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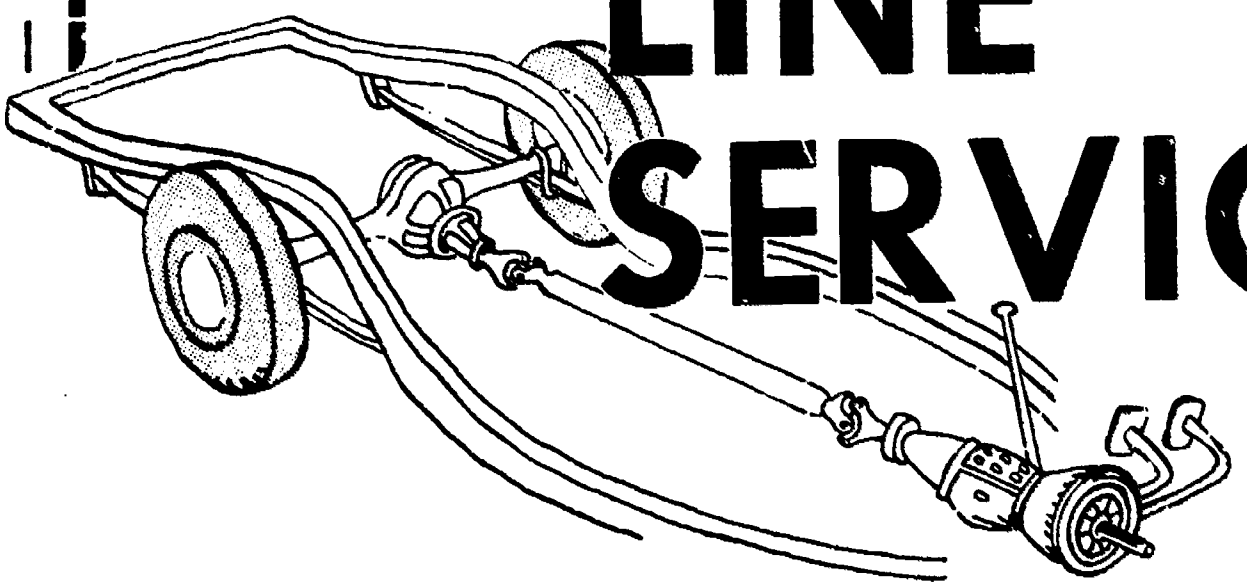
ABSTRACT

The Drive Line Services guide is designed to prepare students for employment in a specialized area of automotive services. The six units outlined are: an introduction (a course overview and a discussion of eye safety devices and the relevant legislation); clutches; drive lines; manual transmissions; overdrive units; and rear axle assemblies. Each unit consists of objectives stated in terms of performance activities, a content outline, and topics for review discussion. The left-hand column of each unit contains a suggested topical outline; the right-hand column gives related factual information as well as suggested teaching techniques and page references in selected textbooks. Also provided are a sample final examination, a section on the use of audiovisual materials, advice on the preparation and use of transparencies, and a glossary of automotive terms. Appended are a four-page bibliography and a resource materials directory. (BP)

AN INSTRUCTOR'S GUIDE FOR A PROGRAM IN

DRIVE LINE SERVICES



TRADE AND TECHNICAL EDUCATION

THE UNIVERSITY OF THE STATE OF NEW YORK / THE STATE EDUCATION DEPARTMENT
BUREAU OF CONTINUING EDUCATION CURRICULUM DEVELOPMENT
BUREAU OF SECONDARY CURRICULUM DEVELOPMENT / ALBANY, NEW YORK 12224

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FOREWORD

Drive Line Services was developed from the suggested services for clutches, manual transmissions, drive lines, and drive axle assemblies that are listed in the *Automotive Services Occupations*. The content may be used in secondary schools and adult programs to assist in preparing individuals who wish to enter the automotive field or to upgrade personnel already working as automotive mechanics.

Appreciation is expressed to Rocco A. Calandra, coordinator of the automobile mechanics department at Burgard Vocational High School, Buffalo, for development of the original instructional materials. Assistance relating to content was provided by Charles A. Stebbins, associate in the Bureau of Trade and Technical Education. The project was coordinated and the manuscript prepared for publication by Nelson S. Maurer, associate in the Bureau of Continuing Education Curriculum Development.

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MESSAGE TO THE INSTRUCTOR

Drive Line Services is designed to prepare students for employment in a specialized area of automotive services. Units are presented in numerical order, but the sequence may be altered to accommodate the needs and backgrounds of the trainees. The availability of tools and equipment also may necessitate adaptations in the use of the materials.

This guide suggests methods and materials that should enrich a course and help achieve a more effective presentation. The general objectives for each unit are stated in terms of performance activities that the student is able to do as a result of the instruction. The standards, as determined by the instructor, should be at least the minimum proficiency necessary for entry employment in the area of drive line services. More detailed objectives may be developed and these also should be stated as observable behavior that the learner is able to do when applying the skills and knowledges acquired. The left-hand column of each unit contains a suggested topical outline; the right-hand column gives related factual information, as well as suggested teaching techniques and page references for selected textbooks. At the conclusion of each unit, topics for review discussion are included. Also, a sample final examination is provided. Additional help in test construction procedures may be obtained from *Improving the Classroom Test* published by the State Education Department, Bureau of Elementary and Secondary Educational Testing, Albany, New York.

The use of instructional aids will greatly clarify the presentation of the material. A list of suggested aids is given in the bibliography. Excellent instructional materials are available from various automobile and automotive equipment manufacturers. Local dealers will often donate service instructional materials after they have presented the information to their own mechanics. Specific items may be located in *Automotive Instructional Material* published by the Automotive Service Industry Association. Many useful teaching aids may be fabricated from samples or discarded equipment.

New instructional aids are constantly being made available to instructors. Current releases of audiovisual aids are usually listed in issues of such publications as *American Vocational Journal*, *Industrial Education*, and *School Shop*. New information relating to the automotive industry is available from automotive trade magazines and automotive enthusiasts publications.

CARL G. BENENATI, *Chief*
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INTRODUCTION

OBJECTIVES

The student will be able:

- To assess the value of the course in meeting his perceived occupational needs
- To demonstrate appropriate work habits and attitudes during training and on the job
- To demonstrate a high regard for the safety of himself and his fellow workers during training and on the job
- To identify and explain the function of the major components of the drive train

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Importance of Drive Train Services	Indicate that basically the drive train transmits the power of the engine to the drive wheels. This has to be done under varying vehicle speeds and differing road conditions which means that flexibility is needed in the drive system. The constantly changing speed of the component parts of the drive line makes for vibration which causes wearing of parts. Thus, it is very important that all parts of the drive line be correctly alined, properly mounted, and adequately lubricated. Back lash and noise are the usual indications of trouble in the drive line. When these occur the problem needs to be identified and corrected quickly before more serious damage takes place. The purposes of the course are: • To permit individuals who are now working as automotive mechanics to improve and update their knowledge in the area of drive line service

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• To provide training in drive line service for students in vocational and occupational education programs as well as other interested persons
II. Overview of Course	Indicate that the course will cover all areas of the drive line including the operation, maintenance, and repairs of: • Clutches • Drive shafts • Universal joints • Manual transmissions • Overdrive units • Rear axle assemblies Point out that each student will learn the theory from class presentations and textbooks and then will have the opportunity to apply this knowledge by working on live jobs. Indicate also such items as the length of each session, the number of sessions, the procedures to be followed in class, the reasons for homework, and in general, the expectations for each class member. Emphasize that there will be quizzes throughout the course as well as a final examination. Note that following the final examination, time will be allotted for a review of the test and for answering questions about the course.
A. Individual needs	Determine the background and needs of each student. Use this information to adapt the course content to meet as many of the individual needs as possible, keeping in mind the equipment available. Develop a card data file for each student listing address, phone number, needs, goals, training, work experience, and other pertinent information. This file will be valuable in

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	giving individual aid during the course. Also, it will help to maintain contact with students after employment. Many times former students can provide up-to-date trade information, training aids, and placement assistance.
B. Work habits and attitudes	Discuss the importance of good work habits and show how these might aid an individual in maintaining and improving his position. Include such items as: • Sense of responsibility to employer and other employees • Appreciation of safety rules and regulations • Accuracy and speed Discuss the attitudes that employers expect to find in employees. Indicate that many times the cause of a worker's dismissal is related to his poor work habits and not to his lack of knowledge. Emphasize the importance of developing good work habits and desirable attitudes during the course. (Ref. What Employers Want; Why Young People Fail To Get and Hold Jobs)
III. Course Requirements	
A. Textbook	If a textbook is to be used, give its title, price, and source. Arrange for a group order.†
B. Notebook	Indicate that a looseleaf notebook is necessary for keeping class notes, job information, specification booklets, and other materials distributed during the course.
IV. General Safety	Review general rules of safety for the service garage employee. (Ref. A, pp. 47-49; General Safety Instructions; Safety in Your Future; Your Guide to Safety as a Service Garage Employee) Use films or transparencies that deal with safety to emphasize the importance of

†Reference citations are shown on page 60.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	practicing safe work procedures when performing any type of repair work. Ask students to discuss their own experiences with accidents and have them indicate the procedures that should have been followed. Discuss the dangers of horseplay and hot rodding, and give examples of the possible consequences of each. Show the location of fire extinguishers and discuss fire control procedures. Explain the precautions to take when lifting heavy objects and working near rotating parts. Point out the safety procedures to follow when using compressed air for cleaning and lifts and jacks for supporting a vehicle and its component parts such as the transmission and engine.
A. Protective clothing	State school policy relative to coveralls, shop coats, or uniforms. Mention possible storage areas for clothes and outer garments.
B. Safety glasses	Point out the regulations relative to eye safety. See regulations on pages 10 to 17. Arrange for a group purchase of approved safety glasses for those who wish to have their own glasses.
V. Drive Train	Explain and illustrate with charts, films, and overhead transparencies the function of each unit in the drive train as power is transmitted from the engine to the rear wheels. Include the following units: • Clutch • Transmission • Drive shaft and universal joints • Differential • Rear axles (Ref. A, pp. 15-18; Ref. B, pp. 3-17)

THE UNIVERSITY OF THE STATE OF NEW YORK
THE STATE EDUCATION DEPARTMENT
ALBANY, NEW YORK 12224

ASSOCIATE COMMISSIONER FOR
INSTRUCTIONAL SERVICES

February 1973

EYE SAFETY DEVICES
Education Law and Regulations
of the Commissioner of Education

To: City, Village and District Superintendents of Schools
Diocesan Superintendents
Supervising Principals
Principals of Public, Private and Parochial Elementary and Secondary Schools
Presidents of Public and Private Institutions of Higher Learning

Section 141.8 Part 141 of the Regulations of the Commissioner of Education amended by the Board of Regents, February 1971, provides for conformity to revised standards for eye safety devices.

