Study Unit

Introduction to Auto Repair

Preview

Auto repair is a growing field that can provide a fascinating career, a good income, job security, and self-fulfillment to anyone with a desire to work hard and succeed. The modern automobile is an amazing piece of technology, with its many components working together to provide safe, reliable transportation. It takes highly trained, talented people to keep these high-tech vehicles in running order. Since professional auto repair technicians possess specialized abilities that few others have, their skills are always in demand. As an auto technician, you'll do interesting work that's essential to everyone who owns a car. For this reason, a skilled auto technician is always highly regarded in the community and commands the respect and admiration of friends and coworkers.

There are many reasons why you may be interested in taking this program. You may be preparing to start a full-time career in the automotive repair field. If you're already employed in another field, maybe you're simply interested in expanding your horizons. Perhaps you want to work only part-time, performing repairs only occasionally; or, maybe you're interested in saving money by performing repairs on your own vehicle. We believe that once you understand how many different career opportunities are available to skilled auto repair technicians, you'll understand how rewarding and enjoyable the field of automobile repair can be. No matter what your career goals are, this program is designed to help you succeed.

Home study provides millions of people with the opportunity to learn new skills, earn diplomas, and start new careers. Anyone who has the desire to succeed can find personal satisfaction and professional success through home study programs. By making the commitment to complete this program and earn your diploma, you're making a valuable investment in your future. Remember that each and every skill that you'll be learning in this program has a real-life, hands-on application that can help you earn money and improve your job outlook. This fact alone should keep you working hard at your lessons.

Now, let's begin your lessons. As you start reading this first study unit, you'll learn about the growing automotive repair field and the increasing need for professional auto technicians. You'll discover the many exciting career opportunities that are available to skilled auto technicians. You'll learn about the basic operation of engines and automotive systems. You'll be introduced to the specialized tools that automotive technicians use, and learn how to purchase the professional tools you'll need to get started in the field. Finally, you'll learn the important safety procedures that must be followed when you're performing auto repairs.

When you complete this study unit, you'll be able to

- Name and describe the seven basic operating systems in a vehicle
- Describe the basic operation of a four-cycle internal-combustion engine
- Define the terms *horsepower*, *displacement*, and *compression ratio*
- List the various hand tools and specialized tools you'll use when working with engines

- Describe the safe work practices that must be used when working on automobiles
- Explain how personal protective equipment is used to prevent personal injury
- Discuss the employment possibilities that are available in the auto repair field
- List and describe the steps needed to attain certification in the auto servicing field

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Introduction to Auto Repair

INTRODUCTION

The Rapidly Growing Field of Automotive Repair

The men and women who pioneered the development of the automobile 100 years ago could never have imagined how the automobile would revolutionize the world. In those days long ago, automobiles were rare, luxurious "toys" owned only by the wealthy. Today, automobiles are owned by ordinary people everywhere and are generally considered to be a necessity of life. Unless you live in a major metropolitan area with a large public transportation system, you probably rely on an automobile to get to work, school, the local shopping mall, and just about everywhere else. The use of the automobile is so widespread that today, in the United States, there are approximately 185 million registered automobiles on the road (Figure 1). This is an average of about 1.07 cars for every licensed driver!

What do these statistics mean to you? Well, think about all those automobiles, and then think about all the people who depend on those cars to get them to work, school, and to stores. Since most people don't work on their own cars at home, this means that they'll rely on you, the auto technician, to keep their vehicles in running order.

Auto repair shops are regularly filled with customers who need the services of skilled technicians. Every one of those 185 million vehicles will require regular maintenance as well as frequent repairs. Proper maintenance is so important to a vehicle's operation that, typically, an auto manufacturer's warranty won't apply to a car unless the owner performs the recommended maintenance. Therefore, even if we lived in a perfect world where no part ever failed and no car ever broke down, there would still be abundant servicing opportunities for trained auto technicians. Of course, in the real world, cars break down every day, and these repairs represent still more earning opportunities for you.

The average person spends about $1,400 per year on fuel, maintenance, and insurance for his or her car. A large part of that $1,400 goes directly to an auto repair technician to pay for maintenance and repairs. When you multiply that amount by the current number of licensed drivers, you can quickly see that auto repair is a huge business. Auto technicians are seldom out of work, and excellent career opportunities are available to highly trained and skilled technicians.

FIGURE 1—All of the 185 million vehicles on the road today will require the regular services of automotive repair technicians

The better your education and professional qualifications are, the better your chances will be to advance rapidly in this lucrative industry.

The automotive repair field is not only big—it's continually growing. It provides an opportunity to earn a good income and offers many chances for personal advancement. You can work at the automotive repair trade in any area, 365 days a year—there are no seasonal or regional restrictions on the job. Professional auto technicians enjoy the benefits of job security, interesting work, and a wide variety of different employment opportunities. If you enjoy fixing things and working with your hands, you'll find personal satisfaction in the ability to repair vehicles on which others depend. A check of the classified ads in your local newspaper will no doubt indicate the many job opportunities available for skilled auto repair technicians in your area.

Remember, your customers will place their trust in you, the person who keeps their vehicles safe and reliable. For this reason, talented auto repair technicians are always in demand and are respected by everyone who owns or operates a vehicle.

Automotive Mechanics and Automotive Repair Technicians

You may have noticed that we prefer to use the job title "automotive repair technician" instead of "automotive mechanic" when referring to the professionals who repair vehicles. What exactly is the difference between these job titles? Well, the answer is simple—the difference is the *image* that they represent. For many years, the people who repaired automobiles were referred to as mechanics, and are often still referred to that way. However, unlike the automobiles of the past, today's vehicles are far more technologically advanced. Modern vehicles contain computerized and electronic control systems, emission control systems, and advanced diagnostic equipment.

Since today's mechanics are required to learn very high-tech skills as well as the more traditional mechanical repair techniques, many service people now prefer to call themselves "automotive repair technicians" to reflect the wider scope of their jobs (Figure 2). In addition, most automobile manufacturers and parts suppliers also use this newer title. The job title you choose to use is entirely up to you—there's certainly nothing wrong with being called a mechanic. However, if you prefer, why not call yourself an automotive repair technician? This newer title more accurately describes the type of repair work you'll do, and it can help you reflect a modern professional image.

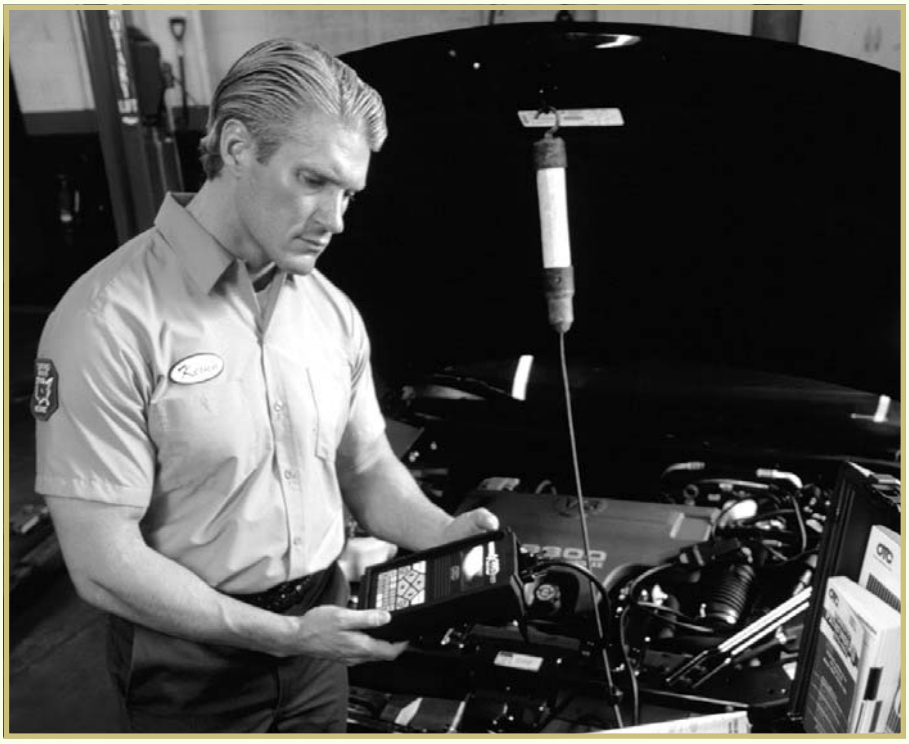


FIGURE 2—Today's automotive repair technician will need many high-tech skills as well as traditional mechanical repair knowledge.

