to these many people. All cooperated with the aim of providing accurate and complete information that would be useful in the training of automotive mechanics. Special thanks are due to the following organizations for information and illustrations that they supplied: AC Spark Plug Division, Buick Motor Division, Cadillac Motor Car Division, Chevrolet Motor Division, Delco Products Division, Delco-Remy Division, Detroit Diesel Engine Division, Frigidaire Division, Oldsmobile Division, Pontiac Motor Division, Saginaw Steering Gear Division, and United Motors Service Division of General Motors Corporation; Allen Electric and Equipment Company; American Exporter's Automotive World; Akron Equipment Company; American Motors Corporation; Barrett Equipment Company; Bear Manufacturing Company; Bendix Products Division of Bendix Aviation Corporation; Black and Decker Manufacturing Company; Carter Carburetor Company; Chrysler Sales Division, De Soto Division, Dodge Division, and Plymouth Division of Chrysler Corporation; Clayton Manufacturing Company; Henry Disston and Sons, Inc.; Eaton Manufacturing Company; E. I. du Pont de Nemours & Company, Inc.; Electric Auto-Lite Company; Federal-Mogul Corporation; E. Edelmann and Company; Federal Motor Truck Company; Ford Motor Company; Gemmer Manufacturing Company; B. F. Goodrich Company; Greenfield Tap and Die Corporation; Hall Manufacturing Company; Jam Handy Organization, Inc.; Hercules Motors Corporation; Hobart Brothers; Hotpoint, Inc.; Houde Engineering Division of Houdaille-Hershey Corporation; International Harvester Company; Kaiser Motors Corporation; K-D Manufacturing Company; Kelsey-Hayes Wheel Company; Kent-Moor Organization, Inc.; Johnson Bronze Company; King-Seeley Corporation; Lincoln-Mercury Division of Ford Motor Company; Linde Air Products Company; Mack-International Motor
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Special thanks are also due to the staff and instructors at General Motors Institute; they supplied the author with much excellent information and gave him great assistance during certain phases of the work on the McGraw-Hill Automotive Mechanics Series. To all these organizations and the people who represent them, sincere thanks!

WILLIAM H. CROUSE
1: Power train components

THIS BOOK has been prepared to give you an understanding of the construction, operation, maintenance, and servicing of automotive power trains. By the time you have finished this book, you should have a good acquaintance with the various components of the automotive power train, including the clutch, transmission, propeller shaft, and differential. Also, if you are able to visit or work in an automotive repair shop or school automotive shop during the time you study this book, you should ultimately be able to service these various power-train components yourself. Naturally, you do not expect to become an expert in this work overnight, because that takes long practice and experience. However, this book, combined with necessary practical shopwork, is designed to give you the basic information you need to become an expert.

§ 1. Components of the automobile Before we begin our studies of the power train, let us first take a quick look at the complete automobile. This will show us how the power train operates in relation to the other parts of the automobile. The automobile might be said to consist of five basic parts, or components. These are:

1. The power plant or engine, which is the source of power.
2. The frame-and-wheel assembly, which supports the engine and body.
3. The power train, which carries the power from the engine to the car wheels and which consists of the clutch, transmission, propeller shaft, differential, and axles.
4. The car body.
5. The car-body accessories, which include the heater, lights, radio, windshield wiper, convertible-top raiser, air conditioner, and so on.

Many of these components can be seen in the illustration of the automotive chassis (Fig. 1-1). The engine (Figs. 1-2 and 1-3)
produces power by burning a mixture of gasoline vapor and air in the engine combustion chambers. This creates high pressure, which forces the engine pistons downward. The downward thrusts on the pistons are carried through connecting rods to cranks on the engine crankshaft. These thrusts on the cranks cause the crankshaft (Fig. 1-4) to rotate. The engine flywheel is attached to the rear end of the crankshaft. The rear face of the flywheel is flat and smooth and serves as the driving member of the clutch. When the clutch is engaged, the rotary motion of the engine crankshaft is carried through the flywheel and clutch to the other members of the power train (transmission, propeller shaft, and differential).

§ 2. **Power train** The power train (Fig. 1-5) carries the power from the engine to the rear wheels. The power train can provide several different gear ratios (explained in §5) between the engine crankshaft and the wheels. In the standard arrangement the gear ratio can be changed so the engine crankshaft will rotate approximately four, eight, or twelve times to cause the wheels to rotate once. On cars equipped with automatic transmissions, these approximate
Power Train Components

§3

Gear ratios may not hold true. Automatic transmissions with torque converters provide a very large number of gear ratios. All this is explained in detail in later chapters. For the moment, let us concentrate on the standard power-train arrangement. An understanding of this arrangement will lead us to an easier understanding of automatic transmissions. The standard power train consists of a series of gears and shafts which mechanically connect the engine shaft and car wheels. As mentioned above, it contains the clutch; a transmission, or change gears; a propeller shaft; and the final drive, or the differential and wheel axles. Let us look at each of these in more detail.

§3. Clutch The clutch (Fig. 1-6) permits the driver to connect the crankshaft to, or disconnect it from, the power train. A clutch...
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Fig. 1-3. Cross-sectional view of a six-cylinder engine. The piston is at top of stroke. Both the piston and cylinders are shown cut in half. (Chevrolet Motor Division of General Motors Corporation)

Fig. 1-4. Crankshaft and related parts used in an eight-cylinder, V-type engine. (Mercury Division of Ford Motor Company)
or disconnecting device is necessary, since the automobile engine must be started without load. That is, it must not be required to deliver any power during the starting period. In order for the engine to deliver power, the crankshaft must be rotating at a reasonable speed of several hundred revolutions per minute. The engine will start at speeds below 100 rpm (revolutions per minute), but it would not continue to operate at this low speed if a load were immediately thrown on it. Consequently, a clutch is placed in the power train between the crankshaft and the transmission. The clutch permits the engine to run freely without delivering power to the power train. It also permits operation of the trans-

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**Fig. 1-5.** View from top of a typical automotive chassis showing locations of engine, transmission, propeller shaft, differential, and rear-axle housing. *(Dodge Division of Chrysler Corporation)*
mission so that the various gear ratios between the engine crankshaft and the wheels may be obtained.

The clutch contains a double-faced friction disk (or driven plate) about a foot in diameter. The friction disk is splined to the clutch shaft, and there is a spring arrangement for forcing this disk tightly against the smooth face of the engine flywheel. The splines are internal teeth on the friction-disk hub and matching external teeth on the clutch shaft. They permit the disk to move back and forth along the shaft but cause the disk and shaft to rotate together. Internal splines can be seen in the hub in Fig. 2-11. External splines can be seen on the shaft in Fig. 1-6. The flywheel is attached to the end of the engine crankshaft. When the clutch is engaged, the friction disk is held against the flywheel so that it revolves with the flywheel. This rotary motion is carried through.

Fig. 1-6. Sectional view of a clutch, with linkage to clutch pedal shown schematically. (Plymouth Division of Chrysler Corporation)
the clutch and the clutch shaft to the transmission and from there to the car wheels.

When the clutch pedal is pushed down, the clutch fork moves against the clutch throwout bearing, forcing the bearing inward. This operates release levers that take up the spring pressure so that pressure against the friction disk is relieved and it can move away from the flywheel face. When this happens, the friction disk and the shaft stop revolving. When pressure on the clutch pedal is removed, the springs again force the friction disk against the flywheel face so that it once more rotates with the flywheel.

§4. Transmission

The transmission, or change gears, provides a means of varying the gear ratio. Thus the engine crankshaft may turn four, eight, or twelve times for each wheel revolution (approximately). In addition, a reverse gear is provided that permits backing the car. The operation of the transmission is explained in §6.

The varying gear ratios are necessary, since the gasoline engine does not develop much power at low engine speeds. It must be turning at a fairly high speed in order to deliver enough power to start the car moving. Thus, on first starting, the gears are placed in low so that the engine crankshaft will turn approximately twelve times for each wheel revolution. The clutch is then engaged so that power is applied to the wheels. Car speed increases with engine speed until the car is moving 5 or 10 mph (miles per hour). At this time the engine crankshaft may be turning as many as 2,000 rpm. The clutch is then disengaged and the engine crankshaft speed reduced, to permit gear changing. The gears are shifted into second, and the clutch is again engaged. Since the ratio is now about 8:1, a higher car speed is obtained as engine speed is again increased. The gears are then shifted into high, the clutch being disengaged and engaged for this operation, so that the ratio between the engine and wheels will be approximately 4:1. In other words, the engine crankshaft will turn four times to cause the wheels to turn once.

In automatic transmissions, the varying ratios between the engine crankshaft and the wheels are achieved by automatic means. That is, the driver does not need to shift gears, because the automatic controls in the automatic transmission supply the proper ratio to suit the driving conditions. Such transmissions make use of a fluid

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coupling or a torque converter as well as mechanical, hydraulic, or electrical controls. All these are discussed in detail in later chapters.

§ 5. Gears and torque Before we consider the transmission further, we might take a closer look at gear action. Let us find out what takes place when power is transmitted from one to another meshing gear. The relative rotation between two meshing gears (or the

![Fig. 1-7. Two meshing gears with same number of teeth.](image)

![Fig. 1-8. Two meshing gears of different sizes. The smaller gear will turn more rapidly than the larger one.](image)

gear ratio) is determined by the number of teeth in the gears. For instance, when two meshing gears have the same number of teeth, they will both turn at the same speed (Fig. 1-7). However, when one gear has more teeth than the other, the smaller gear will turn more rapidly than the larger one. Thus, a gear with 12 teeth will turn twice as fast as a gear with 24 teeth (Fig. 1-8). The gear [8]
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ratio between the two gears is 2:1. If the 12-tooth gear were meshed with a 36-tooth gear, the 12-tooth gear would turn three times for every revolution of the larger gear. The gear ratio between these gears would be 3:1.

1. Torque. Not only does the gear ratio change with the relative number of teeth in the meshing gears, but the torque also changes. Torque is twisting or turning effort. When you loosen the lid on a jar, you apply a twisting force, or torque, to it (Fig. 1-9). Torque is measured in pound-feet (abbreviated lb-ft). Torque should not be confused with work which is measured in foot-pounds (ft-lb).

To calculate torque, multiply the push (in pounds) by the distance (in feet) from the center to the point where the push is exerted. For example, suppose that you had a wrench 1 foot long and that you used it to tighten a nut (Fig. 1-10). If you put 10 pounds pressure on the wrench, as shown, you would be applying 10 lb-ft torque to the nut. If you put 20 pounds pressure on the wrench, you would be applying 20 lb-ft torque. If the wrench were 2 feet long and you applied 10 pounds pressure, the torque on the nut would be 20 lb-ft.

Any shaft or gear that is being turned has torque applied to it. The engine pistons and connecting rods push on the cranks on the crankshaft, thereby applying torque to the crankshaft and causing it to turn. The crankshaft applies torque to the gears in the transmission so the gears turn. This turning effort, or torque, is carried through the power train to the rear wheels so that they turn.
§5 Automotive Transmissions and Power Trains

2. Torque in gears. Torque on shafts or gears is measured as a straight-line force at a distance from the center of the shaft or gear. For instance, suppose we want to measure the torque in the gears shown in Fig. 1-8. If we could hook a spring scale to the gear teeth and get a measurement of the pull, we could determine the torque. (Actually, a spring scale could not be used, although there are devices to measure torque of rotating parts.) Suppose, for example, we found that the tooth of the driving gear is pushing against the tooth of the driven gear with a 25-pound force (Fig. 1-11). This force, at a distance of 1 foot (the radius, or distance from the center of the driving gear), means there is a torque of 25 lb-ft. That is, the smaller (driving) gear is delivering a torque of 25 lb-ft.

The 25-pound push from the gear teeth of the smaller gear is applied to the gear teeth of the larger gear. But it is applied at a distance of 2 feet from the center. Therefore, the torque on the larger gear is 50 lb-ft \((25 \times 2)\). The same force is acting on the teeth of the larger gear, but it is acting at twice the distance from the shaft center.

3. Torque and gear ratio. Now, the important point of all this is that if the smaller gear is driving the larger gear, the gear ratio will be 2:1. But the torque ratio will be 1:2. The larger gear will turn only half as fast as the smaller gear. But the larger gear will have twice the torque of the smaller gear. In gear systems, speed reduction means torque increase. For example, in the previous [10]
section we mentioned that when the transmission is in low gear, there is a speed reduction \( (or \text{ gear reduction}) \) of 12:1 from engine to wheels. That is, the crankshaft turns twelve times to turn the rear wheels once. This means that the torque increases twelve times (ignoring losses due to friction). In other words, if the engine produced a torque of 100 lb-ft, then 1,200 lb-ft torque would be applied to the rear wheels.

To see how this torque produces the forward thrust, or push, on the car, refer to Fig. 1-12. In the example shown, the torque being delivered by the engine is assumed to be 100 lb-ft. We assume also that the gear reduction from the engine to rear wheels is 12:1, with a torque increase of 1:12. Wheel radius is assumed to be 1 foot (for ease of figuring). With the torque acting on the ground at a distance of 1 foot (radius of wheel), the push of the tire on the ground is calculated.

![Diagrams of various types of gears](image)

Fig. 1-13. Various types of gears. The bottom gear set is a disassembled view of a planetary gear system. Planetary gears are used in overdrives and automatic transmissions. The "spider" to the lower left is also called a planet-pinion cage.
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ground is 1,200 pounds. Consequently, the push on the wheel axle, and thus the car, is 1,200 pounds.

Note: Actually, the torque is split between the two rear wheels. Thus, the torque on each rear wheel is 600 lb·ft and each tire thus pushes on the ground with a force of 600 pounds. Both tires together push with a force of 1,200 pounds, giving the car a forward thrust of 1,200 pounds.

4. Other gears. The gears discussed above are spur gears. The teeth are parallel to, and align with, the center line of the gear. Many types of gears are used in the automobile. They differ mainly from the spur gear in the shape and alignment of the gear teeth. Thus, helical gears are like spur gears except that the teeth have, in effect, been twisted at an angle to the gear center line. Bevel gears are shaped like cones with the tops cut off; the teeth point inward toward the apex of the cone. Bevel gears are used to transmit motion through angles. Some gears have their teeth pointing inward; these are internal gears. Several typical gears are shown in Fig. 1-13.

Check Your Progress

Progress Quiz 1

In almost any job you are doing, it is a good idea to pause occasionally and check the progress you are making. For instance, when the battery man has a storage battery on charge, he checks the battery periodically to see how the battery is taking the charge. In a somewhat similar way, the progress quizzes you find every few pages in this book will help you check yourself to find out how you are taking the "charge" of new information. The questions that follow give you a chance to determine quickly how well you remember the important facts you have just read on the past few pages in the book. If you have difficulty answering any of the questions, don’t be discouraged. Just reread the pages that will give you the answer. Most students make a practice of reading and rereading their lessons several times. This helps them to understand and remember the facts covered in the lessons.

You are asked to write down the answers to the questions in your notebook. Writing down the answers, plus reviewing the pages in the book covered by the quiz, will help to fix the essential facts firmly in your mind. As you continue to do these things during your progress through the book, you will find it easier and easier to remember the important points covered in the book. In other words, you will become an expert

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student. And from an expert student to an expert automotive mechanic is only a step.

Correcting Parts Lists

The purpose of this exercise is to enable you to spot the unrelated item in a list. For example, in the list dog, cat, horse, chair, bird, you can see that chair does not belong because it is the only thing named that is not an animal. In each of the lists below, you will find that one item is included that does not belong. Write down each list in your notebook, but do not write down the item that does not belong.

1. Heater, radio, windshield wiper, hoist, air conditioner.
3. Clutch, friction disk, rear axle, throwout bearing, pressure springs, release levers.
4. Gear ratios in power train with standard transmission are: 4:1, 8:1, 12:1, 16:1.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. The power train includes the clutch, propeller shaft, differential, and ____________ steering gear.
2. There is a double-faced friction disk splined to a shaft in the ____________ engine clutch.
3. Two meshed gears have a gear ratio of 3:1. Every time the larger gear turns once, the smaller gear will turn ____________
   once three times
4. If two meshing gears have a 4:1 gear ratio and the smaller gear has 12 teeth, the larger gear will have ____________
   36 teeth 36 teeth
5. The device that produces different gear ratios in the power train is called a ____________ transmission speed changer
6. In gear systems, speed reduction means torque ____________ reduction
   stabilization increase
7. In the example shown in Fig. 1-12, if the gear reduction were 8:1, the push on the car would be ____________
   1,200 pounds 800 pounds

[13]
§6. In the example shown in Fig. 1-12, if the wheel radius were 18 inches (1.5 feet), the push on the car would be 800 pounds, 1,200 pounds, or 1,600 pounds.

§6. Operation of transmission There are many kinds of transmission. Some of the simpler types are found on passenger cars. More complex transmissions are used on trucks and busses. However, all manually shifted transmissions are quite similar in operation even if different in construction. Let us look at a simple transmission and find out how it works. Later, in another chapter, we shall see that the more complex transmissions work on the same principles. The transmission we shall discuss consists essentially of three shafts and eight gears of various sizes (Fig. 1-14). In the illustration, only the moving parts are shown. The transmission housing and bearings are not shown.

Four of the gears are rigidly connected to the countershaft (Fig. 1-14). These are the drive gear, second gear, low gear, and reverse gear. When the clutch is engaged and the engine is running, the clutch-shaft gear drives the countershaft drive gear. This turns the countershaft and the other gears on the countershaft. The countershaft rotates in a direction opposite, or counter, to the
rotation of the clutch-shaft gear. With the gears in neutral as shown in Fig. 1-14, and the car stationary, the transmission main shaft is not turning. The transmission main shaft is mechanically connected by shafts and gears in the final drive to the car wheels. The two gears on the transmission main shaft may be shifted back and forth along the splines on the shaft by operation of the gearshift lever in the driving compartment. The splines are matching internal and external teeth that permit endwise (axial) movement of the gears but cause the gears and shaft to rotate together. Note, in the illustrations that follow, that a floor-board shift lever is shown. This type of lever is shown since it illustrates more clearly the lever action in shifting gears. The transmission action is the same, regardless of whether a floor-board type of shift lever or a steering-column lever is used.

1. Low gear. When the gearshift lever is operated to place the gears in low (Fig. 1-15), the large gear on the transmission main shaft is moved along the shaft until it meshes with the small gear on the countershaft. The clutch is disengaged for this operation, so the clutch shaft and the countershaft stop rotating. When the clutch is again engaged, the transmission main shaft is caused to rotate
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as the driving gear on the clutch shaft drives it through the countershaft. Since the countershaft is turning more slowly than the clutch shaft and since the small countershaft is engaged with the large transmission main-shaft gear, a gear reduction of approximately 3:1 is achieved; that is, the clutch shaft turns three times for each revolution of the transmission main shaft. Further gear reduction in the final drive at the rear wheels produces a still higher gear ratio (approximately 12:1) between the engine crankshaft and the wheels.

2. Second gear. When the clutch is operated and the gearshift lever moved to second (Fig. 1-16), the large gear on the transmission main shaft de-meshes from the small countershaft gear. The smaller transmission main-shaft gear is slid into mesh with the large countershaft gear. This provides a somewhat reduced gear ratio, so that the engine crankshaft turns only about twice while the transmission main shaft turns once. The final drive-gear reduction increases this gear ratio to approximately 8:1.

3. High gear. When the gears are shifted into high (Fig. 1-17), the two gears on the transmission main shaft are de-meshed from the countershaft gears, and the smaller transmission-shaft gear is
forced axially against the driving gear. Teeth on the ends of the two gears mesh so that the transmission main shaft turns with the clutch shaft, and a ratio of 1:1 is obtained. The final drive-gear reduction produces a gear ratio of about 4:1 between engine crankshaft and wheels.

4. Reverse gear. When the gears are placed in reverse (Fig. 1-18), the larger of the transmission main-shaft gears is meshed with the reverse idler gear. This reverse idler gear is always in mesh with the small gear on the end of the countershaft. Interposing the idler gear between the countershaft gear and the transmission main-shaft gear causes the transmission shaft to be rotated in the opposite direction, or in the same direction as the countershaft. This reverses the rotation of the wheels so that the car backs.

While the above description outlines the basic principles of all transmissions, somewhat more complex transmissions are used on modern cars. These include helical or herringbone gears and gear shifting in conjunction with synchromesh devices that synchronize the rotation of gears that are about to be meshed. This eliminates clashing of gears and facilitates gear shifting.
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FIG. 1-18. Transmission with gears in reverse.

FIG. 1-19. Partial disassembled view of one type of propeller shaft, partly disassembled so the component parts can be seen.

§7. Final drive The final drive transmits the power from the transmission to the rear wheels and consists of the propeller shaft and the differential. The propeller shaft connects the transmission shaft and the rear-wheel driving mechanism, or differential (Figs. 1-5 and 1-19). The propeller shaft is more than a simple line shaft, [18]
since it is connected at one end to the rigidly mounted transmission and at the other end to the wheel axles that move up and down with the wheel-spring movement. Two separate effects are produced by this movement. First, the distance between the transmission and wheel axles decreases as the springs compress and the axles move toward the car frame, and the distance increases as the springs expand. Second, the driving angle changes with the spring movement.

1. *Universal joints.* To take care of the differences in the angle of drive as the axle moves up and down, the propeller shaft incorporates one or more universal joints. A universal joint (Fig. 1-20) is essentially a double-hinged joint through which the driving shaft can transmit power to the driven shaft even though the two shafts are some degrees out of line with each other.

Each of the two shafts has a Y-shaped yoke on the end, and between these yokes there is a center member that is shaped like a cross. The four arms of the center member are assembled in bearings in the ends of the shaft yokes. The bearings can turn on the crossarms to take care of any angularity between the shafts as the shafts rotate. The driving shaft causes the center member to rotate by its pressure on two of the crossarms. The other two crossarms cause the driven shaft to rotate. Many types of universal joint have been designed. It will be found that the actual universal joint in use on the modern automobile is somewhat more complicated than that described above. The principle is the same, however.

2. *Slip joint.* Since the propeller shaft tends to shorten and lengthen with the wheel-axle movement, it is necessary that some device be incorporated that will permit this action. The device used is the slip joint, located at either the front or the rear end of the propeller shaft (Fig. 1-21). The slip joint is merely an externally splined shaft and a matching internally splined shaft. The two shafts can slide back and forth with respect to each other and still transmit driving power. The slip joint shown in Fig. 1-21 consists of the externally splined slip yoke (8) and the internally splined front shaft (17).
Fig. 1-21. Propeller shaft and support bearing partly disassembled so the slip joint can be seen. External splines are on universal-joint yoke (8) and internal splines are in shaft (17). (Studebaker-Packard Corporation)

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Nut</td>
<td>Nut</td>
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<tr>
<td>2. Lock washer</td>
<td>Lock washer</td>
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<tr>
<td>3. Plain washer</td>
<td>Plain washer</td>
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<tr>
<td>4. Support cushion</td>
<td>Support cushion</td>
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<tr>
<td>5. Stud</td>
<td>Stud</td>
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<tr>
<td>6. Lock washer</td>
<td>Lock washer</td>
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<tr>
<td>7. Nut</td>
<td>Nut</td>
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<tr>
<td>8. Slip yoke</td>
<td>Slip yoke</td>
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<tr>
<td>9. Grease washer nut</td>
<td>Grease washer nut</td>
</tr>
<tr>
<td>10. Washer retainer</td>
<td>Washer retainer</td>
</tr>
<tr>
<td>11. Grease washer</td>
<td>Grease washer</td>
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<tr>
<td>12. Lock plate</td>
<td>Lock plate</td>
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<tr>
<td>13. Spacer</td>
<td>Spacer</td>
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<tr>
<td>14. Support</td>
<td>Support</td>
</tr>
<tr>
<td>15. Support bearing</td>
<td>Support bearing</td>
</tr>
<tr>
<td>16. Dust shield</td>
<td>Dust shield</td>
</tr>
<tr>
<td>17. Front shaft</td>
<td>Front shaft</td>
</tr>
</tbody>
</table>

§8. Differential

If the car were to be driven in a straight line without having to make turns, then no differential would be necessary. However, when the car rounds a turn, the outer wheel must travel farther than the inner wheel. If a right-angle turn is made with the inner wheel turning on a 20-foot radius, this wheel travels about 31 feet (Fig. 1-22). The outer wheel, being nearly 5 feet from the inner wheel (56 inches), turns on a 24½-foot radius and travels nearly 39 feet (Fig. 1-22).

If the propeller shaft were geared rigidly to both rear wheels so that they would both have to rotate together, then each wheel would have to skid an average of 4 feet in making the turn discussed above. On this basis, tires would not last long. In addition, the skidding would make the car hard to control on turns. The differential eliminates these troubles because it allows the wheels to rotate different amounts when turns are made.

To study the construction and action of the differential, let us build up, in effect, a simple differential (Fig. 1-23). The two rear wheels are attached, through the axles, to two small bevel gears [30].
There is a differential case assembled around the left axle (Fig. 1-23b). The case has a bearing that permits it to turn independently of the left axle. Inside the case is a shaft that supports a third bevel gear (Fig. 1-23c). This third bevel gear, called the **differential pinion gear**, is meshed with the two axle bevel gears. Thus, when the differential case is rotated, both axle bevel gears rotate and thus both wheels turn. However, let us suppose that one wheel is held stationary. Then, when the differential case is rotated, the differential pinion gear will also rotate as it "runs round" on the stationary axle bevel gear. As it rotates in this manner, it carries rotary motion to the other axle bevel gear, causing it, and the wheel, to rotate.

It can be seen that when one rear wheel turns more rapidly than the other, the differential pinion gear spins on its shaft, transmitting more rotary motion to one rear wheel than to the other. When both turn at the same speed, the differential pinion gear does not rotate on its shaft.

The differential case is rotated by means of a ring gear attached to it. This ring gear is meshed with a drive pinion on the end of the propeller shaft (Fig. 1-23d). When the car is on a straight road, the ring gear, differential case, differential pinion gear, and two axle bevel gears all turn as a unit without any relative motion. However, when the car begins to round a curve, the differential pinion gear...
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rotates on its shaft to permit the outer rear wheel to turn more rapidly than the inner rear wheel.

The actual differential is somewhat more complicated than that shown in Fig. 1-23. An actual differential, partially cutaway to show the parts, is illustrated in Fig. 1-24. The driving power enters the differential through the drive pinion on the end of the propeller shaft (No. 8 in Fig. 1-24). The drive pinion is meshed with a large ring gear (No. 5) so that the ring gear revolves with the pinion. Attached to the ring gear (through the differential case) is a differential pinion shaft (No. 15), on which are assembled two diff-
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Differential pinion gears (No. 6). Each rear car wheel has a separate axle, and there are two side gears (No. 12) splined to the inner ends of the two wheel axles (No. 11). The two differential pinion gears mesh with these two side gears. When the car is on a straight road, the two differential pinion gears do not rotate on the pinion shaft; but they do exert pressure on the two side gears so that the side gears turn at the same speed as the ring gear, causing both rear wheels to turn at the same speed also. When the car rounds a curve, the outer wheel must turn faster than the inner wheel. To permit this, the two pinion gears rotate on their pinion shaft, transmitting more turning movement to the outer side gear than to the inner side gear. Thus the side gear on the outer wheel axle turns more rapidly than the side gear on the inner wheel axle.
mitting the outer wheel to turn more rapidly while the car is rounding the curve.

CHECK YOUR PROGRESS

Progress Quiz 2

The following questions will help you to determine how well you remember what you have been reading. If you have difficulty answering any of the questions, you should reread the past few pages. Most students make a practice of reading and rereading their "lesson" several times in order to make sure they understand it. Do not be discouraged if the questions "stump" you the first time. Just reread the past few pages and try the questions again. As you do this, you will begin to learn how to pick out the important facts you should remember. After you have repeated this procedure in the next few sections of the book, you will begin to find it is increasingly easy to read and retain the essential facts. By the time you have finished the book, if you continue the practice, you will have become an expert student. And from an expert student to an expert automotive mechanic is only a step.

Correcting Parts Lists

The purpose of this exercise is to enable you to spot the unrelated part in a list. For example, in the list clutch: friction disk, rear axle, throwout bearing, pressure springs, shaft, you can see that rear axle does not belong because it is the only item named that is not part of the clutch.

In each of the lists, you will find one item that does not belong. Write down each list in your notebook, but do not write down the item that does not belong.

4. Countershaft drive gear, countershaft second gear, countershaft low gear, countershaft reverse gear, countershaft bevel gear.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the
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sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. Essentially, the transmission described in the chapter consists of three shafts and three shaft idler gear clutch gear output gear
gears

2. When shifting into low, a gear on the transmission main shaft is moved into mesh with the countershaft low gear countershaft idler gear clutch gear output gear

3. In the transmission, the countershaft drive gear is meshed with a gear on the output shaft main shaft clutch shaft

4. In high gear, the transmission main shaft turns at the same speed as the countershaft clutch shaft idler shaft

5. To take care of the difference in driving angle as the rear axle moves up and down, the propeller shaft has one or more slip joints elbow joints release joints universal joints

6. To take care of the lengthening and shortening of the propeller shaft with rear axle movement, the propeller shaft has a slip joint elbow joint release joint universal joint

7. In the differential, the drive pinion meshes with the bevel gear pinion gear ring gear

8. The bevel gears on the rear axles are meshed with the differential bevel gear pinion gear ring gear

CHAPTER CHECKUP

Note: Since the following is a chapter review test, you should review the chapter before taking it.

Now that you have completed a chapter in the book, you will want to test your knowledge of the subjects covered in the chapter. The questions that follow have two purposes. One is to test your knowledge. The second purpose is to help you review the chapter. It may be that you will not be able to answer, offhand, all of the questions. If this happens, turn back into the chapter and reread the pages that will give you the answer. For instance, under "Listing Parts," you are asked to list the parts, besides bearings, that are in motion when the car is moving. If you cannot remember them all, turn back to the illustrations of the differential in the chapter and refer to them when writing your list. The act of writing down the names of the parts will help you to remember them.

Note: Write down your answers in your notebook. Then later, when you have finished the book, you will find your notebook filled with valuable information to which you can refer quick'
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Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. The power train transmits power from the engine to the crankshaft steering gear front wheels rear wheels
2. The clutch part that is between the pressure plate and the engine flywheel is called the throwout bearing clutch fork friction disk clutch pedal
3. The gear in the transmission that is always in mesh with the clutch gear is called the second-and-high-speed gear low-speed gear idler gear countershaft drive gear
4. The propeller shaft has one or more elbow joints universal joints fluid couplings spur gears
5. In the standard differential described in the chapter, the total number of gears and pinions is 2 3 6 11
6. In the differential, the ring gear is attached to the bevel gear drive gear differential case propeller shaft
7. The device in the propeller shaft that permits changes in shaft length is called the length joint change joint slip joint shaft joint
8. In the transmission, the reverse idler gear is always in mesh with the low gear second gear countershaft reverse gear main-shaft reverse gear

Listing Parts

In the following, you are asked to list parts that go into various automotive components discussed in the chapter. Write down this list in your notebook.

1. List four major components of the automobile.
2. List four major components of the power train.
3. List five parts in a clutch.
4. List six gears used in a typical standard transmission.
5. List two types of joint used in a propeller shaft.
6. List the major parts in the differential, apart from bearings, that are in motion when the car is moving.
7. List the parts through which power is flowing in the transmission when the gears are in first. In second. In reverse.
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Purpose and Operation of Components

In the following, you are asked to write down the purpose and operation of certain components of the automobile discussed in the chapter. If you have any difficulty in writing down your explanation, turn back in the chapter and reread the pages that will give you the answer. Then write down your explanation. Don’t copy; try to tell it in your own words, just as you would explain it to a friend. This is a good way to fix the explanation more firmly in your mind. Write in your notebook.

1. What is the purpose of the clutch?
2. How does the clutch operate?
3. What is the purpose of the transmission, or change gears?
4. Explain what takes place when the transmission gears are shifted into low, second, high, and reverse.
5. What is the purpose of the universal joints in the propeller shaft?
6. What is the purpose of the slip joint in the propeller shaft?
7. Explain what happens in the differential when the car turns a corner.

Suggestions for Further Study

If you would like to study further the various components of the automobile, aside from the power-train components discussed in this book, then you will want to study the other books in the McGraw-Hill Automotive Mechanics Series. From these books you will learn how the engine; the engine fuel, lubrication, and cooling systems; the electrical system; and the various chassis units operate. In addition, you can spend some time in your local school automotive shop or a friendly service shop where repair work on various automotive and power-train parts is done. By watching what goes on, you can learn a great deal about how the various automotive parts are constructed and how they are put together and serviced.

You may be able to obtain shop repair manuals from your local school automotive shop or service shop. These manuals are very interesting since they contain many illustrations and detailed explanations of automotive components, including clutches, transmissions, propeller shafts, and differentials. A careful study of these manuals will prove very rewarding. Be sure to write down in your notebook any important facts that you learn.
2: Clutches

THIS CHAPTER discusses the purpose, construction, and operation of various types of automotive clutches. The chapter that follows describes the trouble-shooting and servicing of clutches.

§ 9. Function of clutch  The clutch is a form of coupling placed between the engine and the transmission (Figs. 1-5, 1-6, and 2-1 to 2-6) that permits the driver to couple or uncouple the engine and the transmission. With the engine coupled, power is delivered to the transmission; with the engine uncoupled, by operation of the clutch, the engine runs free without delivering power to the transmission. One purpose of the clutch is to uncouple, temporarily, the engine and the transmission so that the transmission gears can be shifted. Without such means of temporarily interrupting the flow of power between the two, it would be difficult to de-mesh and [28]
mesh the transmission gears. The pressure between gear teeth in a set of gears through which power is flowing makes it hard to shift the gears out of mesh. Also, without a clutch, shifting gears into mesh would be a hazardous procedure. The driving gears and the driven gears would probably be running at different speeds and broken gear teeth would result as meshing was attempted. The clutch, when operated, interrupts the flow of power so that gear-tooth pressure is relieved for de-meshing. With the gears de-meshed and the engine uncoupled by operation of the clutch, the transmission driving gear runs free so that it can attain synchronous speed with other transmission gears. Meshing can thus be accomplished without clashing of gears.

At times during car operation, the clutch is operated to permit shifting of the transmission into neutral. This de-meshes the transmission gears so that, even when the clutch is again engaged, engine power cannot be transmitted through the transmission. The engine can thus be started and brought to speed without delivering power through the transmission and power train to the car wheels. The amount of power that a gasoline engine can deliver during starting and at speeds below idle is small, too small to put the car into motion or keep it in motion. The engine must be rotating at several hundred rpm before it is able to deliver any appreciable amount of power. After the engine has been started, the clutch is operated to permit shifting of gears through the various speed ratios (Chap. 4) so that the car can be set into motion and increased in speed.

Figures 2-1 to 2-6 show various clutch parts and their relationship to the clutch pedal in the driving compartment of the car. Figure 2-1 shows the relative sizes of the engine flywheel, clutch plate or friction disk, and cover. Figure 2-2 shows, in disassembled view, the clutch and linkage parts between the clutch and the clutch pedal. This clutch is different in some details from the one shown in Fig. 2-1. Figure 2-3 shows the clutch-linkage parts in assembled view on an application somewhat different from the others. You will notice, as you study different clutches on various cars, that several linkage systems are in use. The arrangements of the linkages may differ, but the end result in the clutch is the same; a throwout bearing in the clutch is forced inward to cause declutching when the clutch pedal is pushed down. This action is explained in detail on later pages.
Fig. 2-3. Clutch and linkage parts between the clutch and the clutch pedal. (Studebaker-Packard Corporation)
§10. Types of clutches

The type of clutch used on an automobile depends upon several factors, including the maximum engine torque developed, the type of transmission, and the nature of the service in which the clutch will operate. While numerous types of clutch have been, and are being used, the one most widely used today is the single-dry-plate type. This type of clutch includes a disk, faced on both sides with friction material. The disk hub is attached to a shaft (called the drive pinion, main drive gear, or clutch shaft) by means of splines. The attachment is such that the disk hub can move endwise along the shaft but is forced to rotate with, and at the same speed as, the shaft. When the clutch is engaged, the disk is held tightly between two parallel metal faces by springs. In this position the friction between the disk facing and the two metal faces causes the disk and the metal faces to rotate as a unit. Figure 1-6 illustrates an automotive clutch of this type, while
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Fig. 2-4. Exploded view of clutch illustrated in Fig. 1-6. The flywheel is not shown. (Plymouth Division of Chrysler Corporation)

1. The flywheel is not shown.
2. Pressure plate
3. Disk assembly
4. Cover
5. Pressure spring
6. Pressure-plate baffle
7. Release lever
8. Release lever spring
9. Release lever eye-bolt
10. Release lever strut

Fig. 2-5. A cutaway view of a clutch. (Oldsmobile Division of General Motors Corporation)
Clutches

Fig. 2-4 is an exploded view of the clutch. Figure 2-5 is a cutaway view of a somewhat similar clutch. Figure 2-6 shows the clutch illustrated in Fig. 2-3 partly disassembled.

Other clutches include the multiple-disk type, in which several friction disks are used, and the wet-disk clutch, which operates in a bath of oil. The use of such clutches is confined to specialized applications, and they will not be considered further herein.

§11. Operation of clutch

The operation of the clutch is based on the frictional contact between two smooth metallic driving surfaces and the facings riveted to the friction disk (also called the driven plate or the clutch disk). One of the metallic surfaces is on the flywheel, while the other metallic surface is on the clutch pressure plate (Figs. 1-6, 2-1 to 2-6). When the clutch is in the engaged position, spring pressure between the clutch cover and the pressure plate clamps the disk tightly between the pressure plate and the flywheel face. The friction between these surfaces causes the disk to rotate with the flywheel and the pressure plate when the engine is running and the clutch is engaged. Since the hub of the disk is splined to the clutch shaft, the shaft rotates with the disk.

To uncouple the engine and the transmission, the clutch pedal is depressed. This in turn, through a series of levers, operates the clutch-yoke or fork assembly, causing the yoke or fork to move a throwout bearing (also called the release bearing) in toward the flywheel. Movement of the throwout bearing in this direction releases the spring pressure that holds the flywheel, friction disk, and [33]
pressure plate together, causing the pressure plate to be moved away from the friction disk. This permits the flywheel and the pressure plate to rotate independently of the friction disk and the clutch shaft. Figures 2-2, 2-3, and 2-7 show typical linkage between the clutch pedal and the fork. Figure 2-8 illustrates one type of clutch-yoke assembly. The yoke protrudes through the side of the clutch housing and, on the installation illustrated, includes a spring-loaded dust seal around the clutch housing hole. Inside the housing,

![Clutch pedal and linkage to throwout-bearing fork, or yoke.](Chevrolet Motor Division of General Motors Corporation)

a clutch ball stud (stud with a round end) provides a ball joint around which the yoke can pivot when its outer end is moved back and forth by operation of the clutch pedal. This movement causes the throwout bearing, assembled to the forked end of the yoke, to be slid back and forth along the clutch shaft.

As the throwout bearing is slid in toward the clutch, it comes up against a series of three or more release levers equally spaced around the clutch. The release levers pivot about pins, taking up the spring pressure and causing the pressure plate to be moved...
Clutches

*Fig. 2-8.* Clutch yoke assembly with throwout bearing. (*Oldsmobile Division of General Motors Corporation*)

*Fig. 2-9.* The two limiting positions of the pressure plate and release lever. (*Oldsmobile Division of General Motors Corporation*)
away from the friction disk. Figure 2-9 illustrates the two positions of a release lever: the engaged and the released position.

The pressure of the throwout bearing against the inner end of the release lever causes it to move to the left (Fig. 2-9). This causes the lever to pivot around the floating pin in the eyebolt. The outer end of the release lever is moved to the right, exerting pressure through the strut against the pressure plate and causing the plate to be moved to the right. This movement compresses the coil springs and relieves the spring pressure between the pressure plate, friction disk, the flywheel. Also, as the pressure plate moves to the right, clearances appear between the pressure plate and the friction disk, and between the friction disk and the flywheel. This allows the flywheel and the pressure plate to rotate independently of the friction disk.

The clutch may have nine coil springs, as shown in Fig. 2-4, or it may have only three (Fig. 2-10). In any case, the clutch action is the same.

The friction disk may embody both a cushioning device, to provide a cushion effect between the facings when the clutch is being engaged, and a dampening device, to prevent torsional vibration of the engine from being transmitted through the clutch. Figure 2-11 illustrates a typical friction disk. See also Fig. 2-5 for constructional details of a friction disk. The cushioning device consists of waved cushion springs to which the friction facings are riveted. These waves are compressed slightly as the clutch engages, to provide the cushioning effect. The dampening device embodies a series [36].

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**Fig. 2-10. Exploded view of three-spring clutch.**
Clutches §12

of heavy coil springs placed between the drive washers, which are riveted to the cushion springs, and the hub flange, which is attached to the disk hub. The disk hub is thus driven through the springs, and they absorb 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.

§12. Diaphragm-spring type of clutch One type of clutch incorporates a diaphragm spring that not only provides the spring pressure required to hold the friction disk against the flywheel but also acts as the release levers that take up the spring pressure when the clutch is disengaged. Two variations of this design are in general
use: the tapering-finger type (Figs. 2-1 and 2-12), and the crown-pressure-spring type (Fig. 2-15). Although somewhat different in construction, they are alike in action.

The tapering-finger type unit has a one-piece diaphragm that is a solid ring on the outer diameter and has a series of tapering fingers pointing inward toward the center of the clutch. The action of the clutch diaphragm is somewhat like the flexing action that takes place when the bottom of an oil can is depressed. When the throwout bearing moves in against the ends of the fingers, the entire diaphragm is forced against a pivot ring, causing the diaphragm to dish inward. This raises the pressure plate from the friction disk.

Figures 2-13 and 2-14 illustrate the two positions of the diaphragm spring and clutch parts. In the engaged position (Fig. 2-13), the diaphragm spring is slightly dished, with the tapering fingers pointing slightly away from the flywheel. This places spring pressure against the pressure plate around the entire circumference of the diaphragm spring. The diaphragm spring is naturally formed to exert this initial pressure. When the throwout bearing is moved inward against the spring fingers (as the clutch pedal is depressed), the spring is forced to pivot round the inner pivot ring, dishing in [38].
the opposite direction. The outer circumference of the spring now lifts the pressure plate away, through a series of retracting springs placed about the outer circumference of the pressure plate (Fig. 2-14).

The crown-pressure-spring type of clutch (Fig. 2-15) is a variation of the diaphragm-spring clutch. In the crown-pressure-spring type, the diaphragm spring is formed of a single corrugated plate of spring metal (Fig. 2-16). The action is similar to that of the diaphragm-spring clutch; the movement of the throwout bearing against the central section of the diaphragm causes it to flex so that the outer circumference lifts the pressure plate away from the friction disk and the flywheel, thus relieving the pressure and disengaging the clutch.

§13. Semicentrifugal clutch In construction, the semicentrifugal clutch is much like the type of clutch shown in Fig. 2-4. The sem-
Centrifugal-clutch release levers, however, have weights placed at their outer ends. The weights are so related to the release levers that, as speed increases, centrifugal force on the weights causes the release levers to exert added pressure on the pressure plate. Figure 2-17 illustrates a clutch of this type partly disassembled. Figure 2-18 shows in disassembled view one of the release levers from this type of clutch. When the clutch is not rotating and is engaged, the only pressure on the pressure plate is produced by the springs. However, as soon as the clutch begins to revolve, centrifugal action on the release-lever weights causes the release levers to increase the pressure on the pressure plate. The higher the speed, the greater the pressure.

**CHAPTER CHECKUP**

Note: Since the following is a chapter review test, you should review the chapter before taking it.

Again, you will want to test your knowledge of the chapter you have just completed and find out how well you remember what you have been studying. The questions that follow have two purposes. One is to test your knowledge. The second purpose is to help you to review the chapter and fix more firmly in your mind the facts covered. It may be

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**FIG. 2-15.** Pressure plate assembly of a crown-pressure-spring clutch. The operator is shown removing a retaining spring so the diaphragm and cover can be separated. See next illustration. (*Buick Motor Division of General Motors Corporation*)

**FIG. 2-16.** Clutch spring of a crown-pressure-spring clutch. (*Buick Motor Division of General Motors Corporation*)
Clutches

Fig. 2-17. Semicentrifugal clutch partly disassembled. (Cadillac Motor Car Division of General Motors Corporation)

Fig. 2-18. Assembly details of semicentrifugal-clutch release lever. (Monmouth Products Company)

that you will not be able to answer, offhand, all of the questions. If this happens, turn back into the chapter and reread the pages that will give you the answers. For instance, under "Listing Parts," you are asked to list parts in clutches. If you cannot remember them all, turn back to the illustrations and refer to them as you make your list. The act of writing down the names of the parts will help you to remember them.
Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. The friction disk is splined to a shaft which extends into the differential propeller shaft transmission engine.
2. The friction disk is positioned between the flywheel and the engine crankshaft pressure plate.
3. When the clutch is engaged, spring pressure clamps the friction disk between the pressure plate and the flywheel differential reaction plate clutch pedal.
4. Depressing the clutch pedal causes the throwout bearing to move in and force the pressure plate to release its pressure on the throwin bearing pressure springs friction disk.
5. The clutch cover is bolted to the friction disk flywheel car frame engine block.
6. In the typical friction disk, the cushioning device consists of a series of waved cushion pads cushion bolts cushion springs disks.
7. The release levers in the typical clutch pivot on springs lever threaded bolts pins.
8. In the typical friction disk, torsional vibration is absorbed by the use of a series of heavy cushion bolts waved pads coil springs.
9. In the diaphragm-spring clutch, inward movement of the throwout bearing causes the diaphragm spring to dish inward expand contract.
10. In the semicentrifugal clutch, pressure of the pressure plate against the friction disk increases with speed because of weights located on the pressure plate flywheel release levers clutch shaft.

Listing Parts

In the following, you are asked to list parts that go into various automotive clutches discussed in the chapter. Write down the lists in your notebook.
Clutches

1. Make a list of the various parts used in typical clutch-pedal-to-clutch linkage systems.
2. Make a list of the various parts used in a nine-spring clutch.
3. Make a list of the various parts used in a diaphragm-spring clutch.

Purpose and Operation of Components

In the following, you are asked to write down the purpose and operation of the clutches discussed in the chapter. If you have any difficulty in writing down your explanation, turn back into the chapter and reread the pages that will give you the answer. Then write down your explanation. Don’t copy; try to tell it in your own words. This is a good way to fix the explanation more firmly in your mind. Write in your notebook.

1. What is the purpose of the clutch?
2. Explain how the three-spring or the nine-spring clutch operates.
3. Explain how the diaphragm-spring clutch operates.
4. Explain how the crown-pressure-spring clutch operates.
5. Explain how a semicentrifugal clutch operates.
6. Describe the construction of a typical friction disk and explain the purpose of the coil and waved cushion springs.

Suggestions for Further Study

In your school automotive shop or in a service garage, examine various clutches and clutch parts. Notice how these parts are constructed and how they go together. Observe the different methods of linking the clutch pedal with the clutch on various cars. Study whatever shop manuals you can find, and note carefully the manufacturer's explanations of how his clutches are constructed and how they operate.
**3: Clutch service**

This chapter describes the trouble-shooting, removal, overhaul, adjustment, reassembly, and installation of various types of clutches used on passenger cars.

### §14. Clutch trouble-shooting chart

Several types of clutch trouble may be experienced. Usually, the trouble itself is fairly obvious and falls 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. The chart that follows lists possible causes of each of these troubles and then refers to numbered articles after the chart for fuller explanations of the way to locate and eliminate the troubles.

**Note**: The complaints and possible causes are not listed in the chart in the order of frequency of occurrence. That is, item 1 (or item a) does not necessarily occur more frequently than item 2 (or item b).

**Clutch trouble-shooting chart**

(See §§15 to 21 for detailed explanation of trouble causes and corrections listed below.)

<table>
<thead>
<tr>
<th>Complaint</th>
<th>Possible Cause</th>
<th>Check or Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Clutch slips while engaged (§15)</td>
<td>a. Incorrect pedal-linkage adjustment</td>
<td>Readjust</td>
</tr>
<tr>
<td></td>
<td>b. Broken or weak pressure springs</td>
<td>Replace</td>
</tr>
<tr>
<td></td>
<td>c. Worn friction-disk facings</td>
<td>Replace facings or disk (§30)</td>
</tr>
<tr>
<td></td>
<td>d. Binding in clutch-release linkage</td>
<td>Free, adjust</td>
</tr>
<tr>
<td></td>
<td>e. Grease or oil on disk facings</td>
<td>Replace facings or disk (§30)</td>
</tr>
<tr>
<td></td>
<td>f. Release levers incorrectly adjusted</td>
<td>Readjust</td>
</tr>
<tr>
<td>Clutch Service</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Complaint</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Clutch chatters or grabs when engaging (§16)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible Cause</td>
<td>Check or Correction</td>
<td></td>
</tr>
<tr>
<td>a. Oil or grease on disk facings, or facings loose or glazed</td>
<td>Replace facings or disk (§30)</td>
<td></td>
</tr>
<tr>
<td>b. Binding in clutch-release linkage</td>
<td>Free, adjust</td>
<td></td>
</tr>
<tr>
<td>c. Binding of friction-disk hub on clutch shaft</td>
<td>Lubricate, replace defective parts</td>
<td></td>
</tr>
<tr>
<td>d. Broken disk facings, springs, or pressure plate</td>
<td>Replace broken parts</td>
<td></td>
</tr>
<tr>
<td><strong>Possible Cause</strong></td>
<td><strong>Check or Correction</strong></td>
<td></td>
</tr>
<tr>
<td>a. Incorrect pedal-linkage adjustment</td>
<td>Readjust</td>
<td></td>
</tr>
<tr>
<td>b. Warped friction-disk or pressure plate</td>
<td>Replace defective part</td>
<td></td>
</tr>
<tr>
<td>c. Loose friction-disk facing</td>
<td>Replace facings or disk (§30)</td>
<td></td>
</tr>
<tr>
<td>d. Improper release-lever adjustment</td>
<td>Readjust</td>
<td></td>
</tr>
<tr>
<td>e. Friction-disk hub binding on clutch shaft</td>
<td>Lubricate, replace defective parts</td>
<td></td>
</tr>
<tr>
<td><strong>Possible Cause</strong></td>
<td><strong>Check or Correction</strong></td>
<td></td>
</tr>
<tr>
<td>a. Friction-disk hub loose on clutch shaft</td>
<td>Replace worn parts</td>
<td></td>
</tr>
<tr>
<td>b. Friction-disk dampener springs broken or weak</td>
<td>Replace disk or springs</td>
<td></td>
</tr>
<tr>
<td>c. Misalignment of engine and transmission</td>
<td>Realign</td>
<td></td>
</tr>
<tr>
<td><strong>Possible Cause</strong></td>
<td><strong>Check or Correction</strong></td>
<td></td>
</tr>
<tr>
<td>a. Clutch throwout bearing worn, binding, out of lubricant</td>
<td>Lubricate or replace</td>
<td></td>
</tr>
<tr>
<td>b. Release levers not properly adjusted</td>
<td>Readjust</td>
<td></td>
</tr>
<tr>
<td>c. Pilot bearing in crankshaft worn or out of lubricant</td>
<td>Lubricate or replace</td>
<td></td>
</tr>
</tbody>
</table>
### §14 Complaint

#### 6. Clutch-pedal pulsations (§19)
- **Possible Cause**
  - d. Retracting spring (diaphragm clutch) worn
  - a. Engine and transmission not aligned
  - b. Pressure-plate assembly not aligned
  - c. Warped pressure plate or friction disk
  - d. Release levers not evenly adjusted
  - e. Clutch housing distorted
  - f. Flywheel not seated on crankshaft flange or flange bent

- **Check or Correction**
  - Replace
  - Realign
  - Realign
  - Realign or replace
  - Readjust
  - Realign or replace
  - Seat properly, straighten (Also causes engine vibration)

#### 7. Rapid friction-disk-facing wear (§20)
- a. Improper pedal-linkage adjustment
- b. Clutch-release linkage binding
- c. Weak or broken pressure springs
- d. Warped pressure plate or friction disk
- e. Excessive use of clutch
- f. Driver "rides" clutch

- **Check or Correction**
  - Readjust
  - Free, adjust
  - Replace
  - Replace defective part
  - Reduce use
  - Keep foot off clutch except when necessary

#### 8. Clutch pedal stiff (§21)
- a. Clutch linkage binding
- b. Misaligned linkage parts
- c. Overcenter spring out of adjustment

- **Check or Correction**
  - Free, lubricate
  - Realign
  - Readjust
§15. Clutch slips while engaged  Slipping of the clutch while it is engaged is extremely hard on the clutch facings. The relative movement between the facings on the friction disk and the flywheel and pressure plate causes heat to develop. In a short time this heat, plus the wearing effect of the slippage, will burn and wear the facings so badly that the clutch will 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 as clutch engagement is completed.

Several conditions can cause clutch slippage while the clutch is engaged. One possibility is that the clutch linkage between the pedal and throwout bearing is not properly adjusted. With an incorrect adjustment that reduces pedal lash too much, the throwout bearing will still press against the release levers even with a fully released clutch pedal. Since 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 is to readjust the linkage (§22).

If the clutch-release linkage binds, it may not return to the fully engaged position when the clutch pedal is released. This causes clutch slippage, which can sometimes be eliminated by lubricating all points of friction in the linkage and by realigning and readjusting the linkage if necessary (§22). If readjusting, lubricating, and freeing the linkage do not eliminate the slippage, then the trouble is probably inside the clutch itself; this requires removal of the clutch from the car 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 (§30).
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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 are adjusted as explained in following sections covering servicing of various clutches.

§16. Clutch chatters or grabs when engaging A clutch that chatters or grabs when engaging is easily recognized. No matter how easily and carefully the clutch pedal is released, the clutch will not take hold evenly and smoothly. It grabs suddenly with a hard jerk, or else it chatters and takes hold with a series of small jerks. As a rule, the trouble is inside the clutch itself and the clutch will have to be taken off the car for servicing. 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.

If the clutch linkage is free and working smoothly, then the trouble could be due to oil or grease on the disk facings or to glazed or loose facings. In addition, 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.

§17. 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, 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 floor board will not force the throwout bearing in against the release levers (or diaphragm spring) far enough to release the clutch fully. If adjustment of the [48]
linkage to reduce pedal lash or "free" travel does not correct the
trouble (see §22), 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 which requires replacement. Also, it could
be due to a loose friction-disk facing which requires replacement.
On the type of clutch with adjustable release levers, improper ad­
justment 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 pressure plate moves
back to relieve pressure on the friction disk. Binding may be relieved
by cleaning up the splines on the shaft and in the hub and by
lubricating the splines.

§18. Clutch noises  Clutch noises are usually most noticeable when
the engine is idling. To diagnose clutch noise, first note whether it
is heard when the clutch is engaged or when the clutch is disen­
gaged. Most clutch noises indicate trouble inside the clutch that
must be corrected by removing the clutch from the engine with
the exceptions noted below.

Noises that come from the clutch when the clutch is engaged
(clutch pedal released) 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. Mis­
alignment 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 the clutch is disengaged
(clutch pedal depressed) could be due to a defective 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 bear­
ing 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 bear­
ing 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 car 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.

In the diaphragm-spring clutch, worn or weak retracting springs will cause a rattling noise when the clutch is disengaged and the engine is idling. This noise can be eliminated by replacing the springs, a job that can be done without removing the clutch from the engine (§28).

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 should be checked for wobble, since a bent crankshaft flange or a flywheel that is not seated on the crankshaft flange may cause clutch-pedal pulsations and also engine vibration. A flywheel that is not seated on the crankshaft flange should be removed and remounted to seat it properly. 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 is sometimes 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 release levers do not meet the throwout 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, the cover sometimes can be straightened to restore alignment.

§20. 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 slipping may take place. Likewise, frequent use of the clutch or excessively slow releasing of the clutch after de-clutching 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 may 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 are warped or out of line, they 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.

§21. Clutch pedal stiff A stiff clutch pedal, or a pedal that is hard to depress, is apt to result from lack of lubricant in the clutch linkage, from binding of the clutch-pedal shaft in the floor-board seal, or from misaligned linkage parts that are binding. In addition, the over-center spring (on cars so equipped) may be out of adjustment. Also, if the clutch pedal has been bent so it rubs on the floor board, it may not operate easily. The remedy in each of these cases is obvious: parts must be realigned, lubricated, or re-adjusted as necessary.

CHECK YOUR PROGRESS
Progress Quiz 3

The material on trouble-shooting clutches that you have just been studying is not the easiest material to study. The listings of clutch troubles, along with the brief descriptions of them, supply a great many facts about clutch troubles, and these many facts are not all easy to remember. At the same time, it is important to try to remember them
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because knowing these facts will help you when you go into the automotive shop. The quiz below will help you find out how well you remember the material you have just read on clutch trouble-shooting. It will also help you to review the material so that important points will be more firmly fixed in your mind. If any of the questions seem hard to answer, reread the pages that will give you the answers.

Correcting Troubles Lists

The purpose of this exercise is to help you to spot related and unrelated troubles on a list. For example, in the list clutch slips: incorrect pedal-linkage adjustment, broken pressure springs, engine misses, grease on facings, you can see that engine misses is the only condition that would not be directly related to clutch slippage and therefore does not belong in the list. Any of the other conditions could cause the trouble.

In each of the lists below, you will find one item that does not belong. Write down each list in your notebook, but do not write down the item that does not belong.

1. Clutch pedal stiff: clutch linkage binding, misaligned linkage parts over-center spring out of adjustment, pressure springs weak.
2. Rapid friction-disk-facing wear: driver rides clutch, warped pressure plate or friction disk, clutch-release linkage binding, weak or broken pressure springs, high octane gas, improper pedal-linkage adjustment.
3. Clutch-pedal pulsations: engine and transmission out of line, pressure plate out of line, warped pressure plate or friction disk, release levers not evenly adjusted, clutch housing distorted, differential out of line, flywheel not seated on crankshaft flange, crankshaft flange bent.
4. Clutch noises with clutch disengaged: pilot bearing in crankshaft worn or out of lubricant, release levers not properly adjusted, gear worn, throwout bearing worn or dry.
5. Clutch noises with clutch engaged: friction-disk hub loose on clutch shaft, friction-disk dampener springs broken or weak, engine and transmission out of line, propeller shaft out of line.
6. Clutch spins when disengaged: incorrect pedal-linkage adjustment warped friction disk or pressure plate, loose friction-disk facing improper release-lever adjustment, spring weak, friction disk binding.
7. Clutch chatters or grabs when engaging: oil or grease on disk facing, binding in clutch-release mechanism, friction-disk hub binding on clutch shaft, floating axle loose, broken disk facings or springs.
8. Clutch slips while engaged: incorrect pedal-linkage adjustment, broken or weak pressure springs, worn friction-disk facings, loose friction-disk facings, binding in release mechanism, grease or oil on facings, release levers incorrectly adjusted.

§22. Clutch-pedal adjustment  Clutch-pedal-linkage adjustment may be required from time to time on a car to compensate for friction-disk-facing wear. In addition, certain points in the linkage or the pedal support may require lubrication. The adjustment of the linkage changes the amount of “free” clutch-pedal travel (or pedal lash as it is also called). The “free” travel of the pedal is the amount of travel that the pedal has before the throwout bearing comes up against the release levers in the clutch. After this happens, there is a definite increase in the amount of pressure required for further pedal movement; pedal movement from this point on causes release-lever movement and contraction of the clutch-pressure-plate springs. The test of the pedal free travel should be made with one finger rather than the foot or even a hand. The finger can detect the increase of pressure more accurately than the foot or hand. Methods of adjusting the free travel on different cars is outlined below.

1. Chevrolet. The clutch-pedal free travel should be 3/4 to 1 inch. Adjustment is made by loosening the check nut A (Fig. 3-1) and turning the adjusting nut B until the correct free travel is obtained. Then the check nut A should be tightened.

The only point of lubrication required is at the bushing in the master-brake cylinder which supports the clutch-pedal shaft. There is a plug which can be removed so that chassis lubricant can be added to the lubricating reservoir around the shaft bushing in the master-brake cylinder. This also lubricates the brake-pedal shaft.

Caution: The pedal shafts must not be overlubricated since lubricant would drip down on the rubber boot on the front of the brake main cylinder and damage it. Be sure the plug is tightly replaced.

2. Ford. Linkage should be adjusted to allow between 1 and 1 1/4 inches free travel of the clutch pedal. Adjustment is made (on late models) by loosening a lock nut and turning an adjusting nut on the pull rod attached to the clutch fork. Earlier models use a
clevis to connect to a shaft linked with the fork. The clevis must be turned on the adjusting rod after the lock nut is loosened to make the adjustment. The clutch-pedal-shaft bushing is lubricated through a fitting.

3. Plymouth. Linkage should be adjusted to give ¼- to ½-inch free play in the clutch fork (Fig. 3-2). This will give 1-inch free travel of the clutch pedal. Adjustment is made by loosening the lock nut and turning the adjusting nut (Fig. 3-2). Lubrication of the pedal shaft is through a fitting.

A second adjustment, seldom necessary, establishes the distance between the clutch-pedal pad and the floor board. The adjustment is made by turning a setscrew located on a bracket mounted on the frame and to the rear of the pedal shaft. The screw must be turned in to increase the distance. On some models it is located [54].
on a boss on the pedal. On these, the screw must be turned out to increase the distance.

A third adjustment, also seldom necessary, positions the over-center spring so as to ease the movement of the clutch pedal. If the over-center spring is incorrectly adjusted, the clutch-pedal

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**Fig. 3-2.** Provision for adjusting clutch-pedal free travel. A free travel of \( \frac{3}{4} \) inch of the fork gives a pedal free travel of 1 inch. *(Plymouth Division of Chrysler Corporation)*

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**Fig. 3-3.** Over-center spring adjustment in clutch-pedal linkage. *(Plymouth Division of Chrysler Corporation)*

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movement will be harder and, in addition, the pedal may not fully return when released. The spring is correctly adjusted when the measurements are as shown in Fig. 3-3. It is possible that the pedal action may still be sluggish even with these measurements. In this case, it is suggested that further adjustments be made in an attempt to reduce the effort required to depress the clutch pedal.
These last two adjustments are correctly set on original installation and should not require readjustment unless they have been tampered with.

§23 Clutch removal and replacement

Variations in construction and design make it necessary to use somewhat different procedures and tools when removing and replacing clutches on different cars. As a first step in clutch removal, the transmission must be removed. Transmission removal and replacement is covered in Chap. 6. One general caution to observe when the transmission is being removed is to pull it straight back from the clutch housing until the clutch shaft is clear of the friction-disk hub. Then the transmission can be lowered or raised out of the car. This procedure prevents distortion of, and damage to, the friction disk. Recommendations usually call for using special, long pilot pins installed in place of two of the transmission bolts so the transmission will maintain alignment as it is moved back.

1. Clutch removal. On some cars, the engine must be supported by a special support bracket during transmission and clutch removal. With the transmission off, the clutch housing pan or flywheel lower cover must be removed and the clutch-fork or yoke linkage disconnected. On some cars, the brake-arm linkage also must be detached. Next, the throwout bearing (where separate and detached) is taken out.

Caution: The cover must be reattached to the flywheel in exactly the same positions as on the original assembly. If it is not, balance may be lost so that vibration and damage will occur. To assure correct realignment on reinstallation, both the flywheel and the cover are stamped with an "X" or some similar marking. These markings should align when the clutch is reinstalled on the engine. If you cannot locate the markings, you should carefully mark the clutch cover and flywheel with a hammer and punch before taking the clutch off so you can restore the clutch to its original position.

On some cross-shaft-type clutches, the release fork and the shaft must be pulled partly out of the clutch housing in order to provide room for the clutch assembly to pass the cross shaft. This can be done after the clutch-release-fork bracket is disconnected at the clutch housing and the release-fork-flange cap screws are
Clutch Service

§ 23

taken out. On other cross-shaft clutches, it is necessary only to detach the cross shaft so that the fork can be swung up out of the way. On the diaphragm-spring clutch or the clutch using a ball stud on which the fork pivots, snap the fork off the ball stud with a screw driver after removing the lock nut from the adjusting link.

Install special clutch pilot tool (Fig. 3-4) in friction-disk hub and crankshaft pilot bearing so the friction disk will not be damaged. This holds the friction disk in proper alignment and correctly centered during the time that the clutch housing is being removed.

Loosen the clutch attaching bolts one turn at a time so the clutch cover will be evenly loosened and distortion will not occur. Loosen bolts evenly until spring pressure is relieved; then take bolts out. A tool such as shown in Fig. 3-5 is very handy for turning the flywheel to get at the upper bolts. When the spring pressure is relieved and the bolts are out, the clutch can be lowered from the car.

2. Clutch replacement. In general, replacement of the clutch is the reverse of removal. Before the clutch is replaced, the condition
of the pilot bearing in the end of the crankshaft should be noted and replacement made if necessary (§30). In addition, the condition of the throwout bearing, as well as other clutch parts, should be checked so that defective parts can be discarded (§30).

Turn flywheel until the "X" or other marking is at the bottom. Then, use special clutch pilot tool (Fig. 3-4) to maintain alignment between the friction-disk hub and the pilot bearing in the crankshaft, and put friction disk and clutch cover in place. Turn cover until the "X" or other marking on it aligns with the similar marking on the flywheel. Install attaching bolts, turning them down a turn at a time to take up the spring tension gradually and evenly. Use a flywheel turning tool (Fig. 3-5) to make it easier to turn the flywheel and get at the upper bolts.

As a final step in the procedure, after the transmission has been
reinstalled and the clutch linkages reattached, check the pedal free travel and make whatever adjustments are necessary (§22).

§24. Clutch service  Clutch service varies according to the type of clutch. Clutches used on late-model cars can be classified into five general types: (1) the coil-pressure-spring type with adjusting screws in the ends of the release levers (Long clutch, Fig. 2-5), (2) the coil-pressure-spring type with adjusting eyebolt nuts (Borg and Beck, Fig. 2-4), (3) the coil-pressure-spring type with adjusting screws under the release levers (Auburn, Fig. 2-10), (4) the diaphragm-spring clutch (Fig. 2-12), and (5) the crown-pressure-spring clutch (Fig. 2-16). Type 1 has been used on Cadillac, Ford, Lincoln, Mercury, Oldsmobile 8, and Packard. Type 2 has been used on Chrysler, De Soto, Dodge, Frazer, Kaiser, Mercury, Nash, Oldsmobile, Plymouth, Studebaker, and Willys. Type 3 has been used on Frazer, Kaiser, Plymouth, and Willys. Type 4 has been used on Chevrolet and Pontiac. Type 5 has been used on Buick.

You will note, in examining the application data in the previous paragraph, that one car may be shown as using two clutches. For example, part of the Plymouths since 1948 used Borg and Beck clutches, while the rest of them used the Auburn clutch. This same holds true for Kaiser and Frazer cars, which split production between the two types of clutch. Thus, until you actually look at it, you cannot necessarily tell which clutch is being used on a particular model car. Following articles describe the servicing of these various types of clutch.

Note: Servicing the clutch used with the Gyro-Matic type of transmission is discussed in Chap. 9.

§25. Long clutch service  A clutch of this type is shown in Fig. 2-5. A distinguishing characteristic is that there are adjusting screws in the inner ends of the release levers. Disassembly, reassembly, and adjustments are detailed below.

1. Disassembly

a. Make sure that cover and pressure plate are marked so they can be reassembled in same relative positions. Use a hammer and punch to mark the two if they are not already marked. Balance will be lost and clutch vibration will result if the
pin and a single roller. On this type of construction, the roller should be installed on the side away from the pressure plate.

2. Reassembly

a. To reassemble the clutch, put the pressure plate on a support block in the arbor press and set the clutch springs in place. Be sure the spring insulators are in position and the springs are all centered over the bosses.

b. Put a small amount of lubricant (Lubriplate is recommended) on the driving lugs.

c. Put cover in position, making sure that punch marks on the cover and pressure plate align. Rest cover on the springs and turn yokes up in vertical position in alignment with holes in cover. To maintain this alignment, insert long screws through holes in cover and into holes in yokes as shown in Fig. 3-9.

d. Put a block across the cover on the spring bosses and apply pressure through the arbor press to compress the springs (Fig. 3-8).
3-9). Remove long screws and install yoke attaching screws. Make sure yokes are square with cover when the screws are tightened.

e. Release and apply pressure to the assembly several times in order to make sure that all parts are settled into their working positions.

Fig. 3-9. Using press to reinstall cover on pressure plate. Note that new copper thrust washers should be used at the release levers. The long cap screws are used to maintain alignment between the holes in the cover and the yokes on the release levers as the cover is forced down towards the plate. (Oldsmobile Division of General Motors Corporation)

3. Adjustment

a. To adjust the clutch, a flywheel and a special height gauge are required. The gauge is placed on the flywheel in the position normally occupied by the friction disk and the clutch assembly is placed on top of it.

b. Attach cover to the flywheel, tightening each screw one or two turns at a time so that cover is brought down evenly to flywheel.
c. Work the release levers several times to make sure that they are free and that bearings are centered.

d. Lay a straightedge across the center of the gauge (Fig. 3-10) and check the clearance between the straightedge and adjusting screws on the release levers. On the particular model shown, the clearance should be between zero and 0.0625 inch (0.030 inch is about right). Also, the levers should all have uniform clearance with a variation of not more than 0.015 inch.

e. If the levers are not more than 0.025 inch off, adjustment can be made by lightly tapping the yoke mounting-screw heads with an 8-ounce hammer. This will bend the cover slightly so as to permit lever alignment. Do not strike heavy blows.

f. If the levers are more than 0.025 inch off, adjustment must be made by turning the adjusting screws. First, the stakings must be cut with a hacksaw blade. Then, the screw, or screws, must be turned until clearances are correct.
g. Adjusting screws that have been freed and turned must be firmly staked to prevent their moving after adjustment has been corrected. This is done by taking clutch assembly off the flywheel (loosening attaching bolts one turn at a time to avoid cover distortion) and then resting the head of the screw firmly on a solid metal block. Finally, a blunt chisel should be used to restake the screw.

Note: Since there is not too much material on the end of the release levers, it is not safe to restake a screw more than once. Thus, if additional adjustments are required, new levers should be installed.

h. After restaking the adjusting screws, the adjustment should be rechecked as outlined in paragraphs a to e above.

§26 Borg and Beck clutch service  A clutch of this type is shown in Fig. 2-4. A distinguishing characteristic is that the release levers are adjusted by means of adjusting nuts on the lever eyebolts. Disassembly, reassembly, and adjustments are detailed below.

1. Disassembly
   a. Make sure that the cover and pressure plate are marked so they can be reassembled in the same relative positions. Use a hammer and punch to mark the two if they are not already marked. Balance will be lost and clutch vibration will result if the cover is not attached to the pressure plate in the original position.
   b. Use a hacksaw to break the staking of the release-lever adjusting nuts.
   c. Put the assembly in an arbor press with the pressure plate resting on a block slightly shorter than the plate diameter. Cover should be free to move down without hitting the block. Then put a block across the top of the cover so it rests on the spring bosses. This setup is similar to that shown in Fig. 3-6.
   d. Apply pressure on the upper block so as to take up the spring pressure. Hold the cover in this position and remove the release-lever adjusting nuts. Then slowly release the pressure and lift cover off.
   e. A special fixture, as shown in Fig. 3-11, can also be used to disassemble the clutch, instead of using an arbor press. This
Special clutch-cover fixture for disassembling or assembling clutch, and for adjusting release levers. 1, fixture; 2, clutch pressure plate; 3, punch marks on pressure plate and cover; 4, clutch cover. (Plymouth Division of Chrysler Corporation)

Fig. 3-12. Procedure for removing release lever. (Oldsmobile Division of General Motors Corporation)

The fixture has, in addition, special feeler gauges built in, which aid in the adjustment of the release levers on reassembly.

f. Release levers may be detached from the pressure plate by lifting the end of the lever and moving the eyebolt so that the end of the lever and the end of the eyebolt are as close together as possible (Fig. 3-12). Then lift the strut up over
the ridge on the end of the lever, and lift off the lever and eyebolt.

g. Inspect and check the pressure-plate springs, friction disk, throwout bearing, pressure plate, and pilot bearing in the crankshaft. At the same time, the flywheel and housing should be checked for alignment. These inspection procedures are outlined in §30.

2. Reassembly

a. If a baffle plate is used, install baffle plate as shown in Fig. 3-13. Note that the ears are placed on the spring-seat ribs adjacent to the pressure-plate lugs (in counterclockwise direction). The springs, when in place, then retain the baffle plate in position.

b. Replace the release levers on the pressure plate. Do this by inserting the strut in the slots of the pressure-plate lug, dropping it slightly, and tilting it back as shown in Fig. 3-14. Then hold the ends of the eyebolt and lever as close together as possible and insert the end of the bolt into the hole in the
pressure plate. Finally, with the parts in the position shown in Fig. 3-14, slide the strut upwards in the slots in the lug, lift it over the end of the lever, and drop it down into the ridge in the end of the lever as shown in Fig. 3-15.

**Fig. 3-14.** Starting the assembly of the release lever and eyebolt to the pressure-plate lug. 1, release lever; 2, eyebolt; 3, lug; 4, strut; 5, pressure plate. (Studebaker-Packard Corporation)

**Fig. 3-15.** Completing the assembly of the release lever and eyebolt to the pressure-plate lug. 1, release lever; 2, eyebolt; 3, strut; 4, lug. (Studebaker-Packard Corporation)

c. Apply a small amount of lubricant (Lubriplate is recommended) around the working edges of the struts and release levers and on the sides of the pressure-plate ears that extend through the clutch cover.
d. Put springs in place on the pressure plate.
e. Assemble the antirattle springs in cover and put cover into place on pressure plate. Make sure that markings align and that coil springs seat in the bosses in the cover.

Fig. 3-16. Special fixture for checking adjustment of release levers. 1, feeler blades; 2, compression plate; 3, spacers; 4, clutch-release-lever eyebolt; 5, eyebolt nut; 6, stake marks to lock nut. (Plymouth Division of Chrysler Corporation)

f. Apply pressure to cover so as to compress springs and permit the eyebolts to be guided through the holes in the cover. Pressure can be applied in an arbor press (Fig. 3-9) or with a special fixture (Fig. 3-11).
With the cover held down, put adjusting nuts on the eyebolts and turn the nuts down until their tops are flush with the ends of the eyebolts.

Release and reapply pressure several times to make sure all parts are settled into place.

3. **Adjustment**

a. If the clutch is installed in a special fixture as shown in Fig. 3-11, adjustment is made by turning the adjusting nuts on the eyebolts one way or the other until all three of the feeler gauges have the same slight drag or feel when pushed in or pulled out (Fig. 3-16). Tighten nuts to decrease drag; loosen, to increase the drag.

b. If a special fixture is not available, the clutch should be installed on a detached flywheel with a special aligning gauge tool (Fig. 3-17). The attaching bolts should be turned down one turn at a time in order to bring the clutch cover down into position without distorting it. Then, a straightedge or a lever height gauge should be used to determine the difference in height between the ends of the levers and the boss on the gauge. With the lever height gauge, the levers should just...
touch the gauge when it is held on the boss. Adjustment is made by turning the nuts on the eyebolts (Fig. 3-16). With the straightedge, adjustment should be made until the clearance between the straightedge and the levers is within 0.005 inch.

c. With adjustment complete, the nuts should be staked into position with a hammer and pointed punch so they are locked as shown in the upper right in Fig. 3-16.

d. Retest the adjustment after staking the nuts.

§27. Auburn clutch service A clutch of this type is shown in Fig. 2-10. A distinguishing characteristic is that it has three pressure springs, and these springs seat in the release levers (or pressure-plate levers). Disassembly, reassembly, and adjustments are detailed below.

1. Disassembly

a. Make sure that the cover and pressure plate are marked so they can be reassembled in the same relative position. Use a hammer and punch to mark the two if they are not already marked. Balance will be lost and clutch vibration will result if the cover is not reattached to the pressure plate in the original position.

b. Place the assembly in the special clutch fixture as shown in Fig. 3-18. With compression washer in place, as shown, turn down compression nut to fully compress the fingers. Remove adjusting screws, washers, and lever clips (or plate return springs, as they are also called).

c. Place ½-inch steel blocks under outer ends or heels of the fingers as shown to right in Fig. 3-18. Back off the compression nut slowly until the release-lever heels move down and come to rest against the steel blocks. Remove the compression nut and washer from the fixture.

d. Take out each pressure spring by pushing the lever down by hand, taking out the block, and then releasing the lever slowly.

e. Release levers may be taken off the cover by cutting off the ends of the pins or by filing off the peened-over part with a file so the pins can be removed.
f. Inspect and check the pressure-plate springs, friction disk, throwout bearing, pressure plate, and pilot bearings in the crankshaft. At the same time, the flywheel and housing should be checked for alignment. All these inspection procedures are outlined in §30.

![Fig. 3-18. Clutch in special fixture in preparation for disassembly. Turning down the compression nut compresses the springs.](Plymouth Division of Chrysler Corporation)

2. Reassembly

a. To reassemble the clutch, first attach the levers to the cover with new lever pins. Peen over the ends of the pins.
b. Then put the pressure springs between the levers and cover. Be sure the springs rest in the bosses of the cover and levers.
c. Press down on the release levers and insert steel blocks under the heels of the levers.
d. Put pressure plate in the fixture and place the cover on top with the markings aligned. Put spacer, compression plate, self-aligning washer, and compression nut on the center screw
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of the fixture, and tighten the nut to take up the spring pressure.

e. Remove steel blocks from under the heels of the levers and install the lever clips, washers, and adjusting screws at each lever.

3. Adjustment

a. To adjust the clutch, it should be in a fixture as shown in Fig. 3-18.
b. Adjust the adjusting screws at each lever until each of the three feeler gauges has the same slight drag or feel when being pushed in or pulled out. Tighten the adjusting screws to decrease the drag or loosen them to increase the drag. Recheck the adjustment of each lever and tighten lock nuts.

§28. Diaphragm-spring clutch service A clutch of this type is shown in Figs. 2-12 to 2-14. A distinguishing characteristic is that the clutch has a single diaphragm spring. There is very little in the way of service that this clutch requires. On early models, it was possible to separate the cover and spring, but on late models, the only disassembly that can be made is to remove the clutch pressure-plate retracting springs (Fig. 3-19) so the pressure plate and cover can be separated. The clutch cover, diaphragm spring, and pivot rings
are assembled with rivets and must be serviced as a unit. Parts should be inspected as outlined in §30.

NOTE: If the retracting springs are worn or weak, they may cause a rattling sound when the clutch is disengaged and the engine is idling. The retracting springs can be replaced without taking the clutch off the engine, by removing the clutch housing underpan, hand-cranking the engine, and replacing the three springs, one at a time.

§29. Crown-pressure-spring clutch service A clutch of this type is shown in Figs. 2-15 and 2-16. A distinguishing characteristic is that the clutch has a single wavy, or crown-type, spring.

1. Disassembly

a. To disassemble the clutch, lay the assembly on a flat surface and mark the pressure plate, crown spring, and cover, with dabs of paint or a chalk mark so they can be reassembled in same relative positions. Do not use a punch since this would damage the crown spring.

b. Unhook the six retaining springs from the clutch cover (Fig. 2-15). Work the springs slightly toward the center of the pressure plate, using care to avoid damaging the parts. A special tool, as shown, is recommended.

c. After removing the cover, unhook all retainer springs from the crown spring by working one leg of the retainer spring toward the center of the clutch and the other leg away from the center (Fig. 2-16).

d. Inspect all parts as detailed in §30. In addition, put the cover on a flat surface and check the height of the six ears (where retainer springs attach). Distance, to top surface of the ears, should be 1\(\frac{1}{8}\) inches, as shown in Fig. 3-20. Ears can be bent if dimension is not correct, provided cover is otherwise in good condition and ears are not bent so much the metal cracks. Another special check is to measure the height of the clutch spring from a flat surface (Fig. 3-21). If it is less than minimum height, the spring should be replaced. Also, if the inner surface of the spring (where it contacts the throwout bearing) is so worn that there are holes or sharp edges in the metal, the spring should be discarded.
2. Reassembly

a. At points of wear, or where spring or spring retainers will rub, apply a light coat of lubricant (Lubriplate is recommended).

b. Install spring retainers through holes in pressure plate, curves on ends pointing up, one end in toward the center of the plate, the other end out as shown in Fig. 2-16.

c. Put clutch spring on pressure plate with chalk or paint markings aligned. Push spring retainers up over the spring.
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d. Put cover over spring and pressure plate with chalk or paint markings aligned. Use special tool (Fig. 2-15) to hook loop of each spring over the ears on clutch cover.

§30. Inspecting and servicing clutch parts The various clutch parts as well as the housing and flywheel alignment, should be checked as follows.

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 (or driven plate or driven disk, as it is also called) should be carefully inspected to make sure it is in good condition. Several things 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.

a. 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 if installation of new facings on the disk is attempted. To replace the facings, drill out (do not punch out) old rivets with a drill just rivet size (usually 3/16 inch). New facings are then placed on the flywheel side of the disk with countersunk holes lined up with rivet holes in the cushion spring (Fig. 3-22). Proper rivet holes for flywheel-side facings align with the neck of the cushion spring as at B. Insert rivets and roll (do not split) rivets. After installing all facings on the flywheel side, turn disk over and install pressure-plate side facings. Note that each rivet goes through only one facing.

b. Cushion springs. If the cushion springs under the facings appear to be cracked or weak, the friction disk should be replaced.

c. Torsional springs. Torsional springs that are loose and seem to have lost tension require replacement of the complete friction disk.
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d. Hub splines. The fit of the hub to the clutch shaft should be tested. It should slide on without difficulty and should not have any noticeable rotary play. Excessive play means worn splines and either (or both) the shaft and disk should be replaced.

![Diagram of clutch components](image)

Fig. 3-22. Method of riveting new facings to the cushion springs of the friction disk. A, cushion spring; B-B and C-C, sectional views showing how cushion spring is riveted alternately to one, and then the other, side of the facings. (Studebaker-Packard Corporation)

e. Friction-disk run-out. Distortion of the friction disk can be checked by placing the disk on the clutch shaft protruding from the transmission, front side (flywheel side) facing toward the transmission (Fig. 3-23). A dial indicator can then be set up as shown and the friction disk rotated to see how much out of alignment it is (or how much it runs out). This check is not one that is widely
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required, but at least one car manufacturer (Buick) recommends it. If the run-out exceeds 0.025 inch, the disk should be discarded.

4. Throwout bearing. The throwout, 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 original assembly and thereby ruin the bearing. If the bearing runs roughly or seems loose or noisy, it should be replaced. On the type bearing shown in Fig. 3-24, the groove in which the fork lugs ride should be coated with high-melting-point grease. The recess should be packed with grease. On the type of bearing shown in Fig. 3-25, the old bearing, after removal, can be used to install the new bearing on the bearing sleeve. Turn the two bearings so their front sides are together and align them with the bearing sleeve. Place them in a vise and tighten the vise, meantime continuously revolving the bearings. Tighten the vise until the new bearing is flush with the shoulder on the bearing sleeve.

5. 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 [78]

Fig. 3-23. Friction disk mounted temporarily on clutch shaft in transmission to check disk run-out with a dial indicator. (Buick Motor Division of General Motors Corporation)
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has been removed and replaced. However, if clutch-pedal pulsations are noticed or if gear shifting is hard and gears jump out of mesh, there is a possibility that misalignment exists. It can be checked with a special alignment arbor and dial indicator as shown in Fig. 3-26. The alignment arbor is centered in the crankshaft pilot bearing and attached to the flywheel. Then, as the crankshaft is rotated slowly, variations in the inside diameter of the housing bore can be checked. If variations exceed 0.005 inch, correction must be made. Correction varies on different cars. To correct the condition on some, shims may be placed between the housing and engine or between the housing and transmission. On others, the dowel pins must be removed and the housing tapped one way or the other.

Fig. 3-24. On the type of throwout bearing shown, the groove should be coated, and the recess packed with high-melting-point grease. (Chevrolet Motor Division of General Motors Corporation)
Fig. 3-25. Using the old bearing to install the new bearing on the release-bearing sleeve. (Plymouth Division of Chrysler Corporation)

Fig. 3-26. Using a special alignment arbor and dial indicator to check the alignment of the clutch housing to the engine. (Plymouth Division of Chrysler Corporation)
until it shifts into better alignment. Then, the dowel holes must be reamed and larger dowel pins installed.

6. Pilot bearing in crankshaft. The pilot bearing in the crankshaft is usually either a bushing or a ball bearing. The old bushing can be removed and a new one installed with a special tool (Fig. 3-27). A small amount of short-fiber grease should then be placed in the bushing. Do not put grease on the end of the clutch shaft.

7. Flywheel alignment. The flywheel can be checked for wobble, or an out-of-line condition, by mounting a dial indicator of the type shown in Fig. 3-26 on the clutch housing with the indicating finger on the face of the flywheel. Then, the flywheel can be rotated. If it is out of alignment, the dial indicator will show the condition. Correction can sometimes be made by removing the flywheel, cleaning the flange mounting, and reinstalling the flywheel. If the flange or crankshaft is bent, replacement is required.

CHECK YOUR PROGRESS

Progress Quiz 4

Once again you have the chance to stop and check your progress by answering a series of questions. If you have no trouble answering
the questions, you have done an exceptional job of remembering the material you have just read on clutch-trouble diagnosis and service. If you do have some difficulty in answering the questions, don’t worry. Simply reread the pages that will give you the answers. Many students find they remember their lessons better if they reread them several times. Rereading fixes important points more firmly in your mind.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. The Borg and Beck clutch described in the chapter has coil pressure springs and is adjusted by screws in the levers screws under the levers eyebolt nuts
2. The Long clutch described in the chapter has coil pressure springs and is adjusted by screws in the levers screws under the levers eyebolt nuts
3. The Auburn clutch described in the chapter has coil pressure springs and is adjusted by screws in the levers screws under the levers eyebolt nuts
4. One part in the clutch that must never be cleaned in cleaning solvent, as this would remove the lubricant and ruin the part, is the clutch cover clutch gear throwout bearing release levers
5. On the diaphragm-spring clutch, removal of the retracting springs permits separation of the cover from the pressure plate diaphragm spring release levers
6. The cover is removed from the crown-pressure-spring clutch by removing six screws unlocking six springs removing attaching nuts
7. In the Auburn clutch, the release levers are attached to the cover by pins screws nuts and bolts springs
8. A warped pressure plate should be retempered straightened replaced refaced
9. In the coil-spring type of clutch, when the pressure plate and cover are separated, the spring pressure must be held by hand by an arbor press by a lever by a heavy weight
10. If the facings on the friction disk are worn down nearly to the rivet heads, then either the friction disk should be replaced or new rivets installed new facings installed new springs installed
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CHAPTER CHECKUP

Note: Since the following is a chapter review test, you should review the chapter before taking it.

Clutch service tends to become a specialty in itself, but a good automotive mechanic should know how clutches operate, what troubles they may have, and how to locate the causes of the troubles and eliminate them. The chapter you have just completed covers clutch troubles and services. Now, in the checkup that follows, these different troubles and clutch services are high-lighted. Thus, the checkup will help you to fix these troubles and services in your mind. If you are not sure about the correct answer to any of the questions, turn back into the chapter and review the pages that will answer it for you. Write down the answers in your notebook. Not only does writing answers help you to remember them but it also will make your notebook a valuable source of information you can refer to quickly in the future.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. Clutch slippage while clutch is engaged is particularly noticeable during idle at low speed during acceleration when starting the engine.
2. Clutch chattering or grabbing is noticeable during idle at low speed when engaging the clutch when accelerating.
3. Clutch dragging is noticeable on acceleration at road speed when clutch is disengaged at high speed.
4. Clutch noises are usually most noticeable when the engine is accelerating decelerating idling being started.
5. Clutch-pedal pulsation, or a nervous pedal, is noticeable when the engine is running and accelerating decelerating a slight pressure is applied to the pedal the car is moving at steady speed.
6. Slippage between the friction-disk facings and the flywheel or pressure plate will cause clutch-pedal pulsation rapid facing wear excessive acceleration.
7. The free travel of the pedal, or pedal lash, is the amount of travel the pedal has before the throwout bearing comes up against the release levers flywheel floor board stop.

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8. A distinguishing feature of the Long clutch described in the chapter is that there are adjusting screws on the release levers, adjusting screws under the release levers, adjusting nuts on the lever eyebolts.

9. A distinguishing feature of the Borg and Beck clutch described in the chapter is that there are adjusting screws on the release levers, adjusting screws under the release levers, adjusting nuts on the lever eyebolts.

10. A distinguishing feature of the Auburn clutch described in the chapter is that it has three coil springs, a single diaphragm spring, a single crown-pressure spring.

Troubles and Service Procedures

In the following, you should write down in your notebook the trouble causes and service procedures asked for. Do not copy the procedures from the book but try to write them in your own words. Writing them down in your own words will be of great help to you because this will enable you to remember them better; you will thereby be greatly benefited when you go into the automobile shop.

1. Describe clutch slippage and list possible causes.
2. Describe clutch chatter or grabbing and list possible causes.
3. Describe clutch spinning or dragging when disengaged and list possible causes.
4. List possible causes of clutch noise when the clutch is engaged.
5. List possible causes of clutch noise when the clutch is disengaged.
6. Describe clutch-pedal pulsation and list possible causes.
7. List possible causes of rapid friction-disk-facing wear.
8. Describe a typical clutch-pedal-linkage adjustment.
10. Make a list of the five clutches described in the chapter, together with the cars using each type.
11. Describe the disassembly, reassembly, and adjustment of a Long clutch.
12. Describe the disassembly, reassembly, and adjustment of a Borg and Beck clutch.
13. Describe the disassembly, reassembly, and adjustment of an Auburn clutch.
14. Describe the disassembly and reassembly of a diaphragm-spring clutch.
15. Describe the disassembly and reassembly of a crown-pressure-spring clutch.

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16. Describe the checks to be made on a friction disk to determine whether or not it is fit for further use.

SUGGESTIONS FOR FURTHER STUDY

When you are in the automotive service shop, keep your eyes and ears open so you can learn more about how the various clutch service jobs are done. Notice the special tools required and how these tools are used. Study various car manufacturers' manuals in order to become more familiar with different clutch constructions and servicing procedures. Keep jotting down in your notebook the important facts you come across so you will have a permanent record of them.
4: Transmissions

WITH THE INTRODUCTION of different types of semiautomatic and automatic transmissions in recent years, a great variety of transmissions are to be found on automobiles. Thus, there are many cars with the standard manually operated gearshift. Other cars have devices that help the driver move the gearshift lever and thus make it easier for him to shift gears. However, gear shifting is still necessary with these. Then there are semiautomatic gear-shifting devices; on these, some form of mechanism is employed to shift certain gears during certain phases of car operation. For instance, on some cars, pushing all the way down on the accelerator causes the transmission to drop into a lower gear for improved pickup when passing another car. On many of these cars, a fluid coupling (described on a later page) supplements or supplants the clutch. Many cars are equipped with completely automatic transmissions; these are so automatic that there is no clutch and thus no clutch pedal. In recent years, the torque converter (also described on a following page) has come into use; this device provides varying gear ratios (more strictly, drive ratios) without shifting of any gears at all. The various semiautomatic and automatic transmissions use rather complex controlling devices, as might be expected. These devices, however, function on very simple operating principles as we shall see in later chapters.

In this book, several chapters are devoted to transmissions. The present chapter describes standard passenger-car and truck transmissions. Following chapters are devoted to transmission overdrives and semiautomatic and automatic transmissions.

§31. Function of transmission As already explained (§6), the standard passenger-car transmission provides three gear ratios between the engine crankshaft and the car wheels, so that the crankshaft will be required to revolve approximately four, eight, or twelve
times for each car-wheel revolution. In low gear the crankshaft revolves about twelve times per wheel revolution, thus permitting the engine to operate at fairly high speed when the car is first set in motion. Without this high gear ratio, the engine would be turning so slowly that it could deliver little power to the wheels. The engine crankshaft must be turning fairly rapidly before the engine will develop sufficient power to start the car moving. After the car has begun to move, a somewhat reduced gear ratio between the engine crankshaft and wheels is desirable. In the low-gear position, medium to maximum engine speed will cause the car to move only a few miles per hour. Shifting to the intermediate-gear position provides a middle step of gear ratio of approximately 8:1 between the engine crankshaft and the wheels; medium to maximum engine speed thus produces a car speed above 30 mph (miles per hour). Shifting to the high-gear position provides a gear ratio of about 4:1 between the engine and the wheels. This permits higher car speeds at high engine speeds and also allows the engine to operate at lower and more efficient speeds when the car is traveling at fairly low or intermediate speeds. While the car is in motion and in high gear, it is normally not necessary to shift gears except when the car is brought to a stop, or when additional power at low car speed is required. Such additional power is needed, for example, when the car is climbing a steep hill or when rapid acceleration for low speed is desired. In addition to these three forward gear positions, the reverse-gear position provides a means of reversing the direction of car motion so that the car can be backed.