The Z87 standard (which superseded an earlier Z2 standard) prescribes quality and strength specifications for safety eyewear to be used by laboratory and shop students, their teachers and visitors. It is recommended that all bid and purchase terminology include the phrase: "Equipment must meet or exceed all ANSI Z87 standard requirements" and that suppliers be required to furnish written proof to this effect.

Personal "safety eyeglasses" - unless validated in writing as complying with all Z87 lens and frame specifications by the ophthalmic specialist who fabricated them - should not be allowed in educational labs and shops, or in industry. Likewise, contact lenses do not provide approved eye protection. The selection, maintenance, and disinfection of approved safety eyewear is detailed on page 29 of the Z87 document.

You are urged to revise, adopt and implement local policies to fit your particular circumstances at the earliest possible time.

Any inquiry concerning these regulations should be directed to the appropriate unit in the Department.

William L. Bitner

WILLIAM L. BITNER

EDUCATION LAW

§ 409-a. Eye safety devices for certain students and teachers.

1. The board of education, trustees, principal or other person in charge of every public or private school or educational institution within the state, wherein shops or laboratories are conducted providing instructional or experimental programs involving:

a. Hot solids, liquids or molten metals; or

b. Milling, sawing, turning, shaping, cutting, or stamping of any solid materials; or

c. Heat treatment, tempering, or kiln firing of any metal or other materials; or

d. Gas or electric arc welding; or

e. Repair or servicing of any vehicle; or

f. Caustic or explosive chemicals or materials, shall arrange for and require, in accordance with regulations of the commissioner, that every student and teacher participating in any such program wear eye safety devices at the times and under the conditions prescribed in such regulations.

2. The commissioner shall by regulation prescribe the safety standards to be met before the use of any eye safety device may be required and shall include in such regulations requirements relating to the times and conditions when and under which such eye safety devices shall be worn.

3. Visitors to such shops or laboratories shall be furnished with and required to wear such eye safety devices at the times and under the conditions prescribed in such regulations while in such shops or laboratories.

REGULATIONS OF THE COMMISSIONER OF EDUCATION

§ 141.8 Eye Safety devices

(a) It shall be the duty of the board of education, trustees or person in charge of every public and private school and educational institution in this State to provide eye safety devices for the protection of employees, pupils and visitors and to require that such devices be worn in shops or laboratories whenever such persons are in dangerous proximity to a potential eye hazard. In shop or laboratory situations where the activity is such that hazards may develop without warning, safety devices must be worn by all persons in the area.

(b) A potential eye hazard is deemed to be present in any situation where there is a possibility of an eye injury or impairment of sight and shall include, but not be limited to, activities in a shop or laboratory involving:

(1) hot solids, liquids or molten metals; or

(2) milling, sawing, turning, shaping, cutting or stamping of any solid materials; or

(3) heat treatment, tempering, or kiln firing of any metal or other materials; or

(4) gas or electric arc welding; or

(5) repair or servicing of any vehicle; or

(6) caustic or explosive chemicals or materials.

(c) Eye safety devices within the meaning of this regulation shall include face shields, goggles, safety glasses, welding helmets, hoods and other specialized equipment in compliance with the American National Standard Practice for Occupational and Educational Eye and Face Protection, Z87.1-1968, promulgated by the American National Standards Institute, Inc.

(d) It shall be the duty of the board of education, trustees or person in charge of every public and private school and educational institution to insure that said devices are properly repaired, cleaned and stored. Procedures should be adopted to prevent the spread of germs or diseases when the user changes.

Development of District Policies for Eye Protection
Suggested Guidelines

The amended Regulations of the Commissioner of the State of New York effective March 1, 1971 outline in general terms the time and place when eye protective devices should be worn. Boards of education are urged to adopt rules for implementing the Law and Regulations of the Commissioner of Education. Industrial quality eye protective devices as used in the Regulation are defined as those devices meeting standards of the American National Standard Practice For Occupational and Educational Eye and Face Protection, Z87.1-1968, promulgated by the American National Standards Institute, Inc.

Therefore, the following are provided as guides to implementation of eye safety programs. It is suggested:

- That school districts formulate specific policies for the implementation of eye protection programs.
- That school district committees for developing district policy relating to eye safety devices include:
  - professional staff members representing instructional areas
  - community resource persons familiar with industrial eye safety programs
  - school district insurance representative(s)
  - optometrist or other medical authority
  - school district legal authority
- That policies be reviewed periodically to implement amendments to the legislation and the Regulations of the Commissioner.
- That suppliers be required to meet or exceed the standards of the American Standard Practices For Occupational and Educational Eye and Face Protection, Z87.1-1968, promulgated by the American National Standards Institute, Inc.
- That sanitary storage facilities relating to eye protective devices be planned for each shop, laboratory or instructional area where eye protective devices are required.
- That quality eye safety devices be available for the protection of all students in classes where potential hazards exist.

Acquisition and Maintenance

We receive numerous inquiries about the Z87 standard. Therefore, we enclosed a reprint of important excerpts from the Z87.1-1968 USA Standard Practices for Occupational and Educational Eye and Face Protection.

The total publication was screened and the selection chart, information on maintenance and disinfection, fitting of goggles and spectacles, and selection of shade numbers for welding filters were considered to be the most pertinent.

The following two notes relate to general acquisition policies:

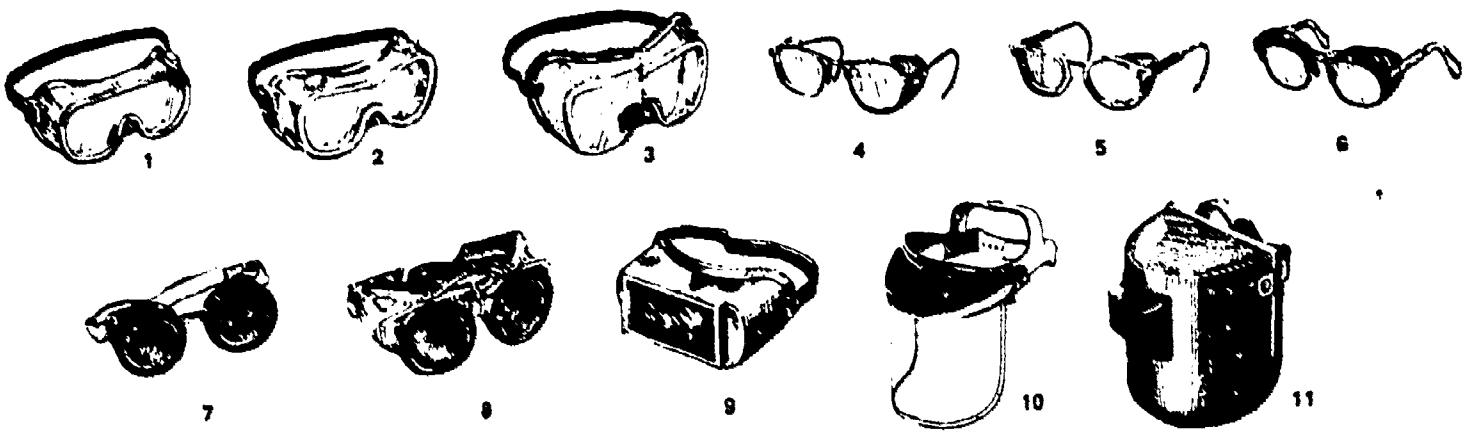
- Z87 specifications for eye safety devices are no different than those set forth in the old Z2 specifications. The revision came about as a result of separating respiratory devices from the previous eye and face specifications.

- State agencies and political subdivisions may secure eye safety devices from state contract, thereby assuring compliance with regulations.

These excerpts from the Z87.1-1968 USA Standard Practices for Occupational and Educational Eye and Face Protection relate to the use of eye safety devices. This information represents factors for school districts to consider in the acquisition and maintenance of eye protective devices. The remainder of the Bulletin is information about technical testing and production standards.

Selec.ion Chart

Recommended Eye and Face Protectors for Use in Industry, Schools, and Colleges



1. **GOGGLES,** Flexible Fitting, Regular Ventilation
2. **GOGGLES,** Flexible Fitting, Hooded Ventilation
3. **GOGGLES,** Cushioned Fitting, Rigid Body
*4. **SPECTACLES,** Metal Frame, with Sideshields
*5. **SPECTACLES,** Plastic Frame, with Sideshields
*6. **SPECTACLES,** Metal-Plastic Frame, with Sideshields
** 7. **WELDING GOGGLES,** Eyecup Type, Tinted Lenses (Illustrated)
7A. **CHIPPING GOGGLES,** Eyecup Type, Clear Safety Lenses (Not Illustrated)
** 8. **WELDING GOGGLES,** Coverspec Type Tinted Lenses (Illustrated)
8A. **CHIPPING GOGGLES,** Coverspec Type, Clear Safety Lenses (Not Illustrated)
** 9. **WELDING GOGGLES,** Coverspec Type, Tinted Plate Lens
10. **FACE SHIELD** (Available with Plastic or Mesh Window)
11. **WELDING HELMETS

*Non-sideshield spectacles are available for limited hazard use requiring only frontal protection.
**See appendix chart "Selection of Shade Numbers for Welding Filters."

APPLICATIONS		
OPERATION	**HAZARDS**	**RECOMMENDED PROTECTORS:** Bold Type Numbers Signify Preferred Protection
ACETYLENE–BURNING ACETYLENE–CUTTING ACETYLENE–WELDING	SPARKS, HARMFUL RAYS, MOLTEN METAL, FLYING PARTICLES	**7, 8, 9**
CHEMICAL HANDLING	SPLASH, ACID BURNS, FUMES	**2, 10** (For severe exposure add **10** over **2**)
CHIPPING	FLYING PARTICLES	**1, 3, 4, 5, 6, 7A, 8A**
ELECTRIC (ARC) WELDING	SPARKS, INTENSE RAYS, MOLTEN METAL	**9, 11** (**11** in combination with **4, 5, 6,** in tinted lenses, advisable)
FURNACE OPERATIONS	GLARE, HEAT, MOLTEN METAL	**7, 8, 9** (For severe exposure add **10**)
GRINDING–LIGHT	FLYING PARTICLES	**1, 3, 4, 5, 6, 10**
GRINDING–HEAVY	FLYING PARTICLES	**1, 3, 7A, 8A** (For severe exposure add **10**)
LABORATORY	CHEMICAL SPLASH, GLASS BREAKAGE	**2** (**10** when in combination with **4, 5, 6**)
MACHINING	FLYING PARTICLES	**1, 3, 4, 5, 6, 10**
MOLTEN METALS	HEAT, GLARE, SPARKS, SPLASH	**7, 8** (**10** in combination with **4, 5, 6,** in tinted lenses)
SPOT WELDING	FLYING PARTICLES, SPARKS	**1, 3, 4, 5, 6, 10**

Selection of Shade Numbers for Welding Filters[5]

The following is a guide for the selection of the proper shade numbers of filter lenses or plates used in welding. Shades more dense than those shown for various operations may be selected to suit the individual's needs.