Your Educational Goals

There are many different reasons why students are interested in taking this program, and these reasons vary according to each person's individual goals. What are your educational goals, and how can our program help you reach them?

Well, perhaps you've just finished school and are considering a career in automobile repair. Or, maybe you're a professional who already works in another field, and you're interested in a career change. Either way, we believe that you'll find this program to be both informative and useful. This program is designed to fit the needs of both beginners and more advanced students. The topics are approached in a step-by-step manner, so you can learn correctly from the beginning without feeling overwhelmed. You'll also learn about the many career opportunities in the automotive repair profession, and how you can seize one of those opportunities for yourself.

If you're already employed in the automotive field, you may be interested in upgrading your skills or in obtaining professional certification. Maybe you feel that you need to brush up on the theory of automobile operations, update your knowledge of the latest computer systems, or learn about new antilock brake systems. Perhaps you would just like to have a professional diploma that will prove your skills to your employer. If you're one of these people, this program will help you to fine-tune the skills you already have. The program information is presented in an easy-to-understand format, but is also designed to be interesting to the intermediate or more advanced student. You'll learn lots of practical, professional tips that can help you do your job better, so you'll never be bored. This program is also an excellent tool to help you prepare to successfully pass a professional certification exam, such as the *Automotive Service Excellence (ASE)* exam. (We'll discuss certification examinations in more detail later in the study unit.)

If you work on cars as a hobby or for your own enjoyment, perhaps you would like to take your hobby one step further and start your own automotive repair business. Imagine being able to earn money doing something that you enjoy! For many people, it's a lifelong dream to work at a job they truly love. If this is your dream, you've already taken the first step toward making it come true by enrolling in this program. You may decide to start your own auto repair business, either as a full-time or part-time enterprise. With a little effort and the willingness to learn, you'll be well on your way to owning a successful business.

Perhaps you're not looking for a career in auto repair at this time, but would simply like to become a more informed consumer. Well, having knowledge is like having money in your pocket. For example, many of us have looked at new cars at dealerships and been confused by the

technical jargon on the stickers. What exactly are you buying? Often, a used car in good condition is the best value for your money, but how can you be sure that a used car is in good condition? The knowledge you'll get from this program can help you judge the condition and quality of a car so that you'll understand exactly what you're buying (and maybe even help you get a great deal). You could also use your skills to help relatives, friends, and neighbors when they're purchasing cars.

Maybe you would like to be able to maintain and repair your own car. How much money do you think you could save in a year by doing repairs yourself? Even if you don't wish to do your own repairs, you'll be able to make sure that your local mechanic is doing the job properly (without overcharging you). A strong knowledge of automobile repair can also make you feel safer and more confident when vehicle emergencies occur far from home. Many emergency automotive problems can be solved quickly and easily without calling for help, if you have the know-how. Compare the cost of this program to the cost of towing and expensive roadside repairs, and you'll see how quickly your learning can pay for itself.

This practical program is designed to teach you all the basic knowledge and skills you'll need to start working as a professional auto technician. The program topics are all presented in an interesting, easy-to-understand, and enjoyable format, with plenty of photos, diagrams, and other illustrations to enhance your learning. You'll learn through step-by-step instruction that takes you from the basics of automobile operation to the latest, high-tech repair techniques. You can study at any time that fits your schedule, and at the pace that fits your needs (as fast or slow as you wish). Therefore, you'll get all the benefits of professional instruction and training with none of the hassles of a formal classroom. You can start using your new skills right away, either by making repairs to your own automobiles or by obtaining employment in the auto repair field. So, you'll quickly get the most out of your investment in training. We're confident that no matter what your educational goals are, this training program can help you meet them successfully.

What Will I Learn?

Some students are unsure about how they'll learn automotive repair through home study. You may wonder, "Will I really be prepared to work in the auto repair field when I complete this program? Will I be able to fix any type of car?" The answer to both of these questions is yes.

It's important to remember that today, all successful professional auto technicians have one thing in common—training. In the past, "back-

yard mechanics" learned their skills by tinkering with cars in their own garages. However, because of the complex, high-tech systems that are used on today's cars, you probably wouldn't be able to learn how to fix vehicles properly without some formal training. To properly repair a vehicle today, you must thoroughly understand how all the systems work and how they work together. The easiest, fastest way to get this understanding is to complete a formal training program.

This doesn't mean that a person can't easily learn to make repairs to his or her own car. In fact, many of the basic skills of engine repair have remained the same for decades. However, it's important to remember that today's automotive mechanics (no matter how or where they choose to apply their skills) are highly skilled technicians who have learned their trade through formal training programs such as this program. You'll be proud to join the ranks of these professionals when you complete your training.

The topics in this first lesson will serve as a solid foundation of knowledge for you to build on as you move through the program. We'll start by reviewing the basics of four-stroke engine operation and some important engine performance terminology that you should know. Then, we'll talk about the basic operating systems that make up the automobile. Finally, we'll end your first study unit with a discussion of automotive tools and safe work practices.

If you've already worked on automobiles in the past, you may already know some of the information we'll discuss in this first study unit. If so, that's great! You'll have a head start on completing the rest of the program. (Remember, though, it won't hurt to review these important concepts.) If you're new to these automotive topics, take some time to study this first lesson carefully. As you proceed through the program, the study units will quickly become more challenging, covering more detailed automotive repair topics. You'll learn all the hands-on skills you need to perform repairs on every automotive system. For example, later in the program, you'll learn about engine rebuilding, brakes, electrical systems, fuel systems, transmissions, computer control systems, emission control systems, and all sorts of high-tech automotive testing and repair techniques.

Don't let the idea of "high-tech" automotive systems intimidate you. Remember that today's automobiles are similar in many ways to those of years past. Yes, today's engines contain electronic control systems, but these systems are simply "add-ons" to the same old gas-powered engine. All the other fundamental engine components have remained the same for many years. Today's engines still have pistons, crankshafts, camshafts, oil pumps, bearings, and so on, just like the engines in our grandparents' day. In fact, it's far more likely that a problem will occur in one of these basic mechanical components than in an electronic component. Therefore, while today's technicians must know

about the latest electronic systems, they still need the same foundation of basic knowledge that was required in years past.

In this program, we'll concentrate on the repair of automobiles and light trucks (such as minivans, pickup trucks, and sport utility vehicles). As you'll quickly learn, while the exact design of a vehicle will vary from one manufacturer to another, all gas-powered vehicles work according to the same principles. Therefore, you'll be able to apply the skills you learn in this program to just about any type of automobile or light truck there is—both domestic and foreign. It's important to keep this in mind, because imported cars account for a large percentage of the vehicles sold today in the United States. When you complete the program, you'll have the basic skills you need to work on almost any vehicle manufactured and sold today.