Note: It is suggested that the fundamentals of transmission operation (§6) be reviewed. This will be of help in understanding the modern transmissions discussed below.

§32. Types of transmission In addition to the conventional three-speeds-forward-and-one-speed-reverse type of transmission found on many passenger cars and trucks, special types of transmission for heavy-duty bus and truck operations provide as many as ten speeds forward and two speeds reverse. The latter are combination units employing a five-speeds-forward-and-one-speed-reverse transmission with a two-speed auxiliary. Essentially, there is little difference between these various types of transmission except that those providing more gear ratios have, of course, additional gears and
shifting positions. Figures 4-1 to 4-10 illustrate various types of manually shifted transmissions in sectional and disassembled views. These include both passenger-car units with three forward speeds and one reverse speed, and a four-forward-and-one-reverse-speed truck-type transmission. Descriptions of their operation follow.

Many late-type transmissions utilize synchromesh devices that make gear shifting easier; these devices assure that gears about to be meshed are revolving at synchronized speeds. This means that the gear teeth which are about to mesh are moving at the same speed. As a result, the teeth mesh without any gear clashing. Following sections describe the action of these devices.

A variety of devices to assist in the shifting of gears have been used. One type makes use of an electromagnetic solenoid that, when energized, causes the gears to be shifted. In a second type of device, the engine actuates a vacuum booster that causes the gears to be shifted. Semiautomatic and fully automatic gear-shifting devices are also in use. These include overdrive controls, the Hydra-Matic, and other automatic transmissions. On some of these latter, the mechanism automatically selects the proper gear ratio according to engine and car speed and throttle opening. On others, a torque converter automatically varies the drive ratio, without gear shifting, to suit varying operating conditions. The operation of these automatic transmissions is detailed in following chapters.

The car of some years ago used a gearshift lever which went through the floor board and was attached at its lower end to the transmission case. This type of gear-shifting mechanism is used in §6 to explain transmission action since the linkage to the yokes or forks that move the gears is simpler and easier to understand than such linkages on more recent cars. Today, cars using standard transmissions have the gearshift lever mounted on the steering column. With this mounting, the linkages between the lever and the transmission are somewhat more complex (§36). However, the action in the transmission is similar; movement of the lever causes gears to move out of, or into, mesh.

\textbf{NOTE:} Heavy-duty applications using transmissions with more than three forward speeds (Figs. 4-8 and 4-9) usually have a floor-board type of gearshift lever.

\textbf{(33. Operation of transmission} The transmission shown in Figs. 4-1 and 4-4 provides three forward speeds and one reverse speed. Shift-
Transmissions

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Transmissions is accomplished when either of the shifter levers (No. 24 or No. 25 in Fig. 4-1) is actuated by operation of the gearshift lever on the steering column. The manner in which the shifter-lever forks are assembled in the side cover of the transmission is shown in Fig.

Fig. 4-1. Sectional view (from top) of transmission incorporating synchromesh, three forward speeds and one reverse speed. (Chevrolet Motor Division of General Motors Corporation)

1. Clutch-gear-bearing retainer
2. Clutch-gear bearing
3. Clutch gear
4. Synchronizer ring
5. Synchronizer drum spacer
6. First-and-reverse sliding gear
7. Reverse idler gear
8. Second-speed gear
9. Mainshaft rear bearing
10. Speedometer drive-gear spacer
11. Speedometer drive gear
12. Universal-joint spacer
13. Main-shaft
14. Transmission case
15. Rear-bearing-support bushing
16. Rear-bearing support
17. Second-and-third shifter fork
18. Detent spring
19. Detent ball
20. First-and-reverse shifter fork
21. Interlock retainer shifter fork
22. Side cover
23. Seal
24. Second-and-third shifter lever
25. First-and-reverse shifter lever

4-3. The four gear positions of a somewhat similar transmission are shown in Fig. 4-5.

1. Gearshift-lever action. In any transmission, operation of the gearshift lever does two things: (1) It selects the gear assembly to be moved and (2) it moves the gear assembly in the proper direction, so that the correct gears mesh. In addition, the synchromesh device assures meshing of the gears without clash. In the trans-

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mission, when the clutch is engaged and the engine is running, the clutch gear (No. 3 in Fig. 4-1) is turning and driving the counter-gear assembly. The counter-gear assembly is not visible in Fig. 4-1, although it can be seen in the side sectional view of the similar transmission shown in Fig. 4-2. Note that the counterdistributed gear is meshed with the clutch gear (also called the drive pinion). Also, note that when the countergear assembly is turning, the second-speed gear will also turn since it is in constant mesh with the counter second-speed gear of the countergear assembly.

Fig. 4-2. Sectional view (from side) of a passenger-car synchromesh transmission with three forward speeds and one reverse speed. (Chevrolet Motor Division of General Motors Corporation)

The second-speed gear can spin freely on the main shaft since it has an internal bearing surface. The main shaft, which is connected through the universal joint to the propeller shaft, is supported by the rear main bearing and the needle bearing in the clutch-gear shaft. The teeth on the main shaft are at a slight angle to the shaft. The synchronizing drum has internal teeth that match the main shaft, although it can move back and forth on the shaft (moving between the clutch gear and the second-speed gear). The outside of the drum also has teeth, on which the inside teeth of the first-and-reverse gear are engaged.

Before we describe the remainder of the transmission, let us consider the first-and-reverse-gear positions, since they do not employ synchronizing devices. The main shaft normally is not turning
when the car is shifted into first or reverse, and thus a synchronizing device is not required.

2. Shifting into first. When the shift to first is made, the operation of the gearshift lever produces two actions. First, the linkage to the first-and-reverse shifter lever (No. 25 in Fig. 4-1) is selected. Then, this lever is actuated to cause the first-and-reverse shifter fork (No. 20 in Fig. 4-1) to move to the left (Fig. 4-1) so that the first-and-reverse gear (No. 6) is also moved to the left (or toward front of car). As it moves to the left, it is meshed with the counterlow-speed drive gear. When the engine clutch is engaged, the clutch gear, driving through the counterdriven and low-speed drive gears, causes the first-and-reverse gear to rotate. This rotary motion passes through the synchronizing drum to the main shaft. The synchronizing drum is held in position by the second-and-third-speed shifter fork so that it cannot move endwise on the main shaft. The first-and-reverse gear, drum, and main shaft rotate as a unit without relative motion between the three.

3. Shifting into reverse. Reverse is attained by moving the first-and-reverse gear to the right (Fig. 4-1) and into mesh with the reverse idler gear, causing the drive to be through this gear from the countershaft. This imposes an extra gear in the gear train so that the main shaft is rotated in the reverse direction.

4. The synchronizing device. The synchronizing device, used in shifting to second and to high gear, is a simple cone clutch. Let us consider the second-gear synchronizer, which is practically identical to the high-gear synchronizer. The synchronizer drum (No. 21 in Fig. 4-4) has a cone braking surface at the end of its inner diameter. A synchronizing ring (No. 19) fits loosely into this section of the drum, held in position by the ring retainer (No. 20 in Fig. 4-4).
FIG. 4.4. Disassembled view of transmission. (Chevrolet Motor Division of General Motors Corporation)

1. Clutch-gear-bearing retainer
2. Clutch-gear-bearing retainer gasket
3. Clutch-gear-bearing snap ring
4. Clutch-gear bearing nut and oil slinger
5. Clutch-gear bearing
6. Clutch gear
7. Main-shaft pilot-needle bearings
8. Main shaft
9. Second-speed gear
10. Second-speed gear-thrust washer
11. Transmission case
12. Main-shaft rear bearing
13. Main-shaft rear-bearing snap ring
14. Speedometer-drive gear spacer
15. Speedometer-drive gear
16. Universal-joint spacer
17. Rear-bearing support gasket
18. Rear-bearing support
19. Synchronizer ring
20. Synchronizer-ring snap ring
21. Synchronizer drum
22. First-and-reverse gear
23. Transmission-cover gasket
24. Speedometer-driven gear
25. Countershaft
26. Countergear thrust washer
27. Countergear assembly
28. Reverse-idler shaft lock pin
29. Reverse-idler shaft
30. Reverse-idler gear-thrust washer
31. Reverse-idler gear
32. Expansion plug
33. Shifter-interlock-retainer stud nut
34. Shifter-interlock-retainer stud-nut lock
35. Shifter-interlock retainer
36. Shifter-interlock-retainer stud
37. Shifter-interlock gear
38. Second-and-third shifter fork
39. First-and-reverse shifter fork
40. Shifter-fork detent spring
41. Shifter-fork detent ball
42. Transmission cover
43. Shifter-shaft lever
The outer face of the ring matches the inner cone face of the drum, and the braking effect, which produces synchronization, takes place between these two surfaces. Two cams on the inner face of the synchronizing ring fit into two grooves on the small gear section of the second-speed gear. This causes the synchronizing ring to turn with the second-speed gear.

5. Shifting into second. Let us shift into second and note the actions that take place. The selector selects the second-and-high shifter lever and fork (Nos. 24 and 17 in Fig. 4-1). The two fingers of the fork extend on both sides of the collar around the outside of the left end of the synchronizing drum. Movement of the second-and-high shifter fork to the right thus causes the complete synchronizing drum to move to the right. Meanwhile, the first-and-reverse gear on the outside of the drum is prevented from moving endwise by the first-and-reverse shifter fork. As the synchronizing drum moves to the right, it presses against the synchronizing ring so that the ring is also moved to the right. At this stage, the synchronizing drum and the second-speed gear may be turning at different speeds; synchronization has not yet taken place.

As the synchronizing ring is pushed to the right by the drum, the two cams on the inner face of the ring strike a small ring spring placed in an undercut back of the small gear section of the second-speed gear. This momentarily halts the endwise movement of the synchronizing ring, causing the outer face of the ring to press hard against the inner cone face of the synchronizing drum. During this interval, the car is in motion, and the main shaft and synchronizing drum are revolving, being driven, for the moment, by the car. Since the engine clutch has been released, the second-speed gear, counter-gear assembly, and clutch gear are revolving freely without being driven by the engine. However, as soon as pressure is exerted between the inner cone face of the drum and the outer face of the synchronizing ring, the friction between the two surfaces imposes a drag on the second-speed gear. The synchronizing ring, it will be remembered, is rotating with the second-speed gear. This frictional drag brings the drum and the second-speed gear into synchronism, so that both are turning at the same speed.

As the drum moves to the right, the two cams on the inner face of the synchronizing ring compress the small ring spring in the second-gear undercut. The cams ride over the spring, allowing the
ring to move farther to the right and clear the small-gear section of the second-speed gear. As this is happening, the synchronizing drum is also moving to the right and the teeth on its inner surface mesh with the small gear section of the second-speed gear. Meshing is thus completed without clash. When the engine clutch is engaged, the engine drives the main shaft through the clutch gear, countergear assembly, and second-speed gear. The main shaft rotates at the same speed as the second-speed gear, being driven through the synchronizing drum.

6. *Shifting into high*. Essentially the same action takes place when the gears are shifted into high, or direct, gear. When this action takes place, the synchronizing drum is moved toward the front of the car (left in illustration). Frictional drag between the inner cone face at the left end of the synchronizing drum and the left synchronizing ring brings the clutch gear into synchronism with the synchronizing drum. Further movement of the drum to the left
causes the teeth on the inner face of the drum to mesh with the small gear section on the end of the clutch-gear shaft. The main shaft and the clutch-gear shaft must then turn together so that there is a direct drive through the transmission.

7. Other standard transmissions. Figures 4-5 and 4-6 illustrate a transmission that is similar in many respects to the one covered in

![Image](Fig. 4-6. Exploded view of the transmission shown in the previous illustration.)

the preceding paragraphs. There are a number of differences, however, as will become evident if the various illustrations are compared. Note particularly that the countershaft gear cluster (also called the counthergear assembly) contains four gears instead of three as on the transmission previously described. The additional gear meshes with the reverse idler gear to drive it. On the other transmission, the reverse-idler-gear assembly has two gears, one of which meshes with the counter low-speed drive gear. The other
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gear is the reverse idler gear with which the first-and-reverse gear moves into mesh when the shift into reverse is made. Also, note that the first-and-reverse gear on the transmission shown in Fig. 4-5 is mounted directly on the main shaft and not on the synchronizing drum. Other differences in construction can be noted.

8. Other synchronizing devices. The synchronizing device described above consists of a pair of cone clutches. Other synchronizing devices are also used. For example, the one shown in Fig. 4-7 makes use of a pair of stop rings, each having three pins which pin them to the clutch-gear sleeve. The clutch gear is splined to the main shaft; external teeth on the clutch gear mesh with internal teeth in the clutch gear sleeve. Thus, the clutch gear, clutch-gear sleeve, and two stop rings are always rotating with the main shaft. When the shift is made into second, the main shaft and associated parts may be rotating at a different speed than the second-speed gear. However, as the clutch-gear sleeve is moved toward the second-speed gear, the rear inner stop ring moves against the face of the second-speed gear, bringing it into synchronous rotation with the clutch-gear sleeve. This permits alignment of the external teeth on the clutch gear and the teeth on the small diameter of the second-speed gear. Now, the clutch-gear sleeve can slip over the teeth of the second-speed gear to couple the second-speed gear and the clutch gear. Then, when the clutch is engaged and the engine again delivers power through it, the second-speed gear drives the main shaft through the clutch gear and the clutch-gear sleeve.

The action in shifting to high is very similar. The third and direct-speed gear is supported on roller bearings.

§34. Four-forward-speed transmission  Figures 4-8 and 4-9 illustrate a truck-type sliding gear, four-forward-and-one-reverse-speed transmission. This transmission makes use of a floor-board-type gearshift lever, and its construction is somewhat more complex than the other transmissions discussed in previous paragraphs. It contains additional gearing to provide for the fourth speed. Let us see how this transmission is constructed and how it operates.

Let us first orient ourselves with the various illustrations in Fig. 4-8. A is a top view of the transmission with the transmission-case cover (No. 13 in Fig. 4-9) cut away to show the gearshift rails (Nos. 6, 7, and 21). C is a side sectional view of the transmission.
Fig. 4-7. Disassembled view of a pin-type synchronizing device used to assure gear synchronization when shifting into second and third gears. (Dodge Division of Chrysler Corporation)
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D illustrates the reverse-plunger arrangement, a device used only on four-or-more-forward-speed transmissions. E is the reverse-idler-gear arrangement.

To provide a means of moving the gears, forks (Nos. 3, 4, and 60 in Fig. 4-9) are placed in undercut sections of the gear assemblies. The forks are attached to sliding gearshift rails (Nos. 6, 7, and 21 in Fig. 4-9). The gearshift lever (No. 8) has a ball that fits into a socket in the top of the transmission-case cover (No. 13). This permits swiveling of the gearshift lever into any of the various gearshift positions. Movement of the gearshift lever causes a finger on the lower extremity of the lever to select and move one of the gearshift forks and a gear assembly.

Let us follow the action that takes place as the gears are shifted from neutral through the various gear ratios to high, as shown in the small figure B in Fig. 4-8. With each gearshift the clutch must, of course, be operated. As the gearshift lever is moved from N (neutral) to the left (facing the front of the vehicle), the finger on the lower extremity of the lever moves into the slot in the low-and-second gearshift fork (No. 4, Fig. 4-9). In other words, this first [98]
action selects the fork and thus the gear assembly to be moved. Then, as the gearshift lever is pushed forward into first, the gearshift fork (No. 4) is pushed toward the rear of the vehicle. This moves the first-and-second-gear assembly (No. 38) toward the rear, meshing the larger, or first, gear with the smallest gear on the countershaft gear assembly (No. 40).

To shift into second, the gearshift lever is pulled back, causing the gearshift fork to move the first-and-second-gear assembly (No. 38) forward, meshing the smaller, or second, gear with the next larger countershaft gear.

When the shift is made from second to third, the sideward movement of the shift lever (facing the front of the vehicle) causes the finger on the lower end of the shift lever to move out of the slot in the low-and-second gearshift fork (No. 4) and into the slot in the third-and-high gearshift fork (No. 3). When the shift lever is then pushed forward into third, the gearshift fork (No. 3) moves the third-and-high-gear assembly (No. 33) toward the rear, so that its external teeth mesh with the next to largest gear on the countershaft.

When the shift is made into high or direct gear, the third-and-high-gear assembly is moved forward so that its internal teeth mesh with the external teeth on the main drive pinion (No. 32). This provides a direct drive through the transmission, and the transmission main shaft (No. 44) turns at the same speed as the driving pinion.

The gearshift-rail poppets (No. 23) are spring-loaded balls that drop down into undercuts on the gearshift rails as the rails are moved into the various gearshift positions. This provides a locking arrangement to hold the gears in mesh. Interlock plungers (No. 1) are placed between the gearshift rails to prevent the movement of more than one rail at a time. When a rail is moved, the plungers are forced out of the undercuts in the side of the rail and into the undercuts on the other rails, locking them firmly into position.

Reverse is obtained by moving the shift lever so that the finger moves through the slot in the third-and-high gearshift fork and into the reverse gearshift fork rail end (No. 5). Then, pulling the gearshift lever back into reverse causes the reverse gearshift fork (No. 60) to move the reverse idler gear (No. 62) into mesh with
FIG. 4-9. Exploded view of transmission shown in previous illustration. (Dodge Division of Chrysler Corporation)

1. Gearshift-rail interlock plunger
2. Gearshift-rail interlock pin
3. Gearshift fork, third and direct
4. Gearshift fork, low and second
5. Gearshift reverse-rail end
6. Gearshift rail, third and direct
7. Gearshift rail, low and second
8. Gearshift lever
9. Gearshift-lever dust cover
10. Gearshift-lever spring seat
11. Gearshift-fork and end-lock screw
12. Gearshift-fork and end-lock-screw lockwire
13. Transmission-case cover
14. Transmission-case-cover reverse-plunger plug
15. Gearshift-lever reverse plunger
16. Gearshift-lever reverse-plunger spring
17. Gearshift-lever pivot pin
18. Gearshift-lever reverse-plunger retainer
19. Gearshift-lever reverse-plunger retainer lock nut
20. Gearshift-lever reverse-plunger lock
21. Gearshift rail, reverse
22. Gearshift-rail poppet spring
23. Gearshift-rail poppet

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countershaft and main-shaft gears. Interposing the extra gear reverses the direction on main-shaft rotation, so that the vehicle is backed. The reverse plunger, a special device used only on four-or-more-forward-speed transmissions, offers spring pressure against the sideward movement of the gearshift lever as it is brought into the reverse position. This reduces the possibility of

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
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<tbody>
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<td>24.</td>
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<td>25.</td>
<td>Transmission main-drive pinion snap ring</td>
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<td>26.</td>
<td>Transmission main-drive pinion-bearing snap ring</td>
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<td>27.</td>
<td>Transmission-drive pinion-bearing oil-retainer washer</td>
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<td>28.</td>
<td>Transmission main-shaft pilot bearing</td>
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<td>29.</td>
<td>Transmission main-drive pinion-bearing retainer</td>
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<td>30.</td>
<td>Transmission main-shaft pilot-bearing spacer</td>
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<td>31.</td>
<td>Transmission main-drive pinion-bearing retainer gasket</td>
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<tr>
<td>32.</td>
<td>Transmission main-drive pinion</td>
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<td>33.</td>
<td>Transmission main-shaft third and direct gear</td>
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<td>Transmission countershaft</td>
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<td>35.</td>
<td>Transmission-case cover gasket</td>
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<td>Transmission-case cover expansion plug</td>
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<td>37.</td>
<td>Transmission countershaft bearing</td>
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<td>38.</td>
<td>Transmission main-shaft low and second gear</td>
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<td>40.</td>
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<td>42.</td>
<td>Transmission countershaft-bearing spacer</td>
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<tr>
<td>43.</td>
<td>Transmission countershaft bearing</td>
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<td>44.</td>
<td>Transmission main shaft</td>
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<td>Transmission-case drain plug</td>
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<td>46.</td>
<td>Transmission main-shaft rear-bearing snap ring</td>
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<td>47.</td>
<td>Transmission main-shaft rear-bearing washer</td>
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<td>48.</td>
<td>Transmission main-shaft rear-bearing oil-retaining washer</td>
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<td>49.</td>
<td>Transmission main-shaft rear bearing</td>
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<td>50.</td>
<td>Transmission main-shaft rear-bearing retainer gasket</td>
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<tr>
<td>51.</td>
<td>Speedometer-drive gear spacer</td>
</tr>
<tr>
<td>52.</td>
<td>Transmission main-shaft rear-bearing retainer and hand-brake support</td>
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<tr>
<td>53.</td>
<td>Speedometer-drive gear</td>
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<td>54.</td>
<td>Transmission main-shaft rear-bearing retainer oil seal</td>
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<td>55.</td>
<td>Propeller-shaft yoke (flange)</td>
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<td>Gearshift reverse-fork rail cotter</td>
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<td>Transmission reverse-idler shaft</td>
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<td>59.</td>
<td>Gearshift reverse-fork rail</td>
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<td>60.</td>
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<td>62.</td>
<td>Transmission reverse idler gear</td>
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<td>63.</td>
<td>Transmission reverse-idler gear bushing</td>
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<td>64.</td>
<td>Transmission counter-shaft and reverse-idler-shaft lock plate</td>
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<td>65.</td>
<td>Case-cover screw and lock washer</td>
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<tr>
<td>66.</td>
<td>Gearshift-lever spring</td>
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<tr>
<td>67.</td>
<td>Main drive-pinion-bearing-retainer screw and lockwasher</td>
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<tr>
<td>68.</td>
<td>Power take-off cover gasket</td>
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<tr>
<td>69.</td>
<td>Shaft lock-plate-screw and lock washer</td>
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<tr>
<td>70.</td>
<td>Propeller shaft-yoke-nut washer</td>
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</tbody>
</table>
§35. **Constant-mesh transmission** Some cars use a constant-mesh transmission, in which the gears on the main shaft and the countershaft are in constant mesh (Fig. 4-10). The gears on the main shaft are equipped with bearings, so that they may rotate independently of the main shaft. When gears are shifted, external and internal teeth are meshed. Synchromesh devices come into use when gears are shifted into second and high.

When the gears are shifted into first, the first-and-reverse sliding gear to the right on the main shaft (Fig. 4-10) is moved to the left, so that its inner teeth mesh with the small-gear section on the main-shaft first gear next to it. Shifting into second brings the synchromesh device into action. The second-and-high shifter fork moves the synchronizing drum to the right, causing the drum and the synchronizing ring surfaces to throw a frictional drag on the engine clutch shaft and countershaft so that synchronism takes place and the small-gear section of the second-speed gear is meshed with the gear teeth on the inner face of the synchronizing drum. Shifting into high is accomplished by moving the synchronizing drum to the left.

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CHECK YOUR PROGRESS

Progress Quiz 5

Here is your progress quiz on the first half of Chap. 4. Find out how well the material you have just read has “stuck with you” by answering the questions below. If you are not sure about some of the answers, reread the past few pages and try the questions again. This review will help you to remember the important facts.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. Synchronizing devices are designed to prevent gear clash when shifting into first and reverse first and second second and high
2. The conventional passenger-car transmission has two forward speeds three forward speeds four forward speeds
3. The standard transmission has one shifter fork two shifter forks three shifter forks four shifter forks
4. In the Chevrolet transmission, movement of the first-and-reverse sliding gear toward the rear of the car causes it to mesh with the reverse idler gear countershaft second gear countershaft drive gear
5. There are two separate movements of the gearshift lever; the first movement selects the linkage to the correct shaft shifter fork shifter shift pedal
6. The second movement of the gearshift lever produces gear shifting releases the clutch moves the drive gear shifts the countershaft
7. In the Chevrolet transmission, movement of the first-and-reverse sliding gear toward the front of the car causes it to mesh with the countershaft second gear drive gear low or first gear
8. The synchronizing device used in the Chevrolet transmission uses cone braking surfaces synchronizing pins flat braking surfaces
9. When shifting the Chevrolet transmission into high, the synchronizing drum is moved toward the front of the car so the teeth of the inner face of the drum mesh with the small-gear section on the countershaft idler shaft clutch-gear shaft
Fig. 4-11. Steering-column gearshift mechanism and linkages. (Studebaker-Packard Corporation)

Fig. 4-12. Close-up of the actuating mechanism that is at the lower end of the steering column of the gearshift mechanism shown in previous illustration. (Studebaker-Packard Corporation)
10. In the constant-mesh transmission described in the chapter, the gears that are always in mesh include all gears first and reverse gears first and second gears.

§36. Selector and shifter Two separate motions of the gearshift lever are required in shifting gears. The first motion selects the gear assembly to be shifted; the second motion moves the gear assembly in the proper direction. A number of different types of selector and shifter devices are in use. Practically all modern passenger cars have the gearshift lever mounted on the steering column. One type is shown in Figs. 4-11 and 4-12. Figure 4-11 is a top view of the steering column, with the shift lever and linkages shown. Figure 4-12 is a close-up of the gear selector and shifter rods, with the transmission in neutral. The tongue is attached to the lower end of the shift-control shaft and is raised or lowered as the gearshift lever is lifted or released. This action places the tongue in either the first-and-reverse shift fork, or in the second-and-high shift fork.
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Fig. 4-14. Disassembled view of a linkage arrangement between the gearshift lever and the selector and operating levers on the transmission. (Dodge Division of Chrysler Corporation)
After the fork has been selected, the gearshift lever is moved parallel to the steering wheel to complete the shift. This causes the tongue to rotate, producing a rotary motion of the fork that has been selected. The fork is linked to the transmission (Fig. 4-11), and the direction of rotation determines the direction the gear assembly is moved.

A similar type of linkage between the gearshift lever and the transmission is shown in Fig. 4-13. The shifter-lever forks with which this linkage is connected are shown in place in the side cover of the transmission in Fig. 4-3. When the gearshift lever is moved up or down to select either the first-reverse position or the second-third position, the tongue, or control-shaft lever, moves into either the upper or the lower shifter gate. If the gearshift lever is lifted, then the control lever moves into the upper gate. When the gearshift lever is moved parallel to the steering wheel to shift into either first
Fig. 4-16. Steering-column control using vacuum-power shifter device. (Chevrolet Motor Division of General Motors Corporation)

1. Swivel
2. Lever assembly
3. Antirattle spring
4. Lower support
5. Bushing assembly
6. Bushing lever
7. U bolt
8. Toe-pan seal
9. Bushing assembly
10. Control shaft
11. Master-jacket grommet
12. Selector rod
13. Control rod
14. Swivel
15. Bushing
16. Antirattle spring
17. Lever
18. Knob
19. Lever
20. Spring (coil)
21. Lever swivel
22. Control shaft
23. Upper support
24. Antirattle spring
25. Pivot-pin spring
26. Wheel
27. Bolt
28. Steering-gear master jacket
29. Clamp
30. Transmission-cover assembly
31. Support
32. Vacuum-power-cylinder assembly
or reverse, the outer lever on the upper side is rotated, causing the first-reverse control rod to move and thereby move the first-reverse shifter lever in the transmission side cover.

Another linkage system is shown in Fig. 4-14 in disassembled view. In this system, raising or lowering the gearshift lever causes the rod lever and end assembly to move up or down. This, in turn, causes the selector lever to pivot. As it pivots, it pushes or pulls on the gearshift selector rod, thereby causing the selector lever in the transmission to turn and select either the first-reverse position or the second-third position. Now, when the gearshift lever is moved parallel to the steering wheel to shift into gear, the rod lever and end assembly turn with the gearshift rod, causing the front control rod to move. This movement, through the bell crank, causes the rear control rod to move and thereby move the operating lever in the transmission. This operating lever, as it moves, produces the shifting of the selected gear.

Figure 4-15 gives you a close-up of the linkage arrangement between the selector levers (or shifter levers) on the outside of the transmission and the shifter yokes inside one type of transmission. Note that the shifter yokes in this transmission are mounted on shafts that can move back and forth in bearings in the transmission housing. The shifter levers move the shafts to produce shifter-yoke movement and gear shifting. Each shifter yoke has a poppet ball which is spring-loaded against a detent, or undercut, in the shaft. This holds the shaft in place and prevents it from moving until sufficient pressure is applied through the gear-shifting linkage.

Another type of selector and shifter mechanism, also mounted on the steering column, is illustrated in Fig. 4-16. This application uses a vacuum power shifter that aids the shifting action. The

| 33. Muffler   | 44. Exhaust pipe |
| 34. Air-inlet hose | 45. Intake manifold |
| 35. Boot       | 46. Pipe fitting |
| 36. Clamp      | 47. Exhaust manifold |
| 37. Boot unit  | 48. Pedal shaft |
| 39. Operating-lever assembly | 49. Button |
| 40. Vacuum hose | 50. U bolt |
| 41. Bracket    | 51. Carburetor |
| 42. Bell crank | 52. Air cleaner |
vacuum power shifter is discussed in §37. The upward and downward movement of the gearshift lever, the first step in shifting, forces the control shaft to move up or down. This movement causes the selector rod to operate the selector crank inside the transmission (Fig. 4-17). As the selector crank is actuated, it moves into either one or the other of the two shifter-fork slots, locking that fork so that it cannot move. The second action of shifting causes the control shaft to rotate, and this motion is transmitted through linkage to the operating shaft inside the transmission. The operating shaft rotates, causing the shifter-fork lever to move. This lever pivots about the fulcrum pin in the locked fork, causing the shifter fork that is free to be moved along the shifter-fork guide bar. The relationship of the guide bar, shifter forks, selector crank, and shifter-fork lever is illustrated in Fig. 4-17.

§37. Vacuum gearshift The vacuum, or power, gearshift uses intake-manifold vacuum to provide the power needed to shift the gears. This relieves the driver of most of the gear-shifting effort; the driver merely operates the gearshift lever on the steering column to select the proper gear position; this actuates a vacuum-power cylinder that produces the shifting action. Figure 4-16 illustrates the general layout of the gearshift mechanism, including the

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vacuum-power cylinder. The relationship of these parts varies somewhat on different applications, but the principle of operation is the same.

Figure 4-18 illustrates the exterior of the vacuum-power cylinder with the transmission operating-lever assembly. The operating lever is clamped around the operating shaft in the transmission and is linked by the control rod (No. 13, Fig. 4-16) to the control shaft on the steering column. Moving the gearshift lever into any of the four gearshift positions causes the control shaft on the steering column to rotate. This rotary motion is carried through the control rod (Fig. 4-16) to the operating lever. The operating lever in turn rotates, causing the previously selected gear to mesh. Most of the power required to move the operating lever is provided by the vacuum-power cylinder.

The vacuum-power cylinder (Figs. 4-19 and 4-20) consists of a cylinder with a piston that divides the cylinder into two compartments. The piston is connected by a hollow shaft to the operating lever. Inside the hollow shaft is an inner hollow shaft attached at one end to the control-rod link of the operating lever. A sleeve valve is attached to the opposite end of the inner hollow shaft. The control-rod link has some degree of movement independent of the operating lever since the two are loosely attached. When the control rod is moved in response to movement of the gearshift lever, the inner hollow shaft (to which the sleeve valve is attached) moves with respect to the outer hollow shaft. Figure 4-19 illustrates the action that takes place when the gearshift lever is placed in the [111]
FIG. 4-19. Vacuum cylinder in sectional view showing position of valve and direction of piston movement when shifting into reverse or second speed is underway. (Chevrolet Motor Division of General Motors Corporation)

FIG. 4-20. Vacuum cylinder in sectional view showing position of valve and direction of piston movement when shifting into low or high speed is underway. (Chevrolet Motor Division of General Motors Corporation)
reverse- or second-speed position. This movement pulls the inner hollow shaft and the valve to the left, opening the two valve ports in the outer shaft. Air can now pass into the right-hand compartment, while air in the left-hand compartment is pulled out by engine vacuum. This causes the piston to be pushed to the left. The piston movement is transmitted through the outer hollow shaft to the operating lever, causing the operating lever to rotate the transmission operating shaft. This moves the unlocked shifter fork so that gear shifting is accomplished.

The piston movement is in the nature of a follow-up to the inner hollow-shaft and sliding-valve movement. The movement of the gearshift lever, control shaft, control rod and link, and inner hollow shaft and valve continues until the gear is shifted. During this interval the valve maintains its relative position with the outer shaft and piston as shown in Fig. 4-19, although both it and the outer shaft and piston are moving to the left.

Figure 4-20 illustrates the action that takes place when the gears are being shifted into low or high. Initial movement of the gearshift lever, control shaft, control rod, control-rod link, and inner hollow shaft and valve causes the valve to move to the right. The valve ports in the outer hollow shaft are thus uncovered as shown in Fig. 4-20. Air is now admitted into the left-hand compartment, while engine vacuum is applied to the right-hand compartment. The piston moves to the right, providing the power for shifting into low or high gear. Here again, as in shifting into second or reverse, the valve is leading, uncovering the valve ports, and the piston and outer shaft follow.

Even without engine vacuum, gear shifting may be accomplished, although considerably more pressure must be applied to the gearshift lever. With the vacuum-power cylinder inoperative, sufficient pressure must be applied through the gearshift lever to cause the operating lever to be moved and the operating shaft to be rotated.

§38. Vacuum-operated clutch and gearshift A further development of the vacuum gearshift described in the previous section is shown in Fig. 4-21. In this arrangement, vacuum from the intake manifold not only shifts the gears as desired by the driver but also operates the clutch automatically. When the driver does not want automatic clutch and gear-shifting action, he can turn off the mechanism by pressing a button on the car dash. But when he wants automatic
Fig. 4-21. Layout of the Hudson Drive-Master. (American Motors Corporation)

1. Air intake pipe
2. Vacuum pipe
3. Mounting bracket studs
4. Bell crank bracket
5. Accelerator switch to cross shaft rod
6. Power unit to air cleaner pipe
7. Accelerator switch
8. Clutch power cylinder tension spring
9. Mounting bracket
10. Compensator trip lever
11. Compensator trip lever spring
12. Solenoid valve
13. Throttle lock solenoid valve
14. Solenoid to power shift pipe
15. Solenoid gasket
16. Vacuum pipe
17. Clutch power unit cylinder
18. Throttle lock diaphragm cylinder
19. Throttle lock solenoid
20. Compensator trip lever shaft
21. Piston rod guard
22. Piston rod
23. Piston rod pivot bolt
24. Piston valve and rod link pin
25. Piston valve and rod link
26. Piston valve and rod
27. Valve lever eccentric bushing
28. Bell crank and compensator
29. Valve lever cam
30. Bell crank to clutch coupling lever rod
31. Accelerator pedal to bell crank rod
32. Threaded sleeve rod swivel
33. Threaded sleeve rod
34. Control lever to bell crank rod ball joint
35. Bell crank bracket stop
36. Bell crank bracket
37. Check nut
38. Bell crank rod and ball joint
39. Adjusting screw nut
40. Transfer diaphragm solenoids
41. Solenoids to power cylinder tube
42. Power cylinder
action, he presses the button marked HDM (Hudson Drive-
Master).

Now, he merely places the car in high gear, after the engine has
started, and depresses the accelerator pedal. The car will move for-
ward in second gear and will shift into high automatically when the
driver momentarily releases the accelerator pedal. Further, the
transmission will downshift when the car is stopped and will re-
main ready to move as soon as the accelerator pedal is again
depressed.

There are two major components of this system, the clutch-
control mechanism and the gear-shifting mechanism. The clutch-
control mechanism makes use of a power cylinder which is linked
to the clutch. This cylinder is much like the vacuum cylinder used
with the transmission shown in Fig. 4-16. When the accelerator
pedal is depressed, a valve is moved which equalizes the pressure
in both sides of the cylinder. The clutch therefore is engaged. But
when the accelerator is released, full manifold vacuum is admitted
at the front end of the cylinder so the piston is pulled forward.
This movement is carried through a series of levers and rods to the
clutch, causing the clutch to be disengaged.

The gear-shifting mechanism also makes use of a power cylinder
which is linked to the shift lever in the transmission. When the
piston in the cylinder moves to the rear, the transmission is shifted
into second gear. When the piston moves to the front, the trans-

43. Transfer diaphragm 59. Shift shaft (hand shift) lever
44. Stud, nut, spacer and ferrule 60. Lever pin
45. Power cylinder piston guard 61. Transmission shift rod
46. Transfer diaphragm and rod 62. Cross shaft operating rod
47. Lock nut 63. Adjusting screw
48. Engaging rod 64. Lever rod
49. Control switch 65. Off-on switch operating rod
50. Selector switch lever 66. Bell crank bracket shaft
51. Neutral and limit switch rod 67. Rod swivel
52. Mounting bracket 68. Cross-over switch rod clip
53. Transfer rod ball joint 69. Hand shift bell crank support
54. Transfer key 70. Lock nut
55. Rod lock nut 71. Hand-shift bell crank
56. Trunnion block 72. Cross-over switch rod
57. Rod lock nut 73. Shift-rail switch
58. Transfer key and hub 74. Governor switch

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mission is shifted into high gear. The piston is made to move in one direction or the other as engine intake-manifold vacuum is admitted into one end of the cylinder or the other.

Admittance of intake-manifold vacuum into either end of the cylinder is accomplished by valves. These valves open or close in response to electrical controls that signal when the right speed for shifting is attained. In addition, operation of the accelerator pedal, as noted above, permits the proper valve to open either for upshifting into high or for downshifting into second.

CHECK YOUR PROGRESS

Progress Quiz 6

Here is your opportunity to check up on how well you remember the material you have just covered on various gear-shifting devices. If some of the questions “stump” you, go back and reread the pages that will give you the answers. This will help you to remember the important facts.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. The shifter mechanism (gearshift lever) on the steering column is normally connected to the transmission by a single link two linkages four linkages

2. Lifting the shift lever toward the steering wheel selects the first-reverse shifter lever first-second shifter lever second-high shifter lever

3. Moving the shift lever down away from the steering wheel selects the first-reverse shifter lever first-second shifter lever second-high shifter lever

4. To sum up the actions of the gearshift lever, it could be said that the first lever movement selects the gear while the second lever movement releases the gear shifts the gear engages the clutch

5. Moving the gearshift lever parallel to the steering wheel with the lever lifted toward the wheel causes movement of the first-and-reverse gear first-and-second gear second-and-third gear
Transmissions

6. In the vacuum-gearshift mechanism, shifting assistance is offered by the movement of a poppet valve throttle linkage bell-crank linkage a piston in a cylinder

7. In the vacuum gearshift, the piston moves back and forth in the cylinder in response to changing engine vacuum gearshift lever movement clutch-pedal movement

8. In the Hudson Drive-Master described in the chapter, intake manifold vacuum not only shifts the gears, but also operates the clutch operates the gearshift lever operates the throttle valve

CHAPTER CHECKUP

Note: Since the following is a chapter review test, you should review the chapter before taking it.

You have been making good progress in your studies of automotive power trains and their components. Of these components, the transmission is one of the most important, and it is by far the most intricate. The automotive transmissions described in the chapters that follow may seem much more complicated than those covered in the chapter just completed. However, even though they may have more parts, they are no harder to understand. Thus, if you understand the construction and operation of the standard transmissions described in this chapter, you are well equipped to tackle the automatic transmissions described later in the book. To give you a chance to check yourself on how well you understand and remember the details of the standard transmissions, the following questions have been included. If any of the questions are hard to answer, just turn back into the chapter and reread the pages that will give you the information you need.

Completing the Sentences

1. Synchromesh devices in the transmission synchronize gears about to be meshed de-meshed stopped

2. Synchromesh devices are not normally used on the first-and-reverse first-and-second second-and-high gear positions.

3. Considering that the gearshift lever requires two separate motions to shift gears, the first movement moves gear assembly selects the gear meshes the gears

4. The vacuum gearshift, to supply the power to shift gears, uses exhaust-manifold vacuum engine compression intake manifold vacuum
5. The standard transmission has one two three four shifter forks or yokes.
6. In the four-forward-speed transmission described in the chapter, there are four five six seven shift-lever positions, counting neutral and reverse.
7. The standard passenger-car transmission has three four five six shift-lever positions, counting neutral and reverse.
8. In the standard transmission, the countershaft gears turn faster than slower than at same speed as the clutch gear.

Listing Parts

In the following, you are asked to list parts that go into various automotive transmissions discussed in the chapter. Write down the lists in your notebook.

1. Make a list of the major parts used in a typical standard transmission.
2. Compare the illustrations of the standard and the four-forward-and-one-reverse-speed transmission in the chapter and make a list of major parts that only the latter transmission contains.
3. List the parts that make up a typical linkage system between the steering-column gearshift lever and the transmission.
4. List parts that are special for the vacuum gearshift described in the chapter.
5. List parts that are special for the vacuum-operated clutch and gearshift described in the chapter.

Purpose and Operation of Components

In the following, you are asked to write down the purpose and operation of the transmissions and transmission components described in the chapter. If you have any difficulty in writing down your explanation, turn back into the chapter and reread the pages that will give you the answer. Then write down your explanation. Don’t copy; try to tell it in your own words, just as you might explain it to a friend. This is a good way to fix the explanation more firmly in your mind. Write in your notebook.

1. What is the purpose of the transmission?
2. Describe the action that takes place as the transmission is shifted into first and list the parts through which the power flows.
3. Describe the action that takes place as the transmission is shifted into second and list the parts through which the power flows.
Transmissions

4. Describe the action that takes place as the transmission is shifted into high and list the parts through which the power flows.

5. Describe the action that takes place as the transmission is shifted into reverse and list the parts through which the power flows.

6. Describe the operation and construction of a typical synchromesh device.

7. Describe the construction and operation of a typical gearshift-lever-to-transmission linkage.

8. Describe the operation of the vacuum gearshift.

SUGGESTIONS FOR FURTHER STUDY

Always keep your eyes open when in your school automotive shop or in a automotive service garage so you can observe the various service operations that are going on. Note particularly the construction of different transmissions and the sizes and shapes of the various gears and other parts that go into them. If the automotive shop has cutaway models of transmissions, study them carefully; you can easily follow the movement of the gears as they are meshed and de-meshed. Notice, on different cars, the various methods of linking the gearshift lever with the transmission. Study whatever shop manuals you can find, and note carefully the manufacturers' explanations of how their transmissions are constructed and how they operate.


5: Overdrives

THIS CHAPTER discusses the purpose and function of the overdrive and describes the manner in which it operates. The description of the planetary gear system in the pages that follow is especially important since planetary gear systems are used in many automatic transmissions. In order to understand the automatic transmissions, you must understand the planetary gear system. Thus, be sure you spend enough time on studying planetary gears so that you understand how they operate.

§39. Purpose of overdrive In standard transmissions the high-gear position imposes a direct, or 1:1, ratio between the clutch shaft and the transmission main shaft. It is desirable at intermediate and high car speeds, however, to establish a still more favorable ratio between the two shafts, so that the transmission main shaft will turn more rapidly than the clutch shaft. This will reduce engine speed at high car speeds and provide more economical operation and less engine and accessory wear per car-mile.

For these reasons, several car manufacturers supply overdrive mechanisms as special equipment. Overdrives function to cause the main shaft to overdrive, or turn more rapidly than, the clutch shaft. While the ratio varies somewhat on different cars, the overdrive, when brought into operation, drops the engine speed about 30 per cent without any change of car speed. Thus, on a car where direct or high gear provides 40 mph (miles per hour) car speed at 2,000 engine rpm (revolutions per minute), the overdrive would drop the engine speed to 1,400 rpm while still maintaining a car speed of 40 mph.

Overdrives as used on modern cars are automatic, coming into operation when the car speed reaches a predetermined value, usually somewhere around 30 mph. They contain a selective feature that permits the car driver to remain in direct drive or, if he prefers,
to shift into overdrive by merely raising his foot from the accelerator momentarily. When the car driver wishes to come out of overdrive, he merely depresses the throttle past wide-open position. This actuates a throttle switch that causes electric circuits to function and bring the car out of overdrive. There are thus two separate controls: a centrifugal device, or governor, that places the car into overdrive when the cut-in speed is reached; and an electrical control that brings the car out of overdrive when the driver wishes it.

§40. Overdrive components The overdrive is located just back of the transmission, between the transmission and the propeller shaft.

Fig. 5-1. The overdrive is located between the transmission and propeller shaft. (Fig. 5-1). Essentially, it is made up of two parts: a planetary gear system and a freewheeling mechanism, together with the necessary controls and supports. It is important to understand the operation of these devices since this will lead to a more ready understanding of the automatic transmissions described in following chapters. Such automatic transmissions commonly use planetary gear systems. Let us examine the freewheeling mechanism and the planetary gear system in greater detail.
§41. Freewheeling mechanism

Essentially, the freewheeling mechanism is a coupling between two shafts that are in line with each other (Fig. 5-2). This coupling contains an inner and an outer shell (or race) with rollers between. The coupling is often called an overrunning clutch. The name comes from the action of the mechanism. When shaft \( A \) (Fig. 5-2) is applying driving torque through the coupling, or overrunning clutch, the clutch acts as a solid drive and causes shaft \( B \) to turn at the same speed as shaft \( A \). However if shaft \( A \) should slow down or stop, shaft \( B \) could still turn faster than, or overrun, shaft \( A \). In this case, the clutch "uncouples" the two shafts and thereby permits shaft \( B \) to overrun.

In the car, shaft \( A \) would be attached to the transmission output shaft while shaft \( B \) would be attached to the propeller shaft. With the engine driving the car, the overrunning clutch would "clutch" and act as a solid drive so that shafts \( A \) and \( B \) would turn at the same speed. But with the accelerator pedal released so the engine slows down, shaft \( B \) could then overrun shaft \( A \) and the car would therefore coast or freewheel. This is the actual operation of freewheeling devices used on cars a number of years ago. In the overdrive, however, the action is somewhat different.

Figure 5-3 shows the inner parts of an overrunning clutch used in an overdrive. The only additional item needed to complete the overrunning clutch shown is an outer shell or race that encloses the rollers. Figure 5-4 shows, in end view, the action of the overrunning clutch. The clutch contains an inner shell, or race, which has a series of high spots or cams evenly spaced around its entire circumference. There is one cam for each roller. This inner race, with cams, is usually called the clutch cam. A number of hardened-steel rollers lie in the low areas between the high spots on the clutch cam. These rollers, in turn, are held in place by an outer shell, or race. There is also a roller retainer, or roller cage, as shown in Fig. 5-5, which simply retains the rollers in the proper relative
Overdrives

§42

positions. The inner race drives, the outer race is driven. Also, the outer race can overrun, or turn faster than, the inner race.

When the inner race is driving, and turning the outer race at the same speed, then the condition is as shown at A in Fig. 5-4. The rollers have been turned up onto the high spots, or cams, of the inner race, thus jamming between the two races. The outer race therefore is forced to turn with the inner race. The overrunning clutch acts as a solid drive.

Fig. 5-3. The inner parts of an overrunning clutch, or freewheeling mechanism, used in an overdrive. The rubber band is not part of the assembly, but is shown since it is temporarily holding the rollers in place. In the actual assembly, an outer race holds the rollers in place. (Studebaker-Packard Corporation)

However, if the inner race should slow down or stop, the outer race can continue to turn, or overrun, the inner race. As this happens, the rollers are rolled forward into the low spots on the clutch cam. There, they no longer jam between the two races and the outer race can overrun freely (B in Fig. 5-4). But when the inner race speeds up again and catches up with the outer race, the rollers once more jam so that the inner race drives the outer race, both again turn at the same speed.

§42. Planetary gear system The planetary gear system as used in the overdrive and in automatic transmissions consists of an outer ring gear (sometimes called the internal gear because its teeth are
Fig. 5-4. Action in the overrunning clutch when driving (A) and when overrunning (B). (American Motors Corporation)

Fig. 5-5. Parts in a planetary gear system. (American Motors Corporation)

inside), three planet pinions held on pinion shafts in a cage, and a sun gear (Fig. 5-5). The planetary gear system gets its name from the fact that the pinions revolve around the sun gear and rotate at the same time, just as the planets in our solar system rotate and revolve around the Sun. Figure 1-13 shows a disassembled view of a simple planetary gear system.
Before we discuss the manner in which the planetary gear system is used in the overdrive, let us see just how the system functions when we hold one of the three members (ring gear, planet-pinion cage, or sun gear) stationary and turn another member. The chart, Fig. 5-6, shows what will happen with different combinations, and the following paragraphs explain these various combinations.

1. **Speed increase.** If we turn the planet-pinion cage and hold the sun gear stationary, the planet-pinion shafts will be carried around with the cage. As this happens, the planet pinions must rotate on their shafts since the pinions are meshed with the sun gear. In a sense, they "walk around" the stationary sun gear, rotating on their shafts as they and the cage revolve around the sun gear. And since the planet pinions are meshed with the ring gear, they also cause the ring gear to rotate. Actually, the ring gear, in this case, will rotate faster than the planet-pinion cage.

Figure 5-7 illustrates how the stationary sun gear causes the ring gear to turn faster than the planet-pinion cage. At any given instant, the pinion tooth meshed with the sun gear is stationary since the sun gear itself is stationary. The pinion, therefore, can be said to be pivoting around this stationary tooth. If the pinion shaft is moving 1 foot per second, as shown in the illustration, then the outside tooth must be moving faster than 1 foot per second. That is, the outside tooth, and also the ring gear with which it is meshed, moves faster than the shaft. Thus the ring gear rotates faster than the planet-pinion cage.

![Chart showing the various conditions that are possible in the planetary gear system if one member is held and another is turned.](image)

**Legend:**
- D—Driven
- H—Hold
- T—Turn or Drive
- R—Reverse
- I—Increasing of Speed
- IR—Increasing of Speed and Reverse
- L—Reduction of Speed

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Fig. 5-6. Chart showing the various conditions that are possible in the planetary gear system if one member is held and another is turned.

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The ratio between the planet-pinion cage and the ring gear can be altered by changing the sizes of the different gears. In the example shown in Fig. 5-8, the ring gear makes one complete revolution while the planet-pinion cage turns only 0.7 revolution. In other words, the ring gear is running faster than the cage, and the gear ratio between the two is 1:0.7. The system functions as a speed-increasing mechanism since the driven member (ring gear) turns faster than the driving member (planet-pinion cage).

2. Speed reduction. If we turn the ring gear while holding the sun gear stationary (Fig. 5-6), the planet-pinion cage will turn more slowly than the ring gear. In this case, the system functions as a speed-reducing mechanism since the driven member (planet-pinion cage) turns more slowly than the driving member (ring gear).

3. Speed reduction. Let us try another combination and see what happens if we hold the ring gear stationary and turn the sun gear. We find that the planet pinions turn on their shafts. They must also "walk around" the ring gear since they are in mesh with it. As they do this, the planet-pinion cage is carried around. The cage therefore rotates, but at a speed less than the sun-gear speed. In this case, the system functions as a speed-reducing mechanism. The driven member (planet-pinion cage) turns more slowly than the driving member (sun gear).

4. Speed increase. Another combination would be to hold the ring gear and turn the planet-pinion cage. In this case, the sun gear would be forced to rotate faster than the cage and the system would function as a speed-increasing mechanism. The driven member (sun gear) turns faster than the driving member (planet-pinion cage).

5. Reverse. Still another combination would be to hold the
Overdrives

planet-carrier cage stationary and turn the ring gear. In this case, the planet pinions act as idlers, similar to the reverse idler gear in a standard transmission, and thereby cause the sun gear to turn in the reverse direction to ring-gear rotation. Thus, the system functions as a reverse-rotation system, with the sun gear turning faster than the ring gear.

6. Reverse. There is still one more combination. If the cage is held and the sun gear is turned, then the ring gear will turn in a reverse direction, but slower than the sun gear.

7. Direct drive. If any two of the three members (sun gear, cage, ring gear) are locked together, then the entire planetary gear system is locked out and the input shaft and output shaft must turn at the same speeds. That is, there is no change of speed through the system and the drive ratio is 1:1. On the other hand, if no member is held stationary and no two members are locked together, then the system will not transmit power at all. The input shaft may turn but the output shaft does not.

8. Planetary gear system applied to overdrive. In the overdrive, the ring gear is attached to the output shaft while the three planet pinions are assembled into a cage that is splined to the transmission
Fig. 58. Disassembled view of an overdrive.

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Overdrives

main shaft. The sun gear has an arrangement whereby it may be permitted to turn or it may be locked in a stationary position. When it is locked, the ring gear (and thus the output shaft) is forced to turn faster than the transmission main shaft. In other words, the output shaft overdrives the transmission main shaft. Various views of the overdrive parts show the planetary gear members (Figs. 5-9 to 5-15).

Overdrive operation

Figure 5-9 shows the component parts of one type of overdrive in exploded view, with all major parts disassembled but lined up in their approximate relationship in the actual assembly. Figures 5-9 to 5-15 show various operating aspects of the overdrive assembly. Figures 5-10 and 5-11 illustrates the relationship of the overdrive parts and the power path through the overdrive when it is in direct drive. The transmission main shaft
and the output shaft turn at the same speed, and the driving action is through the overrunning clutch or freewheeling mechanism. In both illustrations, the power path is shown by a white line or by arrows. Note that the power path is directly to the clutch cam which is splined to the transmission main shaft. From the clutch cam, it passes through the rollers to the outer shell or race which is attached to the output shaft. Figure 5-10 shows the overdrive in cutaway view while Fig. 5-11 shows the overdrive partly cut away with the parts extended so they can be more easily seen.

1. **Going into overdrive.** In Figs. 5-10 and 5-11, although the overdrive is in direct drive, it is ready to go into overdrive just as soon as the car speed is great enough and the driver momentarily releases the accelerator. Note that, in the two illustrations, the pawl in the solenoid is out of the way of the sun-gear control plate. It is held in this position by the blocker ring as shown at A in Fig. 5-12. The blocker ring is loosely assembled onto the sun-gear control plate so it can turn a few degrees one way or the other.

When the car reaches overdrive cut-in speed (roughly between 18 and 21 mph), a governor driven from the overdrive output shaft closes electric contacts. This connects the solenoid to the battery and the solenoid is therefore energized. This spring-loads the solenoid pawl so it attempts to move upward and into a notch in the
sun-gear control plate. However, the pawl is held away by the blocker ring as shown at A in Fig. 5-12.

When the driver momentarily releases the accelerator pedal, the engine speed drops. As it drops, the freewheeling mechanism goes into action to permit the output shaft to overrun the transmission shaft. When this happens, the sun gear slows and then reverses direction. It does this because the ring gear (which rotates with the output shaft) begins to drive it through the planet pinions.

At the moment that the sun gear reverses directions, it moves the blocker ring around a few degrees as shown at B in Fig. 5-12. When this happens, the pawl can move inward and into the next notch on the sun-gear control plate that comes around. This locks the control plate in a stationary position.

Since the control plate is splined to the sun gear, this action also locks the sun gear in a stationary position. Now, when the driver again steps on the accelerator and engine speed increases, the car goes into overdrive. With the sun gear locked, the power flow is as shown in Figs. 5-13 and 5-14. The transmission main shaft drives through the planet pinion cage (splined to the transmission main shaft) and causes the pinions to rotate around the sun gear as shown in Fig. 5-7. The ring gear is attached to the output shaft through the outer race of the freewheeling mechanism. Thus the ring gear and output shaft overdrive (turn faster than) the trans-
Fig. 5-13. With the sun gear held stationary and the planet-pinion cage being driven by the transmission main shaft, the ring gear (and output shaft) is forced to turn faster than (or to overdrive) the main shaft. (*Ford Division of Ford Motor Company*)

mission main shaft. Note that under this condition the freewheeling mechanism is freewheeling. That is, the outer race is overrunning the clutch cam and thus the transmission main shaft.

2. Coming out of overdrive. To come out of overdrive, the driver merely pushes the accelerator all the way down. This would be the action the driver would take when he wants an extra burst of power, for example, to pass another car. Pushing the accelerator all
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the way down causes the accelerator pedal to operate a kick-down switch. Operation of this switch produces two actions. First, it opens the solenoid circuit so that the solenoid attempts to withdraw the pawl from the sun-gear control plate. However, there is considerable pressure on the pawl since it is holding the sun gear stationary and the planet pinions are thrusting hard against the sun gear as they drive the ring gear. The second action of the kick-down switch momentarily relieves this drive, however, since the kick-down switch also opens the ignition circuit and thereby prevents the engine from delivering power. Since the engine will slow down if it is not delivering power, the driving thrust of the planet pinions on the sun gear is almost instantly relieved. This frees the sun gear and sun-gear control plate and the drive pawl is pulled back by the spring in the solenoid. As the drive pawl plunger in the solenoid “bottoms,” it reestablishes the electric circuit to the ignition system so the engine once again begins to deliver power. Now, with the sun gear unlocked, drive is again direct as shown in Figs. 5-10 and 5-11.

The ignition system is disconnected for such a short time that the interruption of the flow of power is not noticeable. The entire sequence of events that takes place when the kick-down switch is closed may be completed in less than a second; the car goes from overdrive into direct drive very quickly.

When the driver again wants to go into overdrive, he has merely to lift his foot momentarily from the accelerator pedal as already explained.

The electric controls involved in the overdrive action are described in the following section. Figure 5-16 illustrates the wiring circuit of the controls.

3. Locking out the overdrive. If the driver wants to lock out the overdrive, he pulls out a control knob on the car dash. This forces the control rod in the direction shown in Fig. 5-15. As the control rod moves in this direction, it forces the sun-gear cover plate and sun gear to move toward the planet-pinion cage. The sun-gear teeth enter into mesh with internal teeth in the planet-pinion cage so that the two lock up. Under this condition, the sun gear and pinion cage must turn together, and thus the entire assembly turns as a unit so there can be no overrunning effect. The movement of the control rod also operates an electric switch that opens the circuit
between the governor and solenoid so that the electric control circuit is inoperative.

Note: The overdrive explained above is but one of several types that have been used on automobiles. It is typical of them all, however, since all are essentially similar in construction and action.

Fig. 5-15. Positions of the internal parts when the overdrive is locked out. Movement of a dash control shifts a control rod which locks up the sun gear and the planet-pinion cage so the two must turn together. (American Motors Corporation)

§44. Overdrive electric controls Various types of electric controls of overdrives have been used, but essentially, they have the same purpose. They must energize the solenoid as the car reaches cut-in speed. They must also disconnect the ignition circuit momentarily and at the same time open the solenoid circuit when the kick-down switch is closed as the driver wants to come out of overdrive.
Overdrives

Figure 5-16 shows a wiring circuit of the electric control system used with the overdrive described on previous pages. Note that the system also includes an overdrive lock-out switch, which is connected into the circuit between the governor switch and the solenoid. When the overdrive is locked out, this switch is open so that the electric control circuit is inoperative. Let us trace this circuit in detail.

When the driver wants to go into overdrive, he pushes in the control knob on the dash. This places the system in the condition shown in Fig. 5-10 and connects the governor switch to the solenoid relay (through the upper contacts of the kick-down switch, as you will notice). When the car reaches cut-in speed, the governor closes its contacts to connect the overdrive relay winding to the battery. The overdrive relay, in turn, closes its contacts to connect the solenoid to the battery. Now, the overdrive is ready to go into action. When the driver momentarily releases the pedal, the solenoid can send the pawl into a notch in the sun-gear control plate. This puts the transmission into overdrive.

To come out of overdrive, the driver pushes all the way down on the accelerator pedal, thus causing the upper contacts of the kick-
down switch to open and the lower contacts to close. Opening the upper contacts opens the overdrive relay circuit. The overdrive relay therefore opens its contacts to open the solenoid circuit. Also, closing the lower contacts in the kick-down switch directly grounds the ignition coil and thereby prevents any ignition. With this interruption of ignition-system action, the engine stops delivering power and begins to slow down. As it does this, the thrust of the solenoid pawl is relieved, and the spring pressure pulls the pawl out of the notch in the sun-gear control plate. When the solenoid pawl snaps into the "out" position, the contacts in the solenoid are opened to "unground" the ignition coil and thereby permit the ignition system to again function. The engine again begins to deliver power. This series of actions take place so quickly that no appreciable lag in power delivery is noticeable.

CHAPTER CHECKUP

Note: Since the following is a chapter review test, you should review the chapter before taking it.

You have been making very good progress in your studies of automotive power trains and their components. In Chap. 4, you studied various transmissions used on cars, and in the chapter just finished, you studied overdrives used with some of these transmissions. Actually, there is a double purpose in your studying the overdrive. First, of course, you should know how these devices are constructed and how they operate. Second, the component parts are used in one way or another in different automatic transmissions. Thus, a good understanding of the overdrive will lead to much easier understanding of the most intricate types of automatic transmissions. To give you a chance to check yourself on how well you understand and remember the overdrive, the following questions have been included. If any of the questions cause you trouble, just turn back into the chapter and reread the pages that will clear up the difficulty.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. The overdrive is located between the transmission and clutch.

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2. The freewheeling mechanism contains a planetary gear, a transmission, an overrunning clutch, and a propeller shaft.
3. The number of gears and pinions in the planetary gear system described in the chapter is two, three, five, or eight.
4. The sun gear in the planetary gear system meshes with the ring gear, clutch gear, planet pinions, and pinion cage.
5. Holding the sun gear stationary and turning the planet-pinion cage causes the ring gear to turn slower than faster than at the same speed as the planet-pinion cage.
6. In the overdrive, there is an arrangement whereby it is possible to lock stationary the ring gear, sun gear, planet-pinion cage.
7. In order to go into overdrive, the planet-pinion cage, sun gear, and ring gear must be prevented from turning.
8. When coming out of overdrive, the overdrive electric control momentarily declutches the engine, interrupts ignition system action, de-meshes the sun gear.
9. If the ring gear is turned while the sun gear is held stationary, the planet-pinion cage will turn slower than at the same speed as faster than the ring gear.
10. If the cage is held and the sun gear is turned, the ring gear will turn in a reverse direction but slower than at the same speed as faster than the sun gear.

Listing Parts

In the following, you are asked to list parts that go into various automotive transmissions discussed in the chapter. Write down the lists in your notebook.

1. Make a list of the parts in the planetary gear system.
2. Make a list of the parts in the overrunning clutch.
3. Make a list of the electrical components in the control circuit of the overdrive.
4. Make a list of major parts in the overdrive.
5. Make a list of the parts through which the power passes when the car is in overdrive.

Purpose and Operation of Components

In the following, you are asked to write down the purpose and operation of the overdrives and overdrive components described in the chapter. If you have any difficulty in writing down your explanation, turn
back in the chapter and reread the pages that will give you the answer. Then write down your explanation. Don't copy; try to tell it in your own words, just as you might explain it to a friend. This is a good way to fix the explanation more firmly in your mind. Write in your notebook.

1. What is the purpose of the overdrive?
2. How does the planetary gear system work when the sun gear is held stationary?
3. What is the purpose of the solenoid pawl? Describe the actions that permit the pawl to enter a notch in the sun-gear control plate.
4. Explain how the overdrive is locked out.
5. Explain what happens when the driver pushes the accelerator all the way down to come out of overdrive.
6. Explain the operation of the electric controls when the car speed increases to cut-in and the overdrive goes into operation.

SUGGESTIONS FOR FURTHER STUDY

If you are able to get hold of an overdrive or the parts of an overdrive, make a careful examination of the parts to determine how they fit together and operate. Note particularly the construction and operation of the overrunning clutch and the planetary gear system. Study car manufacturers' manuals to learn more about overdrives. While the unit described in the chapter is the most commonly used overdrive, other types have been used. Learn all you can about these other types by studying the manuals or by actually examining them, if possible. Be sure to write down in your notebook any important facts you come across.
6: **Standard transmission and overdrive service**

THIS CHAPTER describes the trouble-shooting, removal, overhaul, and reassembly procedures on various standard transmissions and overdrives. Following chapters discuss the operation and maintenance of the different semiautomatic and automatic transmissions in use on passenger cars.

§45. **Diagnosing standard transmission and overdrive troubles** As a first step in any transmission or overdrive service, diagnosis of the trouble should be made in an attempt to pin-point the trouble in the malfunctioning unit. Sometimes it is not possible to determine the exact location of a trouble and the unit must be removed from the car so it can be torn down and examined. At other times diagnosis will lead to the point of trouble so that it can be eliminated without major disassembly. It is also true that the diagnosis may indicate that the transmission or overdrive must be removed. Nevertheless, it is a saving in time and effort in the long run to always check the operation of the assembly on the car in an effort to find the source of trouble. It may be that what was thought to be a case of transmission trouble is actually a trouble located in some other component of the car.

The chart that follows lists the various troubles that might be blamed on the transmission or overdrive, together with their possible causes, the checks to be made, and the corrections needed.

§46. **Transmission and overdrive trouble-shooting chart** The chart below is divided into three parts: Transmission Troubles, Vacuum-gearshift Troubles, and Overdrive Troubles. Most transmission troubles can be listed under a few headings such as “hard shifting,” “will not stay in gear,” “noises,” and so on. In the chart, possible causes of the various troubles are listed, and references are made to
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numbered sections where fuller explanations are found of how to find and eliminate the troubles.

NOTE: The troubles and possible causes are not listed in the chart in the order of frequency of occurrence. That is, item 1 (or item a) does not necessarily occur more frequently that item 2 (or item b).

TRANSMISSION TROUBLE-SHOOTING CHART

(See §§47 to 53 for detailed explanations of trouble causes and corrections listed below.)

<table>
<thead>
<tr>
<th>Complaint</th>
<th>Possible Cause</th>
<th>Check or Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hard shifting into gear (§47)</td>
<td>Clutch not releasing</td>
<td>Adjust. See §17</td>
</tr>
<tr>
<td></td>
<td>Gearshift linkage out of adjustment</td>
<td>Adjust</td>
</tr>
<tr>
<td></td>
<td>Improper lubrication of linkage</td>
<td>Lubricate</td>
</tr>
<tr>
<td></td>
<td>Shifter fork bent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sliding gear tight on shaft splines</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sliding-gear teeth battered</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Synchronizing unit damaged</td>
<td>Replace defective parts</td>
</tr>
<tr>
<td>2. Transmission sticks in gear (§48)</td>
<td>Clutch not releasing</td>
<td>Adjust. See §17</td>
</tr>
<tr>
<td></td>
<td>Gearshift linkage out of adjustment</td>
<td>Adjust</td>
</tr>
<tr>
<td></td>
<td>Improper lubrication of linkage</td>
<td>Lubricate</td>
</tr>
<tr>
<td></td>
<td>Detent balls (lock-out) stuck</td>
<td>Free</td>
</tr>
<tr>
<td></td>
<td>Gears tight on shaft splines</td>
<td>Clean splines or replace shaft or gears</td>
</tr>
<tr>
<td>3. Transmission slips out of first or reverse (§49)</td>
<td>Gearshift linkage out of adjustment</td>
<td>Adjust</td>
</tr>
<tr>
<td></td>
<td>Gear loose on main shaft</td>
<td>Replace shaft or gear</td>
</tr>
<tr>
<td></td>
<td>Gear teeth worn</td>
<td>Replace gear</td>
</tr>
<tr>
<td></td>
<td>Excessive end play of gears</td>
<td>Replace worn or loose parts</td>
</tr>
</tbody>
</table>
### Standard Transmission and Overdrive Service

<table>
<thead>
<tr>
<th>Complaint</th>
<th>Possible Cause</th>
<th>Check or Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Transmission slips out of second (§49)</td>
<td>e. Insufficient shift-lever spring (lock-out) tension</td>
<td>Install new spring</td>
</tr>
<tr>
<td>4. Transmission slips out of second (§49)</td>
<td>f. Bearings worn</td>
<td>Replace</td>
</tr>
<tr>
<td>4. Transmission slips out of second (§49)</td>
<td>a. Gearshift linkage out of adjustment</td>
<td>Adjust</td>
</tr>
<tr>
<td>4. Transmission slips out of second (§49)</td>
<td>b. Gear or drum loose on main shaft</td>
<td>Replace worn parts</td>
</tr>
<tr>
<td>4. Transmission slips out of second (§49)</td>
<td>c. Excessive main-shaft end play</td>
<td>Replace worn or defective parts</td>
</tr>
<tr>
<td>4. Transmission slips out of second (§49)</td>
<td>d. Gear teeth worn</td>
<td>Replace gears</td>
</tr>
<tr>
<td>4. Transmission slips out of second (§49)</td>
<td>e. Insufficient shift-lever spring (lock-out) tension</td>
<td>Install new spring</td>
</tr>
<tr>
<td>5. Transmission slips out of high (§49)</td>
<td>a. Gearshift linkage out of adjustment</td>
<td>Adjust</td>
</tr>
<tr>
<td>5. Transmission slips out of high (§49)</td>
<td>b. Misalignment between engine and transmission</td>
<td>Realign</td>
</tr>
<tr>
<td>5. Transmission slips out of high (§49)</td>
<td>c. Excessive main-shaft end play</td>
<td>Replace worn or defective parts</td>
</tr>
<tr>
<td>5. Transmission slips out of high (§49)</td>
<td>d. Gear teeth worn</td>
<td>Replace gears</td>
</tr>
<tr>
<td>5. Transmission slips out of high (§49)</td>
<td>e. Insufficient shift-lever spring (lock-out) tension</td>
<td>Replace spring</td>
</tr>
<tr>
<td>5. Transmission slips out of high (§49)</td>
<td>f. Bearings worn</td>
<td>Replace</td>
</tr>
<tr>
<td>5. Transmission slips out of high (§49)</td>
<td>g. Synchronizing unit worn or defective</td>
<td>Replace worn parts</td>
</tr>
<tr>
<td>6. No power through transmission (§50)</td>
<td>a. Clutch slipping</td>
<td>Adjust (§15)</td>
</tr>
<tr>
<td>6. No power through transmission (§50)</td>
<td>b. Gear teeth stripped</td>
<td>Replace gear</td>
</tr>
<tr>
<td>6. No power through transmission (§50)</td>
<td>c. Shifter fork or other linkage part broken</td>
<td>Replace</td>
</tr>
<tr>
<td>6. No power through transmission (§50)</td>
<td>d. Gear or shaft broken</td>
<td>Replace</td>
</tr>
<tr>
<td>7. Transmission noisy in neutral (§51)</td>
<td>e. Drive key sheared</td>
<td>Replace</td>
</tr>
<tr>
<td>7. Transmission noisy in neutral (§51)</td>
<td>a. Transmission misaligned with engine</td>
<td>Realign</td>
</tr>
<tr>
<td>7. Transmission noisy in neutral (§51)</td>
<td>b. Bearings worn or dry</td>
<td>Replace, lubricate</td>
</tr>
</tbody>
</table>
### Automotive Transmissions and Power Trains

**Complaint**

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Check or Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Transmission noisy in gear (§51)</td>
<td></td>
</tr>
<tr>
<td>a. Clutch friction disk defective</td>
<td>Replace</td>
</tr>
<tr>
<td>b. Engine torsional-vibration damper defective</td>
<td>Replace or adjust</td>
</tr>
<tr>
<td>c. Main rear bearing of transmission worn or dry</td>
<td>Replace or lubricate</td>
</tr>
<tr>
<td>d. Gears loose on main shaft</td>
<td>Replace worn parts</td>
</tr>
<tr>
<td>e. Gear teeth worn</td>
<td>Replace gears</td>
</tr>
<tr>
<td>f. Speedometer gears worn</td>
<td>Replace</td>
</tr>
<tr>
<td>g. Conditions noted in item 7, Transmission noisy in neutral. Refer to item 7, above, for other causes.</td>
<td></td>
</tr>
<tr>
<td>9. Gears clash in shifting (§52)</td>
<td></td>
</tr>
<tr>
<td>a. Clutch not releasing</td>
<td>Adjust</td>
</tr>
<tr>
<td>b. Synchronizer defective</td>
<td>Replace defective parts</td>
</tr>
<tr>
<td>c. Gears sticky on main shaft</td>
<td>Free, Replace defective parts</td>
</tr>
<tr>
<td>10. Oil leaks (§53)</td>
<td></td>
</tr>
<tr>
<td>a. Improper lubricant</td>
<td>Use recommended lubricant</td>
</tr>
<tr>
<td>b. Lubricant level too high</td>
<td>Use proper amount, no more</td>
</tr>
<tr>
<td>c. Gaskets broken or missing</td>
<td>Install new gaskets</td>
</tr>
<tr>
<td>d. Oil seals damaged or missing</td>
<td>Install new oil seals</td>
</tr>
<tr>
<td>e. Oil slingers damaged, improperly installed, or missing</td>
<td>Install oil slingers properly</td>
</tr>
</tbody>
</table>
Standard Transmission and Overdrive Service

Complaint Possible Cause Check or Correction

f. Drain plug loose Tighten

g. Transmission bearing-retainer bolts loose Tighten

h. Transmission case cracked Use new case

Vacuum-gearshift Troubles

(The vacuum gearshift may have any of the troubles listed in the chart above. In addition, there are certain special troubles it may have, as follows.)

11. Hard shifting (§54) Vacuum cylinder inoperative Eliminate vacuum line leaks, adjust linkages, replace damaged piston or valves in cylinder

12. Shift lever jams (§54) a. Pivot pins binding Free, adjust

b. Bent rod or lever Straighten, replace

c. Linkage out of adjustment Adjust

13. Slipping out of mesh (§54) a. Defective vacuum cylinder Replace valves, piston, or other defective part

b. Linkages out of adjustment Adjust

14. Gear position blocked out (§54) a. Bent linkage rod Straighten

b. Linkage out of adjustment Adjust

c. Mechanical interference around vacuum cylinder Eliminate interference

Overdrive Troubles

(The overdrive may have any of the trouble listed below. Be careful, in analyzing trouble on a car equipped with overdrive, not to blame the overdrive for troubles in the transmission, or vice versa. For example, a certain overdrive trouble may prevent shifting the transmission into reverse. It would be easy to blame this on the transmission, whereas the fault would actually lie in the overdrive.)
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<table>
<thead>
<tr>
<th>Complaint</th>
<th>Possible Cause</th>
<th>Check or Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>15. Will not go into overdrive (§55, 1)</td>
<td>a. Wiring defective</td>
<td>Tighten connections,</td>
</tr>
<tr>
<td></td>
<td>b. Governor defective</td>
<td>Install new wiring</td>
</tr>
<tr>
<td></td>
<td>c. Kick-down switch defective</td>
<td>Install new switch</td>
</tr>
<tr>
<td></td>
<td>d. Relay defective</td>
<td>Install new relay</td>
</tr>
<tr>
<td></td>
<td>e. Solenoid defective</td>
<td>Install new solenoid</td>
</tr>
<tr>
<td></td>
<td>f. Linkage to control knob on dash out of adjustment</td>
<td>Adjust</td>
</tr>
<tr>
<td></td>
<td>g. Defect in overdrive including gear jammed or broken, overrun-ning clutch defective, excessive shaft end play</td>
<td>Disassemble overdrive to eliminate defective part, tighten flange nut</td>
</tr>
<tr>
<td>16. Will not come out of overdrive (§55, 2)</td>
<td>a. Wiring defective</td>
<td>Tighten connections,</td>
</tr>
<tr>
<td></td>
<td>b. Kick-down switch defective</td>
<td>Install new wiring</td>
</tr>
<tr>
<td></td>
<td>c. Solenoid defective</td>
<td>Install new switch</td>
</tr>
<tr>
<td></td>
<td>d. Pawl jammed</td>
<td>Free pawl</td>
</tr>
<tr>
<td></td>
<td>e. Sun gear jammed</td>
<td>Disassemble overdrive to eliminate jam and replace defective parts</td>
</tr>
<tr>
<td>17. Cannot shift into reverse and overdrive dash knob jammed in OD position (§55, 3)</td>
<td>a. Pawl jammed in sun-gear control plate</td>
<td>Replace solenoid</td>
</tr>
<tr>
<td></td>
<td>b. Solenoid defective</td>
<td>Replace solenoid</td>
</tr>
<tr>
<td></td>
<td>c. Relay defective</td>
<td>Replace relay</td>
</tr>
<tr>
<td></td>
<td>d. Governor grounded</td>
<td>Replace governor</td>
</tr>
<tr>
<td></td>
<td>e. Reverse lock-out switch grounded</td>
<td>Replace switch</td>
</tr>
<tr>
<td></td>
<td>f. Kick-down switch defective</td>
<td>Replace switch</td>
</tr>
<tr>
<td></td>
<td>g. Wiring defective</td>
<td>Tighten connections,</td>
</tr>
<tr>
<td></td>
<td>h. Sun gear jammed</td>
<td>replace wiring</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disassemble overdrive to eliminate jam</td>
</tr>
<tr>
<td>Complaint</td>
<td>Possible Cause</td>
<td>Check or Correction</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>18. No power through</td>
<td>a. <strong>Overrunning</strong> clutch slipping</td>
<td>Replace defective parts in overdrive</td>
</tr>
<tr>
<td>overdrive (§55, 4)</td>
<td>b. Planetary parts broken</td>
<td>Replace defective parts</td>
</tr>
<tr>
<td>19. Noises in overdrive (§55, 5)</td>
<td>a. Gears worn, chipped, broken</td>
<td>Replace defective gears</td>
</tr>
<tr>
<td></td>
<td>b. Main-shaft bearing worn or scored</td>
<td>Replace</td>
</tr>
<tr>
<td></td>
<td>c. <strong>Overrunning</strong> clutch parts worn or scored</td>
<td>Replace</td>
</tr>
<tr>
<td>20. Oil leaks (§55, 6)</td>
<td>a. <strong>Defective or broken</strong> gaskets or oil seals</td>
<td>Replace</td>
</tr>
<tr>
<td></td>
<td>b. Loose mounting</td>
<td>Tighten mounting bolts</td>
</tr>
<tr>
<td></td>
<td>c. Excessive lubricant</td>
<td>Put in only specified amount, no more</td>
</tr>
</tbody>
</table>

**§47. Hard shifting into gear**

Hard shifting into gear might be caused by improper linkage adjustment between the gearshift lever and the transmission. Improper adjustment might greatly increase the pressure necessary for gear shifting. The same trouble could result when the linkage is badly in need of lubrication and is rusted or jammed at any of the pivot points. Adjustment and lubrication of linkages is discussed in §60.

Another cause of this trouble could be due to failure of the clutch to release completely. If the clutch linkage is out of adjustment or if other conditions, as outlined in §17, prevent full clutch disengagement, then it will be difficult to shift gears into or out of mesh. Gear clashing will probably result since the engine will still be delivering at least some power through the clutch to the transmission. See §17 for corrections of this sort of clutch trouble.

Inside the transmission, hard gear shifting could be caused by a bent shifter fork, sliding gear tight on the shaft splines, sliding-gear teeth battered, or a damaged synchronizing unit. A bent shifter fork, which might make it necessary to exert greater pressure in order to shift gears, should be replaced or, if not too badly bent,
straightened. The splines in the gears or on the shaft may become gummed up or battered from excessive wear so that the gear will not move easily along the shaft splines. If this happens, the shaft and gears should be cleaned or, if worn, replaced. If the gear teeth are battered, they will not slip into mesh easily. Nothing can be done to repair gears with battered teeth; new gears will be required.

The synchronizing unit could be tight on the shaft, or it could have loose parts or worn or scored cones; any of these would increase the difficulty of meshing. To clear up troubles in the transmission, it must be removed and disassembled. Sections in the latter part of the chapter describe these operations.

§48. Transmission sticks in gear

A number of the conditions that cause hard shifting into gear can also cause the transmission to stick in gear. For instance, improper linkage adjustment between the gearshift lever and the transmission, as well as lack of lubrication in the linkage, could make it hard to shift out of mesh. Adjustment and lubrication of linkages is discussed in §60.

Another cause could be failure of the clutch to release completely. Improper clutch-linkage adjustment, as well as other conditions outlined in §17 that prevent full release of the clutch, could make it hard to shift out of mesh. See §17 for correction of this type of clutch trouble.

If the detent balls (or the lock-out mechanism in the transmission) stick and do not unlock readily when shifting is attempted, it will be hard to shift out of gear. They should be freed and lubricated.

If the gears do not slide freely on the shaft splines, then it will be hard to come out of mesh. The shaft and gears should be cleaned or, if worn, replaced. See the latter part of this chapter for transmission removal, disassembly, reassembly, and replacement procedures.

§49. Transmission slips out of gear

Improperly adjusted gearshift linkage between the gearshift lever and transmission might produce pressure on the linkage in such a way that gears would work out of mesh. Linkage adjustment is outlined in §60.

Worn gears or gear teeth may also increase the chances of gears coming out of mesh. Likewise, if the detent balls (or lock-out mechanism in the transmission) lack sufficient spring pressure,
there will be little to hold the gears in mesh and they may slip out. Worn bearings or gears loose on the shaft tend to cause excessive end play or free motion that allows the gears to de-mesh.

In addition, if the transmission slips out of high gear, it could be due to misalignment between the transmission and the engine. This is a serious condition which can soon damage the clutch as well as transmission parts. This misalignment can often be detected by the action of the clutch pedal; it causes clutch-pedal pulsations or a nervous pedal as explained in §19. Section 30 describes the procedure of checking clutch housing alignment; if the clutch housing is out of line, then the transmission will also be out of line.

**§50. No power through transmission** If the transmission is in mesh and the clutch is engaged and yet no power passes through the transmission, then it could be that the clutch is slipping. Section 15 describes various causes of clutch slippage. If the clutch is not slipping, then the trouble is in the transmission and the indication is that something serious has taken place which will require complete transmission overhaul. Conditions inside the transmission that would prevent power from passing through include gear teeth stripped from gear, shifter fork or other linkage part broken, a gear or shaft broken, and a driving key or spline sheared off. The transmission must be taken off and disassembled as explained in the latter part of the chapter so the damaged or broken parts can be replaced.

**§51. Transmission noisy** Several types of noise may be encountered in transmissions. Whining or growling, either steady or intermittent, may be due to worn, chipped, rough, or cracked gears. As the gears continue to wear, the noise may take on a grinding characteristic, particularly in the gear position that throws the greatest load on the worn gears. Bearing trouble often produces a hissing noise that will develop into a bumping or thudding sound as bearings wear badly. Metallic rattles could be due to worn or loose shifting parts in the linkage or to gears loose on shaft splines. Sometimes, if the clutch friction-disk cushion springs, or the engine torsional-vibration dampener, are defective, the torsional vibration of the engine will carry back into the transmission. This would be apparent only at certain engine speeds.
As a first step in analyzing noise in the transmission, note whether the noise is obtained in neutral with the car not moving or in certain gear positions. If the noise is evident with the transmission in neutral with the car not moving, disengage the clutch. If this does not stop the noise, then the chances are the trouble is not in the transmission at all (provided the clutch actually disengages and does not have troubles such as outlined in §17). In this case, the noise is probably in the engine or clutch. But if the noise stops when the clutch is disengaged, then the trouble is probably in the transmission.

Noise obtained in neutral with the clutch engaged could come from transmission misalignment with the engine, worn or dry bearings, worn gears, a worn or bent countershaft, or excessive end play of the countershaft. Notice that these are the parts which are in motion when the clutch is engaged and the transmission is in neutral.

Noise obtained in gear could result from any of the conditions noted in the previous paragraph. Also, it could be due to a defective friction disk in the clutch or a defective engine torsional vibration damper. In addition, the rear main bearing of the transmission could be worn or dry; gears could be loose on the main shaft, or gear teeth could be worn. Another cause of noise could be worn speedometer gears. Careful listening to notice the particular gear position in which the most noise is obtained is often helpful in pinpointing the worn parts producing the noise.

Worn transmission parts should be replaced after transmission removal and disassembly, as outlined in the latter part of the chapter.

§ 52. Gears clash in shifting Gear clashing that accompanies shifting into either second or high may be due to failure of the synchronizing mechanism to operate properly. This might be caused by a broken synchronizer spring, incorrect synchronizer end play, or defective synchronizer cone surfaces. It could also be due to gears sticking on the main shaft or to failure of the clutch to release fully. Gear clash can be obtained in low or reverse on many cars if a sudden shift is made to either of these gears while gears are still in motion. These two gear positions ordinarily do not have synchronmesh devices, and to prevent gear clash when shifting into...
either of these positions, it is necessary to pause long enough to allow the gears to come to rest. Of course, if the clutch is not releasing fully, then the gears will still be driven and may clash when the shift is made.

Conditions that may prevent the clutch from releasing fully are discussed in §17. The latter part of this chapter describes transmission removal and disassembly to replace defective synchromesh parts.

§53. Oil leaks If the lubricant in the transmission case is not of the correct type, it may foam excessively. As it foams, it will completely fill the case and begin to leak out. The same thing might happen if the oil level is too high. In addition, if gaskets are broken or missing or if oil seals or oil slingers are damaged or missing, oil will work past the shafts at the two ends of the transmission. Also, if the drain plug is loose or if the transmission bearing retainer is not tightly bolted to the case, then oil will be lost. A cracked case will also leak oil. The right amount of the recommended oil should be used in the transmission to prevent excessive oil leakage from foaming. The latter part of the chapter explains how to remove and disassemble the transmission so that defective gaskets, oil seals, and slingers can be replaced.

§54. Vacuum-gearshift troubles In addition to the transmission troubles described above, the vacuum-gearshift transmission may be subject at times to other difficulties resulting from improper action of the vacuum-gearshift mechanism. When shifting is hard, it is likely that the vacuum cylinder is not operating normally because of vacuum-line leaks, a damaged piston or valves, or improperly adjusted linkages. Failure of the shift lever to return to the bottom position when released is due to binding at the pivot pins, antirattle bushings, or linkage, or to a bent rod or lever. If the transmission slips out of gear, it may be due to a defective vacuum cylinder or improperly adjusted linkage. Blocking out of a gear position will result from a bent rod, improperly adjusted control lever or linkages, or mechanical interference in or around the vacuum cylinder.

§55. Overdrive troubles Certain conditions in the overdrive will cause such troubles as failure to go into overdrive, failure to come
out of overdrive, inability to shift into reverse or to pull the dash control knob out from the overdrive position, power not passing through the overdrive, noises, and oil leaks. Trouble-shooting these various conditions is detailed in following paragraphs.

1. Will not go into overdrive. If the transmission will not go into overdrive, then a series of electrical tests must be made to determine whether the various electrical components are in normal condition. Refer to Fig. 6-1 to determine points in the electric circuit to make the following checks. First, check the fuse in the overdrive relay. If it is O.K., remove the wire from the governor (No. 15), turn on ignition switch, and touch the wire clip to ground. If a click is heard, the chances are the governor is defective and it should be replaced.

If no click is heard, use a 6-volt lamp in a socket to which two wires are connected (Fig. 6-2) to check for current in various parts of the circuit as explained below. Put one wire end on terminal
No. 2 of the relay and the other wire on ground. If the lamp does not light (ignition switch on), replace the relay. If the lamp lights, check further with the test lamp at terminal No. 9 on the kick-down switch. If the lamp does not light, replace the switch. If it does, then check for current at terminal No. 14 of the lock-out switch. If the lamp does not light, replace the switch. If it does, then current is available through the circuit so far checked.

Next, use the test lamp to check for current at terminal No. 15 on the governor (lead reconnected to this terminal). If the lamp again lights, the circuit from the ignition switch to the governor is in normal condition, and the circuit to the solenoid must be checked.

This is done by first grounding relay terminal No. 2 with a lead connected from this terminal to ground. Then check for current with the test lamp at terminal No. 4. If the lamp does not light, the relay should be replaced. If it does light, then ground terminal No. 15 on the governor and check with test lamp from terminal No. 11 on the solenoid to ground. If the lamp lights, then the solenoid is defective and it must be replaced.

In addition to the electrical tests, certain conditions in the overdrive will prevent it from going into the overdrive position. If the electrical checks prove the electric system is normal, then the overdrive must be removed and disassembled to determine what has caused the difficulty. One condition that does not require removal and disassembly is a loose universal-joint companion-flange nut. This allows shaft end play which might prevent overdrive action. The nut can be tightened by detaching the universal from the companion flange.
2. **Will not come out of overdrive.** Refer to Fig. 6-1 and use a 6-volt test lamp as shown in Fig. 6-2 to test components for current as follows: With ignition switch turned on and distributor contact points open, push kick-down switch into "down" position and check for current at terminal No. 12 on the solenoid. If there is current, the solenoid should be replaced. (Also, mechanical trouble in the overdrive which has jammed the solenoid pawl or sun gear could be holding the mechanism in overdrive.) If there is no current at terminal No. 12, check for current at terminal No. 8 of the kick-down switch. If there is current, adjust the switch linkage in an attempt to get current through to terminal No. 12 when the kick-down switch is pushed down. If adjustment does not help, replace the switch.

3. **Will not shift into reverse and overdrive dash knob is jammed in OD position.** Refer to Fig. 6-1 in making the electrical tests that follow. First, turn ignition switch on and off. If a click is heard in the solenoid when the switch is turned off, one set of tests is to be made. If no click is heard, a second set of tests is to be made.

   a. If a click is heard in the solenoid, if the transmission can now be shifted into reverse, and if the knob can now be pulled out, then disconnect lead from terminal No. 15 on the governor with the ignition switch on. If a click can again be heard, the governor is grounded and it should be replaced. If no click is heard, reconnect lead to terminal No. 15 and disconnect lead from terminal No. 13 of the lock-out switch. If a click is heard, the switch is grounded and it should be replaced. If no click is heard, reconnect lead to terminal No. 13 and disconnect lead from terminal No. 7 of kick-down switch. If a click is heard, the switch is grounded and should be replaced. If no click is heard, reconnect lead to terminal No. 7 and disconnect lead from terminal No. 4 of relay. If a click is heard, replace relay. If no click is heard, then proceed as explained in following paragraph.

   b. If no click is heard when making the original test by turning the ignition switch on and off, as explained in paragraph before last, the probability is that the overdrive solenoid is at fault. It should be replaced. If the solenoid can be pulled straight out without turning one way or the other, check the
pawl control rod to see if it is worn or defective. If the rod will not turn, try to pull pawl out. If it will not come, pawl can usually be released by working it loose with a small rod pushed through the solenoid hole in the adapter plate. If it will not come free, the overdrive must be disassembled.

4. No power through overdrive. This condition could result from broken planetary parts or worn or broken overrunning-clutch components which permit the clutch to slip in the driving position. Either of these conditions requires disassembly of the overdrive so defective parts can be replaced.

5. Noises in the overdrive. Noises in the overdrive can arise from conditions similar to those in the transmission which produce noise. Thus, worn or chipped gears, worn bearings, or worn overrunning-clutch parts will cause noise. Damaged parts must be replaced after the unit is disassembled.

6. Oil leaks. Oil will leak from the overdrive if there is excessive lubricant, if the mounting is loose, or if there are defective gaskets or oil seals. Defective gaskets or oil seals must, of course, be replaced.

CHECK YOUR PROGRESS

Progress Quiz 7

Knowledge of what to check for and what to expect when certain troubles occur helps greatly in diagnosing troubles. If you are acquainted with the various possible conditions that could cause a certain trouble, you will find it much easier to locate the cause quickly. Thus, the material just covered will prove of great value to you as you go into the service shop and begin to service cars with various types of transmission trouble. The quiz below will help you find out just how well you are remembering the material. It will also help you to review the material so that the important points will be fixed more firmly in your mind. If any of the questions stumps you, reread the pages that give the answer.

Correcting Troubles Lists

The purpose of this exercise is to help you to spot related and unrelated troubles on a list. For example, in the list, hard shifting into gear: clutch not releasing, linkage out of adjustment, differential defective, shifter fork bent, sliding gear tight on shaft, gear teeth battered, you
can see that differential defective does not belong because it is the only condition that would not cause hard shifting into gear. Any of the other conditions in the list could cause this trouble.

In each of the lists, you will find one item that does not belong. Write down each list in your notebook, but do not write down the item that does not belong.