Welding Operation	Suggested Shade Number
Shielded metal-arc welding $\frac{1}{16}$-, $\frac{3}{32}$-, $\frac{1}{8}$-, $\frac{5}{32}$-inch diameter electrodes	10
Gas-shielded arc welding (nonferrous) $\frac{1}{16}$-, $\frac{3}{32}$-, $\frac{1}{8}$-, $\frac{5}{32}$-inch diameter electrodes	11
Gas-shielded arc welding (ferrous) $\frac{1}{16}$-, $\frac{3}{32}$-, $\frac{1}{8}$-, $\frac{5}{32}$-inch diameter electrodes	12
Shielded metal-arc welding $\frac{3}{16}$-, $\frac{7}{32}$-, $\frac{1}{4}$-inch diameter electrodes	12
$\frac{5}{16}$-, $\frac{3}{8}$-inch diameter electrodes	14
Atomic hydrogen welding	10-14
Carbon-arc welding	14
Soldering	2
Torch brazing	3 or 4
Light cutting, up to 1 inch	3 or 4
Medium cutting, 1 inch to 6 inches	4 or 5
Heavy cutting, over 6 inches	5 or 6
Gas welding (light), up to $\frac{1}{8}$ inch	4 or 5
Gas welding (medium), $\frac{1}{8}$ inch to $\frac{1}{2}$ inch	5 or 6
Gas welding (heavy), over $\frac{1}{2}$ inch	6 or 8

Fitting of Goggles and Spectacles

A3.1 Cup Goggles. The first step in fitting cup goggles is to adjust the nose bridge. Both the ball and link-chain and leather or plastic strap bridges of goggles are adjustable to accommodate the individual wearer. Both types of bridges usually have some means for shortening or lengthening. In either case, to shorten or lengthen the bridge, the instructions of the manufacturer should be followed. Chain, leather, or plastic not needed after adjustment should be cut off. The chain should be insulated to protect the nose of the wearer.

The proper procedure for adjusting headbands is to keep the band loose enough to slip two fingers under it, palm side down, without stretching. Headbands should be worn low and flat and approximately at the base of the skull in order to hold goggles in a comfortable position. Most cup goggles are thinner and slanted away at the lower nasal sides, which makes for comfort as well as easy identification in getting them right side up.

A3.2 Spectacles. The first step in fitting spectacles is to determine the proper eye and bridge sizes. This is done best by using fitting samples and placing the sample spectacles on the nose to arrive at the proper size. The adjustable rocker pads should fit flush against the sides of the nose without allowing the metal bridge of the spectacles to rest on the nose bridge of the wearer. The small metal arms, to which the pearloid pads are attached, can be readily adjusted by round nose pliers which are especially designed for this purpose. To fit the temples comfortably over the ears, hold the spectacle firmly in one hand and shape the bow of the temple gradually by drawing it slowly between thumb and forefinger of other hand. Temples should be angled down from frame to ear so that the lenses will be perpendicular to the line of vision.

Prescription safety spectacles should be fitted only by qualified optical personnel.

6.4 Maintenance and Disinfection of Eye Protectors

6.4.1 *Maintenance*

6.4.1.1 It is essential that the lenses of eye protectors be kept clean. Continuous vision through dirty lenses can cause eye fatigue and become a contributory factor to accidents. Daily cleaning of eye protectors is recommended.

6.4.1.2 *Pitted or scratched lenses reduce vision and seriously reduce protection. They shall be replaced immediately.*

6.4.1.3 Replace headbands. Slack, worn-out, sweat-soaked, knotted, or twisted headbands do not hold the eye protector in proper position. Visual inspection can determine when the elasticity is reduced to a point beyond proper function.

6.4.1.4 To prolong the life of eye protectors, they shall be placed in suitable cases or containers between periods of use.

6.4.2 ***Issue and Use.*** Protectors are a personal item and should be for the individual and exclusive use of the person to whom they are issued. If circumstances require reissue, *the protectors shall be thoroughly cleaned and disinfected as hereinafter described.*

6.4.3 *Disinfection*

6.4.3.1 *General.* When a person is assigned protective equipment, it is recommended that this equipment be cleaned and disinfected regularly, without sharing by another person unless disinfected as herein specified.

6.4.3.2 *Procedure.* Thoroughly clean all surfaces with soap or suitable detergent, and warm water. Carefully rinse all traces of soap or detergent. Completely immerse the protector for 10 minutes in a solution of modified phenol, hypochlorite, or quaternary ammonium compounds, in a strength specified by the manufacturer, at a room temperature of 68°F. Remove protector from solution and suspend in a clean place for air drying at room temperature, or with heated air. Do not rinse because this will remove the residual effect.

Ultraviolet disinfecting equipment may be utilized in conjunction with the washing procedure above, when such equipment can be demonstrated to provide comparable disinfection.

Protectors showing need for extensive cleansing should be disassembled to the extent possible without tools, prior to the washing and disinfection procedure. Replace defective parts with new ones.

6.4.3.3 *Storage.* The dry parts or items should be placed in clean, dust-proof containers to protect them.

CLUTCHES

OBJECTIVES

The student will be able:

- To explain the purpose and operation of a clutch in a vehicle
- To identify the various parts of clutch assemblies
- To explain the different types of clutches in common use
- To identify the need for making adjustments to a clutch
- To make clutch adjustments
- To identify the symptoms and causes of clutch malfunctions
- To remove clutches from vehicles
- To disassemble and inspect clutches and discard worn and defective parts
- To order replacement parts for clutches using a parts manual
- To reassemble clutches following the procedures given in service manuals
- To replace clutches in vehicles
- To check clutch performance by a road test or dynamometer

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Purpose	Explain the purpose of the clutch. Point out that the clutch permits the driver of a vehicle equipped with a standard transmission to couple or temporarily interrupt the flow of power from the engine to the transmission in order to put the vehicle in motion or to change its speed. (Ref. A, p. 390; Ref. B, p. 21; Ref. D, pp. 361-363)†
II. Operation	Explain and illustrate the operations of a clutch assembly including the following parts:

†Reference citations are shown on page 60.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• Clutch disc • Pressure plate • Diaphragm springs • Release bearing and lever • Flywheel and pilot bearing or bushing • Transmission shaft and splines (Ref. B, pp. 25-28; Ref. C, pp. 324-332; Ref. D, p. 362) Use a mockup and other visual aids to clarify the operation of a clutch assembly.
III. Types	Explain and illustrate the different types of clutches in common use. Point out that the type of clutch used is related to the kind of service expected of that clutch. (Ref. A, pp. 391-396; Ref. B, pp. 21-24, 29-31) Use overhead transparencies and a mockup to assist in presenting the topic.
IV. Service	
A. Malfunctions	Point out the malfunctions usually associated with clutches and explain the specific conditions which cause each malfunctions. Include the following items: • Slipping, chattering, or grabbing when clutch is engaged • Spinning or dragging when clutch is disengaged • Specific clutch noises • Clutch-pedal pulsation • Rapid friction-disc-facing wear • Stiff pedal (Ref. A, pp. 398-400; Ref. B, pp. 40-41; Ref. C, pp. 332-333).

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Explain how to diagnose clutch malfunctions. Use charts to help locate specific problems. (Ref. B, pp. 35-40; Ref. E, pp. 24-14 — 24-16)
B. Adjustments	Demonstrate how to perform the following clutch adjustments: • Free play in pedal • Release lever height (for equal contact) Refer to manufacturers' service manuals for procedures and specifications. (Ref. B, pp. 41-43) Emphasize the importance of disconnecting the battery terminal prior to starting any clutch repair work to prevent the starter from being operated accidentally and causing injury to the mechanic. Point out that the problems associated with incorrect clutch adjustments include: • No free pedal • Binding of release mechanism • Slippage • Chatter • Drag • Pulsation • Noises Explain why an incorrectly adjusted clutch might prevent the driver from shifting gears normally. *Have students practice making adjustments on shop units of various types of clutch assemblies.* *Have students check for and make necessary clutch adjustments on live vehicles. Use manufacturers' service manuals for procedures and specifications.*
C. Removal	Demonstrate the procedures for removing a clutch assembly from a vehicle including the following:

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• Disconnecting rear axle (when necessary) • Disconnecting linkage and speedometer cable • Installing engine support • Removing transmission • Removing bolts and installing pilot or guide pins • Removing clutch release bearing • Making marks on clutch cover and flywheel for correct positioning during reinstallation (Ref. B, pp. 44-47; Ref. E, p. 24-2) Emphasize the importance of having the vehicle properly supported when servicing a clutch.
D. Repair	Point out that the clutch is subjected to the following types of damage: • Wear (normal and "riding" the clutch) • Accident (bent or broken parts) • Abuse (drag racing) • Improper lubrication Demonstrate how to disassemble and inspect a clutch assembly including: • Clutch plate • Clutch disc • Pilot bushing or bearing • Release lever • Throwout bearing (Ref. B, pp. 47-52; Ref. D, pp. 366-370; Ref. E, pp. 24-2 — 24-6) Refer to manufacturers' service manuals for correct procedures and specifications.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Point out that a throwout bearing should be replaced if it turns rough, seems loose, or is noisy.
	Explain how to use a parts book to order necessary replacement parts.
E. Reassembly	Demonstrate how to reassemble a clutch assembly including making all necessary adjustments. (Ref. E, pp. 24-6 — 24-14)
	Emphasize the importance of cleanliness during reassembly.
	Explain how grease or oil on clutch disc facing may cause grabbing, chattering, or slipping.
	Caution students not to wash throwout bearings in solvent because this removes the lubricant placed in bearing during the original assembly.
F. Replacement	Demonstrate how to replace a clutch.
	Have students practice removing, disassembling, repairing, and replacing clutch assemblies until they acquire the proficiency necessary for an entry mechanic. Be sure that all safety precautions are being followed. Check each student's work for proper procedures.
	Have students use manufacturers' service manuals for procedures and specifications and parts books for ordering replacement parts.
G. Road test	Explain how to check the operation of a clutch by making a road test or using a dynamometer.
	Have students check the operation of clutches they have repaired by making road tests.

Review Discussion

1. Describe the various types of clutches in common use.
2. Describe how to adjust a clutch.
3. List common malfunctions of clutches with symptoms for each malfunction.
4. What is the purpose of the pressure plate and release levers?
5. Why is a road test a necessary part of a clutch repair?