Also, since many of the basic principles of operation, repair, and troubleshooting apply to other types of vehicles, you'll be able to further your training in the future if you wish. Perhaps someday you'll want to learn to repair medium or heavy trucks, buses, or diesel engines. If so, this program can provide you with a strong foundation in basic skills that you'll be able to expand on at a later date.

Where Do I Start?

In your first shipment of materials, you'll find some important student information and an outline of your program. If you haven't read through your student information and your program outline yet, take a few moments to do so now.

Then, when you're ready, start your lessons by reading through the material in this first study unit. At the end of each section of the study unit, you'll find a short quiz called a "Power Check." These quizzes are provided for you to review your learning. These quizzes aren't graded by the school. Simply fill in the answers to the questions right on the page, and refer back to the text if you need help at any time. As you work through the study unit, remember that you can call your instructor for guidance whenever you have questions. The phone numbers and calling times are listed in your student information.

Relax—you're not in grade school any more! Many of us have negative memories of school or of test-taking. However, remember that the point of taking this program is to learn a professional trade. You shouldn't feel any of the pressures of the formal schoolroom—you make your own schedule. Take all the time you need to read the study unit, review the material, and complete the review quizzes. We want you to do well at your studies!

At the end of each study unit in the program, you'll find a multiple-choice examination that will test your learning. These examinations will be graded by the school. However, there are no time limits or restrictions of any time on the exams. Don't rush—take all the time you need to review the study unit. When you're confident that you understand the material, complete the exam and send your answers in to the school for grading. As you work on the exam, feel free to refer back to the study unit at any time for reference. The questions are designed to test you on your overall understanding of the topics, so there's nothing wrong with refreshing your memory. Remember, the only object is to learn the material.

In addition to your regular study units, you'll also receive specially designed practical exercises with this program. These fun, interesting activities will help you to better understand the practical, hands-on applications of your learning. At the end of each practical exercise, you'll complete a multiple-choice practical examination and send your answers in to the school for grading. The questions in the practical exam are designed to let you use your learning in real-life repair situations, so you can begin applying your knowledge right away.

Upon completing all your program requirements, you'll receive a diploma from the school that records your achievement. You'll be proud to display your well-earned diploma in your home or your business.

After you complete your learning program, you'll find that your texts will serve as a valuable reference source, helping you to understand and solve all types of repair problems. In addition, all the valuable tools that come with the program are yours to keep and to use when you start your professional career.

Now, let's start your study of automotive repair with a review of the basic systems of the automobile.

OVERVIEW OF AUTOMOTIVE SYSTEMS

The average automobile is made up of hundreds of different parts, all working together to make the vehicle run. It's easier to understand the functions of all these parts if we discuss them in groups. The many parts of an automobile can be grouped into seven basic operating systems. These seven systems are

1. The engine
2. The brake system
3. The suspension and steering systems

4. The transmission and transaxle
5. The drive train
6. The electrical and electronic systems
7. The heating and air conditioning system

Note that these same seven systems will be covered in Automotive Service Excellence (ASE) certification examinations (in addition to the topic of overall engine performance). Since our program is designed to cover these seven systems, your learning will be very useful if you eventually decide to take the ASE certification examination.

Later in the program, you'll be learning about each of these seven automotive systems in great detail. We'll examine the parts that make up each system, how the systems operate, how they're repaired, and how they relate to each other. As you proceed through the program, you'll quickly come to understand how each of these systems contributes to the overall performance of an automobile. For now, however, let's start with a brief review of the function of each of these operating systems to familiarize you with them.

The Engine

A vehicle's *engine* is the source of its power. That is, the engine does the basic work needed to operate all the other parts of the vehicle. Almost all automobiles contain four-stroke, gasoline-burning engines (Figure 3). Although automotive engines come in a wide variety of sizes, models, and designs, the basic operating principles of all engines are the same. In this program, we'll discuss how basic four-stroke engines work, as well as the operation of a variety of engine designs. Naturally, we can't cover every possible type and design of engine in the program. However, once you thoroughly understand the operation of a typical engine, you'll easily be able to apply that knowledge to virtually any type of automotive engine you may come across in the future.

Modern automotive engines contain a variety of electronic and computerized control systems that allow the engine to operate as efficiently as possible. With the use of this modern technology, today's engines can perform in ways that weren't possible years ago. Engines today produce far more power (but fewer harmful exhaust emissions) than similar engines from the past—all while using less fuel! This technology is highly beneficial: the environment is kept cleaner, natural resources are preserved, and the consumer gets a car that performs better and more reliably.

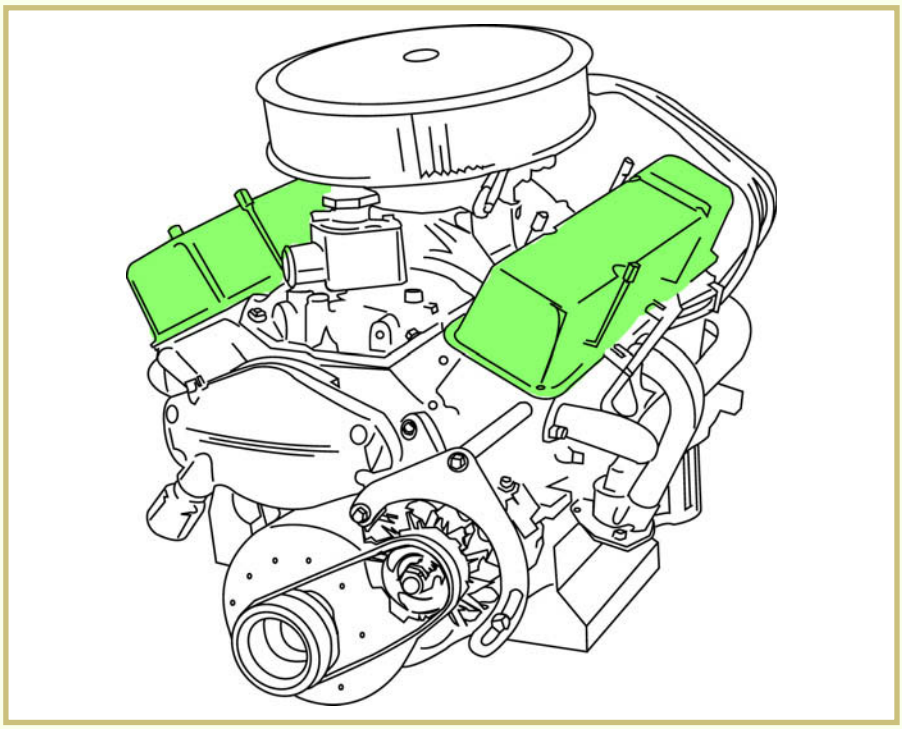


FIGURE 3—A four-stroke, gasoline-burning automotive engine is shown here.

As you learn more about engines and electronic control systems, you'll probably agree that these systems aren't really that hard to understand. In fact, many technicians find that engines equipped with electronic control systems are easier to troubleshoot and repair than older engines. No matter how you feel about electronic controls, the fact is, they're here to stay. Therefore, in order to be a successful auto repair technician, you'll need to understand how these systems work.