1. Hard shifting into gear: clutch not releasing, linkage out of adjustment, shifter fork bent, sliding-gear teeth battered, gear tight on shaft, crankshaft worn, synchronizing unit damaged.
2. Transmission sticks in gear: clutch not releasing, linkage out of adjustment, transmission shifter-lock-out stuck, distributor jammed, gears tight on shaft splines.
3. Transmission slips out of first or reverse: clutch not releasing, linkage out of adjustment, gear loose on shaft, gear teeth worn, excessive end play of gears, bearings worn.
4. Transmission slips out of second: linkage out of adjustment, idler gear loose, gear teeth worn, excessive end play of main shaft.
5. Transmission slips out of high: clutch slipping, transmission misaligned, gears or bearings worn, excessive main-shaft end play.
6. No power through transmission: clutch slipping, gear teeth stripped, shifter-linkage part broken, gear or shaft broken, propeller shaft bent.
7. Transmission noisy in neutral: transmission misaligned with engine, synchromesh cones worn, bearings or gears worn, countershaft bent or has excessive end play.
8. Transmission noisy in gear: bearings or gears worn, clutch friction disk defective, engine torsional-vibration dampener defective and allowing engine vibration to appear in transmission, gears loose on main shaft, steering gear worn.
9. Gears clash in shifting: clutch not releasing, synchronizer defective, gears sticky on main shaft, overrunning clutch slipping.
10. Oil leaks from transmission: foaming, excessive lubricant, gaskets defective, oil seals damaged, clutch slipping.

 Transmission removal and installation
Because of the variations in construction of transmissions on different types of automobile, different procedures must be followed in the removal, disassembly, repair, assembly, and installation of their transmissions. These operations require from about 5 to 7 hours, the difference in time being due to variations in the procedures. Basically, however, the procedures are similar, although it may be found helpful to refer
in general, the following steps are required:

1. Drain lubricant. Some manufacturers recommend flushing the transmission before removal. This is done by filling the transmission with gasoline or kerosene after the lubricant is drained, and then operating the engine with the transmission in neutral for 15 seconds. Then the cleaner should be drained.

2. Disconnect rear axle, front end of propeller shaft, or universal joint, according to type. Where needle bearings are used, tape the bearing retainers to the shaft to avoid losing needles.

3. Disconnect shifting linkages from transmission, hand-brake linkage or spring, and speedometer cable.

4. Install engine support, where specified (see Fig. 6-3).

5. Remove attaching bolts or stud nuts. Where recommended, two pilot or guide pins should be used (Fig. 6-4). These pins are substituted for transmission bolts and prevent damage to the clutch friction disk as the transmission is moved back. The transmission is then moved toward the rear until the main gear shaft clears the clutch disk. It can then be lowered to the floor or raised up through the body, as specified.

6. In general, installation is the reverse of removal. Be sure the matching faces of the transmission and flywheel housing are clean. Place a small amount of lubricant on the splines of the
main gear shift. Carefully support transmission (using guide pins if specified) and move it forward into position. Turn shaft, if necessary, to secure alignment of shaft and clutch-disk hub splines. Put bolts in place and tighten them to the correct tension.

**Caution:** If the transmission does not fit snugly against the flywheel housing, do not force it. Roughness or dirt, or possibly a loose snap ring or other part, may be blocking the transmission. If the bolts are tightened under such circumstances, the transmission case may be broken.

§57. **Transmission disassembly** Transmission service requires a number of special tools, and transmission disassembly should not be attempted without them. Following pages describe and illustrate these tools in use. Because transmission construction varies with [156]
different cars, it is suggested that the manufacturer's shop manual be referred to before disassembly is attempted. Typical disassembly procedures follow.

1. **Chevrolet.** After the transmission has been removed from the car, it may be mounted in a special holding fixture to facilitate its disassembly (Fig. 6-5). Then proceed as follows: Remove four screws, shifter cover, the shifter assembly. Place the transmission in two gears at once to lock the main shaft. In shifting gears into second or third, use care to avoid damaging parts. Detach the universal-joint front yoke and spacer by removing the screw and the lock washer.

Remove clutch gear and bearing by removing four bearing-retainer screws and lock washers and the retainer. A special puller is required to remove the gear and the bearing (Fig. 6-6). Do not attempt to drive the gear and the bearing out, since this will damage the bearing and bearing surfaces. Remove the 14 roller bearings from inside the clutch gear.

Turn the yoke of the special main-shaft removing tool back on the threads and screw the puller shaft into the threaded end of the main shaft. Bolt the yoke of the tool to the face of the transmission case (Fig. 6-7). Turn the front synchronizer ring to line up the
Shift the second-speed gear into the synchronizing drum. Remove the drum assembly, first-and-reverse sliding gear, and the second-
speed gear from the case as a unit. Take the second-speed-gear thrust washer from the case.

Expand the rear-bearing lock ring with a special tool (Fig. 6-8), and tap the bearing into the case. Tap on the outer-bearing race.

Remove the countershaft by driving it from the rear to the front of the case with a soft-steel drift. Remove countergear and thrust washers. Drive out the reverse-idler-shaft expansion plug from the inside of the case with a hook-nosed punch. Drive the idler-shaft lockpin into the shaft. This pin is shorter in length than the diameter of the shaft so that the shaft may be removed while the pin is in the shaft. Do not turn the shaft while removing it, for this might allow the pin to drop down between the idler-shaft bushings where it would wedge. Remove reverse-idler shaft and thrust washers.

Disassemble the clutch gear by clamping the shaft in the soft jaws of a vise and using a special wrench (Fig. 6-9). Remove the bearing from the shaft by using the special press plate over the gear and against the bearing, pressing the shaft out with an arbor press (Fig. 6-10). Do not attempt to drive the shaft out of the bearing as this will damage the bearing.

Disassemble the synchronizing drum by removing the second-speed gear and first-and-reverse sliding gear. Turn the synchronizing
ring in the drum until the ends of the synchronizing-ring retainers can be seen through the slot in the drum sleeve. Use special pliers to expand the retainer so that the synchronizing ring can be removed (Fig. 6-11).

2. **Ford.** Late-model Ford transmissions (Figs. 6-12 and 6-13) are disassembled by taking out the cap screws and loosening the extension from the rear of the case, turning it one-quarter turn, so that the countershaft can be removed. The countershaft is driven out the rear with a dummy shaft (shorter than the countershaft). The countershaft gears, with dummy shaft holding them in alignment, will drop to the bottom of the case. Tap the extension lightly to pull it from the case. The main-shaft assembly will come with it. Do not lose the front bearing rollers. Separate countershaft gears, bearing retainers, rollers, spacers, and dummy shaft. The reverse idler can be removed by driving the shaft from the case with a...
Fig. 6-19. Disassembled view of transmission. (Ford Division of Ford Motor Company)
drift. The main-shaft assembly is disassembled by removing the snap ring, tapping the main shaft out of the extension with light hammer blows, and then taking the parts off the shaft. The parts are held in place with snap rings.

3. Plymouth. Transmissions used in Plymouths in recent years (Fig. 6-14) are disassembled as follows: Remove the speedometer drive pinion, selector-ball-spring screws, and cover assembly. Turn the transmission over and remove the selector balls. Use a special puller to remove the main-shaft flange and brake drum. Take out shifter-fork guide rail. Then, put the gears in neutral and remove the lock screws and shift forks. Take out the lower shifter-rail plug and remove the shifter rails through the front.

Lift out the shifter forks and then remove the extension with the main-shaft assembly. Handle the assembly carefully to prevent disassembly of the synchronizer clutch. Take off the snap ring so that the synchronizer unit and second and low gears will come off. Remove the rear-bearing snap ring and pull the main shaft from the extension. Use a special arbor to drive the countershaft from rear of the case. Pick the key out of the shaft as it clears, and leave the arbor in place to keep the bearing rollers from dropping out. Remove the main-drive pinion and bearing assembly, take off the snap ring and main-gear bearing rollers. Then remove the snap ring and bearing. The countershaft gear set may now be lifted from the case. The reverse-idler gear shaft may be driven out the rear of the case with a special arbor.

58. Inspection of transmission parts After the transmission is disassembled, all parts should be cleaned and carefully inspected as explained in the following paragraphs.

1. Ball bearings. Wash bearings in cleaning solvent to remove old lubricant and dirt (except for sealed bearings which should not be washed). After a bearing is washed, it should be blown dry with compressed air. Do not spin the bearing when drying it since this may damage the races. Hold it to keep it from turning. Examine bearings for cracked races, damaged balls, and wear. Put oil on bearing balls and turn bearing slowly by hand. If a bearing turns roughly, if races are loose, or if the balls or races are discolored (blue- or straw-colored) from overheating, they should be replaced.

2. Roller bearings. Examine the rollers carefully after they have

[163]
| 6.     | Gearshift-rail plug                  | 33. | Drive-pinion bearing                  |
| 7.     | Gearshift rail: second and direct    | 34. | Main-shaft pilot-bearing rollers      |
| 8.     | Gearshift-fork lock screw           | 35. | Main-shaft pilot-bearing snap ring    |
| 10.    | Gearshift rail: first and reverse   | 37. | Synchronizer spring                  |
| 11.    | Gearshift-rail interlock plug       | 38. | Synchronizer shifting plate          |
| 13.    | Gearshift lever                     | 40. | Clutch gear                          |
| 14.    | Gearshift-lever return spring       | 41. | Extension gasket                     |
| 15.    | Gearshift-selector cam and shaft    | 42. | Main-shaft rear-bearing snap ring    |
| 16.    | Gearshift-lever shaft               | 43. | Main shaft                           |
| 17.    | Gearshift-housing seal              | 44. | Main-shaft rear bearing              |
| 18.    | Gearshift housing                   | 45. | Speedometer-drive gear               |
| 19.    | Gearshift-lever shaft screw and     | 46. | Extension                            |
| 20.    | lock washer                         | 47. | Speedometer-drive pinion             |
| 21.    | Gearshift-operating lever           | 48. | Main-shaft bearing spacer            |
| 22.    | Gearshift-selector lever            | 49. | Extension bearing                    |
| 23.    | Gearshift-selector ball spring      | 50. | Main-shaft rear-bearing oil seal     |
| 24.    | screw washer                        | 51. | Main-shaft flange                    |
| 25.    | Gearshift-selector ball-spring      | 52. | Main-shaft flange washer             |
| 26.    | screw                                | 53. | Main-shaft flange nut and lock washer|
| 27.    | Gearshift-selector pin-lock spring  | 54. | Drive pinion                         |
| 29.    | Gearshift-lever pin                 | 56. | Clutch-gear sleeve                   |
| 30.    | Camshaft-selector camshaft seal     | 57. | Second-speed gear                    |
| 31.    | Drive-pinion-bearing snap ring      | 58. | Countershaft bearing spacer          |
| 32.    |                                      | 59. | Sliding gear: first and reverse      |
| 33.    |                                      | 60. | Countershaft thrust washer           |
| 34.    |                                      | 61. | Countershaft key                     |
| 35.    |                                      | 62. | Reverse-idler-gear bearing rollers   |
| 36.    |                                      | 63. | Extension-screw grommet              |
| 37.    |                                      | 64. | Extension screw and lock washer      |
| 38.    |                                      | 65. | Reverse-idler gear                   |
| 39.    |                                      | 66. | Reverse-idler shaft key              |
| 40.    |                                      | 67. | Reverse-idler shaft key              |
| 41.    |                                      | 68. | Reverse-idler-gear washer            |
| 42.    |                                      | 69. | Speedometer-drive-pinion sleeve      |
| 43.    |                                      | 70. | Speedometer-drive-pinion oil seal    |
| 44.    |                                      | 71. | Transmission, or hand brake, drum    |
| 45.    |                                      | 72. | Universal-joint attaching bolt       |
| 46.    |                                      | 73. | Gearshift-operating lever-nut plain washer |
| 47.    |                                      | 74. | Gearshift-selector lever-nut and lock washer |
| 48.    |                                      | 75. | Speedometer-drive-pinion oil seal    |
| 49.    |                                      | 76. | Transmission-case filler plug        |
| 50.    |                                      | 77. | Gearshift-housing screw and lock washer |
| 51.    |                                      | 78. | Gearshift-operating lever-nut and lock washer |
| 52.    |                                      | 79. | Countershaft-bearing spacer          |
| 53.    |                                      | 80. | Sliding gear: first and reverse      |
| 54.    |                                      | 81. | Countershaft thrust washer           |
| 55.    |                                      | 82. | Countershaft key                     |
| 56.    |                                      | 83. | Reverse-idler-gear bearing rollers   |
| 57.    |                                      | 84. | Extension-screw grommet              |
| 58.    |                                      | 85. | Extension screw and lock washer      |
| 59.    |                                      | 86. | Reverse-idler gear                   |
| 60.    |                                      | 87. | Reverse-idler shaft key              |
| 61.    |                                      | 88. | Reverse-idler-gear washer            |
| 62.    |                                      | 89. | Speedometer-drive-pinion sleeve      |
| 63.    |                                      | 90. | Speedometer-drive-pinion oil seal    |
been cleaned. Rollers that are worn, cracked, chipped, or that have flat spots should be replaced. Examine races in which rollers turn and replace any part that shows signs of wear.

3. Gears and Shafts. Examine the gears and gear teeth carefully. Check for worn, burred, or broken teeth and for fit on shaft or sliding sleeve. Do not confuse tool marks left in manufacturing the gears with actual scores or nicks. Try the fit of splined gears on shaft or sliding sleeve. If fit is too loose or if gear teeth are damaged, the gear should be replaced. Also, if the splined shaft or sleeve is worn, it will require replacement. On the other hand, if the splines are battered so the gear does not easily slip back and forth on the splines, you may be able to smooth down burrs and improve the fit by using an oil stone.

Note the condition of shafts that ride on rollers or turn in bushings. If the bearing surface on the end of the shaft is worn, the shaft should be replaced.

Inspect the conical surfaces of gears as well as synchronizing rings for scores or burrs. If these parts show wear or roughness, they should be replaced. It is not recommended that any attempt be made to polish away roughness on these parts since this would change the angles or clearances and thereby prevent normal synchronizing action when shifts are made into second and high. One check for wear of these parts is to place the contacting surfaces together in the positions they would take when operating and then try to rock them. If the parts do not fit snugly together, replacement should be made.

4. Transmission case. Clean case thoroughly and check it for cracks. Inspect the front mounting face for burrs that would prevent square mounting with the clutch housing. Burrs should be knocked off with a fine-cut file. Oil seals in place in the case should be checked and if worn or showing signs of leakage, they should be replaced. Bolt holes in the case should be checked for stripped threads.

5. Snap rings, oil seals, gaskets. Such parts as snap rings, oil seals, and gaskets should be carefully inspected and discarded if they show any signs of wear or damage. New gaskets should be used when the transmission is reassembled to guard against oil leakage.
6. Shifter mechanism. Shifter forks or yokes that are bent or otherwise damaged should be replaced since this would cause hard shifting. Likewise, the condition of the shifter interlock should be noted and defective parts replaced.

7. Checking for transmission case misalignment. If the transmission is noisy and jumps out of high gear, there is a possibility that misalignment exists between the transmission case and engine block. This can be checked with the transmission and clutch off the engine by using a special alignment-indicator tool, such as shown in Fig. 3-26, to determine whether the hole in the clutch housing is off center with the flywheel. The same indicator can then be used to determine whether the face of the housing is in alignment. Correction involves shifting the housing (after drilling out the dowel-pin holes to a larger size) and, possibly, shimming between the housing and engine-block attaching bolts to achieve alignment.

§59. Assembly of transmission The assembly of a transmission is essentially the reverse of disassembly. During reassembly, all parts should be lubricated as they are replaced. This not only assures an initial supply of lubricant to all vital parts but is also helpful in the reassembly procedure. For instance, a trace of grease on a washer will cause it to stick into place on the case while the shaft is being inserted. New gaskets, oil seals, and snap rings are usually specified by the manufacturer when a transmission has been disassembled and is being reassembled. Typical reassembly procedures follow.

1. Chevrolet. Lubricate and install the reverse idler and thrust washers. Chamfered-tooth gear goes toward the rear. Install the shaft, making sure that the shaft hole lines up with the pin hole in the case. Coat the new pin with Permatex or similar sealer and drive it about \( \frac{1}{8} \) inch beyond flush with the case. Peen the hole slightly so that the pin will not work out. Install expansion plugs in the shaft holes. Put the countershaft in the case with the front thrust washer. Feed a special assembly tool, tapered end first, in from the front of the case. Follow it with the countershaft. The tool aligns the parts for the shaft. As the tool nears the rear, install the thrust washer. Make sure that the flat on forward end of the shaft
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is horizontal and at top as it comes out the front of the case. This flat engages in clutch housing when transmission is installed on the car.

Install the rear-bearing snap ring, expand it with a tool, and tap the bearing into place until the snap ring will seat in the undercut when the tool is removed. Install synchronizer rings and retainers in counterbores in the ends of the clutch sleeve, and then place first-and-reverse gear on the second-and-third clutch. Mesh the clutch teeth of the second gear with the internal splines of the second-and-third clutch.

Place the thrust washer on the back face of the second gear and install the second-and-third-clutch assembly in the case. Line up the thrust washer and push the main shaft into the clutch sleeve as far as possible, picking up the second gear and washer. Make sure that the lugs on the front synchronizer align with the main-shaft splines. Attach a rear-bearing support and use a special replacing tool to complete replacement of shaft, forcing the shaft in until it seats on the rear bearing. Put grease in the pilot hole in the main gear and install 14 rollers. Then put the main gear and bearing in the case, tapping the outer race of the bearing into position with soft drift until the lock ring seats. Synchronizing ring lugs must align with the slots between the clutch teeth.

Finally, install the main-gear bearing retainer, using a new gasket, making sure that the oil slots align. The speedometer gear, universal-joint spacer, and front yoke may then be put on. Install the gearshift housing.

2. Ford. In general, reassembly is the reverse of disassembly. Use a dummy shaft to assemble the countershaft gears, bearings, and thrust washers. Install the reverse idler and shaft, making sure that the pin holes in the shaft and the case align. Put the pin in place. Install the main bearing and retainer on the front of the case. Install the synchronizer block springs at each end of the hub, place the blocks on the hub, and push the hub inside the sleeve. Place the synchronizer ring on the assembly, making sure that the slots align with the blocks. Use a special tool to install the rear bushing in the transmission extension and the oil seal in the end of the extension. Put the main-shaft rear bearing on the shaft and press it into place. Put the speedometer gear key and gear on the shaft and secure with the lock ring. Then install the sliding gear, intermediate gear,
and synchronizer assembly and secure them with a snap ring. Place the main-shaft assembly in the extension and secure it with a snap ring. Use a new gasket on the front of the extension and install the extension on the case. Be careful to avoid displacing the bearing rollers when the front end of the main shaft enters the pilot in the main gear.

Turn the extension so that the countershaft may be installed. This operation requires an aligning tool, which is pushed through by the shaft. Make sure that the shaft-pin hole aligns with the case-pin hole. Install the pin. Then, turn the extension into position and secure it with bolts. Install the gearshift housing, using a new gasket.

3. Plymouth. Place the countershaft-gear thrust washers into position with steel washers next to the rollers and bronze next to the case. Use a special tool to install the oil seal in the rear end of the extension. Assemble the synchronizer unit. Place one bent-up end of the spring into the pocket of the shifting plate. Then install the bent-up end of the other spring into the pocket of the same plate on the opposite side of the synchronizer. Finally, install the synchronizer unit on the main shaft. Install the shifter rails and gearshift housing.

§60. Steering-column gearshift mechanism The steering-column gearshift mechanism, together with the linkages to the transmission, is differently constructed for each model of vehicle, and few general directions for its adjustment, disassembly, and assembly can be given. For specific instructions refer to the vehicle shop manual. Figures 4-11 to 4-15 illustrate typical gearshift mechanisms, from which an idea of the relationship of parts may be gained. Figure 6-15 illustrates the relationship of parts on a steering-column gearshift mechanism that is directly linked to the transmission without vacuum booster or other shifter aid.

Adjustment of linkages must be correct to allow proper selection of gears and completion of gearshifts. On the type of shifter mechanism shown in Fig. 6-15, two adjustments are required. These are the lower selector-rod adjustment, which determines the vertical distance between the gearshift lever and the steering wheel, and the lower control-rod adjustment, which determines the radial position of the gearshift lever.
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The selector-rod adjustment is made by removing the cotter and through pin (A in Fig. 6-15) and turning the adjustment screw B. The transmission must be in neutral. After adjustment is made, secure the screw with pin, making sure the wave washer inside lever C is in place. The pin must pass through the hole in the wave washer.

![Fig. 6-15. Relationship of parts in steering-column gearshift mechanism. (Oldsmobile Division of General Motors Corporation)](image)

The lower control-rod adjustment is made by using a special locating gauge assembled around the lower end of the steering column. The lower control shift rod is first disconnected from the transmission shift lever by removing the clevis pin. The gauge is then placed around the steering column so that the slotted opening in the gauge fits around the lower lever. With the transmission in neutral, the clevis is adjusted until the clevis pin enters the clevis and transmission shift lever freely.

Linkage adjustments on another gearshift-linkage arrangement are shown in Fig. 6-16. On this system, the gear selector rod is ad-[170]
justed first. The lock nut on the selector rod is loosened, and then the adjusting nut is tightened until all play of the rod is taken up. Then the adjusting nut should be backed off one-half turn for clearance and the locking nut tightened. Next, the gearshift control rod should be adjusted, if necessary, to change the position of the gearshift lever (which should be horizontal when the transmission is in neutral). To change the gearshift-lever position, loosen the lock bolt on the upper lever at the lower end of the steering column as shown in Fig. 6-16. Locate the gearshift lever correctly and then tighten the lock bolt.

![Fig. 6-16. Gearshift linkage adjustment. (Plymouth Division of Chrysler Corporation)](image)

Lubricate pivot points or points of wear where binding could occur, with appropriate oil or grease recommended by the car manufacturer. Usually a few drops of light engine oil on the pivot points is all that is required.

§61. Overdrive service Overdrive disassembly and reassembly varies from model to model. When working on a specific model, the applicable shop manual should be followed carefully. Disassembly of a later-type overdrive used (with slight variations) on such cars as Studebaker, Ford, Packard, Kaiser, Frazer, and Nash is detailed below. (Refer to Fig. 5-9 for an exploded view of this unit.)
1. Disassembly. With transmission and overdrive assembly off the car and mounted on transmission stand, disassemble as follows:

a. Remove companion-flange nut and flange from end of shaft with special holding tool and puller.
b. Disconnect wires and take off lock-out switch and governor (Fig. 6-17). Governor must be unscrewed from housing.
c. Drive out tapered locating pin (1 in Fig. 6-18) and pull shift shaft out as far as possible to disengage the operating cam from the shift rail. Then remove the four cap screws holding the overdrive housing to the transmission case. Tap the end of the overdrive shaft lightly with a lead hammer while removing the housing so the shaft will not come off with the housing and spill the freewheeling rollers.
d. Hold the adapter plate to the case by replacing cap screw in upper right hole. Then remove the shift-rail reverse-lockup spring, shift lever, shift shaft, and shaft oil seal. Now, removal of the rear oil seal permits removal of the two snap rings and overdrive-shaft rear bearing.
e. Remove the speedometer and governor drive gears from the
Fig. 6-18. Removing locating pin (1) so shift lever (2) with shift shaft (3) can be pulled out far enough to disengage operating cam from shift rail. (Studebaker-Packard Corporation)

Fig. 6-19. Holding hand under assembly to catch rollers as the main shaft is removed. (Studebaker-Packard Corporation)

shaft. The overdrive main shaft can now be pulled out. Hold one hand under the assembly to catch rollers as they drop out (Fig. 6-19).

f. Ring gear can now be taken off the overdrive shaft by removing the large snap ring.
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Fig. 6-20. Removing retaining clip holding free-wheeling unit in place. (Studebaker-Packard Corporation)

Fig. 6-21. Separating freewheeling unit from pinion-cage assembly by removing retaining clip. (Studebaker-Packard Corporation)

g. With freewheeling rollers out of the cage, remove the retaining clip (Fig. 6-20), and take off the freewheeling unit and pinion-cage assembly from the transmission main shaft.

h. To separate the freewheeling unit and pinion-cage assembly, take out the retaining clip (Fig. 6-21).
i. Overdrive sun gear (Fig. 6-22) and shift-rail assembly can now be removed. Shift collar can be taken off sun gear by removing snap rings.

j. Overdrive solenoid can be taken off by removing cap screws and turning the solenoid one-fourth turn.
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k. Take out large snap ring and then pull sun-gear cover plate and blocker assembly out (see Fig. 6-23).

l. If the transmission also requires disassembly, the main shaft, with adapter plate and gears, can be removed as a unit from the transmission case.

2. Inspection of parts. Inspection of overdrive parts is very similar to inspection of transmission parts as outlined in §58. Note particularly the condition of oil seals, gears, and bearings. In addition, the electrical condition of the electrical components should be noted. That is, the operation of the governor, solenoid, relay, and switches should be checked. These checks require electrical testing instruments such as are described in another book in the McGraw-Hill Automotive Mechanics Series (Automotive Electrical Equipment).

3. Reassembly of overdrive. Essentially, reassembly is the reverse of disassembly. When replacing the rollers, use a little Lubriplate or wheel-bearing grease to hold them in position during the assembly process. Also, be sure to use new gaskets. When installing the sun-gear blocker assembly, make sure the blocker ring and pawl are properly positioned as shown in Fig. 6-24. Also, make sure that the freewheeling retainer springs are installed correctly. They should be so installed that when viewed from the rear, the ends of the springs which are outside should point in a clockwise direction (Fig. 6-25).

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CHAPTER CHECKUP

NOTE: Since the following is a chapter review test, you should review the chapter before taking it.

Some automotive mechanics are transmission specialists and spend a great part of their time working on transmissions. However, any good, all-round automotive mechanic should know how to diagnose transmission trouble and correct it, if necessary, by removing and disassembling the transmission. The chapter you have just finished describes different transmission troubles, methods of tracking down their causes, and repair procedures to eliminate these causes. Now, in the check up that follows, these different transmission troubles and services are high-lighted. Thus, the check up will help you to fix these troubles and services in your mind. If you are not sure about the correct answer to any of the questions, turn back into the chapter and review the pages that will answer them for you. Write down the answers in your notebook. This act of writing down the answers helps you to remember, and the notebook will become a valuable source of information you can refer to quickly in the future.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. Improperly adjusted gearshift linkage could cause hard shifting into gear clutch slippage noise in neutral
2. Misalignment between the transmission and engine is most apt to cause no power through transmission transmission slipping out of high gear transmission slipping out of first
3. Transmission noise in neutral could result from misadjusted gear linkage worn gears worn speedometer gears loose propeller shaft
4. Clashing of gears when shifting into high could result from engine misalignment drive key sheared a defective synchronizer
5. Failure of the overdrive to go into overdrive could be due to incorrect clutch-pedal adjustment defect in electric circuit gearshift linkage misadjusted
6. Pilot or guide pins are used in transmission removal to prevent damage to the clutch shaft clutch friction disk countershaft gearshift linkage
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7. Transmission noise in gear could result from
   a bent shifter fork
   a worn rear transmission bearing
   clutch not releasing

8. Ball bearings with discolored or cracked balls or races should be
   relubricated replaced reoiled recleaned

Troubles and Service Procedures

In the following, you should write down in your notebook the trouble causes and service procedures asked for. Do not copy the procedures from the book; try to write them in your own words. Writing them down in your own words will be of great help to you because this will enable you to remember them better; you will thereby be greatly benefited when you go into the automotive shop.

1. List conditions that could result from the gearshift linkage being out of adjustment.
2. List conditions that could result from worn gears in the transmission.
3. List conditions that could result from lack of lubrication in the transmission and gearshift linkage.
4. List conditions that could cause hard shifting.
5. List conditions that could cause the transmission to slip out of gear.
6. List possible causes of noise in the transmission.
7. Describe the electrical checks to be made if the overdrive does not go into overdrive.
8. Describe the electrical checks to be made if the overdrive does not come out of overdrive.
9. Describe the electrical checks to be made if shift into reverse cannot be made and overdrive dash knob is jammed in OD position.
10. Refer to the shop manual of a specific-model car and list the steps to be taken to remove, disassemble, reassemble, and replace the transmission.
11. List the checks to be made on the parts of a disassembled transmission.
12. Refer to the shop manual of a specific-model car and list the steps to be taken to adjust the gearshift linkage.

Suggestions for Further Study

When you are in the automotive service shop, pay special attention to the men working on transmissions so you can learn more about how various transmission-repair and readjustment jobs are done. Notice the special tools required and how these tools are used. Study different car manufacturers' manuals in order to become more familiar with different transmission constructions and servicing procedures. Be sure to write down in your notebook any important facts you come across so you will have a permanent record of them.
THE PURPOSE of this chapter is to describe the operation of fluid couplings and, in addition, to explain the construction and operation of transmissions using fluid couplings.

For many years, engineers and inventors have searched for means of making gear shifting easier. The introduction of synchronizing devices such as the synchromesh was one result of their efforts; this mechanism makes it virtually impossible to clash gears when shifting into second or high. However, it was still necessary to operate a clutch to interrupt the flow of power and to move a lever to shift the gears from one to another meshing position.

In recent years, automatic devices have been brought out which eliminate this job. That is, the gear ratio through the transmission is changed semiautomatically or automatically in accordance with car and engine speed and the driver's wishes.

With this type of gear-ratio-changing device, the power flow through the transmission must still be interrupted, even though momentarily, so the gear-ratio change can be achieved. Thus, there is the problem of making this power-flow interruption and reaplication smoothly. If it is done too abruptly, the occupants of the car will be jarred. Worse, the power-train components and engine will be subjected to shock strains that, sooner or later, might cause failure of some part. To eliminate this sort of sudden jarring change in the power-flow pattern, fluid couplings were introduced.

The fluid coupling couples the engine with the power train, and since it transmits engine-power output through a fluid, it tends to smooth out any shock-loading or unloading effect produced by the action of the automatic gear-ratio changing device. That is, it absorbs the shock of any sudden change and cushions the engine and power train from the shock.
62. Hydraulics  Before we get into a discussion of the fluid coupling and the various transmissions with which it is used, we should first understand something about hydraulics. Hydraulics is the science of liquids, such as water or oil. Our special interest, so far as automatic transmissions is concerned, is in the pressures that can be exerted by liquids.

1. Incompressibility of liquids. If a gas, such as air, is put under pressure, it can be compressed into a smaller volume (Fig. 7-1).

![GAS CAN BE COMPRESSED](image1)

![LIQUID CANNOT BE COMPRESSED](image2)

Fig. 7-1. Gas can be compressed when pressure is applied. Liquid, however, cannot be compressed by application of pressure. (Pontiac Motor Division of General Motors Corporation)

However, applying pressure to a liquid will not cause it to compress; it stays the same volume.

2. Transmitting motion by liquid. Since liquid is not compressible, motion may be transmitted by liquid. For example, Fig. 7-2 shows two pistons in a cylinder with a liquid between them. When the applying piston is moved into the cylinder 8 inches, as shown, then the output piston will be pushed along the cylinder the same distance. In the illustration, you could substitute a solid connecting rod between piston A and piston B and get the same
Motion can be transmitted by liquids. When the applying piston A is moved 8 inches, then the output piston is also moved 8 inches. (Pontiac Motor Division of General Motors Corporation)

Motion may be transmitted through a tube from one cylinder to another by hydraulic pressure. (Pontiac Motor Division of General Motors Corporation)

Result. But the advantage of such a system is that you can transmit motion between cylinders by a tube (Fig. 7-3). In Fig. 7-3, as the applying piston is moved, liquid is forced out of cylinder A, through the tube, and into cylinder B. This causes the output piston to move in its cylinder.
Transmitting pressure by liquid. The pressure applied to a liquid is transmitted by the liquid in all directions and to every part of the liquid. For example (Fig. 7-4), when a piston with 1 square inch of area applies a force of 100 pounds on a liquid, the pressure on the liquid is 100 psi (pounds per square inch). This
pressure will be registered throughout the entire hydraulic system. If the area of the piston is 2 square inches and the piston applies a force of 100 pounds, then the pressure is only 50 psi (Fig. 7-5).

With an input-output system (Fig. 7-6), we can determine the force applied to any output piston by multiplying the pressure in pounds per square inch by the area of the output piston in square inches. For example, the pressure shown in Fig. 7-6 is 100 psi. The output piston to the left has an area of 0.5 square inch. Thus, the output force on this piston is 100 times 0.5 or 50 pounds. The center piston has an area of 1 square inch and its output force is therefore 100 pounds. The right-hand piston has an area of 2 square inches and its output force is therefore 200 pounds (100 X 2). The bigger the output piston, the greater the output force. If the area of the piston were 100 square inches, for example, then the output force would be 10,000 pounds. Likewise, the higher the hydraulic pressure, the greater the output force. If the hydraulic pressure on the 2-square-inch piston went up to 1,000 psi, then the output force on the piston would be 2,000 pounds.

In all the illustrations above, a piston-cylinder arrangement has been shown as the means of producing the pressure. However, any sort of pump can be used. We will learn, in studying the various
automotive transmissions, that several types of pump have been used (gear, rotor, vane).

4. **Hydraulic valves.** A simple application of the above principles is found in a pressure-regulating valve (Fig. 7-7). The valve is spring-loaded and is essentially a small piston that can move back and forth in a cylinder. The valve acts to produce a constant pressure from a variable-pressure source. For example, suppose the pressure source is an oil pump being driven by an automobile engine. When the engine is operating at high speed, the oil pump is also being operated at high speed and will produce a high pressure. The pressure-regulating valve reduces this pressure to a preset value, however, in the following manner.

As the pressure goes up, there is an increasing force on the valve. Finally, when the preset value is reached, the oil pressure is great enough (in pounds per square inch) to overcome the spring pressure. The valve is moved back in its cylinder. As it moves back, it uncovers an opening, or port, which is connected to a low-pressure return line to the oil reservoir. Now, part of the oil from the pump can flow through this return line. This reduces the pressure so that the valve starts forward again (moved by the spring pressure). However, as it moves forward, it partly shuts off the port to the return line. Since less oil can now escape, the oil pressure goes up and the valve is again moved back. Actually, the valve does not normally move back and forth, as described above. Instead, it seeks and finds the position at which the oil pressure just balances the spring pressure. Then, if the oil pressure changes (due to a change in pump speed), the valve position will change. In action, the valve maintains a constant output pressure by dumping a smaller

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**Fig. 7-7.** A pressure-regulating valve (A). As pump pressure increases, the spring-loaded valve moves back against spring pressure (as at B), dumping more of the oil from the pump into the return line. This maintains a constant output pressure.
or greater part of the oil from the pump. As pump pressure goes up, for example (which means the pump delivers more oil), the valve moves back to open the port wider and permit more of the oil to flow into the return line.

5. Balanced valve. In automatic transmissions, balanced valves are used to produce pressure changes that are proportional to the movement of mechanical linkage or to variations in spring pressure. A balanced valve is shown in Fig. 7-8. It contains a valve spool which is essentially a solid cylinder with an undercut section. The valve spool moves back and forth in a cylinder. Oil pressure works against it on one end, and spring pressure against it on the other end. In the centered position shown in Fig. 7-8, input oil, under constant pressure, passes into the cylinder, around the undercut section of the valve spool, through the bypass line, and then out through the return line and the output pressure line. Input pressure is held constant by a pressure-regulating valve as explained in the previous paragraph. Let us see how variations in spring pressure can cause variations in output pressure.

In A in Fig. 7-9, the mechanical linkage has been moved so as to increase the spring pressure against the end of the valve spool. The valve spool therefore moves (to the left in the illustration). This movement tends to close the return line. As the return line is closed,
pressure begins to build up on the output end of the valve (just as in the pressure-regulator valve discussed above). The increasing pressure acts against the output end of the valve and this pressure works against spring pressure. When a balanced condition is reached (output pressure balances spring pressure), the valve stops moving.

![Diagram A](image)

**FIG. 7-9.** If the linkage is moved to increase the spring pressure (A), then the valve spool will be moved toward the output end to partly close off the return line and permit a hydraulic pressure increase to balance the spring-pressure increase. However, if the linkage is moved to reduce the spring pressure (B), then the hydraulic pressure forces the valve spool away from the output end to partly close off the input-pressure line so hydraulic pressure is reduced to balance the spring-pressure reduction.

If the spring pressure is reduced by movement of the linkage (B in Fig. 7-9), then the pressure on the output end of the valve can move the valve (to the right in the illustration). As the valve moves, it tends to close off the input pressure line. Consequently, less oil can enter, and a lowered pressure results. The pressure falls.
off until a balanced condition results (output pressure balances spring pressure). Then the valve stops moving.

To show you exactly how the valve might work, let us look at a couple of examples. Suppose the output end of the valve has an area of 1 square inch and that the input pressure is 100 psi. Now, let us apply a spring pressure of 10 pounds on the valve spool (see Fig. 7-10). In order for the valve to balance, there must be only 10 pounds force on the output end. The oil pressure, as it enters and goes through the bypass to the output end, forces the valve to the right (in the illustration). This movement tends to shut off the input pressure. The pressure is therefore reduced until a balance is attained. If the pressure on the spring reaches 100 pounds, then the full input pressure (of 100 psi) can pass unhampered through the valve; this then becomes the output pressure. A spring pressure of above 100 pounds cannot, however raise the pressure above 100 psi since that is all the pressure (the input pressure) that is available.

6. Servos. Let us take a look at a different sort of hydraulic device used in automatic transmissions (and countless other mechanisms). This device is the servo (Fig. 7-11). Essentially, the servo is a cylinder and piston. Hydraulic pressure can be admitted to one or the other end of the cylinder. This causes the piston to move; mechanical linkage from the piston then causes movement of some mechanism. Thus, hydraulic pressure is used to produce a mechanical action. In the illustration (Fig. 7-11), if hydraulic pressure is applied to the piston, the piston will move (to the right in the
This action causes the piston rod to apply the brake band. Thus, the brake drum can be made to stop turning by increasing the hydraulic pressure. As a matter of fact, the hydraulic brakes used in automobiles work on exactly this principle. Operation of a foot pedal increases the hydraulic pressure in the master brake cylinder and this increasing hydraulic pressure causes pistons in the wheel cylinders to move. As the wheel-cylinder pistons move, they force the brake shoes against the brake drums so the car is braked.

In automatic transmissions, we will find several different types of servos as well as several varieties of control, regulating, and balanced valves. All operate on the principles described above.

**CHECK YOUR PROGRESS**

**Progress Quiz 8**

The hydraulic fundamentals we have covered in the past few pages apply to all types of automatic transmissions. Thus, you should have a good understanding of those fundamentals before you proceed with your studies of transmissions. The following quiz will help you review the fundamentals and thus fix them more firmly in your mind. If you have any trouble answering the questions, review the past few pages. Remember, a good student may reread his lessons several times in order to make sure he has learned all the essential details.

**Completing the Sentences**

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence.
Transmissions with Fluid Couplings

sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. If a liquid is put under pressure, it will **compress** not **compress** increase in volume
2. Since a liquid is incompressible, it can be used to transmit motion and pressure rotation and speed vacuum and heat
3. A piston with an area of 5 square inches is pushed into a cylinder filled with a liquid with a force of 200 pounds; the pressure developed is 40 psi 200 psi 1,000 psi
4. A piston with an area of 0.25 square inch is pushed into a cylinder filled with liquid with a force of 200 pounds; the pressure developed is 30 psi 200 psi 800 psi
5. An output piston against which hydraulic pressure is working has an area of 12 square inches and the hydraulic pressure is 240 psi. The force on the piston is 20 pounds 240 pounds 2,400 pounds 2,880 pounds
6. An output piston against which hydraulic pressure is working has an area of 0.5 square inch and the hydraulic pressure is 240 psi. The force on the piston is 24 pounds 120 pounds 240 pounds 1,200 pounds
7. If the pressure-regulating valve described in the chapter has an area of 2 square inches, and the spring pressure imposes a force of 25 pounds on it, then the regulating pressure would be 12.5 psi 25 psi 50 psi
8. If the spring pressure on the balanced valve is 25 pounds, the input pressure is 100 psi, and the area of the output end of the valve is 2 square inches, then the output pressure would be 12.5 psi 25 psi 50 psi
9. If the spring pressure on the balanced valve is 250 pounds, the input pressure is 100 psi, and the area of the output end of the valve is 2 square inches, then the output pressure would be 100 psi 125 psi 250 psi 500 psi
10. If the end of the servo piston has an area of 4 square inches and a pressure of 200 psi is applied to it, then the piston rod will deliver a force of 50 pounds 200 pounds 400 pounds 800 pounds

§63. Operation of fluid coupling The clutch used in automotive power trains is a mechanical coupling. When engaged, it couples the engine to the transmission. The fluid coupling is a hydraulic coupling. It is always "engaged" but since the coupling is produced by a fluid, the driven member can slip, or turn slower than, the driving member.
1. Fluid coupling. A simple sort of 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 (Fig. 7-12). In this case the air is the fluid, but since the two fans are not enclosed or closely coupled, this sort of fluid coupling is not very efficient. To make a more efficient fluid coupling, oil is used as the fluid and the two halves, or members, of the coupling are mounted very close together and enclosed in a housing. Figure 7-13 shows the two members of a fluid coupling. Note that they resemble a hollowed-out doughnut sliced in half, with blades or vanes set radially into the hollow halves. Figure 7-14 is a cross section of a fluid coupling. The driving member is attached to the engine crankshaft, while the driven member is attached to the transmission shaft. This shaft is, in turn, connected through gearing and the propeller shaft, to the differential and the rear wheels.

The hollow space in the two members is filled with oil. When the driving member begins to rotate (as the engine is started and runs), the oil is set into motion. The vanes in the driving member start to carry the oil round with them. As the oil is thus spun round, it is thrown outward, or away from the shaft, by centrifugal force. This means that the oil moves outward in the driving member in a circular path, as shown by the dotted arrows in Fig. 7-14. Also,
Fig. 7-13. Simplified version of two members of a fluid coupling. (Chevrolet Motor Division of General Motors Corporation)

Fig. 7-14. Cross-sectional view of a fluid coupling. (Studebaker-Packard Corporation)
since the oil is being carried round with the rotating driving member, it is thrown into the driven member at an angle, as shown in Fig. 7-15. The oil thus strikes the vanes of the driven member at an angle, as shown, thereby imparting torque, or turning effort, to the driven member. The faster the driving member turns, with the driven member being stationary, the harder the oil strikes the vanes of the driven member. The harder the oil strikes the vanes, the greater the turning effort imparted to the driven member (within limits).

![Diagram of Fluid Coupling](image)

**Fig. 7-15. Fluid coupling in action. Oil is thrown from driving into driven member. Outer casings have been cut away so vanes can be seen. (Studebaker-Packard Corporation)**

This turning effort, carried to the wheels, sets the car into motion. As the driven member approaches the speed of the driving member, the effective force of the oil on the driven-member vanes is reduced. If the two members turn at the same speed, then the oil would not pass from one to the other member. With no oil passing from one to the other member, no power is being transmitted through the coupling. Thus, this "same-speed" condition would not exist when the engine is driving the car. The driving member always has to be turning a little faster than the driven member in order for engine power to flow through the fluid coupling to the car wheels.

However, if the engine speed is reduced so that the car begins to drive the engine, there would be a point at which both members turn at the same speed. Then, as the engine slowed further, the
driven member would temporarily become the driving member (since the car would be driving it). As this happens, the normally driven member would begin to pass oil into the normally driving member. Now, the engine would exert a braking effect on the car (the same condition that results in a clutch-equipped car when you release the accelerator and coast).

2. **Guide ring.** The simple fluid coupling described in previous paragraphs would not be very efficient under many conditions be-

![Fig. 7-16. Turbulence in oil flow in center sections of fluid-coupling members. (Studebaker-Packard Corporation)](image1)

![Fig. 7-17. Split guide ring designed to reduce oil turbulence. (Chevrolet Motor Division of General Motors Corporation)](image2)

cause of the turbulence that would be set up in the oil. Turbulence is a state of violent random motion or agitation. Thus, under certain conditions (when there is considerable difference in speed between the driving and driven members), the oil would be striking the vanes of the driven member with great force. This would cause the oil to swirl about in all directions, particularly in the center sections of the members (Fig. 7-16). To reduce this turbulence, and thereby make the coupling more efficient, some fluid couplings use a split guide ring centered in the members (Fig. 7-17). The guide ring
FIG. 7-18. Sectional view of a fluid coupling and conventional clutch. (Dodge Division of Chrysler Corporation)

1. Flange stud nut
2. Fluid Drive assembly
3. Floating seal ring
4. Seal-ring gasket
5. Seal-ring gasket retainer
6. Seal housing
7. Seal-housing gasket
8. Rumer bushing—rear
9. Filler plug
10. Filler-plug gasket
11. Clutch driving plate
12. Driving-plate lock washer
13. Clutch pressure plate
14. Clutch cover
15. Clutch pressure spring
16. Clutch release bearing
17. Clutch release-bearing sleeve
18. Clutch release-bearing-sleeve pull-back spring
19. Clutch release fork
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looks much like a hollowed-out doughnut, sliced in half. Each half is attached to the vanes of one of the coupling members. With this arrangement, the oil does not have a chance to set up the turbulences as shown in Fig. 7-16.

3. Operating characteristics of fluid coupling. Essentially, the fluid coupling is a special form of clutch which provides a smooth, vibrationless coupling between the engine and transmission. It operates at maximum efficiency when the driven member approaches the speed of the driving member. If there is a big difference in the speeds of the two members, power is lost and efficiency is low. In the following chapter, on torque converters, we will examine more closely the reason for this loss of efficiency. The fluid coupling is used with a gear-shifting mechanism and a form of transmission which provides the varying gear ratios between the engine and rear wheels. Following sections describe various transmissions using fluid couplings.

§64. Fluid coupling and clutch  Figure 7-18 is a sectional view of a fluid coupling and conventional-type clutch. Figure 7-19 shows the same assembly with the clutch parts detached in a partially exploded view. This assembly is used with an automatic transmission on cars manufactured by the Chrysler Corporation. The transmission is variously known as the Gyro-Matic, Prestomatic, and the Tip-Toe Shift. The fluid coupling is called, by the manufacturer, a Fluid Drive. On late-model cars the fluid coupling, or fluid drive, has been replaced with a torque converter (Chap. 8), or Fluid-Torque Drive, as it is called by the manufacturer. The transmission itself is a four-forward-and-one-reverse speed unit (§65). An automatic control system (§66) provides control of the transmission so the driver is not required to do more than a minimum of gear shifting. The transmission has two manually selected forward operating positions (low and high) as well as reverse. In the low position, the transmission will automatically shift from first

<table>
<thead>
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<tr>
<td>21. Clutch release-lever eyebolt and nut</td>
<td>27. Seal-spring retainer snap ring</td>
</tr>
<tr>
<td>22. Clutch release-lever spring</td>
<td>28. Seal spring</td>
</tr>
<tr>
<td>23. Clutch release-lever pin</td>
<td>29. Driving flange stud</td>
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<tr>
<td>25. Clutch disk assembly</td>
<td>31. Runner bushing—front</td>
</tr>
<tr>
<td></td>
<td>32. Driving plate key</td>
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[195]
to second or from second to first, according to car speed and throttle movement. In the high position, the transmission will automatically shift from third to fourth or from fourth to third, according to car speed and throttle movement. These actions are described in following sections.

The fluid coupling is used with the transmission to provide a flexible coupling that will cushion and absorb the shock of de-

![Diagram of fluid coupling](image-url)

**Fig. 7-19.** Disassembled view of the clutch used with the fluid coupling shown in previous illustration. *(Dodge Division of Chrysler Corporation)*

1. Flange stud nut
2. Fluid Drive assembly
3. Floating seal ring
4. Seal assembly
5. Seal spring retainer
6. Seal retainer gasket
7. Runner bushing—rear
8. Clutch driving plate
9. Driving-plate lock washer
10. Clutch cover
11. Clutch disk assembly
12. Driven plate nut
13. Seal spring retainer snap ring
14. Seal spring
15. Seal plug
16. Filler plug gasket
17. Driving flange stud
18. Runner bushing—front
19. Driving-plate key
20. Seal damper

meshing from one gear position and meshing in another gear position. The clutch is used when a shift is manually made into or out of the high, low, or reverse operating positions.

Note, in Figs. 7-18 and 7-19, that the fluid coupling is enclosed in a case which is attached to the engine crankshaft. In Fig. 7-18, you will notice that the left-hand half of the fluid coupling is attached to the case so that it rotates with the crankshaft. This is the
driving member of the fluid coupling. The right-hand half of the
coupling, the driven member, is keyed to the clutch driving plate.
The clutch driving plate, in this arrangement, serves the same pur­
pose as the engine flywheel in conventional clutches; it supplies a
driving face against which the friction disk of the clutch can be
held by the clutch pressure plate. The driven member of the fluid
coupling is supported at the left (toward front of car) by a ball
bearing. The driven member and clutch driving plate can turn
independently of the driving member of the fluid coupling. Also,
note that the clutch shaft, to which the friction disk is splined, is
supported inside of the driven-member shaft on two bushings.

The fluid coupling operates as already described. When the
driving member is turned by the engine crankshaft, it throws oil
against the vanes of the driven member, causing the driven member
to rotate also. If the clutch is engaged, then this rotary motion is
carried through the driven member of the fluid coupling to the
clutch driving plate and from there to the friction disk and clutch
shaft. The clutch shaft has a gear on its rear end (to right in illu­
stration) which is part of the transmission. This gear is not shown
in Fig. 7-18 but can be seen to the left in Fig. 7-20, where it is
called the drive pinion.

NOTE: The Fluid-Torque Drive, which has supplanted the above-
described fluid drive on late-model cars, is described in §77.

§65. Transmission used with fluid coupling  The transmission used
with the fluid coupling described in the previous section is shown
in exploded view in Fig. 7-20. In this illustration, all transmission
parts, as well as various controls, are shown. Figure 7-21 shows the
transmission partly disassembled; in this view, the various gears on
the main shaft are more easily seen. The direct-speed clutch sleeve
and the third-speed gear are assembled onto the shaft on bearings
so they can turn independently of the shaft. The first-speed gear
can likewise turn independently of the main shaft. The counter­
shaft has a freewheeling gear assembled on it, and this freewheeling
gear has, under it, a form of overrunning clutch much like the one
used in the overdrive (§41). This permits the freewheeling gear to
drive the main shaft through the countershaft gears under certain
conditions and to "idle" without transmitting power under other
conditions. Let us see how the transmission works.
Fig. 7-20. Disassembled view of transmission used with fluid coupling. (Dodge Division of Chrysler Corporation)
Transmissions with Fluid Couplings

1. Neutral. In neutral, the manual-clutch gear sleeve is centered on the clutch gear as shown in Fig. 7-22. The power travels through the main drive pinion, freewheeling gear, and overrunning clutch to the countershaft. The countershaft gears turn the third-speed gear and the first-speed gear, but since neither of these is locked to the main shaft, the main shaft does not turn.

2. First or low. In first speed, the manual-clutch gear sleeve is moved to the right, as shown in Fig. 7-23, by movement of the selector lever on the steering column. Notice that this locks the first-speed gear to the main shaft through the manual-clutch gear sleeve and clutch gear. When the clutch is engaged, power then travels through the transmission as shown in Fig. 7-23. The power travels from the main drive pinion through the freewheeling gear and overrunning clutch to the countershaft. The countershaft turns and both gears on the main shaft which are meshed with countershaft gears also turn. Since the first-speed gear is locked to the main shaft through the manual-clutch gear sleeve and clutch gear, the main shaft must now turn.

3. Second. As already mentioned, the transmission will automatically upshift from first into second gear under the proper operating conditions of speed and throttle movement. To produce this
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Fig. 7-22. Transmission gears in neutral. (Dodge Division of Chrysler Corporation)

Fig. 7-23. Transmission gears in first or low gear. (Dodge Division of Chrysler Corporation)
action, automatic controls cause the direct-speed clutch sleeve to be moved to the left as shown in Fig. 7-24. When this happens, the main drive pinion is locked to the third-speed gear through the sleeve so that the third-speed gear turns with the main drive pinion. At the same time, the leftward movement of the direct-speed clutch sleeve forces the freewheeling control sleeve on the countershaft to move to the left. As it does this, the control sleeve disengages the freewheeling gear, preventing the freewheeling gear from driving the countershaft. As the third-speed gear turns with the main drive pinion, it drives the countershaft gear with which it is meshed. Notice (Fig. 7-24) that the countershaft now turns faster than the freewheeling drive gear; this is because of the gear ratio between the third-speed gear and its meshing countershaft gear. The power travel through the transmission is now from the third-speed gear through the countershaft and first-speed gear to the main shaft.

4. Third. In order for the transmission to operate in third-speed gear, the selector lever on the steering column must be shifted to the high range. When this is done and the clutch is again engaged, the power travel through the transmission is as shown in Fig. 7-25.
Shifting of the selector into the high range moves the manual-clutch gear sleeve to the left so that the third-speed gear is locked to the main shaft through the sleeve and the clutch gear. Now, with the direct-speed clutch sleeve to the right (as automatically positioned by the controls), the power travel will be from the main drive pinion through the freewheeling gear and countershaft, through the third-speed gear to the main shaft (see Fig. 7-25). Note that the power travel is through the overrunning clutch which, in this position, is locked up and driving.

Fig. 7-25. Transmission gears in third. (Dodge Division of Chrysler Corporation)

5. Fourth. The transmission will automatically upshift from third to fourth speed under the proper operating conditions of speed and throttle movement. When this happens, the automatic controls move the direct-speed clutch sleeve to the left (Fig. 7-26) so that the main drive pinion and third-speed gear are locked together and turn as a unit. At the same time, the leftward movement of the direct-speed clutch sleeve forces the freewheeling control sleeve on the countershaft to move to the left and thereby unlock the overrunning clutch. This permits the freewheeling gear to disengage from the countershaft so it idles. The third-speed gear and main drive pinion turn together, as already mentioned. Since the third-speed gear is already locked to the main shaft through the
Transmissions with Fluid Couplings

CONTROL SLEEVE DISENGAGES FREE WHEELING GEAR
FREE WHEELING GEAR "IDLING"

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FIG. 7-26. Transmission gears in fourth. (Dodge Division of Chrysler Corporation)

FIG. 7-27. Reverse idler gear in the disengaged and in the engaged positions. (Dodge Division of Chrysler Corporation)

manual-clutch gear sleeve and clutch gear, this means that the main shaft turns at the same speed as the main drive pinion; there is direct drive through the transmission.

6. Reverse. For reverse, the reverse idler gear must be shifted. Figure 7-27 shows this gear in the disengaged and engaged positions. When it is shifted by movement of the selector lever on the
steering column to the reverse position, the reverse idler gear (which is in mesh with the small gear on the countershaft) goes into mesh with the reverse gear attached to the main shaft (at right in Fig. 7-27). At the same time, movement of the selector lever places the manual-clutch gear sleeve in the neutral position as shown in Fig. 7-22. Interposing an additional gear into the gear train in this manner causes the main shaft to turn in the opposite direction so that the car backs up when power is applied through the transmission. The power travel, in this case, is from the main drive pinion through the freewheeling gear, through the countershaft, through the reverse idler gear, and through the reverse gear to the main shaft.

Transmission controls

The transmission described in the previous section has a control system utilizing the controls shown in Fig. 7-28. In addition, the carburetor contains a kick-down switch and an antistall control. The wiring circuit of the system is shown in Fig. 7-29. As already mentioned, control of the transmission depends on car speed and throttle movement. The governor, which is mounted on the transmission case as shown in Fig. 7-28 and is driven from the countershaft, turns faster or slower as car speed is increased or decreased. When the proper speed is attained, the governor opens a set of contacts, causing the transmission to upshift into a higher gear (from first to second, or from third to fourth). On the other hand, if the driver wishes to downshift so as to have more power for passing, for example, he pushes the accelerator pedal all the way down. This closes the kick-down switch in the carburetor, producing the downshift action. Power for upshifting is obtained from an oil pump which produces hydraulic pressure. The hydraulic pressure then causes a piston to move in a cylinder. This type of device, which produces mechanical movement from hydraulic pressure, is called a servo (§62, 6). Let us see how the complete system functions.

1. Action in the downshifted position. In the downshifted position, the transmission is in either first or third, depending upon the position of the selector lever on the steering column. Figure 7-29 shows the relationship of the parts in third speed. Relationship of the parts in first would be similar except that the transmission parts would be as shown in Fig. 7-23. For the parts to be as shown in Fig.
Fig. 7-38. Transmission controls. (Dodge Division of Chrysler Corporation)
7-29, car speed must be below approximately 12 mph (miles per hour). With this condition, the governor contacts are closed and the solenoid is thereby connected to the battery through these contacts (and the ignition switch). The solenoid is thus energized and is holding down its plunger so the plunger rod is holding the ball valve open. Oil from the oil pump therefore passes through the opened valve and no appreciable oil pressure builds up. The direct-speed fork holds the direct-speed clutch sleeve to the right so the transmission is in third gear. This gear position is shown somewhat more graphically in Fig. 7-25.

2. Action during upshift. As car speed increases, the governor turns faster and faster and, at somewhere above approximately 14 mph (when in third speed), the governor opens its contact points. This opens the circuit between the solenoid and the battery. The solenoid is thereby deenergized and it releases its plunger. The plunger rod now moves up out of the way and allows the ball valve to seat. With the ball valve seated, the condition shown in Fig. 7-30 results. Here, with the ball valve closing off the drain, the oil from the oil pump is forced at high pressure against the direct-speed piston. This moves the direct-speed piston to the left and compresses the small spring under the piston, thereby spring-loading the direct-speed fork. Now, when the accelerator is momentarily released, the pressure on the gear teeth is relieved and the direct-speed fork can move forward (to the left in Fig. 7-30). This moves the direct-speed clutch sleeve to the left so that the main drive pinion is locked to the third-speed gear. The two turn as a unit. Thus, since the third-speed gear is locked to the main shaft by the manual-clutch gear sleeve and clutch gear, the main shaft turns at the same speed as the main drive pinion. In other words, there is direct drive through the transmission.

The piston movement uncovers oil relief holes which allow some oil drainage from the cylinder so that excessive oil pressures do not build up.

3. Action during downshift. When the car slows down, the governor will close its contacts. When this happens, the solenoid becomes connected to the battery through the governor contacts and it therefore opens the ball-type valve. This relieves the oil pressure on the direct-speed piston and the piston moves to the rear (right in Fig. 7-29). As it so moves, a ramp, or high ridge, on the piston presses...
Fig. 7-29. Control circuit for transmission showing conditions when transmission is in third speed below 12 mph. (Dodge Division of Chrysler Corporation)
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![Diagram of automotive transmission and power train](image)

Fig. 2-20. Conditions in the control circuit with the transmission in fourth speed above 14 mph. (Dodge Division of Chrysler Corporation)
Transmissions with Fluid Couplings

up on the interrupter-switch ball, thereby momentarily interrupting the action of the ignition system. It does this by momentarily grounding the ignition circuit through the closed governor contacts. Grounding the ignition circuit momentarily relieves the driving pressure on the transmission gears and the direct-speed fork therefore can move to the rear (right in Fig. 7-29) so as to return the transmission to third gear (or first gear if it were in second).

At speeds above the governor closed-contact speed, downshift can be made by pushing the accelerator pedal all the way down. This actuates a linkage in the carburetor which closes the throttle kick-down switch. With the kick-down switch closed, the solenoid is connected to the battery through the kick-down switch contacts (Fig. 7-31). The sequence of actions described in the previous paragraph then takes place and downshift is accomplished.

At speeds above 45 mph (speed varies on different applications), better acceleration can be obtained in fourth. Therefore, arrangement has been made to prevent downshift above this speed. This is accomplished by incorporating (in system shown) a small vacuum piston in the kick-down switch. The vacuum-piston cylinder is connected to the large venturi in the carburetor. At speeds above the 45-mph limit, the air speed through the carburetor is great enough to create a sufficient vacuum to lift the vacuum piston. As the vacuum piston moves up, it carries the contacts out of the way so the kick-down switch is inoperative.

Note: The shuttle valve at the oil pump acts to relieve oil pressure in case the solenoid does not energize for downshifting as explained above. This failure to energize could be due to some defect in the solenoid or electrical circuit. Under the circumstances, there could be a long ignition interruption if it were not for the shuttle valve. The shuttle valve moves up as oil pressure drops with reduced engine speed to quickly relieve oil pressure and permit the direct-speed piston to quickly move on back so the ignition and engine can again function.

4. Antistall control. An antistall control is included in the carburetor and it has the job of preventing quick closing of the throttle and consequent stalling of the engine. In the system shown, it consists of a small solenoid which operates a ball-check valve. The solenoid is energized when the governor contacts are closed (see Fig. 7-29). With the solenoid energized, the ball-check valve
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Fig. 7.31. Conditions occurring when a downshift results as kick-down switch is operated. (Dodge Division of Chrysler Corporation)
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is held closed. Now, when the throttle is suddenly released, a dashpot arrangement linked to the throttle prevents rapid closing of the throttle. But when speed is great enough to open the governor contacts, the solenoid is not energized and the check valve is open so no dashpot action takes place. At such speeds, there is no danger of stalling the engine by closing the throttle suddenly for the reason that transmission is in either second or fourth speeds. These speeds are nonfreewheeling and the engine cannot slow down so suddenly that it will stall, as it could in first or third speeds.

§67. Vacuum-operated transmission

In the previous article, an automatic transmission actuated by hydraulic oil pressure was described. An earlier version of this same system made use of a vacuum piston which furnished the power to upshift or downshift. Engine intake-manifold vacuum actuated the diaphragm and caused the diaphragm stem to move to the left when the solenoid was deenergized (by opening of the governor contacts). This diaphragm-stem movement permitted the kick-down lever to operate and shift the transmission from third to fourth (or from first to second). As can be seen, the general principle of this transmission is very similar to the hydraulically operated transmission.

CHECK YOUR PROGRESS

Progress Quiz 9

The automatic transmission described in the preceding pages is used on a number of cars, and it will be of value to you to know how this transmission and its controls function. If you are acquainted with the fundamentals of the system, you will be able to understand variations of the system that might appear on later model cars. If, for example, you were acquainted with the earlier version of this system which used intake-manifold vacuum to produce the shifting, you would have no trouble understanding the newer system which uses oil pressure from an oil pump. Further, an understanding of this transmission and its controls will lead to understanding of other more complex transmissions, such as are described on following pages. The quiz below will help you to find out how much you have remembered about the transmission just covered. It will also help you review the material and thereby fix the important points in your mind. If any of the questions stumps you, reread the pages that will give you the answer.

[211]
Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. One device in the fluid coupling that helps to reduce turbulence is the coupling case guide ring clutch

2. In order for power to flow through the fluid coupling from the engine to the car wheels, the driving member must be turning slower than driven member at same speed as driven member faster than driven member

3. The greater the difference in the speeds of the driving and driven members, the lower the turbulence the greater the turbulence the higher the coupling efficiency

4. The greater the difference in the speeds of the driving and driven members, the lower the turbulence the lower the coupling efficiency the higher the coupling efficiency

5. In the Gyro-Matic transmission, placing the gearshift lever in low will produce automatic shifting between first and second second and third third and fourth

6. In the Gyro-Matic, placing the gearshift lever in high will produce automatic shifting between first and second second and third third and fourth

7. In the Gyro-Matic, there is an overrunning clutch, or freewheeling device, on the main drive-pinion shaft main shaft countershaft

8. To produce an upshift in the Gyro-Matic, hydraulic oil pressure causes a servo to move the freewheeling gear manual-clutch gear sleeve main drive pinion direct-speed clutch sleeve

9. During the action of downshifting, the movement of the direct-speed piston actuates the interrupter switch which, in turn, momentarily interrupts carburetor action grounds the ignition circuit grounds the solenoid circuit

10. Under the proper conditions, downshifting may be accomplished by fully depressing the accelerator to close the kick-down switch; this opens the solenoid circuit completes the solenoid circuit closes governor contacts

§68. Hydra-Matic transmission Two versions of the Hydra-Matic transmission, used on a number of different cars, are shown in Figs. [212]
Transmissions with Fluid Couplings

Fig. 7-38. Partial sectional view of Hydra-Matic transmission using two fluid couplings. (Oldsmobile Division of General Motors Corporation)
Transmissions with Fluid Couplings

7-32 and 7-33. The one shown in Fig. 7-32 is the more recent model; it has two fluid couplings. Note that each member of the fluid couplings is called a torus by the manufacturer. The earlier transmission (Fig. 7-33) has one fluid coupling (§63), three planetary-gear systems (§42), plus devices to control the planetary-gear systems. These devices include oil pumps to furnish hydraulic pressure, valves to control the pressure, and pistons that move in cylinders as the pressure is applied. Movement of the pistons controls the planetary-gear systems.

There are several earlier models. All provide one reverse and four forward gear ratios. When the selector lever is placed in DR (drive), the transmission automatically shifts upward in accordance with engine and car speeds and throttle opening. There are some variations in the shift pattern on different models. Some skip the first-gear position in DR. Others have an additional selector lever.
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position (called Super-performance or Performance) that holds the transmission in third until a relatively high speed is attained; this provides better acceleration.

The model shown in Fig. 7-32 has two fluid couplings, three planetary-gear systems, and devices to control the planetary-gear systems. The larger fluid coupling is similar to that used in the earlier models. The second coupling is smaller and is of the controlled type. That is, it can be filled with oil to provide a coupling effect, or it can be emptied to take it out of action entirely. Figure 7-34 is a simplified diagrammatic drawing of the transmission. When the second coupling is filled, it locks the front planetary-gear system (located in the first coupling housing). This provides direct drive through the front planetary-gear system. When the second coupling is empty, it has no coupling action; and this permits the front planetary-gear system to go into reduction. The use of the second coupling provides a smooth transition as the front system upshifts.

The coupling acts in much the same manner as a clutch, but it is more gentle in application than a clutch. The oil cushions the effect of the application.

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§ 69. Planetary gears in Hydra-Matic  We have already described planetary gears in some detail (§42), and you should review §42 if you are not sure you understand their construction and operation. Figure 7-35 shows a planetary gearset used in the Hydra-Matic transmission. It contains the usual three members: sun gear, planet pinions in a cage, and ring gear (or internal gear as it is often called). As already explained (§42), holding one member and turning another causes the assembly to become a speed-reducing or a speed-increasing unit, while locking two members together produces a direct drive (1:1) through the gearset. Also, if the cage is held stationary and the ring gear is turned, the sun gear will turn in the reverse direction. In the Hydra-Matic, the planetary gear systems function either as direct drives or as speed-reducing units. In addition, the systems function together when the selector lever is in reverse to produce reverse rotation of the tail shaft (output shaft) and backing of the car.

§70. Planetary-gear-system control  We have seen in previous sections, how holding one and turning another member of the planetary

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Fig. 7-35. Planetary gearset. (American Motors Corporation)
Automotive Transmissions and Power Trains

The gear system can result in increased or reduced speed and also reverse rotation. Let us examine the means used in the Hydra-Matic to hold one or another of the members and to lock two members together to establish a 1:1 gear ratio (both input and output shafts turning at same speed) through the system.

Figure 7-36 illustrates the mechanisms used in a planetary system to achieve the various conditions. There are two of these mechanisms: a multiple-plate clutch, and a brake band and brake drum. Note that the input shaft has the internal gear (ring gear) on it, while the planet-pinion cage (or carrier) is attached to the output shaft. The sun gear is separately mounted, and it has a brake drum as part of the sun-gear assembly. The sun gear and brake drum turn together as a unit.

Note: This is the arrangement used on the front planetary gear system in the Hydra-Matic. In the rear (not reverse) planetary gear system, the brake drum and internal, or ring, gear are integral while the planet-pinion cage is directly attached to the output shaft. Also, the sun gear is integral with the intermediate shaft which is splined to the driven member of the fluid coupling. The reverse planetary [218]
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gear system has still another arrangement as explained in following paragraphs.

The brake band is operated by a servo as shown in Fig. 7-37. The servo consists of two pistons on a single stem (or rod), all mounted in a cylinder and linked to the brake band which is positioned around the brake drum. Without pressure on either side of the servo pistons, the spring pressure holds the brake band free of the brake drum, and the sun gear is therefore not held stationary. How-

Fig. 7-37. Arrangement of the servo, brake band, and brake drum. (American Motors Corporation)

ever, under the proper operating conditions, oil under pressure is admitted to the left part of the cylinder as shown in Fig. 7-38, forcing the piston to the right. This action compresses the spring and tightens the brake band on the drum, thus bringing the drum and sun gear to a halt. The sun gear is therefore held stationary. With the ring gear being turned and the sun gear held, condition 2 (Fig. 5-6) is obtained and there is speed reduction, or gear reduction, through the system.

Under certain other conditions, the brake band must be released. This takes place when the hydraulic control system directs oil into
the right chambers of the servo cylinder. This forces the pistons to move to the left (Fig. 7-39). At the same time that this happens, the clutch is actuated so as to lock the sun gear and the planet-pinion cage together. The clutch consists of a series of clutch plates alternately fastened to the cage and to the inner face of the brake drum (see Figs. 7-36 and 10-12). When the clutch is disengaged, these plates are held apart. However, simultaneous with the re-

Fig. 7-38. When hydraulic pressure is applied back of the piston at A, the piston and rod move (to the right in the illustration) to cause the brake band to tighten on the brake drum. The brake drum (and sun gear) is thus held stationary. (American Motors Corporation)

leasing of the brake band as explained above, oil is directed into the chamber back of the annular (ring-like) piston in the brake-drum sun-gear assembly. This forces the piston to the left (Fig. 7-40) so that the clutch plates are forced together. Then, friction between the plates locks the sun gear and the planet-pinion cage together. When this happens, the planetary gear system acts like a direct-drive coupling and both the input and the output shafts turn at the same speed (1:1 gear ratio).

To achieve reverse, a third planetary gear system is incorporated in the transmission, to the rear of the other two. In this special system, the ring gear is locked for reverse. This action, in com-
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Fig. 7-39. When the hydraulic control system admits oil under pressure at B and C, the pressure forces the pistons to the left (in illustration) and thereby causes the brake to release the brake drum and sun gear so the sun gear can rotate. (American Motors Corporation)

Fig. 7-40. One set of clutch plates is splined to the sun-gear drum. The other set is splined to the planet-pinion carrier. When the hydraulic control system directs oil back of the annular piston, the clutch plates are forced together so the sun gear and planet-pinion carrier are locked together. (American Motors Corporation)
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Combination with the action of the other planetary systems, causes the transmission main shaft to reverse directions. This is explained in a following section.

§71. Shift control As we have seen, applying the brake band on the planetary-gear set (or system) so the sun gear is held stationary produces a gear reduction through the system. On the other hand,

![Diagram of hydraulic control system for brake-band servo and clutch.](image)

Fig. 7-41. Schematic diagram showing the hydraulic control system for the brake-band servo and the clutch. In the system shown, the band is normally on and the clutch off; this produces gear reduction. But when the shift valve is moved, pressure from the oil pump is admitted to the front of the brake-band piston and to the clutch piston. This causes the brake to release and the clutch to apply. Now, with the clutch locking two planetary members together, the planetary system goes into direct drive. (Oldsmobile Division of General Motors Corporation)

If the brake band is released and at the same time the clutch is applied, the planetary set upshifts or goes into direct drive. This shifting must be controlled so as to take place only under certain operating conditions. Figure 7-41 illustrates the shifting control circuit schematically.

Let us see what produces an upshift—that is, what causes the brake band to release and the clutch to apply. There are two controlling factors in the shift: car speed and throttle opening. These [222]
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two factors produce two varying oil pressures that work against opposite ends of the shift valve. One pressure is from the governor and is based on car speed. The other pressure is from the throttle valve and is based on throttle opening. The two pressures are called governor pressure and throttle pressure (or sometimes TV–throttle-valve—pressure).

1. Governor pressure. The governor consists essentially of a rotor, or housing, driven from the tail shaft of the transmission. Inside the housing there is a governor valve. The valve has two opposing forces acting on it: centrifugal force, due to rotation of the housing; and oil pressure (from the oil pump) admitted to the housing by the valve. With low car and governor speed, the valve is positioned near the center of the housing and passes only a small oil pressure. However, as car speed increases, the governor housing rotates more rapidly and centrifugal force causes the valve to move outward. The valve thus passes a larger percentage of the pump pressure. This increasing pressure (governor pressure) is applied to one end of the shift valve.

2. Throttle pressure. Opposing governor pressure on the shift valve is spring pressure and also throttle pressure (from the throttle valve). The throttle valve, as you will note, is our old friend the balanced valve (§62, 5). In this valve, output pressure equals spring pressure. With only a small throttle opening, only a small spring pressure will be applied and thus there will be only a small output pressure (throttle pressure). But as the throttle is opened wider, the spring pressure is increased and thus the throttle pressure is also increased. The throttle pressure is applied to the spring end of the shift valve (end opposite governor-pressure end).

3. Effects of governor and throttle pressures on shift valve. We have seen how the two varying oil pressures are applied to the two ends of the shift valve. Now, let us see how these two oil pressures (throttle and governor) control the shift valve and thus the band and clutch in the planetary gearset. As car speed increases, governor pressure also increases. This pressure, applied to one end of the shift valve, tries to move the shift valve. However, the other end of the shift valve has spring pressure and throttle pressure against it. With a small throttle opening, throttle pressure is low. This means that car speed and governor pressure do not have to go very high to overcome the spring pressure (and low throttle pressure). Thus, when governor pressure goes up enough, it forces the shift
valve to move. As the shift valve moves, it uncovers the inlet port which admits pump pressure to the valve body. This pump pressure now travels through the valve body and connecting tubes to the clutch and servo. Pump pressure thus releases the brake and applies the clutch. With the clutch applied, the planetary set goes into direct drive.

If the throttle is opened wider, the throttle pressure is increased. This means that higher governor pressure (and higher car speed) is required for upshifting. Thus, upshifting is controlled by both throttle opening and car speed. With a light throttle (small throttle opening), upshifting will occur at a relatively low car speed. But with a heavy throttle, upshifting will not occur until a much higher car speed is reached. This improves performance since the transmission remains in the lower gear during heavy acceleration. When the driver wants to accelerate quickly, as when passing another car, he holds the throttle down. This keeps the transmission in the lower gear where acceleration is better. On the other hand, when cruising along the highway at intermediate speed and with a light throttle, it is desirable to upshift as early as possible in order to take advantage of the higher, and also the more economical, gear ratio.

To sum up: The shift valve is an “on-off” valve. Either it admits oil pressure to the servo and clutch, or it shuts off the pressure. When it admits pressure, the planetary gearset is in direct drive. When it shuts off the pressure, the planetary gearset drops into gear reduction.

The governor pressure varies with car speed. The throttle pressure varies with throttle opening. These two pressures oppose each other on the two ends of the shift valve. Governor pressure must go high enough to overcome throttle pressure (and the spring pressure) to produce shift-valve movement and an upshift.

4. Other valves in the hydraulic system. There are other valves in the hydraulic system of the Hydra-Matic. Actually, the hydraulic system is rather complex. The additional valves function to smooth out the shifts, and to hasten the shifts at higher engine speeds (to prevent the engine from “running away” momentarily during shift). Also, they aid in downshifts, provide quick parking when the engine is turned off, etc. After we have discussed the operation of the power-transmitting units in the Hydra-Matic, we will return to the valves and the hydraulic system.
§72. Hydra-Matic operation  In the Hydra-Matic with one fluid coupling (Figs. 7-42 to 7-45b), each forward planetary unit has a separate servo for applying and releasing its brake band. Each also has a clutch operated by an annular piston (§71). Each is controlled by a separate shift valve (Fig. 7-41).

In the model with two fluid couplings, the front unit is controlled by the second fluid coupling and a sprag or one-way clutch (see Fig. 7-42). Hydra-Matic components arranged in the order in which they actually transmit power from the engine to the transmission output shaft. Note that the power passes through the front planetary unit before it enters the fluid coupling (torus members). The reverse planetary unit is not shown. (Oldsmobile Division of General Motors Corporation)

§77. The rear unit is controlled by a sprag clutch and a multiple-disk clutch actuated by an annular piston (see Figs. 7-46a to 7-48).

On both models discussed here, each planetary unit can shift separately to give four forward gear speeds as follows:

<table>
<thead>
<tr>
<th>Gear ratio</th>
<th>Front planetary</th>
<th>Rear planetary</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>Downshifted (in reduction)</td>
<td>Downshifted (in reduction)</td>
</tr>
<tr>
<td>Second</td>
<td>Downshifted (in direct drive)</td>
<td>Downshifted (in reduction)</td>
</tr>
<tr>
<td>Third</td>
<td>Downshifted (in reduction)</td>
<td>Upshifted (in direct drive)</td>
</tr>
<tr>
<td>Fourth</td>
<td>Upshifted (in direct drive)</td>
<td>Upshifted (in direct drive)</td>
</tr>
</tbody>
</table>

§73. Hydraulic controls  We have already described the shift control circuit (§71), which automatically produces upshifting or...
FIG. 7-43a. Hydra-Matic in neutral with the engine running. With all clutches and bands off, no power can flow through the transmission. (Oldsmobile Division of General Motors Corporation)

FIG. 7-43b. Hydra-Matic in first. With both bands on and both clutches off, both planetary units are in reduction. The gear reduction of the front unit is 1.45:1, of the rear unit 2.63:1, and of the two together 3.82:1 (1.45 × 2.63). Flow of power is shown by the arrows. (Oldsmobile Division of General Motors Corporation)
FIG. 7-44a. Hydra-Matic in second. The front clutch is locking the front planetary so that, with the front brake off, the front planetary is in direct drive. With the rear planetary in reduction, the total gear reduction is 2.63:1. (Oldsmobile Division of General Motors Corporation)

FIG. 7-44b. Hydra-Matic in third. The front band is on and the front clutch is off; therefore, the front unit is in reduction. The rear band is off and the rear clutch is on; therefore, the rear unit is in reduction to provide a total gear reduction of 1.45:1. Note that the power (more properly torque) is split between the main shaft (7) and the intermediate shaft (4) but reunites at the rear planet-pinion carrier (9). (Oldsmobile Division of General Motors Corporation)
Fig. 7-45a. Hydra-Matic in fourth. Both planetary units are in direct drive. (Oldsmobile Division of General Motors Corporation)

Fig. 7-45b. Hydra-Matic in reverse. The front unit is in reduction (band on, clutch off), the rear unit is in neutral (both off), and the reverse unit clutch is engaged. The rear unit planet pinions act as idlers, imposing an extra gear in the train to reverse the direction of rotation. (Oldsmobile Division of General Motors Corporation)
FIG. 7-46a. Hydra-Matic with two fluid couplings in first. The front unit coupling is empty and the front sprag clutch is on; therefore, the front unit is in reduction. The rear sprag clutch is on and the rear clutch is released; therefore, the rear planetary is also in reduction. With both planetaries in reduction, the maximum gear reduction is achieved. (Cadillac Motor Car Division of General Motors Corporation)

FIG. 7-46b. Hydra-Matic in second. The front unit fluid coupling has filled with oil so that, with the front sprag clutch off, the front unit is in direct drive. The rear unit is still in reduction. (Cadillac Motor Car Division of General Motors Corporation)
FIG. 7-47a. Hydra-Matic in third. The front unit fluid coupling has emptied and the front sprag clutch is on; therefore, the front planetary is in reduction. The rear sprag clutch is off and the rear unit clutch is engaged; therefore, the rear planetary is in direct drive. (Cadillac Motor Car Division of General Motors Corporation)

FIG. 7-47b. Hydra-Matic in fourth. Both planetary gearsets are in direct drive. The band shown around the outside of the rear unit is an overrun brake band which comes into action when the car tries to drive the engine (as when coasting down hill) to keep the output shaft from overrunning the rest of the transmission. (Cadillac Motor Car Division of General Motors Corporation)
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downshifting of the planetary unit. Figure 7-49 shows the complete control circuit, valves, servos, governor, etc., of the Hydra-Matic which uses only one fluid coupling (Figs. 7-42 to 7-45b). The Hydra-Matic transmission with two fluid couplings, shown in Figs. 7-46a to 7-48, has a very similar control system. However, this transmission has the second (or front) fluid coupling instead of a clutch. It also has an overrun brake band (see Fig. 7-47b) and an overrun clutch. These operate under various conditions to prevent overrunning and to provide a means of permitting the engine to brake the car, as for example, when going down a hill. This saves the brakes since they have to be applied less often to keep the car from excessive speed. Let us trace the circuits and learn how the various components operate. As we do this, we will find that the circuits, in essence, are no more complicated than the circuit shown in Fig. 7-41. Figure 7-41 illustrates the actions of the throttle valve, the shift valve, and the governor in controlling upshifting or downshifting. That is the function of the various circuits in Fig. 7-49. However, since the actual Hydra-Matic must have several shifts (instead of the two shown in Fig. 7-41), there must be several circuits. Each circuit handles one shift. All circuits must be intercon-

![Diagram](image-url)
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neeted so only one shift at a time will occur. Also, the shifts must occur more rapidly at high engine speed in order to keep the engine from running away. They must occur more slowly at low engine speed to prevent sudden grabbing and rough shifts. Then too, at wide-open throttle, when more power is being transmitted through the transmission, the pressure must be increased for heavier band application. This prevents band slippage. Various components in the circuit produce all of these actions.

1. Neutral—car standing and engine not running. Both pumps are inoperative. Since there is no oil pressure in the system, the front band, front clutch, rear clutch, and reverse clutch are released. The rear band is applied, since it is spring-applied and is always on when there is no oil pressure in the rear servo. If the selector lever is in R (reverse), the parking pawl will engage the reverse internal gear. Since the rear band is applied, this locks the output shaft for parking.

2. Neutral—engine running. With the engine running and the selector lever in the neutral position, the manual valve is pushed all the way into the valve body. This is the position shown in solid line in the upper part of Fig. 7-50. Figure 7-50 is an enlarged part of the complete circuit (Fig. 7-49). The manual valve is a spool valve (similar to the balanced valve described in §62, 5). When it is in the neutral position shown in Fig. 7-50 (top), then the center valve land, or enlarged section, is between the port delivering pump pressure to the valve and the DR port. No oil can pass the land; no oil pressure can be applied to the operating parts of the control system.

Oil pressure is supplied by the front pump only. The front pump is driven when the engine is operating. The rear pump operates only when the car is in motion since it is driven by the tail shaft (or output shaft) of the transmission.

Even though the pump pressure cannot pass the center land of the manual valve, the pump pressure does pass through other parts of the circuit to produce various actions. Trace the circuit in Fig. 7-49 as we describe these actions. Pump pressure passes between the second and third lands of the manual valve and becomes RBR pressure, thus causing the rear servo to release the rear band. RBR pressure also opens the 1-2 shift valve (moves it to left in Fig. 7-49). It also moves the double-transition valve (DT) in so that...
1-2 oil is cut off from the front clutch. One-two oil closes the rear-servo exhaust valve. In addition to these various pressure effects, pump pressure acts on the parking blocker piston to prevent the parking pawl from engaging the reverse internal gear.

3. Drive—in first gear. When the selector switch is moved from neutral to DR, the manual valve is shifted to the DR position as shown to the lower left in Fig. 7-50. Now, pump pressure can pass through the valve body and out the DR port. Also, movement of the manual valve causes the second land (from the left in Fig. 7-49) to cut off RBR pressure; oil from this line is exhausted through the 2-3 shift valve. The rear band is now applied by spring pressure. The pump pressure, as it passes through the valve body (via the DR port), becomes FBA pressure and causes the front band to be applied. Now, with both bands applied and both clutches off, the transmission is in first (see Fig. 7-43b).
Pump pressure is supplied (through the DR port) to the 2-3 shift valve, the 3-4 shift valve, the T valve, throttle valve, and compensator valve (Q). But it does nothing until the throttle is opened and the car is set into motion. Then, the compensator pressure (Comp.) will provide additional holding force for both servos as the throttle is opened and the car moves forward. Compensator pressure is applied in the front servo through a second piston. It is applied in the rear servo against a pair of pistons. G-1 and G-2 pressures are directed against the governor plugs. G-1 pressure is directed against the reverse blocker piston to prevent reverse engagement above about 10 mph. Throttle pressure (also called TV pressure) is directed against the regulator plugs in readiness to help control shifting. This pressure, you will recall, is a variable pressure that depends on the amount of throttle opening (§71). Throttle pressure also acts on the TV regulator plug (J in Fig. 7-49). The regulator plug then modifies, or modulates, line pressure. This modulated pressure is directed against the ends of the shift valves and opposes shifting. However, as explained below, shifting will occur as governor pressure reaches shifting pressure.

4. Upshift from first to second in DR range. To go from first to second, the front clutch must be applied and the front band must be off. The rear clutch must be off and the rear band applied (see Fig. 7-44a). Thus, the only change required to shift from first to second is to release the front band and apply the front clutch. The increase in governor pressure brought on by increased car speed produces this action.

G-1 pressure on the 1-2 governor plug and on the 1-2 shift valve tends to open the shift valve. But the 1-2 shift-valve spring and modulated throttle-valve pressure (from J, the regulator plug) on the shift valve oppose governor pressure. But when G-1 pressure exceeds these two opposing pressures, the shift valve must open.

Opening the 1-2 shift valve now allows pump pressure to pass the 1-2 shift valve and enter the double-transition valve (DT). The double-transition valve has been moved outward by compensator pressure. In this position, the pressure is directed to the front planetary unit where it releases the band and applies the clutch. The transmission is now in second. Note that in Fig. 7-49, this pressure is indicated as pump pressure, then oil from 1-2 valve, then

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FCA pressure, and finally FBR (front band release) pressure (at upper left).

Here is how the FBR pressure releases the front band. This pressure is directed against the release sides of the two pistons in the front servo and aids the spring pressure in overcoming the FBA pressure so that the band is released just as the front clutch is engaged.

5. Upshift from second to third in DR range. In order to shift from second into third, the front band must be applied and the front clutch released. At the same time, the rear band must be released and the rear clutch applied. Thus, to shift from second to third, both bands and both clutches must be actuated one way or the other (see Fig. 7-44b). This double shift is produced as follows:

Increasing car speed causes increasing governor pressure. This increasing governor pressure, when the shifting point is reached, overcomes the modulated throttle pressure and spring pressure acting on the 2-3 shift valve. Thus, the 2-3 shift valve opens (moves to left in Fig. 7-49) and directs oil pressure to the rear unit. The oil pressure passes through the 3-2 timing valve (and becomes RCA pressure). Thus, the rear clutch is applied. The RCA pressure passes through the manual valve (between the first and second lands) and comes out as RBR pressure. This means that as the rear clutch is applied, the rear band is released. Now, the rear unit is in direct drive.

At the same time, the RBR pressure moves the double-transition valve in (to left in Fig. 7-49). This cuts off the oil from the 1-2 shift valve. Now, the FCA oil exhausts through the 3-4 shift valve exhaust port. The FBA and compensator pressures can now apply the front band. Now, the front unit is in reduction.

6. Upshift from third to fourth in DR range. In order to shift from third to fourth, the front unit must go into direct drive. This means the front band must release and the front clutch apply. This is accomplished by further increase of governor pressure with further car-speed increase. This increasing governor pressure finally reaches the shifting point and is sufficient to overcome the 3-4 shift valve spring pressure and modulated throttle pressure. The 3-4 shift valve thus opens and directs oil (FCA and FBR) through the double-transition valve to the front unit. Now, the front clutch is
applied and the front band released so the front unit goes into direct drive. With both units in direct drive (Fig. 7-45a) the transmission is in fourth.

7. **Downshifts.** The transmission will downshift from fourth to third, from third to second, and from second to first (selector lever in DR) as car speed is reduced. These downshifts are caused by the reduced governor pressure which permits the shift-valve springs and modulated throttle pressure, to shift the valves. However, downshifting may be accomplished at higher speeds by pressing the accelerator pedal all the way down.

8. **Forced downshift—fourth to third.** To improve acceleration at relatively high speed, the transmission includes a provision for downshifting from fourth to third. This is done by pushing the accelerator all the way down. This action compresses the throttle-valve spring until the T valve contacts the throttle valve with the throttle valve against the 4-3 detent plug (L in Fig. 7-49). Now, throttle pressure back of the detent plug resists further throttle movement. But if the driver presses harder on the accelerator pedal, he can move the detent plug and throttle valve on back until the T valve lands close off the T valve exhaust port and opens a pressure port. Now, T pressure is released from the T valve. The T pressure passes the 3-4 lock-out valve and is applied back of the 3-4 shift valve. This additional pressure (added to the spring and modulated throttle pressure) shifts the 3-4 shift valve to the closed position. The transmission then downshifts from fourth to third.

To properly time the downshift (and prevent a sudden hard shift), the 4-3 valve (to upper left in Fig. 7-49) delays the application of the band until the engine speed increases sufficiently. The delay is produced by the 4-3 valve as follows: At speeds above about 25 mph, G-1 pressure moves the 4-3 valve into the FBA passage. Now, when the downshift occurs, the FBA oil is metered through a small alternative passage. It flows through more slowly and thus band application is slightly delayed.

9. **Forced downshift—third to second.** Below about 19 mph, a forced 3-2 downshift may be obtained by pushing the accelerator to the floor. This opens the T valve and permits T pressure to act on the 3-2 detent plug and the 2-3 shift valve. The 2-3 shift valve is thus closed and the downshift occurs. T pressure also relocates the 3-2 timing valve and this causes the exhaust of RBR and RCA...
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to be metered through a small orifice of the bypass valve. This delays the application of the rear band until the front clutch apply oil is obtained. This prevents a shift from third to first and then to second.

10. Forced downshift—second to first. A 2-1 downshift may be obtained at low speed by pressing the throttle wide open. This action directs T pressure on the 1-2 regulator plug and 1-2 shift valve and causes the shift valve to close so that the downshift occurs. This action is very similar to that happening on the other forced downshifts mentioned above.

11. Second gear in LO range. When the selector lever is in the LO position, the transmission cannot shift above second. It is restricted from shifting above second, as described below.

With the manual valve in LO (lower right in Fig. 7-50), pump pressure can pass through the LO port in the valve body. This LO pressure is directed to the 2-3 auxiliary valve (V in Fig. 7-49) where it opposes governor pressure and prevents a 2-3 upshift. LO pressure is also directed to the overcontrol valve (lower right). The purpose of this is to prevent a 4-2 forced downshift when shifting from DR to LO at speeds above the lock-out point.

12. Reverse. When the selector lever is moved to reverse, then the manual valve is moved all the way to the right (Fig. 7-50). Pump pressure can now flow to the reverse cone clutch to cause it to engage. At the same time, oil is directed to the front servo to apply the front band and to the rear servo to release the rear band. Now, the transmission goes into reverse (see Fig. 7-45b).

The manual valve also directs oil to the reverse booster plug in the pressure regulator valve (in front pump). This increases the oil pressure temporarily in order to have additional pressure which will prevent slippage of the cone clutch.

13. S range—third gear. The S, or Super-Performance range, keeps the transmission in third gear over most of the operating range. It is obtained by placing the selector lever in the S position. This moves the manual valve to the S position (shown dotted at top of Fig. 7-50). Now, the manual valve directs pump pressure (S pressure) to the 3-4 governor plug, against the 3-4 lock-out valve, and to the 3-4 shift valve. This delays upshifting from third to fourth until governor pressure has built up enough to open the overcontrol valve. When this happens, the upshift will occur.
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14. Pump pressures. The front pump shown in Fig. 7-49 is of a special vaned type with a spring-loaded slide. When the slide is centered, then its inner circumference is exactly concentric with the rotor. This means that the rotor vanes will not move in or out at all (their outer ends rest on the inner circumference of the slide). With this condition, there will be no oil pumped. However, when the system requires the front pump to deliver oil, then the slide moves away from the center position (moved by the spring pressure). Then, when the pump pressure increases to the regulated value, the pressure regulator (C in Fig. 7-49) shifts to allow oil pressure to be directed to one side of the slide. The slide is therefore forced to move toward center. As it does so, the rotor vanes can deliver less oil and thus pump pressure is not able to increase any further. In action, the slide seeks and finds the position at which the pump will be able to deliver the amount of oil called for by the system and still maintain the correct, regulated pressure.