DRIVE LINE

OBJECTIVES

The student will be able:

- To explain the purpose and operation of drive shafts
- To explain the different types of drives used on various vehicles
- To explain the purpose and operation of universal joints
- To diagnose malfunctions of drive shafts and universal joints
- To inspect, remove, and replace drive shafts and universal joints
- To practice safe work procedures when inspecting, removing, repairing, and replacing drive shafts and universal joints

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Drive Shaft	Explain the function and location of the drive shaft. Indicate that the drive shaft connects the transmission output shaft to the differential. Explain how the drive shaft mechanism allows for changes in the drive angle as well as changes in length caused by the rear axle housing moving over irregularities in the road. (Ref. A, p. 452; Ref. B, p. 423; Ref. C, pp 375-375; Ref. D, p. 414-419)†
A. Types	Explain the different types of drive shafts in common use. (Ref. A, p. 452; Ref. B, p. 423-424)
B. Inspection	Demonstrate how to inspect a drive shaft for balance, alinement, and accident damage. Indicate when a drive shaft should be replaced. Demonstrate how to check a drive shaft center bearing.
C. Replacement	Demonstrate how to remove and replace a drive shaft. Show how to remove and replace a drive shaft center bearing. Emphasize the

†Reference citations are shown on page 60.

CONTENT OUTLINE		UNDERSTANDINGS AND TEACHING APPROACHES
		importance of having the vehicle properly supported while servicing the drive shaft. Refer to manufacturers' service manuals for specific procedures and specifications. (Ref. C, pp. 380-381; Ref. E, pp. 27-4 — 27-6, 27-11 —27-14)
II.	Types of Drives	Explain the different drive arrangements used on vehicles including the following: • Front-engine rear-wheel drive • Rear-engine rear-wheel drive • Front-engine front-wheel drive • Front-engine four-wheel drive • Front-engine rear-wheel drive (transaxle) (Ref. A, pp. 454-458; Ref. B, pp. 429-434)
III.	Universal Joints	Explain and demonstrate the operation of universal joints. (Ref. A, p. 452)
	A. Types	Explain and show examples of the different types of universal joints including: • Cross and yoke • Spider and two-yoke • Constant velocity • Ball and trunrion (Ref. A, pp. 452-453; Ref. B, pp. 424-427; Ref. C, pp. 377-380)
	B. Inspection	Show how to inspect universal joints for wear and indicate when they should be replaced.
	C. Lubrication	Show how to lubricate universal joints. Refer to manufacturers' service manuals for lubrication procedures. Point out the importance of inspecting universal joints even though most are now lubricated and sealed at the factory. Indicate that replacement units do have to be lubricated.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
D. Replacement	Demonstrate the procedure for removing and replacing a universal joint. (Ref. B, pp. 434-437; Ref. D. pp. 425-429; Ref. E. pp. 27-5 — 27-11) Explain why the bolts and nuts used for installing universal joints are made of special high strength material. Explain and show the different locking devices used to hold bolts and nuts in place. *Have students practice inspecting, removing, lubricating, and replacing universal joints and drive shafts, Use manufacturers' service manuals for specific procedures and specifications.* *Check each student's work to see that correct procedures are being followed.*
IV. Safety	Emphasize the importance of following safe work procedures and having the vehicle properly supported when servicing the drive mechanism. Indicate the importance of doing careful work and point out that an error made during the diagnosing or servicing of the drive mechanism could endanger the driver's life. Review court cases in which mechanics and garages have been held responsible for errors they made.

Review Discussion

1. Explain the purpose of the drive shaft and universal joints.
2. Explain the location and purpose of the drive shaft slip joint.
3. Describe how to check drive shafts and universal joints for wear.
4. Explain the procedure for lubricating universal joints.
5. Discuss the methods for removing and replacing universal joints from drive shafts.
6. Discuss the purpose and servicing of a drive shaft center bearing.

MANUAL TRANSMISSIONS

OBJECTIVES

The student will be able:

- To explain the purpose and operation of manual transmissions
- To explain the purpose and operation of synchronizing mechanisms
- To adjust gear-shift linkages on various types of vehicles
- To identify the symptoms and causes of manual transmission malfunctions
- To explain the effects that various malfunctions have on the other components of the transmission
- To make repairs to manual transmissions without removing them from the vehicles
- To remove and reinstall manual transmissions
- To disassemble, clean, inspect, repair, and reassemble manual transmissions
- To select the correct type of lubricant to use when servicing or overhauling manual transmissions
- To use safe work procedures when servicing and repairing manual transmissions
- To check the proper operation of a repaired transmission by making a road test or using a dynamometer

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Purpose	Explain the purpose of a manual transmission, including the need of varying the power requirements with changes in vehicle speed, load, and road conditions. (Ref. A, p. 402; Ref. B, p. 53)†
	Explain and show how gears are used to change the direction, power, and speed of a vehicle. (Ref. A, pp.402-402; Ref. C, pp. 336-338;

†Reference citations are shown on page 60.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Ref. D, pp. 372-374)
II. Operation	Explain the operation of a simple three-speed gear train by using a mockup, charts, or overhead transparencies. (Ref. D, pp. 404-405; Ref. B, pp. 54-66; Ref. C, pp. 341-343; Ref. D, pp. 375-377)
	Explain the function of shift rails and detent ball and springs.
	Point out the need for an interlock to prevent the transmission from going into two gear positions at the same time.
	Explain the purpose and operation of different types of synchronizers. (Ref. A, pp. 409-411; Ref. B, pp. 57-62; Ref. C, pp. 339-341)
	Explain why gears must be turning at the same speed when they are shifted. Point out how this is accomplished during the shifting process.
	Explain the different types of gearshift levers in common use. (Ref. A, pp.405-409; Ref. B, pp. 70-74)
	Show how to diagnose problems that cause manual transmissions to malfunction. Use charts to assist in locating specific problems. Also, include methods of correcting the problems. (Ref. B. pp. 91-97, 99-100; Ref. D, p. 301; Ref. E, pp. 25-3 — 25-4, 25-25 — 25-29)
	Explain the effects that the various malfunctions have on other components of a manual transmission. Show the results by using discarded parts.
	Have students identify the component parts of a manual transmission.
	Have students identify, from a collection of worn and defective components, the causes of various part failures and describe the symptom or effect each part would produce.
III. Adjustments	Demonstrate how to adjust the gearshift linkages on various types of vehicles. Use manufacturers' service manuals for procedures and specifications. (Ref. B, pp. 121-123)

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Have students practice making gearshift linkage adjustments on live vehicles.
IV. Removal	Demonstrate the procedure for the removal of a manual transmission from a vehicle. Emphasize the need of having the car and engine properly supported when the transmission is removed. Use manufacturers' service manuals for correct procedures. (Ref. B, pp. 100-101; Ref. E, pp. 25-4 — 25-5)
	Point out the importance of being sure that the repair of the transmission requires its removal from the car. Indicate the type of repairs that may be made with the transmission still in the vehicle.
V. Disassembly and Repair	Demonstrate the procedure for disassembling a manual transmission. Indicate the importance of following manufacturers' service manuals for the recommended order of parts removal.
	Point out, if no service manual is available, to first drain the lubricant and then remove the cover and gasket, the input shaft bearing retainer, and the extension housing fasteners. This allows the input or output shaft to be pulled out enough so that the exact removal order of parts may be determined by a careful study of the transmission. (Ref. B, pp. 101-107, 110-111, 115-117; Ref. D, pp. 382-385; Ref. E, pp. 25-5 — 25-6)
	Explain why steel parts should be loosened or driven into place with a brass or plastic-tipped hammer instead of a ball peen hammer.
	Emphasize the importance of keeping track of all needle and roller bearings, detents, springs, interlocks, and set screws and of handling all parts carefully to avoid chipping or nicking.
	Show how to clean and inspect parts and to discard defective items such as broken gears or gears that have chipped, broken, worn, or scored teeth and bearings that have pitted surfaces. (Ref. D, pp. 385-387; Ref. E, pp. 25-6 — 25-14)
	Show how to use a parts book to order replacement parts.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Have students practice removing, disassembling, cleaning, and inspecting manual transmissions. Also, have students order replacement parts from a parts catalog. Check each student's work to see that correct work procedures are being followed.
VI. Reassembly	Demonstrate how to reassemble a manual transmission. Indicate that, basically, reassembly is the reverse of disassembly. Emphasize the importance of following the manufacturer's procedures for reassembly. (Ref. B, pp. 107-110, 113-115, 120-121; Ref. D, pp. 388-392; Ref. E, pp. 25-14 — 25-17)
	Point out that all parts must be clean, lubricated, and properly positioned before being installed.
	Caution students against the use of excessive force in order to make parts fit. When parts do not fit easily, be sure students correct the problem before they continue reassembling the transmission.
	Emphasize the importance of using new washers, gaskets, and snap rings. Also, indicate the necessity of using a sealer on all plugs and at places where pins pass through the outer wall of the case.
	Have students practice reassembling manual transmissions. Inspect each student's work to see that correct procedures are being followed.
VII. Reinstallation	Show how to reinstall a manual transmission. Point out that guide pins are used to keep the weight of the transmission from resting on the clutch shaft. (Ref. E, pp. 22-17 — 25-18)
	Have students practice reinstalling manual transmissions. Check each student's work to see that correct procedures are being followed.
VII. Road Test	Explain how to check the operation of a repaired transmission by making a road test or using a dynamometer.
	Have students check the proper performance of repaired transmission by making a road test or using a dynamometer.

CONTENT OUTLINE UNDERSTANDINGS AND TEACHING APPROACHES

Review Discussion

1. Explain the power flow in all gear positions of a manual transmission.

2. Explain the operation of gear shift rails and detents.

3. Explain the operation of the interlock mechanism.

4. Explain the operation of the synchronizing mechanism.

5. Explain the role of the cluster gear in supplying lubricant to various transmission components.

6. Identify the symptoms and causes of different malfunctions of manual transmissions.

7. How can a mechanic verify a transmission leak?

8. Discuss the importance of cleanliness during the rebuilding of manual transmissions.

9. Why is it important to hesitate for a brief moment in the neutral range when shifting a manual transmission?

10. Explain why it is important to make a road test after a manual transmission has been repaired.

11. Explain how sound may be used to help in the diagnosis of a defective transmission gear or bearing.

12. Explain why the full weight of the transmission should not be allowed to rest on the clutch shaft during the removal or reinstallation of the transmission.