If you find the thought of working on electronic controls to be a bit overwhelming, remember that these systems are only a part of the entire engine system. The engine is made up primarily of mechanical parts that are relatively simple in design and operation. Therefore, understanding how the mechanical components of an engine operate is just as important as knowing about the latest electronic control systems.

The Brake System

We all know that an automobile's brake system is used to slow or stop its wheels. However, you may not be aware that almost all brakes can be classified into two categories: *drum brake systems* and *disc brake systems*. We'll discuss both of these systems in detail in upcoming study units.

In the past, the automotive brake system had a serious disadvantage. If the driver needed to suddenly apply the vehicle's brakes, the wheels would tend to *lock up* (stop turning). This would cause the car to slide

on the road surface, creating two dangerous problems. First, the sliding motion would increase the distance required to stop the vehicle. Second, when a car slides with its wheels locked, the driver can't steer it. Either one of these situations could cause the car to be involved in an accident.

For this reason, most new cars are equipped with electronically controlled brake systems called *antilock systems.* An *antilock system* prevents the wheels from locking up during sudden stops. In addition, since stopping a vehicle quickly and safely is so important, many new cars also contain electronic systems that monitor and control the braking action. These systems have helped to make vehicles safer and have reduced the number of accidents.

The Suspension and Steering Systems

A vehicle's *suspension and steering systems* allow the driver to properly control the automobile on the road. The steering system allows the driver to control the direction of the vehicle's motion (Figure 4), while the suspension system keeps the tires in contact with the road (even while the vehicle is traveling over rough road surfaces).

To permit easier driver control, virtually all steering systems produced today contain some type of *power assist*. The power assist helps the driver by making it easier to turn the steering wheel. This type of steering system is commonly called *power steering*, and it's standard on almost all vehicles. The power assist is usually provided by a hydraulic system. Hydraulic fluid is pressurized by a pump and then directed into the steering system to help turn the car's wheels.

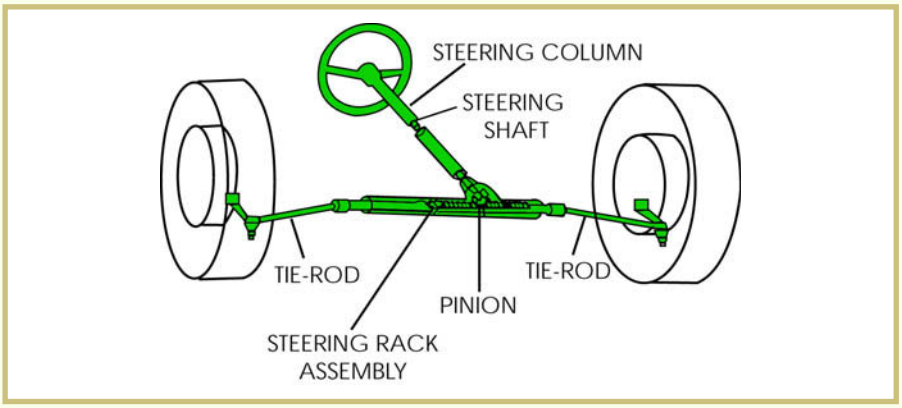


FIGURE 4—The steering system enables the operator to control a vehicle's motion. The basic parts of a steering system are shown here.

An automobile's suspension system not only keeps the tires in contact with the road, but also provides a smooth ride for the passengers. When a vehicle travels over a rough road surface, the suspension system absorbs

the bumps and prevents them from disturbing the vehicle's passengers (Figure 5). Modern suspension systems are designed to provide a smooth ride at highway speeds as well as at lower speeds. Note that the smooth ride must be achieved while still keeping the vehicle in firm contact with the road so that it can be safely controlled by the driver.

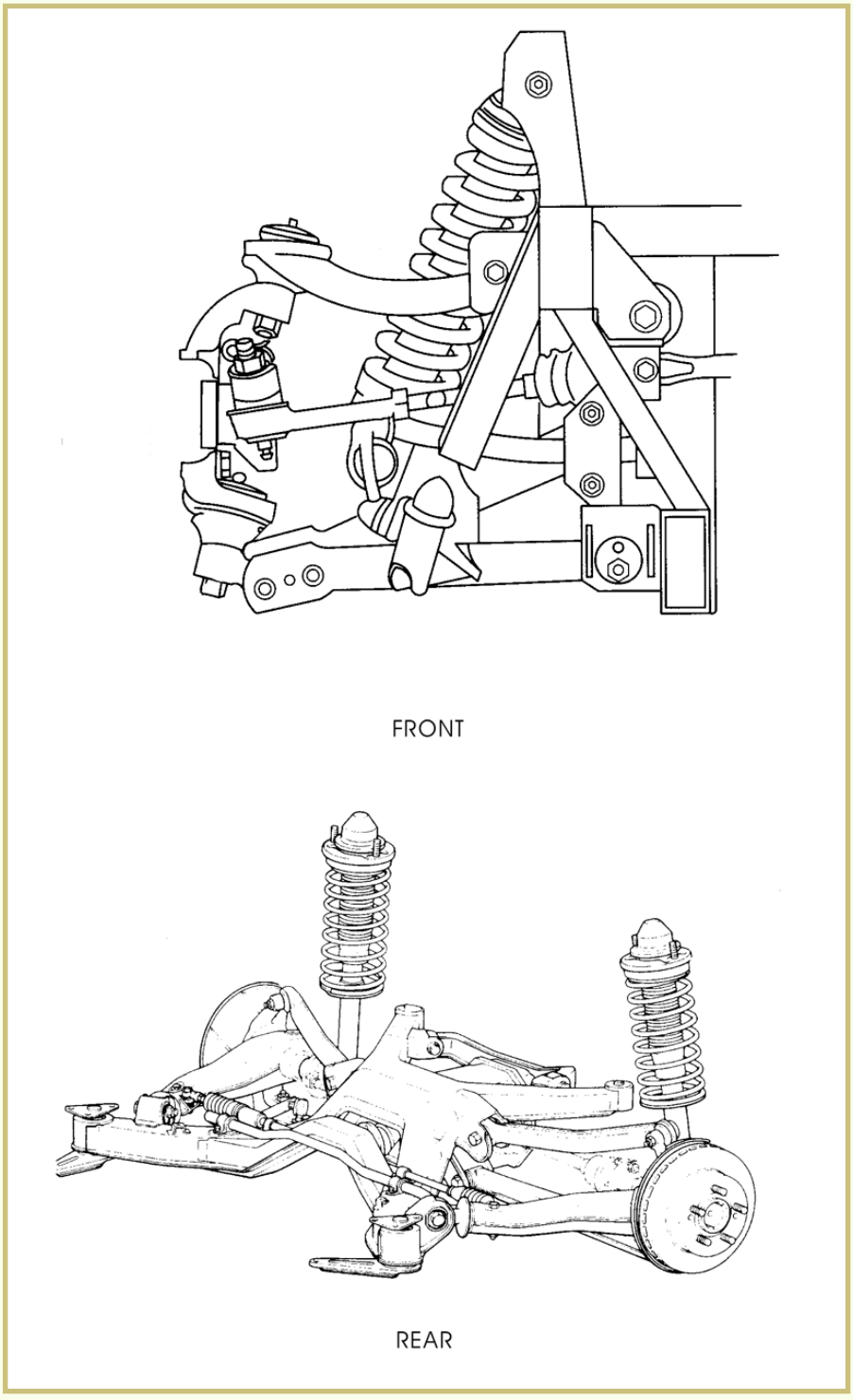


FIGURE 5—A vehicle's suspension system uses heavy-duty springs, shock absorbers, and struts to absorb bumps and provide a smooth ride when the vehicle is driven on rough roads.