CHECK YOUR PROGRESS

Progress Quiz 10

The automatic transmission described in the past few pages has been widely used, both on passenger cars and, with some variations, on heavy-duty vehicles. Thus, when you go into the automotive service shop, you will run into cars equipped with this transmission again and again. You should be well acquainted with its construction and the manner in which it operates. This understanding will help you in your service work and will also help you to understand other automatic transmissions described on following pages. The quiz below gives you a chance to determine how well you remember the essential points of the Hydra-Matic as described on the preceding pages. If any of the questions seems hard to understand, reread the pages that will give you the answer.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. The number of planetary-gear sets in the Hydra-Matic is
   two three four five

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2. The number of oil pumps in the Hydra-Matic is two three four.
3. In the LO range, shifting will be between first and second first, second, and third first, second, third, and fourth.
4. In the DR range, shifting will be between first and second first, second, and third first, second, third, and fourth.
5. In the Hydra-Matic, the planetary gearsets function either as direct-drive units or as speed-reducing units speed-increasing units.
6. The planetary gearsets are controlled by multiple-plate clutches and single-plate clutches ratchets and pawls brake bands.
7. With the brake band on and the clutch off, the planetary gearset is in direct drive reduction reverse.
8. In the front unit, application of the brake band holds the sun gear stationary, while in the rear unit, application of the brake band holds the sun gear stationary ring gear stationary planet carrier stationary.
9. With both bands on and both clutches off, the Hydra-Matic is in first second third fourth.
10. With the front band and rear clutch on and front clutch and rear band off, the Hydra-Matic is in first second third fourth.
11. The point at which shifting occurs is determined by car speed and output-shaft speed input-shaft speed throttle opening.
12. The two oil pressures working on the shift valve are governor pressure and pump pressure rotor pressure throttle pressure.
13. Car speed at which an upshift occurs increases with increased throttle opening governor speed pump pressure.
14. With the front unit in direct drive and the rear unit downshifted, the Hydra-Matic is in first second third fourth.
15. With the transmission in third, all of the power is delivered to the intermediate shaft but there it splits, 40 percent entering the torus and 60 percent entering the rear sun gear front sun gear rear ring gear.
16. When upshifting from second to third in the DR range, governor pressure overcomes modulated throttle pressure and spring pressure acting on the 1-2 shift valve 2-3 shift valve 3-4 shift valve 4-3 shift valve.
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17. In a forced downshift from high, T pressure passes the 3-4 lockout valve and is applied back of the 1-2 shift valve 2-3 shift valve.
18. In reverse, oil pressure leaves the valve body through the REV port and causes engagement of the reverse cone clutch reverse brake band rear clutch front clutch.
19. In the S range, upshifting into fourth is delayed until the governor pressure has built up enough to open the high-speed valve overcontrol valve overrun control valve.
20. As the slide in the front pump (vane type) shifts from the center position, the pump delivers more oil less oil higher speed.

CHAPTER CHECKUP

Note: Since the following is a chapter review test, you should review the chapter before taking it.

You have been making steady progress in your studies of automatic transmissions and have, in fact, covered most of the basic material you need to understand almost any type of automatic transmission, including those using torque converters. The chapter you have just finished covers two widely used automatic transmissions which were among the first in the field. The following checkup will not only help you to review the important details of these transmissions, but will also assist you to remember the important points about them. Reviewing the important details and writing down essential data on the transmissions will fix the information in your mind. Also, since you will write in your notebook, you will be making your notebook a valuable source of information you can refer to quickly in the future.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. The purpose of the fluid coupling is to act as a synchronizing device automatic gear changer flexible power-transmitting coupling.
2. The fluid coupling consists essentially of two doughnuts vane members guide rings driving shafts.
3. Another name for a fluid coupling is converter torus freewheel planetary.

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4. In the fluid coupling, oil passes from the driving member to the coupling vanes driven member gear.

5. The purpose of the guide ring in the fluid coupling is to reduce oil movement between members turbulence level in coupling.

6. The fluid coupling has maximum efficiency when the driving and driven members are turning at high speed at low speed at different speeds at about the same speed.

7. The Gyro-Matic transmission is also known as the torque converter synchromesh. Prestomatic Hydra-Matic.

8. In the Gyro-Matic, the fluid coupling is used in connection with a torque converter conventional clutch multiple-plate clutch.

9. In the downshifted position (Gyro-Matic) the transmission is in either first or third second or fourth second or reverse.

10. During upshift, (Gyro-Matic) the direct-speed fork moves the direct-speed clutch sleeve so that it locks the main drive pinion to the first-speed gear third-speed gear drive pinion.

11. In the Hydra-Matic, the front ring (internal) gear is connected to the torus cover output shaft sun-gear shaft pinion cage.

12. The front planet-pinion cage (or carrier) is attached to the input shaft intermediate shaft sun-gear shaft front drum.

13. The front sun gear is separately mounted and is attached to the input shaft output shaft brake drum.

14. In the Hydra-Matic, the rear ring (or internal) gear is integral with the planet-pinion cage sun gear rear brake drum.

15. The rear planet-pinion cage (or carrier) is attached to the input shaft output shaft sun-gear shaft.

16. The driven member of the fluid coupling is attached, through the main shaft, to the planet-pinion cage internal gear sun gear of the center planetary.

17. In first speed, gear reduction is obtained through front planetary only both planetary sets rear planetary only.

18. In second speed, gear reduction is obtained through front planetary only both planetary sets rear planetary only.

19. In third speed, gear reduction is obtained through front planetary only both planetary sets rear planetary only.

20. A planetary set is in reduction with brake on, clutch off brake off, clutch on brake on, clutch on.
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Purpose and Operation of Components

In the following, you are asked to write down the purpose and operation of the automatic transmissions and transmission controls described in the chapter. If you have any difficulty in writing down your explanations, turn back into the chapter and reread the pages that will give you the answers. Then write down your explanation. Don't copy; try to tell it in your own words. This is a good way to fix the explanation more firmly in your mind. Write in your notebook.

1. Explain the purpose of the fluid coupling.
2. Describe the fluid coupling.
3. What is the purpose of the guide ring used in some fluid couplings and how does the guide ring work?
4. Explain why the fluid coupling is most efficient when both members are turning at about the same speed.
5. In the Gyro-Matic transmission, name the parts, in order, that carry power from the engine crankshaft to the drive pinion in the transmission.
6. In the Gyro-Matic, name the parts, in order, that carry power from the main drive pinion to the main shaft when in first gear.
7. In the Gyro-Matic, name the parts, in order, that carry power from the main drive pinion to the main shaft when in second.
8. In the Gyro-Matic, name the parts, in order, that carry power from the main drive pinion to the main shaft when in third.
9. Describe the actions that take place in the transmission itself when the Gyro-Matic upshifts from first to second. From third to fourth.
10. Describe the actions that take place in the control circuit of the Gyro-Matic when the transmission upshifts. When it downshifts due to reduced speed. When it downshifts due to operation of the kickdown switch.
11. Explain the purpose and operation of the antistall control.
12. In the Hydra-Matic, name the parts, in order, that carry power from the flywheel to the output shaft when the transmission is in first. In second. In third. In reverse.
13. Explain how the clutch and brake band on the front planetary can convert the planetary from a speed-reduction to a direct-drive unit.
14. Explain how the shift control operates in the Hydra-Matic (governor pressure opposing throttle pressure).
16. Describe the action and purpose of the second fluid coupling in the Hydra-Matic with two fluid couplings.
Transmissions with Fluid Couplings

SUGGESTIONS FOR FURTHER STUDY

If at all possible, examine the complete transmissions and also the transmission parts and controls described in the chapter you have just completed. Many school automotive shops have these available, and often automotive service shops will have defective parts or units that you can examine. In addition to this, try to trace the electric circuits in the Gyromatic on a car to see how the parts are connected. Study carefully any shop manuals from the manufacturers of the automatic transmissions to gain a more complete idea of how the units are constructed and how they operate. Be sure to write down in your notebook any important facts you come across.
8: Transmissions with torque converters

THIS CHAPTER describes the construction and operation of torque converters, compares them with fluid couplings, and discusses the automatic transmissions with which torque converters are used. Following chapters then explain how to trouble-shoot, service, and repair this equipment.

§74. Fluid couplings compared with torque converters  At first glance torque converters appear to be very similar to fluid couplings. Both have a driving member and a driven member. Both transmit torque (or power) by passing oil from the vanes of the driving member to the vanes of the driven member. However, the fluid coupling is essentially a special form of clutch that transmits torque at maximum efficiency when both members are turning at close to the same speed. When the driving member turns appreciably faster than the driven member, then the efficiency with which torque is delivered to the driven member is lowered. Here's the reason:

When the driving member is turning considerably faster than the driven member, the oil is thrown onto the vanes of the driven member with considerable force. It strikes the driven-member vanes and splashes, or "bounces back," into the driving member. In other words, this effect actually causes the oil to work against the driving member. Thus, when there is a big difference in driving and driven speeds, a good part of the driving torque is used in overcoming this "bounce-back" effect. Torque is lost; there is a torque reduction through the fluid coupling.

The situation is greatly different in the torque converter. This device is so designed as to prevent or reduce to a minimum the bounce-back effect. The result is that torque is not reduced when there is a large difference in driving and driven speeds. Quite the
Transmissions with Torque Converters

§76. Torque converter action The torque converter provides varying drive ratios between the driving and driven members, thus providing varying amounts of torque increase. It accomplishes this by means of curved vanes in the driving and driven members and by the use of one or more extra members (between driving and driven members). These extra members act to reduce the splashing or “bouncing-back” effect mentioned in §74. You will recall that this effect causes torque loss in a fluid coupling since the bouncing oil strikes the forward faces of the driving-member vanes and thereby tends to slow down the driving member.

Note: In the torque converter, the driving member is usually referred to as the pump (also called the impeller) while the driven member is called the turbine. In operation, the pump drives the turbine.

1. Curved vanes in torque converter. As already mentioned, the vanes in the driving and driven members of the torque converter are curved. This curvature is shown in Fig. 8-1. Note how the curving vanes allow the oil to change directions rather gradually as it passes from the driving to the driven member. The heavy arrows show the oil paths. The small arrows indicate the driving force with which the oil strikes the vanes of the driven member. It can be seen that the oil, which is moving round with the driving member, is thrown with a forward motion or velocity into the driven member. As the oil passes into the driven member, it “presses” forward all along the vanes as shown by the small arrows. This produces the push which causes the driven member to rotate.

[245]
2. Bouncing-back effect without additional members. When the two members are revolving at about the same speed, there is relatively little movement of oil between the two. This is similar to the action in the fluid coupling. However, when the driving member is revolving considerably faster than the driven member, the oil is thrown forward with considerable velocity into the driven member. You will recall the difficulty this produces in the fluid coupling because of the bouncing-back effect. You can see how this effect occurs in Fig. 8-2. In this illustration, the front parts of the vanes and the guide ring have been cut away so the inner ends of the vanes can be seen. Compare this illustration with Fig. 8-1.

Note: In actuality, the inner ends of the vanes are not shown in Fig. 8-2. This illustration is included merely to show what would happen if the vanes were continuous and if there were no additional members in the assembly.

As the oil passes through the driven member, as shown by the heavy arrows (Fig. 8-2), it moves along the curved vanes of the driven member. It is still moving rapidly as it leaves the trailing edges of the driven-member vanes. (The trailing edges are the back edges, or the edges that the oil passes last as it leaves the member.) However, note that the oil has changed directions. The curved
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vanes of the driven member have caused the oil to leave the trailing edges of the vanes so that it is thrown against the forward face of the driving-member vanes. This is shown by the small arrows in Fig. 8-2. The oil thus opposes the driving force of the driving member. With a big difference in speeds between the driving and driven members, this opposing force would use up a good part of the power being applied by the driving member. Thus,

Fig. 8-2. This illustration is designed to show what would happen if the vanes in the previous illustration were continuous. Actually, the inner ends of the vanes are not as shown here, but are as pictured in following illustrations. In the illustration here, the split guide and the outer ends of the vanes have been cut away. If the vanes were as shown here, the oil leaving the trailing edges of the driven member would be thrown upward against the forward faces of the driving-member vanes, thus opposing the driving force. This effect, shown by the small arrows, would cause wasted effort and loss of torque.

some means of reducing this effect must be used if the torque converter is to function efficiently when the driving member is turning considerably faster than the driven member.

A simple method of overcoming this effect, and at the same time increasing the push (or torque) on the driven member, is shown in Fig. 8-3. In Fig. 8-3A, a jet of oil is shown striking a hemispherical bucket attached to the rim of a wheel. This compares to the oil being thrown from the driving member into the curved vanes of the driven member in the torque converter. The jet of oil swirls around the curved surface of the bucket and leaves the bucket with almost the same velocity as it had when entering the bucket. In exactly the same way, the oil is thrown into the driven member (Fig. 8-2); the curved vanes of the driven member react against it, change its direction, and throw it back to the driving member.
In Fig. 8-3A, the oil will give up very little of its energy to the bucket and there will be only a small push on the bucket. That is, there will be but little torque applied to the driven member.

Furthermore, it is this returning oil which bounces back into the driving member and causes the loss of torque as already explained. However, we can prevent this effect if we install a stationary curved vane as shown in Fig 8-3B. Now, the oil, as it comes out of the bucket, enters the stationary curved vane and will again be reversed in direction. That is, it will once more be directed into the bucket. Theoretically, the oil could make many complete circuits between the bucket and the vane. Each time it reentered the bucket, it would impart a further push (or added torque) to the bucket. This effect is known as torque multiplication.

In an actual torque converter, there are stationary curved vanes which reverse the direction of the oil as it leaves the driven member. Thus, the oil enters the driving member in a "helping" direction, passes through and then reenters the driven member where it gives the vanes of the driven member another "push." In other words, the oil is repeatedly redirected into the driven member, each time adding torque to the driven member. Thus, there will be an increase in torque; torque has been multiplied. Following paragraphs explain how this effect is achieved in actual torque converters.

3. Changing direction of oil flow. In an actual torque converter, one or more additional members are placed between the trailing edges of the driven-member vanes and the leading edges of the
driving-member vanes. The trailing edges are the edges of the vanes that the oil passes last as it leaves a member. The leading edges are the edges onto which the oil first flows. The additional members in the torque converter have curved vanes that change the direction of the oil into a "helping" direction instead of a "hindering" direction. The effect illustrated in Fig. 8-3B is thus achieved.

Figures 8-4 and 8-5 are sectional and cutaway views of an actual torque converter, illustrating these additional members and their
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effect in changing the direction of oil flow. The torque converter illustrated has five members, as noted in the illustration. (Some torque converters have as few as three members.) Every vane of any one of the members has the same shape. Thus, all vanes on the primary pump, or driving member, are identical in shape. As can be seen, however, the shapes differ on the different members. There are five members and five types or shapes of vanes. They are numbered in the order in which the oil moves past them. That is,

the oil would move from vane No. 1 (in primary pump or driving member), past vanes No. 2, No. 3, No. 4, and No. 5, and then back to No. 1 again.

The five members in the torque converter illustrated in Figs. 8-4 and 8-5 are separately mounted on shafts in such a way as to have some degree of independent rotation. Figure 8-6 shows these five members separately. Compare this illustration with Figs. 8-4 and 8-5 and note the names of the members. Let us see how this torque converter operates under different driving conditions.

4. Operation of torque converter. The operation of the torque converter permits an efficient variation of drive, or torque, ratios [250]
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through it. For example, with the driving member rotating at a constant speed, the driven member begins to rotate and comes up almost to that speed, passing through a considerable variation in drive ratios as it does so. Let us see how the torque converter operates under various conditions.

a. Heavy load and hard acceleration. When the car is first started, or is under heavy load (as, for instance, going up a hill), the engine is turning at relatively high speed while the car is moving slowly. This means that the driving member, or primary pump (No. 1), is rotating considerably faster than the driven member, or turbine (No. 2). Without the additional members (Nos. 3, 4, and 5), there would be a strong bouncing-back effect, as illustrated in Fig. 8-2. However, in the actual unit, the direction of the oil is changed by the vanes of the secondary and primary stators (Nos. 3 and 4 in Fig. 8-5). Thus, the oil direction is changed to a forward, or helping, direction again. During this phase of car operation, the stators are stationary; that is, they are not revolving at all.

Refer once again to Fig. 8-3B. Note that as the oil is changed in direction by the stationary curved member, it reenters the bucket and imparts additional torque to the wheel. In a like manner, the stationary stators change the direction of the oil so that it reenters the driving and driven members and imparts additional torque to the driven member. In other words, there is a torque increase, or torque multiplication. In actual operation, the torque multiplication may be as much as 2.2:1 in the unit shown. That is, for every pound-foot of torque applied by the driving member, the driven member delivers to the output shaft 2.2 lb-ft (pound-feet) torque. Note that this is done at the expense of speed; the driving member turns much faster than the driven member. This might be compared to the speed-reduction, torque-increase effect in a pair of gears (see §5).

The secondary pump (No. 5) is not needed during heavy-load, hard-acceleration operation. To keep it from hindering the action of the torque converter at this time, it is allowed to overrun, or spin faster than, the primary pump. It is mounted on a freewheeling, or overrunning, clutch to make this possible. The clutch most widely used is similar to the freewheeling mechanism used in overdrives in construction and operating principles (see §41). It allows the
secondary pump to spin faster than the primary pump but locks or "clutches" when the secondary pump attempts to rotate more slowly than the primary pump. And when it "clutches," it locks the two pumps together so both must turn at the same speed. Figure 8-7 shows a typical freewheeling device, or overrunning clutch, used to support a stator in a torque converter. The same sort of overrunning clutch is used with the secondary pump. When the secondary pump spins faster than the primary pump, the

Fig. 8-7. Details of an overrunning clutch used to support a stator in a torque converter. (De Soto Division of Chrysler Corporation)

rollers move into the larger spaces in the overrunning clutch cam. There, they have ample room to turn, thus permitting free overrunning of the secondary pump. However, when the secondary pump slows down to primary-pump speed, then the springs force the rollers forward where they jam tightly between the overrunning-clutch hub and the clutch cam. Now, the secondary pump must turn as fast as the primary pump; the two turn together.

The force that causes the secondary pump to spin faster than the primary pump comes from the oil striking the back faces of the
secondary-pump vanes. This is shown in Fig. 8-5. In effect, the vanes are pushed out of the way so that they do not interfere with the oil flow from the stators into the pump.

b. Medium load and light acceleration. During operation under medium load and light acceleration, the turbine (No. 2) is picking up speed and thereby is approaching the speed of the primary pump (No. 1). Under these conditions, the oil is not being thrown back so hard as it leaves the trailing edges of the turbine blades. This means that the oil no longer thrusts against the secondary-stator blades (No. 3). As a result, the secondary stator is no longer held stationary, and it begins to rotate, or to move with the rotating mass of oil, so that it no longer enters into the converter action. The secondary stator is also mounted on a freewheeling, or overrunning, clutch, just as is the secondary pump.

During this phase of operation, the primary stator is still locked stationary. Its function during this time is to produce a relatively small change in direction of the oil. The secondary pump, however, has ceased to overrun because the oil is no longer striking the back sides of its vanes. The secondary pump is actually beginning to help the primary pump. That is, it is beginning to impart some forward motion, or driving force, to the oil.

c. Light load and steady driving. During operation under light loads and steady driving, the torque converter becomes simply a fluid coupling. That is, oil no longer passes rapidly from one member to the next, and the primary pump (or driving member) and the turbine (or driven member) are turning at approximately the same speed. Under this condition, the oil no longer needs any appreciable change of direction as it leaves the trailing edges of the driven-member vanes. As a result, the primary stator now begins to freewheel along with the secondary stator. Both rotate, or move with, the mass of oil. Neither contributes anything to the operation of the converter action.

The secondary pump remains locked to the primary pump, the two rotating as a unit to impart driving force to the oil.

d. General. Actually, the change-over from one to the next phase of operation, as outlined above, is not sudden but gradual and is in accordance with the changing demands of the operation. Thus, when starting and accelerating, the primary and secondary stators remain stationary and the secondary pump overruns. Then,
as turbine speed nears primary-pump speed, the changing pattern of oil flow eases the back pressure on the secondary-stator vanes so that the secondary stator begins to revolve. Also, the oil stops striking the back side of the secondary-pump vanes, and the pump stops overrunning. Then, as a steady speed is reached on a level road, primary pump and turbine speeds become nearly equal. This means that further changes in the pattern of oil flow have taken place to permit the primary stator to begin to rotate with the secondary stator.

\section{Torque converters with four members}

Other torque converters, while similar in operation, incorporate some differences in construction. Four different designs of four-member torque converters are discussed in the following paragraphs. One of these, with its transmission, is called the Packard Ultramatic Drive. Another four-member torque converter is used with the Gyro-Matic, Prestomatic, and Tip-Toe Shift transmissions on Chrysler, Dodge, and De Soto cars; it is termed a Fluid-Torque Drive by the manufacturer. An adaptation of this torque converter has been combined with a standard-type transmission for Plymouth (and called the Plymouth Hy-Drive). A somewhat different adaptation of this four-member torque converter is used on De Soto and other Chrysler-made cars with a fully automatic transmission; the combination is called the Powerflite. A still different type of four-member torque converter is the Buick Twin-Turbine used in the Dynaflow. All of these are discussed in the following paragraphs.

\subsection{Packard Ultramatic drive}

The torque converter used with this automatic transmission is shown in Fig. 8-8. It contains four members, two of them rigidly bolted together so that they turn together at all times. The oil passes from the pump to the first turbine, from there to the stator, or reactor, and then to the second turbine, which is rigidly bolted to the first turbine. During acceleration, the stator (reactor) is held stationary by the force of the oil thrown into its vanes from the first turbine. The curved vanes of the reactor change the direction of the oil so that it is thrown into the vanes of the second turbine in the proper direction. There, the oil gives up most of its remaining velocity and so does not offer any great interference to the pump vanes as it moves into the pump. During steady run-
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During running, the converter acts simply as a fluid coupling, with the reactor, which is mounted on an overrunning clutch, rotating with the mass of oil.

The overrunning clutch used in this torque converter is somewhat different from that already described. It is a sprag-type overrunning clutch which acts in the same way but is differently constructed. The sprags are somewhat like flattened rollers (Fig. 8-9). The inner and outer races of the overrunning clutch are not notched but are smooth. A series of sprags are positioned between the inner and outer races and are held in place by two springs put into the sprag notches. The outer race is stationary but the inner race is splined to the reactor hub and therefore turns with the reactor. During steady running, the reactor is not needed, as already men-

Fig. 8-8. Sectional view of a four-member torque converter. (Studebaker-Packard Corporation)
tioned. It rotates. The sprags, being at a slight angle as shown in Fig. 8-9, have no effect on the forward rotation of the inner race. During acceleration, however, the oil must change directions, and it is thrown against the front faces of the reactor vanes, as mentioned in the previous paragraph. This produces a backward thrust or pressure on the reactor vanes that halts the reactor and attempts to turn it backwards. However, as this happens, the sprags jam between the inner and outer races, thereby locking up the inner race so that it cannot turn backward. It becomes stationary so that its vanes can effectively change the direction of the oil flow.

This torque converter also contains a direct-drive clutch, which is mounted directly to the flywheel. The direct-drive clutch (Fig. 8-10) contains a driven plate centered between two driving plates. One of the driving plates can move back and forth a fraction of an inch. At the right time (according to the car speed and accelerator position), an oil passage is opened by a control valve to permit oil to flow to the clutch. This oil exerts pressure through a pressure passage against the movable driving plate, forcing it toward the driven plate. As a result, the driven plate is clamped tightly between the two driving plates so that it turns with the driving plates. Since the driven plate is splined to the transmission input shaft, the effect is to bypass the torque converter and thereby place the car in direct drive. With the car in direct drive, the driving and driven members of the torque converter (pump and turbine) are locked together through the clutch. Clutching action of the direct-drive clutch, and thus direct drive, is achieved by operation of the
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hydraulic system as explained in a following article. The hydraulic system places the converter in direct drive during steady driving and during deceleration. In direct drive, there is no slippage or speed loss through the torque converter.

2. Chrysler Fluid-torque Drive. This four-member torque converter is used with the Gyro-Matic, Prestomatic, and Tip-Toe transmission on Chrysler, Dodge, and De Soto cars. As already mentioned, this torque converter has been adapted for the Plymouth

Figure 8-10. Disassembled view of the direct-drive clutch in the torque converter shown in previous illustrations. (Studebaker-Packard Corporation)

Hy-Drive and a modification of it is used in the Chrysler, De Soto, and Dodge PowerFlite automatic transmission.

Figure 8-11 is a partial cutaway view of this torque converter. The illustration shows it in combination with a clutch assembly and a Tip-Toe Shift transmission. It has supplanted a fluid coupling used with the transmission shown. This earlier fluid coupling, as well as the transmission and controls, is discussed in detail in §§62 to 67.

The Fluid-Torque Drive torque converter contains a driving member, or impeller (called the pump in other torque converters), and a driven member, plus a primary stator and a secondary stator. Each of these stators is mounted on a freewheeling device, or overrunning clutch, as shown in Fig. 8-7. The action in the torque
Fig. 8-11. Cutaway view of the Fluid-Torque Drive, clutch, and Tip-Toe hydraulic-shift transmission. (De Soto Division of Chrysler Corporation)

STARTING FROM STANDSTILL
MAXIMUM TORQUE INCREASE

Fig. 8-12. Action of the Fluid-Torque Drive torque converter when starting from a standstill. Both stators are stationary and are redirecting the oil from the turbine into the impeller (or pump) in a helping direction. (De Soto Division of Chrysler Corporation)

converter when first starting is illustrated in Fig. 8-12. Under these conditions, the driving member is rotating much faster than the driven member. The two stators are stationary, and they redirect the oil as it leaves the driven member into a “helping” direction. This is shown by the arrows. In other words, as the oil comes off the driven-member vanes, it strikes the stationary stator vanes and
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is changed in direction. Then, it enters the driving member in a
direction that does not hinder driving-member rotation.

When the car picks up speed, the driven-member speed increases
until it nears the speed of the driving member. As this happens, the
oil leaving the driven-member vanes gradually changes in direction
until it begins to strike the back faces of the primary-stator vanes.
This causes the primary stator to begin to rotate. It no longer enters
into the action but simply rotates to get out of the way. The
secondary stator still continues to change the direction of the oil,
but it, alone, does not change the direction as much as the two
stators working together did. On the other hand, with the two con­
verter members operating at more nearly the same speeds, the oil
does not require so much change of direction.

When the car is cruising along at a steady speed there is little
difference in the speed of rotation of the two members. The oil
now strikes the back of the secondary-stator vanes. This stator also
begins to rotate so as to get out of the way. Neither stator now
enters into the action; the drive acts simply as a fluid coupling.

The torque converter shown in Fig. 8-11 has its own oil pump
and oil supply. The pump is the rotary type assembled on the im­
peller shaft. The oil is retained in a sump below the clutch housing.
A variation of this same design, used on certain Chrysler and De
Soto models, utilizes the engine oil and does not have an oil sump
of its own. In this latter system, a greater amount of engine oil is
required (13 quarts). However, with the larger volume of oil, it is
necessary to change oil but twice a year under normal driving
conditions. The oil filter should be replaced every 5,000 miles. In
operation, the engine oil pump supplies not only engine lubrication
but also a flow of oil to the torque converter.

3. Plymouth Hy-Drive. The Plymouth Hy-Drive uses an adapta­
tion of the Fluid-Torque Drive described above and illustrated in
Fig. 8-11. The Hy-Drive assembly is shown in sectional view in
Fig. 8-13. If you will compare this illustration carefully with Fig.
8-11, you will note that the torque converters and clutches are
very similar in construction. In the Plymouth, a standard gear­
shift transmission is used with the torque converter. The torque
converter greatly improves the flexibility of the drive, however, and
reduces the number of gearshifts required to a minimum. The
torque converter is supplied with oil by the engine oil pump. Be-
cause of this additional oil requirement, 10 quarts of engine oil is required. Recommendation by Plymouth calls for changing the oil filter every 5,000 miles and the engine oil twice a year.

4. **De Soto Powerflite.** The De Soto Powerflite uses a torque converter similar to the one used on other Chrysler-made cars as illustrated in Figs. 8-11 and 8-13 and described above. Figure 8-14 is a sectional view of the Powerflite. The fully automatic transmission which is part of the assembly is illustrated and described on later pages in this chapter.

5. **Buick Twin-Turbine.** The Buick Twin-Turbine torque converter contains two turbines, a stator, and a pump. The design is somewhat different from other four-member torque converters already described. This unit has two turbines which are interconnected by a planetary gearset. A sectional view of the complete transmission and torque converter is shown in Fig. 8-15. The transmission itself is a fully automatic unit; its construction and operation are described on later pages of the chapter. Let us look [260].
FIG. 8-14. Sectional view of the De Soto Powerflite which includes a torque converter and a fully automatic transmission. (De Soto Division of Chrysler Corporation)
more closely at the torque converter, however, and find out how the two turbines function under different operating conditions.

a. Twin-Turbine construction. Figure 8-16 is a cutaway view of the Twin-Turbine torque converter showing the locations of the turbines, pump, and stator and the manner in which these four members are mounted. The pump is bolted to the engine flywheel and functions in the same manner as the pumps in the other torque converters already described. That is, it delivers oil to the turbines.

The first turbine is supported on a disk and hub which, in turn, is supported by needle bearings on the hub of the second turbine (Fig. 8-16). The first-turbine hub and the second-turbine hub are thus free to turn independently of each other. As part of the first-turbine disk, there is an internal, or ring, gear. This ring gear is the internal gear of the planetary gearset. (If you are somewhat hazy about how planetary gears operate, reread §42.)
The second turbine is bolted to the turbine carrier. The hub of the turbine carrier is splined to the input shaft (input to the transmis­sion). Thus, the second turbine and transmission input shaft must turn together. The turbine carrier is also the planet-pin­ion carrier of the planetary gearset. This means that the planet-pin­ion carrier also rotates with the second turbine and input shaft.

The sun gear of the planetary gearset is independent of the in­put shaft but is attached to the freewheel cam of the stator free­wheeling clutch.

The stator is mounted on a freewheeling clutch. This clutch is very similar in construction and action to those described in §76. That is, when there is a big difference between turbine and pump speeds, oil is thrown from the turbine into the stator vanes in such a direction as to hold the stator stationary. However, when turbine and pump speeds are nearly equal, then the direction of the oil is changed; it now strikes the vanes from the rear so the stator is
set into motion. Now, the stator simply rotates to keep out of the way of the moving oil; it no longer enters into the action of the torque converter.

Let us get back to the planetary gearset again. We have noted that the ring gear is part of the first turbine, the planet-pinion carrier is part of the second turbine, and the sun gear is part of the stator freewheeling-clutch cam. With these details in mind, let us find out how the torque converter operates.

b. Twin-Turbine action during acceleration. When accelerating from a standing stop, there is a big difference in pump and turbine speeds. Oil passes from the pump into the first and second turbines with considerable forward velocity and imparts considerable torque to the turbines. The first turbine starts to rotate in the same direction as the pump, carrying the ring gear around with it. Meantime, the sun gear is held stationary because the stator is stationary. This means that the ring gear (in first-turbine disk) rotates the planet pinions and causes them to "walk around" the sun gear. This action carries the planet-pinion carrier around. The input shaft is splined to the planet-pinion carrier. Thus, torque, or turning effort, is imparted to the input shaft by the action of the first turbine; this action is carried through the planet pinions to the carrier.

Meantime, as the oil passes through the first turbine, it enters the second turbine, still moving with considerable velocity. Thus, torque is applied to the second turbine and this torque adds to the torque from the first turbine (which is passing through the planet pinions and carrier). The two torques join at the planet-pinion carrier and enter the input shaft. This means a substantial torque increase through the converter.

Note that the first turbine imparts torque though the ring gear and planet pinions. The second turbine imparts torque directly since it is splined to the input shaft.

c. Twin-Turbine action as cruising speed is reached. As the car gains speed, the speed of the turbines approach the speed of the pump. This means that the oil leaving the second turbine no longer strikes the forward faces of the stator vanes. Instead, the angle of the oil changes so it begins to strike the rear faces of the stator vanes. Now, the stator is no longer held stationary. It begins to rotate so that, in effect, it moves out of the way of the oil. As the stator starts to rotate, the freewheeling-clutch cam is no longer
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held. It rotates also and thus permits the sun gear to rotate. If the sun gear rotates, instead of being held, then the torque-adding effect of the first turbine is lost. That is, when the sun gear is free, then the ring gear can no longer cause the planetary gears to "walk around" it.

Thus, as turbine speed approaches pump speed, the stator and the first turbine no longer contribute anything to the torque-converter action. They merely spin on their bearings and are no longer effective. All torque now passes from the pump to the second turbine; the assembly acts as a fluid coupling.

Actually, there is no sudden change in the torque converter from the "torque-increase" to the coupling stage. As turbine speed increases and approaches pump speed, the pressure on the stator vanes gradually slacks off. At the same time, the torque applied to the primary turbine slacks off (since oil begins to pass between primary-turbine vanes instead of striking them). Thus, the torque contributed by the primary turbine tapers off as the coupling stage is approached.

d. Variable-pitch Twin-Turbine. A later model of the Buick Twin-Turbine torque converter has variable-pitch stator blades. That is, the blades of the stator can be shifted so their angle, or pitch, can be changed. Otherwise, the torque converter is similar to the one described above. The stator does the same job as in other torque converters. That is, it changes the direction of the oil as it leaves the turbine so it reenters the pump in a helping direction. However, in this unit, the stator blades can be positioned in either of two positions (Fig. 8-16a). In the high-angle, or closed position (to right), the blades are turned almost like the slats of a nearly-closed venetian blind. This is the position they take when the accelerator is wide open for heavy acceleration. With this condition, the pump is turning much faster than the turbines. The oil leaves the turbines with a very heavy reaction force (or "bounce-back"). The high angle of the stator blades then changes the direction of the oil sharply so it can reenter the pump in a fully helping direction. This action increases the torque multiplication in the converter.

As speed increases, the accelerator is eased up. This action causes the stator blades to change angles. They move into the wide-open position (left, Fig. 8-16a). In this position, they still redirect oil from the turbine into the pump into a helping direction. However,
since the pump is not moving a great deal faster than the turbine, the direction of the oil does not have to be changed so much.

Later, when the car attains road speed, the turbine speed approaches pump speed. Now, the oil strikes the back of the stator blades so that the stator spins, or overruns. This is the same action as in other torque converters.

Control of the stator blades is achieved by an annular piston and by cranks on the lower ends of the shafts that support the blades (cranks and shafts are shown dotted in Fig. 8-16a). The crank-ends are set into the annular piston. As the annular piston is moved,

![Fig. 8-16a. The two positions of the stator blades in the Twin-Turbine, variable-pitch torque converter. (Buick Motor Division of General Motors Corporation)](image)

it causes the cranks to turn the shafts so that the blades move from one to the other position (closed or opened). The annular piston is controlled by a linkage between the accelerator pedal and a valve in the valve body. When the accelerator is opened wide, the valve is moved. This admits oil under pressure against the annular piston. The piston is thus forced to move and shift the blades into the high-angle position. Then, when the accelerator is released, the valve moves again. Now, it admits oil under pressure to the other side of the piston so it moves back and turns the blades into their low-pitch position.

§78. Torque converter with three members Figure 8-17 is a partial cutaway view of the Cruise-O-Matic automatic transmission. The [266]
Fig. 8.17: Partial cutaway view of the Ford Cruise-O-Matic transmission which has a three-member torque converter. This transmission is very similar to the Fordomatic transmission. (Ford Division of Ford Motor Company)
Cruise-O-Matic has a torque converter using three members: a pump, a stator, and a turbine. Figure 8-18 shows the three members detached from the assembly and separated. Figure 8-19 is a simplified drawing of the converter. This unit is similar in many respects to the other torque converters previously described. The stator is mounted on a freewheeling mechanism which permits it to run free when the torque members are both turning at about the same speed. However, when torque increase (and drive reduction) takes place, the stator is brought to a halt. The stator then acts as a
reactor and turns the oil from the trailing edges of the turbine into a "helping" direction before it enters the pump. In this torque converter, the maximum torque increase produced is slightly over 2:1. As turbine speed approaches pump speed, the torque increase gradually drops off until it becomes 1:1 as the turbine and pump speeds reach a ratio of approximately 9:10. At this point, the oil begins to strike the back faces of the vanes in the stator so that the stator begins to turn. Thus, in effect, it "gets out of the way" of the oil and thereby no longer enters into the torque-converter action. The converter therefore acts simply as a fluid coupling under these conditions.

Note: Other three-member torque converters include those used in the late-model Chevrolet Powerglide and the Studebaker automatic transmission. See Figs. 8-44 and 8-46.

Check Your Progress

Progress Quiz 11

Torque converters might be called newcomers in the automotive field. Although they have been used for some time, it has been only in recent years that they have been adopted on passenger cars. Thus, you will want to be well acquainted with their construction and operation. You will see many cars with torque converters in the automotive service shop, and a good understanding of these mechanisms will help you in your service work. The quiz below will help you to find out how much you have remembered about the torque converters just covered. It will also help you review the material and thereby fix important points in your mind. If any of the questions stumps you, reread the pages that will give you the answer.

Correcting Parts Lists

The purpose of this exercise is to enable you to spot the unrelated parts in a list. For example, in the list power train: transmission, propeller shaft, radiator, differential, you can see that radiator, does not belong because it is the only item that is not a part of the power train. In each of the lists below, you will find one item that does not belong. Write down each list in your notebook, but do not write down the item that does not belong.

1. Driving member, driven member, pump, turbine, wheel, overrunning clutch.
2. Five-member torque converter: primary pump, secondary pump, primary stator, secondary stator, secondary turbine, turbine.
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5. Fordomatic torque converter: pump, stator, secondary stator, turbine.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. In the fluid coupling, speed reduction means torque reduction. But in the torque converter, speed reduction means [torque increase] [torque loss] [power increase]

2. In the torque converter, oil leaving the turbine is changed into a helping direction by curved [turbine vanes] [pump vanes] [stator vanes]

3. The torque converter must have at least [three members] [four members] [five members] [six members]

4. The fluid coupling has [two members] [three members] [four members]

5. In the five-member torque converter, primary and secondary stators are [rotating] [stationary] [moving out of the way]

6. In the five-member torque converter, during hard acceleration, the secondary pump is [stationary] [overruns primary pump] [locks to primary pump]

7. In the four-member Ultramatic torque converter, the two members bolted together are the first turbine and the [pump] [stator] [second turbine]

8. The four-member Chrysler Fluid-torque Drive contains a pump (or impeller), a turbine, and [a driven member] [a driving member] two stators a secondary turbine

9. In the Buick Twin-Turbine torque converter, the two turbines are interconnected by a [drive shaft] [series of lock bolts] [planetary gearset]

10. The Cruise-O-Matic torque converter has [three members] [four members] [five members]

§79 Automatic transmissions used with torque converters As we have already mentioned, torque converters are used with a variety [270]
of transmissions, including the Plymouth Hy-Drive (which uses a standard gearshift type of transmission), the De Soto Tip-Toe Shift (classified as a semiautomatic transmission), and fully automatic transmissions such as the Chrysler Corporation’s Powerflite and Torque-Flite, Ford Cruise-O-Matic and Fordomatic, Buick Dynaflow, Chevrolet Powerglide and Turboglide, and Packard Ultramatic.

The standard transmission and the Tip-Toe Shift type of transmission have already been discussed (standard transmission in Chap. 4 and the Tip-Toe Shift in §§65 and 66). In the pages that follow, we want to describe the different fully automatic transmissions. Essentially, all are very similar in action even though they may be differently constructed. All have a selector lever or control buttons on the steering column or instrument panel. In most automatic transmissions, there are five selector positions, P (park), N (neutral), DR (drive), LO (low), and R (reverse). In P, the transmission is locked up so the car cannot move. (There is no P position in some transmissions—the Powerflite, for example.) In N, no power flows through the transmission, but the locking effect is off. In LO, there is gear reduction through the transmission; this provides extra torque for a hard pull or for braking when going down a long hill. R is, of course, used to back the car. In the DR position, some transmissions will automatically shift between reduction and direct drive according to car speed and throttle position. This gives extra torque at low speeds (when transmission is in reduction) for better pulling power and acceleration. Other transmissions have only direct drive through the transmission (no shift) in DR. Still other transmissions depend on a planetary gearset or variable-pitch stator blades in the torque converter itself (as in the Buick Twin-Turbine Dynaflow) to provide extra torque during “getaway” and acceleration.

Some of the late model transmissions have hill-holding devices which provide a means of causing the engine to brake the car when the car is going down a hill. Some transmissions have push-button controls instead of a selector lever, as noted above. The push buttons can be located on the steering column or on the instrument panel.

Other special features will be found on the various automatic transmissions. Let us examine these automatic transmissions in detail.
1. Transmission housing
2. Converter-cover O-ring seal
3. Turbine
4. Secondary stator
5. Converter housing
6. Overrun cam roller
7. Primary stator
8. Secondary pump
9. Primary pump
10. Primary-pump O-ring seal
11. Front oil-pump-body oil seal
12. Front oil-pump body
13. Rear oil-pump body
14. Rear oil-pump body
15. Rear oil-pump body
16. Ball-bearing assembly
17. Speedometer-driven gear
18. Universal-joint front yoke
19. Ball-joint seat
20. Ball-joint seat
21. Ball-joint seat O-ring seal
22. Universal-joint housing shims
23. Universal-joint ball collar
24. Ball-joint-collari oil seal
25. Universal-joint ball
26. Universal-joint rear yoke
27. Universal-joint ball-packag retainer
28. Converter cover
29. Converter retaining washer
30. Converter retaining ring
31. Stator support
32. Input-shaft drive flange
33. Turbine bolt
34. Turbine-bolt O-ring seal
35. Special lock washer
36. Input shaft
37. Turbine front-thrust washer
38. Turbine rear-thrust washer
39. Turbine hub-bolt lock
40. Stator race-thrust snap ring
41. Stator race-thrust washer
42. Overrun cam roller and spring retainer
43. Overrun cam roller
44. Overrun cam-roller spring
45. Overrun cam-roller guide
46. Stator race
47. Secondary-pump thrust ring
48. Secondary-pump thrust washer
49. Front oil-pump seal ring
50. Front oil-pump drive gear
51. Oil-pump suction pipe and screen
52. Valve-body gasket
53. Accumulator-piston outer spring
54. Accumulator-piston inner spring
55. Accumulator-piston stop
56. Clutch drum thrust washer
57. Clutch-piston outer ring seal
58. Clutch piston
59. Clutch drive plates
60. Clutch driven plates
61. Clutch spring
62. Clutch spring seat
63. Clutch-flange retainer ring
64. Clutch-flange retainer
65. Parking-lock gear
66. Reverse drum and ring gear
67. Reverse Brake-band strut
68. Planet long pinion
69. Planet carrier
70. Reverse-drum thrust washer
71. Transmission-case rear bushing
72. Planet output shaft
73. Rear oil-pump driven gear
74. Rear oil-pump drive gear
75. Speedometer drive gear
76. Special bolt
77. Universal-joint front-yoke trun-
Fig. 8-21. Cross-sectional view of planetary system used in transmission illustrated in previous figure. This same general arrangement is used in the Dynaflow. (Chevrolet Motor Division of General Motors Corporation)

1. Input shaft
2. Clutch drum
3. Clutch-piston outer ring seal
4. Low brake band
5. Clutch-piston inner ring seal
6. Clutch-driven plates
7. Clutch-flange retainer
8. Clutch-flange retainer ring
9. Planet-pinion pin
10. Planet short pinion
11. Reverse sun gear
12. Reverse brake band
13. Output shaft
14. Clutch piston
15. Clutch spring
16. Clutch drive plates
17. Clutch hub
18. Clutch flange
19. Reverse drum and ring gear
20. Planet long pinion
21. Low sun gear
22. Planet carrier
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Fig. 8-22. Simplified drawing of transmission showing actions when it is in direct drive. This applies to both the Dynaflow and Powerglide. (Buick Motor Division of General Motors Corporation)

Fig. 8-23. Simplified drawing of transmission showing actions when it is in reduction, or low. (Buick Motor Division of General Motors Corporation)
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§80. Automatic transmissions with five-member torque converters

As examples of automatic transmissions using five-member torque converters, we shall use the Chevrolet Powerglide (earlier version) and the Chevrolet Turboglide. They are similar in many respects to the Buick Dynaflow. A later model Powerglide uses a three-member torque converter (§82).

1. Powerglide. Figure 8-20 is a sectional view of the Powerglide. Figure 8-21 shows the planetary system. Note that the planetary system is somewhat more complex than that used in the overdrive (§42) although it is very similar. It has an additional sun gear (reverse sun gear) and an extra set of planet pinions. The two sets of planet pinions are known as the planet short pinions and the planet long pinions. The reverse sun gear and the extra set of planet pinions are included in order to reverse rotation through the transmission and thus back the car.

Refer again to Fig. 8-21 and also to Fig. 8-22 which shows the planetary system in simplified form. Note that the clutch hub is splined to the input shaft so the two must turn together. The clutch-drum-and-flange assembly is splined to the low sun gear so they [276]
must turn together. The low sun gear and the clutch drum can turn freely on the input shaft. The reverse sun gear is splined to the input shaft so that it must turn with the input shaft. The reverse sun gear is meshed with the three planet long pinions, while the planet long pinions are meshed with the planet short pinions. The planet short pinions are, in turn, meshed with the low sun gear.

To sum up: When the input shaft turns, the clutch hub and the reverse sun gear must also turn. If the clutch is applied, then the clutch hub, through the clutch plates, causes the clutch-drum-and-flange assembly to turn, thereby causing the low sun gear to turn.

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![Diagram](image)

Fig. 8-25a. Simplified cutaway drawing of the Turboglide showing the major components of the converter and transmission. (Chevrolet Motor Division of General Motors Corporation)

See Figs. 8-22 to 8-24, which show the transmission in drive, low, and reverse. Figure 8-29 shows the controlling oil circuits.

29 Turboglide. Figure 8-25b is a sectional view of the Turboglide and Fig. 8-25a shows the major elements of the unit. It has three turbines and two planetary gearsets. The first turbine, which is active from stall to about 30 mph (wide-open throttle), is connected to the rear planetary sun gear by a shaft (Fig. 8-26a). During acceleration at low speeds and open throttle, the first turbine drives the rear sun gear. The internal gear is held stationary by the two overrunning clutches and the cone clutch. Therefore, the planetary carrier and output shaft are rotated at reduced speed (with a gear reduction of 2.67:1). At higher speed and at part throttle, less torque and higher output speed are desirable. Under these con-
Automotive Transmissions and Power Trains
1. Needle bearing and races
2. Converter cover hub bushing
3. Caged needle bearings
4. Converter cover
5. Third turbine assembly
6. Stator assembly
7. Converter
8. Second turbine assembly
9. First turbine ring
10. Converter pump
11. Front pump assembly
12. Selective thrust washer
13. Neutral clutch hub
14. Neutral clutch drive plate (3)
15. Neutral clutch driven plate (3)
16. Neutral clutch driven drive plate
17. Front planetary gearset
18. Front sun gear
19. Front sun gear freewheeling assembly (outer sprag)
20. Forward piston return spring
21. Forward piston return spring
22. Forward and brake piston support
23. Rear planet ring gear
24. Brake plate (3)
25. Thick reaction plate (2)
26. Thin reaction plate (2)
27. Rear planetary gearset
28. Caged needle thrust washer
29. Transmission case bushing
30. Rear pump spacer
31. Rear pump assembly
32. Rear pump drive pin
33. Extension vent
34. Speedometer drive gear
35. Output shaft (part of rear planetary gearset)
36. Extension oil seal
37. Transmission extension
38. Speedometer driven gear
39. Rear oil pump bushing
40. Output shaft inner bushing
41. Pinion shaft lock plate
42. Oil pan
43. Brake piston
44. Oil pressure tube (2)
45. Forward piston
46. Forward cone
47. Forward cone ring
48. Main valve body assembly
49. Hydraulic modulator valve assembly
50. Front ring gear hub
51. Hydraulic accumulator
52. Reverse cone
53. Reverse cone ring
54. Return spring
55. Reverse piston
56. Front pump oil seal
57. Stator support shaft
58. Second turbine shaft (integral with front ring gear hub)
59. Turbine shell
60. Third turbine shaft (integral with neutral clutch hub)
61. First turbine shaft (integral with turbine shell)
ditions the first turbine freewheels, or overruns, and thus no longer enters into the converter action. This action is permitted by the overrunning clutch that holds the internal gear.

At intermediate speed the second turbine begins to contribute torque (Fig. 8-26b). It drives the output shaft through the internal gear of the secondary planetary gearset. At light throttle and intermediate speed, the second turbine also begins to freewheel and thus no longer enters into the converter action. An overrunning clutch permits this action.

The third turbine (Fig. 8-27a) comes into operation during cruising and light road-load conditions. With the first two turbines
overrunning, or freewheeling, the third turbine delivers torque directly to the output shaft through the cone clutch. Actually, there is no sudden shift from one turbine to another. There is some overlap so that the transmission shifts smoothly from one phase to another.

**Fig. 8-27a.** Operation of clutches and planetary gears during third turbine phase or direct drive. (Chevrolet Motor Division of General Motors Corporation)

**Fig. 8-27b.** Operation of clutches, planetary gears, and converter when hill-retarder is operating. (Chevrolet Motor Division of General Motors Corporation)

The hill-retarder (Fig. 8-27b) provides braking by the engine through the transmission on steep downgrades. When the transmission lever is shifted to the hill-retarder position (HR), the first turbine is geared to the output shaft at a gear ratio of 2.67:1. Both the second and third turbines freewheel.
In reverse (Fig. 8-28) the reverse clutch engages and the first turbine shaft drives the rear planetary gearset. With the reverse clutch engaged, the front internal gear is held so that the front planet gears are interposed in the gear train to reverse the direction of motion. The output shaft thus turns in the opposite direction to back the car.

Hydraulic controls for the Powerglide are shown in Fig. 8-29. Positioning of the shift lever operates the manual valve which, in turn, directs oil to the servos. The servos then operate to provide the desired drive position.

![Diagram](image)

Fig. 8-28. Operation of clutches, planetary gearsets, and converter in reverse. (Chevrolet Motor Division of General Motors Corporation)

§81. Automatic transmissions with four-member torque converters

Two different automatic transmissions with four-member torque converters are described in the following pages. In one (the Ultramatic), there is an arrangement to lock up the torque converter (with a direct-drive clutch) under the appropriate car-speed and throttle-opening conditions. In the other (the Powerglide), there is an automatic shifting arrangement in DR (shifting between reduction and direct drive) somewhat similar in action to that in the Hydra-Matic (§68).

1. Packard Ultramatic drive. Figure 8-8 illustrates the torque converter used with the automatic transmission described in this section. The operation of the torque converter itself has already been discussed (in §77). Figure 8-30 is a partial cutaway view of the planetary gear system. This gear system is quite similar in [282]
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Fig. 8-29. Oil circuits in the transmission shown in the previous illustrations. (Chevrolet Motor Division of General Motors Corporation)
construction and practically identical in operation to the planetary
gear system of the transmission discussed in the previous section.
In the high, or drive, range, the multiple-disk clutch in the trans­
mission is engaged and the two brake bands are released. In the low
range, the low brake band is applied and the clutch and reverse
brake band are released. In reverse, the clutch and low band are re­
leased while the reverse band is applied. Refer to §80 for detailed

Fig. 8-30. Sectional view of the planetary system used with the torque con­
verter illustrated in Fig. 8-8. (Studebaker-Packard Corporation)

explanations of how the planetary gear system behaves under each
of these conditions.

Application or release of the clutch and brake bands is secured
by movement of the selector lever on the steering column to the
various drive positions. This action operates the control valve in
the transmission which then directs oil to, or relieves oil pressure
from, the servos that operate the bands and clutch.

In addition to these actions, the hydraulic system of this trans­
mision also includes a governor which functions, in conjunction
with car speed and throttle opening, to actuate the direct-drive

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clutch (Fig. 8-10) which is part of the torque converter. The purpose of this clutch is to lock the driving and driven members of the torque converter together under certain conditions so as to eliminate all slippage and thereby improve performance. The conditions under which this clutch will engage to produce lock-up include steady driving and also decelerating at speeds above 13 mph (miles per hour).

Figure 8-31 schematically shows the hydraulic system of this transmission. You will note that it is much like the hydraulic system shown in Fig. 8-29. Although the parts are somewhat differently constructed, they perform the same jobs of applying or releasing the brake bands and clutch. The system shown in Fig. 8-31 also contains a governor, as mentioned above, which is driven from the output shaft of the transmission and a direct-drive shift valve which is interconnected with a throttle valve that is actuated by throttle opening. The purpose of these parts is to control the operation of the direct-drive clutch in the torque converter. Increasing car speed increases the oil pressure from the governor, and this oil pressure is applied to one end of the shift valve. Increased throttle opening opens the throttle valve so that increased oil pressure is applied to the other end of the shift valve. These two pressures (from the governor and from the throttle valve) oppose each other in attempting to move the shift valve. When governor pressure exceeds throttle-valve pressure (as during steady, light-throttle driving or when decelerating), then the shift valve is moved. This opens an oil passage to the direct-drive-clutch piston, causing the direct-drive clutch to engage. These parts are very much like the governor, throttle valve, and shift valve used in the Hydra-Matic transmission; they are described in detail in §71 and illustrated schematically in Fig. 7-41.

2. Powerflite automatic transmission. Figure 8-14 is a sectional view of the Powerflite automatic transmission described in this section. It is supplied on cars built by the Chrysler Corporation—Chrysler, De Soto, Dodge and Plymouth. The four-member torque converter (called the Fluid-torque Drive by the manufacturer) used with this transmission has already been described (§77).

The selector lever in this transmission has four positions: R, N, D, and L. R is reverse, N is neutral, D is drive, and L is low. In reverse, the car is backed. In neutral there is no power flow through the
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Transmission. In drive, it starts out (accelerating) in reduction and then automatically shifts into direct drive. The shifting point is determined by car speed and throttle position. In low, the transmission remains in reduction. Let us examine the actions in the transmission in these various gear positions.

a. In low. Figure 8-32 is a simple diagrammatic drawing of the clutch and planetary gearsets in the transmission, showing the power flow in low, or reduction. The low (kick-down) band is on, the clutch and reverse band are off. Reduction (or low), is attained in the transmission under any of three conditions: (1) when first pulling away (breakaway) in D, (2) when accelerating hard below a specified maximum speed (this gives a forced downshift or kick-down), and (3) when in the L selector-lever position.

In low, the power flow is as shown in Fig. 8-32. It is through the torque converter, through the input shaft, and to the ring gear of the low planetary set (also called the kick-down planetary set by the manufacturer). The low, or kick-down, band is applied and this holds the low sun gear stationary. Thus, the low ring gear, as it rotates, forces the low planet pinions to walk around the low sun gear. They carry the planet-pinion carrier around with them (but at a speed slower than the input shaft is turning). Note that the low planet-pinion carrier and the reverse planet-pinion carrier are
splined together. This means that the reverse planet-pinion carrier must rotate with the low planet-pinion carrier. Notice also that the reverse sun gear is splined to the input shaft and must turn with the input shaft.

Now let us see what we have. The reverse sun gear is rotating at input-shaft speed. The reverse planet-pinion carrier is rotating slower than input-shaft speed. As a result, the planet pinions drive the reverse ring gear, but at a speed slower than input shaft speed. Direction of all members is forward (not reverse) except for the planet pinions. The planet pinions rotate backwards since the sun gear is turning faster than the pinion carrier. The gear reduction through the transmission under these conditions is 1.72:1 (input shaft turns 1.72 times for every revolution of the output shaft).

If the above is hard for you to understand, look at it this way. Suppose the planet-pinion carrier turned at the same speed as the sun gear. The ring gear would then turn at the same speed also, in the same direction. But, at the other extreme, suppose the planet-pinion carrier were held stationary. This means the planet pinions would act as idlers; the ring gear would turn in the reverse direction from the sun gear. Now, suppose we rotated the planet-pinion carrier at a speed about halfway between full stop and full speed. If we chose this speed correctly, we would find that the ring gear would not turn at all. That is, the forward speed of the sun gear would be balanced by the reverse speed of the planet pinions. The ring gear would remain stationary. But if we increased the speed of the planet-pinion carrier a little, then the ring gear would start moving forward. The more we increase carrier speed, the faster the ring gear turns until, when the carrier turns at sun-gear speed, the ring gear also turns at sun-gear speed. In low, carrier speed is somewhat slower than sun-gear speed so the 1.72:1 gear reduction is achieved.

b. In direct drive. In direct drive, the power flow is as shown in Fig. 8-33. The direct clutch is applied and both bands are off. With the clutch on, the input shaft is locked to the low sun gear. Since the low ring gear is splined to the input shaft, this means that the low sun gear and ring gear turn together. Thus, the planet pinions and carrier also turn with the sun and ring gears. The planetary set turns as a unit. The same condition exists in the reverse planetary
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set. The sun gear is splined to the input shaft and must turn at input-shaft speed. Since the planet-pinion carrier is also turning at input-shaft speed (through the low planetary set), then the reverse ring gear must also turn at input-shaft speed. This ring gear is splined to the output shaft. Thus, the output shaft turns at the same

![Diagram 8-33](image1)

**Fig. 8-33.** Power flow through Powerflite transmission in D, or drive. (De Soto Division of Chrysler Corporation)

![Diagram 8-34](image2)

**Fig. 8-34.** Power flow through Powerflite transmission in R, or reverse. (De Soto Division of Chrysler Corporation)

speed as the input shaft; there is direct drive through the transmission.

c. In reverse. Figure 8-34 shows the power flow through the transmission in reverse. The direct clutch and the low band are off, and the reverse band is applied. This holds the planet-pinion carrier stationary. Now drive is from the input shaft through the reverse sun gear (which is splined to the input shaft), through the reverse planet pinions (which act as idlers), and through the reverse ring gear. Since the reverse planet pinions are interposed, as idlers, between the sun and ring gear, the ring gear turns in the
Fig. 8-35. Hydraulic circuit of the Powertite automatic transmission with the manual valve in D or drive. (DeSoto Division of Chrysler Corporation)
reverse direction. The gear reduction in reverse is 2.39:1. That is, the input shaft turns 2.39 times for every rotation of the output shaft (with output shaft turning in reverse direction).

d. Hydraulic circuit. The hydraulic circuit for the Powerflite is shown in Fig. 8-35. The conditions illustrated are for D position or direct drive. You will note that this circuit is very similar to the circuits for other automatic transmissions previously shown (Figs. 8-29 and 8-31). However, there are several differences. The major difference is that this circuit has a throttle valve, a governor, and a shift valve to provide upshifting or downshifting when proper car speed and throttle opening are reached. This part of the hydraulic circuit is very much like the shifting arrangement in the Hydra-Matic described in §71 and illustrated in Fig. 7-41. The throttle valve, a balanced valve, is described in §62, 5. With increasing throttle opening, the output pressure of the throttle valve goes up. This output pressure is called throttle pressure. The governor is driven by the output shaft of the transmission, and thus governor pressure goes up with car speed. Let us see how these, and other, components in the system function.

e. In low and upshifting. When the car first pulls away from a standing stop with selector in D, the transmission is in low. Pump (line) pressure is passing through the manual valve (positioned at D by the selector lever); the pump pressure is admitted by the manual valve to the shift valve, throttle valve, and "apply" side of the low servo. The servo is applying the low band, the clutch is off, and the transmission is in low, as shown in Fig. 8-32. As car speed increases, increasing governor pressure, working against the end of the shift valve, puts an increasing pressure on the shaft valve. Opposing this pressure is throttle pressure applied on the other end of the shift valve. As soon as car speed increases enough, however, governor pressure will be sufficient to overcome throttle pressure, move the shift valve, and cause the transmission to upshift. The car speed required depends on throttle opening. With a light throttle, and thus low throttle pressure, the upshift will take place at a relatively low speed (as low as 15 mph). But with a wide-open throttle and high throttle pressure, the upshift will not occur until car speeds of 60 to 75 mph are reached.

As the shift valve moves, pump (line) pressure is admitted to the release side of the low servo and also to the direct clutch. Thus the
low band is released and the clutch is applied to put the trans-
mision into direct drive (Fig. 8-33).

f. Kick-down. There is a kick-down arrangement in this trans-
mision to permit the driver to downshift into reduction (Fig. 8-32) for rapid acceleration under certain circumstances. This action re-
sults if the throttle is pushed to wide-open position. As the throttle
nears the wide-open position, the driver feels a sudden increase in
pressure required for further throttle movement. This increased
pressure is due to an arm on the throttle cam forcing the kick-down
valve to open. As the kick-down valve opens, it admits additional
pressure to the shift valve. This kick-down pressure forces the shift
valve to overcome governor pressure and then move. As it moves, it
cuts off pump pressure from the direct clutch and the release side
of the low servo. Thus the clutch releases and the low servo applies.
Now the transmission is in low. The other components of the
hydraulic system provide regulation of pump pressure and proper
timing of the clutch and brake band on application and release as
follows:

The regulator valve regulates pump pressure and prevents pres-
sures of above 90 psi (pounds per square inch) from being attained
(except in reverse).

The two pump check valves prevent back flow of oil to the
pumps when a pump is not turning or is delivering very low
pressure.

The converter control valve regulates oil pressure to the con-
verter to a maximum of 60 psi.

The shuttle valve is a timing valve. It speeds up or slows down
the operation of the low servo and direct clutch according to
car speed and operating conditions. For example, consider the
"lift-foot upshift." This occurs as the driver "steps on it" and then,
on attaining the speed he wants, lifts his foot from the accelerator
(or lightens accelerator pressure). During acceleration, the trans-
mision is in low. But when he lifts his foot from the accelerator,
throttle pressure is lowered and the governor pressure is sufficient
to move the shift valve and cause an upshift. Without the shuttle
valve, this upshift could cause a series of lurches as the band
suddenly releases and the clutch applies. The shuttle valve prevents
this. Governor pressure is applied at one end of the shuttle valve,
throttle pressure at the other end. With a wide-open throttle, as
during acceleration, the shuttle valve is forced to move (to the left in Fig. 8-35). Now, when the throttle is suddenly released for lift-foot upshift, throttle pressure is reduced and governor pressure can then move the shuttle valve to the right. Now, pressure in the apply chamber of the servo is released through the shuttle valve to the direct clutch. At the same time, pump (line) pressure is being fed through the servo-pressure bleed valve (a restricting orifice). This pressure is being fed to the bleed valve from the shift valve and the shuttle valve. After it passes through the bleed valve, it enters the direct clutch and the release section of the low servo.

Now see what we have. The low-band apply pressure is released quickly to the direct clutch. But the clutch apply and band release pressure builds up somewhat more slowly. The result is that the band pressure falls off and the clutch pressure builds up with relative slowness to give a smooth shift.

The shuttle valve has a second function: to time kick-downs. At low speeds, the kick-down should be fast; this is because there is little relative change in engine speed (between direct and reduction). But at high car speeds, the engine must speed up considerably; the kick-down must be slower. For fast kick-down at low speed, the shuttle valve feeds line pressure to the apply section of the low zero through two circuits. One is the servo-pressure bleed valve and the other is the servo-pressure port of the shuttle valve. But at higher car speeds, governor pressure moves the shuttle valve so as to cut off the pressure circuit through the shuttle valve to the apply side of the low servo. Thus, apply pressure in the servo can come from only one circuit: through the servo pressure bleed valve. This means the servo applies the low band more slowly; the engine thus has more time to increase in speed before the band is applied.

g. Reverse. As the selector is moved to R, the entire hydraulic circuit from the manual valve on up (except to the reverse servo) is cut off. There is no pressure to the throttle valve, shift valve, shuttle valve, direct clutch, or low servo. These are all inoperative.
Pump pressure is applied to the reverse servo so that the transmission shifts into reverse (Fig. 8-34). An exceptionally high band pressure is required because of the large gear reduction (and thus torque increase on the output shaft). To attain this high band pressure, the pump pressure is temporarily stepped up to a maximum of 230 psi. This is done as the manual valve is shifted to R since
this cuts off line pressure from the secondary reaction area in the regulator valve. With this action, line (pump) pressure must go considerably higher before the regulator valve begins to regulate.

§82. Automatic transmissions with three-member torque converters

As examples of automatic transmissions with three-member torque converters, we will discuss the Cruise-O-Matic, the later model Chevrolet Powerglide, and the Studebaker automatic transmission. All of these incorporate automatic shifts in the DR, or drive, range.

1. Cruise-O-Matic. Figure 8-17 is a partial cutaway view of the Cruise-O-Matic automatic transmission. This transmission uses a three-member torque converter. The same assembly, with some modifications, is used on the Mercury. If you will study Fig. 8-17 [294]
and Figs. 8-36 to 8-40, you will note that this transmission has a gear and clutch arrangement that is somewhat different from the automatic transmissions previously described. It uses short and long pinions (called primary and secondary pinions in the Cruise-O-Matic) such as the Powerglide uses (see §80). But it has two multiple-disk clutches. The arrangement provides an additional forward gear ratio, so the transmission has three (low, intermediate, and high). Let us see how this transmission operates.

Fig. 8-37 gives the clutch and band action in neutral. (Ford Division of Ford Motor Company)

a. Selector lever positions and gear ratios. The Fordomatic selector lever has four positions, N, DR, LO, and R. The Cruise-O-Matic has five, N, D1, D2, L, and R. The table below shows clutch and band action and gear ratios in these selector lever positions.

<table>
<thead>
<tr>
<th>Gear</th>
<th>Selector lever position</th>
<th>Clutch applied</th>
<th>Band applied</th>
<th>Gear ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral</td>
<td>N</td>
<td>None</td>
<td>None</td>
<td>1.47:1</td>
</tr>
<tr>
<td>Second</td>
<td>DR or D1</td>
<td>Front</td>
<td>Front</td>
<td>1.00:1</td>
</tr>
<tr>
<td>Third</td>
<td>DR or D2</td>
<td>Front and rear</td>
<td>Rear</td>
<td>2.40:1</td>
</tr>
<tr>
<td>First</td>
<td>LO or D1</td>
<td>Front</td>
<td>Rear</td>
<td>2.00:1</td>
</tr>
<tr>
<td>Reverse</td>
<td>R or L</td>
<td>Rear</td>
<td>Rear</td>
<td></td>
</tr>
</tbody>
</table>
b. Gears, clutches, and bands. Figure 8-36 is a simplified cutaway showing the transmission elements. Compare this with Fig. 8-17. The arrangement is similar for the two transmissions except that the Cruise-O-Matic has a one-way or overrunning clutch (see Fig. 8-39b).

c. Neutral. In neutral (Fig. 8-37), none of the gear-train members is held or driven, so no power can pass through.

d. Second. In second (Fig. 8-38a), the secondary sun gear is held stationary by the front band, and the primary sun gear is driven.
The primary pinions drive the secondary pinions so they must "walk" around the secondary sun gear. They carry the internal gear and output shaft around with them.

e. Third. In third (Fig. 8-38b), both sun gears are locked together and are driven as a unit. The pinions cannot rotate and the gear train turns as a unit to provide a 1:1 ratio.
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f. **First (Fordomatic, Fig. 8-39a).** Power is transmitted as shown. The secondary sun gear turns free and does not enter into the action.

g. **First (Cruise-O-Matic, Fig. 8-39b).** Here, the pinion carrier is held against rotation by the one-way clutch instead of the rear band as in the Fordomatic.

h. **Reverse.** Reverse is obtained by driving the secondary sun gear and holding the pinion carrier (Fig. 8-40).

i. **Hydraulic-control system.** The various units in the hydraulic system which control the front and rear clutches and bands in the transmission are shown in Fig. 8-41. In this illustration, the transmission is in high. The manual valve has been positioned by movement of the selector lever to the DR position and the car speed and throttle position are such as to cause the system to place the transmission into high (rather than intermediate). The two pumps, working together, supply the oil for controlling the clutches and bands. The oil pressure from the pumps is regulated by the control pressure regulator.

This regulated pressure passes from the regulator through the manual control valve to the front and rear clutches so that both are applied. At the same time, the pressure is cut off from the rear servo so that the rear band is not applied. Also, pressure is intro-
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duced on both sides of the front-servo piston (apply side and release side) so that the piston is balanced and the band is not applied (see Fig. 8-38b).

Let us see what some of the other valves do in the system. We can note their actions during a downshift from high to intermediate (Fig. 8-42). Suppose the car is traveling under 55 mph and the driver pushes the accelerator all the way down. This causes the transmission to downshift from high to intermediate. The accelerator pressure moves the throttle valve so pressure is admitted to the spring side of the shift valve. This moves the shift valve to cut off pressure to the rear clutch so that it releases. Actually, the shift valve, in moving, also opens up a drain port for the oil to drain from the clutch piston so the clutch releases quickly. At the same time, this drain port also drains the oil from the release side of the
front-servo piston so that the front servo applies the front band. The 3-2 valve has the job of preventing too-rapid application of the front band which would cause rough shifting on light throttle. It does this by causing the oil draining from the release side of the front servo piston to drain through a small opening in the 3-2 valve. At wider throttles, the band must apply more quickly. The accelerator pedal positions the throttle valve to produce this action. With a greater throttle opening, more pressure (from throttle valve) is applied to the 3-2 valve piston, thereby opening the drain wider so the oil can drain from the release side of the servo piston more quickly.

The transmission will remain in the intermediate range at low car speeds because at low speeds governor pressure will not be sufficient to force the shift valve in against its spring pressure. It will remain in the position shown in Fig. 8-42. However, when car speed increases sufficiently, then governor pressure goes up and forces

Fig. 8-42. Actions in the hydraulic circuit when the transmission is downshifted (in DR) to intermediate. (Ford Division of Ford Motor Company)
the shift valve to move against its spring pressure (and throttle pressure). When this happens, oil is admitted to the rear clutch so it is applied while oil entering the release side of the front-servo piston releases the front band. The front-servo-apply regulator valve reduces the apply pressure on light throttle opening so as to allow a quicker release of the band. This prevents application of the clutch when the band is still applied. At wider throttle, release pressure will be greater and the operation of the front-servo-apply regulator valve is less important. In intermediate and high range, the modulator and compensator valves work together to modify, or modulate, the control pressure from the control-pressure regulator. This increases the intensity of clutch and band application at higher car speed and wider throttle opening, thereby assuring satisfactory quickness and firmness of application. At the same time, at lower speed and lighter throttle,

Fig. 8-43. Actions in the hydraulic circuit when the transmission is in low (Ford Division of Ford Motor Company)
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Fig. 8-44. Sectional view of Powerglide which uses a three-member torque converter. (Chevrolet Motor Division of General Motors Corporation)
| 1. Transmission housing       | 32. Rear oil-pump body       |
| 2. Cover O-ring seal          | 33. Rear-bearing assembly    |
| 3. Turbine assembly           | 34. Speedometer driven gear  |
| 4. Stator assembly            | 35. Universal-joint front yoke|
| 5. Converter housing and pump | 36. Universal-joint ball seat|
| assembly                      | 37. O-ring seal              |
| 6. Converter pump             | 38. Joint ball-collar shims  |
| 7. Converter-pump thrust washer| 39. Universal-joint ball collar|
| 8. Front oil-pump-body oil seal| 40. Ball-collar oil seal     |
| 9. Front oil-pump body        | 41. Universal-joint ball     |
| 10. O-ring seal               | 42. Universal-joint rear yoke|
| 11. Stator support            | 43. Ball packing retainer    |
| 12. Transmission valve body   | 44. Front-yoke trunion bearing|
| 13. Input-shaft oil-seal ring | 45. Universal-joint bolt     |
| 14. Clutch-drum oil-seal rings| 46. Speedometer drive gear   |
| 15. Clutch relief-valve ball  | 47. Rear-bearing lock plate  |
| 16. Low brake band            | 48. Rear oil-pump drive gear |
| 17. Clutch drum               | 49. Rear oil-pump driven gear|
| 18. Clutch-piston inner seal  | 50. Governor drive gear      |
| 19. Clutch hub                | 51. Governor driven gear     |
| 20. Clutch-hub thrust washer  | 52. Transmission-case bushing|
| assembly                      | 54. Planet pinion            |
| 22. Parking-lock gear         | 55. Reverse band lever       |
| 23. Planet short pinion       | 56. Low-sun-gear thrust washer|
| 24. Planet reverse sun gear   | 57. Planet pinion shaft lock plate|
| 25. Thrust washer             | 58. Reverse drum and ring gear|
| 26. Planet carrier            | 59. Clutch flange retainer   |
| 27. Reverse brake band        | 60. Clutch-flange retainer ring|
| 28. Output shaft              | 61. Clutch-spring seat       |
| 29. Transmission case         | 62. Clutch-spring snap ring  |
| 30. Rear oil-pump gasket      | 63. Clutch spring            |
| 31. Rear oil-pump cover       | 64. Clutch drive plates      |
|                               | 65. Clutch driven plates     |
|                               | 66. Clutch piston            |
|                               | 67. Clutch-piston outer seal |
|                               | 68. Clutch-drum thrust washer|
|                               | 69. Accumulator-piston stop  |
|                               | 70. Accumulator-piston inner spring|
|                               | 71. Accumulator-piston outer spring|
|                               | 72. Drain plug               |
|                               | 73. Transmission-case gasket |
|                               | 74. Front oil-pump driven gear|
|                               | 75. Front oil-pump drive gear|
|                               | 76. Converter drain plug     |
|                               | 77. Converter-housing drain plug|
|                               | 78. Converter-pump housing bolt|
|                               | 79. Converter-pump housing nut|
|                               | 80. Overrun-cam retaining rings|
|                               | 81. Overrun-cam thrust washer|
|                               | 82. Overrun cam-roller and spring retainer|
|                               | 83. Overrun cam roller       |
|                               | 84. Stator race              |
|                               | 85. Converter-cover hub bushing|
|                               | 86. Input-shaft stop ring    |
|                               | 87. Input shaft              |
|                               | 88. Turbine thrust washer    |
|                               | 89. Overrun cam-roller guide |
|                               | 90. Overrun cam-roller spring|
|                               | 91. Stator thrusters         |
|                               | 92. Converter-cover assembly |
|                               | 93. Flywheel-to-transmission anchor nut |
the control pressure is lightened to prevent too-sudden applications which would make for rough shifting. The modulator valve changes position according to throttle-valve position and control pressure. As it does so, it varies the pressure to the compensator valve. This varying pressure in the compensator valve, opposed by governor pressure, changes the compensator valve position. As the compensator valve thus moves, it changes the pressure to the control pressure regulator. The net result of all this is that with wider throttle opening, or with higher car speed, control pressure is increased to increase the intensity of clutch and band application. On the other hand, a lower speed and lighter throttle reduce this intensity because the two valves (modulator and compensator) act to reduce control pressure.

In low, the manual control valve is moved to the position shown in Fig. 8-43. This changes the pattern of control-pressure application so that the front clutch and the rear band are applied while the rear clutch and front band are released. The low regulator cushions the application of the rear band since it acts in accordance with throttle opening. At the same time, the transition valve prevents front-band application in low. The low inhibitor valve prevents the transmission from shifting to low at speeds above 30 mph. At such speeds, the governor pressure closes the low inhibitor valve to shut off the rear servo oil.

2. **Powerglide with three-member torque converter.** Figure 8-44 is a sectional view of the Powerglide automatic transmission which uses a three-member torque converter. The selector lever has five positions (drive, low, reverse, neutral and park) as in the earlier model Powerglide already described (§80). As a matter of fact, the later model Powerglide is very similar to the earlier model with these two exceptions:

   a. The later model Powerglide uses a three-member torque converter (instead of a five-member torque converter).

   b. The later model Powerglide incorporates an automatic shift in the drive range to give automatic shifting between low and direct.

The planetary gearing, clutch, and band arrangement in the two models is practically identical. The major difference between the two models (aside from the torque converter) lies in the hydraulic
Fig. 8-45. Hydraulic circuit of the Powerglide automatic transmission using the three-member torque converter and having the automatic shift in D. (Chevrolet Motor Division of General Motors Corporation)
Fig. 8-46. Sectional view of automatic transmission with three-member torque converter. (Studebaker-Packard Corporation)

Fig. 8-47. Schematic view of automatic transmission shown in Fig. 8-46. The table shows the clutches and bands which become engaged in the three forward speeds and in reverse, as well as the drive and torque ratios achieved. (Studebaker-Packard Corporation)

control circuit. In the later model, the hydraulic control circuit has a governor, a throttle valve, and a shift valve. Their actions are very similar to those already described for the Powerglide and the Fordomatic (§§81 and 82, 1). Figure 8-45 shows the hydraulic circuit of the later model Powerglide. Compare this with the hy-
draulic circuits of the earlier Powerglide and also of the other transmissions already described. Refer to the discussions and illustrations of the earlier Powerglide and other transmissions as you study Fig. 8-45 to learn how the components in this circuit function.

3. **Studebaker automatic transmission** (Fig. 8-46). This transmission has an air-cooling system, an anticreep feature that prevents car creep in low or direct, and a direct-drive clutch like the one in the Packard unit. Figure 8-47 shows the operation of the bands, multiple-disk clutch, and planetary gearsets. The anticreep mechanism is shown in Fig. 8-48. When the car is stationary and in low or direct with the engine running, the pressure and carburetor throttle switches are closed. The no-creep solenoid valve, therefore, holds pressure in the rear-brake cylinders so the brakes remain on.
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after they are applied. When the throttle is opened, the solenoid and pressure are released.

4. Torque-Flite (Fig. 8-49). This transmission has two multiple-disk clutches, an overrunning clutch, two brake bands, and two planetary gearsets. When first starting (in D, or drive), the power flow is as shown in Fig. 8-50: through the front clutch, rear ring, and planetary gears to the rear sun gear. The two sun gears turn together, causing the front planetary gears to drive the front ring gear and thus the output shaft. Gear reduction takes place in both planetaries to provide a 2.45:1 gear ratio. At intermediate speed (Fig. 8-51), the front clutch and kick-down band are applied and gear reduction takes place only in the rear planetary set for a gear ratio of 1.45:1.

In the direct-drive position (Fig. 8-52), both multiple-disk clutches are applied and both bands are released so that the two
planetary gearsets are locked up and no gear reduction can take place. The gear ratio, therefore, is 1:1.

Additional selector positions (1 and 2) are available (see Fig. 8-55) so that the low and intermediate speed gear ratios can be held. For instance, if button 1 is pressed, the situation shown in [310]
Fig. 8-53 will result. This is the same as shown in Fig. 8-50 except that the low and reverse band is applied to hold the front planet carrier stationary and thus provide engine braking.

In reverse (Fig. 8-54), the rear clutch and low and reverse bands are applied. The power flow is now through the rear clutch and front sun gear, planet pinions, and ring gear. Since the planet pinions are...
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interposed in the gear train, they act as idlers to reverse the direction of rotation so the output shaft turns in the reverse direction to back the car. A gear ratio of 2.20:1 results.

§83. Push-button controls Figure 8-55 shows one type of push-button control used with the Torque-Flite transmission described in the previous section. The control is mounted on the instrument panel. It is connected by a push-pull control cable to the manual control-valve lever in the transmission. When a button is pushed, the slide moves the cable actuator. A lock spring holds the button in until another button is pushed. A back-up light switch is used on many models; this switch is closed when the R (reverse) button is pushed. Also, the assembly has a starting-motor switch that is closed when the N (neutral) button is pushed in. As soon as the engine starts, a vacuum switch on the engine opens the starting motor circuit so cranking ends. The starting-motor switch is closed only when the N button is depressed. Thus, no starting motor operation is possible when any of the other buttons are pushed in, even though the engine might die.

CHAPTER CHECKUP

NOTE: Since the following is a chapter review test, you should review the chapter before taking it.

The chapter that you have just finished completes the study of automatic transmission construction and operation. Following chapters describe the trouble-shooting and servicing of various types of automatic transmissions. Intelligent servicing of such units requires a good understanding of their construction and operation. The following checkup gives you a chance to review the important details of these units and also allows you to check your memory so that you will find out how much you remember about them. Thus, if some details are not clear in your mind, you have a chance to go back and reread the sections of the chapter that are hazy in your mind. Reviewing important details and writing down essential data in your notebook help to fix the information firmly in your mind. Also, since you write the answers in your notebook, you make the notebook a valuable source of information to refer to at any time in the future.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the [315]
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sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. The fluid coupling is most efficient at a drive ratio approaching 1:1 2:1 1.5:1 1:3 1:2
2. Speed reduction through the torque converter means torque reduction increase loss subtraction
3. The fluid coupling vanes are usually flat while the torque converter vanes are radial curved circular
4. In the torque converters described in the chapter, the rotating members vary from between two and five three and six three and five two and six
5. A torque converter requires at least two three four five notable members.
6. As the oil leaves the trailing edges of the turbine vanes, it must be changed in direction; the vanes on the pump stator turbine produce this change.
7. The Chevrolet Powerglide torque converter (the earlier model) has two three four five members.
8. The Packard Ultramatic torque converter has two three four five members.
9. In the Packard Ultramatic torque converter, the first turbine and the reactor pump second turbine stator are bolted together.
10. The Fordomatic torque converter has two three four five members.
11. The automatic transmission described in the chapter all contain a direct-drive clutch planetary-gear system sprag unit.
12. The Powerflite torque converter has two three four five members.
13. In the Powerglide automatic transmission, the reverse sun gear is meshed with the planet short pinions planet long pinions ring gear.
14. In the Powerglide automatic transmission, the low sun gear is meshed with the planet short pinions planet long pinions ring gear.
15. In the Powerglide automatic transmission, the ring gear is meshed with the low sun gear planet short pinions planet long pinions.
16. When the Powerglide automatic transmission is in low, the clutch drum and low sun gear are rotating held stationary speeded up reversed.

[313]
17. When the Powerglide automatic transmission is in reverse, the planet carrier is **held stationary** speeded up turned in reverse direction
18. In the Powerglide, the device that varies the oil pressure with changing load requirements is called the **modulator** planetary brake-band servo
19. In the Ultramatic transmission, a governor and throttle valve work together to actuate a shift valve which, in turn, controls the action of the planetary system direct-drive clutch brake bands
20. In Powerflite transmission, the low sun gear meshes with the planet short pinions planet long pinions low planet pinions
21. In Powerflite transmission, the reverse ring gear meshes with the planet short pinions planet long pinions reverse planet pinions
22. When the Powerflite is in direct drive, the conditions are: clutch on and low band off both clutches on both clutches off both bands on
23. In Fordomatic transmission, the internal gear is meshed with the primary pinions secondary pinions secondary sun gear
24. In the Fordomatic transmission, the secondary sun gear is meshed with the primary pinions secondary pinions internal gear
25. The number of gear ratios that the Fordomatic transmission has in forward speed is **two three four five**
26. When the Fordomatic transmission is in low, the planet-pinion carrier is turning in reverse direction held stationary rotating
27. When the Fordomatic transmission is in intermediate, the front clutch and front brake band are released applied applied and released respectively released and applied respectively
28. When the Fordomatic transmission is in high, the front clutch and the rear clutch are both released both applied applied and released respectively
29. The torque converter in the Studebaker automatic transmission uses **two three four five** members.
30. To prevent creeping of the car when it is stationary, the engine is idling, and the transmission is in drive, the Studebaker automatic transmission incorporates a no-creep solenoid valve and a piston pressure switch pressure regulator disk clutch

Purpose and Operation of Components

In the following, you are asked to write down the purpose and operation of the torque converters and automatic transmissions described in the chapter. If you have any difficulty in writing down your explanations, turn back into the chapter and reread the pages that will give you the...
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1. Explain how a fluid coupling loses power when the driving member is turning considerably faster than the driven member.
2. List the members of the five-member torque converter and describe their actions during heavy acceleration. During medium load and light acceleration. During steady driving.
3. List the four members in the Ultramatic Drive torque converter and describe their action during acceleration. During steady driving.
4. Explain the operation of the overrunning clutch in the Powerglide.
5. Explain the operation of the overrunning clutch used in the Ultramatic.
6. Name the different gears and pinions used in the Powerglide planetary-gear system.
7. List the various components in the Powerglide transmission through which power passes when in drive. When in low. When in reverse.
8. Describe the action of the modulator in the Powerglide.
9. List the various components in the Powerglide through which power passes when in drive. When in low. When in reverse.
10. Explain how the Powerglide upshifts when in drive. Explain how a kick-down shift is obtained.
11. Explain how the direct-drive clutch in the Ultramatic is controlled.
12. List the various components in the Fordomatic transmission through which power passes when in low. When in intermediate. When in high. When in reverse.
13. Explain how the Fordomatic downshifts when the car is traveling less than 55 mph and the driver pushes the accelerator all the way down.
14. Explain how, in the Fordomatic, the modulator and compensator valves work together to modify, or modulate, the control pressure from the control-pressure regulator. What is the purpose of this modulation?
15. Refer to the schematic view of the Studebaker automatic transmission and make a list showing whether the multiple-disk clutch and direct-drive clutch are on or off and which bands are on and off when in direct drive, intermediate, low, and reverse.
16. Explain how the antirecreep feature in the Studebaker automatic transmission operates.

Suggestions for Further Study

Whenever you have a chance, carefully examine the various automatic transmissions and transmission parts. These are available in many school.
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shops as well as in automotive service shops. Sometimes cutaway models are available and if so, study them carefully. Note particularly the sizes and relationships of the gears and various parts and the methods of controlling them. Study all car shop manuals you can get your hands on. The shop manuals describe particular models in considerable detail and will help you to a better understanding of these models. You will also find that automotive trade magazines often contain articles describing the operation and construction of the different torque converters and automatic transmissions. Gather your information from whatever sources you can. Try to remember it all, but to be on the safe side, be sure to write down the important facts in your notebook. Then later, if some point becomes hazy in your mind, you can look it up quickly and refresh your memory.
9: Gyro-Matic type transmission service

THIS CHAPTER describes the trouble-shooting, maintenance, and servicing of one type of hydraulic-shifted transmission supplied by the Chrysler Corporation for their Chrysler, De Soto, and Dodge cars. This transmission is variously called Gyro-Matic, Prestomatic, and Tip-Toe Shift. Earlier models used a fluid coupling (called a Fluid Drive by the manufacturer). Later models use a torque converter (called a Fluid-Torque Drive by the manufacturer). The construction and operation of this transmission is discussed in §§63 to 67.

§84. Diagnosing troubles in Gyro-Matic transmission  As a first step in diagnosing troubles in this type of transmission, an attempt should be made to determine the exact location of the trouble cause. The trouble could be in the electric system, in the hydraulic system, or it could be purely mechanical. A logical analysis will go far toward determining a trouble cause and thus will save time and effort. Actually, the recommendation is that a definite testing procedure be followed so the cause can be isolated in the electric or hydraulic system or in the transmission itself.

Caution: If you road-test the car to check transmission operation, be sure to observe all traffic laws. Drive safely. If a chassis dynamometer is available, it can be used and it will not be necessary to take the car out of the shop. See Appendix.

The chart that follows lists troubles that might be blamed on the transmission, together with possible causes, checks to be made, and corrections needed.

§85. Transmission trouble-shooting chart  The chart below, as well as the remainder of this chapter, is concerned mainly with the special sort of trouble that the type of transmission under discus-
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Some additional troubles, as indicated in the clutch trouble-shooting chart (§14) and the standard transmission trouble-shooting chart (§46) may occur. However, the most likely troubles of the Gyro-Matic type of transmission can be classified into two categories: failure to upshift and failure to downshift.

Possible conditions that could cause either of these troubles, as well as other transmission or Fluid Drive (or Fluid-Torque Drive) troubles, are listed in the chart, along with corrections to be made.

### Gyro-Matic-Type Transmission Trouble-Shooting Chart

(See §§88 to 93 for detailed explanations of the trouble causes and corrections listed below. Note that the Fluid Drive and the Fluid-Torque Drive may have special troubles, as indicated below.)

<table>
<thead>
<tr>
<th>Complaint</th>
<th>Possible Cause</th>
<th>Check or Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Failure to upshift (§88)</td>
<td>a. Insufficient or improper oil in transmission</td>
<td>Drain old oil, put in 3 pints 10-W</td>
</tr>
<tr>
<td></td>
<td>b. Oil strainer clogged</td>
<td>Clean</td>
</tr>
<tr>
<td></td>
<td>c. Oil pump defective so oil pressure is insufficient</td>
<td>Repair or replace</td>
</tr>
<tr>
<td></td>
<td>d. Ball valve stuck</td>
<td>Free, replace if damaged</td>
</tr>
<tr>
<td></td>
<td>e. Direct-speed piston stuck in cylinder</td>
<td>Free, replace damaged parts</td>
</tr>
<tr>
<td></td>
<td>f. Oil leaks in oil passages</td>
<td>Tighten mountings replace gaskets or broken parts</td>
</tr>
<tr>
<td></td>
<td>g. Governor points not opening</td>
<td>Free points, replace governor if defective</td>
</tr>
<tr>
<td></td>
<td>h. Kick-down switch stuck closed</td>
<td>Free points, replace switch if defective</td>
</tr>
<tr>
<td></td>
<td>i. Solenoid plunger stuck, keeping valve open</td>
<td>Free plunger, replace plunger or solenoid if defective</td>
</tr>
<tr>
<td></td>
<td>j. Engine idling too fast</td>
<td>Reduce idle speed</td>
</tr>
</tbody>
</table>

[318]
<table>
<thead>
<tr>
<th>Complaint</th>
<th>Possible Cause</th>
<th>Check or Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Failure to downshift (§89)</td>
<td><strong>k. Direct-speed fork loose</strong></td>
<td>Tighten screw</td>
</tr>
<tr>
<td></td>
<td><strong>l. Direct-speed rail damaged</strong></td>
<td>Replace</td>
</tr>
<tr>
<td></td>
<td><strong>m. Direct-Speed clutch sleeve binding</strong></td>
<td>Clean, stone off burrs, replace sleeve or pinion if teeth are damaged</td>
</tr>
<tr>
<td></td>
<td><strong>n. Direct-Speed blocker ring damaged</strong></td>
<td>Replace</td>
</tr>
<tr>
<td>3. Car creeps when idling (§90)</td>
<td><strong>a. Ball valve stuck</strong></td>
<td>Free, replace if damaged</td>
</tr>
<tr>
<td></td>
<td><strong>b. Direct-speed piston stuck</strong></td>
<td>Free, replace damaged parts</td>
</tr>
<tr>
<td></td>
<td><strong>c. Governor points not closing</strong></td>
<td>Free, clean points, replace governor if defective</td>
</tr>
<tr>
<td></td>
<td><strong>d. Solenoid stuck or open-circuited</strong></td>
<td>Free, replace if defective</td>
</tr>
<tr>
<td></td>
<td><strong>e. Interruptor switch defective</strong></td>
<td>Replace</td>
</tr>
<tr>
<td></td>
<td><strong>f. Kick-down switch defective</strong></td>
<td>Free, replace if damaged</td>
</tr>
<tr>
<td></td>
<td><strong>g. Bad connections, defective wiring</strong></td>
<td>Clean and tighten connections, replace defective leads</td>
</tr>
<tr>
<td>4. Fluid Drive or Fluid-Torque Drive slips (§91)</td>
<td><strong>h. Freewheeling-control sleeve binding</strong></td>
<td>Free, replace if damaged</td>
</tr>
<tr>
<td></td>
<td><strong>i. Loose, damaged or binding conditions in transmission as noted in k to n under item 1, above.</strong></td>
<td>Adjust idle</td>
</tr>
<tr>
<td></td>
<td><strong>Idle speed excessive</strong></td>
<td>Replace fluid, install new seal. Also, in Fluid-Torque Drive, check for a sticking relief valve</td>
</tr>
<tr>
<td>Complaint</td>
<td>Possible Cause</td>
<td>Check or Correction</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>----------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>5. Fluid Drive or Fluid-Torque Drive noisy</td>
<td>a. Seal squeals</td>
<td>Install dampener</td>
</tr>
<tr>
<td></td>
<td>b. Bearings worn</td>
<td>Replace bushings or, if ball bearing is worn, replace fluid drive or Fluid-Torque Drive</td>
</tr>
<tr>
<td>6. Fluid-Torque drive overheats</td>
<td>a. Fluid lost</td>
<td>Replace, install new seal</td>
</tr>
<tr>
<td></td>
<td>b. Oil not circulating</td>
<td>Check for stuck relief valve</td>
</tr>
<tr>
<td></td>
<td>c. Oil not cooling</td>
<td>Check oil cooler, water pump</td>
</tr>
<tr>
<td></td>
<td>d. Overload</td>
<td>Check for dragging brakes, parking brakes being on, vehicle overload, etc.</td>
</tr>
</tbody>
</table>

§86. Electric-circuit tests

The manufacturer recommends that the following tests be made if electrical trouble is suspected. These tests are comprehensive but can be made very quickly. Only a 6-volt test lamp (Fig. 6-2) with long leads is needed. Before making the tests, be sure the proper amount and grade of oil is in transmission (3 pints of 10-W) and that engine is idling at between 450 and 475 rpm (revolutions per minute). Then raise the right-side floor mat and remove floor panel cover so wiring and connections to transmission can be checked. Next, make the checks that follow. Refer to Fig. 9-1.