OVERDRIVE UNITS

OBJECTIVES

The student will be able:

- To explain the purpose of an overdrive unit
- To describe the operation of an overdrive unit including its component parts
- To diagnose the symptoms and causes of malfunctions of overdrive units
- To check the mechanical and electrical components of overdrive units
- To remove and reinstall overdrive units
- To disassemble, clean, inspect, repair, and reassemble overdrive units
- To check the performance of repaired overdrive units by making road tests or using a dynamometer

CONTENT OUTLINE		UNDERSTANDINGS AND TEACHING APPROACHES
I.	Purpose	Explain the purpose of an overdrive unit and discuss the following advantages: • Slower engine speed compared to vehicle speed • Lower engine noise level • Longer engine life • Lower engine vibration • Better gasoline economy (Ref. A, p. 415; Ref. B, p. 77)†
II.	Operation	Explain the operation of an overdrive unit

†Reference citations are shown on page 60.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	including the following devices: • Overrunning clutch • Planetary gearset • Balk ring and gear • Pawl • Return spring • Relay • Solenoid • Governor • Manual control selector • Kickdown switch • Electric controls (Ref. A, pp. 415-421; Ref. B, pp. 77-88; Ref. D, pp. 377-381)
III. Malfunctions	Show how to diagnose problems that cause overdrive units to malfunction. Use charts to assist in locating specific problems. Also, include methods of correcting the problems. (Ref. A, pp. 425-426; Ref. B, pp. 93-94, 97-99; Ref. E, pp. 25-19, 25-28 — 25-29) Point out the importance of being sure that the repair of the overdrive unit requires its removal from the car. Indicate the type of repairs that may be made with the unit still on the car.
IV. Removal, Disassembly, and Inspection	Demonstrate the removal of an overdrive unit. Emphasize the need of having the vehicle and engine properly supported. Demonstrate the disassembly of an overdrive unit, identifying each part as it is removed. (Ref. B, pp. 125-129; Ref. E, pp. 25-20 — 25-22) Demonstrate how to clean and inspect the component parts of an overdrive unit. (Ref. B, p. 125; Ref. E, pp. 25-22 — 25-23)

CONTENT OUTLINE		UNDERSTANDINGS AND TEACHING APPROACHES
		Discuss the tolerances allowed for wear or damage to parts. Point out that if the surface of the output shaft appears worn or has chatter marks, the shaft has to be replaced. Show how to check the clutch rollers for cracks and wear. Indicate that if any of the clutch rollers are worn, all the rollers must be replaced.
V.	Reassembly and Reinstallation	Demonstrate the reassembly of the overdrive unit. (Ref. B, pp. 125-126) Emphasize the importance of using new seals, lock washers, and gaskets. Show how to coat parts with a lubricant and gaskets with a sealer to hold them in place during reassembly. Show how to check the force required to turn the clutch ring assembly. Indicate that if the force required to turn the clutch ring is not within the specifications, the assembly must be replaced. Explain why it is important to follow clean work procedures when repairing overdrive units. Show how to reinstall an overdrive unit. *Have students practice removing, disassembling, cleaning, inspecting, overhauling, and reinstalling overdrive units. Check each student's work to see that correct work procedures are being followed.*
VI.	Road Test	Explain the importance of checking the operation of a repaired overdrive unit by making a road test or using a dynamometer. *Have students practice checking the operation of repaired overdrive units by making road tests.*

Review Discussion

1. Explain why an overdrive unit would fail to engage, release, or kickdown.

2. Explain why the engine stops when kickdown is attempted.

CONTENT OUTLINE UNDERSTANDINGS AND TEACHING APPROACHES

3. Explain how to check the voltage at the relay, fuse, governor, and relay circuit of an overdrive unit.

4. Explain how to check the operation of the shift lever, kickdown switch, solenoid, and pawl.

5. Explain how to locate the source of the malfunction when an overdrive unit will not release.

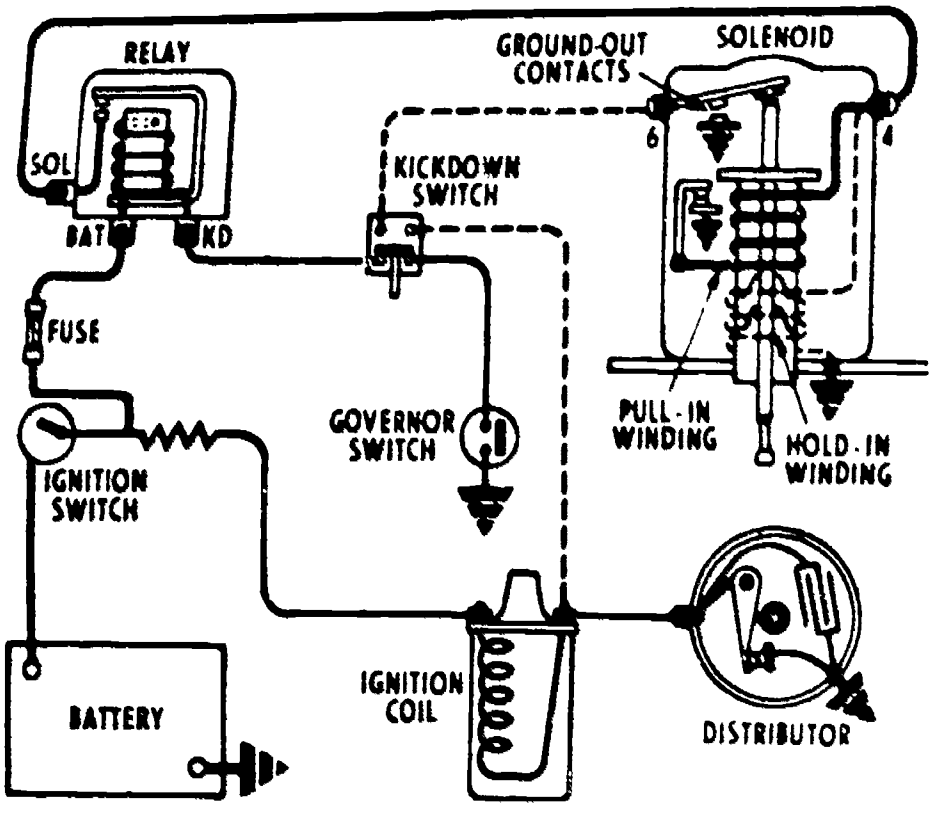
6. Explain the checks a mechanic would make when diagnosing an overdrive unit that does not kickdown.

7. Explain how the overdrive unit shifts into direct drive any time the accelerator is depressed to the floor.

8. Discuss the importance of cleanliness during the inspecting and reassembling of an overdrive unit.

9. Explain why all the rollers have to be replaced when only one is found to be defective.

10. Explain why the output shaft has to be replaced when the surface shows "chatter" marks.



The above diagram represents an electric control circuit for a Borg Warner overdrive unit.

REAR AXLE ASSEMBLIES

OBJECTIVES

The student will be able:

- To explain the purpose and operation of a differential, including all the component parts
- To explain how a gear reduction is effected by the differential and how it can be changed
- To explain the purpose and operation of a limited-slip differential
- To identify the symptoms and causes of differential malfunctions
- To remove, clean, repair, and replace the component parts of standard and limited-slip differentials
- To check the operation of repaired differentials by making a road test or using a dynamometer
- To be able to identify symptoms and causes of rear axle malfunctions
- To be able to remove and replace rear axle bearings, seals, shafts, and housings

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Differential	Explain the purpose of the differential. (Ref. A, p. 460; Ref. B, p. 439)†
	Explain and illustrate with a model, charts, and overhead transparencies the operation of (straight ahead and around curves) and the power flow through a differential, including the following:
	• Drive pinion
	• Ring gear
	• Differential case
	• Differential pinion gears

†Reference citations are shown on page 60.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• Differential side gears • Differential carrier • Rear axle housing (Ref. A, pp. 460-463; Ref. B, pp. 439-440; Ref. C, pp. 386-393; Ref. D, pp. 421-423)
A. Gear design	Explain the nomenclature relating to gears, including: • Heel • Toe • Face • Flank • Pitch line • Clearance • Backlash • Hypoid Explain the design and operation of hunting and nonhunting gear sets, and show illustrations of each. (Ref. B, p. 442) Explain how a gear reduction is accomplished by the differential and show how it may be changed. (Ref. A, pp. 463-464; Ref. B, pp. 440-442)
B. Limited slip	Explain the purpose and operation of the limited-slip differential. (Ref. A, pp. 462-463; Ref. B, p. 443; Ref. C, pp. 393-394; Ref. D. pp. 423-425)
C. Service	Explain how to use a road test to diagnose differential troubles by noise and conditions under which the noise occurs. Use charts to assist in locating specific problems. Also, include methods of correcting the problems. (Ref. A, pp. 464-465; Ref. B, pp. 443-445; Ref. D, p. 426; Ref. E, pp. 28-1 — 28-3, 28-29 — 28-31)

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Point out the importance of checking the lubricant level of the differential before making a road test.
	Show how to check the lubricant level of a differential. Indicate the type of lubricants used in differentials.
	Demonstrate how to remove and replace a drive-pinion oil seal. (Ref. B, pp. 449-450; Ref. E, pp. 28-3 — 28-5)
1. Removal, disassembly, cleaning, and inspection	Demonstrate how to remove a differential from a vehicle. Use manufacturers' service manuals for correct procedures. (Ref. B, p. 450; Ref. D, p.432)
	Emphasize the importance of having the vehicle properly supported when making repairs to differentials.
	Explain why, and show how to examine the gear-tooth-contact pattern before disassembling a differential. (Ref. B, pp. 453-458)
	Demonstrate how to disassemble, clean, and inspect the component parts of a differential. Use manufacturers' service manuals for correct procedures. (Ref. B, pp. 458-461; Ref. D, pp. 432-435; Ref. E, pp. 28-12 — 28-15)
	Show how to identify worn and defective bearings and gears. Explain how to detect a warped gear case. Indicate how to use a parts catalog to order replacement parts.
2. Reassembly and adjustment	Demonstrate how to reassemble and adjust a differential. Use manufacturers' service manuals for correct procedures and specifications. (Ref. B, pp. 435-439; Ref. E, pp. 28-15 — 28-23)
	Show how to preload pinion-gear bearings. (Ref. C, p. 400; Ref. E, p. 28-21)
	Demonstrate how to use a pinion depth gauge and dial indicator to adjust the ring and pinion gears. Also, show how to use red lead to indicate tooth-contact patterns.
3. Limited slip	Demonstrate how to disassemble, clean, inspect, and reassemble a limited-slip differential. Use

CONTENT OUTLINE		UNDERSTANDINGS AND TEACHING APPROACHES
		manufacturers' service manuals for correct procedures and specifications. (Ref. B, pp. 461-465; Ref. E, pp. 28-25 — 28-27)
	4. Reinstallation	Demonstrate how to reinstall a differential. Use manufacturers' service manuals for correct procedures. (Ref. B, p. 45)
	5. Road test	Explain the importance of checking the operation of a repaired differential by making a road test or using a dynamometer. *Have students practice removing, disassembling, cleaning, inspecting, repairing, reassembling, adjusting, and reinstalling differentials. Use manufacturers' service manuals for correct procedures and specifications. Check each student's work to see that correct work procedures and standards are being followed.* *Have students check performance of repaired differentials by making a road test or using a dynamometer.*
II.	Rear Axles	Explain the power flow from the differential to the rear wheels. Identify the component parts of a rear axle. Show the location of rear axle oil seals and indicate the possible causes of oil leakage, including: • High lubricant level • Plugged breather • Defective seal
	A. Types	Explain and show different types of rear axles including: • Flanged • Inner locked • Tapered (with key or spline) (Ref. C, pp. 388-393) Explain and show examples of the different types

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	of rear axle supports in common use, including: • Semifloating • Three-quarter-floating • Full-floating
B. Service	Demonstrate how to remove and replace rear-wheel bearings and seals. Use manufacturers' service manuals for correct procedures. (Ref. B, pp. 447-449; Ref. E, pp. 28-8 — 28-10) Emphasize the importance of having the vehicle properly supported when servicing or repairing rear axles. Demonstrate how to remove and replace different types of rear axles, including: • Flanged • Inner locked • Tapered (with key or spline) Use manufacturers' service manuals for correct procedures and specifications. (Ref. E, pp. 28-5 — 28-8, 28-10 — 28-11) Demonstrate how to remove and replace a rear axle housing. Use manufacturers' service manuals for correct procedures and specifications. (Ref. B, pp. 451-453; Ref. D, pp. 429-430) *Have students practice removing and replacing rear axle shafts, oil seals, bearings, and housings. Use manufacturers' service manuals for correct procedures and specifications. Check each student's work to see that correct procedures are being followed.*

Review Discussion

1. Describe the operation of a standard differential.
2. Explain the symptoms and causes of differential malfunctions
3. Describe how to check differential gears for backlash, tooth contact, gear runout, and preload.
4. Explain how to remove and replace a rear-axle bearing.