The Transmission and Transaxle

An automobile must be able to reach a wide variety of speeds over varying terrain. A car must be able to travel at slow speeds through city streets, at high speeds along expressways, and at steady speeds when traveling uphill. The automobile's *transmission system* helps the vehicle change speeds to operate efficiently under all these conditions.

In order to better understand what the transmission does, let's look at the operation of a bicycle. A car's transmission can be compared to the gears on a bicycle, and the car's engine can be compared to the bike's rider. Most modern bicycles allow the rider to change gears as the bike is being ridden. So, when you ride your bike on a flat road, the higher you set the gear, the faster the bike will go. However, if you want to go uphill when the bike is in high gear, you'll have to apply a lot more effort to the pedals. To make it easier to pedal up the hill, you would need to change to a lower gear.

The same is true for an automobile. In order to drive a car uphill in high gear, the car's engine will have to produce an excessive amount of power. Shifting the car to a lower gear will make it much easier for the engine to move the vehicle uphill.

The opposite of this explanation also applies. If a bicycle is traveling downhill or along a flat road in low gear, you'll have to pedal very fast to produce any kind of speed. This will put a lot of strain on you. Therefore, to make it easier to move the bike along, you would need to change to a higher gear. This allows the bicycle to travel faster with less pedaling.

This same action occurs in an automobile. As you increase the speed of your car, the engine has to operate at higher and higher speeds in order to move the car along. If the engine was left in a low gear, the speed could become so excessive that it might damage the engine. To prevent this from occurring, you would simply shift the vehicle into a higher gear to reduce the required speed of the engine.

Two types of transmissions are commonly used in automobiles: the *automatic transmission* and the *manual transmission*. Most vehicles today contain automatic transmissions, although manual transmissions are available on most new car models. An automatic transmission usually has either three or four gear selections. The gears are shifted automatically with only a limited amount of input from the driver. In contrast, a manual transmission usually has either four or five gear selections, and the shifts must be performed manually by the driver.

The type of transmission a vehicle contains is generally a buyer option. Most new vehicles can be purchased with either type of transmission. However, because automatic transmissions are easier to operate than manual systems, most customers prefer them.

Many modern automobiles (especially vehicles with front-wheel drive) use a special type of transmission called a transaxle. A *transaxle* is a device that combines a transmission and a drive train all in one unit. (We'll discuss drive trains in a moment.) When both systems are combined in one unit, space is saved, the device is lighter in weight, and it's easier to maintain. This makes a transaxle a good choice for use in smaller or compact cars. Transaxles can contain either manual or automatic transmission components.

The Drive Train

The *drive train* is the system that connects the engine and the transmission to the wheels. There are three basic categories of drive train systems: front-wheel drive systems, rear-wheel drive systems, and four-wheel drive systems. Each system is named according to the wheels that are driven by the engine. Let's look at each of these drive systems.

Front-Wheel Drive Systems

The *front-wheel drive (FWD)* system is the most common drive train used today. In this system, the two front wheels of the vehicle are driven (rotated) by the engine, and the two rear wheels rotate freely (Figure 6). Front-wheel drive systems are most often used in compact and midsize automobiles. In these cars, the engine and transmission are normally located at the very front of the vehicle, above the front wheels. Because of the engine's location, the majority of the vehicle's weight is positioned over the front wheels. The front-wheel drive system takes advantage of this weight to help provide better traction on slippery roads. Also, because the entire drive system is located at the front of the vehicle, the rest of the car can be designed to have more space inside for passengers and cargo.

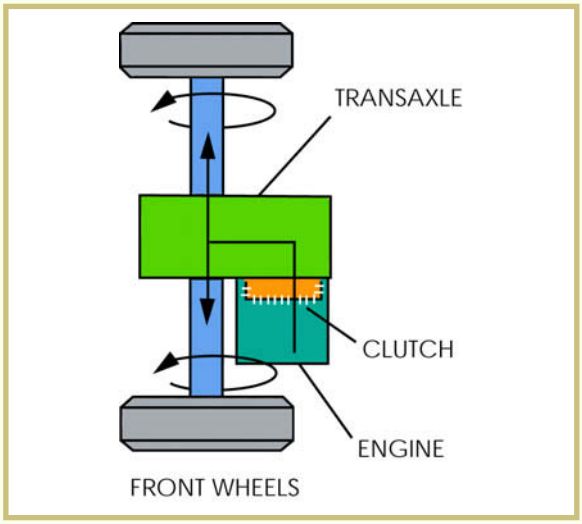
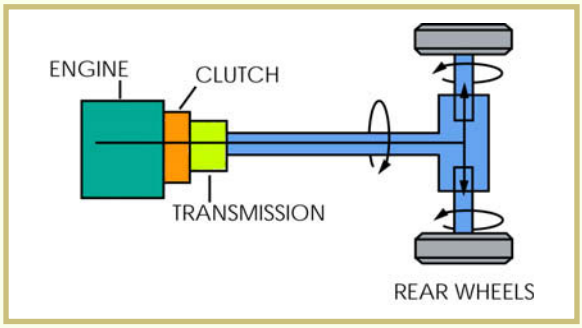


FIGURE 6—In a front-wheel drive system, the two front wheels of the vehicle are driven by the engine. The two rear wheels rotate freely.

Rear-Wheel Drive Systems

In a *rear-wheel drive (RWD)* system, the engine drives only the two rear wheels of the vehicle (Figure 7). The front wheels in this type of vehicle rotate freely. Rear-wheel drive systems are most often used on larger passenger cars and some light trucks. In a larger vehicle, the rear wheels carry much of the machine's weight. Rear-wheel drive systems can be made slightly larger and stronger, so they can withstand heavier loads than front-wheel drive systems. This makes the rear-wheel drive system the better choice for larger vehicles.

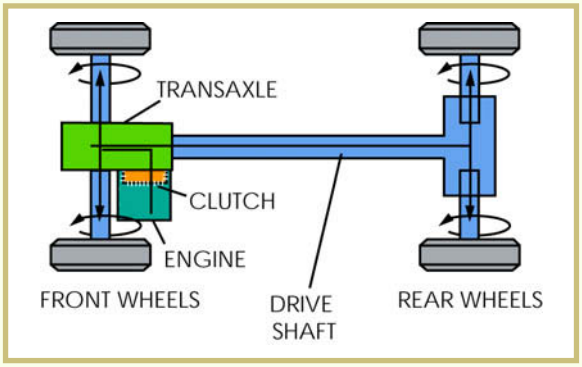
FIGURE 7—In a rear-wheel drive system, the engine drives only the two rear wheels of the vehicle. The two front wheels rotate freely.



Four-Wheel Drive Systems

The final category of drive trains is the *four-wheel drive (4WD)* system (also sometimes called an *all-wheel drive system*). In this type of system, all four wheels of a vehicle are driven by the engine (Figure 8). Because all four wheels are driven, this type of drive system offers better traction on slippery roads than either an FWD or an RWD system. In fact, four-wheel drive vehicles have such good traction that they're often used in off-road conditions, where no established road is present. Four-wheel drive systems are commonly used on light trucks and sport utility vehicles.

FIGURE 8—In an all-wheel drive system, all four of the vehicle's wheels are driven by the engine.