1. Connect test light between circuit breaker (at A) and ground and turn on ignition switch. If light does not come on, wiring or circuit is defective.

2. To test circuit breaker, connect test light between circuit breaker (at B) and ground and turn on ignition switch. If light does not go on, circuit breaker is defective and should be replaced. If circuit breaker starts to click, there is a short or ground in the circuit to the antistall control or solenoid.

3. Connect test light between solenoid terminal C, and ground and turn on ignition switch. If light does not come on, circuit is open. Check connections and wiring.
4. Connect test light between antistall terminal D (brown-lead terminal) and ground and turn on ignition switch. If light does not come on, wire or connections are defective and should be checked.

5. To test antistall control, turn ignition switch on and hold the tip of a screwdriver (be sure it is not magnetized) on the cover of the antistall control. A magnetic pull should be felt. Try with ignition switch on and off to make sure this magnetic pull exists when the switch is on. If no magnetic pull can be felt, the antistall control is defective and should be replaced.

6. Test the solenoid in a similar manner with a piece of soft steel (unmagnetized) held on the solenoid body. Also connect test lamp between terminals C and E of solenoid. With ignition switch on, a magnetic pull should be felt. If no pull is felt but the light is on, the solenoid is defective and it should be replaced.

7. Test the governor and kick-down switch by connecting test lamp between terminals C and F. Jack both rear wheels off floor and start engine. Accelerate engine to between 15 and 40 mph (miles per hour). Then push in the kick-down switch plunger (G in Fig. 9-1) by hand. When ignition switch is
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first turned on, the test lamp should come on, indicating that the governor contacts are closed. Then, test lamp should go out and come on again as engine is speeded up to above about 14 mph and then slowed down to below this speed. If it does not, the governor is probably defective and should be replaced. Then, with the engine accelerated to between 15 and 40 mph, when the kick-down switch plunger is pushed in, the light should come on. If it does not, the kick-down switch is not operating.

8. Test the interrupter switch by disconnecting the lead from the switch terminal H (blue-wire terminal) and connecting the test lamp between this terminal and terminal C on the solenoid. Accelerate and decelerate engine between 8 and 15 mph. Through deceleration from 12 to 10 mph, the light should glow. The glow will be dim and to be seen, the bulb should be cupped in the hands. If the light does not glow, the switch is defective and should be replaced.

9. The solenoid can be tested off the transmission by connecting it to a 6-volt battery and then noting the pounds of push required to force the plunger rod into the solenoid. It should require about twenty-five pounds push.

10. The governor can be checked off the transmission if a special drive coupling is available to drive it from a distributor tester. The contacts should open above the specified speed and close as the speed drops to the proper amount below this valve.

§87. Hydraulic-mechanism tests To test the hydraulic system, first make sure the transmission has the correct amount and grade of oil (3 pints of 10-W). Then remove the floor panel cover, disconnect the two wires at the interrupter switch and remove the switch. Jack up the rear wheels, start engine and engage transmission in low range.

Accelerate engine to approximately 8 mph and watch for piston movement through interrupter-switch mounting hole. The piston should move forward just enough to completely cover the hole. If the piston does not move forward, there is some difficulty in the system which could be due to any of the following:

1. Oil pump defective due to sheared drive pin or broken part.
2. Direct-speed piston stuck in cylinder.
3. Cylinder or piston badly worn.
4. Ball valve stuck open.
5. Relief valve stuck open.
6. Oil pump badly worn because of operation for many thousands of miles.

**§88. Failure to upshift** Causes of failure of the transmission to upshift can be divided into three categories: hydraulic, electrical, and mechanical.

1. **Hydraulic.** Anything that would prevent sufficient oil at sufficient pressure from entering the direct-speed-piston cylinder would prevent piston movement and thus upshifting. Conditions to consider include insufficient or improper oil in the transmission, a clogged oil strainer, a defective or worn pump, or a stuck ball valve. With insufficient or incorrect grade of oil, a clogged oil strainer or improperly working oil pump, the oil pressure will not build up enough to produce upshifting. Likewise, if the ball is stuck open, oil from the pump will simply flow into the drain and not into the piston cylinder. The same condition could result if there were oil leaks in the oil passages. It is also possible that the direct-speed piston could become stuck in the cylinder due to dirt, metal chips, or wear. In such case, it is sometimes possible to clean and smooth the parts to restore normal operation. A check of the hydraulic system is outlined in §87.

2. **Electrical.** Any condition that would keep the ball valve from closing prevents upshifting. Thus, if the governor points do not open because of some governor defect, then the solenoid will remain energized at higher speeds and the upshift cannot be made. Likewise, if the kick-down switch contacts are stuck closed, the same effect will result. Also, if the solenoid plunger is stuck so it holds the ball valve open, the upshift will not take place. The solenoid plunger might stick from mechanical damage or (rare) from a grounded solenoid winding. Section 86 outlines a comprehensive check of the electric system.

3. **Mechanical.** Any condition in the transmission proper that would prevent normal action of the shifter fork as it moves the direct-speed clutch sleeve would prevent upshifting. Thus, if the fork is loose or the direct-speed rail damaged, the fork would not move normally in response to the direct-speed-piston movement.
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Likewise, if the clutch sleeve binds on the third-speed gear, it will not move easily and may hang up. The sleeve can be installed in any one of six positions on the gear and if it binds in one position, other positions should be tried until a free, sliding fit is attained. Also, if the sleeve binds on the main-drive-pinion gear, it will not lock up with the main-drive pinion so upshifting is not achieved. In such case, it is often possible to improve the fit by stoning off burrs and rough spots on the internal sleeve teeth and pinion-gear teeth. Another condition that prevents upshifting is a damaged direct-speed blocker ring; this prevents normal clutch-sleeve movement.

§89. Failure to downshift

Causes of failure of the transmission to downshift can be divided into three categories: hydraulic, electrical, and mechanical.

1. Hydraulic. Anything that would prevent releasing of the oil pressure and piston return would hold the transmission in the upshifted position. Actually, in the hydraulic system about the only conditions that could cause this trouble would be a stuck ball valve (rare) or a stuck direct-speed piston. The position of the piston can be checked as explained in §87 by removing the interrupter switch.

2. Electrical. Anything that would prevent normal energizing of the solenoid for downshifting would prevent opening of the ball valve by the solenoid. This could be caused by a defective governor that does not close its points, by a stuck or open-circuited solenoid, by a defective kick-down switch that does not close its contacts, or by poor connections or bad leads in the electric circuit. In addition, if the interrupter switch does not interrupt the ignition momentarily, then the driving pressure, or torque, through the gears in the transmission will keep the transmission in the upshifted position. A comprehensive check of the electric system is outlined in §86.

3. Mechanical. Binding of the freewheeling control sleeve, as well as any of the conditions discussed in §88,3 above, could prevent downshifting. In other words, any mechanical binding or looseness of moving parts is apt to prevent normal transmission action on either upshifting or downshifting.

§90. Car creeps when idling

If the car creeps forward when in gear and with the engine idling, then the chances are the idling
§92. Drive is noisy

Noise from the Fluid Drive or Fluid-Torque Drive could come from the bearings or from the seal. A test for bearing noise can be made by disengaging the clutch with the engine running and the car standing still. If the noise is noticeable, it is possible that the two bushings which support the clutch shaft (or main-pinion shaft) are worn. These bushings can be replaced as explained in §§97 and 98. However, if the noise is noticeable with the clutch engaged and the car in gear (particularly on fast acceleration), there is a possibility that the front ball bearing is at fault. This bearing cannot be replaced in the field; the drive assembly must be replaced.

A squealing noise from the Fluid-Drive or Fluid-Torque Drive seal is usually most obvious at speeds below 15 mph or when the
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§93 car is held by the brakes and in gear with the clutch engaged. It disappears when the clutch pedal is depressed. This noise can be eliminated by installing a damper (§96, 1, a).

Note: Be careful to make other checks for noise, as outlined in §§18 (clutches) and 51 (transmissions), when the Fluid Drive is suspected of producing noise. It is possible, of course, that the noise could be coming from an entirely different component and is not the fault of the drive at all.

§93. Fluid-Torque Drive overheats The Fluid-Torque Drive, if overheated, will cause high engine temperatures and will emit a hot, oily smell. Overheating of the drive may be caused by loss of fluid (see §91), failure of the oil to circulate, failure of the oil cooler to function, or overload. Loss of fluid could result from a bad oil seal. It could also result from a relief valve that is stuck open. This condition permits the oil to flow directly from the pump back to the reservoir without entering the Fluid-Torque Drive. Without sufficient oil, the Fluid-Torque Drive overheats. The oil then becomes excessively hot, and some of it is lost through the breather tube. Naturally, if the oil lines are clogged, or if the oil pump is defective, the same condition would result. Also, if the oil cooler is not functioning normally due to clogged tubes or to a defective water pump, then the oil and drive will overheat. If the drive is overworked by a heavy overload, it is apt to overheat. However, if the overload is relieved, then the drive will soon settle back to normal operating temperatures.

CHECK YOUR PROGRESS

Progress Quiz 13

The ability to diagnose troubles in any mechanism requires an understanding of the construction and operation of the mechanism. Also, it requires a knowledge of what to check for, what troubles may occur, and the effects these troubles will cause. The material just covered outlines the different troubles in Gyro-Matic type transmissions with Fluid Drives and Fluid-Torque Drives; it explains how to determine the trouble-cause by analysis of the conditions found. The quiz below will help you to find out how well you remember the trouble-shooting procedures just described. If any of the questions stumps you, reread the pages of the book that will give you the answer.
Some of the statements below are true. Some are false. Read each statement carefully and then decide whether it is true or false. If you believe it to be true, write it down in your notebook. Verify it by rereading the past few pages.

1. Failure to upshift could be caused by hydraulic, electrical, or mechanical troubles.
2. Failure to downshift could be caused by hydraulic, electrical, or mechanical troubles.
3. If the car creeps when idling, it is likely that the engine idle speed is excessive.
4. If the Fluid Drive or Fluid-Torque Drive slips excessively, the trouble is probably due to loss of fluid.
5. If the Fluid-Torque Drive overheats, the chances are it is due to excessive fluid in the drive.
6. Insufficient oil in the transmission might result in failure to upshift.
7. Failure of the governor points to open would prevent upshifting.
8. Noise from the Fluid Drive or Fluid-Torque Drive is most likely coming from the bearings or seal.
9. In the hydraulic-mechanism test, you should watch for piston movement through the interrupter-switch mounting hole.
10. The transmission requires three gallons of 10-W oil.

Correcting Troubles Lists

The purpose of this exercise is to help you spot related and unrelated troubles on a list. For example, in the list failure to upshift: insufficient oil, oil pump defective, governor points not opening, idle speed too low, you can see that idle speed too low does not belong because it is the only condition that would not cause failure to upshift. Any of the other conditions listed could cause the trouble.

In each of the lists, you will find one item that does not belong. Write down each list in your notebook, but do not write down the item that does not belong.

1. Hydraulic causes of failure to upshift: insufficient oil in transmission, oil strainer clogged, oil pump defective, direct-speed piston stuck, battery low.
2. Electrical causes of failure to upshift: governor points not opening, kick-down switch stuck closed, insufficient oil, solenoid plunger stuck.
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4. Mechanical causes of failure to downshift: freewheeling control sleeve binding, defective wiring, direct-speed fork loose, direct-speed rail damaged.
5. Hydraulic causes of failure to downshift: ball valve stuck, direct-speed piston stuck, kick-down switch stuck.
7. Fluid Drive or Fluid-Torque Drive noisy: seal squeals, governor points open, bearings worn.
8. Fluid-Torque Drive overheats: fluid lost, oil line clogged, relief valve stuck, overload, fast idle, seal defective.

Removing transmission, clutch, and Fluid Drive

The following procedure applies specifically to cars equipped with the Gyro-Matic transmission and a Fluid Drive. For the procedure on cars equipped with a Fluid-Torque Drive, see the following section. The transmission must be removed before the clutch and drive can be taken off. The transmission and clutch are removed almost in the same manner as standard transmissions (Chap. 6) and clutches (Chap. 3). Special tools, as noted below, are required for transmission, clutch, and Fluid Drive service.

1. Transmission removal
   a. Raise right side of floor mat and remove floor-board access cover.
   b. Disconnect speedometer cable from transmission.
   c. Disconnect wires from governor, solenoid, and interrupter switch and take off these three electrical components. Plug holes in transmission case to prevent dirt from entering.
   d. Disconnect hand-brake cable from brake band and take off cable and anchor bracket.
   e. Disconnect the front propeller-shaft universal and push yoke back.
   f. Remove brake support, brake band, brake adjusting-bolt bracket, and lever as a unit.
   g. Disconnect gearshift operating rod and selector rod from transmission.
   h. Remove attaching bolts, supporting transmission to prevent its sagging and thereby damaging the clutch friction disk. Pull transmission straight to rear and lower to floor.
2. Clutch removal. (This procedure is similar to that used for removing clutches from the same makes of cars not equipped with Fluid Drive and Gyro-Matic type of transmission.)

a. With transmission and clutch housing pan off, pull out clutch release bearing and sleeve.

b. Mark clutch cover and clutch driving plate so they can be realigned in same position and then remove cap screws, loosening each a few turns in succession so as to uniformly relieve the spring pressure. When spring pressure is released, finish unscrewing screws and take off clutch assembly.

3. Fluid Drive removal

a. With transmission, clutch housing pan, and clutch assembly off, use special box wrench as shown in Fig. 9-2 and take off stud nuts.
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b. When taking stud nuts off, rotate the Fluid Drive so as to get at the upper nuts. Support drive as nuts are removed.

c. Move drive straight back and take it out of clutch housing.

§95. Removing transmission, clutch, and Fluid-torque Drive

The following procedure applies specifically to cars equipped with a Fluid-Torque Drive. For cars equipped with a Fluid Drive, see the previous section. Figure 9-3 shows the Fluid-Torque Drive and clutch assemblies in exploded view. Note that in this illustration, the torque-drive parts are called torque-converter parts. These two names may be used interchangeably on this application. Figure 9-4 shows the clutch control linkage.

1. After draining the reservoir of oil, remove cap screws and reservoir from bottom of clutch housing. Then disconnect battery and remove starting motor and lower half of the flywheel housing pan. Drain oil from torque drive by removing drain plug, allowing oil to drain and then turning drive 180 degrees and removing second plug to finish draining operation. Disconnect oil lines from support plate.

2. Remove transmission as noted in the previous section.

3. Unhook clutch release-fork pullback spring. Disconnect ends of clutch fork-rod assembly by removing cotter keys, washers, and pin (see Fig. 9-4).

4. Push clutch pedal all way to floor board. This will guard you against getting hurt if the pedal should accidentally be pushed down and snapped to the floor board due to the over-center spring action.

5. Remove release bearing by pivoting the assembly away from fork so assembly and spring will slide off (Fig. 9-5). Do not attempt to pull the assembly straight back, since this will spread the pullback spring which would then permit lost motion between the fork and bearing on reassembly.

6. Detach the torque-shaft pivot bracket from the clutch housing by removing two cap screws (Fig. 9-4). Take opposite end of pivot bracket from torque shaft.

7. Support engine with jack and wood block under oil pan (or use a special engine support tool as shown in Fig. 9-6). Remove bolts attaching the clutch housing to cross member;
Fig. 9-3. Disassembled view of Fluid-Torque Drive (also called torque converter), and clutch assemblies. (Chrysler Sales Division of Chrysler Corporation)
FIG. 9-5. Pivoting the clutch-release bearing for removal or installation. (De Soto Division of Chrysler Corporation)

Fig. 9-6. View from under car looking forward showing the engine-support fixture in place in readiness for clutch removal. (De Soto Division of Chrysler Corporation)
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then remove bolts attaching cross member to frame and re­move cross member.

8. Release jack or back off support nuts slightly so engine will be lowered. (Caution: Not more than 3 inches!) Now, remove the clutch-housing screws so housing can be taken off.

9. Take clutch assembly from clutch driving plate by removing bolts. Be careful to avoid getting oil on the clutch disk assembly.

10. Pull clutch driving plate and the Fluid-Torque Drive support plate from flywheel housing.

11. Remove six cap screws and take drive off.

§96. Servicing the clutch The clutch is very similar in construction to the standard Borg and Beck unit, servicing of which is described in §26. The essential difference so far as servicing is concerned is that a special installation procedure is required for the clutch and this is detailed on a following page (§99).

§97. Servicing the Fluid Drive There is not a great deal in the way of service that the Fluid Drive requires. It is a welded assembly which must be replaced if major difficulties occur inside the unit. The oil seal which retains the oil in the drive can be replaced, as can the two bushings which support the clutch shaft (main drive-pinion shaft). It is also possible to replace the ring gear in case it has become damaged to such an extent that starting difficulty is experienced.

§98. Servicing the Fluid-Torque Drive The Fluid-Torque Drive is a welded assembly which cannot be disassembled in the field and therefore there is little in the way of service that it can be given. However, the drive can be checked for run-out when installed on the car. In addition, the oil pump, the turbine shaft, the shaft bearing, and the seal can be removed and replaced in the support plate. These, and other services that may be required on the Fluid-Torque Drive are outlined below.

Note: Some models of the Fluid-Torque Drive, as already mentioned (§77), do not have an oil pump but are supplied oil from the engine oil pan by the engine oil pump. On these, the servicing procedure is simplified since no oil-pump-disassembly or reassembly procedure is required.
1. Disassembly of oil pump from support plate. For this operation, the plate must be heated to 160–170°F. The best way to do this is to place three or four 150- or 250-watt heat lamps around the support plate as shown in Fig. 9-7, turning the plate occasionally to assure even heating.

With the plate at proper temperature and the six bolts holding the pump to the plate removed, use special tools to remove pump (Fig. 9-7). Thread two tools into pump body evenly until body is lifted from support plate. Stator shaft, plate, and transfer plate can then be lifted from support plate.

2. Removing turbine shaft, bearing, and seal from support plate. Remove small snap ring from turbine shaft with special tool, and then use the tool shown in Fig. 9-8 to press shaft from bearing. The bearing is removed next with a puller. Bearing must not be driven from the plate since this might damage the plate. Finally, the turbine-shaft seal can be driven from the support plate with a suitable drift.

3. Replacing turbine shaft, bearing, and seal in support plate. Inspect turbine-shaft oil-seal ring, relief-valve chambers, and sup-
Fig. 9-8. Removing turbine shaft from support plate. (*De Soto Division of Chrysler Corporation*)

Fig. 9-9. Installing turbine-shaft bearing. (*De Soto Division of Chrysler Corporation*)
port-plate passages before replacing bearing. Position bearing over bore and use special tool to drive it home (Fig. 9-9). Secure it with snap ring. Install new seal from opposite side with special drift. Then, use special drift to replace support plate and bearing on the turbine shaft. Secure with snap ring on turbine shaft. Snap rings are available in three thicknesses; the one that fits best should be used.

4. Installing oil pump on support plate. During reassembly, check clearance between gear faces and plate as shown in Fig. 9-10. Limits are 0.001–0.003 inch.

5. Replacing turbine-shaft bushing. The turbine-shaft (drive-pinion) bushing can be removed with a puller. After removal, make sure the hole in the end of the shaft is free of cuttings and metal chips. Install new bushing with special driver. The driver has a ground end on which the bushing should be placed. As the bushing is driven in, it tightens up on the driver. Then, to remove the driver, an outer sleeve and nut are placed in the driver (Fig. 9-11). As the nut is tightened, the driver is pulled out, burnishing the bushing at the same time.

6. Replacing drive-plate ring gear. If necessary, the old ring gear can be removed and a new one welded on.

7. Removing and installing the oil cooler. Drain the water from the radiator, remove the battery and battery pan, detach lower water hose from oil cooler, detach both oil tubes, and then remove
flange nuts holding oil cooler to the water pump. To install the oil cooler, clean the mating surfaces on the pump and cooler, install a new gasket, and then attach the oil cooler to the water pump with the nuts. Install the oil tubes, attach the lower water hose, replace battery pan and battery, and refill radiator.

8. **Checking torque-drive run-out.** With the torque drive in place, attach a dial indicator with indicating button against drive hub as shown in Fig. 9-12. Rotate torque drive (removal of spark plugs is necessary) and note run-out, or amount of misalignment. If it exceeds 0.005 inch, mark the high spot with an H as shown. Turn H to same side as indicator and use a pry bar between flywheel housing and a bolt on the drive plate as shown in Fig. 9-12. Apply pressure on bar towards rear of car to flex the assembly and reduce run-out. Repeat the checking and flexing until the assembly is in alignment.

### §99 Servicing the transmission

The complete disassembly and reassembly procedure for the Gyro-Matic transmission follows. Other,
and similar, transmissions would require similar procedures, of course, but there might be some variations due to individual requirements of the application. It is suggested that reference be made to the shop manual applying to the particular unit being serviced when you are actually working in the service shop.

**Fig. 9-12. Checking and correcting converter run-out. (De Soto Division of Chrysler Corporation)**

1. **Disassembly.** In actual practice, you probably would not disassemble the transmission any further than necessary to correct a trouble or to replace defective parts. All oil should be drained before disassembly. See Fig. 7-20, which is an exploded view of the complete transmission.
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a. Remove gearshift housing, brake drum with propeller-shaft flange, and extension housing with main-shaft assembly.

b. Disassemble main shaft (type shown in Fig. 7-21), by first removing speedometer drive gear and rear oil seal. Then press main shaft out of extension (Fig. 9-13) and take other parts off main shaft.

c. On type shaft with pin synchronizer (Fig. 4-7), put pan under gears to catch rollers and other parts loosened as gears are removed.

Caution: Be sure to note relationship of parts so you can put them back in same position.

d. For disassembly of other parts, refer to Fig. 7-20 and also to the applicable car shop manual.

2. Reassembly. Before reassembly, the various transmission parts should be inspected for damage or wear as explained in §58. Defective or worn parts should, of course, be discarded. Reassembly of the transmission follows.

a. Reassembly of countershaft gearset.

1. Install key and freewheeling control sleeve on countershaft gear cluster.

2. Hook the anchor ends of the two springs in the holes in the gear cluster so they wrap in a right-hand direction (viewed from anchor end) as shown in Fig 9-14.

3. Put the roller retainer over the gear with the lugs over the spring anchors, and rotate clockwise until the retainer lug is over the slot in the control sleeve (Fig. 9-14). Make sure the springs have snapped into the grooves in the retainer.
4. Slide control sleeve forward until retainer lug fully engages in slot in control sleeve (see Fig. 9-14).
5. Put freewheeling rollers in place and install thrust washer over rollers.

6. Put freewheeling gear on countershaft gear and install the 45 bearing rollers between gear and countershaft gear.
7. If the countershaft roller bearings have been removed, put the special arbor through the countershaft gear assembly and stand the assembly on end, freewheeling gear up. Then put three or four of the rollers in the bottom of the hole to center the arbor. Install bearing spacer and rest of rollers, followed by bearing washer and thrust washer.
8. Turn assembly over and install bearing rollers and steel thrust plate.
9. Put assembly in bottom of transmission case. Install the main drive pinion as explained in the following paragraph and then
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Lift assembly up into position and push shaft into place. This will push arbor out. Shaft should be pushed in through front of case. Slide the rear bronze washer into place as the shaft passes through the countershaft assembly and into rear of case. Secure with key as shaft goes in. See Fig. 9-15. Check end play between rear thrust washer and case. It should be between 0.002 and 0.008 inch. If end play is not correct, pull shaft out slightly and substitute a bronze washer which will give proper end play. Bronze washers are available in various thicknesses to permit correction of end play.

b. Installation of main drive-pinion assembly. Install the main drive-pinion assembly, first replacing bearing on pinion shaft (if it has been removed) by holding it in position and installing bearing retainer without using the bearing-retainer gasket. Fasten retainer with bolts and then check clearance between the retainer flange and case with feeler gauges. Select a gasket of same or slightly greater thickness than this clearance, remove retainer, and reinstall with gasket in place. Use rubber gaskets on bolts on reinstallation.

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Gyro-Matic Type Transmission Service

c. Installation of direct-speed piston. Install direct-speed piston with special tool to compress the return spring and install snap ring. Then put direct-speed gearshift rail into place after fork has been positioned. Note that the rail has a screw slot in the rear which is off center. The slot must be horizontal in the case with the smaller shoulder toward the side of the case. This permits location of the setscrew hole in the rail so it is in line with the hole in the case. After the rail is in place and the fork is properly fastened to it, install rail guide, snap ring, and direct-speed blocker ring.

d. Assembly of extension housing. Assemble extension housing by assembling valve parts and installing oil-pump rotors and bearing retainer. Then install rear bearing and snap ring, followed by oil seal (using suitable driver).

e. Assembly of main shaft (type with Fig. 7-21 type synchronizer). Assemble main shaft by first installing reverse gear and the center main-shaft bearing. Put snap ring in place. Use the thickest snap ring that can be installed. Then put oil-pump rotor pin in shaft and clamp shaft in vise, front end up. Install additional parts as follows:

1. Put on first-speed-gear rear thrust washer, gear, and front thrust washer.
2. Install clutch-gear stop ring, clutch-gear sleeve assembly, snap ring, and front stop ring.
3. Put on third-speed-gear rear thrust washer so it indexes with splines on shaft with recess side toward the rear.
4. Insert third-speed-gear bearing race in gear (groove toward front) and assemble 36 rollers in gear, followed by bearing spacer, second set of rollers, and thrust washer.
5. Install gear, with bearings, on shaft, followed by thrust bearing and washer.
6. Use a special thimble to install snap ring, driving it down into position with special tool and soft mallet. Measure end play between thrust washer and snap ring; it should be 0.003 to 0.008 inch. If not correct, remove snap ring and install snap ring of different thickness.
7. Press main shaft into extension housing, making sure that the pin in the shaft lines up with the slot in the oil-pump inner rotor.
8. Install speedometer drive pinion.
f. Assembly of main shaft (type with pin synchronizer shown in Fig. 4-7). Assemble main shaft by first clamping the splined end of main shaft in soft jaws of vise with unsplined end up. Install rear low-and-second-speed-gear thrust washer, low-and-second-speed gear (with clutch teeth facing up), and front thrust washer. Make sure the two thrust washers are being replaced in exactly the same positions as on original assembly. Install inner stop ring. Put clutch-gear sleeve on clutch gear, indexing the grind mark on the clutch-gear sleeve teeth with the paint mark on the clutch-gear tooth. Put this assembly on the main shaft, making sure that both the extended part of sleeve hub and the shoulder side of the clutch gear are facing up.

Then install inner stop ring with the three pins entering the other three holes in the clutch sleeve. Install outer synchronizer stop ring and third-and-direct-speed-gear thrust washer (thick washer). Put blocker ring on geared portion of the third-and-direct-speed gear with prongs pointing toward stop ring. Then install needle-bearing thrust washer (small), 36 bearing rollers, bearing-roller spacer, 36 bearing rollers, and put gear on shaft. Install thrust-bearing assembly, thrust washer, and snap ring. Install spreader-spring washer and spring, coating them with heavy grease first, so they will stay in place and not drop off when the main shaft assembly is being reinstalled in the transmission case.

g. Installation of reverse idler gear. Install reverse idler gear by positioning it in case. Then align the shaft and key with cutout in case and drive shaft into place with a soft mallet.

h. Assembly of extension housing. Assemble extension housing with main shaft assembly on case as follows:

1. Push freewheeling control sleeve (see Fig. 7-21) on countershaft toward rear. With direct-speed clutch sleeve and blocker ring in place as shown in Fig. 7-21, start main shaft into case. Blocker ring should go in tapered end first.
2. Blocker spring and blocker-spring washer should be in place in third-gear assembly. A light coat of grease will hold them in place during the assembly process.
3. Use new gasket between case and extension and attach extension to case with bolts. Tighten bolts to 30-35 lb-ft. torque. Note in Fig. 7-21 that paint marks are indicated on the clutch
sleeve and direct-speed gear. These paint marks should be put on the two parts when they are disassembled to mark the relative position between the two that work best. This position has best freedom of motion.

Caution: Each tooth of the third-speed gear should index in the center of a group of three teeth of the clutch sleeve. Also, the drive pinion must be rotated so lugs on blocker ring register with the slots in the direct-speed gear.

i. Installation of brake drum. Install brake drum and propeller-shaft flange with lock washer, washer and nut, tightening the nut to 95–105 lb-ft torque. Make sure reverse idler gear and manual-clutch-gear sleeve are in rear position to lock transmission.

j. Installation of gearshift housing. Install gearshift housing after first sliding reverse idler gear forward and manual-clutch-gear sleeve into neutral position. Tighten bolts to 10–15 lb-ft torque.

§100. Installing Fluid Drive, clutch, and transmission The following procedure applies specifically to cars equipped with the Gyro-Matic transmission and a Fluid Drive. For procedures on cars equipped with a Fluid-Torque Drive, see the following section. The three assemblies, Fluid Drive, clutch, and transmission, must be installed in the reverse order from which they were taken off the car. That is, the Fluid Drive must be installed first, followed by the clutch and then the transmission.

1. Install Fluid Drive after making sure crankshaft flange and driving flange are smooth and clean by putting it into place and fastening with nuts. Pull nuts down evenly so assembly will not get cocked to one side.

2. Before installing clutch, clean the surfaces of the clutch driving plate and clutch pressure plate thoroughly with a clean, dry cloth. Be sure all traces of oil are removed. Then hold friction disk in position and bolt clutch cover plate loosely to driving plate with marks on cover and driving plate lined up. Then insert aligning tool (or a main drive pinion) to properly align friction disk and tighten the clutch-cover bolts. Tighten each in rotation a turn or two until all are brought down evenly and tight.
3. To install transmission, use special pilot pins (§56, 5) so as to avoid damaging the clutch friction disk. Lift transmission up into position and slide it forward so pinion shaft enters the friction-disk hub. Be sure shaft and hub splines line up. Attach transmission with bolts or nuts tightened to 40–45 lb-ft torque. Then connect gearshift-operating and selector rods, install brake adjusting-bolt bracket and lever, brake band and support. Connect universal-joint yoke. Install hand-brake cable and anchor bracket and attach cable to brake band.

4. Install governor, solenoid, and interrupter switch and attach leads. Then reconnect speedometer cable. Finally, readjust operating and selector-rod linkages and hand-brake cable as necessary.

5. The transmission should be filled with 10-W oil to the bottom of the filler-plug hole. The transmission should be checked every 1,000 miles or 30 days and oil added as necessary to maintain the oil level. Every 10,000 miles, or once a year, the transmission should be drained and refilled with new oil. To fill the Fluid Drive, the drive should be rotated until a filler plug is opposite the inspection hole in the clutch housing. Then the plug should be removed with a magnetic socket (to prevent dropping of plug) and oil added until it is at the bottom of the filler-plug opening. After the first 1,000 miles of operation, the level should be checked again. If the level is still correct, the next inspection will not be required for 10,000 miles.

8101 Installing Fluid-torque Drive, clutch, and transmission

The following procedure applies specifically to cars equipped with the Fluid-Torque Drive. For cars equipped with a Fluid Drive, see the preceding section.

1. Installing torque drive. Check mating faces of crankshaft and torque-drive flanges to make sure they have no burrs and are clean. Then attach drive to crankshaft flange with special tool as shown in Fig. 9-2. Tighten nuts evenly to prevent cocking of the assembly. Check run-out as already explained (§98, 8).

2. Installing drive support plate with clutch on drive

a. First, check the mating faces of the clutch driving and pressure plates to make sure they are clean and smooth. Then install
clutch disk and pressure-plate assembly on clutch driving plate and tighten screws to specified torque.

b. Lift support plate, with clutch attached, into position and slide turbine shaft into Fluid-Torque Drive, turning drive slowly to index internal and external splines on turbine and turbine shaft. When they index, the assembly can be moved forward a little. Now, the splines on the stator shaft must be made to index with the internal splines on the stator by slightly turning the assembly as it is moved further forward. Next, turn the support plate until the dowel-pin holes in the plate line up with the pins on the flywheel housing. Rotate the torque drive until the driving sleeve indexes with the oil-pump pinion. Then push support plate up against the flywheel housing.

c. Install lower flywheel housing cover with six bolts.

d. Mount clutch housing to flywheel housing.

e. Assemble release bearing to clutch fork by inserting tip ends of pull-back springs into the fork prongs and pivot the bearing assembly around toward the fork so it slides easily into place (Fig. 9-5). Do not force.

f. Assemble torque-shaft pivot-bracket assembly to torque shaft and attach bracket assembly to clutch housing with two bolts (Fig. 9-4).

g. Attach long end of clutch-fork-rod assembly to torque shaft and short end to fork, noting carefully the exact relationship of washers, springs, pins, and cotter pins as shown in Fig. 9-4.

h. Hook on the fork pull-back spring.

i. Lubricate the rubber oil seals with chassis lubricant and install the three connectors in drive oil reservoir. Mount reservoir to clutch housing with two short bolts at front and two long bolts, with spacers, at back.

j. Connect oil-cooler lines to support plate.

k. Jack engine up above normal height, install cross member or frame, let engine down again and attach clutch housing to cross member.

l. Reinstall transmission, using special pilot pins (§65, 5) so as to avoid damage to the clutch friction disk. Lift transmission up into position and slide it forward so pinion shaft enters the friction-disk hub, making sure that the internal and external splines align. Attach transmission with nuts or bolts
tightened to the proper tension. Attach gearshift-operating and selector rods, brake adjusting-bolt bracket and lever, brake band, and support. Connect universal-joint yoke, install hand-brake cable and anchor bracket and attach cable to brake band.

m. Install and attach other parts (governor, solenoid, leads, speedometer cable) that have been detached.

n. Add oil to transmission as noted in §100, 5.

o. Add oil to torque drive by removing filler plug on side of reservoir and filling with SAE 10-W oil to the bottom edge of filler-plug hole. Then start engine and run it between 500 and 750 rpm with transmission in neutral. With engine running, continue to add oil until oil level remains constant at the filler-plug hole.

**NOTE:** If oil level does not go down when engine is first started, the oil pump is probably not primed. It can be primed by removing breather-tube connection from the oil reservoir and applying low air pressure (less than 5 pounds) to the reservoir (filler plug should be in place). This will force oil up into the pump and cause it to start working. If this does not work, chances are the oil-pump pinion is not indexed with the driving sleeve on the torque drive.

**§102. Towing car to start engine** With a run-down battery, it is often the practice to push or tow a car in order to start the engine. With the transmission and Fluid Drive or Fluid-Torque Drive described in the chapter, a special procedure must be used. Some earlier models using the fluid drive and automatic transmission have a special lock-out control in the driving compartment (on the steering column). On these, the procedure is to shift the shift lever into the low range, hold the clutch pedal down, pull out the lock-out control button, and turn on the ignition switch. Then the car can be pushed or towed. When it reaches a speed of about 10 mph, the clutch can be engaged. As soon as the engine starts, the lock-out control button should be released. When the control button is pulled out, it locks up the freewheeling mechanism in the transmission. It must never be pulled out except for starting the engine by towing the car.

On later models, it is necessary only to turn the ignition switch on, disengage the clutch by pushing the clutch pedal down, and
then place the shift lever in the low range position. When the car is being pushed or towed at a speed of about 10 mph, the clutch should be engaged. The transmission will now shift into second (a nonfreewheeling speed) so the engine will be cranked for starting.

CHECK YOUR PROGRESS

Progress Quiz 14

It may be that, when you go into the service shop, you will not be called upon to service transmissions, Fluid Drives, or Fluid-Torque Drives of the type described in the chapter. However, it is desirable for you to know how these mechanisms are serviced since there is always the chance that you will have a servicing job of this sort handed to you. The automotive mechanic should be familiar with all mechanisms used on modern cars and, with the help of the applicable shop manual, should be able to handle service on the different transmissions and drives discussed on the past few pages. The quiz that follows will help you to review the material you have just covered and find out how well you have remembered the essential points described. If any of the questions gives you trouble, just reread the pages in the book that will give you the answer.

True or False

Some of the statements below are true. Some are false. Read each statement carefully and then decide whether it is true or false. If you believe it to be true, write it down in your notebook. Verify it by rereading the past few pages.

1. In actual practice, the transmission must be completely disassembled every time a trouble is corrected or a defective part replaced.
2. Main shaft must be locked before the drum-and-flange attaching nut can be loosened.
3. Main shaft must be removed from extension housing before it can be disassembled.
4. Shuttle valve is in the extension housing.
5. Direct-speed piston is held in case by snap ring.
6. The governor drive gear must be taken out before the main drive pinion can be removed.
7. The countershaft is removed by pushing it out with a special arbor which is shorter than the countershaft.
8. Countershaft-gearset assembly is disassembled by standing it on end with the freewheeling gear up.
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9. Transmission must be completely disassembled before the rear oil seal can be serviced.
10. The cam rollers and the bearing rollers are one and the same thing.
11. Countershaft is installed by pushing it in through front of case.
12. First step in assembling the main shaft is to install reverse gear and center main-shaft bearing.
13. The transmission described uses several roller bearings.
14. End play between rear thrust bearing on countershaft and case should be between 0.2 and 0.8 inch.
15. On reinstallation, the fluid drive must be reinstalled first, followed by the clutch and then the transmission.
16. When installing clutch on fluid coupling, an aligning tool or a main drive pinion should be used to assure alignment of the friction disk.
17. The Fluid Drive is filled with oil before it is installed on the car.
18. On the Fluid-Torque Drive, if the oil level does not go down when the engine is first started, the oil pump is probably not primed.
19. When a car with Fluid-Torque Drive is towed for starting, it should be moving at a speed of 20 mph before the clutch is engaged.
20. The transmission should be filled with 10-W oil to the bottom of the filler plug after it is reinstalled on the car.

CHAPTER CHECKUP

NOTE: Since the following is a chapter review test, you should review the chapter before taking it.

The chapter you have just completed describes the servicing of one type of automatic transmission used on cars manufactured by the Chrysler Corporation, including trouble-shooting, removal, disassembly, re-assembly, and replacement. The following checkup will help you review these procedures and determine how much you remember about them. If some details are not clear in your mind, you will be able to go back into the chapter and study the material that will clear up the details for you. Such review helps to fix essential points more clearly in your mind. Write the answers in your notebook; this not only helps you remember them, but also makes the notebook a valuable source of information you can refer to in the future.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

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1. Insufficient oil in the transmission may cause failure to upshift. sticking governor points sticking solenoid plunger low idle speed.

2. If the governor points do not open, the transmission would not downshift upshift.

3. An open-circuited solenoid will not allow the transmission to downshift upshift.

4. Insufficient oil pressure could prevent the transmission from downshifting upshifting.

5. The direct-speed piston is moved by hydraulic pressure to produce downshifting upshifting.

6. A squeal from the oil seal can often be eliminated by installation of a new clutch damper new drive.

7. Two types of seal that have been used on the Fluid Drive are the solid-sleeve type and the ring lever bellows plate type.

8. When towing the car to start it, the ignition switch should be turned on and the shift lever should be in low range high range neutral.

Troubles and Service Procedures

In the following, you should write down in your notebook the trouble causes and service procedures asked for. Do not copy the procedures from the book but try to write them in your own words. Writing them down in your own words will be of great help to you because this will enable you to remember them better. And of course, this will be of great value to you when you go into the automotive shop.

1. List conditions that could cause failure to upshift.
2. List conditions that could cause failure to downshift.
3. List conditions that could cause the Fluid-Torque Drive to overheat.
4. Make a list of the electric-circuit tests to be made on the transmission-control electric circuit.
5. Explain how to test the antistall control and solenoid with a piece of unmagnetized steel.
6. Explain how to test the governor and kick-down switch.
7. Explain how to test the interrupter switch.
8. Explain how to test the hydraulic system.
9. List the steps in removing the transmission.
10. List the steps in removing the Fluid Drive.
11. List the steps in removing the Fluid-Torque Drive.
12. Explain how to remove oil pump from support body on the Fluid-Torque Drive.
13. List the steps in installing oil pump on support plate.
14. Explain how to check and correct torque-drive run-out.
15. List the essential steps in disassembling the transmission.
16. List the essential steps in assembling the transmission.
17. List the essential steps in installing the Fluid Drive, clutch, and transmission.
18. List the essential steps in installing the Fluid-Torque Drive, clutch, and transmission.
19. Explain how to add oil to a Fluid-Torque Drive.
20. Explain how to tow a car equipped with Fluid-Torque Drive to start it.

SUGGESTIONS FOR FURTHER STUDY

A good place to learn more about the drives and transmissions covered in the chapter is in a shop handling the servicing of this equipment. School shops also may have such equipment, so set up that it can be disassembled and reassembled to give the student practice in servicing it. You should take every opportunity to handle the equipment and the parts that go into it. Complete tear-down and rebuilding of the transmission will be especially interesting. Study shop manuals issued by the manufacturers of the equipment; they contain detailed disassembly-reassembly information that you will find of value. Write down in your notebook any important facts you come across so you will have a permanent record of them.
10: Hydra-Matic-transmission service

THIS CHAPTER describes the trouble-shooting, maintenance, and overhaul procedures on the Hydra-Matic transmission. There are numerous models of this transmission, but essentially there are only two basic types—the single-coupling and the two-coupling (see §72). They are both covered on the following pages.

§103. Diagnosing Hydra-Matic-transmission troubles As a first step in diagnosing Hydra-Matic transmission troubles, an attempt should be made to determine the exact location of the trouble. In many cases, this is easy to do since certain difficulties in the transmission produce typical malfunctioning patterns. Thus, sticking valves in the valve body or governor can usually be blamed if the transmission fails to upshift or downshift or if it misses an intermediate speed as it upshifts. Actually, it has been estimated that most Hydra-Matic troubles are due to improper linkage adjustments, to incorrect fluid level in the fluid coupling, and to improper engine idle speed. The charts that follow list various transmission troubles together with possible causes, checks to be made, and corrections needed.

Caution: If you road-test the car to check transmission operation, be sure to observe all traffic laws. Drive safely. If a chassis dynamometer is available, use it rather than take the car out of the shop. See Appendix.

In the charts below, many transmission parts are named. To identify them, refer to the illustrations on following pages. If a trouble is not due to such relatively simple causes as improperly adjusted linkages, low fluid level, or incorrect engine idle speed, then the transmission must be partly or completely disassembled to clean, repair, adjust, or replace the malfunctioning parts. Section 104 out-
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#### CONDITIONS

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>POSSIBLE CAUSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward drive in &quot;N&quot;</td>
<td>M4, D4, F4, G5</td>
</tr>
<tr>
<td>Reverse drive in &quot;N&quot;</td>
<td>H3, H4</td>
</tr>
<tr>
<td>No drive resulting in neutral condition</td>
<td>A1, A2, E2, B1, D2, M3, M4, N1</td>
</tr>
<tr>
<td>Neutral condition in &quot;R&quot;</td>
<td>H3, H4, A2, E2</td>
</tr>
<tr>
<td>Locked-up condition in &quot;R&quot;</td>
<td>H3, H2</td>
</tr>
<tr>
<td>No reverse drive-slips</td>
<td>D4, F4, G4, E3</td>
</tr>
<tr>
<td>Selector lever won't go into &quot;R&quot;</td>
<td>H1, H3, A1, A2</td>
</tr>
<tr>
<td>Slips in 1st and 3rd in Dr-4</td>
<td>A1, A2, B3, B4, B6, B1, B2, E2, N1, K1, K4</td>
</tr>
<tr>
<td>Slips in 2nd and 4th in Dr-4 and Dr-3</td>
<td>C1, C2, C3, C4</td>
</tr>
<tr>
<td>Slips in 2nd and 3rd in &quot;Lo&quot; on coast</td>
<td>D1, D2, E1, E2, E3, D4, D5, D6</td>
</tr>
<tr>
<td>Slips in 1st and 2nd in all drive ranges</td>
<td>B1, B2, B3, B4, B6, B1, B2, E2, E3, D1, D2, D3</td>
</tr>
<tr>
<td>No upshifts</td>
<td>H1, H3, A1, A2, A3, E2, E3, D1, D2, D3, D4, D5, D6</td>
</tr>
<tr>
<td>Misses 2nd</td>
<td>J1, J3, J4</td>
</tr>
<tr>
<td>Rough 2-3 shift</td>
<td>K1, K2, K3, K4</td>
</tr>
<tr>
<td>Locks up in 3rd and 4th</td>
<td>K3, K4</td>
</tr>
<tr>
<td>Locks up in 2nd and 4th</td>
<td>L2</td>
</tr>
<tr>
<td>Uptake high</td>
<td>J1, J2, J3, M2, K4</td>
</tr>
<tr>
<td>Uptake low</td>
<td>J1, J3, M1, K4</td>
</tr>
</tbody>
</table>

#### LEGEND

- **A.** Front sprag clutch slipping
- **B.** Front unit coupling cover seals leaking
- **C.** Overrun clutch slipping or burned
- **D.** Neutral clutch slipping or burned
- **E.** Rear sprag clutch slipping
- **F.** Rear unit clutch slipping or burned
- **G.** Servo piston binding in case or in servo and accumulator body
- **H.** Reverse piston apply restricted or leaking
- **I.** Governor valve sticking
- **J.** Governor valve sticking
- **K.** Coupling valve sticking
- **L.** Reverse blocker piston stuck open
- **M.** Throttle linkage adjusted long
- **N.** Low oil pressure
- **O.** Trimmer valve stuck

**FIG. 10-1. Two-coupling Hydra-Matic trouble-diagnosis chart. (Cadillac Motor Car Division of General Motors Corporation)**
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lines comprehensive tests of various components and the complete transmission, which will help in any diagnosis of troubles. Subsequent sections describe transmission disassembly, repair, adjustment, and reassembly.

The chart that follows applies to the single-coupling Hydra-Matic. The chart on page 354 (Fig. 10-1) applies to the two-coupling unit. There are some variations in different models of these two types, particularly in the valve body, pumps, and reverse assembly. Refer to the applicable shop manual or to the actual assembly for special details of these assemblies.

**HYDRA-MATIC-TRANSMISSION TROUBLE-SHOOTING CHART**

Single-coupling Type

**Note:** Be sure to classify the complaint accurately before attempting an analysis of the trouble. For example, determine that the trouble is actually slipping in second and fourth rather than in first and third before proceeding with a check of possible causes. Repeat the tests several times until you are satisfied that you are accurately classifying the complaint.

<table>
<thead>
<tr>
<th>Complaint</th>
<th>Possible Cause</th>
<th>Check or Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Transmission jumps out of reverse</td>
<td>a. Linkage to transmission too short</td>
<td>Adjust (§113)</td>
</tr>
<tr>
<td></td>
<td>b. Reverse anchor to internal-gear backlash wrong</td>
<td>Adjust (§111, 4)</td>
</tr>
<tr>
<td></td>
<td>c. Manual lever binding or stops short of reverse detent</td>
<td>Align or raise side cover to give free and sufficient lever travel</td>
</tr>
<tr>
<td>2. Transmission will not reverse when shifted to reverse</td>
<td>a. Broken reverse-detent shift lever</td>
<td>Replace lever</td>
</tr>
<tr>
<td></td>
<td>b. Broken reverse crankshaft</td>
<td>Replace reverse bracket assembly</td>
</tr>
<tr>
<td></td>
<td>c. Broken reverse anchor</td>
<td>Replace anchor</td>
</tr>
<tr>
<td></td>
<td>d. Governor G-1 valve stuck open</td>
<td>Clean governor assembly</td>
</tr>
</tbody>
</table>

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### §103

**Complaint**

3. Hard to shift out of reverse

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Check or Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. High engine idle speed</td>
<td>Adjust engine speed</td>
</tr>
<tr>
<td>b. Linkage binding</td>
<td>Readjust, free</td>
</tr>
<tr>
<td>c. Interference between reverse anchor and internal gear</td>
<td>Free, readjust (§111, 4)</td>
</tr>
<tr>
<td>d. <em>Internal parts</em> rough and binding</td>
<td>Inspect and correct</td>
</tr>
<tr>
<td>e. Backlash between anchor and gear wrong</td>
<td>Readjust (§111, 4)</td>
</tr>
<tr>
<td>f. Low front pump pressure</td>
<td>Check pump, pressure-regulator control</td>
</tr>
</tbody>
</table>

4. First to second, second to third, third to fourth, light-throttle shift points high, but full-throttle shift points normal

| Throttle-linkage adjustment incorrect             | Readjust (§113)                      |

5. Full-throttle shift points high, low, or absent

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Check or Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Governor valves operating improperly</td>
<td>Check for damaged or sticky valves</td>
</tr>
<tr>
<td>b. Leakage at governor</td>
<td>(§109, 7)</td>
</tr>
<tr>
<td>c. Broken oil rings</td>
<td>Check oil-seal rings, sleeve, oil-pipe connections</td>
</tr>
<tr>
<td>d. Missing governor plug</td>
<td>Replace</td>
</tr>
<tr>
<td>e. Ring lands worn</td>
<td>Replace governor</td>
</tr>
</tbody>
</table>

6. No throttle downshift fourth to third (DR) above 20 mph

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Check or Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Accelerator travel insufficient</td>
<td>Remove interference, adjust</td>
</tr>
<tr>
<td>b. Throttle control out of adjustment</td>
<td>Readjust (§113)</td>
</tr>
<tr>
<td>c. Levers bent or loose on shaft</td>
<td>Straighten, replace, tighten</td>
</tr>
<tr>
<td>d. Downshift-valve spring lock missing (front servo)</td>
<td>Replace, repositioning valve in servo body</td>
</tr>
<tr>
<td>Hydra-Matic-Transmission Service</td>
<td>Possible Cause</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td><strong>Complaint</strong></td>
<td></td>
</tr>
<tr>
<td>7. Transmission does not respond to selector lever position</td>
<td>Manual valve in valve body not operating —pin not engaged with groove in valve</td>
</tr>
</tbody>
</table>
| 8. Transmission fails to drive car with lever in any drive position | Usually due to band (or bands) not applying because of:  
  a. Low oil level  
  b. Regulator valve stuck open  
  c. Oil leakage at front servo or valve assembly  
  d. Front pump inoperative  
  e. Band adjustment incorrect  
  f. Manual valve mispositioned  
  g. Sticking torus check valve | Add oil  
  Free, replace defective parts  
  Check valve, piston fit, oil-pipe connections  
  Check (§104, 2)  
  Readjust (§113)  
  Remove side cover and check for pin engagement in valve groove  
  If this, car will move after engine runs awhile  
  Replace sticky valve (§110, 13)  
  Replace lever assembly |
| 9. Erratic response to shift lever | Inner manual-control lever loose on shaft  
  Rear clutch not applying, due to:  
  a. Line to clutch or valve body leaking  
  b. Passage in case clogged | Fix connections, replace valve body |
| 10. Transmission drives car in first or second but acts as if it were in neutral after shifting out of second |                     | Clean out |

[357]
<table>
<thead>
<tr>
<th>Complaint</th>
<th>Possible Cause</th>
<th>Check or Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Transmission slips in second and fourth</td>
<td>Front clutch does not apply for same reasons listed in item 10, above.</td>
<td>Clean, replace, relocate</td>
</tr>
<tr>
<td>12. Transmission slips in first, third and reverse but operates O.K. in second and fourth</td>
<td>Front brake band not holding due to:</td>
<td>Replace</td>
</tr>
<tr>
<td></td>
<td>a. Loose band adjustment</td>
<td>Replace seal, also clutch parts if worn</td>
</tr>
<tr>
<td></td>
<td>b. Leak in valve body, case or servo</td>
<td>Free, replace damaged parts</td>
</tr>
<tr>
<td></td>
<td>c. Sticking servo piston</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d. Band defective or improperly installed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>e. Valves sticking in valve body</td>
<td></td>
</tr>
<tr>
<td></td>
<td>f. Throttle linkage out of adjustment</td>
<td></td>
</tr>
<tr>
<td>13. Transmission slips in first or second but is O.K. in third, fourth, and reverse</td>
<td>Rear brake band not holding for same reasons outlined in item 12, above</td>
<td>Adjust band (§113) (Do this first)</td>
</tr>
<tr>
<td>14. Slips in LO range but O.K. in reverse</td>
<td>Rear brake band not holding for reasons outlined in item 12, above</td>
<td>Disassemble body, check valve fits, replace parts or assembly as necessary Adjust (§113)</td>
</tr>
</tbody>
</table>
Hydra-Matic—Transmission Service

Complaint

15. Transmission slips or chatters on throttle downshift third to second

Possible Cause

a. Rear band not operating
b. Rear servo inoperative
c. Insufficient compensator pressure, throttle linkage incorrectly adjusted, stuck compensator valve

Check or Correction

See item 12, above
Check for stuck accumulator valve, weak or broken springs
Make corrections as necessary

16. Throttle downshift from third does not occur until throttle is opened excessively or long after car is stopped

a. Sticking valves in valve body
b. Sticking valve in governor

disassemble, free valves, replace assembly if worn
free valves, replace governor if parts are worn

17. Severe clunk on third to second or first-speed shift at excessively high speed with throttle closed

a. Rear-servo check valve stuck
b. Stuck or broken ring in accumulator piston
c. Sticking valves in valve body
d. Rear-clutch piston binding

Free, replace if needed
Replace ring, other parts if necessary
Disassemble, free valves, check fit, replace if needed
Clean piston pilot

18. Downshifts into second at excessively high speed with throttle closed

a. Leakage at governor
b. Oil-seal rings worn or broken
c. Missing governor plug

Check connections
Replace rings, other parts
Replace

19. Transmission downshifts to third with light throttle, above 20 mph or hunts between fourth and third

a. Throttle linkage improperly adjusted
b. Valves stuck in valve body

Readjust (§113)
Disassemble, free valves, check fit, replace parts if needed

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Check or Correction

Make corrections as necessary
<table>
<thead>
<tr>
<th>Complaint</th>
<th>Possible Cause</th>
<th>Check or Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>20. Car starts in third or fourth in DR and second in LO, LO may have third gear</td>
<td>a. One or both governor valves stuck</td>
<td>Disassemble, clean, check fit, replace parts as necessary</td>
</tr>
<tr>
<td></td>
<td>b. Valves sticking in valve body</td>
<td>Disassemble, free valves, check fit, replace parts as necessary</td>
</tr>
<tr>
<td>21. Shifts hard or misses a speed</td>
<td>Valves in governor body stuck</td>
<td>See item 20, above</td>
</tr>
<tr>
<td>22. Car will not back up unless throttle is opened excessively. Transmission is locked up on light or closed throttle</td>
<td>Rear band not releasing due to low oil pressure from leakage or compensator-valve auxiliary-plug pin missing</td>
<td>Check front-pump pressure (§104) and correct as necessary. Replace missing pin</td>
</tr>
<tr>
<td>23. Car creeps excessively</td>
<td>Engine idle high</td>
<td>Readjust idle</td>
</tr>
<tr>
<td>24. Car creeps forward when lever is in R</td>
<td>a. Rear unit inoperative</td>
<td>Adjust, repair</td>
</tr>
<tr>
<td></td>
<td>b. Drag in rear-unit clutch</td>
<td>Disassemble, repair</td>
</tr>
<tr>
<td>25. With lever in DR, LO, or R, engine speeds up and bands are applied violently</td>
<td>a. Low oil level</td>
<td>Check oil level (§113, 1)</td>
</tr>
<tr>
<td></td>
<td>b. Low oil pressure</td>
<td>Check pressure (§104, 2)</td>
</tr>
</tbody>
</table>

§104. Transmission tests

If oil pressure is not correct, clutches and brake bands will not function properly, shifts may be incorrect, and excessive wear may result. Engine must be in normal condition. If it lacks power, transmission may seem to function poorly. Check oil pressure and then make other tests as follows:

1. **Oil level and cleanliness.** First check oil level and bring it up to the proper level if necessary. Add special Hydra-Matic fluid, not ordinary oil. If oil on dip stick seems dirty or has fine metallic particles in it, the unit should be disassembled, cleaned, and worn parts replaced.

2. **Checking oil pressures.** Attach oil pressure gauge to the transmission at the checking point. Be sure to wipe case before removing [360]
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test plug to avoid getting dirt into the transmission. With car on jack stands or on dynamometer (or on road), make following checks:

a. Check pressure with engine idling and selector lever in drive range. Pressure should be (on late models) around 60 to 70 psi. Momentarily push throttle all the way down. Pressure should increase at least 20 psi. If pressure is low on idle, or pressure does not increase as the throttle is opened, the pressure regulator or front pump is at fault or there is a leak.

b. To test rear pump, drive at 40 to 45 mph, shift to neutral, and turn ignition off. Pressure should be at least 60 psi.

c. On late models, check reverse pressure by shifting to reverse with engine idling. The pressure should be as high or higher than previous pressure checks. Apply foot brake and open throttle half way. Pressure should go up to 180-200 psi.

3. Stall test. This test checks the operation of the bands and clutches as well as the control and oil systems. Since it puts a heavy strain on transmission parts, it should be done very quickly—in a few seconds. If excessive speeds are reached, it should be halted at once to avoid injury to transmission parts. To make the test, apply hand and foot brakes, put selector lever in drive range, and push throttle to floor. Excessive speed indicates slipping clutches or, on earlier models, bands.

§105. Factors affecting transmission operation

Several important things should be remembered about Hydra-Matic-transmission operation and the conditions that affect its performance.

1. Oil pressure. Without the proper oil pressure at the proper points in the transmission, the clutches and brake bands are not going to work properly. Slippage, rough shifting, and improper shifting will occur. Further, transmission parts may not be properly lubricated so that wear and early failure will result.

2. Oil level. Low oil level is apt to reduce oil pressure or at least cause erratic oil delivery which will result in a fluctuating oil pressure. This would cause erratic transmission action, and also, the torus, lacking oil, might slip excessively so that high engine speeds would be required for starting and accelerating.

3. External oil leaks. Oil leaks will, of course, cause low oil level and low oil pressure with the resulting troubles noted in the past.
two paragraphs. Oil leaks can occur at a number of places as noted in Fig. 10-2.

4. Internal oil leaks. Internal oil leaks are oil leaks that reduce oil pressure to the servos and other operating parts, and perhaps may even cut off oil circulation to certain parts entirely. Naturally, this might cause rapid wear and early failure of those parts starved for oil. Also, with low oil pressure, erratic and improper shifting will occur. It is also possible that the leaking oil may build up pressure in the wrong line and cause application or release of a brake band or clutch at the wrong time. This could throw transmission action completely off. A low pressure could also cause brake-band drag since the pressure would not be sufficient to overcome the spring pressure and cause release of the band.

5. Oil cleanliness. Dirty oil is going to cause serious trouble in the transmission. The valve parts will stick and thereby prevent proper action of the brake bands and clutches so that shifting will be incorrect or will not take place at all. Dirt in the oil, including fine metallic particles, is a signal that all is not well in the transmission, that parts are wearing and depositing the metallic particles in the oil. The transmission should be disassembled so that parts can be inspected for wear and worn parts should be replaced.

6. Engine performance. A sluggish engine will not give the transmission a chance to perform properly. Shifting will be delayed, but even after it occurs, the engine will labor and will not have enough power to pull the car and accelerate normally.

7. Throttle and control linkages. If the throttle and control linkages are not properly adjusted (see §113), the transmission will not shift properly and may be rough and erratic in action. In addition, rapid wear of some parts will take place. For example, if linkages are so adjusted as to permit a brake band to apply before the clutch is released, or on the other hand, to allow the clutch to apply before the brake band is released, then either the clutch or the brake band is going to slip and wear rapidly.

8. Brake band adjustment. If the brake bands are not properly adjusted (see §113), then their application and release will not synchronize with the release and application of the clutch, with the result noted in the previous paragraph—that is, rapid wear of parts.

9. Touring instructions. Cars equipped with the Hydra-Matic transmission may be towed for 50 to 75 miles with the selector lever
Fig. 10-2. Possible points of oil leakage. (Oldsmobile Division of General Motors Corporation)

1. Crankshaft to flywheel gasket
2. Between flywheel and ring gear
3. Flywheel to flywheel cover
4. Dampener rivets
5. Flywheel cover hub (pin hole in weld)
6. Front-cover screws
7. Front-cover casting (sand hole)
in neutral provided low towing speeds are maintained. The car should not be towed faster than 15 to 25 mph; higher speeds would be apt to prevent lubrication to the transmission parts.

**Caution:** If the car is new (less than 1,000 miles), it should not be towed unless the propeller shaft is disconnected so the transmission will not be operative. The reason for this is that with a new car, the transmission parts have not yet worn in fully: The front clutch would be apt to drag and burn up.

**CHECK YOUR PROGRESS**

**Progress Quiz 15**

Before you can diagnose troubles in the Hydra-Matic, you must have some understanding of how it is constructed and how it operates. In addition, you need to know what to check for, what troubles may occur, and the effects these troubles have on the operation of the transmission. Previous chapters describe the construction and operation of the Hydra-Matic transmission. The past several pages supply, in chart form, the various troubles that might occur in a Hydra-Matic and their causes. In addition, the different transmission tests and factors affecting transmission operation are described in detail. These various facts are all important to the man who is planning to check and repair this type of transmission. To see how well you remember them, the following quiz has been included. If any of the questions causes you difficulty, go back to the page in the book that will give you the answer. The review will help your memory.

**Completing the Sentences**

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. The single most important factor in Hydra-Matic-transmission operation is
   - air pressure
   - engine speed
   - oil pressure
   - clutch pressure

2. Driving the car at 40 mph, shifting to neutral and turning ignition switch off checks the
   - front pump
   - center pump
   - rear pump

8. Front-cover oil seal
9. Front-cover oil-seal rings
10. Front cover to transmission case
11. Rear main bearing (do not mistake for oil leak around fluid coupling)
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3. With the oil-pressure gauge installed, the engine idling and the selector lever in drive, the gauge will indicate pressure of
front pump  center pump  rear pump

4. Moving the throttle from closed to wide-open position with the transmission in drive and the car moving at about 30 mph should cause line pressure to

- decrease 20 pounds
- increase 20 pounds
- increase 60 pounds

5. With everything in the transmission in normal condition, hand brake and foot brake applied, selector lever in drive, and throttle wide open, the bands should slip  bands should not slip  fluid coupling should not slip

Correcting Troubles Lists

The purpose of this exercise is to help you to spot related and unrelated troubles on a list. There is a series of lists below, and in each list there is one item that does not belong. That is, there is one item that will not cause the trouble given in the list. Write down each list in your notebook, but do not write down the item that does not belong.

1. Transmission jumps out of reverse: linkage to transmission too short, low oil level, backlash between reverse anchor and internal gear.
2. Transmission will not reverse when shifted to reverse: valve stuck in governor, broken reverse anchor, broken reverse crankshaft, broken reverse-detent shift lever.
3. Hard to shift out of reverse: high engine idle speed, linkage binding, interference or wrong backlash between reverse anchor and internal gear, rear band not holding.
4. Full-throttle shift points at incorrect speed or absent: oil leakage at governor, governor valves not operating properly, engine idle low.
5. No throttle downshift (fourth to third) above 20 mph: front servo faulty, linkage out of adjustment, accelerator travel insufficient, control lever bent or loose, rear servo faulty.
6. Transmission fails to drive car in any drive position: band (or bands) not applied, clutch not applied, low oil level, incorrect band adjustment, pump inoperative.
7. Transmission drives car in first or second but acts as if in neutral after shifting out of second: rear clutch not applying, rear band not applying, clutch piston stuck, oil-delivery sleeve clogged, oil line leaking, sleeve ring broken.
8. Transmission slips in second and fourth: rear clutch not applying, front clutch not applying.
9. Transmission slips in first, third, and reverse but operates O.K. in second and fourth: front brake band not holding, loose band adjust-
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ment, valves sticking in valve body, loose clutch adjustment, sticking servo piston.

10. Transmission slips in first or second but is O.K. in third, fourth, and reverse: front brake band not holding, rear brake band not holding.

11. Transmission slips in LO but is O.K. in reverse: front band not holding, rear band not holding.

12. Transmission slips or chatters on throttle downshift third to second: rear band not holding, front band not holding, rear servo inoperative, insufficient compensator pressure.

13. Severe clunk or third- to second-speed shift at excessively high speed with throttle closed: rear-servo check valve stuck, defective ring in accumulator piston, center clutch defective, valve sticking in valve body.

14. With shift lever in DR, LO, or R, engine speeds up and bands are applied violently: low oil pressure, pressure-regulator valve sticking, front pump not operating properly, anchor backlash excessive.

15. Valves in governor stuck: transmission misses third, will not shift into fourth, will not reverse, starts in third or fourth in DR and second in LO.

§106 Transmission removal The transmission, torus cover, torus members, and torus housing (also called flywheel housing) are removed from the car as a unit. A typical removal procedure follows.

1. Raise car off floor so you can work on it from the under side. A twin-post hoist, a jack or block at each wheel to raise wheels about a foot, will be satisfactory.

2. Drain oil by removing drain plug at rear of transmission.

3. Disconnect side pan at rear and drop it so you can remove cranking motor. (Earlier six-cylinder cars do not require cranking-motor removal.)

4. After cranking motor is removed (tag wires so you can reconnect them correctly), remove exhaust-pipe bracket and crankcase-ventilator bracket from lower flywheel housing and then take off lower flywheel housing. Housing is held in place by eight cap screws.

5. Take off flywheel-housing pan and take out oil-drain plug to drain oil from torus.

6. Disconnect propeller shaft at the rear universal joint and slide it rearward out of the way.
8. Take filler tube from transmission oil pan.
9. Remove the 30 torus-cover-to-flywheel attaching screws, using a special tool to rotate the flywheel. If the engine spark plugs are removed, it will be much easier to rotate the flywheel.
10. Install engine rear-support bar and remove bolts and cap screws attaching engine to frame cross member. Then remove bolts attaching cross member to frame. Use jack, hoist, or special lift (Fig. 10-3) to raise and support engine and transmission.
11. Raise engine about ½ inch (no more than necessary) to remove cross member.
12. Lower engine just barely enough (not more than 1½ inches) to remove the upper cap screws attaching the transmission to the housing, adjusting engine support bar as necessary.
13. Remove the remaining cap screws attaching the transmission. Transmission assembly can now be moved toward the rear of the car and lowered toward the floor.
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Rear Bearing Retainer Oil Seal Installer

Front Servo Gauge

Rear Bearing Extension Bushing Service Set

Front Pump Cover Oil Seal Installer

Mainshaft Snap Ring Remover

Extension Rear Oil Seal Installer

Mainshaft Endplay Dial Indicator Extension Rod

Throttle Lever Bending Tool

Oil Delivery Sleeve Ring Compressor

Front Pump Cover Oil Seal Installer

Transmission Holst

Front Drum Spacer

Transmission Lifting Eye Bolt

Rear Clutch Hub Retainer Bracket

Planet Pinion Swaging Set

Fig. 10-4. Tools required for servicing
Hydra-Matic Transmission Service

- Transmission Bearing Retainer Remover
- Governor Flange & Pump Riveting Set
- Front Pump Holder & Socket Set
- Front Planet Carrier Assembly Holder
- Planet Assembly Holding Fixture
- Speedometer Drive Gear Spacer
- Throttle Lever Checking Fixture
- Transmission Mainshaft Endplay Guide

Hydra-Matic. (Kent-Moore Organization, Inc.)
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14. To keep the end of the main shaft from hanging up on the crankshaft bolts, turn the crankshaft so the end of the main shaft can pass between two bolts.

§ 107. Transmission disassembly The proper tools must be used for transmission servicing. Makeshifts make more work and increase the chances of poor workmanship. Two procedures for disassembling the transmission into major subassemblies follow, one for the single-coupling transmissions, the second for the two-coupling transmissions. Subsequent sections explain how to disassemble and service these subassemblies.

Note: When disassembling the transmission, do not scatter the parts carelessly on the bench. Take them off and lay them out on the bench in definite order. If you do this, and if you study the relationship of the part you are removing from the transmission to the other parts, you will have no difficulty in reassembling the transmission. If you lay out the parts on the bench in the order in which they came off the transmission, you will have no trouble putting them back in the proper order. Be clean and careful in your work. Remember that the transmission is built to close tolerances, and dirt or careless workmanship may ruin it.

SINGLE-COUPLING HYDRA-MATIC

1. Put manual lever in reverse, remove lock plate and main-shaft lock nut. Slide driven torus off. Take off snap ring, driving torus, and then torus cover. Use caution to prevent damage to oil-seal rings. Take hold of cover with both hands, work it back gently through the oil seals and pull forward with one quick jerk.

2. Remove four cap screws and flywheel housing. Take out oil-level dip stick and ¼ inch oil-pressure-line plug and put transmission in fixture (Fig. 10-5). Take off manual control lever, driven-torus snap ring from main shaft, oil pan, side cover, and rear-pump intake-pipe screen.

3. On some models, the front-pump intake pipe comes off with the screen. On others, loosen two screws, hold pipe so they do not drop off, and lift pipe off. Remove governor oil-delivery
pipe (where present) by prying under two bends with two screw drivers.

4. Remove servos and oil pipe, valve-body assembly (first move manual control lever so steel ball is in LO detent position), reverse shifter-bracket assembly or parking-brake-and-governor-sleeve bracket (later models), rear oil pump and governor (Fig. 10-6), pressure regulator, front pump and front-planetary drive gear.

5. Check main-shaft end play with guide tool and dial indicator (Fig. 10-7). Put block between front drum and cen-
ter-bearing cap to hold planetary in forward position. Move main shaft back and forth and write down end play so proper space washer can be used on reassembly. Proper end play is between 0.004 and 0.015 inch.

6. Reverse-gear assembly of the type shown in Fig. 10-8 is removed by taking out six drive-flange screws, bolt and anchor, and five screws. Reverse-gear assembly with the cone clutch is removed by knocking out the oil seal from the end of the housing, removing six bolts attaching flange to brake drum, and then removing the bolts attaching the housing to the case.

7. Install rear-hub holding tool (Fig. 10-9). Remove center-bearing cap and front and rear planetary units as a unit.

8. Take planetary units from shaft by removing snap ring and taking rear planetary and clutch hub as a unit from shaft. Remove clutch-hub snap ring, oil-delivery sleeve, front-unit-sun-gear snap ring, and front planetary. Do not mix steel and
bronze washers in drum back of front-unit sun gear with other similar-appearing washers from other parts of the transmission.

TWO-CO UPL IN G HY DRA-MATIC

1. In general, the procedure of removing the driven torus, snap ring, and driving torus is the same as with the previous models (see Fig. 10-10).

2. Remove front-unit sun gear, internal gear and associated washers, and torus cover, working cover in through oil seal and pulling it out with a quick jerk. Use special seal protector (Fig. 10-11) and remove flywheel housing.

3. Remove oil-cooler pipes, cooler, cooler adapter, gasket, sleeves, and seals.

4. Check main-shaft end clearance (see 5 above).

5. Put transmission in holding fixture with oil pan up. Remove front-coupling assembly, oil pan, oil-intake pipes and oil screen, accumulator-servo assembly (Fig. 10-12), control-valve assembly and channel plate.

6. With transmission extension housing down, remove front pump (with puller if necessary) after taking out locating screw and washer and pressure regulator plug. Remove clutch plate, spring and thrust washer, and front-sprag inner race.

7. Install neutral-clutch retainer with locking screw toward front.
Fig. 10-10. Torus assembly of two-coupling transmission. (Oldsmobile Division of General Motors Corporation)

Fig. 10-11. Removing flywheel housing, or cover. (Oldsmobile Division of General Motors Corporation)

Fig. 10-12. Removing accumulator and servo. (Oldsmobile Division of General Motors Corporation)
Fig. 10-13. Removing reverse internal gear. (Oldsmobile Division of General Motors Corporation)

Fig. 10-14. Front planetary unit of single-coupling transmission. To disassemble, snap ring (No. 11) must be removed after pressure is applied to clutch drum in arbor press. (Oldsmobile Division of General Motors Corporation)

1. Clutch drum
2. Annular piston
3. Front planetary assembly
4. Brake drum
5. Clutch-release springs
6. Brass liners
7. Rubber seals
8. Composition plate
9. Thrust washers
10. Steel plate
11. Snap ring
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Remove extension housing, governor assembly, rear pump, reverse-unit parts (Fig. 10-13), and large center-bearing support ring.

8. Turn transmission to horizontal, bottom up, remove center-bearing-support locking screw, support, neutral clutch and rear unit as an assembly.

9. From case, remove stop key, overrun band, inside detent control and throttle control-lever assembly, parking-brake lever spring and bracket, and parking-brake pawl pin, spacer, lever, and pawl.

§108. Disassembly of transmission components Figures 10-14 to 10-22 are disassembled views of the various transmission subassemblies. Follow these illustrations when disassembling these components.

§109. Inspection of parts It is extremely important to inspect all transmission parts carefully after disassembly. In addition, analysis

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**Fig. 10-15.** Rear planetary unit of single-coupling transmission disassembled. Removing snap ring (No. 5) permits disassembly. (Oldsmobile Division of General Motors Corporation)

1. Rear-clutch drum
2. Brake drum
3. Rear-drum internal gear
4. Rear-clutch hub
5. Snap ring
6. Annular piston
7. Rubber oil seals
8. Brass expanders
9. Oil-delivery sleeve
10. Oil-seal rings
11. Composition plates
12. Steel plates
13. Release-spring guide pins
14. Clutch-release spring

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Fig. 10-16. Exploded view of vane-type front pump. 1, pump body; 2, rotor; 3, vanes; 4, front-unit gear; 5, pump relief valve; 6, neoprene seal; 7, spring; 8, guide; 9, retaining pin; 10, vane rings; 11, slide; 12, slide spring; 13, pump cover. (Cadillac Motor Car Division of General Motors Corporation)

Fig. 10-17. Disassembled view of rear oil pump and governor (single coupling): 1, rear-oil-pump body; 2, drive flange; 3, rear-pump cover; 4, oil-pump gears; 5, G-2 governor sleeve and valve; 6, governor assembly; 7, housing; 8, stop plate; 9, oil-seal rings. (Oldsmobile Division of General Motors Corporation)
Fig. 10-18. Exploded view of reverse assembly using reverse cone clutch. (Cadillac Motor Car Division of General Motors Corporation.)

1. Friction spring retainer
2. Clutch-release friction spring
3. Internal reverse gear
4. Thrust washer
5. Stationary cone
6. Snap ring
7. Reverse-clutch-release springs
8. Main-shaft bearing
9. Reverse-clutch piston
10. Spacer
11. Snap ring
12. Extension housing
13. Parking-brake anchor
14. Cone key
15. Reverse-clutch-release spring retainer
16. Reverse-piston outer seal
17. Reverse-piston inner seal
18. Main-shaft bearing spacer
19. Snap ring
20. Gasket
21. Screw
22. Lock washer
23. Rear-bearing-housing cover
24. Gasket
25. Main-shaft selective washer
26. Speedometer drive
27. Steel thrust washer
28. Snap ring
29. Reverse-unit planet carrier
30. Output shaft
31. Rear-unit planet carrier
32. Bronze thrust washer
33. Reverse-unit center gear and drive flange
FIG. 10-19. Disassembled view of valve body in one model of Hydra-Matic. (Oldsmobile Division of General Motors Corporation)

1. Regulator-plug end plate
2. Separator plate
3. Compensator-valve end plate
4. Detent plug
5. Compensator valve and spring
6. Outer valve body
7. Compensator-valve auxiliary plug
8. Auxiliary-plug pin
9. Double-transition valve spring
10. Double-transition valve
11. T valve
12. Throttle spring
13. Throttle valve
14. Manual valve
15. Detent ball
16. Detent spring
17. Detent end casting
18. Regulator-plug end casting
19. Number 2 regulator plug
20. Number 1 regulator plug
21. Number 3 regulator plug
22. Number 2 regulator-plug spring
23. Number 2 shifter spring
24. Number 1 shifter spring
25. Number 3 shifter spring
26. Number 2 shift valve
27. Number 1 shift valve
28. Number 3 shift valve
29. Inner valve body
30. Governor plugs
31. Number 1 governor plug spring
32. Governor-plug end plate
33. Governor-plug end casting

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Fig. 10-20. Rear unit assemblies (two coupling). (Oldsmobile Division of General Motors Corporation)
Fig. 10-21. Front coupling unit parts (two coupling). (Oldsmobile Division of General Motors Corporation)

Fig. 10-22. Rear oil pump, disassembled (two coupling). (Oldsmobile Division of General Motors Corporation)
of the amount and type of wear must be made. This is necessary because wear of one part may be due to improper functioning of another part. And unless that other part is also serviced, simply replacing the worn part will not help much because the replacement part will wear rapidly too. Thus, wear of clutch disks might be caused by improperly adjusted throttle linkage which results in delayed release of a brake band after a clutch is applied so that the clutch slips. But this could also be caused by a slow-acting servo which is either worn or dirty or is not being supplied with sufficient oil because of a faulty oil-control valve in the valve body. You can therefore see that unless all parts are carefully studied, a defective part which would later cause transmission trouble might be overlooked.

As a rule, it is better to replace parts that look suspiciously worn rather than to take a chance on them. On the other hand, you should distinguish between parts that are "worn-in" and parts that are "worn-out." Parts that are worn-in are just at the point where they are working best. Parts that are worn-out are just at the point of failing or causing some other part to malfunction or fail in the transmission.

CHECK YOUR PROGRESS

Progress Quiz 16

The material you have just covered describes the method of removing, disassembling, and inspecting the component parts of a Hydra-Matic transmission. It may be that you would not often be called upon to perform this service. But it is very desirable for you to know how it is done so that, with the help of the applicable shop manual, you could proceed with confidence to handle the job if it did come your way. You have just read the procedures; now the quiz below will give you a chance to check up on yourself so you can learn how well you remember what you have just read. Reread the pages in the book that will give you the answers if any of the questions stump you.

True or False

Some of the statements below are true. Some are false. Read each statement carefully, and then decide whether it is true or false. If you believe it to be true, write it down in your notebook. Verify it by rereading the past few pages.
1. Before the transmission is removed from the car, the frame cross member must be removed.
2. The torus cover is attached to the frame cross member by three screws.
3. In disassembling the transmission, the first major part to be removed is the driven torus member.
4. Torus cover and driving torus member are usually removed together.
5. Four cap screws attach the flywheel housing to the transmission case.
6. Both servos are removed as a unit on some models.
7. Main-shaft end play should be between 0.05 and 0.18 inch.
8. The first item to remove in disassembling the front planetary unit is the clutch-drum retainer ring.
9. After taking the holding tool off the drum of the rear planetary unit, the rear clutch hub and front thrust washer should be removed.
10. The rear planetary unit has six inner and six outer springs on guide pins.
11. More than one type of front pump has been used on the different transmission models.
12. Burrs on the valves in the oil-control-valve body usually can be removed with a flat stone.
13. When inspecting brake bands, pry them open and straighten them so they can be laid out on a flat surface.
14. As a rule, it is better to replace parts that look suspiciously worn rather than take a chance with them.
15. If the oil-control-valve body is dropped or gripped in a vise, it might become so distorted as to cause faulty valve action.

§110. Reassembly of transmission components

After all parts have been cleaned and inspected and defective parts replaced, reassembly of the transmission components can be started. Parts should be laid out, in order, on a clean bench (preferably on strips of clean wrapping paper), and all tools, as well as your hands, should be clean. If you get any dirt in the assembly while you are putting it together, the transmission will very likely soon cause trouble.

Note: Since the actual assembling procedure may vary for different models, always refer to the applicable car shop manual for details of the procedures outlined below.

1. Front planetary-unit reassembly—single coupling (see Fig. 10-14). Special points to watch in reassembly include:
   a. Square notches of steel plates go over drive pins.
   b. Seal goes over brass expander in clutch-drum seal groove, lip down.
c. Seal goes over brass expander in clutch-piston seal groove, lip up.

d. Clutch drum must be pressed down in an arbor press to install snap ring.

e. Ring gap should go between two drive-pin holes.

2. Rear planetary-unit reassembly—single coupling (see Fig. 10-15). Special points to watch in reassembly include:

a. Install plates, seals, springs, piston, and snap ring as in a to e in previous paragraph.

b. Put petroleum jelly on bronze thrust washer to hold it in place and then install washer in deep counterbore of clutch hub. Install clutch hub and thrust washer in drum assembly by rotating assembly on bench with hub pushed inward until splines of clutch plates and hub align. Hold hub in place by installing hub tool (see Fig. 10-9).

c. Put rings on oil-delivery sleeve and then install sleeve over intermediate shaft (long bearing up). Compress rings with special compressor and tap sleeve into bore of front drum with plastic hammer (Fig. 10-23).

d. Install snap ring in second groove on intermediate shaft. Then use ring compressor to compress sleeve rings and install rear drum assembly. Lock it with snap ring.
3. Reverse planetary-unit reassembly—single coupling (Fig. 10-18). Points to watch include:

a. Do not spread stationary cone more than necessary when installing it.

b. Outer seal goes on clutch piston, lip down (Fig. 10-24).

c. Clutch-piston inner seal goes on, lip down.

d. Use special seal compressor to install piston.

e. Use ball bearing as a guide to install retainer over output shaft. Then remove ball bearing, install snap ring, reinstall bearing and outer snap ring.

![Fig. 10-24. Installing outer seal on clutch piston. (Oldsmobile Division of General Motors Corporation)](image)

4. Vane-type front-pump reassembly (see Fig. 10-16). Use special tool to hold pump when installing screws. When installing vanes, full-wear edges go out. When installing front pump on drive gear, align key and slot. Pump should slide on easily.

5. Rear-pump-and-governor reassembly. There are several types of rear-pump-and-governor assemblies. Refer to the applicable shop manual for reassembly details. One type is shown in Fig. 10-17. Handle oil-seal rings carefully to avoid damaging them.

6. Front-servo reassembly. Several types of front servos have been used. If you study the locations of parts during disassembly, and refer to the applicable shop manual, you will have no trouble reassembling this unit.
7. Rear-servo reassembly. Use a special installing tool clamped in a vise to compress the springs during reassembly.

8. Oil-control-valve-body reassembly. If you have noted carefully the locations and relationships of the various parts, you will have no trouble reassembling the valve body. Refer to the applicable shop manual for details of the procedure.

9. Installing check valve in driven torus. Position spring in torus, put check valve into spring, followed by retainer. Press assembly into driven torus and attach with two cap screws. Bend ends of retainer against flats of screw cap to lock screws.

10. Front-unit coupling—two coupling (see Fig. 10-21). Use special studs from cover installing tool to put cover into drive torus. Tap studs evenly to force cover squarely into place. Secure with large snap ring.

§ 111. Assembling components into case Two procedures are outlined below—one for the single-coupling transmission and one for the two-coupling transmission.

SINGLE-COUPING HYDRA-MATIC

1. Installing planetary units
   a. Before installing the front-and-rear-planetary assembly, put the rear brake band on rear drum so anchor end will fit over adjusting screw in case.
   b. Put assembly into case by lowering front end of the shaft first and guiding it through opening in front of case. Position brake bands over adjusting screws.
   c. Make sure the single hole in the oil-delivery sleeve is centered between bearing-cap mounting-screw holes and is facing up. Put center bearing cap over sleeve, indexing dowel with dowel hole in sleeve. Tap bearing cap into place with light hammer and brass drift and fasten with a new lock plate and bolts. Bend up plate around bolts with large pliers. Do not use a screw driver since this may scratch finished surfaces of case.
   d. Put special tool between outer bearing cap and rear-clutch drum to keep drum from moving forward.
   e. Take clutch-hub holding tool from rear drum. Coat rear clutch-hub thrust washer with petroleum jelly and position it in counterbore in hub.
f. Install spacer washer of correct thickness in counterbore of driven (output) shaft after coating it with petroleum jelly. Correct thickness is determined by end play of main shaft as explained in §107, 5.

g. Install stationary-cone lock key after coating it with petroleum jelly so it will stay in place. Put main shaft in output shaft, revolving output shaft so gears will mesh. Put assembly in place on case, first revolving output shaft so gears mesh and also aligning stationary-cone lock key with keyway in case. Start five bearing retainer bolts and parking-pawl bolt, tap retainer against case with soft hammer, and tighten retainer bolts finger-tight. Remove special tool from between bearing cap and rear clutch drum. Now, tighten the five retaining bolts to 28-33 lb-ft torque. At this point, specifications call for rechecking the main-shaft end play (§107, 5). If it is correct, install new rear bearing-retainer oil seal, using special tool, after coating it with Permatex No. 3 at points where it fits against retainer.

2. Installing front pump and drive gear

a. Put gasket (or rubber seal) over front-pump cover and put bronze thrust washer over intermediate shaft so it is up against bearing surface of front planet-pinion carrier.

b. Put front-pump assembly and drive gear on intermediate shaft, aligning pump-cover locating slot with counterbore in case and install locating washer in counterbore. Attach pump with two cap screws and large washers.

Note: With pump in place and screws tight, pump cover should protrude 0.003 to 0.013 inch out of case. If it does not, add an extra gasket. Loosen screw after measuring this to permit easy installation of front servo on pump discharge pipe.

c. Install first bronze, and then steel, thrust washers over intermediate shaft and then put snap washer on intermediate shaft. Then install open-type snap ring in groove on main shaft.

3. Installing rear pump and governor. First make sure the mating surfaces between case and pump are smooth and free of nicks or burrs that would prevent proper alignment. Then turn the governor
so large weight is toward front of transmission and turn reverse-drive flange so mounting screw is up and slide assembly into case as shown in Fig. 10-6. Attach with two mounting screws and lock washers. Make sure plug is in governor sleeve.

4. Installing reverse-shifter bracket and shims (on models so equipped). When installing the reverse-shifter bracket, backlash between the reverse internal gear and anchor must be checked and corrected by shimming, as necessary.

   a. First position spring and roller on bracket and then assemble bracket and steel shims to case and attach with bolts and lock washers.
   b. Use special backlash-checking gauge and tools to check backlash. With reverse anchor all the way into reverse, remove any anchor play by pushing against it with a screwdriver. Then rotate reverse internal gear with special tool and note backlash as recorded on indicator. Remove or add steel shims between bracket and case to obtain 0.016 to 0.049 inch backlash.

5. Installing oil-control-valve body. Put three oil delivery pipes into holes in governor sleeve and, with shift lever in LO and reverse crank up, push valve body into position and attach with four screws and lock washers. Tighten screws to between 6 and 8 lb-ft—no more, no less. Do not under- or overtighten. Overtightening will warp the valve body and cause the valves to malfunction. Under-tightening will allow the screws, and valve body, to loosen.

6. Installing servos
   a. Put front-pump oil-delivery pipe into pump body.
   b. Position both servos on transmission case. Engage rear brake-band strut with actuating lever and front-servo piston pin in anchor on end of front brake band.
   c. Lift assembly if necessary to get front-pump oil-delivery pipe to enter hole in front servo body.
   d. Put rear-pump oil-discharge pipe into hole in rear pump and then swing it into fitting on front servo.

Note: The servo end of pipe has a small hole near the end.

   e. Attach servos to case with four bolts and lock washers.
   f. Install intake pipe on front pump with a new gasket, mounting screws, and locks. Bend locks up against screw heads.
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7. Checking governor run-out. The governor must not be excessively out of line since eccentricity, or run-out, which is excessive will cause rapid governor wear and poor governor action. Run-out may be checked by placing a dial indicator on the case with the button of the indicator resting on the governor oil-delivery sleeve as shown in Fig. 10-25. Then, the transmission driven shaft should be turned by hand several revolutions. Governor eccentricity will cause the sleeve to move up and down. If this eccentricity, or run-out, exceeds 0.005 inch, make the following check.

a. Mark position of governor on drive flange and detach governor. Relocate dial indicator so button rests on the face of drive flange and rotate driven shaft of transmission to determine eccentricity of face. If it exceeds 0.002 inch, it may be necessary to replace the flange, gearset, and rear-pump assembly.

b. If run-out of flange is less than 0.002 inch, install governor on flange again but turn it 180 degrees from original position. Now recheck sleeve eccentric movement as shown in Fig. 10-25. If eccentricity still exceeds 0.005 inch, the governor and sleeve require replacement.
8. Adjusting front-servo band

a. Remove the screw plug from bottom of front servo and screw special gauge in, finger-tight only. Turn drum so band centers on drum. Band should be slack on drum. The ½-inch hexagonal adjusting screw in the gauge should be backed out until about ¼ inch of thread shows.

b. Tighten the ½-inch hexagonal adjusting screw with the fingers until the stem of the gauge is felt to just touch the piston in the servo. Then use a ½-inch end wrench to tighten this hexagonal adjusting screw exactly five complete turns.

c. Now, tighten the front-band adjusting screw until the knurled washer on top of the gauge just begins to loosen. Keep turning drum to position band during the tightening operation.

d. Hold adjusting screw and tighten lock nut securely. Then loosen the hexagonal adjusting screw in the gauge and take gauge off servo. Install plug.

9. Adjusting rear-servo band

a. Use special gauge and tighten servo adjusting screw until front face of gauge touches band actuating lever (Fig. 10-26). Keep turning drum so band stays centered.

Caution: If you go beyond adjustment, back screw off three turns and turn it in again.

b. Lock screw with lock nut. Do not allow screw to turn from the adjusted position while locking it.


11. Checking servo and clutch action. After the various internal parts are installed, some mechanics check the operation of the bands and clutches with compressed air. This is a good procedure provided no dirt or moisture is introduced into the oil lines. Thus, you must be sure that the compressed air is clean and dry and that you do not accidentally blow dirt or moisture into the lines of the transmission. To make the checks, locate the oil passages in the side or bottom of the transmission case through which oil will
be applied to cause servo or clutch action. Then apply air pressure at these openings to see if the servos and clutches operate normally.

Caution: Be sure air source is clean and dry. Do not apply metal tip of air-hose chuck directly to transmission case since this might scratch the case or knock off bits of metal which would then enter the oil lines. Instead, use a rubber tip on the chuck, or interpose a rubber washer between the chuck and case.

12. Side-cover installation. Line up pan by starting attaching screws. Then center hole over manual-lever shaft and tighten screws. Remember that the five screws along the bottom flange have copper washers. Put outer control lever on shaft and tighten clamp bolt.

Note: The outer throttle lever, removed while the transmission was still in the car, should not be reinstalled until the transmission is back in the car. This protects the throttle lever from accidental bending or damage.

13. Housing and torus-members installation
   a. Put transmission on bench and position rear half of housing on front of case and attach with four screws and lock washers.
   b. Install torus cover on splines of front drive gear, working carefully to avoid damaging oil-seal rings.
   c. Install driving member on intermediate shaft and put retaining snap ring in place.
   d. Install driven member on main shaft.
   e. Move manual (short) lever into reverse (all the way back) and install a new lock plate and nut. Tighten nut and bend lock plate up around nut. Then install oil dip stick.

TWO-COUPLING HYDRA-MATIC

1. Install parking brake assembly, overrun band, neutral clutch drum, stationary stop key, and inside detent and throttle control assembly.
2. Install center bearing support, neutral clutch, and rear unit assemblies. Align slot in drum with stop key in case and also align hole for bearing support locking screw. Use snap rings to retain bearing support and other parts.
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3. Check main-shaft end play with special tools and dial indicator. If end play is incorrect (should be 0.004 to 0.018 inch), install thrust washer of proper thickness to correct end play.

4. Install overrun clutch and front pump. Use special tool to install front pump squarely and prevent it from cocking in the bore. Use air pressure in the neutral clutch hole in the case to position center bearing support against snap ring.

5. Install control valve and accumulator and servo assemblies.

6. Install oil pan, oil screen, and intake pipes.

7. Install front unit coupling assembly. Check front unit end play and install proper bronze thrust washer to bring it within limits.

8. Install flywheel housing, torus cover, torus members, and flywheel. Use seal protector when installing housing.

§112. Installing transmission in car

Before installing the transmission, make sure the flywheel face is clean, smooth, and free of burrs. A new gasket should be put on the face of the flywheel. It can be held in place with petroleum jelly. Shellac or sealer must not be used.

1. Lift transmission into position with hoist, positioning main-shaft pilot in end of crankshaft.

2. Move transmission forward so housing is in position over dowel pins in front housing and torus cover aligns with pins in flywheel. Notice that in many models, one dowel pin is larger than the other so that the cover can be installed in one position only. On other models, the dowels may be of the same size, but one dowel with its corresponding hole is marked with paint as a guide to installation. Attach transmission with two lower cap screws and lock washers.

   Note: Be sure torus cover is aligned with flywheel in original relationship.

3. Attach torus cover to flywheel with cap screws and draw them down to 30 lb-ft torque. Tighten torus-cover and oil-pan drain plugs.