SAMPLE FINAL EXAMINATION

DIRECTIONS: Sample Final Examination Part I — Multiple Choice

For each statement, place the letter of the choice that completes the statement most accurately in the space to the left of the statement.

B 1. The purpose of the clutch is to couple and uncouple the crank shaft from the

(A) driveshaft and pinion gear
(B) transmission
(C) rear end assembly
(D) differential carrier

C 2. The clutch disc is disengaged from the flywheel when the throwout bearing is moved against the

(A) pressure plate housing
(B) flywheel hub
(C) release levers
(D) release springs

A 3. The clutch disc is connected to the transmission by

(A) a splined shaft
(B) the pressure plate
(C) retaining bolts
(D) the diaphragm spring

D 4. A related clutch part is the

(A) universal
(B) drive shaft
(C) rear axle
(D) throwout bearing

C 5. Clutch pedal free play should be

(A) 3 inches from the floor
(B) 2 inches from the floor
(C) according to manufacturer's specifications
(D) zero clearance from the floor

B 6. Material used for facing a clutch plate is

(A) solid metal
(B) similar to brake lining
(C) foam rubber
(D) hardened steel

B 7. Pressing down on the clutch pedal causes the release levers to move the pressure plate away from the

(A) clutch cover
(B) friction disc
(C) throwout bearing
(D) pressure plate baffle

A 8. When the clutch is engaged, clutch slippage is especially noticeable

(A) during acceleration in high gear
(B) when idling
(C) at low speeds
(D) when starting the engine

D 9. Clutch chattering or grabbing is noticable

(A) when idling
(B) at low speeds
(C) when accelerating
(D) when engaging the clutch

C 10. The front end of the clutch shaft is supported by a pilot bearing or bushing located in the

(A) throwout bearing
(B) friction disc
(C) crankshaft or flywheel
(D) transmission

B 11. To prevent distortion on reinstallation, the clutch cover bolts should be tightened

(A) one at a time
(B) evenly
(C) until springs begin to compress
(D) until springs are expanded

D 12. Parts of the clutch that should *not* be cleaned in a solvent include the

(A) friction disc and cover
(B) throwout bearing and springs
(C) release lever and cover
(D) friction disc and throwout bearing

D 13. Specifications are defined as

(A) measurements in general
(B) statements describing general conditions and facts about the vehicle
(C) repair or shop manuals that are supplied by the manufacturer
(D) precise and exact measurements or settings that are used when making repairs or adjustments

C 14. The cluster gear in a standard transmission turns

(A) in first gear only
(B) in third gear only
(C) in all gears
(D) in reverse gear only

A 15. In a standard three-speed transmission, the complete shifting of gears is accomplished by the sliding movement of

(A) one gear and/or one synchronizing assembly
(B) two gears and two synchronizing assemblies
(C) two gears only
(D) two synchronizing assemblies only

C 16. The part of a standard transmission that makes shifting easier is called the

(A) spur gear
(B) sliding gear
(C) synchronizer
(D) detent

B 17. A noise which is heard only when the transmission is in gear and the clutch pedal depressed is most likely caused by a faulty

(A) clutch fork pivot
(B) clutch release bearing
(C) clutch pressure plate
(D) front transmission bearing

A 18. The speeds in a standard transmission that use a sliding gear are

(A) first and reverse
(B) first and third
(C) second and third
(D) second and reverse

D 19. The purpose of the guide pins is to keep the transmission moving straight back and to prevent damage to the

(A) clutch shaft
(B) crankshaft pilot bearing
(C) drive shaft
(D) clutch disc

D 20. The correct lubricant to use in a standard transmission is

(A) Type A
(B) 10W-40
(C) 50W
(D) Specified by the manufacturer

C 21. The synchronizer equalizes the speed of the meshing gear and the

(A) clutch shaft
(B) idler gear
(C) output shaft
(D) counter gear

B 22. To repair a leak at the transmission rear seal, the mechanic needs to

(A) remove the transmission to install seal
(B) remove the drive shaft to install seal
(C) overhaul the transmission
(D) add a can of stop leak to the transmission oil

C 23. The two basic components in the overdrive are the planetary gear system and the

(A) fluid coupling
(B) gear box
(C) free wheeling mechanism
(D) shifter lever

D 24. The sun gear in an overdrive unit is locked by the

(A) brake
(B) hand lever
(C) servo unit
(D) pawl

C 25. To permit the pawl to lock the control plate in an overdrive unit, the driver must

(A) step on the brake
(B) turn off the ignition
(C) momentarily release the throttle pressure
(D) push the throttle wide open

D 26. The function of universal joints on the ends of the drive shaft is to

(A) allow the drive shaft to rotate at different speeds
(B) allow the rear wheels to turn at different speeds
(C) reduce vibration in the drive shaft
(D) allow the driving angle to change as the rear axle moves up and down

A 27. The most common symptoms of failure in a universal joint is a

(A) heavy rumble during acceleration
(B) whine during acceleration
(C) heavy rumble during turns
(D) whine during deceleration

A 28. A leak in a rear axle oil seal could be caused by

(A) a blocked breather vent
(B) using oil with too low a viscosity
(C) an improper mesh of the ring and pinion gears
(D) a loose axle flange

C 29. The type of rear axle assembly commonly used on most passenger cars today is

(A) three-quarter floating
(B) a dead axle
(C) semifloating
(D) full floating

D 30. One purpose of the differential is to

(A) disconnect the drive shaft from the rear axle
(B) disconnect the transmission from the crankshaft
(C) change the direction of the power flow 90° to the drive shaft
(D) change the direction of power flow 90° to the driving axle

B 31. The reduction ratio of a differential with 43 teeth on the ring gear and 11 teeth on the pinion gear is

(A) 4.10:1
(B) 3.96:1
(C) 3.73:1
(D) 3.54:1

C 32. Excessive clearance between the pinion and ring gear may be corrected by

(A) turning both side carrier adjustments in
(B) turning both side carrier adjustments out
(C) turning the right side carrier adjustments out and the left side carrier adjustment in
(D) turning the right side carrier adjustment in and the left side carrier adjustment out

D 33. The rear axle bevel gears in the differential mesh with the

(A) main gear
(B) ring gear
(C) drive pinion
(D) differential pinions

D 34. The rear axle bearings used on present day cars are lubricated

(A) by grease fittings on both axles
(B) pressure from the differential
(C) by oil creeping along the axle
(D) at the factory and permanently sealed

B 35. When an inspection of cleaned differential parts reveals a cracked gear, the mechanic should

(A) replace the complete unit
(B) replace the damaged gear or matched pair of gears
(C) weld the crack and file to original shape
(D) replace the differential gear

B 36. Free clutch pedal travel is adjusted by

(A) bending the pedal stop
(B) adjusting the clutch linkage
(C) placing washers under the clutch cover
(D) alining the clutch housing

C 37. When reinstalling the pressure plate to the flywheel, first

(A) use clamps to hold the unit in place
(B) position and tighten one fastener
(C) aline the assembly marks
(D) lubricate all the parts

B 38. Too much free play in the clutch pedal will cause the

(A) clutch to slip
(B) shifting of gears to be difficult
(C) clutch-pressure plate to wear out quickly
(D) throwout bearing to ride continuously on the release fingers

A 39. The ring and pinion gears in the differential are classified as

(A) hypoid gears
(B) spur gears
(C) worm gears
(D) spiral bevel gears

B 40. A limited-slip differential has a clutch to lock

(A) the slipping axle
(B) both axles to the case
(C) both axles to the housing
(D) the driving axle

Sample Final Examination Part II — Fill-In Statements

Directions: For each statement, write the word or phrase that, when inserted in the blank, will complete the statement correctly.

1. Clutch pulsation is noticable when a slight pressure is applied to the CLUTCH PEDAL.

2. Rapid friction disc wear is a result of RIDING THE CLUTCH.

3. Grease on the friction disc will cause the clutch to CHATTER OR SLIP.

4. The clutch pressure plate is mounted on the FLYWHEEL.

5. A three-speed transmission has TWO shifter forks.

6. Gear clashing when shifting may be due to failure of the SYNCHRONIZING MECHANISM.

7. When a transmission slips out of first and reverse the cause may be abnormal GEAR CLEARANCE OR MISALINEMENT.

8. When a transmission slips out of low and reverse the cause may be a loose fit on the SLIDING SLEEVE.

9. Hard shifting may be caused by an improperly adjusted GEAR SHIFT LINKAGE.

10. On a transmission with a vacuum shift, hard shifting may result from a malfunction of the VACUUM CYLINDER.

11. Excessive noise in any one gear position usually means DEFECTIVE gears.

12. A hissing sound often indicates bearing trouble due to wear or LACK OF LUBRICATION.

13. When two gears of different size mesh, the larger of the two gears will revolve SLOWER than the smaller gear.

14. On a four-speed transmission, a synchronizing device is used for all gears except REVERSE.

15. The planetary gear system is an essential part of the OVERDRIVE UNIT.

16. The free wheeling mechanism allows the output shaft to overrun the TRANSMISSION shaft.

17. In an overdrive unit, the sun gear is locked by a momentary release of the THROTTLE.

18. When removing a flanged type rear axle, it is first necessary to remove the wheel and BRAKE DRUM.

19. The outer end of the rear axle is supported by a BALL OR ROLLER BEARING.

20. Humming of the differential is caused by the improper adjustment of the RING GEAR.

21. A drive pinion gear located below the center line of the ring gear is called a HYPOID GEAR.

22. To prevent the pinion gear from moving away from the ring gear under load, the pinion bearing must be correctly PRELOADED.

23. After an axle has been removed, always install a new OIL SEAL.

24. Before making a road test, check the differential LUBRICANT level.

25. A Hotchkiss drive features a drive shaft that is EXPOSED.

Sample Final Examination Part III — Problems

1. *Directions:* In the space provided, indicate with an "A" those parts from the display that could be used again and with a "U" those parts that should be discarded.