The Electrical and Electronic Systems

The *electrical* and *electronic systems* are the "brains" of the modern automobile. For many years, a car's electrical system contained only a battery, a battery charging system, and the lights or accessories on the vehicle. Today, almost every part of a vehicle is somehow powered by or controlled by an electrical or electronic system. Electrical and electronic systems control everything from engine operation to the temperature inside the car. Some of the electrical and electronic systems found in a typical automobile are the following:

- The battery and battery charging system
- The headlight and directional signal circuits
- The starter system
- The windshield wiper, horn, radio, and other accessory circuits
- The engine control systems

In the study units that cover the electrical system, we'll explore all of these systems to see how they work and how they're repaired. However, for now, you might like to know a few basics about these systems. First of all, it's important to remember that all automotive electrical systems operate on *direct current (DC).* Direct current is a constant source of electrical voltage. In other words, the source voltage is steady and doesn't vary. This constant voltage source is provided by the car's battery. Direct current is the same type of current that's used to power cordless appliances, as well as all other devices that run on batteries. In most automobiles, the battery voltage required to run the electrical systems is approximately 12 volts. (In comparison, a flashlight battery is about 1.5 volts.) A car battery is very similar in operation to a household battery, except that the car battery has a much greater voltage capacity.

All of the electrical and electronic devices in a car operate off the battery. However, the vehicle will also contain a separate electrical system that recharges the battery as the engine is running. This type of charging system usually allows a car battery to last for several years before it must be replaced.

The Heating and Air Conditioning Systems

Not all automotive systems are involved in making the car run—some systems are designed simply to enhance passenger comfort. The *heating and air conditioning system* is an example of a passenger comfort system that the passengers can control. Almost all vehicles contain some sort of heating system, and many contain air conditioning systems as well. When a vehicle is operated in cold weather, its heating system uses some of the heat produced by the running engine to keep the passenger compartment warm. In hot weather, the air conditioning system is used to cool the inside temperature of the passenger compartment.

Although most systems allow the passengers to control the level of heating or cooling in the vehicle, some systems are equipped to maintain desired temperatures automatically. Some modern vehicles even contain systems that allow the driver and the passengers to choose different temperatures for their own seating areas on each side of the vehicle.

Now, take a few moments to review what you've learned by completing *Power Check 1.*

Power Check 1

At the end of each section of *Introduction to Auto Repair*, you'll be asked to pause and check your understanding of what you've just read by completing a "Power Check" exercise. Writing the answers to these questions will help you to review what you've studied so far. Please complete *Power Check 1* now.

1. *True or False?* The average person spends about $400 per year on fuel, maintenance, and insurance for his or her car.

2. How many gear selections do automatic transmissions usually contain?

   _____

3. Two types of transmissions that are commonly used in automobiles are the _____ and the _____.

4. An electronic brake control system that prevents the wheels from locking up during sudden stops is called a/an _____ system

(Continued)

Power Check 1

5. *True or False?* There's a total of approximately 85 million vehicles on the road today in the United States.

6. Because today's mechanics need very high-tech skills in order to do their jobs, many service people prefer to call themselves automotive repair _____ instead of mechanics.

7. What does the abbreviation 4WD stand for?

   _____

8. The most common type of drive train system used in compact and mid-sized automobiles is the _____ system.

9. How many gear selections do manual transmissions usually contain?

   _____

10. The automobile system that allows the driver to control the direction of the vehicle's motion is the _____ system.

11. *True or False?* All automotive electrical systems operate on direct current.

12. List seven basic automotive operating systems that are covered by Automotive Service Excellence (ASE) certification exams.

    _____ _____
    _____ _____
    _____ _____
    _____

Check your answers with those on page 113.

BASIC ENGINE OPERATION

The engines that are used in automobiles are called *internal-combustion engines*. In an internal-combustion engine, fuel is burned *inside* the engine to produce power. The internal-combustion engine produces mechanical energy directly by burning fuel. In contrast, in an *external-combustion engine*, fuel is burned *outside* the engine. A steam engine/boiler is an example of an external-combustion engine. The boiler burns fuel to produce steam, and then steam is sent to the engine to produce power. In an automotive engine, fuel is sent directly to the engine, where it's burned inside to produce the power that's used to run a vehicle.

In this section of your study unit, we'll look at some of the basic parts of a gasoline engine and learn how these parts contribute to overall engine operation. Once you have an understanding of the basic construction of the engine, we'll move on to discuss how an engine operates. Note that this will just be a simple overview. In a later study unit, we'll look at the parts of an engine and their operation in much more detail.

Basic Construction of an Engine

Figure 9 shows a simplified drawing of part of an engine. In this illustration, note the round cylinder with the piston positioned inside it. The *cylinder* is a hollow metal tube that's drilled into the metal *engine block*. The *piston* is a can-shaped metal component that can move up and down inside the cylinder. The piston is the main moving part in an engine. In an actual engine, the top of the cylinder is sealed by a metal cover that's called the *cylinder head*. The cylinder head is bolted onto the top of the cylinder.

Note that when the piston is positioned at the very top of the cylinder, a small amount of open space is still left between the top of the piston and the cylinder head. This small, open space above the piston is called the *combustion chamber*. In the combustion chamber, a mixture of air and gasoline is burned to produce power. When the air-and-fuel mixture burns in the combustion chamber, it produces a small, contained explosion. The air expansion produced by this explosion is strong enough to force the piston downward in the cylinder.

Above the combustion chamber area, note the component called the *spark plug*. The spark plug is screwed into a threaded hole in the cylinder head. The end of the spark plug protrudes right through the cylinder head and into the combustion chamber. The spark plug is used to make sparks that will ignite the air-and-fuel mixture in the cylinder and cause it to burn. The sparking action of the spark plug is controlled by

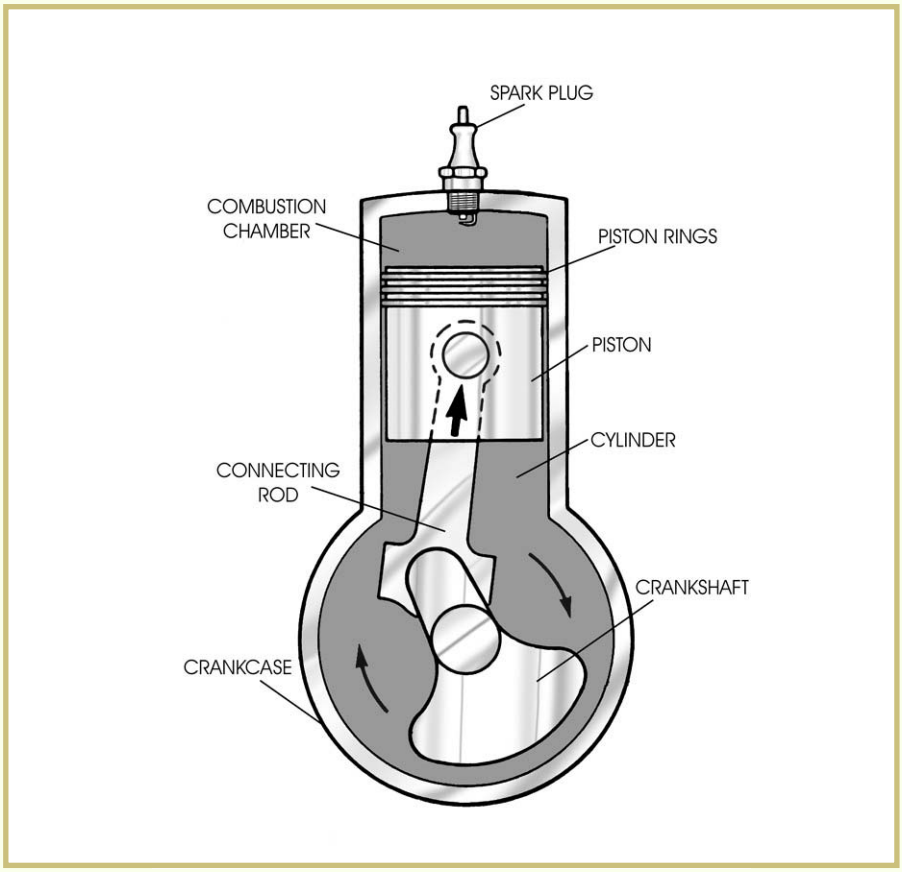


FIGURE 9—A simplified drawing of part of an engine is shown here. Note the locations of the cylinder, piston, connecting rod, crankshaft, combustion chamber, cylinder head, and spark plug.

the engine's *ignition system*, which we'll discuss in detail in a later study unit.