4. Remove engine support bar and lower engine about 1 inch to install the other four housing attaching screws. Then raise
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engine about ½ inch above its normal height and attach cross member to frame.
5. Lower engine and install engine mounting nuts and lock washers.
6. Then install flywheel-housing pan, lower flywheel housing, cranking motor, wiring, side pans, exhaust-pipe bracket, crankcase-ventilator bracket, propeller shaft, speedometer cable, throttle lever, rod, manual-control rods, and clevises.
7. Then remove oil-level dip stick and add 8 quarts of Hydra-Matic fluid. Set hand brake and start the engine. Let engine run for several minutes and add 3½ more quarts of fluid. Check fluid level with dip stick, which should now show "Full."

§113. Hydra-Matic adjustments On the two-coupling unit, the only adjustments required are to the linkage. This varies from model to model, so always check the applicable shop manual before attempting adjustment.

1. Checking oil level. Fluid level should be checked every 2,000 miles and fluid drained and replaced every 12,000 miles. On the single-coupling unit, check with engine idling and selector in LO. On the two-coupling unit, check with engine idling after it has run at a speed of 20 mph for 2 minutes (selector lever in N or P).

2. Brake-band external adjustments (on single-coupling units designed for external adjustment). Set parking brake and block front wheels. Then start engine and let it warm up. Connect engine rpm indicator, put selector lever in LO, and adjust idle to 700 rpm. Use special adjusting tool to loosen front band lock nut and adjusting screw. Loosen screw until engine increases to 900-1,000 rpm. The drum is now spinning freely. Tighten band adjusting screw until engine speed drops to 700 rpm. Wait 30 seconds. If engine speed increases, tighten to get 700 rpm again. Then set counter on tool and turn adjusting screw 5½ turns. Tighten lock nut. Adjust rear band in same way except tighten screw only two turns.

CHECK YOUR PROGRESS

Progress Quiz 17

You have just finished the section in the book on reassembly of the Hydra-Matic transmission. Now you can check your memory to see how well you remember the details of how this job is done. If you are not
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Sure of the answer to any of the questions below, refer to the pages in the book that will give you the answer.

**True or False**

Some of the statements below are true. Some are false. Read each statement carefully, and then decide whether it is true or false. If you believe it to be true, write it down in your notebook. Verify it by rereading the past few pages.

1. When installing clutch plates, start with a composition plate and end with a steel plate.
2. When assembling the front planetary unit, new seals and brass expanders should be used.
3. Piston must be driven into clutch drum with hammer and drift.
4. Before installing the planetary units, the brake bands should be put on the drums.
5. Planetary-unit assembly is put into case by lowering front end of the shaft first and guiding it through opening in front of case.
6. New gaskets should be used on reassembly of the transmission.
7. The oil-control-valve-body attaching screws should be tightened to 80 lb-ft torque.
8. Governor run-out should not exceed 0.005 inch.
9. External adjustment of the brake bands cannot be made without an engine rpm indicator.
10. Manual-control adjustment produces the correct relationship between the selector lever and the transmission manual lever.

**CHAPTER CHECKUP**

Note: Since the following is a chapter review test, you should review the chapter before taking it.

The chapter you have just finished describes, in detail, the trouble-shooting, removal, disassembly, reassembly, and replacement of the Hydra-Matic transmission used on many makes of automobile. It has been used on Cadillac, Frazer, Hudson, Kaiser, Lincoln, Nash, Oldsmobile, and Pontiac. Thus, if you service a wide variety of cars when you go into the service shop, you may be more apt to run into a car with a Hydra-Matic transmission than one equipped with another type of automatic transmission. For this reason, you should have a good understanding of how the transmission works as well as how to trouble-shoot and service it. The checkup that follows will help you to review the servicing part of the story. If some details referred to in the questions are not clear in your mind, go back into the chapter and reread the pages that will clear up the matter for you. Write the answers in your notebook.

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Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. High engine idle speed could make it hard to **accelerate in low range shift out of reverse downshift into third**

2. The complaint of full-throttle shift points being high, low, or absent would most likely arise from **incorrect control-lever-linkage adjustment improperly operating governor valves loose band adjustment**

3. Failure of the transmission to throttle-downshift from fourth to third could be due to **insufficient accelerator travel loose band adjustment excessive idling speed**

4. Failure of the transmission to drive the car with selector lever in any drive position is most likely due to **clutches not disengaging band (or bands) not applying control lever bent**

5. Failure of a band to apply could be due to **incorrect band adjustment high oil level slipping clutch**

6. If the transmission drives the car in first or second but acts as if it were in neutral after shifting out of second, the trouble could be due to **brake band not applying rear clutch not applying front clutch not applying**

7. Failure of a clutch to apply could be due to **loose brake band stuck clutch piston servo piston stuck**

8. If the transmission slips in first, third, and reverse but operates in second and fourth, the chances are that the **rear band is slipping front band is slipping rear clutch is slipping**

9. If the transmission slips in first or second but is O.K. in third, fourth, and reverse, the chances are that the **rear band is slipping front band is slipping front clutch is slipping**

10. If the transmission misses a gear position in upshifting or starts out in the wrong gear position, the trouble could be due to **valves stuck in valve body excessive engine idle rear band not releasing**

Troubles and Service Procedures

In the following, you should write down in your notebook the trouble causes and service procedures asked for. Do not copy the procedures from the book, but try to write them in your own words. Writing them down in your own words will help you to remember the procedures.
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And, of course, having the procedures well in mind is of great value to you in the service shop.

1. List conditions that would make it hard to shift out of reverse.
2. List conditions that would cause full-throttle shift points to be high, low, or absent.
3. List conditions that would prevent throttle downshift from fourth to third above 30 mph (miles per hour).
4. List conditions that would occur if the front band failed to hold. If the rear band failed to hold.
5. List conditions that would prevent application of a brake band.
6. List conditions that would prevent application of a clutch.
7. What is the probable cause if the transmission drives the car in first or second but acts as if it were in neutral after shifting out of second?
8. What is the probable trouble if the transmission slips in second and fourth?
9. List conditions that would result if the valves stuck in the governor or valve body.
10. Describe the procedure of making the oil pressure test.
11. What should be done if the oil is dirty and has metallic particles in it?
12. Explain how to make the stall test.
13. List the major points of Hydra-Matic transmission removal from a car.
14. List the major points of Hydra-Matic transmission disassembly.
15. Describe the disassembly of a front planetary unit.
16. Describe the disassembly of a rear planetary unit.
17. Describe the disassembly of a reverse planetary unit.
18. List important points to watch out for when inspecting transmission parts.
19. List the major points of front planetary-unit reassembly.
20. List the major points of rear planetary-unit reassembly.
21. List the major points of control-valve-body reassembly.
22. List the major points of reassembling the components of the transmission into the case.
23. List the major points of reinstalling the transmission on the car.
24. List the adjustments that should be made on the car after the transmission is reinstalled.

Suggestions for Further Study

Because there are variations between different models of Hydra-Matic transmissions used on the different makes and models of automobiles, you should try to study different shop manuals so you can learn about [396]
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these variations. It is important, naturally, for you to actually handle these transmissions and disassemble, repair, and reassemble them. Much experience along these lines might be gained in an automotive service shop that services Hydra-Matic transmissions. In addition, school automotive shops often have a Hydra-Matic transmission especially for student training in tear-down and build-up. Be sure to keep your notebook handy and write down in it any important facts you come across so you will have a permanent record of them. You will be glad you did. In particular, if you are able to work on only one model of the transmission, and you find it differs from those described in the book, you will want to note carefully those differences in your notebook. It would be helpful to you for you to write down in your notebook the complete disassembly-assembly procedure of the transmission on which you work. You can then compare this to the procedures given in the book and in different shop manuals. In this way, you will be equipping yourself to handle service on any Hydra-Matic transmission.
11: Powerglide and Turboglide service

THIS CHAPTER describes the trouble-shooting, maintenance, and overhauling procedures for the Powerglide and Turboglide transmissions. There are two basic models of the Powerglide. The earlier model has a five-member torque converter. The later model uses a three-member torque converter and has an automatic shift in DR (drive). Both of these models have the same gearing, brake-band, and clutch arrangements. The major differences between the two models lie in the torque converter and in the hydraulic control circuits. The Turboglide also has a five-member torque converter, but it is quite different from the five-member torque converter in the Powerglide since it contains a variable-pitch stator. This variable pitch stator is similar to the assembly used in the Buick Dynaflow (see §77). The Turboglide also has an automatic shift. The planetary systems of all of these transmissions are practically identical. Thus, it will be found that the testing and servicing procedures covering the Powerglide and Turboglide that follow will apply, for the most part, to the Dynaflow. Where individual differences are noted, reference should be made to the applicable shop manual. It is also suggested that Chap. 8 be reviewed in case any of the servicing procedures that follow refer to transmission operation. Tools, hands, and work bench must be clean since traces of dirt in the transmission may cause it to function improperly.

§114. Diagnosing Powerglide and Turboglide troubles The charts that follow, plus §115 (Transmission tests), will help you locate the cause of troubles that might occur in the transmissions.

Caution: If you road-test the car, obey all traffic laws. Drive safely. Use a chassis dynamometer (see Appendix) if available so you will not have to take the car out of the shop.
### Powerglide and Turboglide Service

#### Powerglide Transmission Trouble-Shooting Chart

Note: The chart below covers the two models of the Powerglide, the earlier model with the five-member torque converter, and the later model with the three-member torque converter and the automatic shift (in DR). Troubles related to the Powerglide with the automatic shift are starred (*).

<table>
<thead>
<tr>
<th>Complaint</th>
<th>Possible Cause</th>
<th>Check or Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Excessive slip in all ranges (indicated by high engine speed for car speed, poor acceleration, engine runaway on shifts)</td>
<td>a. Low oil level</td>
<td>Add oil, check for oil leaks</td>
</tr>
<tr>
<td></td>
<td>b. Incorrect linkage adjustment</td>
<td>Adjust linkage</td>
</tr>
<tr>
<td></td>
<td>c. Oil lines to pumps leaking air</td>
<td>Tighten, replace gaskets</td>
</tr>
<tr>
<td></td>
<td>d. Front-pump pressure low</td>
<td>Front pump internally damaged, stuck regulator valve, oil screen clogged, oil line leaking</td>
</tr>
<tr>
<td>2. Excessive slip in drive range</td>
<td>a. Incorrect linkage adjustment</td>
<td>Adjust linkage</td>
</tr>
<tr>
<td></td>
<td>b. Defective clutch-piston seal</td>
<td>Replace seal, check clutch plates for damage</td>
</tr>
<tr>
<td></td>
<td>c. Damaged (worn or burned) clutch plates</td>
<td>Replace seal and plates</td>
</tr>
<tr>
<td></td>
<td>d. Overheated clutch</td>
<td>Add water to radiator, check thermostat valve, repair or replace oil cooler, adjust dragging low band</td>
</tr>
<tr>
<td>3. Excessive slip in low range</td>
<td>a. Incorrect linkage adjustment</td>
<td>Adjust linkage</td>
</tr>
<tr>
<td></td>
<td>b. Incorrect low-band adjustment</td>
<td>Adjust band</td>
</tr>
<tr>
<td></td>
<td>c. Accumulator valve stuck</td>
<td>Free, replace damaged parts</td>
</tr>
</tbody>
</table>

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### Automotive Transmissions and Power Trains

<table>
<thead>
<tr>
<th>Complaint</th>
<th>Possible Cause</th>
<th>Check or Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Excessive slip in reverse</td>
<td>d. Modulator piston or lever stuck</td>
<td>Free, replace damaged parts</td>
</tr>
<tr>
<td></td>
<td>e. Defective low-servo piston ring</td>
<td>Replace</td>
</tr>
<tr>
<td></td>
<td>a. Incorrect linkage adjustment</td>
<td>Adjust linkage</td>
</tr>
<tr>
<td></td>
<td>b. Incorrect reverse-band adjustment</td>
<td>Adjust band</td>
</tr>
<tr>
<td></td>
<td>c. Front-pump pressure low</td>
<td>Check for oil leaks in line to reverse servo</td>
</tr>
<tr>
<td></td>
<td>d. Defective reverse-servo piston ring</td>
<td>Replace</td>
</tr>
<tr>
<td></td>
<td>e. Also, c and d in item 3, above.</td>
<td></td>
</tr>
<tr>
<td>5. Car creeps forward in neutral</td>
<td>a. Incorrect linkage adjustment</td>
<td>Adjust linkage</td>
</tr>
<tr>
<td></td>
<td>b. Clutch not releasing</td>
<td></td>
</tr>
<tr>
<td>6. Car creeps forward in reverse or backward in low range</td>
<td>Incorrect linkage adjustment</td>
<td>Adjust linkage</td>
</tr>
<tr>
<td>7. Car will not move; rear wheels locked</td>
<td>a. Emergency brake on</td>
<td>Release</td>
</tr>
<tr>
<td></td>
<td>b. Parking pawl engaged</td>
<td>Release, check for damage or improper assembly</td>
</tr>
<tr>
<td></td>
<td>c. Broken parts in unit</td>
<td>Disassemble to overhaul</td>
</tr>
<tr>
<td>8. Car will not move in any range after reversing car (If this occurs at other times, see items 1 to 4.)</td>
<td>a. Rear pump leaks air into line</td>
<td>Repair pump, replace pump gasket</td>
</tr>
<tr>
<td></td>
<td>b. Excessive clearance in front pump</td>
<td>Repair front pump</td>
</tr>
<tr>
<td>9. Rough upshifts or downshifts</td>
<td>a. Improper low band adjustment</td>
<td>Adjust band</td>
</tr>
</tbody>
</table>
### Powerglide and Turboglide Service

<table>
<thead>
<tr>
<th>Complaint</th>
<th>Possible Cause</th>
<th>Check or Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>(manual or automatic)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>10. Rough shift from neutral to reverse</strong></td>
<td>a. Improper reverse band adjustment</td>
<td>Free, replace band as necessary</td>
</tr>
<tr>
<td></td>
<td>b. Accumulator piston stuck closed</td>
<td>Free modulator piston, lever. Repair or replace modulator</td>
</tr>
<tr>
<td></td>
<td>c. Modulator causing excess apply pressure</td>
<td>Free</td>
</tr>
<tr>
<td></td>
<td>d. Accumulator dump-valve orifice plugged</td>
<td>Adjust</td>
</tr>
<tr>
<td></td>
<td>e. Throttle-valve linkage out of adjustment</td>
<td>Free, replace valve and body if necessary</td>
</tr>
<tr>
<td></td>
<td>f. Shift valve sticky</td>
<td>Adjust and repair modulator</td>
</tr>
<tr>
<td><strong>11. Chatter when pulling away from curb</strong></td>
<td>a. Low band out of adjustment</td>
<td>Readjust band</td>
</tr>
<tr>
<td></td>
<td>b. Reverse band out of adjustment</td>
<td>Readjust band</td>
</tr>
<tr>
<td></td>
<td>c. Clutch sticking</td>
<td>Check plates, piston, piston vent valve</td>
</tr>
<tr>
<td></td>
<td>d. Rough drums or bands</td>
<td>Replace parts as necessary</td>
</tr>
<tr>
<td><strong>12. Dragging or jerky in reverse</strong></td>
<td>a. Ringing noise in converter (due to insufficient oil in converter)</td>
<td>Add oil, check for oil leaks. Make sure return lines are tight and not leaky. Free pres.</td>
</tr>
<tr>
<td><strong>13. Noises</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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Complaint Possible Cause Check or Correction

14. Loss of oil
   a. Oil leaks
      b. Oil forced out filler tube
   See §116 for causes
   See §116 for causes

15. Will not upshift
   a. Governor defective
      b. Throttle-valve linkage out of adjustment
      Adjust linkage
   c. Shift valve stuck
      Free, replace valve and body if necessary
   d. Clutch defective
      Repair or replace
   e. Leakage in hydraulic system
      Replace seals, parts, and tighten connections

16. Will not downshift in drive range
   a. Shift or regulator valve stuck
      Free, replace valve and body if necessary
   b. Throttle-valve linkage out of adjustment
      Adjust linkage

§115 Transmission tests Testing oil pressure under various operating conditions is helpful in locating trouble causes. A stall test can also be used on some models.

1. Checking oil level and warming transmission. Check oil level
Powerglide and Turboglide Service

<table>
<thead>
<tr>
<th>Complaint</th>
<th>Possible Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No drive in any selector position</td>
<td>Front pump assembled backward</td>
</tr>
<tr>
<td>2. Drive in GR only</td>
<td>Both overrun clutches backward</td>
</tr>
<tr>
<td>3. Drive in GR and R only</td>
<td>Outer overrun clutch backward, Oil leak prevents application of forward and neutral clutches</td>
</tr>
<tr>
<td>4. Drive poor at low speed; no R; GR normal</td>
<td>Inner overrun clutch backward</td>
</tr>
<tr>
<td>5. Car moves in N; R normal</td>
<td>Neutral clutch not releasing</td>
</tr>
<tr>
<td>6. Car moves O.K. in N and D at low speed; no R</td>
<td>Forward clutch not releasing</td>
</tr>
<tr>
<td>7. Will not shift to high-angle stator position—acceleration logy</td>
<td>Stator control linkage out of adjustment, Oil leakage causing malfunctioning of valve or stator</td>
</tr>
<tr>
<td>8. Cannot push-start car</td>
<td>Rear oil pump malfunctioning</td>
</tr>
<tr>
<td>9. GR applies slowly</td>
<td>Control linkage to manual valve out of adjustment; neutral clutch does not disengage because of internal damage or oil leak</td>
</tr>
<tr>
<td>10. No D or GR; R normal</td>
<td>Reverse clutch not disengaging</td>
</tr>
<tr>
<td>11. GR brakes violently; stator oil pressure high</td>
<td>Vacuum hose disconnected</td>
</tr>
<tr>
<td>12. Shifts slowly from standstill</td>
<td>Linkage out of adjustment; accumulator control valve stuck closed; leakage</td>
</tr>
<tr>
<td>13. Shifts harshly from standstill</td>
<td>Accumulator valve malfunctioning</td>
</tr>
</tbody>
</table>

Note: The “check or correction” column is omitted here since the corrections are obvious.

2. Stall test. The Turboglide must never be stall-tested. The Powerglide can be stall-tested but never for more than ten seconds. To make the test, apply parking and foot brakes and check engine speed (with a tachometer) in different selector-lever positions at wide-open throttle. If engine will not come down to specified stall speed, the transmission is at fault, owing to slippage of clutches or brake bands, oil leaks, or malfunctioning of the valves.
3. Oil pressure tests. On the Powerglide, connect four gauges as shown in Fig. 11-1. The Turboglide has one pressure check point (on left side close to converter). Operate the engine at various speeds and throttle positions; note the oil pressures and engine rpm (with tachometer). Refer to the applicable car shop manual for specifications. In general, incorrect oil pressure is due to stuck valves, oil leaks, or defective pumps. Excessive engine speed indicates slipping clutches or brake bands.

§ 116. Oil loss Oil can be lost from the transmission by leakage past a gasket, diaphragm, or seal, or by foaming out the filler tube. This latter condition can occur if a return-line seal is defective, causing air to enter and mix with the oil. Oil leakage could occur past sealing gaskets, shaft seals, O rings, or oil-drain or pressure-test plugs.

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CHECK YOUR PROGRESS

Progress Quiz 18

The first step in automatic transmission service is often diagnosis of trouble to locate the cause. Thus it is important to know what the most common troubles can be and what could cause them. Review what we have covered on this subject by taking the following quiz.

Correcting Troubles Lists

This exercise will help you spot related and unrelated troubles on a list. In each list given below, there is one item that does not belong, that is, one item that will not cause the trouble given in the list. Write down each list in your notebook, but do not write down the item that does not belong. All the lists given below refer to the Powerglide.

1. Excessive slip in all ranges: low oil level, incorrect linkage adjustment, air leaks in oil lines, low front-pump pressure, high front-pump pressure.
2. Excessive slip in drive range: incorrect linkage adjustment, defective clutch-piston seal, damaged clutch plates, front servo released, clutch hot.
3. Excessive slip in low range: incorrect linkage adjustment, incorrect clutch adjustment, incorrect low-band adjustment, accumulator valve stuck, modulator piston or lever stuck, defective low-servo piston ring.
4. Excessive slip in reverse: incorrect linkage adjustment, incorrect reverse-band adjustment, front-pump pressure high, defective reverse-servo piston ring.
5. Rough upshifts or downshifts: incorrect low-band adjustment, clutch plates worn, modulator causing excessive apply pressure, accumulator dump-valve orifice plugged, clutch servo out of adjustment.
6. Chatter when pulling away from curb: low band out of adjustment, reverse band out of adjustment, clutch out of adjustment, drums or bands rough.
7. Will not upshift in drive range: governor defective, throttle-valve linkage out of adjustment, shift valve stuck, selector lever in drive, clutch defective, leakage in hydraulic system.
8. Will not downshift in drive range: shift valve stuck, regulator valve sticking, throttle-valve linkage out of adjustment, converter turbine rotating.

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§117. Removal of transmission  The removal procedures for different transmissions are very similar. Powerglide removal procedures follow.

1. Raise car and put on stand jacks. Then remove the floor mat, transmission hole cover, and toe-pan plate.
2. Work through toe-pan hole and remove the three top turbine-housing attaching screws.
3. Disconnect speedometer cable from driven gear. Disconnect parking brake rod from cross shaft and drop cross shaft, cables, and spring.
4. Disconnect propeller shaft as follows: Remove cap screws holding universal joint collar to rear of transmission case, and slide universal ball and collar back on propeller-shaft housing. Then put a jack under the propeller shaft, split the universal joint by removing cap screws attaching front trunnion bearings to front yoke, and lower free end of propeller shaft.
5. Remove two upper transmission-to-converter housing bolts and install lift sling. Then put transmission hoist in car over transmission and attach lift cable to the sling. Attach lift chain to the two top universal-joint-collar attaching holes in transmission case.
6. Drain transmission and converter by removing transmission and converter drain plugs.
7. Disconnect vacuum line and oil-cooler lines from transmission.
8. Remove spark plugs from engine so engine can be turned over easily.
9. Remove two lower converter-housing attaching bolts and flywheel cover and flywheel underpan extension.
10. To provide clearance, disconnect exhaust pipe from manifold, disconnect muffler support, and tie exhaust pipe and muffler to left-frame side member.
11. Disconnect transmission short shift rod from parking lock lever and the long shift rod from the bell crank. Tie long shift rod up out of way. Disconnect the throttle-valve control rod from the outer lever assembly (on later models).
12. Remove bell-crank lever and stud from transmission case.
13. Use special tool to turn engine over and remove six flywheel-to-converter bolts, working through the opening in the housing on the left side of the engine.

14. Remove filler tube and dip stick by first cleaning around filler tube and then taking out the converter-housing bolt holding the tube in position. Cover hole in side cover with masking tape.

Fig. 11-2. Special converter-assembly holding tool installed to keep the assembly from falling out. (Chevrolet Motor Division of General Motors Corporation)

15. Put hydraulic jack under engine oil pan and remove transmission-to-rear-support bolts and support. Then remove the remaining converter-housing retaining bolts on each side, lifting or lowering the engine and transmission to get enough clearance to remove them.

16. Move transmission assembly back to clear the flywheel pilot from the flywheel. Be sure to move it straight back so you do not damage the pilot.

17. During the following, install the special converter-assembly holding tool (later models) as shown in Fig. 11-2.

18. Lower transmission assembly a little, lift up on the back end.
of the transmission as far as it will come, and hook chain in notch in back of hoist.

19. Use a pry bar between the transmission and floor opening (on right side) so servo-cover bolts will clear. Then lower the transmission a little more and again pull up on the back end of the transmission as far as possible. Use pry bar between transmission and floor covering so bypass plug clears the opening.

20. Lower transmission on a dolly or creeper. Do not let transmission strike the flywheel as you lower it.

§118. Disassembly of transmission

Disassembly and repair procedure on the earlier, five-member torque converter, Powerglide follows. The disassembly procedures on the later Powerglide and Turboglide are discussed in the latter part of the chapter.

1. Observe cleanliness. It is extremely important to have a clean workbench, clean hands, and clean tools when servicing automatic transmissions. Remember that slight traces of dirt may cause valves or pistons to hang up and thus prevent normal operation of the transmission. For the same reason, wiping cloths or rags should never be used to dry parts after they are washed in cleaning solvent. Lint may deposit on the parts and cause serious trouble later. Instead, after washing the parts, they should be dried with compressed air.

2. Put the transmission in the assembly fixture and remove right-side cover and oil screen.

3. Install locking strap to converter, using flywheel attaching-bolt hole. Now, converter will be held so cover-retaining bolts can be removed. With the bolts out, screw three special T screws into three tapped holes in converter cover so cover is loosened. Remove cover and turbine assembly.

4. Remove primary and secondary stators as a unit and test clutches by hand.

5. Remove converter retaining ring and washer, and slide primary pump from stator support.

6. Remove modulator bolts and modulator, being careful that the plunger and body do not fall out and become damaged.

7. Remove servo-cover bolts, cover, and gasket. Maintain pres-
Powerglide and Turboglide Service

sure against cover while loosening bolts since there is spring pressure on the cover from the servo and pressure-regulator springs. With cover off, remove these springs.

8. Remove pressure-regulator valve, handling it carefully and laying it aside in a safe place so it will not be damaged.

9. Loosen the low-band adjusting-screw lock nut and tighten adjusting screw to hold clutch assembly in place. Then remove transmission-to-converter-housing bolts and separate transmission from converter housing.

10. Remove manual valve from valve body, manual valve lever from converter housing, and bronze thrust washer from valve-body delivery sleeve.

11. Remove valve-body attaching bolts, valve body, and gasket. Handle body carefully to protect it from damage.

12. Remove front oil pump from converter housing with special driver tool (Fig. 11-3).

13. Back off low-servo adjusting screw and remove transmission input shaft and clutch assembly. Then remove low band and strut assembly, piston, and release spring.
14. Take universal-joint front yoke off shaft after removing retainer bolt, lock washer, and yoke-retaining washer.
15. Attach special tool to planet output shaft and transmission case (Fig. 11-4), turn puller handle clockwise, and force shaft out of rear bearing. Then remove special tool and take planet-carrier assembly from front of case.
16. Remove reverse drum, loosen reverse-servo lock nut, back off adjusting screw, and remove band assembly and piston.
17. Remove rear pump and gasket after removing attaching screws.

![Fig. 11-4. Removing planet-carrier assembly with special puller. (Chevrolet Motor Division of General Motors Corporation)](image)

18. Use special tool to engage, twist, and unhook lock-pawl spring. Then remove spring, pawl, lock lever, steel washer, lock-lever shaft, and apply ring.

**Note:** Later models do not have the lock-lever shaft spring. When servicing a model with the spring, discard it and install the new-style shaft.
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19. O rings. When installing new O rings, note the following precautions to avoid damage to them and possible oil leaks. Parts should be clean and without sharp edges or burrs. Make sure O rings are not twisted and do not twist them in installation. Lubricate each O ring and the part on which it is installed with transmission fluid.

§119. Primary pump disassembly and reassembly

1. Disassembly (see Fig. 11-5). Remove snap ring and thrust washer; rotate secondary pump in a clockwise direction and with-

![Fig. 11-5. Primary and secondary pump parts: 1, secondary-pump snap ring; 2, secondary-pump thrust washer; 3, overrun cam roller and spring retainer; 4, secondary pump; 5, overrun cam thrust washer; 6, primary pump and hub assembly; 7, overrun cam-roller guides; 8, overrun cam-roller springs; 9, overrun cam rollers. (Chevrolet Motor Division of General Motors Corporation)]
2. Reassembly

a. Put into secondary pump the cam roller and spring retainer with prongs to rear. Install rollers, spring guides, and springs in cam pockets. Guides are curved; the curves should follow curvature of the cam pockets.

b. Install cam thrust washer, prongs in, holding the spring retainer on the opposite side so it is not pushed out of position.

c. Use special tool to hold everything in place and install secondary pump on primary-pump hub. Rotate secondary pump to make sure it rotates freely in a clockwise direction but locks up in the other direction. Then remove special tool and install stator-race thrust washer and snap ring.
§120. Stators—disassembly and reassembly

1. Disassembly (see Fig. 11-6). Remove stator-race snap ring and thrust washer, rotate secondary stator clockwise, and lift it from race. Then rotate race and remove it from primary stator. Do not lose rollers and springs when separating parts.

Remove spring retainers from stators so rollers, springs, and guides can be taken out. Rollers are not interchangeable. Do not mix primary and secondary rollers.

2. Reassembly. Put secondary-stator spring retainer in place. (This retainer has the long tabs for the long rollers.) Install rollers, springs, and guides. (Guide curvature must follow curvature of hub.) Install cam thrust washer carefully so you do not dislodge rollers, springs, or guides. Then repeat the procedure for the primary stator. Finally use special installing tool to hold parts in place while installing primary stator onto stator race (thrust washer down). Rotate clockwise, so rollers are not pushed out of position. Then install secondary stator with thrust washer down. Install bronze thrust washer and snap ring. Check stator operation. They should freewheel clockwise and lock to stator race in opposite direction.

§121. Turbine disassembly and reassembly

1. Disassembly (see Fig. 11-7). Remove O ring from converter cover. Separate turbine and cover. On earlier models this is done by removing the turbine-bolt cotter key, nut, flat washer, and slotted washer. On later models this is done by removing the flanged-nut center bolt, special lock, and slotted washer. Cover can then be lifted from turbine bolt or flanged nut. Bend down ears of lock plate and take out the three cap screws attaching turbine to turbine drive flange. Take drive flange and bolt, or flanged nut, from turbine. Next remove bolt, or flanged nut and thick and thin thrust washers from flange. Remove small O ring from bolt or nut.

2. Reassembly. Put new O ring on turbine bolt or flanged nut. Put thick thrust washer in turbine, indexing the lugs to locating holes in turbine. Install turbine bolt or flanged nut. Install thin washer to drive flange. Put drive flange over bolt or flanged nut, indexing three dowels with locating holes in turbine. Then secure with lock plate and three cap screws, tightening to 12½–15 lb-ft torque. Bend ears up against cap-screw flats. Install slotted washer over turbine
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bolt or flanged nut, indexing pimples with locating holes in pilot. Then attach cover to turbine. On earlier models, this is done with a washer and nut. Tighten nut to 12½–15 lb-ft torque. If hole in bolt lines up with slot in nut, install cotter key. If not, tighten nut further until cotter key can be inserted. On later models using a

![Turbine parts](image)

**Fig. 11-7. Turbine parts. (Chevrolet Motor Division of General Motors Corporation)**

1. Input-shaft drive flange
2. Turbine rear thrust washer
3. Turbine bolt
4. Turbine-bolt O-ring seal
5. Turbine front thrust washer
6. Turbine
7. Turbine hub-bolt lock
8. Turbine hub bolts
9. Cover O-ring seal
10. Cover
11. Special lock washer
12. Washer
13. Nut

Bolt instead of a nut, install special lock washer and center bolt. Tighten bolt to 12½–15 lb-ft and bend up ears of special lock.

§122. Clutch disassembly and reassembly

1. Disassembly (see Fig. 11-8). From the clutch assembly, remove clutch-flange-retainer snap ring, retainer, and low-sun-gear-and-flange assembly. Then remove thrust washer and clutch plates. Put the clutch drum in an arbor press and use piston-spring compressing tool to compress clutch spring. On units having the relief valve on the face of the clutch drum, be careful to avoid damaging the valve. Use snap-ring pliers to remove snap ring. Release pressure slowly and take spring seat and spring from drum. To take the
Fig. 11-8. Clutch parts: 1, clutch-drum assembly; 2, clutch driven plate; 3, clutch drive plate; 4, clutch hub; 5, clutch-hub thrust washer; 6, low-sun-gear-and-clutch-flange assembly; 7, clutch-flange retainer; 8, retainer snap ring. (Chevrolet Motor Division of General Motors Corporation)

clawt piston from the drum, rap the drum, open end down, on a wooden surface. Then take the outer sealing ring from the clutch piston and the inner sealing ring from the drum hub.

2. Reassembly

a. Put new outer sealing ring on clutch piston. Do not stretch ring. Lip should be toward oil-pressure side of piston. Put new inner sealing ring on drum hub, with lip of seal toward bottom of piston pocket. Put some transmission oil on inner surface of drum and on seals. Install piston in clutch drum, working carefully to avoid damaging the seals. You will find feeler stock very helpful in working the outer seal into the drum.

b. Put clutch spring and seat in place. Use special tool and arbor press to compress spring so snap ring can be installed. Make sure the spring seat does not hang up in the ring groove as you compress the spring; this could damage the groove.

c. Put clutch-hub thrust washer on hub with tabs in slots in hub. Put hub with thrust washer on clutch flange and install five steel and four composition clutch plates (Fig. 11-8 shows the order). Steel plates are dished; the dished side must be toward the low sun gear. Lay plates flat to determine which side is dished.

d. Put drum over flange, invert assembly, and install flange retainer and retainer ring.
e. Check end play between clutch-flange drive lug and the drive slot in the drum, using a feeler gauge. End play should not be more than 0.013 inch. If it is excessive, install a thicker retainer ring. (There are three thicknesses available.)

§123. Modulator disassembly and reassembly

1. Disassembly. Take hydraulic plunger and body from modulator; handle them carefully so they will not be dropped and damaged. Then remove cover attaching screws, cover, spring, and diaphragm.

2. Reassembly. The main point in reassembly is to make sure the diaphragm is properly placed and is not damaged during the process. To assure proper installation, a special assembly tool and two guide pins must be used. Put tool in hydraulic-body bore of modulator, temporarily install two guide pins, position diaphragm and spring, and install cover. Attach cover with attaching screws and tighten. Remove tools and put hydraulic plunger and body in place so plunger will engage with modulator lever when assembly is completed.

§124. Front-pump disassembly, inspection, and reassembly

1. Disassembly (see Fig. 11-9). Take stator support and gears from pump body. Do not drop gears for this would probably nick them. Remove sealing rings from pump body.

2. Inspection. Wash and air-dry parts. Check gears and mating faces on stator support and pump body for nicks or scoring. If seal

![Fig. 11-9. Disassembled view of front pump: 1, stator support; 2, driven internal gear; 3, drive gear; 4, seal ring; 5, pump body; 6, O-ring seal; 7, oil seal. (Chevrolet Motor Division of General Motors Corporation) (416)]
is damaged, pry it out and install a new one with special seal driver. With parts clean and dry, put gears in pump body and check clearances between:

a. Driven (internal) gear and pump body. Should be 0.0025-0.0055 inch.
b. Internal gear and crescent. Should be 0.003-0.009 inch.
c. Pump body and gears. (This is end clearance of gears.) Should be 0.0005-0.0015 inch.

3. Reassembly. Put new sealing rings in body, oil the gears with transmission oil and put them in body. Drive lugs on drive gear (earlier model) should protrude through oil seal. Install stator support, aligning attaching-screw holes.

§125. Rear-pump disassembly, inspection, and reassembly

1. Disassembly (see Fig. 11-10). Remove cover retaining screws, cover, and gears. Check ball bearing by rotating inner race by hand.

If it is rough or if bearing is otherwise defective, remove bearing retaining bolts, washers, and plate. Drive out old bearing, so new one can be installed.

2. Inspection. After parts have been washed in solvent and air-dried, install new bearing (if old has been removed), put gears in pump body, and check clearances between:

a. Driven (internal) gear and pump body. Should be 0.003-0.007 inch.
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b. Internal gear and crescent. Should be 0.002-0.009 inch.
c. Pump body and gears. (This is end clearance of gears.) Should be 0.0005-0.0015 inch.

3. Reassembly. In reassembly, oil the gears generously with transmission oil. Replace parts in original positions.

§ 126. Valve-body disassembly, inspection, and reassembly
1. Disassembly (see Fig. 11-11). The disassembly procedure is a simple matter of removing a snap ring so the valve parts can be taken out as shown in the illustration. In later production, the pressure-relief valve (No. 12 in Fig. 11-11) has been replaced by a pipe plug.

2. Inspection. Wash all parts in cleaning solvent, air-dry parts, and blow out all oil passages in body and valves. Carefully check the fit of the valves in the valve body and make sure that valves and pistons operate freely and are not scratched or burred. Oil-seal rings should be free in the ring grooves and the hooked ends should have clearance when installed in the clutch-drum bore.

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To remove the oil-seal rings from their grooves, press down against the ring close to the gap and press up at other points around the ring so the other end is lifted and unhooked.

3. Reassembly. Follow Fig. 11-11 in reassembling parts. Do not force the close-fitting valves and pistons into position. Instead, align them carefully and they will slide easily into place.

§127. Reverse-servo and low-servo pistons Pistons are easily disassembled by compressing the spring in a press so the retainer keys can be removed (Fig. 11-12). Rings should be removed and installed in the piston bores in the case so the ring gaps can be checked. Gap should be 0.005–0.010 inch.

§128. Planet carrier and input shaft inspection This assembly should not be disassembled unless inspection discloses that parts are worn or damaged.

Inspection. Wash assembly in cleaning solvent, blow out oil passages, and air-dry. Check brake drum for scoring or burring. Examine pinion for nicks or other damage. End clearance of planet
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Pinions should be between 0.006 and 0.030 inch. Examine reverse sun gear, sun-gear thrust washer, output-shaft bearing surfaces, input-shaft splines, and other operating surfaces for wear or damage. Spline should fit clutch hub without excessive play. Make sure oil-seal ring is in good condition. Remove ring and insert it in bore of valve body to make sure hooked ends have clearance.

§129. Transmission case

Wash in cleaning solvent and blow out all oil passages while air-drying case. If the rear bushing in the case is worn or damaged, it may be pressed out and a new bushing pressed into place. Before installing the new bushing, install the rear oil pump so that the rear bearing may be used as a pilot when pressing the new bushing into the case.

§130. Reassembly of Powerglide (earlier model)

The assembly procedure for the earlier, five-member torque converter, Powerglide follows. Assembly procedure on the three-member unit and the Turboglide are on later pages.

1. Install oil sump. Make sure sealing ring is in place.
2. Install valve body on converter housing. To do this, put two guide pins in two attaching-bolt holes in housing. Install new valve-body gasket and then slide valve body over guide pins. Attach with bolts tightened to 10 lb-ft except for the bolt over the pressure-regulator valve; tighten this bolt to only 8 lb-ft. Tighten bolts in a crisscross fashion, and after bolts are tightened, make sure manual and pressure-regulator valves operate freely. If they do not, valve body has been distorted. Loosen and retighten bolts properly.
3. Align holes in stator-support assembly with holes in front-pump body and install two guide pins in pump. Then install pump in converter housing with special driver. Make sure delivery and return holes on left side of pump align. Install five self-locking bolts through valve body and into pump. Tighten bolts directly above and directly below regulator valve to 8 lb-ft. Tighten other bolts to 10 lb-ft. Then recheck regulator valve for freeness. Make sure front pump operates freely.
4. Install rear pump. First use two guide pins in pump holes, install new gasket, and attach pump to case with bolts tightened to 12½-15 lb-ft.
5. Install reverse-servo piston with ring compressor (Fig. 11-13). Notch on shaft should face front of case.

6. Install reverse band and strut with thin edge of band away from piston. Turn adjusting screw in until it indexes with hole in anchor.

7. Put bronze thrust washer on hub of reverse drum and install drum in case.

8. Turn rear-pump drive-gear lug to top of pump and then install planet-carrier assembly in drum, aligning slot on shaft with lug of gear. Check amount of shaft protruding from bearing (at rear end). It should protrude at least 3/8 inch. If it protrudes less, the drive lug is not seating in the shaft slot properly.

9. Adjust the reverse-servo screw with special tool, as follows. Tighten screw until end play, as noted by pulling and pushing on piston assembly, is just taken up. Then back off screw one-eighth to one-quarter turn. Proceed carefully since this is a delicate adjustment. When end play is just taken up, and before backing off the screw, the band must be free on the drum so the drum can be easily rotated by hand.

10. The next step is to determine the thickness of the low-sun-gear-to-reverse-sun-gear thrust washer. This is done by placing the clutch thrust washer and clutch on the oil-delivery
sleeve. Then use special tool to measure distance between the transmission-case flange and the face of the reverse sun gear (Fig. 11-14). Move stem of tool in so it touches the reverse sun gear and then tighten set screw. Select the 0.120-inch-thick steel washer furnished with the tool and place it over the tool pilot. Insert the pilot into the bore of the low sun gear. Check clearance between the face of the low sun gear and the steel washer with a feeler gauge (Fig. 11-15). Clearance should be 0.007-0.035 inch. If clearance is not correct,

![Fig. 11-14. Measuring distance between face of reverse sun gear and the transmission-case flange. (Chevrolet Motor Division of General Motors Corporation)](image)

remove tool and recheck with the 0.095- or the 0.145-inch steel washer. When you find the steel washer that gives the proper clearance, then use, in reassembly, a bronze washer of this same thickness.

11. Remove clutch assembly and clutch thrust washer from oil-delivery sleeve.
12. Install parking-lock lever shaft and apply-spring assembly in case. Put small-lip seal over end of shaft and into counterbore of case, lip of seal toward inside of case. Install flat washer and parking-lock lever on end of lever shaft. Push lever onto shaft so as to get clearance of 0.000-0.010 inch.

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between lever and washer. Tighten lever clamp screw to 8–12 lb-ft.

13. Put parking-lock pawl over pawl-support rod and pawl spring. Wind up pawl spring using special tool so spring catches on inside of case.

14. Put input shaft in clutch unit and install thrust washer previously selected on reverse sun-gear splines of input shaft. Flat side of thrust washer must be toward reverse sun gear.

15. Put assembly into transmission case, indexing input-shaft pilot with pilot in output shaft. Also, index low sun gear with short pinions in planet carrier.

16. Put release spring on low-servo piston shaft and install piston and spring in case, using piston-ring compressor as shown in Fig. 11-13. Then put low band over clutch drum with thin end of band toward piston. Place strut guide spring over piston and anchor strut in piston slot with other end of anchor strut engaging brake band. Place band strut assembly in band groove, engage slotted end of anchor over strut, and locate over adjusting screw.

17. Install speedometer driven gear and tighten to 45–55 lb-ft.
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18. Install manual valve in valve body and inner lever in converter housing, making sure lever pin indexes with slot in manual valve.

19. Locate manual valve in reverse position (end of valve protruding 1½ inches from face of valve body).

20. Install a new valve-body-to-case gasket.

21. Raise transmission manual-valve lever to top detent position (reverse). Now, lever will index with manual-valve inner lever.

22. Put clutch-drum thrust washer over oil-delivery sleeve. Install two guide pins in converter housing and push case and housing together. Make sure reaction lever indexes with manual-valve inner lever. You can note this by removing the left-hand sump cover. Install case-to-housing bolts and tighten to 25–30 lb-ft.

23. Prepare to install servo cover by screwing two guide pins into case. Put on new cover gasket and install pressure-regulator valve and two valve springs. Install reverse-servo return spring and the apply cover, pushing in on it to overcome spring pressure. Attach with cover bolts tightened 12½–15 lb-ft. Make sure springs seat properly in pockets of servo cover.

24. Install new modulator cover gasket and cover, tightening bolts to 12½–15 lb-ft.

25. Adjust low band by tightening servo adjusting screw until it is tight and then backing screw off three turns. Tighten lock nut and replace adjusting-screw cap.

26. Install primary pump, aligning front-pump drive-gear tangs with drive slots in pump hub. Face of pump must be flush with face of housing. Install retaining washer and snap ring. Then install stator assembly to the stator support (small, or primary, stator to rear). Screw two guide pins into two primary-pump-bolt holes, align dowel-pin holes of converter cover and dowel pins in primary pump and install cover assembly. Remove guide pins and secure with 12 cap screws tightened to 15–20 lb-ft, using the following sequence: Install one bolt on each side of dowel pin, skip one hole and then install two bolts alternately around assembly.

27. Install right-hand sump cover with new gasket.

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28. Put O ring on universal-joint ball seat, install seat, and, using four new ball shims, install ball and collar and tighten attaching bolts to 9–12 lb-ft. If ball cannot be moved by hand, add a shim until a smooth firm adjustment is achieved. If ball moves freely, remove shims until proper adjustment is achieved.

**Note:** Do not install ball-joint-collar oil seal (cork) while making this adjustment.

29. After determining proper number of shims, remove universal joint ball and collar and seat. Note number of shims used (for later assembly) and then replace ball, collar oil seal, and collar on end of propeller shaft.

**§131. Bench check of Powerglide** A 3/8- or 5/8-inch power drill can be used to drive the torque converter for a bench check of the Powerglide.
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glide (Fig. 11-16). The check shows oil pressures and also will indicate any points of leakage in the transmission.

§132. Installation of Powerglide in car

1. Put transmission on creeper or dolly and roll it under car. Attach lift sling to transmission and attach hoist cable to the sling. Lubricate flywheel pilot with Lubriplate.

2. Raise transmission, lifting up on rear end and using pry bar so servo cover clears the opening. Lift up and align transmission.

Caution: Do not bump or damage flywheel pilot!

3. At this point, remove the converter-assembly holding tool (on the later, three-member torque converter requiring its use). Then be careful you do not allow the converter to move forward since this would permit the pump-hub drive slots to disengage from the lugs of the front-pump drive gear.

4. Turn the torque converter so the "X" mark on the cover aligns with the "X" mark on the flywheel. These marks are not visible after assembly so you must align them before the transmission is attached.

5. Put a guide pin in the converter cover and bring transmission forward so it enters proper flywheel hole. At the same time, raise or lower transmission to align flywheel pilot. Do not force transmission forward; guide it gently by hand. Flywheel pilot should enter flywheel, and housings should come together without forcing.

6. Install transmission-housing-to-bell-housing bolts.

7. Remove guide pin and install six flywheel-to-converter bolts.

8. Install filler tube and dip stick. Remove hydraulic jack from under engine.

9. Install bell-crank lever and stud on transmission case. Connect short shift rod to parking-lock lever (identification arrows must point up). Connect long shift rod to bell crank. Connect throttle-valve control rod to outer lever assembly (on the later models).

10. Connect exhaust pipe to manifold and attach muffler support.

11. Replace spark plugs, oil cooler and vacuum lines, flywheel underpan extension, and rear transmission support. Then take the transmission-lifting device from driver's compartment.
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12. Put a new O ring on the universal ball seat and insert into rear of transmission case. Connect universal joint and use proper number and thickness of shims (as determined during assembly—§130, 29) when attaching universal ball and collar to case.

13. Replace parking-brake cross shaft, cables, and spring. Connect brake rod to cross shaft.

14. Connect speedometer cable to driven gear.

15. Install top converter-housing attaching bolts. Replace toe-pan plate, transmission-hole cover, and floor mat. Then put 3 quarts of type A automatic-transmission oil in transmission, start engine and complete filling with 7 quarts (6 quarts in later type).

16. Idle engine with selector lever in neutral. Check oil level and add oil if necessary to bring it to “Full” mark on dip stick. Do not overfill.

17. Adjust selector lever as follows:

a. With selector lever in reverse, clearance between the lever and steering-wheel rim should be 1 1/2 inches (plus or minus 1/16 inch). Adjust, if necessary, by loosening lower support clamp bolts and moving support up or down as necessary. Tighten clamp bolts securely. Make sure dowel in support is in slot in mast jacket.

b. With selector lever in reverse, check clearance between reverse stop on the control-shaft lower support and the lower lever. This clearance should be 0.050 inch and is adjusted by loosening the transmission-control-rod swivel. Then, making sure the manual valve in the transmission is raised to the top detent position, move selector lever as necessary (lever in reverse).

18. Road-test the car.

CHECK YOUR PROGRESS

Progress Quiz 19
Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.
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1. After parts have been washed in cleaning solvent, they should be dried with wiping cloths, rags, compressed air, heat.
2. The transmission is removed from the car by taking it out from under car through driving compartment, through engine compartment.
3. To assemble parts with O-rings, use a twisting push, sudden twist, straight push, quick snap.
4. The first major parts taken off the transmission during disassembly, after it is mounted in the assembly fixture, are the primary and secondary stators, cover-and-turbine assembly, front and rear oil pumps, converter housing and pump.
5. In disassembling the primary-and-secondary-stator assembly, it will be found that the parts are held on the stator race by a special screw, tang lock washer, snap ring, set of screws.
6. In the clutch assembly, the flange and the flange retainer are held in the clutch drum by a spring, tang lock washer, screw, snap ring.
7. In the reverse-servo piston, the apply spring and retainer are held on the piston rod by a snap ring, tang lock washer, screw, pair of keys.
8. In the bench test, neutral and drive pressures will be found to be high because the low pressure is low, vacuum modulator is inoperative, rear pump is not operating, front pump is overspeeded.

§133. Disassembly of Powerglide (later model) The later model Powerglide with a three-member torque converter and automatic shift in drive is removed from the car in the same way as the earlier model, with two exceptions. One, a converter holding tool must be used to keep the converter from falling out during the removal procedure (Fig. 11-2). Secondly, the throttle-valve control rod must be disconnected. These exceptions are covered in the removal procedure discussed in §117. The disassembly procedures for the two Powerglide models are very similar, at least so far as the transmission itself is concerned.

§134. Converter disassembly, inspection, repairs, and reassembly (Figs. 11-17 and 11-18)

1. Remove lock nuts and bolts attaching converter cover. Drive two split dowel pins out of converter cover with a small punch.
Now, remove cover, turbine assembly, stator assembly, stator thrust washers, and converter-pump thrust washer. Take thrust washer from hub of turbine and remove O ring from converter cover.

2. Remove stator race from stator. Then remove snap ring and thrust washer so that cam rollers, springs, and guides can be removed. Don’t let the rollers or springs get away from you and become damaged or lost!

3. Inspect parts, after washing everything in cleaning solvent and air-drying them. Check pump-hub surfaces, pump thrust washer, turbine-hub surfaces, turbine thrust washer, converter-cover bushing, stator race, cam rollers, and stator thrust washers, for galling, scoring, or wear. Check vanes on pump, turbine, and stator for looseness or damage.

4. Converter-cover bushing may be replaced, if necessary. Special puller and installer tools are required.

5. To reassemble, first put the cam-roller-and-spring retainer on stator so the prongs are pointed toward the rear of the stator.
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(Front of the stator is marked "Front"; also, vanes are thicker at front.) Install retaining snap ring. Assemble cam rollers, springs, and guides in cam pockets. Guides are curved and this curvature should follow hub curvature. Then install cam thrust washer and retaining snap ring. Coat stator race and special loading tool with a light film of oil. Put stator race on pilot end of tool and carefully rotate stator over tapered end of loading tool and stator race. Do not dislodge rollers. Check operation of stator. It should rotate freely in one direction but should lock up in the other direction.

6. Continue assembly by putting converter pump on bench and installing thrust washer on pump hub. Make sure tabs are engaged in notches of hub flange. Assemble both thrust washers to stator and install stator on pump. Make sure the cutouts in the cam-roller-and-spring retainer face up, or toward the turbine. Put thrust washer on turbine hub and install turbine on converter hub. Put a new O ring on converter
cover, align dowel-pin holes in cover with pins in pump, and
install cover. Then install cover attaching bolts and lock nuts
and tighten to 15–20 lb-ft.

§135. Clutch disassembly, inspection, repair and reassembly
This clutch is similar to the clutch on the earlier model (covered in
§122) with the following three exceptions: The clutch piston is \( \frac{3}{4} \) inch smaller, the steel plates are waved instead of dished, and the
relief valve is a steel ball. With these three exceptions in mind,
you can follow the disassembly, inspection, repair, and reassembly
procedure for the earlier model, as outlined in §122.

§136. Modulator
The modulator on the later model is serviced in
the same manner as the modulator in the earlier model (see §123).

§137. Front pump
The front pump is similar to the unit used on
the earlier model except for the means of driving it. On this model,

![Fig. 11-19. Disassembled view of front pump: 1, stator support; 2, driven
gear; 3, drive gear; 4, pump body; 5, O-ring seal; 6, oil seal. (Chevrolet
Motor Division of General Motors Corporation)]

there are two drive lugs in the inner circumference of the drive
gear; these lugs enter slots in the converter pump hub. On the
protrude through the oil seal. See Figs. 11-9 and 11-19 to compare
earlier model, the drive lugs are on one face of the drive gear and

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the two. The only difference in the servicing of the two is that, on the later model, the clearance between the pump-body bushing and converter-pump hub must be checked. This is done by inserting the hub in the bushing and checking the clearance with a feeler gauge. Maximum allowable clearance is 0.007 inch.

§138. Rear pump

1. Disassemble by removing two screws and pump-body plate, and gears. Wash parts in cleaning solvent and air-dry. Blow out oil passages. Install gears and check clearances. They should be the same as in the front pump.

2. To reassemble, remove gears and oil generously with transmission oil. Then replace gears, cover, and screws. Tighten screws to $3\frac{1}{2}-4$ lb-ft.

§139. Valve-body disassembly, inspection, and assembly (see Fig. 11-20)

1. Disassembly. Remove accumulator snap ring, spring washer, spring, valve, valve body, and accumulator piston, with stop and springs, from valve body. Take clutch low-servo valve assembly from valve body. Put valve body on two blocks of wood and with a small punch, drive retaining pins out so the pressure-regulator governor valve and the converter pressure-regulator valve, with their springs, can be removed. Remove the two clutch-drum oil seals (see §126 for procedure).

2. Inspection. After washing parts in solvent and air-drying them, inspect the parts as follows:

   a. Make sure small fiber valve in accumulator-valve-body assembly operates freely.
   
   b. Make sure bakelite valve operates freely in the clutch low-servo valve.
   
   c. Check oil-seal rings for nicks or burrs and make sure that they are free in the ring grooves. Also, install rings in clutch-drum bore and make sure hooked ends have clearance.
   
   d. Check all valves and valve bores for scoring, burrs, or wear. Make sure valves operate freely in their bores. Also, make sure springs are not distorted.
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1. Snap ring
2. Accumulator-valve spring washer
3. Accumulator-valve spring
4. Accumulator valve
5. Accumulator-valve-body assembly
6. Accumulator piston
7. Accumulator-piston stop
8. Accumulator-piston inner spring
9. Accumulator-piston outer spring
10. Plug
11. Transmission manual valve
12. Plug
13. Pressure-regulator governor-valve-spring stop pin
14. Pressure-regulator governor spring
15. Pressure-regulator governor valve
16. Converter pressure-regulator valve-spring stop pin
17. Converter pressure-regulator valve spring
18. Converter pressure-regulator valve
19. Clutch low-servo valve assembly
20. Clutch-drum oil-seal rings
21. Transmission valve body

3. Reassembly. To reassemble, reverse the disassembly procedure and follow the illustration (Fig. 11-20). Note that the converter pressure-regulator valve spring is longer and of heavier wire than the pressure-regulator governor valve spring.

§140. Low-and-drive valve body In case this body requires disassembly, do not disturb the throttle-valve adjustment. This is preset at the factory (62 psi plus or minus 1 psi) and should not be disturbed except when new parts are required.

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§141. Throttle-valve inner-lever adjustment

If the throttle-valve adjustment has been disturbed, readjust it as follows. Two settings are required.

1. Rotate the throttle-valve inner lever until it just contacts the face of the detent valve. Hold the lever in this position and turn the adjusting screw A in the low-and-drive valve body in until it touches the flat surface on the step of the lever (Fig. 11-21). Back off one turn and lock screw by tightening lock nut securely.

![Fig. 11-21. Making the second setting of the throttle-valve inner lever. (Chevrolet Motor Division of General Motors Corporation)](image)

2. Put positioning gauge between the face of the detent valve and the throttle-valve inner lever. Hold it in this position and turn adjusting screw (B in Fig. 11-21) until it contacts the threaded body of adjusting screw A. Tighten lock nut securely.

§142. Governor disassembly, inspection, and assembly

(see Fig. 11-22) The governor assembly is made by selectively fitted parts, and the only parts that can be serviced separately are the governor-sleeve oil-seal rings. If other parts are damaged, the complete governor assembly must be replaced as a unit.

§143. Reverse-servo and low-servo pistons

Reverse-servo piston is serviced in same manner as on earlier model (§127). But the low-
servo piston has a different construction on the later model. It is disassembled and reassembled as follows.

1. Put piston in an arbor press, supporting the notched end of the rod on a block of wood. Use special tool (17 in Fig. 11-2) and compress piston spring. This spring is under 150 pounds pressure. Remove rod retainer, piston, spring, and washer from the rod. Remove ring from piston and put it in low-piston bore. Ring gap should be 0.005-0.010 inch.

2. To assemble the piston, put ring on piston. Then install washer, spring, and piston on rod. Put assembly in press and use special tool to compress spring so retainer can be installed. Make sure retainer seats in the groove.

§144. Planet carrier, input shaft, transmission case, and brake bands
Service procedure remains the same on the planet carrier and input shaft as on the earlier model (see §128) except that the input shaft has a special snap ring at the front (converter) end. Service is the same on the transmission case and brake bands (§129).

§145. Reassembly of Powerglide (later model) The later model Powerglide with a three-member torque converter and automatic shift is assembled in approximately the same way as the earlier model. There are some minor differences due to variations in the
design of different parts. There is one additional check that must be made on the later model, to assure proper positioning of the throttle-valve linkage. Use the special gauge (Fig. 11-23) to check. If the lever is not positioned properly, loosen the clamp-attaching bolt and reposition it.

§146. Installation of Powerglide (later model) The procedure for installing the later model Powerglide in the car is the same as for the earlier model (§132), except for two items:

1. Just before aligning the "X" marks on the converter cover and flywheel, remove the converter holding tool. Then be very careful that the converter does not move forward since this would cause the pump-hub drive slots to disengage from the lugs on the front-pump drive gear.
2. Connect the throttle-valve control rod to the outer lever assembly and install spring washer, washer, and cotter pin.

§147. Turboglide disassembly After removal, install converter holding tool to keep converter from falling out. Put transmission in holding fixture (Fig. 11-24). Remove converter holding tool, lift out
Fig. 11-24. Turboglide transmission mounted in fixture ready for servicing. (Chevrolet Motor Division of General Motors Corporation)

Fig. 11-25. Valve body bolts and parking pawl spring. (Chevrolet Motor Division of General Motors Corporation)
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converter, and put it in holding stand with output shaft down.  
*Handle with care.*

1. From transmission, remove oil-pan screws, oil pan, speedometer gear housing cap screw and clip, transmission extension, speedometer drive gear (with special puller), rear pump body and seal ring, rear pump drive gear (drive pin can fall out if pointing down), drive pin, and wear plate. Remove parking pawl spring and valve body (Fig. 11-25) and two oil-pressure tubes.

2. Turn transmission with input shaft up, take out seven front pump bolts, and use special puller to remove pump. Pump has two threaded holes to take puller. Remove reverse cone spring and cone (Fig. 11-26). Turn transmission to horizontal.

3. Remove neutral clutch and front ring gear assembly and reverse cone ring (with soft hammer). Remove front planet carrier and sun-gear free-wheeling unit (as an assembly) and separate parts by removing needle bearing, pulling free-wheeling unit out of planetary set, and then removing second needle bearing.

4. Remove forward clutch retaining ring, cone ring, and cone. Take out forward and brake piston (Fig. 11-27). Remove, as a unit, rear unit ring gear and output shaft and rear planet carrier. Then remove grade retarder components including two thin reaction plates, three brake plates, and two thick reaction plates.

5. Take rear ring gear from rear planet carrier by removing retaining ring, two races, and needle bearings. Take caged needle bearing from output shaft.

6. Remove detent control lever, manual selector lever, parking brake bracket, parking lock actuator assembly, pawl, pin, and
O ring. Remove thermal bypass valve and square seal ring (spring under valve cover is under tension), vacuum diaphragm, and valve strut.

§148. Overhaul of assemblies The disassembly and repair of the various subassemblies of the transmission are covered in following paragraphs.

1. Converter (Fig. 11-28). Disassemble by first mounting in support, and then remove cover bolts, cover, square seal ring, and as a unit, the three turbines (first, second, and third), stator assembly, rear thrust pad, and needle bearing parts. Take spring insert from stator and bearing locating ring from pump.

   The turbine can be disassembled by driving out three pins and removing turbine ring, second and third turbines, and needle bearing assemblies. Stator can be disassembled (Fig. 11-29) by removing screws, thrust pad, and other parts as shown. Note relationship of rollers springs and stator blades.

   The converter cover bushing and the first turbine hub bushing
can be replaced with a special tool. Needle bearing (and thrust washers in converter cover) must first be removed before the old bushing can be pressed out. These parts should then be replaced after the new bushing is pressed in.

When installing the stator blades on the rear carrier (Fig. 11-29),
be sure the sharp edges point downward. Freewheel cam rollers go in the smaller ends of the notches in the cam.

To assemble the turbine, put third turbine in turbine shell with vanes up, install second turbine with flange up, align balance marks, and install first turbine inner ring with inner flat surface facing up.
Align drive pin holes with a small drift and install pins with a small C clamp.

To complete the assembly of the converter (see Fig. 11-28), put steel spring ring into thrust bearing opening in pump, invert pump, and install bearing race (thin washer), bearing, and thrust pad (thick washer). Put stator in pump (bolts up). Mount pump face up on stand and index converter turbine shaft through pump and...
stator assembly. Install new square ring on cover and put thrust washer, bearing, and washer on face of hub. Install cover, aligning balance holes on cover and pump, and install bolts on each side of scribe marks, omitting each fourth bolt. Tighten finger-tight; then tighten every third bolt 8–12 lb-ft. Tighten other bolts to the same tension and finish by tightening all in rotation to 13–18 lb-ft.

2. Planet assemblies, pumps, and other parts. If the planet assemblies require repair, refer to Figs. 11-30 and 11-31. Figure 11-32 is a disassembled view of the front pump and reverse piston as-

Fig. 11-34. Correct installation of sprags. (Chevrolet Motor Division of General Motors Corporation)
Fig. 11-35. Disassembled view of neutral clutch and front ring gear assembly.
(Chevrolet Motor Division of General Motors Corporation)

1. Converter oil-seal ring
2. Second turbine shaft oil seal rings
3. Selective thrust washer
4. Front ring gear hub
5. Ring gear hub bushing
6. Third turbine shaft oil seal rings
7. Neutral clutch hub
8. Neutral-clutch-piston hub seal
9. Neutral clutch piston
10. Neutral-clutch-piston outer seal
11. Piston spring
12. Spring retainer
13. Snap ring
14. Drive plates
15. Driven plates
16. Rear drive plate
17. Snap ring
18. Ring gear snap ring
19. Snap ring

Fig. 11-36. Disassembled view of forward and brake pistons and support.
(Chevrolet Motor Division of General Motors Corporation)

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1. Attaching screws
2. Valve body screen
3. Main valve body
4. Pressure-regulator valve spring
5. Hydraulic modulator valve assembly
6. Transfer plate gasket
7. Vacuum modulator valve assembly
8. Vacuum modulator valve gasket
9. Transfer plate
10. Ditch plate gasket
11. Vacuum modulator accumulator check valve
12. Ditch plate
13. Attaching bolts
14. Ditch plate-to-transmission case gasket
15. Pressure tube O rings
16. Vacuum modulator valve attaching screws
17. Pressure tubes
18. Ditch plate-to-case gasket (rear)
19. Pressure tube O rings

When this unit is disassembled, clearances must be checked between the pump body bushing and the converter pump hub, between the driven gear and pump body, between the internal gear and crescent, and between the gears and end plate. If clearance is excessive, worn parts must be replaced.

Figure 11-33 is a disassembled view of the sun-gear freewheeling assembly. When installing the sprags, refer to Fig. 11-34 to make
sure they are not reversed. Stamped arrow on outer cage designates front of transmission. Sprags are properly installed if the units will slip when outer cam is held stationary and sun gear is turned clockwise (viewed from front). See Fig. 11-34.

Neutral clutch and front ring gear assembly is shown disassembled in Fig. 11-35. Selective washer (No. 3) comes in different thicknesses so clearance in transmission can be corrected if necessary. All parts can be removed easily except for the spring retainer snap ring (No. 13), which can be removed only after a special tool is used to press down on the piston (No. 9) to relieve spring pressure. Forward and brake piston and support assembly is shown disassembled in Fig. 11-36. To disassemble, a special support is required into which the assembly can be placed while another tool is used to press the forward piston and the brake piston out.
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The valve body is shown disassembled in Fig. 11-37 and the main valve body assembly disassembled is shown in Fig. 11-38. Major cautions to observe during disassembly and reassembly include: Handle all internal parts with care to avoid scratching or denting valves or distorting springs. After washing the body in solvent, air-dry it (never use rags) and blow out all passages. Observe the exact relationship of valves, springs, the detent ball, and pins during disassembly so parts can be restored properly.

§149. Turboglide assembly  Install valve body controls (Fig. 11-39) and parking lever bracket (torque bolts to 15-18 lb-ft). Put rear race, bearing, and front race on output shaft carrier. Then use a small dab of lubricant to hold bearing in place, and install thrust bearing on rear of output shaft. Install rear ring gear on rear planet carrier and output shaft, and put this assembly into case from the front. Install grade retarder parts in this order: thin steel plate, brake plate (lined), thick steel plate, brake plate, thick steel plate, brake plate, and thin steel plate.

Fig. 11-39. Valve body controls. (Chevrolet Motor Division of General Motors Corporation)
Install forward and brake piston support assembly (piston toward front). Make sure oil-transfer tube holes in case and support line up. Install forward cone (steel) ring and retainer. Be sure retainer is seated in groove. Check forward piston travel with a dial indicator after installing oil pressure tube by applying 100 pounds air pressure. Travel should be 0.027 to 0.080 inch. Overtravel indicates worn parts that should be replaced.

Temporarily install reverse cone ring, cone, spring, and front pump and reverse piston assembly to check reverse piston travel. Mount dial indicator so button rests on flat surface of piston (Fig. 11-40). Apply air pressure to check piston travel which should be 0.057 to 0.086 inch. Replace parts if piston overtravels. Undertravel might result from leaks.

Put race and bearing on front planet carrier. Install tanged washer on front end of front planetary (use a dab of lubricant).

Index keyways on front planetary housing to driven plate lugs in neutral clutch assembly as you bring the two together. Put front sun-gear freewheeling unit over rear extension of planetary, twisting sprag assembly to mate sun and planetary gears. Install bearing over extension of front planetary gear. Install assembly in case, twisting shaft to engage lugs with forward cone. Turn transmission so input shaft is up, and install reverse cone ring, with oil groove at bottom of case.

To determine proper thickness of selective thrust washer, the distance from the end of the rear hub of front pump to the mounting surface of the pump must be compared to the comparable distance in the case (between mounting surface and thrust washer pad of neutral clutch and front ring gear assembly). Measurements can be made with a dial indicator and special tool. Thickness of selective thrust washer must be such as to give a clearance of 0.008 to 0.028 inch.

Install reverse cone ring and cone, meshing tangs with slots in neutral clutch and front ring gear assembly. Put reverse cone spring
in case, rounded ends forward. Put two guide studs in case and install stator support gasket. Place square seal ring on outer lip of support, align tangs of oil-pump drive gear to top and bottom of pump housing, and install pump housing, using guide studs to guide pump into place. Dip bolt heads into nonhardening sealer and secure pump by tightening bolts to 15-18 lb-ft. Remove guide studs.

Install converter assembly. Two slots in hub should be toward top and bottom to engage lugs in pump drive gear. Keep lifting and turning converter until lugs engage. Put converter holding tool on case and turn transmission horizontally.

Turn output shaft to align holes and install rear pump drive pin. Position rear pump on output shaft, indexing drive gear to pin, and secure with bolts tightened to 7-9 lb-ft. Install square seal ring over pump. Install thermal bypass valve and tighten to 7-9 lb-ft. Install vacuum diaphragm, vacuum modulator strut, and two oil pressure tubes, and make the following air checks: Apply compressed air to the five ports shown in Fig. 11-41 and watch for the action of the

Fig. 11-41. Five ports to which compressed air should be applied to check action of clutches and pistons. (Chevrolet Motor Division of General Motors Corporation)
clutch or piston to make sure each functions normally. Lack of normal action indicates improper assembly, damaged parts, or leaks.

Install valve body (Fig. 11-25), making sure to use special hollow bolt at rear of valve body. Torque hollow bolt to 18–21 lb-ft and other valve bolts to 8–10 lb-ft. Index spring in parking lock pawl and then into bracket on rear bolt of valve body. Install speedometer gear, rear extension housing (torque bolts to 23–26 lb-ft), speedometer driven gear, oil gasket, and pan.

§150. Installation of Turboglide

Put transmission in lift, remove converter holding tool, and raise transmission into place. Secure with mounting bolts (installing upper bolts first). Remove temporary engine support and raise rear of transmission to final position. Connect body ground strap. Align flywheel and converter marks and install attaching bolts. Turn engine with cranking motor by using jumper. Reinstall transmission support cross member (using lower set of holes in frame) and remove lift. Connect propeller shaft, manual and throttle valve linkage, oil cooler lines, vacuum modulator hose, and speedometer drive cable. Install transmission filler tube. Make sure drain plug is in place and fill transmission with specified oil. Check linkage for adjustment and operation.

§151. Push-starting and towing car

To push-start the car, leave the selector lever in neutral until a speed of 16 mph (25 mph with Turboglide) is reached. Then shift into L (Powerglide) or GR (Turboglide) and turn engine on. As soon as engine starts, shift to neutral until engine warms up.

Push rather than tow the car for starting. If the car is towed, it might accelerate suddenly after starting and ram the car ahead.

To tow a disabled car, put transmission in neutral and do not tow faster than 30 mph. If damage prevents movement of the selector lever, disconnect the linkage from the transmission and move manual lever by hand. If the transmission itself is locked up, do not attempt to tow the car with the rear wheels on the road.

CHAPTER CHECKUP

Note: Since this is a chapter review test, you should review the chapter before taking it.

The chapter you have just completed describes the trouble-shooting.
Powerglide and Turboglide Service

removal, overhaul, and replacement of the Powerglide transmission. Take the test that follows in order to check up on how well you remember the important points covered in the chapter. If some of the questions stump you, go back into the chapter and reread the pages that cover the subjects asked about in those questions. Write the answers to the questions in your notebook.

Troubles and Service Procedures

In the following, you should write down in your notebook the trouble causes and service procedures asked for. Do not copy the procedures from the book; try to write them in your own words. Writing them down in your own words will help you to remember the procedures. And, of course, having the procedures well in mind is of great value to you in the service shop.

1. List conditions that would cause excessive slip in all ranges. Excessive slip in drive range. Excessive slip in low range. Excessive slip in reverse.
2. List possible causes of rough upshifts or downshifts. Rough shift, neutral to reverse.
3. List possible causes of noises in the transmission.
4. List possible causes of oil loss.
5. List causes of failure to upshift in drive range.
6. List possible causes of failure to downshift in drive range.
7. Describe the procedure of making a stall test.
8. Describe the procedure of making the drive-range pressure test. List possible causes if the pressure is below 75 psi.
9. Describe the procedure of making the low-range pressure test. List possible causes if the pressure is below 125 psi.
10. Describe the procedure of making the reverse-range pressure test.
11. List possible points of oil leakage from the transmission.
12. Describe the procedure of removing the Powerglide from the car.
13. Describe the procedure of disassembling the earlier model of Powerglide.
14. Describe the procedure of disassembling the later model of Powerglide.
15. Describe the procedure of disassembling and assembling the components in the Powerglide, including such parts as the clutch, pumps, valve body, etc.
16. Explain how to make a bench check of the Powerglide.
17. Make a list of the differences in construction between the earlier and the later model Powerglides described in the chapter.
18. Explain how to push-start a car equipped with a Powerglide transmission.

SUGGESTIONS FOR FURTHER STUDY

Study the shop manuals that describe the different models of Powerglide transmissions. Get all the experience you can in disassembling, repairing, and reassembling this transmission. Much experience along this line might be gained at an automotive shop servicing this unit. In addition, many school automotive shops now have the transmission available for demonstration overhaul. Be sure to keep your notebook handy and write down any important facts you come across. Try to get copies of the different diagnosis guides issued by the automotive manufacturers (one is shown in Figs. 12-1 and 12-2) and put them in your notebook. Study these guides carefully since they give you a good coverage of the various troubles (with possible causes and cures) the transmission might have.
12: Fordomatic and Cruise-O-Matic service

THIS CHAPTER discusses the trouble-shooting, maintenance, and overhaul procedures on the Fordomatic and Cruise-O-Matic transmissions. The construction and operation of these transmissions were described in Chap. 8 (particularly §§78 and 82). Note that the trouble-shooting and repair procedures are similar on the two transmissions.

§152. Diagnosing Fordomatic-transmission troubles Figures 12-1 and 12-2 are the two sides of the Fordomatic diagnosis guide, a guide sheet which lists the various checks and adjustments to be made and relates various abnormal conditions with the possible causes. As an example of how the chart in Fig. 12-2 is used, suppose you found a case of severe engagement in LO (low), DR (drive), or R (reverse). You would find this condition under Operating Conditions. Components to check, as indicated by the letters, would be K, B, W, E, and F. K and B, being underlined, are the most likely causes. Study Figs. 12-1 and 12-2 very carefully so you can relate the various troubles and their causes. Various car manufacturers supply diagnosis reports such as the one shown. If you work on an automatic transmission and use such a guide or report, you should be familiar with every entry.

In diagnosing or checking a Fordomatic, the first step should be to make sure fluid level is correct and that the various linkages and bands are correctly adjusted. These checks are covered in §153. Then, the transmission should be stall-tested and given an operating-pressure check (§154). The data from these checks and tests, recorded on the Diagnosis Guide, will generally “put the finger on” the cause of any abnormal condition. Following sections describe the removal, overhaul, and replacement of the converter, transmission, and transmission components.

Tools shown in Fig. 12-3 should be on hand before any service work on the Fordomatic is started.
Fordomatic Diagnosis Guide

Important: Before diagnosis with the steps listed under, “Preliminary Checks and Adjustments,” then road test the vehicle to check the adjustments made. If the road test indicates the need for further adjustments, refer to “Final Diagnosis.”

Preliminary Checks and Adjustments

1. Fluid Level—If low, refill, then immediately turn to Final Diagnosis table of External Fluid Leakages and correct cause before proceeding.
2. Engine idle—Adjust idle, then set anti-stall dashpot.
3. Throttle Linkage—Check free operation and specifications.
5. Stall Test—With engine at operating temperature, attach tachometer and set selector lever in desired position. Apply hand and foot brakes firmly, then accelerate engine to wide open throttle. Read engine R.P.M. and record results in the table.

Caution: Do not hold throttle open longer than five seconds. Release throttle immediately if slipping is indicated.

Road Test Checks

Make all of these checks (State speed laws permitting) to determine the exact operating conditions of the transmission. Record the results opposite each specification.

1. Initial engagements at closed throttle are:  [ ] Smooth; [x] Rough.
2. Reverse start at light throttle: [ ] Smooth; [ ] Chatters; [ ] Slips.
3. Shift points on smooth level road “DR” range (write in actual M.P.H.).
   a. Intermediate to High, minimum throttle 15-20 M.P.H.
   b. High to Intermediate, minimum throttle 56-67 M.P.H.
   c. High to Intermediate, forced downshift 20-62 M.P.H.
   a. High to Intermediate above 21-27 M.P.H.
   b. High to Low below 21-27 M.P.H.
5. Noise occurs in: [ ] Neutral; [ ] Low; [ ] Int.; [ ] Reverse; [ ] Neutral (Coasting at 20-30 M.P.H, with Engine Off).

Fig. 12-1. Fordomatic diagnosis guide, page 1. (Ford Division of Ford Motor Company)
**FINAL DIAGNOSIS**

Final Diagnosis of Operating Conditions, Noise, and External Fluid Leaks will indicate final repairs and adjustments to be made. Components to check are shown in logical sequence with the most probable causes underlined. Checking component symbols against the Legend will point out the items to correct. After immediate corrections have been made, be sure that cause of difficulty has been corrected. Always follow sequence for quickest results.

### OPERATING CONDITIONS

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>COMPONENTS TO CHECK*</th>
<th>CONDITION</th>
<th>COMPONENTS TO CHECK*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe Engagement LO, DR, or R</td>
<td>KB, WE, or R</td>
<td>No Drive in DR</td>
<td>KB, WE, or R</td>
</tr>
<tr>
<td>Rough Shift</td>
<td>KB, WE</td>
<td>No Drive in DR</td>
<td>KB, WE</td>
</tr>
<tr>
<td>Int. All Shift RPM Low, High or Erratic</td>
<td>SB, WE</td>
<td>No Drive in DR</td>
<td>SB, WE</td>
</tr>
<tr>
<td>Severe INT. Int Shift</td>
<td>SB, WE</td>
<td>No Drive in Any Range</td>
<td>SB, WE</td>
</tr>
<tr>
<td>Engine Chattering, Int. Int Shift</td>
<td>SB, WE</td>
<td>Manual Linkage Lock in DR</td>
<td></td>
</tr>
<tr>
<td>No Forced Downshift INT.</td>
<td>SB, WE</td>
<td>Parking Lock Wev Not Held</td>
<td>SB, WE</td>
</tr>
<tr>
<td>Severe INT. Int Shift (Closed Throttle)</td>
<td>SB, WE</td>
<td>Unload to Shift Engine by Pulling</td>
<td>SB, WE</td>
</tr>
<tr>
<td>Excessive Creeping</td>
<td>SB, WE</td>
<td>Transmission Overheating</td>
<td>SB, WE</td>
</tr>
<tr>
<td>Stoppages or Cluster in INT. Ratio</td>
<td>AB, WE, or E</td>
<td>Engine Reverse on Forced Downshift</td>
<td>AB, WE, or E</td>
</tr>
</tbody>
</table>

### NOISE

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>COMPONENTS TO CHECK*</th>
<th>LOCATION</th>
<th>COMPONENTS TO CHECK*</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Neutral</td>
<td>S, WE</td>
<td>Coasting in 1:20-30 MPH, Engine Off</td>
<td>S, WE</td>
</tr>
<tr>
<td>In LOW, INT. or REVERSE Ratio</td>
<td>S, WE</td>
<td>In Converter</td>
<td>S, WE</td>
</tr>
</tbody>
</table>

### EXTERNAL FLUID LEAKAGE

<table>
<thead>
<tr>
<th>WHERE NOTICED</th>
<th>POSSIBLE CAUSES*</th>
<th>WHERE NOTICED</th>
<th>POSSIBLE CAUSES*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Converter Housing or Air Duct</td>
<td>MB, WE</td>
<td>Front of Extension Housing</td>
<td>SV</td>
</tr>
<tr>
<td>Transmission Oil Pan</td>
<td>NO</td>
<td>Rear of Extension Housing</td>
<td>U</td>
</tr>
<tr>
<td>Left Side of Case</td>
<td>PCT</td>
<td>Speedometer Gear Boss</td>
<td>Y</td>
</tr>
<tr>
<td>Right Side of Case</td>
<td>SNT</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**IMPORTANT:** Inoperative vent on right hand side of case can cause general leakage.

**LEGEND**

- **A. Fluid Level**
- **B. Throttle Linkage**
- **C. Manual Linkage**
- **D. Governor**
- **E. Throttle Body**
- **F. Pressure Regulator**
- **G. Front Band**
- **H. Rear Band**
- **J. Rear Tappet**
- **K. Front Clutch**
- **L. Rear Clutch**
- **M. Leakage in Hydraulic System**
- **N. Front Pump**
- **O. Rear Pump**

*Capitalized legends denote repairs not requiring transmission removal from car. Non-capitalized legends denote repairs requiring transmission removal.

Repaired: ___________________  Parts Replaced: ___________________

Remain: ___________________

Fig. 12-2. Fordomatic diagnosis guide, page 2. (Ford Division of Ford Motor Company)
§153. Fluid-level and linkage checks (see Fig. 12-4)

1. Fluid level. With emergency brake applied, start engine and idle until engine and transmission have reached normal operating temperature. Move selector through all ranges to assure fluid distribution throughout the transmission and then place in P. Then, on earlier models, roll right-hand section of floor mat back and remove cover plate. Clean the mat and cover plate so dirt will not drop down onto the transmission. Clean carefully around the fluid-level-indicator cap (dirt must not drop into transmission) and turn cap one-half turn counterclockwise with pliers to remove the indicator. Wipe indicator clean, replace it, and turn it clockwise to make sure it is seated. Then remove it again and note fluid level. Add fluid, if necessary (use only Type A, automatic-transmission
Fig. 12-4. Transmission linkage and control checks and adjustments made on one Ford model, these are specified when a new car is delivered, when it has been driven 1,000 miles, and at other times when a check of transmission operation is required. (Ford Division of Ford Motor Company)
Automotive Transmissions and Power Trains

Fluid) to bring level to "Full" mark on indicator. Then replace indicator, cover plate, and mat.
On later models, the indicator cap is accessible from under the car hood after the hood has been raised. To check the fluid level on these models, raise hood, wipe dirt from indicator cap, remove the indicator, wipe it, and replace and remove it again to note the fluid level. Add fluid, if necessary, as noted in the previous paragraph.

2. Changing fluid. Fluid should be changed at least every 15,000 miles. This is done by removing converter-housing lower plate, removing one converter-drain plug, turning the converter 180 degrees and then removing the other drain plug. Then remove the transmission bottom-pan drain plug. After fluid has drained, replace plugs. Put in 6 quarts of fluid (Type A), start engine, and idle for about two minutes. Then add 3 more quarts and continue to idle until transmission reaches operating temperature. Move selector lever through all positions, put in P, and add fluid, if necessary, to bring level up to "Full."

3. Checking for fluid leaks. If the transmission loses fluid (and also as a safety check against its losing fluid) make the following checks and corrections:

a. Fluid in the bottom of the floor pan at the rear of transmission means the rear extension-housing seal is leaking and it should be replaced.
b. Replace speedometer-cable-connection seal if it leaks.
c. Replace governor-inspection-plate gasket if it leaks.
d. If the oil-pan gasket is leaky, first try to stop it by tightening the pan bolts (10–13 lb-ft [pound-feet]). If this does not do the job, replace the gasket.
e. Drain plug should be tightened to 20–25 lb-ft. If it leaks, replace the plug (gasket not supplied separately).
f. Seals at throttle-lever or manual-lever shaft should be replaced if they permit leakage.
g. The two hex-head pipe plugs at front of transmission (on each side) should be tightened to 7–15 lb-ft to stop leaks or, if necessary, plugs should be replaced.
h. If fluid is found in the discharge air duct, check converter-cover nuts for proper tightness (25–28 lb-ft). Do not tighten cover nuts when hot; this could cause leakage.

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4. Adjusting idle speed. Engine idle speed is adjusted (engine at operating temperature) by turning the idle-adjusting screw (Fig. 12-4). Idle speed varies for different models. Late-model, eight-cylinder, passenger-car engines should idle at 445–455 rpm (revolutions per minute). Some earlier models had a somewhat slower idle (1951 eight-cylinder idle-speed specification was 415–425 rpm, for example). Late-model, six-cylinder engines should idle at 440–460 rpm. Always check the Ford shop manual for the specifications before adjusting a particular model.

Note: Fluid found in the discharge air duct could be engine oil that has leaked past the rear main bearing.

5. Setting dashpot. Antistall dashpot setting (Fig. 12-4) is made by turning engine off, holding throttle closed, loosening the adjusting-screw lock nut, and turning the adjusting screw out until the end of the screw causes the dashpot rod to be pushed up to the end of its travel. Then, adjusting screw should be turned in 1½–2 turns to get 0.045–0.064 inch clearance between the end of the dashpot rod and the adjusting screw. Tighten lock nut.

6. Adjusting control rod. On the type of linkage shown in Fig. 12-4, the manual linkage between the selector lever and the manual lever is adjusted as follows. (Other models may have a different linkage arrangement and thus require a different adjusting procedure; refer to the applicable shop manual.) Disconnect upper end of control rod from selector arm (at steering column). Position selector lever so indicator at steering wheel is down against the stop in the drive position. Position the manual lever (on transmission) in the drive position (second position from bottom). Then adjust rod length by turning sleeve on threaded rod so clevis pin will enter the grommet in the selector arm. Lengthen rod by turning sleeve two full turns and reattach rod to selector arm.

7. Positioning the starter neutral switch. Position the starter neutral switch (Fig. 12-4), if necessary, so that the starter circuit is closed only when the selector lever is in the neutral position.

8. Checking throttle linkage. On the type of linkage shown in Fig. 12-4, the throttle linkage is checked after removing the clip.
and disconnecting the rod between the carburetor and the Z bar at the Z bar. (Other models, with other linkage arrangements, may require a different adjusting procedure.) Then reinsert the rod into the Z bar and put the special tool (shown at No. 7 in Fig. 12-4) on the end of the rod. Rest the tool on the finished surface of the cylinder block and adjust the rod length so the carburetor throttle lever is held against the idle stop. Then remove the tool and reattach the rod to the Z bar with the clip.

Next, detach the clevis from the other end of the Z bar by removing the cotter pin and clevis pin. Pull up on the clevis-ended rod (this rod is attached to the transmission throttle lever) so the lever is held against the stop. Now, adjust the clevis so the clevis pin will freely enter the clevis and the hole in the Z bar. Then, lengthen the rod by turning the clevis 2½ turns and reattach the clevis to the Z bar with pin and cotter pin. Hold clevis square with the Z bar and tighten the lock nut.

9. Road-testing the car. Performance and shift points can be checked as noted at the bottom of the diagnosis guide (Fig. 12-1).

Caution: Do not exceed speed laws and observe every safety precaution in making road checks. If a chassis dynamometer is available, transmission operation can be checked on it and the car will not need to be tested on the road. See Appendix.

Check shift points as follows. With selector lever in drive, apply the accelerator lightly for gradual acceleration. Upshift should occur at 14–19 mph (miles per hour). Close throttle and slow down. Downshift should occur at 7–3 mph.

Increase speed to somewhere below 50 mph. Cruise briefly at this speed and then open accelerator wide. Transmission should downshift.

Drive at 45–50 mph with selector lever in drive and shift it to low. Transmission should shift to intermediate (not low). Slow down and note speed at which shift to low occurs (should be at 23–27 mph).

Drive at 30 mph in drive range and shift to low. Slow down. Shift should again occur at 23–27 mph.

Stop car and shift to reverse. Open accelerator slightly to back the car. Stop car and move selector lever to park. Transmission should now be locked so car cannot move.
10. Tightening converter-cover attaching bolts. Remove housing lower plate and tighten attaching nuts to 25-28 lb-ft with nuts cold. Check converter drain plugs for leakage and replace lower plate.

11. Front-band adjustment\(^1\) (10 in Fig. 12-4). Drain fluid (into a clean container if you expect to reuse it). Remove and clean oil pan and oil screen. Loosen lock nut on front-servo adjusting screw two full turns. Pull back on actuating rod and insert gauge block of adjusting tool between the servo-piston stem and the adjusting screw. Tighten adjusting screw until the wrench handle on the tool overruns (Fig. 12-5). Back off adjusting screw exactly one turn and hold it while tightening the lock nut to 20-25 lb-ft. Remove gauge block and install oil screen and pan (use new gasket). Install drain plug and tighten to 20-25 lb-ft. Refill transmission, as above.

12. Rear-band adjustment\(^1\) Remove cover plate after rolling back right-hand section of floor mat. Clean and oil adjusting-screw threads. Loosen the rear-band adjusting-screw lock nut with special tool (Fig. 12-6). Then tighten T handle of tool until wrench overruns. If adjusting screw is already tighter than wrench capacity, loosen the screw several turns and then retighten it with the T

\(^1\) Specifications call for a first adjustment at 1,000 miles and further adjustments at 12,000-mile intervals.
handle until the wrench overruns. Then back off the adjusting screw 1½ turns, hold it stationary, and tighten the lock nut to 35–40 lb-ft. Replace cover plate and floor mat.

**§154. Trouble-shooting** The road tests of the car (§153, 9) give you part of the information you need to make a complete diagnosis of the transmission operation. The stall test and operating-pressure check, outlined below, which apply to one model of the Fordomatic, give you additional information.

**Caution:** Procedures are different for other models.

![Fig. 12-6. Adjusting rear band. (Ford Division of Ford Motor Company)](image)

1. **Stall test.** Connect a tachometer to read engine rpm. Engine should be at operating temperature and idling at specified speed. Apply parking and foot brakes, put selector lever in drive, and open throttle wide. Engine speed should be between 1,400 to 1,600 rpm.

**Caution:** Do not hold throttle open for more than 5 seconds!

If engine speed exceeds 1,600 rpm, the front band or clutch is slipping. If engine does not attain 1,400 rpm, tune up engine since it apparently lacks power.

Repeat test with selector in reverse. If engine speed exceeds 1,600 rpm, the rear band or rear clutch is slipping.
2. Operating-pressure check. Set parking brake and raise rear of car so wheels are off the floor. Remove converter air-intake duct and screen. Disconnect throttle linkage at the outer throttle lever. Remove the \( \frac{3}{4} \)-inch-pipe plug, near the throttle lever, and connect the pressure gauge so it can be read under the car (Fig. 12-7). Position the throttle-lever protractor gauge over the throttle-lever shaft, locating the large elongated hole over the large shaft to the rear of the control lever (Fig. 12-8). Set indicator on gauge to 0 degrees and lock it with knurled screw. Hold throttle lever up against stop and insert gauge pin through the small elongated hole in the gauge and the hole in the throttle lever. If the pin enters both freely, the throttle mechanism is okay. If it does not, the throttle-control mechanism must be replaced.

With throttle lever still held in up position, lock the lever to the gauge by tightening the thumbscrew on the gauge. Remove the gauge pin, loosen the knurled screw to free the protractor lever. Move the lever to check maximum travel (with throttle lever all the way down). It should be 25–33 degrees.

Set idle speed to 600 rpm, move selector to reverse, and position throttle lever at 0 degrees. Pressure should be 60–80 psi (pounds per square inch).

Fig. 12-7. Pressure-gauge installation. (Ford Division of Ford Motor Company)
Advance the throttle lever. Pressure should start to rise at 4–6 degrees advance. Pressure should reach a maximum of 140–160 psi at 14–16 degrees advance.

Move selector lever to drive and repeat test. Maximum pressure in drive should be 120–135 psi.

3. Conclusions. Here are the conclusions to be drawn from the above tests.

a. With pressures correct and slippage occurring, adjust front and rear bands.

b. If pressures are not correct, adjust front and rear bands and clean or replace the control valve body.

c. If pressures are still not correct after band adjustments and overhauling of the control valve body, then the complete transmission and converter assembly should be overhauled.

4. Final operations. After the tests are completed and adjustments made, remove gauges, install pipe plug, connect throttle lever, and install converter air-intake duct and screen. Reset engine idle and adjust throttle linkage as already noted.
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5. Towing the car. Fordomatic-equipped cars can be towed, the same as cars equipped with standard transmissions, with the following exceptions:

For short hauls (less than 12 miles) put the selector lever in neutral and do not exceed 40 mph.

For longer hauls (more than 12 miles) or when the transmission is inoperative, either tow the car with a rear-end pickup or else remove the propeller shaft. Either way, the transmission is protected for further damage. If the propeller shaft is removed, protect the rear end of the transmission from the entrance of dirt by installing and wiring in place a U-joint knuckle.

CHECK YOUR PROGRESS

Progress Quiz 20

As with most other components of the automobile, the first step in Fordomatic service is often trouble diagnosis. To help the service man, the manufacturer supplies a diagnosis guide (Figs. 12-1 and 12-2). The service man should be familiar with all the entries on this guide. Using the guide properly will be a great help in locating trouble causes. Once causes are known, it is usually much easier to cure the trouble. The following quiz will help you review the material we have covered thus far on trouble-shooting and testing the transmission.

Correcting Troubles Lists

The purpose of this exercise is to help you to spot related and unrelated troubles on a list. There is a series of lists below, and in each list there is one item that does not belong. That is, there is one item that will not cause the trouble given in the list. Write down each list in your notebook, but do not write down the item that does not belong.

1. Severe engagement LO, DR, or R: engine idle speed incorrect, throttle linkage out of adjustment, oil pressures incorrect, valve body at fault, fluid level high, pressure regulator at fault.
2. Intermediate-to-high shift at incorrect speed (high, low, or erratic): throttle linkage out of adjustment, governor faulty, pressure incorrect, valve body faulty, hydraulic system leaks, rear band not applying.
3. Severe intermediate-to-high shift: throttle linkage out of adjustment, front-band apply faulty, valve body faulty, front clutch applied, front servo faulty, pressure regulator faulty.

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4. Engine overspeeds, intermediate-to-high shift: throttle linkage out of
adjustment, front-band apply faulty, valve body faulty, hydraulic
system leaks, rear-band apply faulty.