(U) 1. Pilot bushing (WORN WITH OVERSIZED BORE)

(U) 2. Clutch disc (FACING FLUSH WITH RIVETS)

(U) 3. Throwout bearing (RATTLES)

(A) 4. Synchronizer ring (SHARP REGULAR DOGTEETH-GROOVES STILL SHOW ON CONE CLUTCH SURFACE)

(U) 5. Ballbearing (ONE BADLY CHIPPED BALL)

(U) 6. Pinion bearing race (LIGHT TRACE OF FLAKING)

(U) 7. Ring gear (WORN WITH WRONG MESH PATTERN)

(A) 8. Universal joint cross (USED BUT STILL SMOOTH AND SHOWING NO GAULING)

(U) 9. Axle bearing-double shielded (DRY AND ROUGH TURNING)

(U) 10. Assembled universal joint with drive shaft and yoke. (SHOWS DRY POWDER AND RUST COLORATION AROUND SEAL AREA)

2. *Directions:* From the list given below, number in the correct order in the space provided the steps a mechanic would perform when removing a clutch assembly from a vehicle.

(4) Disconnect linkages and speedometer cable

(6) Remove transmission

(No) Remove oil pan

(7) Remove throwout bearing

(5) Remove dust or inspection cover

(2) Disconnect battery

(8) Remove bolts attaching pressure plate to flywheel

(No) Disconnect vacuum line

(1) Support vehicle securely

(9) Remove clutch and pressure plate assembly

(No) Remove stabilizer bar

(3) Remove drive shaft

3. *Direction:* From the list given below, number in the correct order in the space provided the steps a mechanic would perform when removing a differential from a vehicle.

(4) Remove rear axles

(No) Remove backing plates

(3) Remove rear wheels and drums

(5) Remove differential mounting nuts

(No) Remove parking brake cables

(2) Remove universal joints and drive shaft

(No) Remove rear axle housing

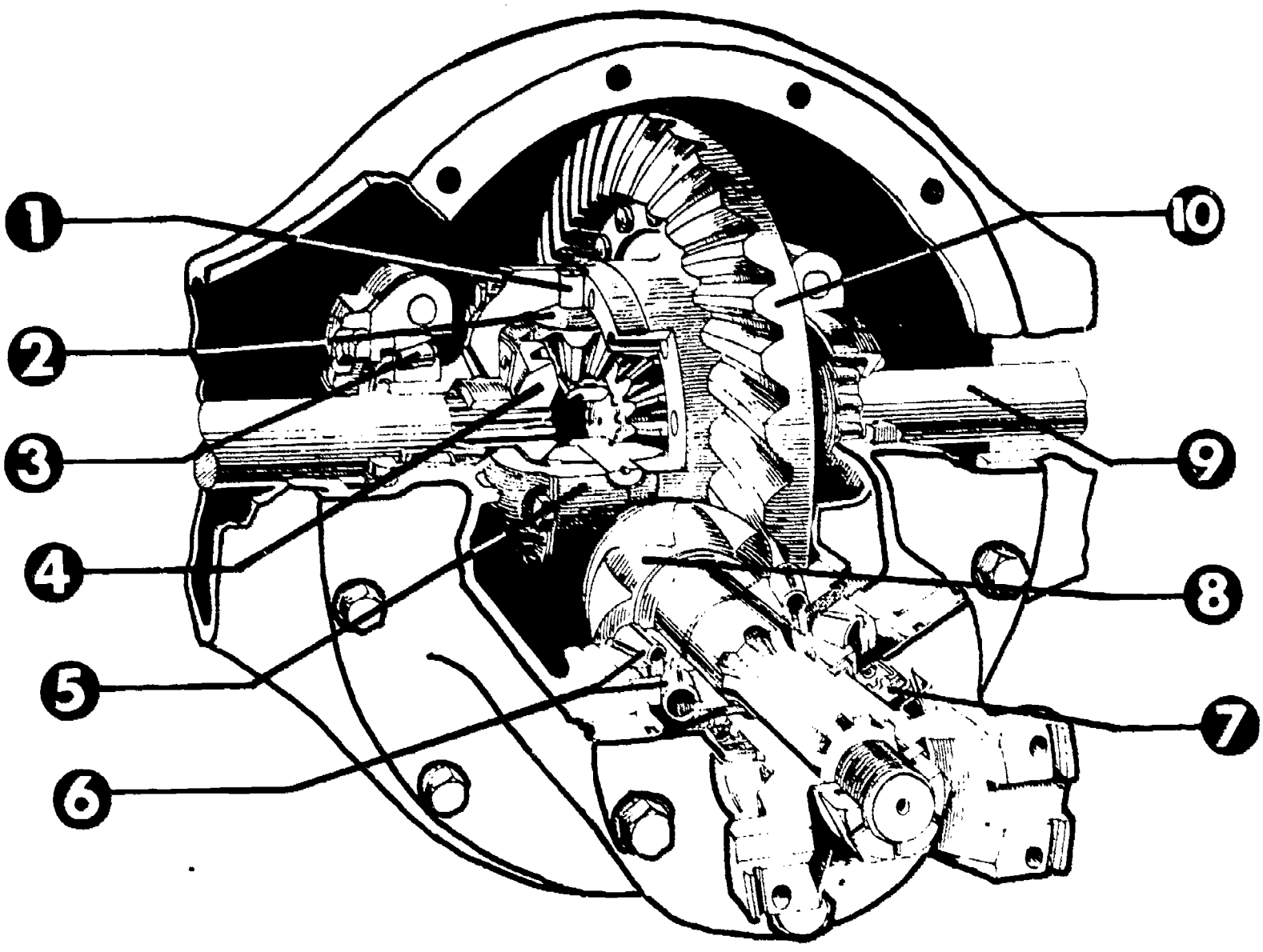
(1) Support vehicle securely

(6) Remove differential

Final Examination Part IV — Identification

Directions: In the space provided after each number, write the correct name of the part indicated by the matching number on the illustration given below.

1. DIFFERENTIAL-PINION SHAFT
2. DIFFERENTIAL-PINION GEAR
3. DIFFERENTIAL CARRIER BEARING
4. DIFFERENTIAL-SIDE GEAR
5. DIFFERENTIAL CASE
6. PINION BEARING
7. SEAL
8. DRIVE PINION
9. AXLE SHAFT
10. RING GEAR



USING AUDIOVISUAL MATERIALS

Audiovisual materials are both a tool for teaching and an avenue for learning. They lend themselves well to getting students involved in the learning process by encouraging them to contribute information and share their experiences. It is well to remember that students can learn much from each other. The following suggestions are made with the idea of assisting the instructor to use audiovisual materials more effectively in his presentation.

Plan the Presentation (Organization and Methods)

Always preview any audiovisual material to become familiar with its content and see that it correlates with the lesson. Students dislike *time fillers* and inappropriate presentations. While previewing the material, prepare comments which might answer such questions as the following:

- What is being illustrated?
- Why is the presented material important?
- What are the important terms and understandings being presented?
- What are some appropriate topics which could be used to stimulate class discussions?

Prepare the Equipment and Materials

Request the required equipment several days ahead of time. Then, see that it is delivered prior to the starting of the class. Check the equipment to see that it is all in working order. Before the class begins, practice using the equipment to become acquainted with its operation. Arrange the room so that everyone can see and is comfortable. Have a screen ready and place it so that the least amount of outside light is reflected onto it. The wall may be used, but a screen is much more desirable. The larger the room and the larger the audience, the larger the screen that is needed. Be sure there is a table for the projector, an electrical outlet, an extension cord, and a spare projector lamp in case the one in use fails.

If the class is held during the day, be sure the room can be darkened and ventilated. Check to see that the lights can be turned off without shutting off the power to the projector. At the conclusion of the presentation, allow the fan on the machine to run for a few minutes before completely shutting off the power to the equipment.

Orient the Class (Background Material)

Explain to the class what they are going to see. Discuss the important terms used and indicate the main points that will be covered.

Make the Presentation

If using a movie or filmstrip, have the film threaded and the projector ready for use. Stop the film or filmstrip for discussion as the need arises during the showing instead of waiting until the presentation has been completed.

If using an overhead projector, have the transparencies readily accessible and arranged in order of presentation. Have the projector focused and adjusted to obtain the best picture. Turn the projector on only during the time it is actually being used. After a pointer has been used remove it quickly or lay it on the transparency because a hand-held pointer soon becomes distracting.

If using a model, be sure everyone can see the action taking place. For complex models use an overhead mirror.

Summarize the Concepts and Understandings

Discuss with students the main points of the presentation and list them on the chalkboard. Allow time for the students to raise other questions which may lead to a more complete understanding of the topic. Encourage students to keep some kind of notation for future review.

Evaluate the Knowledges Acquired

Prepare a list of questions which might assist students to evaluate how well they have learned the important points of the presentation. One approach might be for the instructor to present the question and pause for a few moments to allow the students to form their answers before responding. Interest could be generated by asking the students to keep track of the number of their correct answers.

Return the Equipment and Materials

After the class is over, make arrangements to return the equipment and school-owned audiovisual materials. For an item ordered from an out-of-school source, complete the required attendance report, prepare the material for mailing, and make arrangements so that it may be returned promptly.

PREPARING AND USING TRANSPARENCIES

The overhead projector is a flexible classroom teaching device. It gives the instructor maximum freedom to adapt the material being used to the needs and interests of the group by letting him control the pace, emphasis, and sequence of the presentation. Because the projector is positioned in front of the class, the instructor is able to maintain a more effective rapport with the students, observe their reactions, and lead group discussions more effectively.

The overhead projector is an excellent device to use to present a complex concept or process. Colorful transparencies with multiple overlays break the complicated events into comprehensible units and easily show the interrelationships among the different parts. By using a blank transparency and felt tipped pens or grease pencils, the instructor can develop, ahead of time or with the class, multicolored diagrams and charts which might ordinarily be placed on the chalkboard.