The bottom end of the piston is connected to a *rod and crankshaft* assembly (Figure 10). When the piston is forced downward in the cylinder, the piston's downward motion is transferred to the rod and crankshaft. The rod and crankshaft then convert the up-and-down motion of the piston into *rotary motion* (circular motion).

This conversion of up-and-down motion to rotary motion can be compared to the motion produced by a regular bicycle. When you pedal a bike, the up-and-down motion of your feet on the pedals is converted into circular motion in the rear wheel. The same principle applies to an engine. The up-and-down motion of the piston is converted to circular motion in the crankshaft that can be used to power a piece of equipment.

Thus, during the operation of an engine, the piston continually moves up and down inside the cylinder (Figure 11). Some special terms are used to describe the exact position of the piston in the cylinder at any one time. When a piston is at its lowest position in the cylinder, it's

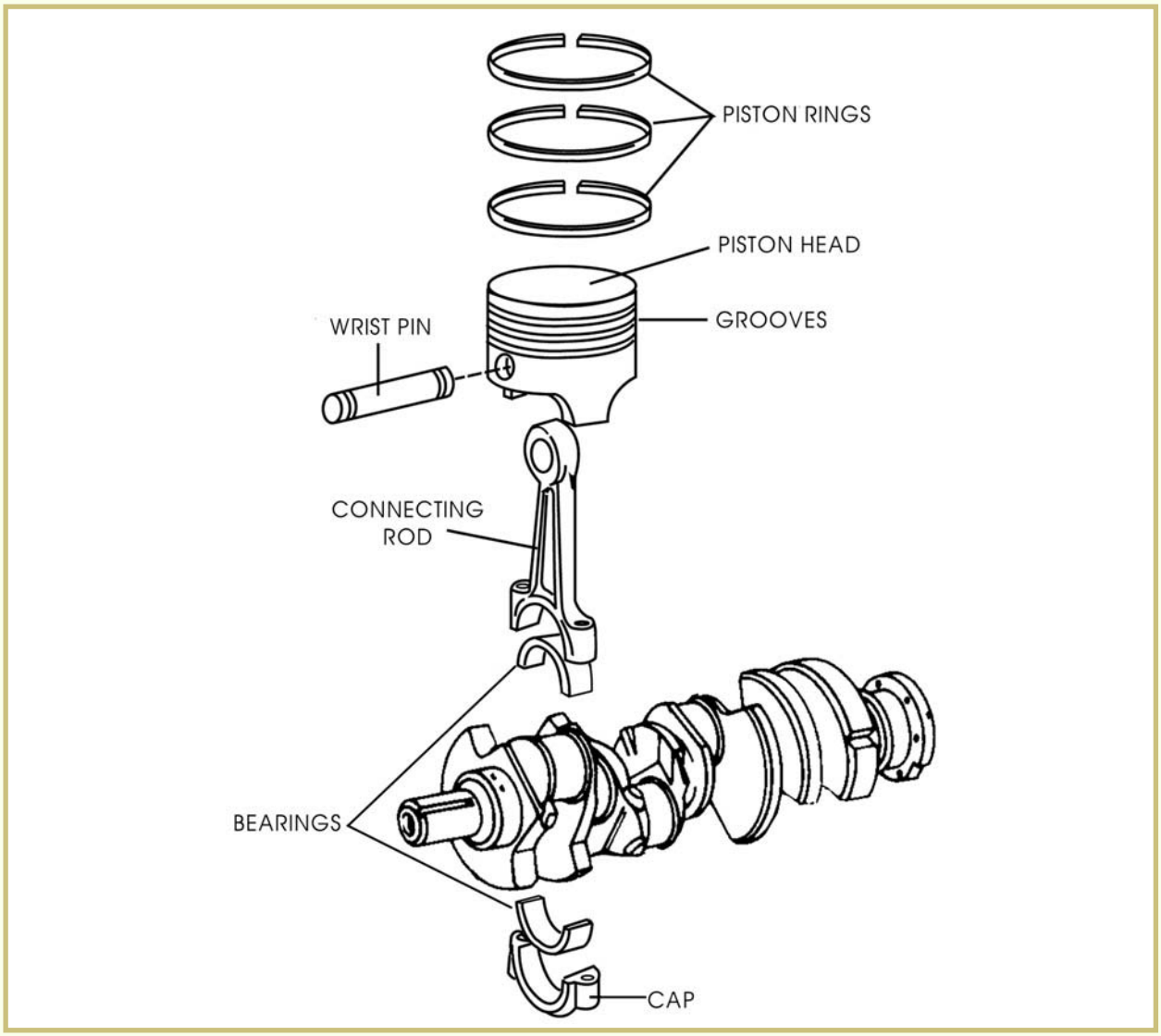


FIGURE 10—The bottom end of the piston is connected to a rod and crankshaft assembly, as shown in this exploded diagram.

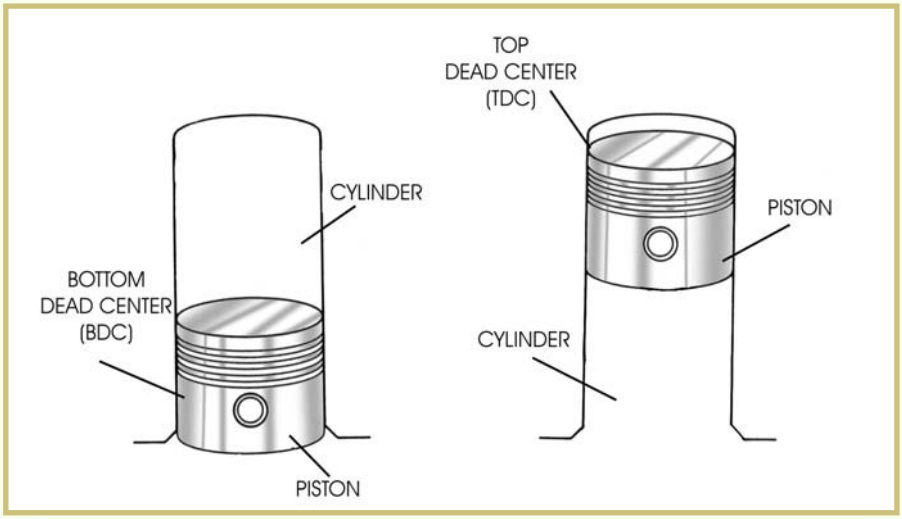


FIGURE 11—A simplified drawing of the cylinder and piston is shown here. During the operation of an engine, the piston continually moves up and down inside the cylinder. Note the position of the cylinder at bottom dead center (BDC) and top dead center (TDC).

said to be at *bottom dead center (BDC).* When the piston is at its highest position in the cylinder, it's said to be at *top dead center (TDC).* The total distance that the piston moves from the top of the cylinder to the bottom of the cylinder is called the *stroke*.