5. No intermediate-to-high shift: governor faulty, idle speed too low,
valve body faulty, rear clutch not applying, hydraulic system leaks.

6. No high-to-intermediate forced downshift: throttle linkage out of ad-
justment, pressures incorrect, valve body faulty, front clutch not
releasing.

7. Severe high-to-intermediate shift (closed throttle): harsh rear-clutch
apply, throttle linkage out of adjustment, engine idle speed incorrect,
valve body faulty.

8. Slippage or chatter: fluid level low, throttle linkage out of adjustment,
band not holding, clutch not holding, valve body faulty, pressure
regulator faulty, governor pressure high, hydraulic system leaks.

9. No drive in drive range: front band not releasing, front clutch not
applying, front servo faulty, rear band not applying, hydraulic system
leaks.

10. No drive in any range: fluid level low, manual linkage out of adjust-
ment, valve body faulty, pressure regulator faulty, hydraulic system
leaks, throttle linkage out of adjustment.

Completing the Sentences

The sentences below are incomplete. After each sentence there are
several words or phrases, only one of which will correctly complete the
sentence. Write each sentence down in your notebook, selecting the
proper word or phrase to complete it correctly.

1. The first step in checking a Fordomatic is to check clutch
linkage fluid level drive pressure reverse pressure

2. Fluid in the bottom of the floor pan at the rear of the transmission
probably means leakage at the rear extension-housing seal
front extension-housing seal oil-pan gasket throttle-lever shaft

3. With selector lever in drive, and on light acceleration, upshift should
occur at 4-9 mph 14-19 mph 40-49 mph

4. In the stall test, engine speed should be between 400 and 600 rpm 800 and 1,200 rpm 1,400 and 1,600 rpm 1,800 and 2,000 rpm

5. With selector in drive, brakes applied and holding, and throttle
wide open, engine speed above 1,600 rpm means that there is slippage
in the rear band or clutch front band or clutch front planetary rear planetary
6. With selector in reverse, brakes applied and holding, and throttle wide open, engine speed above 1,600 rpm means that there is slippage in the rear band or clutch rear planetary or front planetary front band or clutch.

7. Maximum pressure in drive range should be 12–15 psi 20–35 psi 120–135 psi 220–235 psi

8. Maximum pressure in reverse should be 14–16 psi 40–60 psi 140–160 psi 240–260 psi

§155. Removal and replacement of subassemblies and transmission

Several of the subassemblies in the transmission can be removed and replaced without taking the complete transmission and converter assembly from the car. These include the governor, front servo, rear servo, control valve body, pressure regulator, and seals. Removal and replacement of these parts, as well as the transmission alone and the complete transmission and converter assembly, are described below. Following sections discuss repair and overhaul of these subassemblies.

1. Governor. Raise car on hoist, remove governor inspection cover from extension housing, and rotate drive shaft to align governor body with inspection hole so the two attaching screws can be removed. Body will then come off counterweight.

Caution: Do not drop screws or valve into the extension housing!

When replacing governor, remove valve and lubricate with Type A automatic-transmission fluid. Put valve back in governor body, making sure it work freely, and then put governor body on counterweight, side plate forward, aligning the fluid passages in the body and counterweight. Install body attaching screws, inspection cover (with new gasket), and cover screws (tightened to 4–6 lb-ft).

2. Front servo. Remove fluid-level indicator or disconnect filler tube at transmission (later models). Drain transmission fluid and remove oil pan, gasket, and oil screen. Remove lubrication tube and loosen the control-valve-body attaching bolts. Then remove front-servo attaching bolt, hold strut with fingers and remove the servo assembly.

To install, push the servo band forward in the case, band ends down. Align large end of strut with servo actuating lever and align small end with the band end. Rotate band, strut, and servo into [467]
position, aligning the tubes from the valve body to the servo and also the anchor end of the band with the anchor in the case. Install and tighten attaching bolt to 30–35 lb-ft. Tighten control-valve-body attaching bolts to 8–10 lb-ft. Install lubrication tube, adjust front band, install oil screen, oil pan with new gasket, and drain plug. Fill transmission as already explained (§153).

3. **Rear servo.** Remove parts and front servo as already explained. Then remove rear-pump intake tube and rear-servo attaching bolts. Hold actuating and anchor struts with fingers and remove servo assembly. To reinstall, position the servo anchor strut on the servo band and rotate the servo band to engage the strut. Hold the servo anchor strut with the fingers, position the actuating lever strut and install the servo. Install and tighten servo attaching bolts to 40–45 lb-ft.

**Note:** The longer servo attaching bolt goes in the front bolt hole. Reinstall front servo and other parts as already noted.

4. **Control valve body.** Raise the car on a hoist, remove the fluid-level indicator or disconnect filler tube at transmission (later models). Then drain the transmission and remove the oil pan, gasket, and oil screen. Remove the two U tubes from the pressure regulator and control valve body. Loosen front-servo attaching bolt three turns. Remove the three valve-body attaching bolts, lower the valve body and pull it off the servo tubes (Fig. 12-9).
Handle the valve body carefully. Dropping it or banging it may damage it.

Install the control valve body by first aligning the servo tubes with the holes in the control-valve body. Position the manual lever in neutral. Then position the inner throttle lever between the throttle-lever stop and downshift valve, and push the throttle valve in to clear the transmission case. Make sure the manual valve engages the actuating pin in the manual detent lever. Install the two U tubes in the pressure regulator and valve body. Tighten the valve-body attaching bolts to 8-10 lb-ft. Tighten the front-servo attaching bolt to 35-40 lb-ft. Adjust front and rear bands. Install oil screen, oil pan (with new gasket), and drain plug as noted above. Connect filler tube at transmission (later models). Add fluid. Readjust manual and throttle linkages.

5. Pressure regulator. Remove fluid-level indicator or disconnect filler tube at transmission (later model), drain fluid, and remove the oil pan, gasket, oil screen, and lubrication tube. Remove the small and large tubes from the valve body and pressure regulator. Then remove the pressure-regulator spring retainer, maintaining pressure on the retainer to keep the springs from flying out. Remove the control pressure and converter-pressure valves, regulator attaching bolts, and regulator.

To replace, position the regulator body on the transmission case, install and tighten the attaching bolts to 17-22 lb-ft. Install valves, springs, and retainer, followed by the other parts removed as noted in the previous paragraph.

6. Seals. The rear seal in the extension housing and the manual- and throttle-lever seals can be replaced with the transmission on the car.

a. Extension-housing rear seal. Remove the drive shaft and telescopic shield. Then use special remover to remove the oil seal. Inspect the sealing surface of the universal joint for scores. If scores are evident, replace the yoke. Inspect the counterbore in the housing for burrs. If burrs are found, they can be polished out with crocus cloth. To install a new seal, coat the outer diameter of the seal with Permatex No. 3 and put it in the bore of the extension housing, felt side to the rear. Drive it in with special tool until it seats firmly in the bore. Install telescopic shield and drive shaft.
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b. Manual- and throttle-lever seals. Remove control valve body and disconnect the throttle and manual linkages at the transmission. Remove inner throttle-lever shaft nut and lever. Remove the outer throttle lever and shaft and take throttle-shaft seal from counterbore in shaft. Remove cotter pins from ends of parking-pawl torsion-lever rod and remove rod. Rotate manual-lever shaft until the detent lever clears the detent ball, and remove the ball and spring. Don’t let the ball fly out of the case.

Remove the manual-lever shaft nut, detent lever, and outer manual-lever-and-shaft assembly. Manual-shaft seal may now be removed.

Install a new seal in the transmission case with special replacing tool (77288) after coating outer diameter of seal with Permatex No. 3. Insert manual lever and shaft in case and rotate the shaft until the manual lever is pointing down. Put detent lever on the inner end of the shaft. Install and tighten detent-lever attaching nut to 35–40 lb-ft. Put detent spring and ball in case, using a piece of tubing to push ball and spring down so detent lever can be rotated into position.


7. Removal of transmission and converter assembly. The transmission and converter can be removed and replaced as an assembly, or the transmission alone can be removed and replaced. The procedure varies to some extent in different models (six-cylinder and eight-cylinder) and for different model years. Removal and replacement of the assembly on 1954 cars is described below. See the applicable shop manual for procedures on other models.

a. Fold front floor mat from sides to center. Remove rubber plugs over the top cross-member-to-frame bolts on each side and remove bolts. Remove the four rubber plugs and four top converter-housing-to-engine bolts.

b. Raise car on a hoist. Then, on the eight-cylinder car remove starting motor and the converter-housing front plate. On six-cylinder engines, remove the access plate. Drain converter
by removing one plug and then rotating converter 180 degrees and removing second plug (converter can be drained after removal if preferred).

c. On six-cylinder engines, remove all the lower converter-housing-to-engine bolts except the one located over the starting motor and the one located over the exhaust pipe. Remove the transmission-linkage splash shield. Remove the converter air-duct assembly and disconnect the throttle- and manual-control rods from the transmission. Remove the starting motor, drain the transmission fluid, and remove the drive-shaft assembly.

d. On eight-cylinder engines, disconnect the filler tube at the transmission oil pan and drain the transmission. Remove the converter-housing upper cover and remove the six converter-to-flywheel-drive-plate bolts. Then install the engine support bar and adjust it so engine can be lowered $\frac{3}{4}$ inch below its normal position. Then disconnect the manual and throttle linkage at the transmission, disconnect the accelerator-pedal shaft at the accelerator cross shaft, and remove the drive shaft (by removing the four cap screws at the rear end of the shaft). Remove speedometer cable, disconnect the parking-brake assembly at the cross member, and move the cable and equalizer to one side. Remove the two rear engine-support-to-transmission bolts. Raise the transmission slightly with a transmission jack to take the weight off the rear cross member and remove the remaining cross-member attaching bolts and the cross member. Lower the transmission weight until the engine is supported by the support bar. With the transmission supported by the jack, remove the remaining converter-housing-to-engine bolts. Move the jack, with transmission, toward the rear of the car sufficiently to clear converter pilot. Remove the flywheel assembly.

**Caution:** When removing or replacing the converter-and-transmission assembly, be very careful to keep the converter from slipping forward out of the housing.

e. On six-cylinder engines, remove the oval cover on the engine rear plate. Remove six flywheel-to-converter-cover bolts. Install engine support bar and adjust tightly to the oil-pan flanges.
Remove the two remaining converter-housing-to-engine attaching bolts. Tilt converter and transmission slightly and move assembly toward the rear so the six flywheel-to-crankshaft-flange attaching bolts can be removed. Remove the flywheel to provide clearance; then lower the converter and transmission assembly.

8. Installation of transmission and converter assembly. Position converter in housing. Be careful that it does not slip out during installation of the transmission. Then proceed as follows:

a. If a new transmission is being installed, drive the rear-extension-housing dust shield onto the housing with holding and adapter tools.

b. Raise the assembly on a jack until the transmission extension housing can slide over the frame cross member (six-cylinder). Install flywheel assembly on the engine crankshaft flange and tighten the bolts to 75-85 lb-ft.

c. Remove dirt, grease, burrs, etc., from the converter-pilot bore in the flywheel. Apply a heavy film of white grease lubricant (Ford's M-4648-A) evenly, on converter bearing surface. Do not use too much since this would keep the pilot from entering fully.

d. Move assembly forward, aligning pilot and the housing dowel pins. Install the four lower converter-housing-to-engine attaching bolts, tightening them to 40-45 lb-ft.

e. Align one flywheel access hole with one drain plug, and install three drive-plate-to-converter-cover attaching bolts. Tighten bolts to 25-28 lb-ft. Rotate flywheel assembly 180 degrees and install the other three drive-plate-to-converter cover bolts, tightened to 25-28 lb-ft.

f. Raise the engine and replace the cross member and attaching bolts. Lower engine onto cross member, install the engine rear-support bolts, and remove the engine support bar.

g. Apply Type A transmission fluid on universal-joint knuckle and install drive shaft. Install parking-brake assembly and speedometer cable. Connect manual linkage at the transmission manual lever. Connect throttle linkage at the transmission throttle lever.
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h. On eight-cylinder, install converter-housing covers. On six-cylinder, install the access plate. Install starting motor.
i. Connect fluid-filler tube to oil pan. Install the remaining converter-housing-to-engine attaching bolts. Lower car to floor, install the two top converter-housing-to-engine bolts, tightened to 40–45 lb-ft. Replace the access-hole rubber plugs.

j. Fill transmission as noted above (§153). Check for leaks and adjust manual and throttle linkages.

9. Removal of transmission only. If the transmission only is to be removed, proceed as follows:

a. Put car on support stands with all four wheels about twelve inches from the floor. Drain transmission.
b. Then perform operations c to e under 7, above. However, instead of removing the converter-housing bolts, remove the four bolts attaching the transmission to the converter housing. Now, the transmission can be moved toward the rear until the turbine shaft is disengaged. Lower transmission from the car.

10. Installation of transmission only. We have already covered most of the steps required to replace the transmission. Two special guide pins should be put into the two top transmission-to-converter-housing attaching-bolt holes to assure alignment of the transmission as it is lifted and brought forward into position. Then rotate the engine so the front-pump drive lugs on the converter-pump housing are in a vertical position. Then rotate the front pump so the slots in the pump drive gear are in a vertical position. Apply Lubriplate to the converter pump-cover hub.

Then, raise the transmission on a jack and move it forward into position. Turbine-shaft splines must align with splines in the turbine hub, and the pump drive lugs and drive slots must align.

Install the two lower transmission attaching bolts, remove the two guide pins, and install the upper attaching bolts. Tighten to 40–45 lb-ft.

Then raise engine, install the frame cross member, and proceed with the installation as noted in 8, above.

§156. Disassembly of transmission. This section deals with the disassembly of the transmission only. Subsequent sections describe the inspection and repair of component parts and subassemblies and...
the reassembly of the transmission. A separate section deals with the disassembly, inspection, and reassembly of the converter. Transmission disassembly follows.

**Caution:** Utmost cleanliness must be observed during disassembly and overhaul of automatic transmissions. Wiping rags or cloths must not be used to wipe parts after they have been washed in cleaning solvent. Slight traces of dirt or lint may adhere to the parts and cause operating difficulties later. The working area, workbench, work tools, and your hands should be clean. Parts should be dried with moisture-free compressed air after they are washed.

**Note:** The tools shown in Fig. 12-3 must be on hand before any service work on the Fordomatic is attempted.

1. Remove fluid-level indicator, install the transmission in special holder, and remove pan and gasket. Remove oil screen by lifting it off the forward tube and then off the rear tube.
2. Remove pressure-regulator body, servos, and control valve body as noted in §155.
3. With the above parts off, the transmission end play should be checked. This is done with a dial indicator mounted at one of the front-pump attaching-bolt holes (Fig. 12-10). Contact button should rest on the end of the turbine shaft. Install the extension-housing seal replacer on the output shaft as shown, and pry the front-clutch drum to the rear with a screw driver.
Hold the clutch drum to the rear while setting the indicator to zero. Now use the screwdriver to pry between the large internal gear and rear of case so as to move the units forward as far as possible. Record the amount of end play. It should be 0.010-0.029 inch. If it is not within these limits, a selective thrust washer (on rear of pinion carrier) of a different thickness will be required on reassembly of the transmission.

4. Front pump is removed by taking out the rest of the front-pump attaching bolts. Pull pump off shaft carefully so you do not damage the oil seal. Remove gasket. If necessary, tap lightly on the cap-screw bosses with a soft hammer to loosen the pump.

5. Extension housing is removed by taking out the five attaching bolts. These bolts also attach the rear pump, so hold the pump in position while removing the extension housing. Pull the housing off the output shaft carefully so you do not damage the rear oil seal.

6. To remove the distributor (Fig. 12-11), first remove the speedometer drive-gear snap ring. Put one hand under the output shaft and remove the gear. Catch the gear drive ball as the gear is removed. If the ball does not fall out, remove it from the output shaft. Then remove the distributor attaching bolts.
bolts and slide the distributor, with tubes, from the trans-
mission.
7. Slide the distributor sleeve off the output shaft and remove
the four seal rings from the output shaft. Handle the rings
carefully so you do not break them. Now, remove the governor
snap ring from the output shaft and slide the governor as-
sembly off the output shaft. Do not lose the governor drive
ball.

Next, install the tube-extractor tool in the rear-pump dis-
charge tube and remove the tube. Remove the rear pump
and the gaskets for the extension housing and rear pump from
the case.
8. To remove the pinion carrier, first take the rear-pump drive
key from the output shaft and then remove the bronze thrust
washer from the shaft. Hold the rear drum and remove the
output shaft. Remove the selective thrust washer from the
rear of the pinion carrier and use special snap-ring pliers to
remove the two seal rings from the primary-sun-gear shaft.
Do not distort the rings. Now, the primary carrier can be re-
moved.

9. To remove the primary-sun-gear shaft, first remove the bronze
thrust washer from the shaft (if it has not come off with the
carrier). Mark the rear band so you will know its correct
position on reassembly. Then squeeze the ends of the band
together, tilt it forward, and remove it from the end of the
case. Remove the two center-support outer bolts (one on each
side) from the outside of the transmission case. Now, while
exerting sufficient pressure on the end of the turbine shaft to
hold the clutch units together, remove the center support from
the case. The rear and front clutch assemblies can now be
removed from the rear of the case as a unit. Remove front
band from case.

Caution: Hold the clutch assemblies together and do not rock
them; rocking them will damage the seals.

Put the assemblies into bench fixture (tool 77530). Remove
thrust washer from front of turbine shaft. Lift front clutch assembly
from primary-sun-gear shaft. Lift straight up and do not rock the
assembly to avoid damaging seals. Remove bronze and steel thrust
washers from the shaft. Wire the thrust washers together so you can identify them and restore them to their proper places on reassembly. Take front-clutch seal rings from sun-gear shaft with snap-ring pliers. Do not break the rings. Now, the rear clutch assembly can be lifted from the shaft. Lift straight up and do not rock it, to avoid damaging the seals.

§157. Repair of subassemblies  The repair of subassemblies includes disassembly, inspection, and reassembly. During reassembly of subassemblies and installation of the subassemblies in the transmission case, care must be used to install the various thrust washers in their proper places. Figure 12-12 shows the appearance and locations of the various thrust washers in the assembly.

1. General instructions. Handle all transmission parts with care. Remember that nicks, scratches, or burrs on bearings or mating surfaces may cause serious trouble later. Likewise, the workbench and tools must be clean. Traces of dirt can cause faulty operation of valves, servos, and other parts.

After disassembly, parts should be cleaned in solvent and then blown dry with moisture-free compressed air. Do not use cloths or rags to wipe parts; lint may remain on them and cause trouble later.

Minor scores or burrs may be removed with crocus cloth. But when polishing valves with crocus cloth, use extreme care to avoid rounding the edges of valve lands.

Lubricate all internal parts with automatic-transmission fluid Type A during reassembly. Never use any other kind of lubricant. However, gaskets and thrust washers may be coated with vaseline to facilitate assembly.

Check the gears for broken or worn teeth. Defective gears must be replaced.

Check all fluid passages for obstructions.

Check fit of seal rings in grooves. Rings must enter their grooves without bind. Rings must enter the bores in which they are designed to fit with a slight clearance between the ends of the rings.

Shaft splines and splines in mating hubs must be free of burrs and be unworn. Check fits. Clean off burrs with a stone.

Drum-band surfaces, clutch-piston bores, thrust faces, bushings, bearing surfaces, and other surfaces which may wear should be inspected for wear and scoring.
Distorted, weak, or damaged springs should be discarded.

When installing snap rings, make sure they are seated fully in their grooves.

Always use new gaskets and sealing O rings on reassembly.

Tighten bolts and screws to the torques specified.

2. Primary-sun-gear shaft. Two general types of primary-sun-gear shafts have been used (Fig. 12-13). The new shaft has a groove, as shown, in the front-clutch-hub area. The new shaft is for use with the new-type front-drum-and-secondary-sun-gear as-
FIG. 12-13. Old and new primary sun-gear shafts. The new shaft has a groove, as shown. (Ford Division of Ford Motor Company)

FIG. 12-14. Old bushing type and new needle-bearing type front drum and rear-clutch assembly. (Ford Division of Ford Motor Company)

assembly which is equipped with a needle bearing instead of a bushing (see Fig. 12-14). Actually, the new shaft may be used with the older drum which has a bushing. However, the old-style shaft cannot be used with the drum which has the needle bearing.

To inspect the primary-sun-gear shaft, remove the rear-clutch
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Seal rings and thrust washer from the shaft. In addition to inspecting bearing surfaces, gear teeth, splines, and fit of rings in grooves, as noted above, check all oil passages for obstructions and signs of leakage. Reinstall rings.

3. Rear clutch.

a. Types. Two types of front-drum-and-rear-clutch assemblies have been used (Fig. 12-14). The new type has a needle bearing and the clutch-piston spring has been reduced in diameter in order to provide additional clearance between the spring and clutch cylinder. The two springs can be readily distinguished from each other because the new spring has a left-hand coil. The new spring takes a different spring seat (see Fig. 12-14).

**Note:** Whenever a transmission is disassembled for any repair, install the new spring and seat on reassembly.

b. Disassembly. Use special tool in arbor press and snap-ring pliers to remove clutch release-spring snap ring. Then release spring tension gradually, guiding the spring retainer to prevent it from catching in the snap-ring groove. Remove retainer and spring. Then take out the clutch pressure-plate snap ring and remove pressure plate from clutch drum. Take out the four bronze and four steel clutch plates.

To remove the clutch piston from the drum, put the sun-gear shaft in the clutch and use an air hose as shown in Fig. 12-15. Hold finger over other hole (opposite hole where hose nozzle is applied).
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Force clutch piston out of drum with compressed air. Hold hand over piston to prevent it from being damaged.

Remove clutch-piston inner seal ring from clutch drum and remove the outer seal ring from the groove in the piston.

In addition to checking the gears, drum-hand surface, bushings, needle bearing (new type), thrust faces, piston and bore, and fluid passages, as noted above, also check the clutch plates for scores. Make sure the clutch serrations fit the hub or drum serrations and do not tend to hang up. Replace plates that are not in good condition.

Caution. Front-clutch steel plates and rear-clutch steel plates are not interchangeable.

Steel plates should be checked for coning (dishing in at center) with a feeler gauge. Lay plate on flat surface, cone up, and measure between flat surface and inner edge of plate. Plates coned less than 0.010 inch should be discarded.

c. Reassembly. Lubricate all parts (Type A fluid) and install the piston inner seal in the drum-hub groove and the outer seal ring on the piston. Install piston in drum. Install the four steel and four bronze clutch plates, starting with a steel plate, convex side up. Lubricate plates as you install them.

Install clutch pressure plate, bearing surface down, and secure with snap ring. Make sure ring fully seats in groove. Install release spring and retainer with special tool in arbor press and secure with snap ring.

Then install clutch assembly on the primary-sun-gear shaft, centering the seal rings on the shaft to prevent their breaking.

Install steel, then bronze, thrust washer (Fig. 12-12) on shaft and put two seal rings in grooves of shaft.

4. Front clutch.

a. Disassembly. Remove cover snap ring with a screw driver. Remove turbine shaft from drum and bronze thrust washer from clutch hub. Insert finger in hub and lift straight up to remove hub.

Remove the three bronze and the two steel clutch plates and pressure plate from drum. Put front-clutch release-spring compressor on spring and use an arbor press to compress the spring so the release-spring snap ring and the spring can be removed. Piston is removed with compressed air. Use special nozzle on
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air hose and apply it to one of the clutch-apply holes in the clutch housing (cover other hole with finger). This will force piston out. Then, piston inner seal can be removed from the clutch housing and outer seal from the groove in the piston.

Inspect all parts as already noted. Clutch plates should be free of scores and flat (steel plates not dished as in rear clutch). They should fit serrations in shaft and in housing freely. A new type plate is now in use as shown in Fig. 12-16. It should be installed in place of the older type, as noted.

b. Reassembly. Lubricate all parts (Type A fluid) and install new inner and outer piston-seal rings. Put piston in housing. Make sure steel bearing ring is in place on the piston. Position release spring in clutch cylinder, concave side up. Use compressor tool in arbor press to compress spring so snap ring can be installed.

Put front-clutch housing on primary-sun-gear shaft by rotating the clutch units to mesh rear clutch plates with serrations on clutch hub. Install front-clutch hub with the deep counterbore down. Put bronze thrust washer on hub and then install the pressure plate, bearing surface up. Install three bronze and two steel plates alternately, starting with a bronze plate. Lubricate plates as you install them. Install turbine shaft in clutch and secure with snap ring. Put bronze thrust washer on turbine shaft.

5. Front pump.

a. Types. Two designs of front pump have been used (Fig. 12-17). The new design includes a bushing in the front-pump drive gear. The two designs are interchangeable. However, when re-
placing an old-style pump with the new design having a bushing, replace the old converter hub with a new one having a shorter hub (1P-7915-C).

b. Disassembly. Remove cover attaching screws and cover. Mark top surface of driven gear with prussian blue so you will put it back right side up. Take gears from pump body. Inspect gears, pump body, cover, bearing surfaces, bushings, and crescent for wear scores, or other damage. If damage is found, replace the pump as a unit. Minor burrs and scores can be removed with crocus cloth.

To remove the front seal from the body, bolt the pump body to the case and use special oil-seal remover. Remove pump body and use a seal installer to install a new seal. Seal should seat firmly in pump body.

To reassemble the pump, put outer gear in (mark up), followed by inner or drive gear. Install pump cover, with lock washers and screws. Check pump for free movement.

6. Rear pump. Remove pump cover, mark top faces of both gears with prussian blue so you can put them back right side up, and remove them. Inspect parts as noted above (for front pump). Then replace gears (mark up), if everything is in order, and attach cover.
7. Pressure-regulator body (Fig. 12-18). Remove valves from regulator body. Take out screws and remove cover and separator plate. Wash all parts thoroughly in clean solvent and air-dry. Inspect valves and bores for burrs, scores, or other damage. Make sure all oil passages are free. Check valve fit in bores. Valves should fall freely into the bores when dry.

On reassembly, do not force valves into bores. Follow Fig. 12-18 when reassembling the pressure-regulator body.

8. Control-valve body.

a. Disassembly. Figure 12-19 shows, in detail, all the parts in the control-valve body, and their locations. Follow this illustration if you have any doubts about where the various parts should go.

**Caution:** Proceed with the utmost care and cleanliness when disassembling and reassembling the control-valve body. Slight scores or burrs, or tiny traces of dirt, may cause valves to hang up so the transmission will malfunction. Do not separate the valve bodies until the valves have been removed.
Fig. 12-19. Control-valve body, in exploded views. Top view shows the assembly complete. The arrows then show how it is separated into major subassemblies and finally, at the bottom, completely disassembled. Two views each of the upper valve body, lower valve body, and lower-valve-body cover are shown so that parts removed from both sides can be seen. (Ford Division of Ford Motor Company)
9. Governor (Fig. 12-20). Remove the governor-plate screws and plate. Detach governor from counterweight and slip valve from governor body. Clean all parts in solvent and air-dry them. Check valve and bore for scores. Minor scores can be removed with crocus cloth. If parts are damaged, replace the complete governor. Valve should fall freely into bore. If valve or bore is damaged, replace governor. Make sure mating surfaces between governor and counterweight are smooth and flat. Oil passages must be clear.

To reassemble, install the valve and attach body to counterweight. Make sure fluid passages in body and counterweight align. Attach plate.

10. Front servo (Fig. 12-21). Remove the guide snap ring so guide and piston can be removed from the servo body. The piston is spring-loaded, so hold it while the snap ring is removed. Tap the guide lightly with a soft hammer if it sticks. Guide and piston can be separated and the seal ring removed from the guide. Then, the rings can be removed from the piston.

To assemble the front servo, install spring in servo body and put new large and small seal rings on the servo piston. Put new seal rings on servo guide. Lubricate parts (Type A fluid) and put guide on piston. Then put assembly in servo body and secure with snap ring. Make sure snap ring seals fully in its groove.
11. Rear servo (Fig. 12-22). Use a 3/4-inch pin punch to remove acutating-lever-shaft pin and remove shaft and lever. Push down on servo-spring retainer and remove snap ring. Release pressure slowly and then remove retainer, spring, and piston. Use air pressure in apply passage to force piston out. Remove piston seal ring.

To reassemble, lubricate parts (Type A fluid). Put new seal ring on piston and install piston in body. Install spring (small end against piston), put on spring retainer, compress spring, and install snap ring. You can use a small C clamp to compress the spring. Install actuating lever, socket bearing against piston stem, and secure with shaft and pin.

§158. Inspection of other parts Parts not covered in the disassembly and repair instructions (§§156 and 157) are inspected as follows:

1. Output shaft. Thrust surfaces, journals, and inner bushing must be free of scores. Check internal gear, parking gear, and
speedometer gear for broken or worn teeth. Inspect the aluminum sleeve for leakage or scores. Make sure ring grooves, keyway, drive-ball pocket, and splines are free of burrs or other damage.

2. Distributor and sleeve. Check sleeve bore for scores or excessive ring wear. Check fluid passages for obstructions and the distributor mating surfaces to make sure they are flat and smooth. Check fit of tubes in distributor. Spacer must be on center tube.

3. Pinion carrier. Check band surface, inner bushing, and thrust faces for scores or wear. Check pinions for broken or worn teeth. Pinions should have free movement and 0.010-0.020 inch end play. Pinion pins should fit tightly in the carrier. Fluid passages should be clear.

The carrier is serviced as a unit. Pinions are not separately serviced.

4. Extension housing. Inspect drive-shaft slip-yoke bearing surface for scores and gasket surface for burrs. If there is evidence of leakage around the inspection cover, install a new gasket. Make sure fluid baffle is a tight fit in the housing. If the rear seal is hard, cracked, worn, or shows evidence of leakage, replace it (§155, 8, a).

5. Transmission case. After the linkage has been removed from the case (§159), the case should be cleaned with solvent and air-dried. All passages should be blown out. Check tapped holes for stripped threads and the gasket surfaces and mating surfaces for burrs. Inspect case bushing and center-support bushing for scores and the torsion-lever pin for wear.

§159. Transmission-case linkage (Fig. 12-23) To remove the linkage from the case, proceed as follows. Remove the inner-throttle-lever shaft nut, the inner throttle lever, outer throttle lever, and shaft. Take seal from manual-lever shaft. Remove cotter pins and take off parking-pawl torsion rod. Rotate manual shaft until detent lever clears the detent ball and remove ball and spring (do not allow ball to fly out of case).

Remove manual-lever shaft nut, detent lever, and shaft and lever. Remove torsion-lever clip and washer, and lift torsion-lever assembly from case. Disengage pawl return spring from pawl-link pin and remove pin. Remove pawl pin by working pawl back and forth until pin protrudes from case. Pull pin and remove pawl. Then remove the toggle-link-pin retaining clip, pin, pawl return spring.
Fig. 12-23. Disassembled view of transmission-case linkage. (Ford Division of Ford Motor Company)
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spring retainer, and link. Remove toggle-lever pin by tapping lever toward rear of case and remove plug, toggle-lever pin, and lever. (Pin is held in place by plug.) Remove manual-shaft seal and transmission vent.

Reassembly is the reverse of disassembly. Refer to Fig. 12-23 for relationship of parts. Install a new manual-shaft seal in the case with a special driver. When installing the detent ball and detent lever, use a piece of thin-walled tubing to push the ball down while rotating the detent lever into position. Manual-shaft nut should be tightened to 35–40 lb-ft and the inner-throttle-shaft nut to 25–28 lb-ft.

After assembly is complete, check linkage for free operation.

§160. Reassembly of transmission A subsequent section deals with the disassembly, inspection, and reassembly of the converter. Transmission reassembly follows.

1. General. Mating parts should assemble fairly freely. If they do not, never force them but inspect the parts to find out what is causing the "hang-up." Use new gaskets and seals. Lubricate parts with Type A automatic-transmission fluid to facilitate assembly.

2. Installing pinion carrier. Put front servo band in case, aligning anchor end with anchor in case. Lift clutch assemblies out of bench fixture and install them in case from the rear, positioning band on drum. Hold units together and do not rock clutches since this would damage the seals. Position center support in case, aligning hole in center support with hole in the right-hand side of case. Then install the two support outer bolts, with lock washers. Rolled edges of lock washers must be toward transmission case to insure a tight seal. Tighten bolts to 20–25 lb-ft.

Put rear-servo band in case, strut end up, marked side out. Install bronze thrust washer on thrust face behind primary sun gear. To install pinion carrier, position rear band over it while meshing planet pinions.

3. Rear pump. Install the two seal rings on primary-sun-gear shaft and check for free movement of rings in grooves. Put selective thrust washer on the rear of the pinion carrier, using a little transmission fluid to retain it. Thickness of selective thrust washer is determined by the end-play check (§156, 3).
Install output shaft, meshing the internal gear and pinions. Position the seal rings on the primary-sun-gear shaft with gaps up to prevent breakage while installing output shaft.

Put four seal rings into distributor sleeve and check ring gaps. Position rear-pump drive key in the keyway on output shaft. Position new front and rear gaskets on pump body, retaining them with transmission fluid. Install thrust washer on pump body, bronze side up (make sure thrust-washer tangs align with bosses on pump body). Install rear pump, using care to align drive key with keyway in pump drive gear.


5. Distributor. Install distributor sleeve on output shaft, chamfer forward. Lubricate parts to facilitate assembly. Install distributor and tubes on sleeve, making sure fluid passages align. Install attaching bolts and lock-washers, tightening finger-tight. Install distributor tubes into transmission case until spacer on the center tube is against the case. Tighten attaching bolts to 8–10 lb-ft.

6. Extension housing. Position speedometer drive-gear ball in pocket in output shaft, retaining it with fluid. Install speedometer drive gear, chamfered side toward front of transmission. Install gear snap ring. Insert extension-housing oil-seal replacer and pilot in the housing and install the housing on the transmission case. Install attaching bolts and lock washers, finger-tight. Rolled edges of lock washers must be toward the case to insure a tight seal.

Install a new seal ring on the rear-pump discharge tube and install the tube with special tool. Tube must be below the surface of the case. Tighten attaching bolts to 30–35 lb-ft. Install inspection cover with a new gasket.

7. Front pump. Put a new gasket in counterbore of case, install the front pump (aligning dowel and dowel hole) and secure with bolts and lock washers, tightened to 17–22 lb-ft.

8. Transmission end play. Transmission end play should be re-checked at this point as detailed in §156, 3.

9. Servos, pressure-regulator and control-valve bodies. Install as noted in §155.
10. Servo adjustments. Adjust front and rear servos as already noted (§153, 11 and 12).

11. Oil-screen and pan installation. Install oil screen and pan as noted in §153.

§161. Converter overhaul To obtain a more positive seal between the converter cover and the impeller, a new design using an O ring instead of a gasket has been adopted. The new and old covers and impellers are not interchangeable. On reassembly, the converter drive plate must be properly installed on the converter cover or balance will be lost. Correct drive plate position, on both the old and new covers, is shown in Fig. 12-24. Another change that has been made was to cone out the bottom surface of the bolt heads. This change was made since the new design more effectively retains its tightness.

1. Converter removal. To remove the converter from the transmission, grasp it with both hands and pull it straight out. Do not rock it as this could damage the front seal. Converter housing can be removed from the transmission case by removing attaching bolts.

2. Disassembly (Fig. 8-18). To disassemble the converter, put the assembly in special holding fixture, note locations of pump and cover aligning marks, and remove the converter-cover attaching nuts and bolts. Remove cover and gasket or O ring. Take bronze thrust washer from turbine and lift turbine from impeller (also called pump). Note position of stator and lift it from impeller. Remove thrust washer from pump hub. Stator is disassembled by removing the clutch inner race, snap ring, outer hub, sprag assembly, and outer race (Fig. 12-25). Now, snap ring and inner hub can be removed.

Impeller (pump) is disassembled by removing the bolts, hub, and seal (in hub).

3. Inspection. All blades should be inspected for looseness or distortion. Thrust surfaces must be free of scores and turbine splines in good condition. Seal surfaces, front-pump driving lugs, and mating surfaces must be in good condition. Sprag assembly should be inspected for worn or broken sprags or damaged springs.

4. Assembly. Install stator inner hub and snap ring, turn assembly over and install outer race in stator, followed by sprag
assembly (Fig. 12-26). Sprags must point in correct direction. Install outer hub and snap ring. Insert inner-race replacer tool, tapered side first, into the sprag assembly while rotating the tool counterclockwise to position the sprags (right in Fig. 12-26). Install inner race, spline section up. Guide the tool with the hand while pushing the inner race into position. Hold inner race and turn stator. It should turn clockwise only.

Install a new seal on the impeller hub and put hub into impeller. Tighten hub-to-impeller screws to 8-10 lb-ft. Put thrust washer into the hub of the impeller.

Install stator (“Front” mark up). Install thrust washer in hub of turbine, retaining it in place with transmission fluid. Install turbine. Put bronze thrust washer on turbine hub and install converter cover, [494]
using a new gasket or O ring. Note position of cover- and impeller­aligning marks; align and secure cover with 28 cover bolts tightened to 25–28 lb-ft.

5. **Installation.** Position converter housing on transmission case and secure with attaching bolts, tightened to 40–45 lb-ft. Install converter assembly in housing. Do not rock converter while installing it; this could damage the front seal.

**CHAPTER CHECKUP**

**NOTE:** Since this is a chapter review test, you should review the chapter before taking it.

You have completed another of the several chapters in the book that describe the trouble-shooting, removal, overhaul, and replacement of various automatic transmission in use on modern automobiles. Studying these chapter helps you in several ways. You become more familiar with the construction and operation of the various automatic transmissions. You note the similarities and differences between them. You learn how to spot troubles in them. You learn the fundamental service operations required. With this knowledge in mind, you are equipped to enter the service shop and, following the specific and latest instructions from the manufacturer (as noted in his shop manual), service any automatic transmission.

The test that follows will help you to review the chapter just completed. Further, it will help you to remember the important facts in the chapter by bringing them, once again, to your mind as you answer the questions. Write the answers in your notebook.

**Correcting Parts Lists**

The purpose of this exercise is to enable you to spot the unrelated parts in a list. For example, in the list, *driving member, driven member, pump, turbine, wheel,* you can see that *wheel* does not belong because it is the only item that is not part of a torque converter. In each of the lists below, you will find one item that does not belong. Write down each list in your notebook, but do not write down the item that does not belong.

1. Subassemblies that can be removed with the Fordomatic still in the car include: governor, front servo, rear servo, pinion carrier, control-valve body, pressure regulator.
2. Parts that must be removed before the front servo is removed include: oil pan, oil screen, lubrication tube, rear servo.
3. Parts that must be removed before the rear servo is removed include: oil pan, oil screen, lubrication tube, front servo, rear band.
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4. Parts that must be removed before the control valve body is removed include: oil pan, oil screen, U tubes, front servo, valve-body bolts.
5. Parts that must be removed from the car with the eight-cylinder engine as the transmission is removed include: starting motor, frame cross member, converter-housing cover, carburetor.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. Front and rear bands can be adjusted on the car only off the car only on or off the car only
2. During the stall test, the throttle should not be held wide open for more than 5 seconds 15 seconds 30 seconds 5 minutes
3. The front band is adjusted by means of an adjusting nut shims an adjusting screw a tapered pin
4. The rear band is adjusted by means of an adjusting nut shims an adjusting screw a tapered pin
5. The clutches have screw adjustments have shim adjustments are not adjustable
6. During the stall test, if the pressures are correct but slippage occurs, then adjust bands adjust clutches adjust valves adjust throttle
7. When the transmission only is being installed and attached to the converter housing, alignment is maintained by use of two guide pins pilot rod a special jig an extension bearing
8. During disassembly of the transmission, all parts should be cleaned with clean wiping cloths hot soda cleaning solvent acid-type cleaner
9. The selective thrust washer which determines the end play in the transmission is located on the front of pinion carrier rear of pinion carrier extension housing front bearing
10. Instead of a gasket between the converter cover and impeller, the later design of torque converter uses a sealing O ring a spring gasket sealing compound a flat gasket

Troubles and Service Procedures

In the following, you should write down in your notebook the trouble causes and service procedures asked for. Do not copy the procedures from
Fordomatic and Cruise-O-Matic Service

The book; try to write them in your own words. Writing them down in your own words will help you to remember the procedures. And, of course, having the procedures well in mind is of great value to you in the service shop.

1. Make a list of various abnormal operating conditions as listed in Fig. 12-2 and their possible causes.
2. List possible causes of noise in the transmission.
3. List possible causes of oil leakage from the transmission.
4. Describe the procedure of road-testing the car. Of stall-testing the transmission.
5. Describe the procedure of adjusting the bands.
6. Explain how to remove and replace the transmission assembly.
7. List the major points of disassembling the transmission assembly.
8. List important points to keep in mind when inspecting the components of the transmission during disassembly.
9. Describe the assembly procedure on the transmission.
10. Explain how to overhaul the converter.

SUGGESTIONS FOR FURTHER STUDY

Study the shop manuals that describe the different models of Fordomatic transmissions. If possible, gain experience in the removal, overhauling, and replacement of this transmission by watching and assisting in the procedures at a local service shop handling this work. Your local school automotive shop may have these transmissions available for student practice overhaul; such practice is an excellent way of learning more about the transmission. Try to get copies of the various diagnosis guides issued by the transmission manufacturers. Study them carefully since they show in outline form various transmission troubles, causes and remedies. In addition, if you will make lists of possible troubles, and their causes (as asked for in the chapter checkups), you will fix more firmly in your mind the essential points you should remember about the transmissions and their servicing problems.
13: Powerflite and Torqueflite service

This chapter describes the trouble-shooting, maintenance, and overhaul procedures on the Powerflite and Torqueflite transmissions used on Chrysler, De Soto, Dodge and Plymouth automobiles. See Chap. 8 for the construction and operation of these transmissions.

§162. Diagnosing transmission troubles Figure 13-1 is a trouble-shooting chart on the Powerflite, and Fig. 13-2 is a similar chart on the Torqueflite. To determine possible causes of a trouble, first find the vertical column headed with the trouble being experienced; then run down the column and note the black dots. Items to check are on the lines to the left of the black dots.

1. Road tests. A complete diagnosis requires a road test as well as hydraulic-control-pressure checks. Following sections describe these checks.

2. Push-starting. To push-start a car with a Powerflite transmission, turn ignition on, put transmission in neutral, push car at a speed of 25 mph, and shift to low. This allows the car to drive the engine through the transmission. With the Torqueflite, turn ignition on, put transmission in low, open throttle slightly, and push car to 15 mph or faster. Push, rather than tow, the car. If car is towed, it might start suddenly and ram the car ahead.

§163. Oil level checks

1. Oil level. Check oil level every 1,000 miles by setting hand brake, starting engine, and idling with transmission in neutral until operating temperature is reached. Shift transmission through all ranges and then back to neutral. Then remove oil-level indicator, wipe it, insert it, and remove it again to determine oil level. Add oil (use only automatic-transmission fluid Type A) as necessary to bring oil up to "Full" mark.

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2. Changing oil. Transmission oil should be changed every 20,000 miles.

a. Drain transmission by removing oil-pan drain plug. Drain converter by removing flywheel access plate from bottom of housing and then rotating torque converter until the converter-drain plug can be removed. After oil is drained out, replace plugs. Use new plug gaskets if old ones are not in good condition. Tighten torque-converter plug to 45–50 lb-ft (pound-feet) and the oil-pan plug to 20–25 lb-ft. Install access plate.

Fig. 13-1. Trouble-diagnosis chart for Powerflite. Capital-letter items may be performed without removing transmission. Small-letter items require removal of transmission. (Dodge Division of Chrysler Corporation)
FIG. 13-2. Trouble-diagnosis chart for Torqueflite. Capital-letter items may be performed without removing transmission. Small-letter items require removal of transmission. (Dodge Division of Chrysler Corporation)

b. To refill, apply hand brake and add enough automatic-transmission fluid Type A to bring level to full mark on indicator (about five quarts). Run engine at idle speed in neutral for about two minutes. Add enough fluid to bring level back up to full (about eight quarts in all). Allow engine to idle until it
reaches operating temperature. Check oil level as in 1, above, and add more oil if necessary.

**Caution:** When replacing oil-level indicator, make sure it is properly seated in the filler tube so dirt cannot enter.

3. **Checking for leaks.** If the transmission is leaking oil, consider the following points. Some leaks can be repaired with the transmission in the car; others require removal of the transmission, as noted.

a. Leaks repairable in the car by tightening plugs or screws or replacing faulty gaskets, seals, or plugs:
- Transmission output-shaft rear oil seal.
- Speedometer pinion assembly in rear extension.
- Oil-pan drain plug.
- Around oil pan where it fits on case.
- Regulator-valve and converter control-valve plug.
- Governor, line, and throttle-pressure pipe plugs in case.
- Fittings in oil-cooler lines.
- Converter drain plug—allows leakage into converter housing. (Since engine oil could also leak into the housing if the engine rear oil seal is defective, first determine whether it is engine oil or transmission fluid. Transmission fluid Type A has a slightly sulfurous odor.)

b. Leaks requiring removal of the transmission so loose bolts can be tightened or faulty parts replaced:
- Sand holes in case or front oil-pump housing.
- Front oil-pump screws loose or sealing washers damaged.
- Torque-converter impeller-hub seal (on forward end of front oil-pump housing)—also called front oil-pump-housing dust seal.
- Front oil-pump-housing seal (on outside diameter of pump housing).

**§164. Selector-lever or push-button adjustments.** On cars with selector levers, the manual valve must move into the proper positions when the selector lever is shifted. Adjustment is made by increasing or shortening the linkage between the manual control lever on the transmission and the selector lever. Refer to the applicable car
manual for details of the adjustment. On cars with push buttons, the adjustment is made by loosening the adjusting clip screw at the transmission and shifting the cable in or out to find the center of free travel. Then the screw is tightened. During this procedure, the manual valve lever must be held in reverse. This requires draining of some fluid from the transmission and removal of the neutral starting switch so a screwdriver can be inserted to hold the lever in reverse.

As an example, the adjustment procedure on a late-model Plymouth equipped with push button controls follows. The cable-bracket screw hole is elongated to permit adjustment. Loosen the cable-bracket screw sufficiently to permit the cable to slip. Have someone hold the low (L) speed push button in. Make sure the push button is pushed all the way in to its full length of travel so that there is no backlash from the cable actuator (a part of the push-button control unit). Then carefully position the cable bracket in the cable bracket recess on the cable and tighten the screw. Check the operation of the push buttons to make sure that the valve is being moved into the correct positions as the buttons are operated. The cable can be disconnected, if necessary, from either the push-button assembly or the transmission. As a rule, the only time the cable need be disconnected would be for removal of the transmission from the car.

§165. Throttle-linkage and pressure adjustments  The throttle is linked to the throttle valve in the transmission. This valve varies
hydraulic pressure to various components in the transmission so as to control upshifts. Thus at light throttle, upshifts will occur at lower car speeds than at heavy throttle. Proper adjustment of the linkage is therefore quite important. Adjustment procedure varies with different model cars and transmissions. As a first step, engine idle must be accurately set to specified rpm. Then the linkage must be adjusted to give the proper angle between the throttle pedal and the floor. Next a gauge must be connected to the transmission throttle-pressure test hole (Figs. 13-3 and 13-4). The pressure at which a shift occurs can then be determined. To adjust this pressure on the Powerflite, an adjusting screw plug (Fig. 13-3) is removed so the adjusting screw can be turned (this requires a special screw wrench). On the Torqueflite, the transmission must be drained and the oil pan removed. Then a gauge is used to adjust a stop screw on the throttle valve lever.

§166. Transmission-band adjustments. The two bands on the transmission, the kick-down (or front) band and the reverse (or rear) band, are adjusted as follows:

1. Kick-down-band adjustment. On some cars there is an access hole under the front floor mat through which the kick-down band can be adjusted (on other cars adjustment must be done from under the car). Cover is removed from access hole after accelerator pedal and floor mat are removed. Then a special adjusting tool is used to loosen the band adjusting-screw lock nut (Fig. 13-5). If adjusting screw (Figs. 13-3 and 13-4) is free, tighten it to 60–72
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lb.-in. (pound-inches) on Powerflite or 70-75 lb-in. on Torqueflite. Then use counter on the special tool and back out adjusting screw 3 turns (3½ turns on Torqueflite). Next hold screw stationary and tighten lock nut securely. Replace access-hole cover, floor mat, and accelerator pedal.


Tighten adjusting screw 10 turns, hold it, and tighten adjusting screw lock nut. Replace oil pan and refill transmission.

3. Low-reverse-band adjustment (Torqueflite). Loosen lock nut and back off low-reverse-band adjusting screw (Fig. 13-4) 5 turns. Check for freeness of screw. Tighten to 70-75 lb-in. Back off screw 2½ turns and tighten lock nut.

§167: Road tests Before road-testing the transmission, be sure the fluid level in the transmission and the engine idle are correct. Also, make sure that the engine is in good condition; a draggy engine [504]
may cause faulty shifting and other abnormal operating conditions in the transmission.

**Caution:** Obey all traffic laws and drive carefully when road-testing a car. If a chassis dynamometer is available, the operation of the transmission can be checked without taking the car out on the road. See Appendix.

Operate the car at various speeds and throttle openings to note when upshifts and downshifts occur. Actual speeds at which shifts will occur vary somewhat owing to production tolerances in the transmission and car. However, the quality of the shift should be smooth, quickly responsive, and without engine runaway. Shift patterns on the Dodge with Powerflite and with Torqueflite are given below.

### SHIFT PATTERN IN MPH (POWERFLITE)

<table>
<thead>
<tr>
<th>Upshift</th>
<th>Downshift</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light throttle</td>
<td>Wide-open throttle</td>
</tr>
<tr>
<td>13-19</td>
<td>51-61</td>
</tr>
<tr>
<td>13-18*</td>
<td>41-46*</td>
</tr>
</tbody>
</table>

* Six cylinders.

### SHIFT PATTERN (TORQUEFLITE)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Shift</th>
<th>MPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed throttle</td>
<td>1-2 upshift</td>
<td>7-11</td>
</tr>
<tr>
<td>Closed throttle</td>
<td>2-3 upshift</td>
<td>11-15</td>
</tr>
<tr>
<td>Wide-open throttle</td>
<td>1-2 upshift</td>
<td>27-42</td>
</tr>
<tr>
<td>Wide-open throttle</td>
<td>2-3 upshift</td>
<td>59-71</td>
</tr>
<tr>
<td>3-2 kick-down limit</td>
<td></td>
<td>51-64</td>
</tr>
<tr>
<td>3-1 kick-down limit</td>
<td></td>
<td>25-32</td>
</tr>
<tr>
<td>Closed-throttle downshift</td>
<td></td>
<td>6-10</td>
</tr>
</tbody>
</table>

§168. **Hydraulic-pressure checks** Figures 13-3 and 13-4 show the points at which hydraulic pressure checks can be made. These
checks include line pressure, throttle pressure, governor pressure, and lubrication pressure. Since the first three of these vary with engine speed, the pressures must be checked at varying speed. Also, the throttle pressure must be checked at varying throttle openings.

Caution: Torqueflite must not be stalled! Line pressure on the Powerflite is checked at low engine speed with the transmission stalled.

Compare pressures noted with the specifications in the applicable shop manual.

SERVICING THE POWERFLITE

§169. Removal and replacement of subassemblies A number of the component parts of the transmission can be removed and replaced without removal of the transmission from the car.

1. Oil pan. To remove oil pan, drain transmission, take off filler tube from oil pan, remove screws and washers, oil pan, and gasket. Use new gasket when replacing oil pan and tighten screws to 12-17 lb-ft. Refill transmission (§163).

   
a. Removal. Remove oil pan and disconnect throttle-valve lever and manual-control-lever linkages from lever. Loosen the two lever-assembly locking screws. Slide manual-valve lever off its shaft and remove felt retainer and felt. Slide manual-valve lever off its shaft and remove shaft-seal cover. Remove two oil-strainer support screws and washers and the oil-strainer assembly. Remove the five transfer-plate screws and washers and take valve-body-and-transfer-plate assembly off (Fig. 13-6). The assembly is serviced as noted in §172.

b. Replacement. Make sure the mating surfaces on the transmission case and transfer plate are smooth and free of burrs. Put valve-body-and-transfer-plate assembly in position and secure with five screws and lockwashers. Note that two of the screws are 1½ inches long; these go through the transfer-plate cover on the valve body. The other three screws are 1½ inches long. Tighten screws down evenly to 12-17 lb-ft.

Make sure the two oil-strainer tube seals are in place and put oil strainer in position, entering the oil tubes into the valve body. Secure with two screws and lock washers, tightening to 12-17 lb-ft.
Slide manual-valve-lever-shaft seal on shaft, followed by lever (arm side of lever against cover). Tighten locking screw. Put throttle-valve camshaft felt and retainer on throttle-valve shaft, followed by lever. Tighten locking screw.

Check operation of controls by shifting into the four positions. Check operation of throttle-valve lever. Note if normal contact is made with neutral starter and backup-light switches. Then replace oil pan and adjust throttle and selector-lever linkages.

3. Oil seal on manual-control-valve lever shaft. If this seal requires replacement, first remove valve-body-and-transfer-plate assembly, as above. Then drive seal out of transmission case from below. Use special tool, start new oil seal squarely and tighten tool unit until it is flush with case. Seal is then correctly positioned. Replace parts that were removed.

   a. Removal. Remove oil pan and valve-body-and-transfer-plate assembly as already noted. Loosen lock nut and back off the kick-down-band adjusting screw sufficiently to permit removal of the kick-down-band strut (compress band ends).
With kick-down-band lever hanging down, install special tool and apply sufficient pressure on the kick-down-rod guide so snap ring can be removed (Fig. 13-7). Then back off the screw on the tool so the piston-rod guide, spring, piston-rod assembly, and piston cushion spring can be removed. Expand snap-ring pliers inside piston to remove piston. Refer to §172 for servicing and inspection of the piston.

Fig. 13-7. Removal of kick-down piston-rod-guide snap ring with transmission in car. (De Soto Division of Chrysler Corporation)

b. Replacement. Make sure the two interlocking seals are locked in place. Coat all seals with Lubriplate. Put piston into transmission case. Apply slight pressure to piston and at the same time carefully compress bottom seal so piston will enter case.

Caution: After bottom seal has entered, piston will seem to hang at two different locations as it goes on into case. This is due to seals entering the cylinder. Do not force the piston!

Slide piston spring over piston-rod assembly, balance the piston cushion spring on rod assembly (Lubriplate will help hold it in place), and install the piston-rod guide assembly over the rod assembly. Then use the special tool (Fig. 13-7) to install assembly [508]
in case. Compress piston spring to point where the piston-guide seal slightly binds on transmission case. Then work seal into position and continue to compress spring until seal enters case and snap ring can be installed. Make sure snap ring is fully seated in its groove. Remove the tool. Hold one end of kick-down band over adjusting screw, compress the band, and install the strut between the band and band lever. Strut slot must engage strut pin in band end.

Install valve-body-and-transfer-plate assembly and oil pan as above. Adjust kick-down band (§166).

5. Reverse servo.
   a. Removal. Remove oil pan and valve-body-and-transfer-plate assembly as already noted. Loosen lock nut and back servo adjusting screw out enough to permit removal of the reverse-band strut (compress band ends). Then remove reverse-servo piston sleeve.
   
   Mount special tool on transmission case (as shown in Fig. 13-7) and compress reverse-piston spring retainer. Use a screw driver to remove retainer snap ring. Then release pressure and remove spring retainer, spring, piston-and-valve assembly. It may be necessary to guide the retainer so it does not catch in the snap-ring groove. Spring and valve may be removed from the piston by removing the snap ring. See §172 for servicing and inspection of the piston.
   
   b. Replacement. Install valve and spring in piston and secure with snap ring (shaft on valve protrudes through hole in bottom of piston). Coat piston ring with Lubriplate. Insert piston-and-valve assembly in case in a cocked position and then rotate piston while entering it into case. This permits the ring to enter without damage.

   Put piston spring and then spring retainer over piston. Use special tool (Fig. 13-7) to compress spring so snap ring can be installed. Guide the retainer into position so it does not catch on snap-ring groove. Remove special tool and install piston sleeve. Make sure sleeve slides freely on piston by working it up and down. Hook one end of reverse band in reverse-link assembly and compress the other end so strut can be installed. Then adjust reverse band (§166). Install valve body and oil pan.

6. Speedometer pinion. The speedometer pinion is removed by disconnecting the speedometer cable and housing from the sleeve assembly on the transmission and then using a wrench to take out
the pinion and sleeve assembly. On replacement, tighten it to 40–45 lb-ft. Reconnect cable and housing to sleeve assembly.

7. Neutral starter and backup-light switches. Transmission must be drained before these are removed. Then disconnect wires and switch and remove switch. On replacement, put new gasket on switch and tighten to 15–20 lb-ft. Reconnect wires and refill transmission.

8. Output-shaft rear-bearing oil seal.
   a. Removal. Disconnect front propeller-shaft universal joint and attach shaft to frame where it is out of the way. Apply hand brake and remove the propeller-shaft flange nut, shakeproof washer, and washer. Release hand brake. Install brake-drum puller and remove shaft-flange-and-drum assembly. Remove the small transmission-support grease-shield spring and take the brake-support grease shield from the extension housing. If you use a screw driver or other sharp tool to do this last step, be careful to avoid damaging the sealing surface at the bottom of the shield. Install special puller and pull the output-shaft rear-bearing oil seal.
   b. Replacement. Use special seal driver to install a new oil seal.
      Put brake-support grease shield on extension housing. Make sure the indent on the grease shield matches the groove in the housing and that shield goes on far enough to permit installation of the spring. Put spring in place, opening in spring toward adjusting sleeve. Make sure spring seats in the groove. Install brake-drum assembly, first making sure the brake adjustment is backed off sufficiently. It may be necessary to use special tool to press the drum assembly on the output shaft. Install propeller-shaft flange washer, shakeproof washer and nut. Adjust hand brake, apply hand brake, and tighten nut to 140–160 lb-ft. Connect universal joint.

9. Transmission regulator-valve assembly. Remove regulator-valve spring retainer, gasket, and spring (Fig. 13-3). Use a piece of welding rod inserted in the end of the valve to remove it. See §172 for inspection procedure. To replace valve, put it into valve body and install spring, gasket, and retainer and tighten to 45–50 lb-ft.

10. Torque-converter control-valve assembly. Remove control-valve spring retainer, gasket, and spring (Fig. 13-3). Use a piece of welding rod inserted in the end of the valve to remove it. See §172 for inspection procedure. To replace the valve, put it into [510]
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position and install the spring, gasket, and retainer. Tighten to 35-40 lb-ft.

11. Oil cooler.
   a. Removal. Drain water from radiator and remove the following: battery and battery pan, lower radiator-to-oil-cooler water hose, inlet and outlet oil tubes, and flange bolts connecting oil cooler to water pump.
   b. Replacement. Clean mating surfaces thoroughly. Use a new gasket and attach oil cooler to water pump with flange bolts. Install inlet and outlet oil tubes, lower radiator-to-oil-cooler water hose, battery pan, and battery. Refill radiator. Start engine and check for water or oil leaks.

§170. Removal and replacement of transmission The procedure that follows covers, in general, all cars using the Powerflite transmission. However, there may be some variations due to differences in vehicle design.

1. Removal
   a. Disconnect battery and raise car off floor.
   b. Drain transmission and converter. Replace and tighten plugs. Remove filler tube from oil pan.
   c. Disconnect front propeller-shaft universal joint and attach shaft to frame where it is out of the way. Remove adjusting-screw cover plate and cable clamp bolt from hand-brake support. Disengage the ball end of the cable from the operating lever and remove cable from brake support.
   d. Disconnect speedometer cable from transmission extension. Disconnect wires from neutral starter and backup switches. Unclip wires from cross member.
   e. Disconnect linkages from throttle and manual control levers.
   f. Disconnect the two oil-cooler lines from the transmission.
   g. Remove the two screws and lock washers attaching the exhaust-pipe bracket to the transmission case.
   h. Remove the bracket holding the oil-cooler lines to the cylinder block.
   i. Remove the two nuts and lock washers that hold the engine rear-support insulator to the cross member, leaving insulator attached to transmission.
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\(j\). Install engine support fixture. Insert hooks of fixture firmly in holes in side of frame member with support ends up against the underside of the oil-pan flange. Adjust fixture to support the weight of the engine.

\(k\). Raise engine slightly, remove cross-member-to-frame bolts and the cross member. Then lower engine for following operations.  

\textbf{Caution:} Do not lower engine more than 3 inches from floor boards. Lowering it more than this would disrupt the set positions of the water hose and other items attached to the engine.

\(l\). Remove the two upper transmission-case-to-adapter screws and lock washers and install guide studs. Position transmission jack.

\(m\). Remove the two lower transmission-case-to-adapter screws and lock washers and slide transmission straight back on guide studs. The studs prevent damage to the converter driving sleeve. Lower transmission from car.

\(n\). If the front oil-pump drive sleeve remains in the torque-converter hub, remove and examine it. Inspect the driving lugs and machined surfaces for burrs and wear. Check ring for broken ends and freeness in a ring groove.

\(2. \ \textit{Replacement}\)

\(a\). Install guide studs in the two upper transmission-case-to-adapter screw holes. Lubricate front oil-pump drive sleeve ring and bearing surfaces with Lubriplate. Install sleeve in torque-converter hub, making sure driving lugs are properly engaged. Note position of driving lugs on front oil-pump drive sleeve and position from oil-pump pinion accordingly so alignment will be correct during transmission installation.

\(b\). Lift transmission and slide it forward over guide studs. Make sure driving lugs on oil-pump drive sleeve properly engage the pump pinion.

\textbf{Caution:} Do not attempt to use the transmission attaching screws to bring the transmission into position. If transmission will not slide forward into position, chances are the oil-pump lugs are not lined up properly. Realign the oil-pump pinion and try again.

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c. Install the two lower case-to-adapter screws and lock washers but do not tighten. Then remove the guide studs and install the upper screws and lock washers. Tighten all four to 45-50 lb-ft.

d. Put cross member into place and attach with frame bolts, tightened to 50-55 lb-ft.

e. Lower engine, aligning mounting holes in transmission extension with holes in cross member. Install the two nuts and lock washers that hold the rear engine-support insulator to the cross member and tighten to 30-35 lb-ft.

f. Remove engine-support fixture.

g. Install bracket holding oil-cooler lines to cylinder block. Attach exhaust-pipe bracket to transmission case with two screws and lock washers.

h. Install the two oil-cooler lines in transmission and tighten to 5-7 lb-ft. Install filler tube and tighten nut to 35-40 lb-ft.

i. Connect throttle- and manual-control linkages, neutral-starter and backup-switch wires, and speedometer cable.

j. Engage ball end of hand-brake cable in operating lever and install cable clamp bolt. Install adjusting-screw cover plate on hand-brake support.

k. Install propeller shaft and tighten nuts to 33-37 lb-ft.

l. Refill transmission, connect battery, and adjust manual- and throttle-control linkages.

§171. Removal and replacement of torque converter

1. Removal. First remove the transmission as noted in the previous section and then proceed as follows:

a. Turn front wheels to extreme right and remove starting motor.

b. Remove the transmission case adapter by taking out 12 screws and lock washers.

c. Remove lower half of flywheel housing.

d. If torque converter is being removed because of excessive run-out, use a dial indicator to check run-out and mark point of highest run-out on both the converter and the crankshaft flange. Then, when the converter is off, the flange can be checked to determine if the run-out is due to the converter or flange.

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e. Use special long wrench to reach up and remove the eight converter stud nuts and lock washers. Converter can now be slid back and removed from crankshaft.

f. Check crankshaft flange for run-out. It should not exceed 0.002 inch.

2. Repair. The only repair that can be made to the torque converter is removal and replacement (by welding) of the ring gear.

3. Replacement. Inspect mating surfaces of torque converter and crankshaft flange for burrs and dirt. Install torque converter and secure with the eight lock washers and stud nuts, tightened evenly and securely.

Check converter run-out which should not exceed 0.005 inch.

Install lower half of flywheel housing, starting motor, and adapter case. Tighten adapter-case screws to 25–30 lb-ft.

Install transmission and refill as already noted.

§172. Transmission disassembly and inspection (Fig. 13-8)

1. General. Cleanliness is of the utmost importance in transmission overhaul. The unit should be thoroughly cleaned when first removed from the car, preferably by steam. During disassembly, all parts should be washed in cleaning solvent and air-dried with compressed air. Never use wiping cloths! Particles of lint may adhere and cause operational failure after the unit is reassembled.

Handle all parts carefully since nicking or burring of finished surfaces may prevent normal operation. Crocus cloth can be used to smooth away burrs or nicks, provided it is used carefully. When using it on valves, do not round off the sharp edges.

Lubricate all bearings and gears, on reassembly, with automatic-transmission fluid, Type A, unless otherwise specified. Use Lubriplate on all seals, rings, thrust washers and gaskets. Always use new gaskets.

If the transmission being overhauled has considerable mileage on it, use new sealing rings during reassembly. Never take a chance with worn or damaged sealing rings.

Make sure snap rings seat fully in their grooves.

If mating parts do not go together easily, don't try to force them. Instead, check to find the reason.
1. Kick-down-sun-gear snap ring
2. Kick-down-planet-pinion-carrier thrust washer
4. Direct-clutch driving disk assemblies
5. Direct-clutch hub
6. Direct-clutch spring-retainer snap ring
7. Direct-clutch spring, retainer
8. Direct-clutch spring
9. Direct-clutch piston
10. Direct-clutch-piston seal ring
11. Direct-clutch piston retainer
12. Reverse-band adjusting screw
13. Kick-down-band strut
14. Kick-down-band lever
15. Kick-down-band lever shaft
16. Kick-down-band lever-shaft plug
17. Kick-down band
18. Direct-clutch piston-retainer thrust washer
19. Torque-converter reaction-shaft seal rings
20. Torque-converter reaction shaft
21. Neutral starter switch
22. Neutral starter-switch gasket

Fig. 13-8. Disassembled view of Powerflite transmission. (De Soto Division of Chrysler Corporation)
23. Transmission case
24. Oil-pan gasket
25. Reverse-servo piston ring
26. Reverse-servo piston
27. Reverse-servo piston valve
28. Reverse-servo piston-rod guide
29. Reverse-servo-rod piston SPRING snap ring
30. Reverse-servo-piston sleeve
31. Reverse-servo-rod guide snap ring
32. Reverse-servo-rod guide spring retainer snap ring
33. Reverse-servo-rod guide spring retainer ring
34. Kick-down-piston-rod guide seal ring
35. Kick-down-piston-rod guide snap ring
36. Valve-body-and-transfer-plate assembly
37. Oil-strainer assembly
38. Oil pan
39. Oil-pan-screw-and-washer assembly
40. Oil-pan drain-plug gasket
41. Oil-pan drain plug
42. Oil-pan filler tube
43. Oil-pan filler-tube bracket
44. Oil-valve indicator

45. Kick-down-piston-rod guide
46. Kick-down-piston spring
47. Kick-down-piston rod
48. Kick-down-piston ring–large
49. Kick-down-piston cushion spring
50. Kick-down piston
51. Kick-down-piston ring–intermediate
52. Kick-down-piston ring–small
53. Regulator-valve spring retainer
54. Regulator-valve spring-retainer gasket
55. Manual-valve lever-shaft oil seal
56. Regulator-valve spring
57. Regulator-valve spring seat
58. Regulator valve
59. Torque-converter control-valve spring retainer
60. Torque-converter control-valve spring-retainer gasket
61. Front-oil-pump housing seal
62. Front-oil-pump housing
63. Front-oil-pump housing dust seal
64. Front-oil-pump drive sleeve
65. Front-oil-pump drive-sleeve seal ring
66. Front-oil-pump housing screw and lock washer
67. Front-oil-pump pinion
68. Front-oil-pump gear
69. Regulator-valve body
70. Torque-converter control valve
71. Torque-converter control-valve spring
72. Reaction-shaft-to-case screw
73. Reaction-shaft dowel
74. Torque-converter reaction-shaft seal
75. Backup-light-switch
76. Backup-light-switch gasket
77. Reaction-shaft-to-case screw lock washer
78. Throttle-valve adjusting screw plug
79. Manual-valve-lever screw nut
80. Manual-valve lever
81. Throttle-valve operating-lever screw nut
82. Throttle-valve operating lever
83. Throttle-valve operating-lever screw and lock washer
84. Throttle-valve camshaft felt retainer
85. Throttle-valve camshaft felt
86. Manual-valve-lever screw
87. Manual-valve-lever screw lock washer

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2. Preliminary disassembly. Put transmission in stand. Remove oil pan and valve-body-and-transfer-plate assembly as explained in §169. Note that the two lever assemblies are removed also as well as the oil-strainer assembly.

Put valve body in special stand for further disassembly and service.

Remove neutral starter and backup switches.

Check transmission end clearance with a feeler gauge or with a dial indicator (Fig. 13-9). This is done by moving the direct-clutch assembly and carrier housing to the rear and then prying the clutch forward by carefully inserting a screw driver between the clutch and carrier housing. Then remove the screw driver and measure again. Clearance should be between 0.043 and 0.069 inch. If clearance is outside of these limits, then another direct-clutch piston-retainer thrust washer of the proper thickness must be installed (§173, 12).


a. Removal. Use special tool to hold flange and remove the flange nut; lock washer and washer. Remove brake drum with [518]
special puller. Remove brake-support grease-shield spring. This spring acts as a guide for the brake shoes and also holds the grease shield to the transmission extension housing. Put a rubber band around the brake shoes to hold them in position and remove the brake-shoe return spring. Remove the anchor-shoe washer and guide. Then remove brake shoes, adjusting sleeve, nut, screw, and operating-lever link. Remove the other brake-shoe guide from the anchor. Take grease shield from extension housing. Remove this shield with care. Do not use a sharp-pointed instrument that could damage the sealing surface at the bottom of the shield. Slide the brake support from the extension housing and anchor.

b. Inspection. Check drum for scores and linings for wear. Inspect sealing surfaces to make sure they are smooth. Drum must be turned or ground if it is excessively grooved or rough. Linings, if badly worn, must be replaced. Another book in the McGraw-Hill Automotive Mechanics Series (Automotive Chassis and Body) covers these operations.

Remove the speedometer drive pinion. Then use puller to remove the output-shaft rear-bearing oil seal. Remove seven screws and lock washers holding extension housing to case. Install two guide studs on opposite sides of extension housing and use special puller to pull housing (Fig. 13-10). Remove housing gasket.

5. Governor removal and disassembly.
Use a sharp tool, such as an ice pick to remove one of the governor-valve-shaft snap rings. Valve shaft and valve will now come out of governor body. Use snap-ring pliers to remove large governor-weight snap ring. Take out governor weight. Then remove secondary-weight snap ring. Keep thumb pressure against secondary weight when removing its snap ring since it is spring-loaded. Remove secondary weight and spring. Remove governor locating screw and slide body and support from output shaft.

6. Rear-oil-pump removal and inspection.
a. Removal. Remove the five screws and lock washers and take off pump housing and internal gear. Mark front face of internal gear with prussian blue so it will not be reversed on reassembly. Do not mark by scratching face with a sharp tool. Remove pump pinion from shaft. Do not lose pinion ball (which keys pinion to output shaft).
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b. Inspection. Check machined surfaces for nicks and burrs, scores and pitting. Make sure gear teeth are not broken or badly worn. Inspect keyway in pinion and ball pocket in output shaft for wear. Put gear and pinion in pump housing and check clearances between the gear faces and a straightedge laid across the face of the pump housing. Clearances should be between 0.001 and 0.003 inch.

Fig. 13-10. Using special tool and guide studs to remove transmission extension housing from output-shaft support. The guide studs (only one showing) keep the housing aligned while turning the bolt in the tool forces the housing away from the output-shaft support of the transmission case. (De Soto Division of Chrysler Corporation)

7. Output-shaft support, planet-pinion carriers, and direct-clutch removal. Remove output-shaft-support-to-transmission-case screw and washer. Work output shaft up and down with one hand and apply pressure with the other hand to the input shaft. Slide output-shaft rear-support assembly, planet-pinion carrier-housing assembly, and gasket from rear of transmission case.

If the rear support is stuck to the case, install one of the oil-pan screws in the case so you can pry between it and the shaft support. Use care so you do not damage or scratch finished surfaces.

Remove the direct-clutch piston-retainer assembly from the torque-converter reaction shaft; then remove the thrust washer from the reaction shaft. This is a selective washer; proper thick-
ness is selected to secure correct end clearance in the transmission as explained in §172, 2, above. Remove kick-down planet-pinion-carrier thrust washer from direct-clutch retainer.

8. **Removing planet-pinion carriers from housing.** Put assembly upright in holding tool. Use a feeler gauge and check clearance between the kick-down planet-pinion-carrier-housing snap ring and the carrier assembly. (These are, respectively, Nos. 150 and 147 in Fig. 13-8.) Clearance should be 0.012-0.038 inch. If outside of these limits, new thrust washers of the correct thicknesses must be installed on reassembly. The two thrust washers controlling the above-mentioned clearance are Nos. 139 and 145 in Fig. 13-8.

Use a screwdriver and remove the large kick-down planet-pinion-carrier-housing snap ring. Take input shaft, with kick-down planet-pinion-carrier assembly, from the carrier housing. Other parts will come off as snap rings are removed.

9. **Direct clutch piston-retainer disassembly.**

Remove the large kick-down sun-gear snap ring and sun gear. Lift out clutch hub and turn retainer upside down so clutch plates and driving disks come out. Note relationship of plates to disks so they can be replaced in the same order. Use special tool (Fig. 13-11) to compress direct-clutch spring. Remove snap ring, release spring pressure slowly, and remove retainer and spring. Guide the retainer so it does not hang up in snap-ring groove. Then use a twisting motion to remove the direct-clutch piston from the retainer assembly (it can be blown out with air pressure). The piston inner seal ring (in hub in retainer), which is a split ring, should be removed with a special tool. The outer seal ring, of neoprene, is easily removed from the piston.

10. **Direct-clutch piston-retainer assembly.** Put new direct-clutch-piston seal ring on piston, after coating it with Lubriplate, so the lip of the ring faces away from the flange. Coat the direct-clutch piston-retainer seal ring with Lubriplate and install it on the retainer hub with special expanding tool. Lock seal ring into place and make sure it is free in its groove. Put piston into retainer with a twisting motion, pushing it all the way down. Work carefully so you do not damage lip of seal.

Seat the direct-clutch spring retainer on the spring, put snap ring on top of the retainer, and place spring in piston-retainer assembly. Use special tool to compress the spring (Fig. 13-11) and put snap
ring in groove in hub. Guide spring retainer down into place so it does not catch in snap-ring groove.

Put direct-clutch hub in center of piston retainer. Lubricate all clutch plates and driving disks with automatic-transmission fluid Type A and place in assembly. Start with a clutch plate, followed by a driving disk, another clutch plate, another driving disk, and so on.

Note: If the first driving disk was installed with cork portion up, then the remaining disks must be installed in the same position.

![Diagram of direct clutch assembly](image.png)

**Fig. 13-11. Compressing direct-clutch spring with special tool so spring-retainer snap ring can be removed. (De Soto Division of Chrysler Corporation)**

Put kick-down sun-gear assembly in piston retainer and install snap ring. Use a feeler gauge to check the clearance under the snap ring. Clearance should be as close to zero as possible. If there is appreciable clearance, use a thicker snap ring. Snap rings are available in various thicknesses. Make sure snap ring seats in groove.

Mark the reverse band so you will be sure to put it back into place.
the case in the same position. Compress ends and remove the band strut. Unhook reverse band from link and remove band by turning it 90 degrees and then rotating it through rear opening of case.

Compress kick-down band and remove band strut. Note that the strut is grooved so it acts as a guide to the strut pin on the end of the band. Turn the band and rotate it through the rear opening of the case.

   a. Inspection. Check reverse-band-link assembly for wear and riveting. Make sure levers are not worn or otherwise damaged, and that they are free to turn on their shafts. Do not remove these assemblies unless they must be replaced.
   b. Removal. Insert finger in back of reverse-band-link assembly-lever shaft, hold the assembly with the other hand, and push shaft out rear opening in case. Remove kick-down-band lever-shaft plug in front of case and then push shaft out of front of case, holding lever with one hand while pushing shaft out with the other.

13. Front-oil-pump removal, disassembly, and inspection.
   a. Removal. Remove transmission regulator-valve spring retainer, spring, gasket, and valve. Remove torque-converter control-valve spring retainer, spring, gasket, and valve. Remove seven screws and washers holding oil-pump housing to case. Note washers are the sealing type made from copper or aluminum. These washers should be discarded and new ones used on reassembly. Use puller and guide studs as shown in Fig. 13-12 to pull pump from transmission case.
   b. Disassembly. Mark front faces of gears with prussian blue. Do not use scribe marks or otherwise scratch gears. Remove gears, and large neoprene seal. Then use brass drift and drive the housing dust seal from front of oil-pump housing.
   c. Inspection. If housing bushing is worn, replace housing. Replace gears if teeth are worn or otherwise damaged. Put gears into housing and measure clearance between gear faces and a straight-edge laid across pump-housing face with a feeler gauge. Clearance limits are 0.001-0.003 inch. Make sure oil passages are clear.

   a. Removal. Use same puller and guide studs shown in Fig. 13-12 to pull regulator-valve body off the torque-converter reaction shaft.
Valve body is made of aluminum and must be handled carefully since it can be damaged rather easily.

b. Inspection. Put valve body and the two valves (torque-converter control and transmission regulator) in a pan of clean solvent. Wash thoroughly, blow dry with compressed air, and check for wear or other damage. Valves should fall freely into and out of bores in valve body. Crocus cloth can be used to polish valves provided the sharp edges are not rounded off. Slight nicks on the mating surfaces of valve body can be polished off with crocus cloth spread flat on a surface plate. Make sure oil passages are clear.

Put valves in valve body and lay assembly aside in a safe place where it will not be damaged.

15. Reverse-servo-piston removal and inspection. Lift out piston sleeve and check inside bore, lever, and contacting surface on sleeve for scores and wear. Bleeder holes must be open. Use special tool shown in Fig. 13-7 to compress spring retainer so snap ring can be removed. Then, release pressure and take out spring retainer, spring.
piston, and valve assembly. Remove piston ring (neoprene). Remove valve-spring snap ring and remove spring and valve from piston. Check bore and piston for scores.

16 Kick-down-servo-piston removal and inspection. Use tool shown in Fig. 13-7 to compress spring so snap ring can be removed. Then release pressure and remove piston-rod guide, spring, piston-rod assembly, and spring. Remove seal ring from guide. Check rod and guide for scores. Then expand snap-ring pliers in-

side of piston to remove piston from bore. Remove three seal rings (two locking and one open) from piston. Check piston for scores and rings for broken ends.

17. Torque-converter reaction-shaft inspection and removal.
   a. Inspection. Check shaft seal rings (interlocking type) for broken ends and make sure they are free to rotate in their grooves. Check inside of shaft for burrs and splines for burrs or wear. Remove the neoprene shaft seal. Inspect thrust surfaces of shaft for wear or scores. Do not remove the shaft unless inspection shows that it must be replaced.

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b. Removal. Use a brass drift and drive the dowel pin from the reaction-shaft flange and transmission case. Remove the three screws and washers and use special tool to pull shaft from case. Remove the two interlocking seal rings from shaft.

18. Removing other parts. The manual-control-valve lever-shaft oil seal can be driven out of the case with a drift. Install new seal with special screw-type installing tool. Kick-down-band adjusting screw can be removed by loosening the lock nut and backing screw out. Screw must turn easily in tapped hole. If it does not, there may be difficulty in making band adjustment. Check case for cracks, stripped threads in tapped holes, and burrs on mating surfaces. Blow compressed air through oil passages to make sure they are clear.

19. Servicing the valve-body-and-transfer-plate assembly (Fig. 13-13). This assembly must be handled very carefully and utmost cleanliness must be observed. Put the assembly in a special holding tool to disassemble it (Fig. 13-14). Do not clamp it in a vise as this would probably ruin it. Carefully note the locations of the various parts and refer to Fig. 13-13 during disassembly so that you can reassemble the parts in the correct order.

§173. Transmission reassembly

1. Torque-converter reaction shaft. Heat front of transmission case with infrared lamps to 170–190°F. Coat the two shaft seal rings with Lubriplate, install them on shaft, and lock them in place. Make sure they are free to rotate.

Coat portion of shaft that presses into case with Lubriplate. Position shaft in front of case so holes in shaft align with holes in case.

Put a %6-inch by 2¾-inch bolt (0.308–0.311 inch outside diameter in unthreaded section) through dowel-pin holes in case and shaft and install nut on end of bolt. This will hold alignment as shaft is pressed into position. Use the special tool to press shaft into place. Do not remove the %6-inch bolt yet. Install and tighten finger-tight the three transmission-case-to-shaft screws and washers. Now, remove the %6-inch bolt and install dowel from inside of transmission case. Tighten three screws to 10–15 lb-ft. Coat neoprene shaft seal with Lubriplate and install it on shaft.

2. Kick-down piston. Coat the three piston rings with Lubriplate [327]
3. Reverse servo piston. Install as noted in § 169, 4.

4. Regulator-valve body. Make sure the torque-converter reaction-shaft seal is coated with Lubriplate. Put transmission regulator valve and torque-converter control valve in valve body. Install guide studs in front of case and put valve body, oil passages to rear, over reaction shaft and on to guide studs. Seat valve body firmly on case.

5. Front oil pump. Put new seal in front of pump housing (metal part of seal down) and drive it home with seal driver. Coat transmission oil-pump housing seal with Lubriplate and put it on housing.

Put gears in pump housing, driving lugs of pinion facing up. Slide pump assembly over guide studs until housing is flush with transmission case. Use new aluminum or copper washers on screws, start five of the screws, and draw them down evenly so housing is seated squarely in case. Remove guide studs and install other two screws. Tighten all to 12–17 lb-ft.

Try the pump to see if the pinion will turn freely. Use the oil-pump drive sleeve for this test.

Using new gaskets, install the torque-converter and regulator-valve springs, and retainers.

6. Reverse and kick-down bands and lever assemblies. If the two lever assemblies were removed, replace them as follows:

a. Install kick-down-band lever assembly in case and slide lever shaft into position from front. Make sure lever operates freely on shaft. Then install kick-down-band lever-shaft plug in front of case and tighten to 30–35 lb-ft.

b. Put kick-down-band assembly in case. Fit proper end of band over adjusting screw and compress the band so strut can be installed between other end of band and the band lever. Make sure slot in band strut engages with strut pin in end of band.

c. Place the reverse-band lever assembly in reverse-band link assembly and position in transmission case, aligning holes in lever and link assemblies to holes in case. Slide the lever shaft into position from rear of case. Figure 13-15 illustrates the relationship of parts after installation in case.
NOTE: If a new reverse band is to be installed, loosen the lock nut and back adjusting screw out until about an inch of screw is above the lever on the lock nut side.


7. Planet-pinion carriers in housing

a. Put output-shaft support in special tool, bearing surface up. Lubricate bearing surface of planet-pinion housing and put over output-shaft support-bearing surface.

b. Place reverse annulus gear on the output shaft and install snap ring. Support output shaft in soft jaws of vise. Gear must fit tightly on shaft. End clearance is controlled by snap rings of varying thicknesses. Select snap ring that will give minimum end clearance and still seat in ring groove.

c. Coat output-shaft seal ring with Lubriplate and install it. Lock it into position but make sure it rotates freely.

d. Coat planet-pinion-carrier-housing thrust washer with Lubriplate, and slide it over shaft and onto annulus gear.
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e. Put output shaft and annulus gear into position in carrier housing and through the output-shaft support. Do not damage shaft seal ring. Make sure thrust washer seats properly between the annulus gear and carrier housing. Coat shaft splines with Lubriplate.

f. Lubricate thrust surfaces and gear teeth and place carrier assembly in the reverse annulus gear. Make sure driving lugs on carrier assembly engage the slots in the planet-pinion-carrier housing.

g. Coat input-shaft seal rings with Lubriplate and lock into position on shaft. Make sure they rotate freely.

h. Lubricate thrust surfaces and gear teeth on kick-down planet-pinion-carrier assembly. Slide assembly (oil-collector ring up) down on rear end of input shaft and over stop ring. Lubricate teeth and thrust faces of the kick-down annulus gear and slide it onto input shaft down to stop ring. Secure with snap ring.

i. Engage the gear teeth of the kick-down planet-pinion gears with teeth on the kick-down annulus gear. Slide the pinion-gear-and-carrier assembly into kick-down annulus gear.

j. Coat reverse planet-pinion-carrier thrust washer with Lubriplate and install it on kick-down annulus. Place kick-down planet-pinion-carrier assembly, annulus gear, and input shaft into position in carrier housing. Make sure carrier thrust washer remains on annulus and that driving lugs properly engage slots in the planet-pinion housing.

k. Install planet-pinion carrier-housing snap ring. Lubricate gear and splines. Use feeler gauge to check clearance between the kick-down planet-pinion-carrier-housing snap ring and the kick-down planet-pinion-carrier assembly. Clearance should be between 0.012 and 0.038 inch. If it is not within these limits, disassemble and recheck the reverse planet-pinion carrier and the planet-pinion-carrier-housing thrust washers.

8. Output-shaft-support, planet-pinion-carrier, and direct-clutch assemblies

a. Coat kick-down planet-pinion-carrier thrust washer with Lubriplate and put over sun gear and on to thrust face of direct-clutch piston-retainer assembly.
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b. Put direct-clutch piston-retainer assembly over input shaft, engaging sun gear with planet pinions and also engaging splines. Make sure thrust washer remains in position.

c. Coat direct-clutch piston-retainer thrust washer (this is a selective-fit washer) with Lubriplate and install it on the torque-converter reaction shaft inside of transmission case. Don’t damage rings when sliding washer over them.

d. Install guide studs in rear of case, position new output-shaft-support gasket over them. Cover splines on end of input shaft with special protective tool. Then insert shaft, with direct-clutch assembly, planet-pinion-carrier housing, output-shaft support, and output shaft, through the rear of transmission case and through torque-converter reaction shaft. Guide assembly through bands and over guide studs and into position in case. Remove tool from end of input shaft.

**Caution:** Do not force assembly into case. Don’t damage seal rings on reaction shaft.

e. Install output-shaft-support-to-transmission-case screw and lock washer.

9. **Rear oil pump**

a. Coat pinion ball with Lubriplate and insert it in pocket in output shaft. Lubriplate drive pinion, put on output shaft, aligning keyway with ball in shaft.

**NOTE:** Be sure to reinstall pinion and gear with proper side out, as marked on disassembly.

b. Lubriplate gear and put in pump housing. Slide housing over output shaft and secure with five screws and lock washers tightened to 15–20 lb-ft. Check for freeness of pump by rotating output shaft.

**NOTE:** There are two extra holes in pump housing which are vents. Do not try to install screws in these holes.

10. **Governor**

a. Coat two governor piston rings with Lubriplate and install on governor support. Stagger ring gaps and make sure they
are free in grooves. Put governor body on support and install four screws and lock washers loosely.
b. Slide governor and support assembly over output shaft into rear-oil-pump housing. Compress governor-support piston rings with fingers as support enters oil-pump housing.
c. Align locating hole in output shaft to locating-screw hole in governor body. Install screw and tighten to $3\frac{3}{4}-4$ lb-ft. Tighten four governor body screws to $5-10$ lb-ft.
d. Dry governor parts with compressed air. Do not lubricate when assembling. Put governor-weight spring over secondary weight and position in primary weight. Make sure spring seats properly.
e. Guide secondary weight and compress spring sufficiently to permit installation of the snap ring. Then put weight assembly (secondary-weight snap ring up) into governor and secure with snap ring. Slide governor valve, small end up, over governor-valve shaft. Slide shaft into governor body through the output shaft and weight assembly, positioning valve in body. Secure with snap ring.
f. Check operation of weight assembly and valve by turning output shaft. Both should fall freely in body.

11. Transmission extension, oil seal, and bearing. If it was not necessary to install a new bearing, omit the first operation, below.

a. Install new bearing in extension housing with special driver. Make sure bearing seats properly and then lubricate with Type A fluid. Install bearing snap ring, bevel side up.
b. Install breather vent and tighten to $10-12$ lb-ft.
c. Put new gasket over guide studs and against output-shaft support. Do not use any sealing material on gasket. Put extension housing over output shaft and on to guide studs. Use special tool and adapter to press extension housing into place against output-shaft support (Fig. 13-16). Install seven screws and lock washers and draw them down evenly to $25-30$ lb-ft. Tighten output-shaft-support-to-case screw $25-30$ lb-ft. Then turn output shaft to make sure tightening the screws has not produced a bind.
d. Coat speedometer drive pinion with Lubriplate. Install in extension and tighten to $40-45$ lb-ft.
12. Checking transmission end play. At this point, transmission end play should be again checked. This operation was discussed in §172, 2. If the clearance is not within 0.043–0.069 inch, a new direct-clutch piston-retainer thrust washer of a different thickness must be installed. This is done by partly disassembling the transmission so the thrust washer can be removed. Then, its thickness should be measured and a new washer of the proper thickness selected which, when installed, will give the proper end play.

13. Hand brake

a. Make sure neoprene brake-support spacer is on back of support and spacer sleeve is in center of support. Slide support assembly over rear extension housing and anchor pin. Be sure spacer sleeve does not move from center of support. Install grease shield on extension housing. Make sure indent on grease shield matches groove in housing and that shield goes on far enough to permit installation of spring.

b. Put both brake anchor washers on anchor and install locking anchor washer.

c. Put shoes with adjusting-sleeve nut and screw in position on anchor. Make sure shoes are between the anchor washers. Use rubber bands to hold shoes in place.
d. Install operating link. Note link mark for proper installation.
e. Install brake-support grease-shield spring (opening in spring toward sleeve). Make sure spring is seated in groove.
f. Slide brake-shoe return spring behind grease-shield spring and hook it in position.
g. Make sure brake adjustment is loose enough; then install drum assembly. It may be necessary to use a special tool to press drum assembly onto output shaft.
h. Secure drum with flange washer, shakeproof washer, and nut, tightened to 140–160 lb-ft.

14. Adjust kick-down and reverse bands. These operations have already been described (§166).

15. Valve-body-and-transfer-plate assembly. Installation of this assembly has already been covered (§169, 2).

SERVICING THE TORQUEFLITE

§174. Torqueflite service  The previous sections described the servicing of the Powerflite transmission. Servicing of the Torqueflite is similar in many ways. Differences are pointed out in the paragraphs that follow.

1. Valve-body-and-transfer-plate assembly. Before removing this [534]
assembly, it is necessary to disconnect the control cable from the cable housing at the transmission. To do this, first push L (low) button in. Remove throttle valve lever assembly, cable adjustable mounting bracket, and adapter housing plug. Insert screw driver through hole to release cable spring lock so cable can be pulled out. Then proceed as with the Powerflite.

2. Kick-down piston. The procedure is approximately the same as for the Powerflite although a slightly different tool is required (Fig. 13-17).

3. Accumulator piston. Use special tool as shown in Fig. 13-18 to remove and replace this piston.

4. Extension housing, governor, and rear oil pump. On the Torqueflite these can be removed with the transmission still in the car. Procedures are similar to those for the Powerflite covered in §172, 4, 5, and 6.

5. Removal and replacement of transmission. Transmissions using push-button control require disconnecting of the control cable from the transmission. This is done by first pushing the L (low) control button in and then removing the adjustable mounting bracket from the transmission. Take out adapter housing plug and insert a screw driver to unlock cable. To replace, remove neutral starting switch, put manual-valve lever in LOW detent, hold the R (reverse) push button in, and insert the cable assembly in its adapter to engage the cable end with the lock spring. The remainder of the removal and replacement of the transmis-

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replacement procedure is the same as already covered for the Powerflite.

6. Disassembly and reassembly of Torqueflite. The disassembly procedure is similar to the Powerflite. End clearance (actually front clutch end clearance) should be 0.020 to 0.050 inch. Refer to Fig. 13-19 for removal of the output shaft support (which includes governor and pump housing).

The power train is removed in three parts. Unit 1, consisting of output shaft, kick-down planet pinion carrier, and intermediate...
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Fig. 13-22. Disassembled view of Unit 3 of Torqueflite. (Dodge Division of Chrysler Corporation)

Fig. 13-23. Servos and bands in Torqueflite. (Dodge Division of Chrysler Corporation)
shaft (Fig. 13-20), comes out as an assembly; it is disassembled by removing the snap rings. Unit 2 (Fig. 13-21) then comes out as an assembly; it is disassembled by removing snap rings. Before Unit 2 can be removed, the low-reverse and kick-down band adjusting screws must be backed out two or three turns and the intermediate support locating bolts must be taken out. Unit 3 can then be taken out. It also is disassembled by removing snap rings (Fig. 13-22).