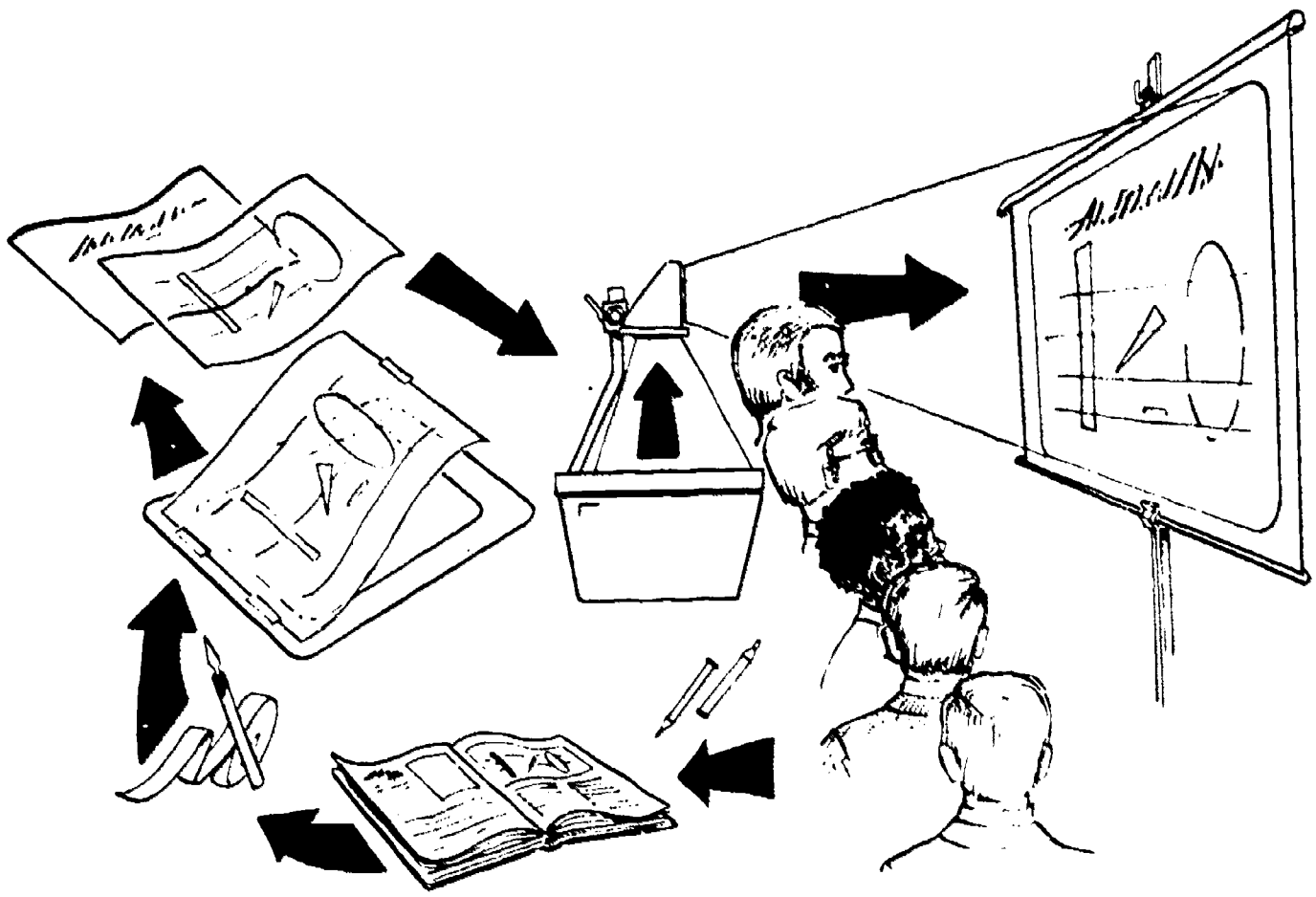
Transparencies may be prepared easily by hand. The following suggestions are presented to help instructors plan and produce their own original transparencies.

- Organize the content of the transparency carefully and plan for horizontal projection.
- Keep the content of the transparency simple.
- Use letters and symbols that are at least $\frac{1}{4}$-inch high. Use a lettering guide or dry-transfer letters and symbols to produce attractive titles or labels.
- Use color to make the transparency attractive, but only enough color for emphasis. Color-toned sheets or colored ink may be used to identify parts of a drawing or picture.
- Leave a three-quarter of an inch margin on all sides of a transparency.
- Use multiple overlays (one transparency over another) for the development of a concept or to show steps. Attach overlays to the sides of the mount with tape or special transparency hinges.
- Keep master and overlays in register with crosshair marks in opposite corners.

- Use a sliding or hinged mask to control the rate of disclosure when more than one step is included on a transparency.

- Place the completed transparency in a special mount. Fasten the film to the mount with pressure-sensitive tape.

Transparencies may be produced from printed matter easily and quickly by the use of the thermal copying process. The process is simple but it does require a special machine. These machines are widely distributed so, if one is not readily available, it should not be too difficult to locate one. Use the recommended type of plastic sheet and follow the simple directions given for the thermocopying machine being used. Place the completed transparency in a special mount. Fasten the film to the mount with pressure-sensitive tape.



GLOSSARY

Acceleration: A change in speed in a given period of time.

Accelerator: A foot-operated pedal connected to the throttle valve in the carburetor that regulates the speed of the engine.

Axle ratio: The ratio of the r.p.m. of the drive shaft to the r.p.m. of the rear wheels.

Backlash: The amount one gear can move back and forth without moving the gear into which it is meshed.

Bevel gear: A gear with teeth cut at an angle which is used to change directions of power flow.

Chassis: The framework of a vehicle exclusive of the body and fenders.

Cluster gears: Gears used in a standard transmission to connect the input shaft to the first, second, and reverse idler gears.

Clutch: A device which connects and disconnects parts that are rotating at different speeds.

Clutch diaphragm spring: A flat, dish-shaped spring steel used to force the pressure plate against the clutch disc.

Clutch disc: A round, flat disc with friction material on both sides that is placed between the pressure plate and flywheel and used to transmit power.

Clutch housing (bell housing): A cast iron or aluminum unit that surrounds the flywheel and clutch.

Clutch pedal free travel: The distance the clutch pedal travels before the throwout bearing contacts the release fingers.

Clutch pilot bearing: A small bronze bushing or ball bearing which supports the transmission shaft.

Clutch pressure plate: The part of the clutch that pushes the clutch disc against the flywheel.

Clutch throwout fork: The device that moves the throwout bearing against the release levers.

Clutch shaft: The shaft coming from the front of the transmission on which the clutch is assembled.

Constant mesh gears: Gears that remain in mesh with each other at all times.

Constant velocity universal joint: A universal joint designed to cancel out vibrations caused by power being transmitted at an angle.

Counter gear: A gear used to change the direction and/or speed of the power flow in a group of gears.

Dead axle: An axle that does not rotate.

Detent: A small depression in a shaft or rod into which a pawl or ball drops to hold a sliding member in position.

Diaphragm spring: A round, thin steel disk with tapering fingers used in some clutches as a type of spring.

Differential: A device that allows one driving wheel to turn at a different speed than the other.

Direct drive: The condition when the engine crankshaft and drive shaft are turning at the same r.p.m.

Drive fit: The condition when a shaft is slightly oversized and must be forced in place.

Drive line: The parts that transmit the power from the engine to the driving wheels.

Drive shaft: The shaft that connects the transmission to the differential.

Extreme-pressure lubricant: A lubricant designed to withstand heavy loads and used in hypoid-gear differentials.

Flywheel: A large wheel which is attached to the crankshaft and serves as part of the clutch assembly.

Freewheeling mechanism: A device that transmits power in one direction only and used in the overdrive unit to allow the vehicle to coast while the engine is slowing down.

Friction: The force which opposes motion.

Full-floating axle: An axle that only drives the wheel and does not support the weight of the vehicle.

Gear ratio: The number of revolutions made by the driving gear compared to one complete revolution of the driven gear.

Helical gear: A gear with teeth cut at an angle to the centerline which allows two pairs of teeth in contact at all times.

Hotchkiss drive: A type of drive in which the driving force of the wheels is transmitted to the frame through the springs.

Hunting gear set: A gearset in which the number of teeth are not proportional and so requires several revolutions for each tooth of the drive pinion to contact every tooth of the drive gear.

Hypoid gears: A gear design with the teeth cut in a spiral form which permits the pinion gear to be placed below the centerline of the ring gear.

Idler gear: A gear placed between two other gears to transmit motion without a change in direction or speed.

Internal gear: A gear with teeth which point toward the center of the gear.

Kick down: A forced downshift in a transmission or shifting from overdrive to direct drive.

Limited-slip differential: A differential designed to provide traction to one wheel when the other wheel is spinning.

Live axle: An axle that drives a vehicle wheel.

Lockout: A manual control that prevents overdrive from functioning.

Overdrive: A device that causes the drive shaft to turn faster than the engine crankshaft.

Overrunning clutch: A clutch that transmits a force in one direction and slips the other direction.

Pawl: A device that is moved into a detent, slot, or groove to hold a part stationary.

Pilot bearing: The bearing in the center of the flywheel that supports the front of the clutch shaft.

Pinion carrier: The part of the rear axle assembly that supports the pinion gear shaft.

Pinion gear: A small gear designed to mesh with a larger gear or gears.

Planet carrier: The part of a planetary gearset that supports the planet gears.

Planet gears: Gears that mesh with both the sun gear and ring gear.

Planetary gearset: A gear unit with a sun gear surrounded by planet gears which mesh with an internal ring gear.

Pressure plate: The part of the clutch which locks against the friction disk when the clutch is engaged.

Ring gear: The large gear in the differential that transmits power from the drive pinion to the live axle. Also, the outer gear in a planetary gearset.

Safety hub: A device used on a rear axle to prevent the wheel from coming off in case the axle breaks.

Semifloating axle: A type of axle that supports the vehicle and drives the wheel.

Shift fork: The device used to move sliding gears back and forth on a shaft.

Shift rails: The rods upon which the shift forks are attached.

Slip joint: A joint that will transmit force from one shaft to another while allowing a change in length to take place.

Spider gears: Small gears mounted in the differential case that mesh with the axle gears.

Spiral bevel gears: A tapered gear with teeth cut on a spiral and used in the differential.

Spline: Grooves or slots cut in a shaft and used to connect and transfer force from one part to another.

Spur gears: A gear with teeth cut parallel to the shaft.

Stick shift: A transmission that is shifted manually.

Sun gear: The central gear in a planetary gearset.

Synchronizer: A device that gets two gears revolving at the same speed before they are shifted.

Throwout bearing: The bearing moved in to the release levers by the clutch pedal which disconnects the engine from the drive train.

Tooth heel: The wider outside end of the teeth.

Tooth toe: The narrower inside end of the tooth.

Torque-tube drive: A type of drive in which the driving force of the rear wheels is transmitted to the frame through a tube surrounding the drive shaft.

Transmission: A device in the power train that provides different gear ratios between the engine and rear wheels.

Universal joint: A type of flexible connection that permits changes in the driving angle.

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Drive line. Sterling Educational Films. 14 min. sound. color. Purchase - Sterling Educational Films.

Safety in the shop: basic practices. Coronet Films. 13 min. sound. color. Purchase - Coronet Films.

FILMSTRIPS

Safety at work. Scott Educational Division. 10 filmstrips. 56 frs. avg. length. color. sound. Purchase - Scott Educational Division.
- On guard
- The safe program
- Practicing safety
- Protecting your eyes
- Using hand and bench tools
- Operating power machines
- Preparing for emergencies
- Wounds - sprains - fractures
- Shock - fainting - burns - eye emergencies
- Artificial respiration

Shop safety. Mt. San Jacinto College. 49 frs. sound. color. Purchase - Mt. San Jacinto College.

SLIDES

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Shop tools. John Deere. 45 slides. color. Purchase - John Deere.

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