The valve body is considerably different from that used in the Powerflite. However, the general procedures outlined apply.

Figure 13-23 shows the relationship of the servos and bands in the Torqueflite. This, as well as Figs. 13-19 to 13-22, can be used as a guide to the disassembly and reassembly of the transmission.

CHAPTER CHECKUP

Note: Since this is a chapter review test, you should review the chapter before taking it.

You have now completed the last of the chapters in the book dealing with automatic transmissions. Automatic transmissions are similar in many ways, but they do have important differences. If you have carefully studied the past several chapters, you can make comparisons between the transmissions discussed and note their differences. Furthermore, if automatic transmissions of still different designs are brought out by the automotive manufacturers, you will have little difficulty in understanding how they operate and how to trouble-shoot and overhaul them.

The test that follows is designed to help you review the chapter you have just finished. This review is valuable to you since it helps you to remember the important points discussed in the chapter. Write the answers in your notebook.

Correcting Parts Lists

The purpose of this exercise is to enable you to spot the unrelated parts in a list. For example, in the list, driving member, driven member, pump, turbine, wheel, you can see that wheel does not belong because it is the only item that is not part of a torque converter. In each of the lists below, you will find one item that does not belong. Write down each list in your notebook, but do not write down the item that does not belong.

1. Seals and gaskets that can be replaced and plugs or screws that can be tightened, without removing the transmission, to repair oil leaks include: output-shaft rear oil seal, oil-pan drain plug, manual-valve-lever-shaft seal, converter drain plug, pump-housing seal.

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2. Powerflite transmission adjustments include: selector-lever linkage, throttle pressure, throttle linkage, transmission band, front and rear clutches.

3. Parts of the transmission that can be removed and replaced with the transmission in the car include: oil pan, oil pump, valve body, kick-down piston, reverse servo, regulator-valve assembly.

4. Parts that must be removed before the reverse servo can be removed include: oil pan, valve-body-and-transfer-plate assembly, front servo.

5. Parts that must be disconnected or removed before the transmission can be removed include: battery, propeller shaft, linkages, intake manifold, frame cross member, oil-cooler lines.

6. Hand-brake parts to be removed during overhaul include: flange nut, brake drum, brake shoes, wheel cylinder, grease shield, brake support.

7. Important points to remember during transmission overhaul include: tools and workbench must be clean; wash all parts in cleaning solvent; wipe parts with clean cloths; air-dry all parts with compressed air; do not burr or nick finished surfaces; use new gaskets on re-assembly.

8. Parts to be removed from the valve-body-and-transfer-plate assembly during overhaul include: transfer-plate cover, transfer plate, valve-body plate, regulator valve, throttle valve, shuttle valve, manual valve.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. During the stall test of the transmission, throttle should not be held open for more than [a few seconds 15 seconds 30 seconds 1 minute]

2. Throttle pressure is adjusted by means of [linkage clevis an adjusting screw a tapered pin an adjusting nut]

3. Kick-down band is adjusted by means of [an adjusting nut shims an adjusting screw a tapered pin]

4. Reverse band is adjusted by means of [an adjusting nut shims an adjusting screw a tapered pin]

5. The clutch has shim adjustments has screw adjustments is not adjustable

6. If engine speed is above 1,550 rpm during the stall test, adjust clutch kick-down band reverse band
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7. During disassembly of the transmission, all parts should be cleaned with clean wiping cloths, hot soda, acid-type cleaner, cleaning solvent.

8. When the transmission is being removed or installed, alignment is maintained by use of a pilot guide, a pilot rod, a special jig, two guide pins.

Troubles and Service Procedures

In the following, you should write down in your notebook the trouble causes and service procedures asked for. Do not copy the procedures from the book; try to write them in your own words. Writing them down in your own words will help you to remember the procedures. And, of course, having the procedures well in mind is of great value to you in the service shop.

1. Make a list of possible trouble causes and the conditions that could result from these causes. In other words, refer to Figs. 13-1 and 13-2 and make lists relating causes and effects.

2. Describe the procedure of changing oil in the transmission.

3. Describe the procedure of adjusting the selector-lever linkage. The throttle pressure. The throttle linkage.

4. Describe the procedure of adjusting the kick-down band. The reverse band.

5. Describe the procedure of road-testing the transmission.

6. Describe the procedure of making hydraulic-pressure checks.

7. Describe the procedure of removing and replacing the transmission. The torque converter.

8. List the major points of disassembling the transmission assembly.

9. List the major points to keep in mind when inspecting the components of the transmission during disassembly.

10. Describe the assembly procedure for the transmission.

11. Explain how to overhaul the converter.

Suggestions for Further Study

In the past several chapters, trouble-shooting material on automatic transmissions is presented in three different ways. One way of presentation was by a chart listing troubles, their possible causes, and the checks or corrections to be made. Chapters 10 and 11 present the material in this manner. Other chapters supply the material in the form of a diagnosis guide (see Figs. 12-1 and 12-2). The third method of presentation uses lists keyed to each other by numbers (Figs. 13-1 and 13-2). These different methods have been used in the book so that you will gain familiar...
**Powerflite and Torqueflite Service**

Try with the various types of instructional material you will use when you get out into the shop. However, as a rule, you will find that the various manufacturers have prepared diagnosis guides. If possible, you should get copies of these guides for each make of automatic transmission. Put these in your notebook and study them carefully. Also, study the shop manuals issued by the various car manufacturers covering the automatic transmissions they use. If possible, try to get practical service experience on several of these automatic transmissions. Write down in your notebook any important facts you learn.
14: Drive lines

This chapter describes the purpose, construction, operation, and servicing of drive lines. Drive lines, in automobiles, consist of the driving connection between the transmission and the driving mechanism at the rear wheels (the differential). The purpose of the drive line is to carry the driving power from the transmission to the rear wheels. It consists of the propeller shaft, a universal joint (or joints), and a slip joint.

§175. Function of propeller shaft The propeller shaft is a driving shaft that connects the transmission main or output shaft to the differential at the rear axles. Rotary motion of the transmission main or output shaft carries through the propeller shaft to the differential, causing the rear wheels to rotate. The propeller-shaft design must take into consideration two facts: First, the engine and transmission are more or less rigidly attached to the car frame; second, the rear-axle housing (with wheels and differential) is attached to the frame by springs. As the rear wheels encounter irregularities in the road, the springs compress or expand. This changes the angle of drive between the propeller and transmission shafts. It also changes the distance between the transmission and the differential (see Fig. 14-1). In order that the propeller shaft may take care of these two changes, it must incorporate two separate types of device. There must be one or more universal joints to permit variations in the angle of drive. There must also be a slip joint that permits the effective length of the propeller shaft to change.

The propeller shaft may be solid or hollow, protected by an outer tube or exposed. Some applications include bearings at or near the propeller-shaft center to support the shaft. Figures 1-19, 14-5, 14-7 and 14-9 illustrate various types of propeller shaft. On some applications the propeller shaft is in two or more sections (see Fig. 1-19), often supported by bearings and coupled together by universal [542]
joints. The two-section shaft shown in Fig. 1-19 has a center support as shown in Fig. 14-2.

§176. Universal joints A simple universal joint is illustrated in Fig. 1-20. It is essentially a double-hinged joint consisting of two Y-shaped yokes, one on the driving shaft and the other on the driven shaft, and a cross-shaped member called the spider. The four arms of the spider, known as trunnions, are assembled into bearings in the ends of the two shaft yokes. The driving shaft causes the spider to rotate, and the other two trunnions of the spider cause the driven shaft to rotate. When the two shafts are at an angle to each other, the bearings in the yokes permit the yokes to swing round on the trunnions with each revolution. A variety of universal joints have been used on automobiles, but the two types now in most common use are the spider and two-yoke design and the ball-and-trunnion design.

The spider and two-yoke design is essentially the same as the simple universal joint discussed above, except that the bearings are often of the needle type (Fig. 14-3). As will be noted, there are four needle bearings, one for each trunnion of the spider. The bearings are held in place by snap rings that drop into undercuts in

Fig. 14-1. As the rear-axle housing, with differential and wheels, moves up and down, the angle between the transmission output shaft changes and the length of the propeller shaft also changes.
Fig. 14-2. Details of propeller-shaft center support and bearing.

Fig. 14-3. Two-yoke and cross universal joint in disassembled view with parts shown in their order of assembly. (Studebaker-Packard Corporation) [564]
the yoke bearing holes. A variation of this design makes use of separately mounted bearing housings on the yokes (Fig. 14-4). Figure 14-5 shows a propeller shaft with two universal joints, one at each end.

![Diagram of yoke and universal joint](image)

**Fig. 14-4.** Two-yoke and cross universal joint disassembled. The bearing housings are separately bolted to the yokes. (*Cadillac Motor Car Division of General Motors Corporation*)

![Diagram of propeller shaft](image)

**Fig. 14-5.** Disassembled view of a propeller shaft (drive line) using two universal joints. (*Ford Division of Ford Motor Company*)

The ball-and-trunnion type of universal joint combines both the universal and the slip joint in one assembly. A universal joint of this design is shown in Fig. 14-6 in exploded view and in sectional view in Fig. 14-7. The shaft has a pin pressed through it, and around both ends of the pin are placed balls drilled out to accom-
modate needle bearings. The other member of the universal joint consists of a steel casing or body that has two longitudinal channels into which the balls fit. The body is bolted to a flange on the mating shaft (not shown in Fig. 14-6 or 14-7). The rotary motion is carried through the pin and balls, according to the direction of drive. The balls can move back and forth in the channels of the body to compensate for varying angles of drive. At the same time, they act as a slip joint by slipping in or out of the channels.

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§177. Slip joint A slip joint is illustrated in Fig. 1-21. As previously explained, the slip joint consists of outside splines on one shaft and matching internal splines on the mating hollow shaft (see Nos. 8 and 17 in Fig. 1-21). The splines cause the two shafts to rotate together but permit the two to move endwise with each other. This accommodates any effective change of length of the propeller shaft as the rear axles move toward or away from the car frame.

§178. Types of drive The rotation of the propeller shaft transmits torque through the differential to the rear wheels, causing them to rotate and move the car. The wheels rotate because torque is applied to them. This torque not only rotates the wheels in one direction; it also attempts to rotate the differential housing in the opposite direction. To understand why this occurs, it is necessary to review briefly the construction of the differential (Fig. 1-24). The ring gear is connected through other gears to the rear-wheel axles; the torque applied through the drive pinion forces the ring gear and wheels to rotate. It is the side thrust of the drive-pinion teeth against the ring-gear teeth that makes the ring gear rotate. This side thrust also causes the drive-pinion shaft to push against the shaft bearing. The thrust against the shaft bearing is in a direction opposite to the thrust of the pinion teeth against the ring-gear teeth. Since the drive-pinion bearings are held in the differential housing, the housing tries to rotate in a direction opposite to the ring gear and wheel rotation. This action is termed rear-end torque, and, to prevent excessive movement of the differential housing from this action, several methods of bracing the housing are used. The two most common types of bracing found on modern...
automobiles are the torque-tube drive and the Hotchkiss drive (Fig. 14-8).

In the torque-tube drive the propeller shaft is encased in a hollow tube. The tube is rigidly bolted to the differential housing at one end and is fastened at the other end to the transmission case through a somewhat flexible joint. On many cars, a pair of truss rods are attached between the rear-axle housings and the transmission end of the torque tube. The torque tube and the truss rods brace the differential housing to prevent excessive differential-housing movement. In other words, these members absorb the rear-end torque. Figure 14-9 illustrates a torque tube attached to the transmission case through the torque-tube adapter and the trunnion bracket. The fitting of the trunnion bracket to the torque-tube adapter is such that the differential end of the torque tube can...
Fig. 14-6. Torque-tube and propeller-shaft arrangement.

(American Motors Corporation)
move up and down, pivoting around the torque tube adapter to compensate for changing angles of drive. A second design of flexible joint at the torque-tube-to-transmission-case connection makes use of a large semiball joint (Fig. 14-10). This design incorporates a flanged semihemisphere, which is retained between an inner and an outer sheathing. The torque tube is bolted to the flange, and move-

Fig. 14-10. Ball joint used on one type of torque-tube drive. The ball joint is located in the rear end (to right) of the transmission case. (Buick Motor Division of General Motors Corporation)

ment of the torque tube causes the semihemisphere to move within the two sheaths. The propeller-shaft universal joint is located within this semiball joint. Only one universal joint is required on the torque-tube-drive propeller shaft; it is located at the transmission end of the shaft.

In the Hotchkiss drive, the rear-end torque is absorbed by the rear springs. The rear springs are attached to brackets bolted to the [550]
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rear-axle housings so that the springs themselves act as the torque absorbing members. Thus, when the car is moving forward, the rear-end torque causes the front halves of the springs to be compressed while the rear halves of the springs are expanded. Two universal joints are required on the propeller shaft in the Hotchkiss drive, one at each end of the shaft (see Fig. 14-5). The reason for this is obvious; the differential housing does rotate as a result of rear-end torque within the limits imposed by car springs.

§179. Universal-joint service

Little maintenance of universal joints is required aside from periodic lubrication. When disassembly is required, it may take from one hour, when only one universal joint is to be overhauled, to approximately four hours, when the propeller shaft is removed and replaced. Typical disassembly and assembly procedures follow.

Note: On many cars, the propeller-shaft and universal-joint parts are carefully balanced during original assembly. To assure reassembly in the correct relationship, so that the balance will be maintained, the parts are marked. If the marks cannot be found, new marks should be made, so that the parts can be reassembled correctly.

1. Chevrolet. Unhook hand-brake spring, disconnect cable clevis from idler lever, and remove lever. Remove cap screws and slide ball-retainer collar and ball back on propeller-shaft housing. Remove cap screws which fasten front trunnion bearings to front yoke. Then, place jack under propeller shaft and remove the two front-yoke trunnion bearings, so that the joint can be separated. Now, the propeller shaft can be lowered, so that the rear yoke and trunnion can be removed from the shaft splines. The front yoke can be taken off by removal of the bolt and lock washer.

Wash all parts in solvent and inspect them for wear. If new rear-trunnion bearings are needed, remove the lock rings and drive on the center of the trunnion with a drift punch, so that the bearings come out. Press new bearings in and install new lock rings. Finally, tap the ends of the trunnions lightly with a hammer, so that the bushings seat against the rings.

The universal-joint ball should be adjusted, if necessary, by adding or removing shims at each of the four cap screws. To check whether or not adjustment is needed, attach the ball to the back
of the case with cap screws and four new torque-ball retainer shims. Tighten the screws and see whether or not the ball can be moved by pressure of both hands on the tube. If it is too loose, remove shims and try again. If too tight, add shims and recheck. With adjustment correct (tube can be moved by pressure of both hands), detach the ball, noting the correct number of shims so that they can be replaced on final assembly.

Reassemble the universal joint by attaching the front yoke to the transmission main shaft, locking it in position with a lock washer and nut. Then, with the ball on the shaft splines, slide the rear yoke and trunnion onto the propeller shaft. Raise the shaft and, with new front trunnion bearings on the trunnion, fasten the bearings to the front yoke and tighten the cap screws to the proper tension. New lock plates must be used under screws, and tangs should be bent up to lock the screws.

Then slide the collar and the ball retainer forward and install collar cap screws. Remove the speedometer driven gear temporarily and fill the housing with \( \frac{1}{2} \) pint of transmission lubricant. Finally, install the hand-brake idler lever and spring and connect the cable clevis.

2. Plymouth. The ball-and trunnion type of universal joint (Figs. 14-6 and 14-7) is disassembled with the propeller shaft off the car. Bend the clip ends of the grease cover so that the cover can be slipped off. Then remove the centering buttons and spring, ball rollers, and thrust washers. Press the trunnion pin through and out of the shaft end.

Inspect all parts for wear after cleaning them in solvent. If the body is worn, then all parts should be replaced.

On reassembly, make sure that the trunnion pin is a tight-press fit in the shaft. Also, the ends of the trunnion pin must protrude the same distance, with a variation of not more than 0.006 inch. A greater variation will cause unbalance and vibration when the car is running. To assure proper installation of the pin, a special jig and locating bushings should be used. The universal-joint body should be packed with 1 1/4 ounces of heavy short-fiber grease during reassembly.

3. Ford. To remove the propeller shaft, remove the cap screws and lock plates attaching the rear universal joint to the joint flange. Tape the universal-joint bearings to the spider so they will not be
damaged. Pull the shaft toward the rear of the vehicle until the front yoke slips off the transmission main-shaft spline.

To install the propeller shaft, slide the front yoke into position on the transmission main shaft. Remove the tape from the bearings and position the rear universal joint on the joint flange. Install lock plates and cap screws to attach the rear joint to the flange.

CHAPTER CHECKUP

Note: Since this is a chapter review test, you should review the chapter before taking it.

The drive line, or propeller shaft, with its universal and slip joints, is a small but important part of the car. You should have a good acquaintance with its purpose, construction, operation, and servicing, as covered in the past few pages. To check yourself on how well you remember the material you have just covered on the drive line, take the following test. Write the answers in your notebook.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. The drive line consists of the propeller shaft with drive and universal joints universal and slip joints slip and drive joints

2. The universal joint permits a change in the speed of rotation angle of drive length of shaft

3. The slip joint permits a change in the speed of rotation angle of drive length of shaft

4. The center part of the typical universal joint is called the trunnion joint bearing spider

5. In the slip joint, slippage occurs between internally and externally mated couplings balls joints splines

6. The attempt of the rear-axle housing to rotate in a direction opposite to rear-wheel rotation is due to acceleration rear-end torque the torque tube

7. In the Hotchkiss drive, the rear-end torque is absorbed by the torque tube rear springs radius rods

8. In the other type of drive discussed in the chapter, the rear-end torque is absorbed by a torque tube rear spring radius rod
To help you remember some of the details of servicing drive lines, write the answers to the following in your notebook. Don’t copy from the book; try to explain the procedure as you would to a friend.

1. Explain how to service the drive line of a car equipped with a torque-tube.
2. Explain how to service the drive line of a car equipped with ball-and-trunnion universal joints.
3. Explain how to service the drive line of a car with a Hotchkiss drive.

**SUGGESTIONS FOR FURTHER STUDY**

Study the various types of drive lines used on different cars. You can see many of these at a service station where cars are put on lifts for lubrication. Your local school automotive shop or a local garage may have universal joints and other parts used in propeller shafts. Examine these if you have a chance. If possible, watch an automotive mechanic as he services the drive lines of various cars. Write down in your notebook any important facts you learn.
15: Rear axles and differentials

THIS CHAPTER describes the purpose, construction, operation, and servicing of differentials and rear axles. The differential is part of the rear-axle housing assembly, which includes the differential, rear axles, wheels, and bearings.

§180. Function of differential As was previously explained (§8), a differential is required to compensate for the difference in distances the rear wheels travel when the car rounds a turn. If a right-angle turn were made with the inner rear wheel turning on a 20-
FIG. 15-2. Exploded view of differential and rear axle shown in sectional view in previous illustration. (Plymouth Division of Chrysler Corporation)

1. Differential-pinion shaft
2. Differential-pinion thrust washer
3. Differential-pinion gear
4. Differential side gear
5. Differential-gear thrust
6. Axle drive-shaft thrust block
7. Axle drive-shaft thrust block spacer
8. Differential-bearing cap
9. Differential-bearing cone and rollers
10. Axle drive shaft
11. Axle drive-shaft-bearing cone and rollers
12. Axle drive-shaft key
13. Axle drive-shaft-nut cotter pin
14. Axle drive-shaft nut
15. Axle drive-shaft-nut washer
16. Axle drive-shaft-bearing cap
17. Axle drive-shaft oil washer
18. Differential-bearing adjuster
19. Axle drive-gear bolt nut
20. Differential-bearing adjuster lock
21. Differential-bearing adjuster-lock-screw lock washer
22. Differential-bearing adjuster lock screw
23. Axle drive-gear bolt
24. Axle drive-gear-bolt nut lock
25. Differential case
26. Axle drive-shaft-bearing oil seal
27. Rear-wheel brake-support-to-axle-housing ball nut
28. Rear-wheel brake-support-to-axle-housing bolt-nut lock washer
29. Rear-wheel brake-support-to-axle-housing bolt
30. Axle drive-shaft-bearing oil-seal retainer gasket
31. Axle drive-shaft-bearing shim
Rear Axles and Differentials

foot radius, it would travel about thirty-one feet, while the outer rear wheel would travel about thirty-nine feet (Fig. 1-22). The differential permits application of power to both rear wheels while allowing the wheels to turn different amounts when the car is rounding a curve (see Fig. 1-23).

§181. Operation of differential Figure 15-1 is a sectional view of a differential. Figure 15-2 shows this same differential in exploded view. Figure 15-3 is a cutaway of a differential of similar construction. In Fig. 15-2, the drive pinion (45) is attached to a shaft that is coupled to the propeller shaft. The drive-pinion shaft is held in bearings (39, 40, 42, 43) in the drive-pinion carrier (53), the carrier being bolted to the axle housing (55). Meshed with the drive pinion is a ring gear (46). The ring gear is bolted to the differential case (25). The case is supported in the axle housing by two roller bearings (only one [8, 9] shown in Fig. 15-2). Attached to the differential case by the differential pinion shaft (1) are the two differential pinion gears (3). The two differential pinion gears are meshed with the two differential side gears (4), which are splined to the two wheel axles (10, 47).

Rotation of the drive pinion causes the ring gear to rotate; this carries the differential case, differential pinion shaft, and differential pinion gears around with the ring gear. When the car is being

32. Axle drive-bearing oil-hole plug 43. Axle drive-pinion rear-bearing cup
33. Differential-pinion-shaft lock pin, or screw 44. Axle drive-pinion rear-bearing washer, or shims
34. Axle drive-pinion-bearing spacer 45. Axle drive pinion
35. Axle drive-pinion flange-nut cot-46. Axle drive-ring gear
ter pin 47. Axle drive shaft
37. Axle drive-pinion flange-nut washer 49. Axle drive-pinion-carrier-screw lock washer
38. Axle drive-pinion flange 50. Axle drive-pinion-bearing oil seal
40. Axle drive-pinion front-bearing cup 52. Differential-bearing cap screw
41. Axle drive-pinion front-bearing adjusting shims 53. Axle drive-pinion carrier and cap
42. Axle drive-pinion rear-bearing cone and rollers 54. Axle drive-pinion-carrier gasket
55. Housing 56. Housing-cover plug

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operated on a straight road, the differential pinion gears do not rotate on the pinion shaft but apply equal torque to the two side gears, so that both rear wheels rotate at the same speed. Under this condition, the ring gear, differential case, differential pinion shaft and pinion gears, and side gears all turn as a unit, without relative motion between any of the parts. When the car rounds a curve, however, the outer rear wheel must turn faster than the inner rear wheel. To permit this, the two differential pinion gears rotate on the pinion shaft, allowing the outer wheel to turn more rapidly than the inner. The differential pinion gears rotate in one direction when the left rear wheel turns more rapidly, and in the opposite direction when the right rear wheel turns more rapidly.

**NOTE:** You might wish to review the explanation of differential operation in §8 if its operation is not clear to you.

§182. **Differential gearing** Since the ring gear has many more teeth than the drive pinion, a considerable gear reduction is effected in the differential. The gear ratios vary somewhat on different cars, depending on car and engine design. Ratios from 3.36:1 upward [558].
to about 5:1 are used on passenger cars. This means that the ring gear has from 3.36 to 5 times as many teeth as the drive pinion, so that the drive pinion has to rotate from 3.36 to 5 times (according to gear ratio) in order to cause the ring gear to rotate once. For heavy-duty applications, such as large trucks, ratios about 9:1 may be used. Such high ratios are secured by use of double-reduction gearing (Fig. 15-6).

The gear ratio in the differential is usually referred to as the axle ratio although it would be more accurate to call it the differential ratio.

**Fig. 15-4.** Spur bevel, spiral bevel, and hypoid differential-drive pinions and ring gears.

Early cars used simple spur-gear type drive pinions and ring gears (Fig. 15-4). In this type of gearing, the lines of the gear teeth are straight and all point toward the center of the gear. The center line of the drive-pinion shaft, if extended, would intersect the center line of the axles.

A later design made use of spiral bevel gears (Fig. 15-4), in which the teeth have a curved or spiral shape. This permits contact between more than one pair of teeth at a time; more even wear and quieter operation result. Extension of the center line of the drive-pinion shaft would intersect the axle center line.
Automotive Transmissions and Power Trains

Modern car design features lower bodies, and this has brought up the problem of interference between the propeller shaft and the floor of the car body. In order to permit further lowering of the car body without interference with the propeller shaft, hypoid differential gears have come into use (Figs. 15-3 and 15-4). These gears are somewhat similar to the spiral bevel gears, except that the tooth formation allows the drive-pinion shaft to be lowered. In this type of gear a wiping action takes place between the teeth as the teeth mesh and unmesh. This wiping action, which is characteristic of hypoid gears, makes the use of special hypoid-gear lubricants necessary.

Figure 15-5 illustrates gear-tooth nomenclature. The mating teeth to the left illustrate clearance and backlash, while the tooth to the right has the various tooth parts named. Clearance is the distance between the top of the tooth of one gear and the valley between adjacent teeth of the mating gear. Backlash is the distance between adjacent meshing teeth in the driving and driven gears; it is the distance one gear can rotate backward, or backlash, before it will cause the other gear to move. The toe is the smaller section of the gear tooth; the heel is the larger section.

§ 183. Double-reduction differentials In order to secure additional gear reduction through the differential and thus provide a higher gear ratio between the engine and the rear wheels, some heavy-duty applications use double-reduction differentials (Fig. 15-6). In this type of differential the drive pinion meshes with a ring gear assembled to a straight shaft on which there is a reduction drive-gear set. The reduction drive-gear set drives a driven-gear set that has a greater number of gear teeth. Gear reduction is thus...
obtained between the drive pinion and the ring gear and also be­
tween the two reduction-gear sets. The driven-gear set is attached
to the differential case, with the case being supported by bearings
in the differential housing in a manner similar to the differential
discussed above. It will be noted that the differential illustrated in
Fig. 15-6 has a four-pinion differential instead of the two-pinion
differential illustrated in Figs. 15-1 to 15-3. Otherwise, the con-
struction and principle of operation are the same as on the differ­
ential described above.

**§184. Nonslip differential** The conventional differential delivers
the same amount of torque to each rear wheel. If one wheel slips on
ice, the other wheel cannot deliver torque. To prevent this, many
cars are now equipped with a nonslip differential (see Fig. 15-7a
and b). This differential is very similar in construction to con­
ventional types except that it has two sets of clutch plates and,
in addition, the ends of the pinion shafts lie rather loosely in

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**Fig. 15-6. Double-reduction differential in sectional view. (International Har­
vester Company)**

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notches in the two halves of the differential case. During normal straight-road driving, power flow is as shown in Fig. 15-8. The turning effort passes from the drive pinion, through the axle drive gear and the differential case to the pinion shafts, the differential pinions and differential side pinions to the axle shaft. Note that the turning differential case carries the pinion shafts around with it. Since there is considerable side thrust, the pinion shafts tend to slide up the sides of the notches in the two halves of the differential case (these notches can be seen in Fig. 15-7a). As they slide up, they are forced outward and this force is transmitted to the clutch plates. The clutch plates thus lock the axle shafts to the differential case. Then if one wheel should encounter a patch of ice or mud that causes it to temporarily

Fig. 15-7. Nonslip differential. (a) cutaway; (b) sectional. (Dodge Division of Chrysler Corporation)
Rear Axles and Differentials

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When rounding a curve, the differential acts in the conventional manner to permit the outer wheel to rotate a little faster than the inner wheel. This action is permitted by slipping of the clutches.

![Diagram of power flow through nonslip differential on straightaway](Fig. 15-8)

![Diagram of power flow through nonslip differential when rounding a turn](Fig. 15-9)

§185. Diagnosis of rear-axle and differential troubles

Most often, it is noise that draws attention to trouble existing in the rear axles or differential. It is not always easy, however, to diagnose the trouble by determining the sort of noise and the operating conditions under which noise is obtained. Such conditions as defective universal joints, rear-wheel bearings, and muffler or tire noises may be improperly diagnosed as differential or rear-axle trouble. Some clue as to the cause of trouble may be gained, however, by noting whether the noise is a hum, growl, or knock; whether it is obtained when the car is operating on a straight road or on turns only; and whether the noise is most noticeable when the engine is driving the car or when the car is coasting.

A humming noise in the differential is often caused by improper drive-pinion or ring-gear adjustment, which prevents normal tooth contact between the gears. This produces rapid gear-tooth wear, so
that noise will gradually take on a growling characteristic. Correction should be made before the trouble progresses this far, since such wear will require pinion and gear replacement.

If the noise is most prominent when the car is being accelerated, the probability is that there is heavy heel contact on the gear teeth; the ring gear must be moved near the drive pinion. If the noise is most prominent when the car is coasting with the car in gear and the throttle closed, it is probable that there is heavy toe contact on the gear teeth; the ring gear must be moved away from the drive pinion. Following sections describe the manner in which gear-tooth contact is tested and ring-gear or pinion-drive adjustment made.

**Note:** Tire noise may sometimes be mistaken for differential noise. Since tire noise varies considerably according to the type of pavement while differential noise does not, the car may be driven over various types of pavement to determine whether or not the noise is resulting from tires or differential.

If the noise is present only when the car is rounding a curve, the trouble is due to some condition in the differential-case assembly. Differential pinion gears tight on the pinion shaft, differential side gears tight in the differential case, damaged gears or thrust washers, or excessive backlash between gears could produce noise when the car turns.

A knocking noise will result if bearing or gears are damaged or badly worn.

### CHECK YOUR PROGRESS

**Progress Quiz 22: Completing the Sentences**

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. In the differential, the ring gear is bolted to the **differential housing**, **differential case**, **drive pinion**, **axle shaft**
2. The drive pinion is assembled into the **carrier** **differential housing**, **axle housing**
3. In the modern differential, the type of gearing used for the drive pinion and ring gear is **spur**, **spiral bevel**, **hypoid**
4. The distance between adjacent meshing teeth of mating gears is called **clearance**, **pitch line**, **backlash**, **flank**
Rear Axles and Differentials

5. In a differential with a gear ratio of 4:1, the drive pinion would revolve four times to cause the ring gear to rotate 1 time

6. The two basic types of axle are dead and floating dead and live floating and semifloating

7. The type of axle in which the wheel end is supported by bearings inside the axle housing is a semifloating axle three-quarter floating axle full-floating axle

8. If a humming noise from the differential is most noticeable when accelerating, chances are there is heavy heel contact on gear teeth heavy toe contact on gear teeth binding in differential case

9. If a humming noise from the differential is most noticeable when coasting with the car in gear and the throttle closed, chances are there is heavy heel contact on gear teeth heavy toe contact on gear teeth binding in differential case

10. If the differential noise is present only when the car is rounding a curve, the trouble could be due to heavy heel contact on gear teeth heavy toe contact on gear teeth binding in differential case

§186. Rear-axle and differential repair
The repair procedures on rear axles and differentials vary somewhat according to their construction. Detailed repair procedures on late-model Chevrolet, Ford, and Plymouth passenger-car differentials and rear axles are outlined below. These three applications represent two types of unit: the Hotchkiss and the torque-tube drive. They also represent two types of wheel attachment. In one, the wheel is attached to a hub held in place on the tapered axle shaft by a key and nut; in the other, the wheel is attached to a flange on the axle shaft by nuts and bolts. These two wheel-attaching methods are not related to the type of drive. The procedures described below will apply, in general, to most cars.

§187. Plymouth rear-axle and differential repair (see Figs. 15-1 and 15-2)

1. Removing and replacing axle shaft and bearing. Jack up and support the rear end of the car and remove the wheel. Remove the wheel hub cap with a screw driver. Remove the axle-shaft cotter pin, nut, and washer. Use a special puller, and pull the hub and brake-drum assembly (Fig. 15-10). Do not strike the end of the
axle to loosen the hub, since this might damage the roller bearings supporting the axle.

Block the brake pedal at the toe board to prevent accidental operation. Disconnect the brake line from the wheel cylinder. Remove stud nuts holding oil seal and brake support to axle housing and detach oil seal and brake support. To protect the oil seal from being damaged on the axle-shaft keyway, use a special protective sleeve when removing the brake-support-and-oil-seal assembly. If shims are removed, their number and thickness must be carefully noted, so that they will be reassembled in the original manner to maintain bearing adjustment. If a new differential carrier, axle shaft, bearing, or housing is to be installed, the axle-shaft end play must be checked and corrected during reassembly.

Remove the axle shaft and bearing with a special puller (Fig. 15-11). Remove the bearing from the axle shaft with a bearing puller (Fig. 15-12). If the oil seal in the axle housing requires replacement, a special puller must be used to remove the old oil seal (Fig. 15-13), and a special drift must be used to install the new oil seal (Fig. 15-14).

Reinstall the axle shaft by first replacing the bearing on the axle shaft (Fig. 15-15) and then inserting the axle shaft in the housing [566]
Fig. 15-11. Removing axle shaft and bearing with special puller. (Plymouth Division of Chrysler Corporation)

Fig. 15-12. Removing bearing from axle shaft with special bearing puller: 1, axle shaft; 2, puller; 3, bearing. (Plymouth Division of Chrysler Corporation)
making sure that the shaft and differential-side-gear splines align. Use a special driver to install the outer bearing race (Fig. 15-16). Install shims, brake support, gasket, and oil seal. Tighten the attaching nuts and check the shaft end play. Adjust, if necessary, as explained below.

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To install the hub, place the hub in position with key slots in the hub and the shaft aligned; then drive the key into position. Install and tighten the shaft nut and secure with a new cotter pin. After installation is complete, bleed the brake lines to all four wheels (Chap. 15 of Automotive Chassis and Body—another book in the McGraw-Hill Automotive Mechanics Series) to make sure all air has been removed from the hydraulic system.
2. Axle-shaft end-play adjustment. The axle-shaft end play should be between 0.003 and 0.008 inch (lower limit preferred) and is checked with a dial indicator mounted as shown in Fig. 15-17. The adjusting shims, brake support, gasket, and oil seals must be in place and the attaching nuts securely tightened when the check is made. The wheel and hub, however, must be removed. To check the end play, rap the axle shaft; then push and pull the axle shaft so that the end play will indicate on the dial. If the end play is incorrect, the oil seal, gasket, and brake support must be removed and shims added or removed as required (Fig. 15-17).

NOTE: In making bearing adjustment, equal thicknesses of shims should be removed or installed on the right and left sides of the axle housing, so that the axle shafts remain centrally located in the housing.

3. Rear-axle-assembly removal and replacement. To remove the rear-axle assembly, jack up and support the rear end of the car. Remove the rear wheels, disconnect the brake hose at the frame bracket, and disconnect the shock absorbers at the bottom end and the rear universal joint at the differential. Then place a jack under the rear-axle assembly and remove the spring hold-down clips and lower the rear-axle assembly from the car.
Replacement is the reverse of removal. Be sure the head of each spring center bolt enters the center hole in the proper spring saddle on the axle housing. Tighten the spring-retaining clips securely. After replacement is complete, bleed all brake lines to all four wheels. Lubricate the assembly by adding hypoid lubricant to the differential and injecting ½-ounce wheel-bearing grease into the wheel bearings through the grease fittings.

Fig. 15-18. Using special support stand to hold carrier assembly while adjusting bearings: 1, adjusting tools. (Plymouth Division of Chrysler Corporation)

4. Differential-carrier-assembly removal and replacement. The differential-carrier assembly may be removed from the car without removing complete axle assembly. Drain the lubricant and disconnect the propeller shaft by removing the rear universal-joint flange bolts. If the drive pinion is to be taken out of the carrier assembly, loosen the propeller-shaft companion flange retaining nut before taking out the axle shafts. Remove axle shafts as outlined above. Remove the cap screws that attach the carrier to the axle housing and pull the carrier away from the housing.

5. Disassembly of differential. A special support stand, such as is shown in Fig. 15-18, will be of great help in disassembling, assembling, and adjusting the differential. Before disassembly, the bear-

[571]
ing-adjusting nuts should be marked as shown in Fig. 15-19 so that the bearings can be approximately adjusted on reassembly and will require only a slight additional adjustment. Also, punch-mark one bearing cap and support so the cap will be replaced on the same support from which it is taken. Caps should not be interchanged.

Disassembly is performed as follows: Remove the adjusting-nut locks. Loosen the bearing-cap retaining screw, unscrew the adjusting nuts to relieve the load on the bearings, and remove the bearing-cap retaining screws and caps. Lift out the differential-case-and-ring-gear assembly. Remove differential bearings with a special puller. Take the ring gear off the differential case by unscrewing the bolts. Then check the side-gear clearances with a feeler gauge. Clearance should be from 0.004-0.012 inch (0.004 inch preferred). If the clearance is incorrect, new side-gear thrust washers should be installed on reassembly.

Continue disassembly by removing the differential pinion-gear shaft after pressing out the shaft-lock pin. Now, the remainder of the differential parts are free and can be lifted from the case.

On reassembly, coat the gears and thrust washers with lubricant and reverse the disassembly procedure outlined above. Peen over
outside edge of hole after installing the differential pinion-gear-shaft locking pin. After assembly has been complete but before installing the bearing adjusting-nut locks, adjust the bearings as outlined in a following paragraph.

6. Removing and replacing drive pinion. First, remove the differential-case assembly as noted above. Then remove the drive-pinion-flange cotter pin, retaining nut, and washer. Pull the drive-pinion-flange, using a special puller if necessary. Then remove the drive pinion. Do not lose shims, since they must be reinstalled in their original relationship to retain proper adjustment. Pull the bearing from the drive-pinion shaft with the puller. If new parts are used on reassembly, the drive-pinion adjustment will have to be checked.

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**PINION BEARING PRELOAD**
Obtained by placing shims between front bearing and bearing spacer. With oil seal out, tighten pinion flange nut to 175 foot-pounds torque. Should require 12 to 15 inch-pounds torque to rotate pinion.

**PINION ADJUSTMENT**
Obtained by placing washer between rear bearing and pinion. Washers supplied in following thicknesses: .001", .002", .003", .004", .005", .006", and .007", install washer with chamfered edge toward pinion.

**RING GEAR AND PINION BACKLASH AND DIFFERENTIAL BEARING PRELOAD**
Obtained by tightening differential bearing adjusters. Check ring gear for runout, and determine high point. Starting with .001" backlash, and adjuster on back face side of ring gear swing against bearing. Tighten adjuster on back face of ring gear to obtain .008" to .001" backlash. Tighten bearing cap screws to 65 to 80 foot-pounds torque.

**CORRECT TOOTH CONTACT**
Sparingly distributed over 25% of tooth length.

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**Fig. 15-20. Differential adjustments. (Plymouth Division of Chrysler Corporation)**
and corrected after reassembly is completed. When removing the oil seal from the carrier housing, use special puller to avoid damaging the housing.

7. **Differential adjustments.** Figure 15-20 illustrates the various adjustments to be made on the differential. It will be noted that the drive pinion can be moved in or out, and the ring gear (with differential case) can also be moved in or out. The relative positions of these two gears determine the type of mesh between the gear teeth. Figure 15-21 shows different ring-gear patterns obtained by applying red lead to the ring-gear teeth and then rotating the drive pinion. In addition to moving the drive pinion and ring gear one way or the other to obtain proper meshing, the pinion bearings and the differential bearings must be preloaded.

8. **Pinion bearing preload.** Preload is established by correct shimming (Fig. 15-20). To check preload, install the drive pinion and bearings, with shims, in the carrier housing. Do not install the oil seal. Tighten pinion-shaft flange nut to 175 lb-ft (pound-feet). Oil bearings lightly and then use torque wrench to determine amount of torque required to rotate the pinion shaft. The bearing preload is correct if the torque is between 15 and 25 lb-in. (pound-inches). If the torque is low, remove shims. If excessive, add shims. Shim location is shown in Fig. 15-20.

9. **Pinion setting.** Pinion setting is obtained by installing a selective adjusting washer of the correct thickness as noted in Fig. 15-20. Notice how a thicker washer would move the pinion toward the ring gear while a thinner washer would move the pinion away from the ring gear. Details of the checking and adjusting procedure are outlined in a following paragraph.

10. **Adjusting differential case in carrier.** The differential case must be properly positioned in the carrier so as to give the proper mesh between the ring-gear and the drive-pinion teeth. Also, the bearings must be adjusted so as to provide the proper bearing preload.

As a first step in the procedure, install the case in the carrier, making sure the bearing caps are restored to their original positions. Then tighten bearing adjusters to remove play from the bearings (Fig. 15-18). While doing this, keep the bearing adjuster behind the ring gear (or to left in Fig. 15-18) backed out enough to provide plenty of backlash. Note that if you turn this adjuster in, you
Rear Axles and Differentials

Move ring gear away from pinion. If necessary to readjust backlash, install thicker washer.

Move ring gear away from pinion. If necessary to readjust backlash, install thinner washer behind pinion.

Move ring gear toward pinion. If necessary to readjust backlash, install thinner washer behind pinion.

Move ring gear away from pinion. If necessary to readjust backlash, install thicker washer.

Move ring gear toward pinion. If necessary to readjust backlash, install thicker washer.

Correct Tooth Contact

Heavy Face

Heavy Flank

Heavy Toe

Heavy Heel

Fig. 15-31. Ring-gear tooth impression, showing patterns for various adjustments. Note that the ring gear can be moved toward or away from the drive pinion. Also, the drive pinion can be moved in or out. These movements are indicated by the arrows at the upper right. (Plymouth Division of Chrysler Corporation)
move the ring gear into tighter mesh with the drive pinion (thus reducing backlash). Make sure you have plenty of backlash to start the adjustment.

Tighten the two lower cap screws (one on each bearing cap) to about 85–90 lb-ft, leaving the other two cap screws loose. Back out the right-hand bearing adjuster (in Fig. 15-18). Screw in the other bearing adjuster (left-hand one on back side of ring gear) to reduce backlash. Measure backlash by installing a dial indicator as shown in Fig. 15-22. Hold the drive pinion stationary and turn the ring gear back and forth so backlash will indicate on the indicator. Check backlash at various places around the ring gear to find the point of minimum backlash. When this point is found, screw in the adjuster on the left (Fig. 15-18) to reduce backlash (keep right-hand adjuster backed out of way so right bearing does not contact it) to 0.001 inch.

Now, turn in the right-hand adjuster until the dial indicator shows 0.006 inch backlash (holding left-hand adjuster stationary).
Lock adjusters in place and tighten the upper cap screws (one on each bearing cap) to 85-90 lb-ft. Recheck backlash. Both backlash and bearing preload are now set.

11. **Adjusting tooth contact.** Even though the bearing preloading and backlash are properly set, the teeth contact may not be correct. Tooth contact can be checked by applying red lead to the ring gear. Then rotate the drive pinion while loading the ring gear with a round bar applied against its back face. Figure 15-21 shows various ring-gear patterns produced by various adjustments. This illustration also explains what to do to correct the adjustment. A thicker or thinner washer may be required behind the pinion, or the ring gear may have to be moved toward or away from the pinion. If tooth-contact adjustment is required, then it will be necessary to reset the backlash, as noted above and also as indicated in Fig. 15-21.

§188. Checking alignment of rear-axle housing If the rear-axle housing has been subjected to severe impact blows or if you suspect it is bent or distorted in any way, it should be checked as follows. Put axle housing in V blocks and use a level as shown in Fig. 15-23 to position the housing so the carrier mounting is up and perfectly level. Now, put a square against the machined surface of the housing end flange and surface plate, as shown in Fig. 15-24.
Amount of housing misalignment will be indicated by the thickness of feeler gauge that can be inserted between the square and the end flange (at either top or bottom of end flange). If the misalignment is excessive, the housing should be replaced.

Turn housing in V blocks so machined surface is vertical. Use a square to make sure the machined surface is vertical (Fig. 15-25). Repeat the check between a square held on a surface plate and the machined surface of the housing end flange (Fig. 15-26). If there is any misalignment of the housing, you will be able to slip a feeler gauge between the square and either the top or bottom of the end flange. The thickness of the feeler gauge indicates the amount of misalignment. Excessive misalignment requires housing replacement.

§189. Chevrolet rear-axle and differential repair (see Figs. 1-24 and 15-27)

1. Removing and replacing axle-shaft assembly. Remove the wheel by raising the car on a jack, prying off the hub cap with a screwdriver.
FIG. 15-25. Squaring axle for vertical alignment. (Dodge Division of Chrysler Corporation)

FIG. 15-26. Checking vertical alignment. (Dodge Division of Chrysler Corporation)
FIG. 15-27. Exploded view of Chevrolet passenger-car rear-axle and differential assembly. (Chevrolet Motor Division of General Motors Corporation) [580]
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driver, unscrewing the hub nuts, and lifting the wheel from the bolts that are attached to the axle-shaft flange. Remove the two brake-drum retaining nuts (Fig. 15-28) and detach the brake drum. Install wheel-cylinder clamp on the brake-wheel cylinder. Drain the differential lubricant and remove the housing cover.

Remove the differential pinion-shaft lock screw, pinion shaft, and axle-shaft spacer as shown in Fig. 15-29. Then remove the pinions and push the axle shafts in toward the center, so that the C washers can be removed from the inner ends of the axle shafts. The axle shafts can now be pulled from the axle housing.

For installation of a new axle shaft, it is necessary to use new bolts, oil deflector, and gasket. The oil drain holes in the shaft flange, gasket, and brake drum must align with the notch in the oil deflector to permit excess oil from the axle to drain out without getting on the brake drum and the brake. The gasket between the shaft flange and the oil deflector should be covered with shellac to provide a good oil seal, all parts aligned as detailed above, and the six bolts installed in the flange holes. The ends of the shoulders

1. Propeller shaft
2. Rear-axle ventilator
3. Propeller-shaft housing and differential carrier
4. Bearing lock screw
5. Differential cap screw
6. Front bushing
7. Rear bushing
8. Oil seal
9. Lock
10. Shim
11. Pinion-shaft front bearing
12. Bearing lock sleeve
13. Lock ring
14. Pinion-shaft rear bearing
15. Ring-and-pinion gears
16. Lock
17. Adjusting nut
18. Differential side bearing
19. Ring-gear screw
20. Differential case
21. Differential side gear
22. Differential pinion
23. Differential-pinion shaft
24. Shaft lock screw
25. Axle-shaft spacer
26. Differential-carrier gasket
27. Housing bolt
28. Axle housing
29. Cover gasket
30. Housing cover
31. Plug gasket
32. Filler plug
33. Spring seat
34. Axle shaft
35. Axle shaft
36. Shaft lock
37. Brake drum
38. Gasket
39. Hub oil deflector
40. Housing oil deflector
41. Oil seal
42. Outer race and rollers
43. Bearing retainer
44. Hub bolt

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Fig. 15-28. Brake-drum retaining nuts. (Chevrolet Motor Division of General Motors Corporation)

Fig. 15-29. Removing the axle-shaft spacer. (Chevrolet Motor Division of General Motors Corporation)
on the bolts should be peened into the countersink around the bolt holes in the flange with the special peening tool and anvil shown in Fig. 15-30. This rivets all parts together—a very important operation. The peening tool should be turned after each hammer blow, to prevent damage to the tool.

Fig. 15-30. Using peening tool and anvil to rivet bolts in axle flange. The peening tool is hollow so that the bolt end fits into it. (Chevrolet Motor Division of General Motors Corporation)

Check the leather oil seal on the inside of the axle housing before replacing the shaft. Slide the axle shafts into the housing, aligning the shafts and the differential slide-gear splines. Replace C washer on the inner end of each shaft, and pry the shaft ends apart so that C washers seat in counterbores in differential side gears. Do not damage the inner ends of shafts. Replace differential pinions, axle-shaft spacer, and shaft. Select the proper size of spacer to provide [583]
correct clearance. Four sizes of axle-shaft spacer are available so that the proper clearance (free fit to a maximum of 0.014 inch) may be obtained between the ends of the shafts and the spacer. Clearance is checked as shown in Fig. 15-31. Secure the assembly with screw and lock washer.

Use a new cork gasket, replace the axle-housing cover, and refill the differential with correct hypoid-gear lubricant.

Fig. 15-31. Checking clearance between spacer and axle shaft with feeler gauge. (Chevrolet Motor Division of General Motors Corporation)

2. Removing and replacing axle-shaft bearing. With the wheel and axle shaft removed, use the special bearing puller shown in Fig. 15-32 to remove the bearing, bearing retainer, and leather oil seal from the axle housing. Replace by using a special driver shown in Fig. 15-33. A few light blows of the hammer will seat the bearing in its correct position, along with the oil seal and retainer. The oil seal should be staked in place with a prick punch.

3. Removing rear-axle assembly. Removing the rear-axle assembly is a major operation. The first step is to jack up and support the rear end of the car and remove the rear wheels and brake...
Rear Axles and Differentials

Fig. 15-32. Using axle-shaft bearing puller to remove bearing. (Chevrolet Motor Division of General Motors Corporation)

Fig. 15-33. Using axle-shaft-bearing-and-retainer replacing tool. (Chevrolet Motor Division of General Motors Corporation)
drums. Install wheel-cylinder clamps on the brake-wheel cylinders. Disconnect or remove parts as follows:

a. Disconnect hand-brake cables from the idler lever.
b. Remove brake cables from the cable clamps on frame.
c. Disconnect the hydraulic brake line at the rear-axle housing.
d. Disconnect the shock-absorber links from the anchor plates.
e. Remove the spring U bolts.
f. Disconnect spring shackles and drop springs.
g. Slide the axle back to disconnect the torque tube at the front end.
h. The axle assembly is now free to be moved to the axle stand.

4. Disassembly of rear-axle assembly. All adjustments should be checked during disassembly, so that improper clearances or adjustments can be corrected during reassembly. Note, in particular, the following: clearance between axle shafts and spacer; ring-gear and drive-pinion backlash; pinion depth in ring gear.

Also, check the ring gear for tightness on the differential case, make sure the propeller-shaft and pinion assembly rolls freely in its bearings, and note whether the propeller shaft is loose in the front bushing.

The rear-axle assembly is disassembled by removing the axle shafts as previously described, and then separating the propeller-shaft housing and differential carrier from the axle housing by removing the nuts from the attaching studs. Remove the differential assembly from the carrier by taking out the two adjusting nut locks and the four differential-carrier cap screws and then removing the bearing caps and adjusting nuts.

The pinion and propeller-shaft assembly can be removed from the propeller-shaft housing and differential carrier by unscrewing the three bearing-retaining screws from the carrier and then dropping the carrier, propeller-shaft splined end down, against a piece of wood. This pushes the drive-pinion shaft out. Remove the bearing shims from the carrier, noting their number and thickness. After disassembly, all parts should be washed in cleaning solvent and inspection made as follows:

a. Note the fit of splines in the universal joint.
b. Check bearings for wear and looseness after cleaning and relubrication with light oil. In particular, the double-row
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Drive-pinion bearing should be inspected for end play, since excessive end play will cause gear damage.

c. Examine both differential side gear bearing surfaces in the differential case.


e. Remove the lock wire and check ring-gear bolts for tightness.

f. Check the differential side gears for scored hubs and fit on the axle shaft.

g. Check the differential pinion-gear thrust surfaces and fit of pinion gears on pinion shaft.

h. During disassembly, check the clearance between the propeller shaft and the bushing. If it is over 0.010 inch, the bushing and the oil seal should be replaced.

Any defect found requires replacement of the part or parts as explained in following paragraphs.

5. Propeller-shaft bushing and oil-seal replacement. To replace the shaft bushings, drill out the dowel pins and drive bushings and oil seals from the pinion end of the housing. Start a new oil seal into the housing, with the free side of the leather toward the front; then install a new rear bushing and seat both the oil seal and the bushing by driving with a special bushing driver. Drill a dowel hole in the bushing, coat the dowel with Permatex or similar compound, and install the dowel and peen into place. Install the front bushing with special bushing driver and drill a dowel-pin hole in bushing, using great care to avoid breaking through the bushing wall. A universal-joint rear yoke should be inserted while peening the dowel pin into place, to prevent bushing distortion. Burrs should be filed off.

6. Propeller-shaft and pinion disassembly. When replacing the propeller shaft, drive pinion, or bearings, the shaft and pinion assembly must be disassembled, as follows:

a. Prepare to separate the drive pinion and propeller shaft by center-punching and drilling out the end of the rivet, then driving the rivet out.

b. Loosen the pinion-bearing lock nut, separate the pinion from the propeller shaft, remove the lock nut, and pull bearing from the pinion shaft with a special puller.

c. Remove the rear pinion-bearing lock ring and bearing.

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7. Propeller-shaft and pinion assembly. Proceed with the propeller-shaft and drive-pinion assembly as follows:

a. Install the rear pinion shaft bearing and lock ring.
b. Slip the lock sleeve on the shaft, beveled side toward the pinion.
c. Press the double-row bearing on the pinion shaft and install the bearing lock nut. Do not tighten at this time.

d. Assemble the propeller shaft and pinion by pressing the splined end of the pinion shaft into the coupling so that rivet holes align. Insert a new rivet and peen over the ends.
e. Tighten the bearing lock nut to 200–240 lb-ft and lock it into the milled slot in the pinion shaft.

8. Differential side-bearing replacement. Differential side bearings are removed by using a special puller, the legs of which fit into...
the two notches in the differential case (Fig. 15-34). After removal, bearings should be cleaned, oiled with light oil, and checked for roughness and wear. Bearings are replaced by use of a special driver (Fig. 15-35). The thick side of the inner bearing race should be toward the differential case as shown in Fig. 15-35.

9. Ring-gear replacement. Remove the ring-gear bolts and tap the ring gear off the case with a soft hammer. Place the case in V blocks, and use a dial indicator to check the ring-gear pilot and case flange for run-out or out-of-round condition. This should not exceed 0.001 inch.

Install a new ring gear, using five guide pins placed in every other hole (Fig. 15-36). Guide pins may be made from \(\frac{5}{8}\)-inch-24 cap screws about 1\(\frac{1}{2}\) inches long by cutting off the heads of the screws and cutting screw slots in the ends. Use of guide pins assures alignment of the ring gear. Install five ring-gear bolts with lock washers and tighten securely. Remove guide pins and install the other five bolts. Tighten all bolts.

**Caution:** The face of the case and back of the ring gear must be clean and free of burrs, so that parts fit squarely.

Mount the assembly in V blocks and use a dial indicator to check run-out of back face of the ring gear (Fig. 15-37). Run-out must not exceed 0.004 inch.
10. Assembling rear-axle assembly. If the original ring gear and drive pinions are to be used, install shims of the same thickness originally found in the propeller-shaft housing. Make sure the shims are flat in the counterbore. Whenever a new ring gear and pinion are installed, use one 0.015-inch and one 0.018-inch shim, since this is the standard arrangement.

Coat the beveled surface of the pinion-bearing lock sleeve with a lubricant and install the propeller shaft and pinion assembly in the housing, driving it in place to seat the bearings. Use a drift in the drive-pinion hole; do not drive against the pinion teeth.

Make sure the outer race locking sleeve is in place against the bearing outer race by checking through the lock-screw holes. Install the three tapered lock screws and draw them down evenly and tightly. Tighten the lock-screw lock nuts.

11. Ring-gear and pinion adjustment. The ring gear and the drive pinion must be adjusted to have the proper tooth contact;
otherwise, rapid tooth wear and tooth breakage will result. The adjustment is made with the differential case installed in the carrier as shown in Fig. 15-38. The adjusting nuts should be slid alongside the bearings so that the nut threads fit into the differential-carrier threads. The bearing caps are then installed, with the marks on the caps and the carrier in alignment, and the cap screws are tightened only until the lock washers just flatten out.

Note: The adjustment is made before the differential-carrier is attached to the axle housing.

To make the adjustment, loosen the right-hand adjusting nut and tighten the left-hand adjusting nut (Fig. 15-38), turning the ring gear at the same time. Continue until tightening the left-hand nut takes all lash out of the gears; then back off the left-hand nut one notch. Tighten the right-hand adjusting nut snugly (nut comes to a definite stop), and then turn the right-hand nut one or two notches more to locking position.

Check backlash by mounting the dial indicator on the carrier (Fig. 15-39). Backlash should be from 0.005-0.007 inch. If the
backlash is more than this, loosen the right-hand adjusting nut one notch and tighten the left-hand adjusting nut one notch. If the backlash is too small, loosen the left-hand adjusting nut one notch and tighten the right-hand nut one notch.

Tighten the bearing-cap bolts securely and recheck the backlash. Make further adjustment if necessary. Install both adjusting-nut locks.

Complete the rear-axle assembly by attaching the axle housing to the differential carrier, using a new gasket. Lubricate the differential side-gear hubs with hypoid-gear lubricant and install them in the differential case. Install the axle shafts, making sure the longer shaft is used on the right-hand side, and install the C-shaped washers on the shaft ends. Spread the ends of the axle shafts to make sure the C washers seat in the counterbores in the differential side gears. Roll the two differential pinion gears into place and install the axle-shaft spacer, pinion-gear shaft, and lock screw. Check clearance between axle-shaft ends and spacer (Fig. 15-31). This should be from a free fit to a maximum of 0.014 inch.

Fig. 15-39. Checking backlash between ring gear and drive pinion with dial indicator. (Chevrolet Motor Division of General Motors Corporation)
Install the housing cover, using a new cork gasket, and fill the differential with 3 1/2 pints of proper hypoid lubricant. Pour about 1/2 pint of transmission lubricant into the front end of the propeller-shaft housing to provide initial lubrication of the propeller-shaft bushings.

12. Replacing rear-axle assembly. Reverse the removal procedure detailed in a previous paragraph to replace the rear-axle assembly. Special care should be taken to make sure that all cotter pins are assembled and securely bent over. The U bolts holding the springs to the spring seats must be drawn up securely. When connecting the brake cables, make sure that all the play is out of the cables before connecting and tightening the check nuts at the idler lever. After replacement of the rear-axle assembly, the brake lines of all four wheels must be bled to remove air. This operation is described in Chap. 15 of Automotive Chassis and Body, another book in the McGraw-Hill Automotive Mechanics Series.

§190. Ford rear-axle and differential repair (see Figs. 15-40 and 15-41)

1. Removing and replacing axle shaft. Remove wheel and brake drum. Then, working through the hole in the axle flange, remove the bolts holding the brake plate to the axle housing. Attach puller to axle flange and pull axle. Do not dislodge the brake plate nor
Fig. 15-41. Disassembled view of differential. (Ford Division of Ford Motor Company)
damage the oil seal in the housing. Figure 15-42 shows the axle, bearing assembly, grease seal, and other parts in partially disassembled view. Install one nut to hold the brake plate in place.

The wheel bearing, which is pressed onto the axle shaft, is of the prelubricated and sealed ball type. It should not be removed from the shaft unless examination shows a new bearing is required. To inspect the bearing, rotate and attempt to rock the outer race. If the race is loose or rolls roughly, or if lubricant seeps out past the seal on the bearing, the bearing will require replacement. To re-

move the old bearing, loosen the bearing retainer ring and then use a puller which will remove the bearing without damaging the shaft. Press on a new bearing, applying pressure on the retainer ring, not the outer race of the bearing.

Before replacing the axle shaft, examine the oil seal. If it appears worn or damaged in any way, replace it. Soak the new seal for at least half an hour in oil. Then use a seal installer to make sure the seal goes in square with the housing and fits tight against the shoulder.

Remove the nut holding the brake plate to the housing. Lubricate the bearing bore in the housing, clean the brake-plate surface, and
install new gaskets between the retainer plate and brake plate. Push axle shaft into place, making sure the shaft splines enter the differential-gear splines. At the same time, work carefully to avoid damaging the oil seal. Make sure the bearing seats tightly against the shoulder in the housing. Position retainer plate on rear-axle-housing bolts and secure with lock nuts. Tighten nuts to 30-35 lb-ft. Install brake drum, secure with special nuts, and install wheel.

2. Replacing drive-pinion oil seal. The drive-pinion oil seal may be replaced without removing the differential from the car. Dis-

connect the propeller shaft at the rear universal joint. Mark the positions of the joint flange, nut, and shaft with a punch so everything can be restored to its original position. Then remove the flange, nut, and washer. Use an oil-seal puller to remove the pinion seal from the housing.

Check the lubricant drain-back passage in the housing, and also the axle-housing vent, to make sure they are free. If they are not, leakage past the oil seal may occur. Make sure the oil-seal seating surface and bore in the housing is free of nicks. Nicks should be removed with a file or stone. Then coat the bore with Permatex and use a special driver to install the oil seal. Put the universal-joint flange on the pinion shaft with the punch marks in line. Use special tool (Fig. 15-43) to complete flange installation. Put washer [596]
in place and tighten the nut on the shaft until the punch mark on it lines up with the mark on the flange. Connect the shaft, aligning the punch marks.

3. **Removing differential carrier from axle housing.** With axle shafts out, drain lubricant, take off the attaching nuts, and pull the carrier from the axle housing. Figure 15-44 shows the carrier assembly as it appears when removed from the axle housing.

![Carrier assembly, with differential assembly installed. (Ford Division of Ford Motor Company)](image)

4. **Differential removal and disassembly** (see Fig. 15-41). Mark the bearing caps and carrier supports with numbers (or punch marks) so caps will be restored to their original positions on reassembly. Remove the adjusting-nut locks, bearing caps, and nuts. Lift the differential assembly from the carrier. Remove the differential bearings with bearing puller (Fig. 15-45).

Take ring gear off the differential case by removing the cap screws and then tapping the ring gear free with a soft hammer. Drive the pinion-shaft locking pin out of the case with a suitable drift, working from the ring-gear side of the case. Now, remove the pinion shaft and all of the gears and thrust washers.
5. Drive-pinion removal and disassembly. Remove universal-joint flange nut and washer and pull flange off the drive pinion. Remove drive pinion and bearing spacer from the carrier. Remove oil seal with special puller as already noted. Take rear bearing off drive-pinion shaft with special puller. Special puller is also required to pull bearing cups from the carrier.

Note: Later models have shims between the rear bearing and pinion gear as shown to the lower left in Fig. 15-41. Earlier model drive pinions are interchangeable provided necessary shims are installed on the shaft.

6. Drive-pinion installation and depth adjustment. In earlier models, shims are used between the rear bearing cup and the housing-to-control pinion depth. In the later models, the shims are used between the pinion bearing and pinion gear (as at lower left in Fig. 15-41).

a. Earlier type. Install the drive-pinion bearing cups in the carrier with special replacer tool. Then use an arbor press to press...
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the pinion shaft into the rear bearing. Bearing must seat on shoulder behind gear. Put pinion shaft into carrier and install front bearing on shaft.

Install universal-joint flange, washer, and nut (see Fig. 15-43). Tighten nut until the bearing is preloaded 15–20 lb-in. Preload is tested by determining the amount of torque required to turn the pinion (Fig. 15-46). When torque required is 15–20 lb-in., preloading is correct.

![Fig. 15-46. Checking pinion-bearing preload with a special tension scale that measures torque required to turn the pinion. (Ford Division of Ford Motor Company)](image)

Use either of the gauges shown in Fig. 15-47 to check the pinion-depth adjustment. When using gauge A, subtract 0.5 inch from the micrometer reading. If the depth reading (on micrometer) exceeds 2 inches (plus or minus 0.002 inch), shims equal to the overage must be installed back of the pinion rear-bearing cup. For example, if the depth reading is 2.007 inches, install a 0.005-inch shim to reduce the measurement to 2.002 inches.

To install the shim, the universal-joint nut, washer, and flange must be removed, and the rear-bearing cup pulled. Then, after the shim is installed, the cup should be reinstalled. Put pinion shaft in carrier and install bearing spacer and front bearing. Put oil seal.
on shaft and drive it into place with special driver. Install universal­joint flange, washer, and nut (Fig. 15-43). Tighten nut to preload bearing to 15–20 lb-in. as already noted (see Fig. 15-46).

**NOTE:** A new bearing spacer must be used every time the pinion­shaft front bearing is removed and reinstalled.

*b. Later type.* Install the drive-pinion bearing cups in the carrier, using special replacer tool. Slide the drive-pinion rear bearing on special master pinion tool as shown in Fig. 15-48. Put tool, with bearing, in carrier and install universal-joint flange, washer and nut. Tighten nut to preload bearing to 15–20 lb-in. as already noted. Use either pinion-depth gauge shown in Fig. 15-47. Sub­tract 2 inches from the micrometer reading if using tool B and subtract 2.5 inches if using tool A. The decimal remainder will be 0.030 inch or more (the master pinion tool allows 0.030 inch for shimming). Remove pinion depth gauge and master pinion tool from carrier.

Determine the amount of shimming (between the drive-pinion gear and rear bearing as shown to lower left in Fig. 15-41) as follows. Note the number etched on the face of the pinion. If the number is 15, the 0.030 or more decimal remainder is the thickness of shim needed. If the etched number is more than 15, subtract 15 and then subtract the remainder from the decimal remainder. For example, suppose the decimal remainder is 0.033 inch (with gauge B in Fig. 15-47 giving a micrometer reading of 2.033 inch). Now,
suppose the number etched on the pinion face is 20. Subtract 15 from 20 to get 5. This is actually 0.005 inch. So subtract this from 0.033 to get 0.028. The actual shimming that must be used between the pinion gear and the gear bearing is 0.028 inch.

If the number etched on the face of the pinion is less than 15, subtract that number from 15 and then add the remainder to the decimal remainder and proceed as noted above.

After the proper shims are installed and the bearing pressed on the pinion shaft, install the pinion shaft, bearing spacer, front bearing, oil seal, universal-joint flange, washer, and nut as already noted. Tighten nut to obtain correct bearing preload.

Caution: Always install the same bearings used with the master pinion tool. If other bearings are substituted, adjustment will not be correct.

7. Assembling differential (see Fig. 15-41). Install side gears, pinions, and thrust washers in the case. Install pinion shaft and shaft pin and stake the edge of the pin hole securely. Position ring gear on case and secure it with screws tightened to 35–40 lb-ft.
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Drive differential bearings onto case hubs with special driver until they are flush with shoulders on the case.

8. Differential installation and adjustment. Adjustments and checks required when the differential is installed include ring-gear backlash, run-out, and gear tooth contact.

Note: When a ring gear or drive pinion requires replacement, both must be replaced since they are supplied as matched sets.

To install the differential in the carrier, put the bearing cups on the bearings and put differential in the carrier. Thread adjusting nuts into place, meshing threads on the nuts with threads in the carrier. Install bearing caps with screws turned down finger-tight. Tighten adjusting nuts hand-tight against bearing cups. Tighten bearing cap screws securely to make sure caps seat and then back off slightly so adjusting nuts can be turned with adjusting-nut wrench (similar to one shown in Fig. 15-38).

a. Ring-gear backlash. Use a dial indicator to check the ring-gear backlash (making a setup similar to that shown in Fig. 15-22 or 15-39). Tighten adjusting nut back of ring gear to move ring gear into deeper mesh with the drive pinion until the backlash is zero. You may have to loosen the other adjusting nut while doing this. Then turn this other adjusting nut back in until it is snug (mean-time holding the adjusting nut back of the ring gear stationary). Turn this adjusting nut on in an additional 1½–2½ notches to impose proper preload on the bearings. Ring-gear backlash should now be correct and between 0.003 and 0.008 inch.

b. Ring-gear run-out. Mount a dial indicator on the carrier back of the ring gear so the contact button rests on the smooth back surface of the ring gear. Rotate ring gear to check run-out. It should not exceed 0.003 inch. If excessive, chances are the ring gear is not mounted properly on the carrier, due to burrs or dirt under it.

c. Gear-tooth contact. Paint the ring-gear teeth with red lead and turn the gear under pressure to get tooth impressions. If tooth contact is not correct, the ring gear or pinion will have to be moved and backlash readjusted. The tooth impressions and corrections indicated in Fig. 15-21 will, in general, apply. With adjustments correct, tighten bearing cap screws to 70–80 lb-ft. Install adjusting-nut locks and tighten nut-lock screws to 15–20 lb-ft.

9. Installing differential carrier in axle housing. Put a new gasket on the axle-housing studs and position carrier on housing. Install
stud nuts and tighten to 30-35 lb-ft. Fill axle housing to the level of the filler plug with recommended lubricant.

§191. Servicing nonslip differential This differential is removed and replaced in the same manner as other differentials. Before disassembly, put scribe marks on the two halves of the differential case so they can be reassembled in the same relative positions. Remove axle drive gear and the bolts attaching the two case halves. All parts can now be separated. Be sure to note the relationship of the clutch plates, lock plates, side gear retainer, side gears, pinion shafts, and pinions. Replace in same order on reassembly.

CHAPTER CHECKUP

Note: Since this is a chapter review test, you should review the chapter before taking it.

With this chapter on differentials, you have completed your studies of the power train. Compared to transmissions, which you studied in previous chapters, the differential may seem like a very simple mechanism. However, even though it is relatively uncomplicated, the repair and adjusting procedures are rather complex. Furthermore, they must be followed exactly if proper differential operation and normal differential life is to be obtained. The test that follows is designed to check your memory on how well you remember the various checking and servicing procedures detailed in the chapter.

Completing the Sentences

The sentences below are incomplete. After each sentence there are several words or phrases, only one of which will correctly complete the sentence. Write each sentence down in your notebook, selecting the proper word or phrase to complete it correctly.

1. Most often, the condition that draws attention to trouble in the differential is rough operation noise power loss
2. A humming noise in the differential is often caused by improper tooth contact between the drive pinion and ring gear axle and side gear pinion and side gears
3. If noise is present in the differential only when the car rounds a curve, chances are the trouble is due to some condition in the drive-pinion assembly differential-case assembly wheel bearing
4. To correct heavy face contact on the ring-gear teeth, move the

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5. To correct heavy flank contact on the ring-gear teeth, move the drive pinion in drive pinion out ring gear out and then adjust backlash, as necessary.

6. To correct heavy heel contact on the ring-gear teeth, move the drive pinion in ring gear toward pinion ring gear away from pinion and adjust backlash.

7. To correct heavy toe contact on the ring-gear teeth, move the ring gear toward pinion ring gear away from pinion drive pinion out and adjust backlash.

8. On Plymouth, drive-pinion-bearing preload is established by shims adjusting nuts bearing adjusters.

9. On Plymouth, the drive pinion is adjusted by use of a selective washer of proper thickness adjusting nuts bearing adjusters.

10. The ring gear is adjusted in the differential by use of selective washers of proper thickness bearing adjusters adjusting screws.

11. Bearing adjusters are held in place in the differential carrier by bearing caps selective washers lock pins.

12. To remove the rear axles from a Chevrolet, it is first necessary to remove the axle-shaft spacer, pinions, and propeller shaft differential case differential carrier C washers.

13. On the Chevrolet, the rear wheels are attached to bolts in flanges on the wheel hubs brake backing plates axle shafts.

14. On Ford, the drive-pinion-bearing preload is measured by determining how much torque it requires to turn the bearing nut drive pinion axle shaft.

15. Generally speaking, the backlash between the drive pinion and the ring gear of a differential should be about 0 0.006 inch 0.060 inch 0.600 inch.

Troubles and Service Procedures

In the following, you should write down in your notebook the trouble causes and service procedures asked for. Do not copy the procedures from the book; try to write them in your own words. Writing them down in your own words will help you to remember the procedures. And, of course, having the procedures well in mind is of great value to you in the service shop.

1. Explain how a differential operates when the car is rounding a turn.

2. List and explain the names used to describe the various parts of gear teeth, including backlash, clearance, heel, toe, face, and flank.
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3. List and describe the three types of live axles discussed in the book.
4. List possible causes of hum in the differential.
5. Explain how to determine axle ratio in a car equipped with Hotchkiss drive.
6. List the main steps in removing and replacing an axle shaft.
7. List the main steps in removing and replacing a differential-carrier assembly.
8. Describe the disassembly and reassembly procedure on one make of differential-carrier assembly.
9. Explain how to adjust the differential in one make of car.

SUGGESTIONS FOR FURTHER STUDY

Examine the differentials used in different cars. If possible, disassemble and reassemble one, and make the adjustments it requires. If you do have a chance to work on an actual differential, be sure to follow the service instructions as outlined in the applicable automotive shop manual. In addition to studying actual differentials, study the shop manuals also, since they contain considerable detailed material applying to particular models of differentials. Be sure you write down in your notebook any important facts you come across.
Appendix A: Chassis dynamometer

THE CHASSIS dynamometer was developed originally to test engine performance in the shop, with the engine in the vehicle. Figure A-1 illustrates a chassis dynamometer for use in the service garage. The car is driven onto the dynamometer as shown in Fig. A-2 so the rear wheels can drive the two rollers. Then, with the instruments connected to the engine, the engine is started and the transmission is put into gear. The engine then drives the dynamometer through the power train and rear wheels. Another book in the McGraw-Hill Automotive Mechanics Series (Automotive Engines) describes dynamometers in some detail and explains how to interpret dynamometer results.
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The chassis dynamometer can also be used to check automatic transmissions in the shop since this device can simulate, on the shop floor, various conditions that a car would meet on the highway. That is, the car, engine, and transmission can be put through their paces under conditions that very closely approximate actual over-the-road operation including low speed, hill climbing, high speed, accelerating, decelerating, and so on. Thus, automatic-transmission operation, including shifting and shift points, can be observed on the shop floor. Furthermore, pressures in the hydraulic system and other pertinent data can be observed at the same time. This, of course, is something that would be difficult to do during a road test.
Appendix B: Glossary

THIS GLOSSARY of automotive terms used in the book is designed to provide a ready reference for the student. The definitions may differ somewhat from those given in a standard dictionary; they are not intended to be all-inclusive but have the purpose of serving as reminders so the student can quickly refresh his memory on automotive terms about which he may be doubtful. More complete definitions and explanations of the terms are found in the text.

Accelerator  The foot-operated pedal linked to the throttle valve in the carburetor.

Air line  A hose or pipe through which air passes.

Air pressure  Atmospheric pressure (14.7 pounds per square inch at sea level) or pressure of air produced by pump, by compression in engine cylinder, etc.

Antifriction bearings  Bearings having rolling contact between the moving surfaces such as in ball and roller bearings.

Atmospheric pressure  Pressure of the atmosphere, or air, due to its weight pressing downward. Average is 14.7 pounds per square inch at sea level.

Automatic transmission  Transmissions that automatically provide varying gear ratios to suit operating conditions.

Axle  A crossbar supporting a vehicle on which one or more wheels turn.

Axle ratio  Ratio between propeller shaft and rear-wheel rpm; gear reduction in the differential.

Backlash  In gearing, clearance between meshing teeth of two gears which will permit backward rotation of driven gear in direction opposite to driving rotation. Generally, the amount of free motion, or lash, in a mechanical system.

Balanced valve  A type of hydraulic valve that produces pressure changes proportional to movement of mechanical linkage or variations in spring pressure.

Ball bearing  Antifriction bearing with an inner and an outer race with one or more rows of balls between them.
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Ball check valve A valve consisting of a ball and seat. Fluid can pass in one direction only; when it attempts to flow the other way, it is checked by the ball seating on the seat.

Bearing Generally, the curved surface on a shaft or in a bore, or the part assembled onto one or into the other to permit relative rotation with minimum wear and friction.

Bevel gear Gear shaped like the lower part of a cone, used to transmit motion through an angle.

Body The assembly of sheet-metal sections, together with windows, doors, seats, and other parts that provide an enclosure for the passengers, engine, etc.

Boiling point The temperature at which a liquid begins to boil.

Bore Diameter of engine-cylinder hole; also diameter of any hole, for instance, the hole in which a bushing fits.

Brake A device for slowing or halting the motion of any object or mechanism.

Brake drums Metal drums mounted on the car wheels; brake shoes press against the drums to slow or stop drum and wheel rotation for braking.

Brakes The mechanism that enables the driver to slow or stop the car by depressing a foot pedal; this action results in the application of a braking or retarding force at the car wheels.

Burr A featheredge of metal left on a part being cut with a file or other cutting tool.

Bushing A sleeve placed in a bore to serve as a bearing surface.

Cam A moving part of an irregular form designed to move or alter the motion of another part.

Carburetor The device in the fuel system which mixes air and gasoline (vaporizing the gasoline as it does so) in varying proportions to suit engine operating conditions.

Chassis The assembly of mechanisms that make up the major operating part of the vehicle. It is usually assumed to include everything except the car body.

Clearance The space between two moving parts, or between a moving and a stationary part such as a journal and a bearing. Clearance is considered to be filled with lubricating oil when mechanism is running.

Clutch In the vehicle, the mechanism in the power train that connects the engine crankshaft to, or disconnects it from, the transmission and thus the remainder of the power train.

Clutch disk Friction disk, which see.

Clutch gear See clutch shaft.
Appendix B: Glossary

Clutch pedal  A pedal in the driver's compartment to operate the clutch.
Clutch shaft  Also called the drive pinion and clutch gear. The shaft on which the clutch is assembled, with gear that drives the countershaft in transmission.
Coil spring  A spring made up of an elastic metal such as steel, formed into a wire or bar and wound into a coil.
Cooling system  In the engine, the system that removes heat from the engine and thereby prevents overheating. It includes the water jackets, water pump, radiator, and thermostat.
Countershaft  The shaft in the transmission which is driven by the clutch gear; gears on the countershaft drive gears on the main shaft when the latter are shifted into gear.
Crankshaft  The main rotating member, or shaft, of the engine with cranks to which the connecting rods are attached.
Cylinder  A tubular-shaped structure. In the engine, the tubular opening in which the piston moves up and down.
Degree  1/360 part of a circle.
Detent  A small depression in a shaft, rail, or rod into which a pawl or ball drops when the shaft, rail, or rod is moved; this provides a locking effect.
Dial indicator  A gauge that has a dial face and needle to register movement. Used to measure variations in size, small movements too little to be measured conveniently by other means, etc.
Diaphragm  A flexible membrane, usually made of fabric and rubber in automotive components, clamped at the edges and usually spring-loaded; used in various pumps and controls.
Diaphragm springs  A type of spring used in some clutches which is shaped like a disk with tapering fingers pointing inward, or like a wavy disk (crown type).
Differential  A mechanism at the rear axles (in passenger cars) that permits one rear wheel to turn at a different speed than the other. It transmits power from the propeller shaft to the wheel axles.
Double-reduction differential  A differential containing an extra set of gears to provide additional gear reduction.
Drive line  The driving connection between the transmission and the differential; consists of the propeller shaft with universal and slip joints.
Driven plate  Friction disk, which see.
Dry-disk clutch  A clutch in which the friction faces of the friction disk are dry, as opposed to a wet-disk clutch, which see.
Dry friction  The friction between two dry solids,
Eccentric  Off center.
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Efficiency  Ratio between the effect produced and the power expended.
Electric system  In the automobile, the system that electrically cranks the engine for starting, furnishes high-voltage sparks to the engine cylinders to fire the compressed air-fuel charges, lights the lights, operates the heater motor, radio, etc. Consists, in part, of starting motor, wiring, battery, generator, regulator, ignition distributor, ignition coil.
Energy  The capacity or ability to do work.
Engine  The assembly that burns fuel to produce power, sometimes referred to as the power plant.
Expansion plug  A plug that is slightly dished out. When driven into place, it is flattened and expanded to fit tightly.
Extreme-pressure lubricant  A special lubricant for use in hypoid-gear differentials.
Feeler stock  Strips of metal of precise thicknesses used to measure clearances.
Final drive  That part of the power train that transmits the power from the transmission to the wheels, consisting of the propeller shaft, differential, and wheel axles.
Fluid coupling  A device in the power train consisting of two rotating members. It transmits power through a fluid from the engine to the remainder of the power train.
Fluid drive  Same as fluid coupling, which see.
Fluid-Torque Drive  A torque converter, which see.
Flywheel  The rotating metal wheel attached to the crankshaft, which helps even out the power surges from the power strokes and also serves as part of the clutch and engine-cranking system.
Frame  The assembly of metal structural parts and channel sections that supports the engine and body and is supported by the car wheels.
Freewheeling mechanism  An overrunning clutch in the transmission which permits the car to coast while the engine slows down. The car cannot drive the engine, but the engine can drive the car.
Friction  The resistance to motion between two bodies in contact with each other.
Friction bearings  Bearings having sliding contact between the moving surfaces. Sleeve bearings, such as those used in connecting rods, are friction bearings.
Friction disk  In the clutch, a flat disk, faced on both sides with friction material, and splined to the clutch shaft. It is positioned between the clutch pressure plate and the engine flywheel.
Fuel system  In the automobile, the system that delivers to the engine cylinders the combustible mixture of vaporized fuel and air.
Appendix B: Glossary

It consists of fuel tank, lines, gauge, carburetor, and manifold.

**Full throttle** Wide-open throttle position with accelerator pressed all the way down to floor board.

**Gasket** A flat strip, usually of cork or other material, placed between two surfaces to provide a tight seal between them.

**Gasket cement** An adhesive material that is used to apply gaskets.

**Gear lubricant** A type of grease or oil designed especially to lubricate gears.

**Gear ratio** The relative speeds at which two gears (or shafts) turn; the proportional rate of rotation.

**Gears** Mechanical devices to transmit power, or turning effort, from one shaft to another; more specifically, gears contain teeth that interlace or mesh as the gears turn.

**Gear-type pump** A pump using a pair of matching gears that rotate; meshing of the gears forces oil (or other liquid) from between the teeth through the pump outlet.

**Generator** That part of the electric system which converts mechanical energy into electric energy for lighting lights, charging the battery, operating the ignition system, etc.

**Goggles** Special glasses worn over the eyes to protect them from flying chips, dirt, or dust.

**Governor** A device that governs or controls another device, usually in accordance with speed or rpm. The governor used in certain automatic transmissions is an example; it controls gear shifting in relation to car speed.

**Gravity** The attractive force between objects that tends to bring them together. A stone dropped from the hand falls to the earth because of gravity.

**Grease** Lubricating oil to which thickening agents have been added.

**Greasy friction** The friction between two solids coated with a thin film of oil.

**Grinder** A machine for removing metal by means of an abrasive wheel or stone.

**Grinding wheel** A wheel, made of abrasive material, used for grinding metal objects held against it.

**Helical gear** A gear in which the teeth are skewed or twisted at an angle to the center line of the gear.

**Hone** An abrasive stone that is rotated in a bore or bushing to remove material.

**Horsepower** A horsepower is a measure of a definite amount of power; 33,000 foot-pounds of work per minute.

**Hotchkiss drive** The type of rear suspension in which the springs absorb the rear-end torque.
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**Hydraulic brakes** - A braking system that uses hydraulic pressure to force the brake shoes against the brake drums as the brake pedal is depressed.

**Hydraulic pressure** - Pressure exerted through the medium of a liquid.

**Hydraulics** - That branch of science dealing with the motion of liquids.

**Hydraulic valve** - A valve in a hydraulic system that operates on, or controls, hydraulic pressure in the system.

**Hypoid gear** - A type of gear used in the differential (drive pinion and ring gear) cut in a spiral form to permit setting the pinion below the center line of the ring gear.

**Idling speed** - The speed at which the engine runs without load when the accelerator pedal is released.

**Ignition coil** - That part of the ignition system which acts as a transformer to step up the battery voltage to many thousands of volts; the high-voltage surge then produces a spark at the spark-plug gap.

**Ignition distributor** - That part of the ignition system which closes and opens the circuit to the ignition coil with correct timing and distributes to the proper spark plugs the resulting high-voltage surges from the ignition coil.

**Ignition system** - In the automobile, the system that furnishes high-voltage sparks to the engine cylinders to fire the compressed air-fuel charges. Consists of battery, ignition coil, ignition distributor, ignition key, wiring, and spark plugs.

**Impeller** - The pump, or driving member, in the torque converter.

**Inertia** - Property of objects that causes them to resist any change in speed or direction of travel.

**Internal gear** - A gear with the teeth pointing inward toward the center of the gear.

**Kick-down** - An arrangement in some automatic transmissions which produces a downshift when the accelerator is pushed all the way down.

**Leaf springs** - A spring made up of a series of flat steel plates of graduated length, assembled one on top of another.

**Line ream** - A method of finishing two or more aligned bushings or bearings so that accurate alignment is achieved.

**Lock nut** - A second nut turned down on a holding nut to prevent loosening.

**Lubrication system** - The system in the engine that supplies moving engine parts with lubricating oil.

**Mechanism** - A system of interrelated parts that make up a working agency.
Appendix B: Glossary

**Micrometer** A measuring device that accurately measures such dimensions as shaft or bore diameter or thickness of an object.

**Multiple-disk clutch** A clutch which has more than one friction disk; usually there are several driving disks and several driven disks, alternately placed.

**Needle bearing** Antifriction bearing of roller type; rollers are very small in diameter (needle-sized).

**Oil cleaner** The device which filters dirt and dust from the oil.

**Oil filter** That part of the lubricating system that removes dirt and dust from the oil circulated through it.

**Oil seal** A seal placed around a rotating shaft, etc., to prevent escape of oil.

**Orifice** A small opening or hole into a cavity.

**O Ring** A type of sealing ring, made of special rubberlike material, which is compressed into grooves to provide the sealing action.

**Overdrive** A device in the power train of some cars which introduces an extra set of gears into the power train. This causes the propeller shaft to overdrive, or drive faster, than the engine crankshaft. Engine speed is thus reduced without reduction of car speed.

**Overrunning clutch** A type of clutch which will transmit rotary motion in one direction only; when rotary motion attempts to pass through in the other direction, the then driving member overruns and does not pass motion to the other member.

**Parking brakes** Mechanically operated brakes that operate independently of the service brakes on the vehicle. They may be set for parking the car.

**Pawl** A locking device which fits into a detent, slot, or groove during certain times to hold a part stationary.

**Pilot bearing** A small bearing in the center of the flywheel, or flywheel flange, which carries the forward end of the clutch shaft.

**Piston** A movable part, fitted to a cylinder, which can receive or transmit motion as a result of pressure changes (fluid, vapor, gas) in the cylinder.

**Planetary gear system** A gear set consisting of a central sun gear surrounded by two or more planet pinions which are, in turn, meshed with a ring (or internal) gear. Used in overdrives and automatic transmissions.

**Planet pinions** In a planetary gear system, the pinions that mesh with, and revolve about, the sun gear. They also mesh with the internal, or ring, gear.

**Power train** The group of mechanisms that carries the rotary motion developed in the engine to the car wheels; it includes transmission, propeller shaft, differential, and something else.
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**Preload**  In bearings, the amount of load originally imposed on a bearing before actual operating loads are imposed. This is done by bearing adjustments and assures alignment and minimum looseness in system.

**Pressure plate**  That part of the clutch which exerts pressure against the friction disk; it is mounted on and rotates with the flywheel.

**Pressure regulator**  A regulating device which operates to prevent excessive pressure from developing; in the hydraulic systems of certain automatic transmissions, a valve that opens to release oil from a line when the oil pressure attains specified maximum.

**Pressure-relief valve**  A valve in the oil line that opens to relieve excessive pressures that the oil pump might develop.

**Propeller shaft**  A shaft in the power train that extends from the transmission to the differential and transmits power from one to the other.

**Psi**  Pounds per square inch; usually used to indicate pressure of a liquid or gas.

**Puller**  Generally, a service tool that permits removal of one part from another without damage. Contains a screw, or screws, that can be turned to apply gradual pressure.

**Pump**  A device to produce motion of a liquid or gas. In the torque converter, the driving member.

**Reactor**  The stator in the torque converter which provides reactive blades against which the fluid can change directions (under certain conditions) as it passes from the turbine to the pump.

**Reamer**  A metal-cutting tool with a series of sharp cutting edges that remove material from a hole when the reamer is turned in it.

**Rear-end torque**  Reactionary torque applied to the rear-axle housing as torque is applied to the wheels; rear-end torque attempts to turn axle housing in direction opposite to wheel rotation.

**Reciprocating motion**  Motion of an object between two limiting positions; motion back and forth, or up and down, etc.

**Release lever**  In the clutch, a lever that is moved by throwout-bearing movement; the movement causes clutch-spring pressure to be relieved so the clutch is released, or uncoupled.

**Relief valve**  A valve that opens when a preset pressure, for example, is reached. This relieves, or prevents, excessive pressures.

**Ring gear**  A large gear carried by the differential case, meshed with, and driven by, the drive pinion.

**Rotor pump**  A type of pump using a pair of rotors, one inside the other, to produce oil pressure and oil circulation.

**Rpm**  Revolutions per minute.
Appendix B: Glossary

**Run-out** Lack of alignment of wheel or gear to axle so that wheel or gear wobbles; certain parts of wheel or gear “run-out” or move out of alignment, as wheel or gear rotates.

**Servo** A device in a hydraulic system that converts hydraulic pressure into mechanical movement. It consists of a piston which moves in a cylinder as hydraulic pressure acts on it.

**Shim** A strip of copper or similar material used under a bearing cap, for example, to increase bearing clearance.

**Shrink fit** A tight fit of one part in another achieved by heating or cooling one part and then assembling it with the other part. If heated, the part then shrinks on cooling to provide a shrink fit. If cooled, the part expands on warming to provide the fit.

**Slip joint** In the power train, a variable-length connection that permits the propeller shaft to change effective length.

**Solenoid** A device which, when connected to an electrical source such as a battery, produces a mechanical movement. This movement can control a valve or produce other controlling movements.

**Spline** Slot or groove cut in a shaft or bore; a splined shaft onto which a hub, wheel, gear, etc., with matching splines in its bore is assembled so the two must turn together.

**Spring** An elastic device that yields under stress, or pressure, but returns to its original state or position when the stress or pressure is removed.

**Spur gear** A gear in which the teeth parallel the center line of the gear.

**Starting motor** The electric motor in the electric system that cranks the engine, or turns the crankshaft, for starting.

**Stator** In the torque converter, a third member (in addition to turbine and pump) which changes direction of fluid under certain operating conditions (when stator is stationary).

**Steering system** The mechanism that enables the driver to turn the wheel axles (usually the front) and thus turn the wheels away from the straight-ahead position so the car can be guided.

**Stud** A headless bolt, threaded on both ends.

**Sun gear** In a planetary gear system, the center gear which meshes with a series of planet pinions.

**Synchromesh** A device in transmission that synchronizes gears about to be meshed so that there will not be any gear clash.

**Synchronous** Occurring at the same time; for example, gears about to mesh in a transmission are rotating at synchronous speed so they can mesh without clash.

**Throttle-return check** A device on the carburetor that prevents excessively sudden closing of the throttle.
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Throttle valve The round disk in the lower part of the carburetor air horn that can be turned to admit more or less air.

Throwout bearing In the clutch, the bearing that can be moved in to the release levers by clutch-pedal action so as to cause declutching, or a disconnection between the engine crankshaft and power train.

Torque Turning or twisting effort, usually measured in pound-feet.

Torque converter A device in the power train consisting of three or more rotating members which transmits power from the engine through a fluid to the remainder of the power train. It provides varying drive ratios; with speed reduction, it increases torque.

Torque-tube drive The type of rear suspension in which the torque tube surrounding the propeller shaft absorbs the rear-end torque.

Torque wrench A special wrench with a dial that indicates the amount of torque being applied to a nut or bolt being turned.

Torus Another name for fluid coupling, which see.

Transmission Also called the change gears. The device in the power train that provides different gear ratios between the engine and rear wheels, as well as reverse.

Trouble-shooting The detective work necessary to run down the cause of a trouble. Also implies the correction of the trouble by elimination of cause.

Turbine A device that produces rotary motion as a result of gas, vapor, or hydraulic pressure. In the torque converter, the driven member.

Universal joint In the power train, a jointed connection in the propeller shaft that permits a change of driving angle.

Vacuum An absence of air or other substance.

Valve A device that can be opened or closed to allow or stop the flow of a liquid, gas, or vapor from one place to another.

Vent An opening from an enclosed chamber through which gas or liquid can pass.

Vibration A complete rapid motion back and forth; oscillation.

Viscosity The resistance to flow that a liquid has. A thick oil has greater viscosity than a thin oil.

Viscous Thick, tending to resist flowing.

Viscous friction Friction between layers of a liquid.

Vise A gripping device for holding a piece while it is being worked on.

Welding The process of joining pieces of metal by fusing them together with heat.

Wet-disk clutch A clutch in which the friction disk (or disks) is operated in a bath of oil.

Yoke In the clutch, a Y-shaped member. The throwout bearing is assembled in the fork of the Y.
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