Note that the outside surface of a piston has several horizontal grooves cut into it. Each of these grooves holds a metal ring called a *piston ring*. A piston ring is a circular piece of metal that's split at one point (Figure 12A). Piston rings are designed to be springy so that they can stretch to fit over the outside of the piston and then snap back into their grooves (Figure 12B).

Once they're in place, the piston rings stick out like ridges on the surface of the piston. When a piston is in place inside a cylinder, the piston rings will press outward against the walls of the cylinder. This action helps form a tight seal between the piston and the cylinder, which is necessary for proper engine operation.

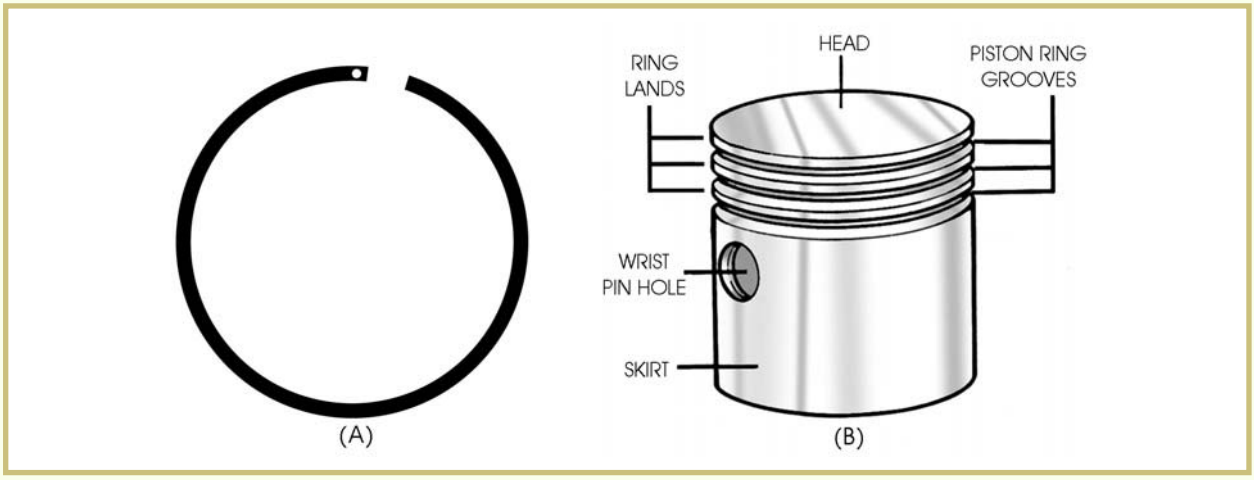


FIGURE 12—Figure 12A shows a piston ring, and Figure 12B shows the ring grooves on a piston. The rings will stretch over the outside of the piston and snap into place in the grooves.

The Four Stages of Engine Operation

So far, we've looked at some of the basic components of a typical engine. Now, let's take a look how these components work together to allow an engine to operate. In order to work, all gasoline engines must do four basic things. An engine must

- Take in air and fuel
- Compress (squeeze) the air and fuel

- Ignite and burn the air-and-fuel mixture
- Get rid of the burned fuel gases

The engine actions we've just described make up the *four stages of engine operation*. The proper names for these stages are *intake*, *compression*, *power*, and *exhaust*. When an engine is operating, it continually runs through these four stages, over and over again. (*Note:* Memorizing the names of these four stages will be helpful as you continue to learn about engine operation.)

Stage 1: During the *intake stage*, air that has been mixed with fuel is drawn into the cylinder.

Stage 2: During the *compression stage*, the piston rises and compresses the air-and-fuel mixture that's trapped in the combustion chamber.

Stage 3: During the *power stage*, the air-and-fuel mixture is ignited by a spark, and the contained explosion of the fuel presses the piston back down in the cylinder. The downward motion of the piston is transferred to the rod and crankshaft.

Stage 4: During the *exhaust stage*, the burned exhaust gases are released from the cylinder. The four stages then begin all over again.

One engine *cycle* is a complete run through all four stages of operation—intake, compression, power, and exhaust. Note that the four stages of operation we've described occur very quickly, and they repeat continually for as long as the engine is running. All automotive engines operate in these same four basic stages, and *all* of the stages must occur in order for the engine to run properly.

To understand how an engine works, one of the most important things you can do is memorize the things that occur during each of the four stages of engine operation. Once you understand these four stages, everything else we discuss about engine operation will fall right into place.

Two-Stroke Engines and Four-Stroke Engines

You should be aware that there are two basic types of gasoline engines: the *two-stroke engine* and the *four-stroke engine.* Each engine type is classified according to the number of strokes its piston takes to complete one full engine cycle. (Remember that a piston stroke is the total distance that the piston moves from the top of the cylinder to the bottom of the cylinder. An engine cycle is a complete run through all four stages of operation.)

In order for any engine to operate, it must run through all four stages of operation. However, two-stroke engines and four-stroke engines accomplish this in different ways. In a two-stroke engine, the piston takes only *two strokes* to complete one full engine cycle of intake, compression, power, and exhaust. In a four-stroke engine, the piston requires *four strokes* to complete one full engine cycle.

Virtually all automobiles today contain four-stroke engines. In a four-stroke engine, the four strokes of the piston that are required to complete the four stages of operation are as follows:

Piston stroke 1: Intake stage

Piston stroke 2: Compression stage

Piston stroke 3: Power stage

Piston stroke 4: Exhaust stage

After the completion of the fourth piston stroke, the engine has gone through all four stages of operation, and the cycle will begin again.

In contrast, in a two-stroke engine, only two strokes of the piston are needed to complete the four stages of operation, as follows:

Piston stroke 1: Intake stage/Compression stage

Piston stroke 2: Power stage/Exhaust stage

So, in a two-stroke engine, the intake and compression stages are combined and completed by one piston stroke. The power and exhaust stages are combined and completed by a second piston stroke. Note that the two-stroke engine must still complete all four stages of operation—it just does this in two piston strokes instead of four.

Two-stroke engines aren't used in modern automobiles, but they're commonly seen in motorcycles. The reason for this is that two-stroke engines aren't very fuel efficient and tend to produce more pollution than four-stroke engines. You should be aware that two-stroke engines exist, but we won't cover them in this program. You'll be concentrating all your study efforts on four-stroke engines.

Four-Stroke Engine Operation

Now, let's take a closer look at the operation of the four-stroke engine. A simplified drawing of a four-stroke engine is shown in Figure 13. Note the position of the piston, the cylinder, and the crankshaft. The crankshaft is connected to the piston by the connecting rod. The spark

plug is positioned at the top of the engine over the combustion chamber.

You'll also notice that we've added two valves to the illustration of the cylinder head. A four-stroke engine will contain at least two mechanical valves: an *intake valve* and an *exhaust valve.* These valves are moved up and down to open and close during engine operation. The intake valve opens to allow the air-and-fuel mixture to enter the cylinder. The exhaust valve opens to allow the exhaust gases produced by the burning mixture to exit the cylinder.

In order to burn properly in an engine, fuel must be mixed with air. The engine part that mixes the two together is the *carburetor*. Fuel moves from the vehicle's fuel tank to the carburetor, where it's vaporized and mixed with air. The air-and-fuel mixture is then delivered to the cylinder through the intake valve. (Note that the carburetor isn't shown in Figure 13.)

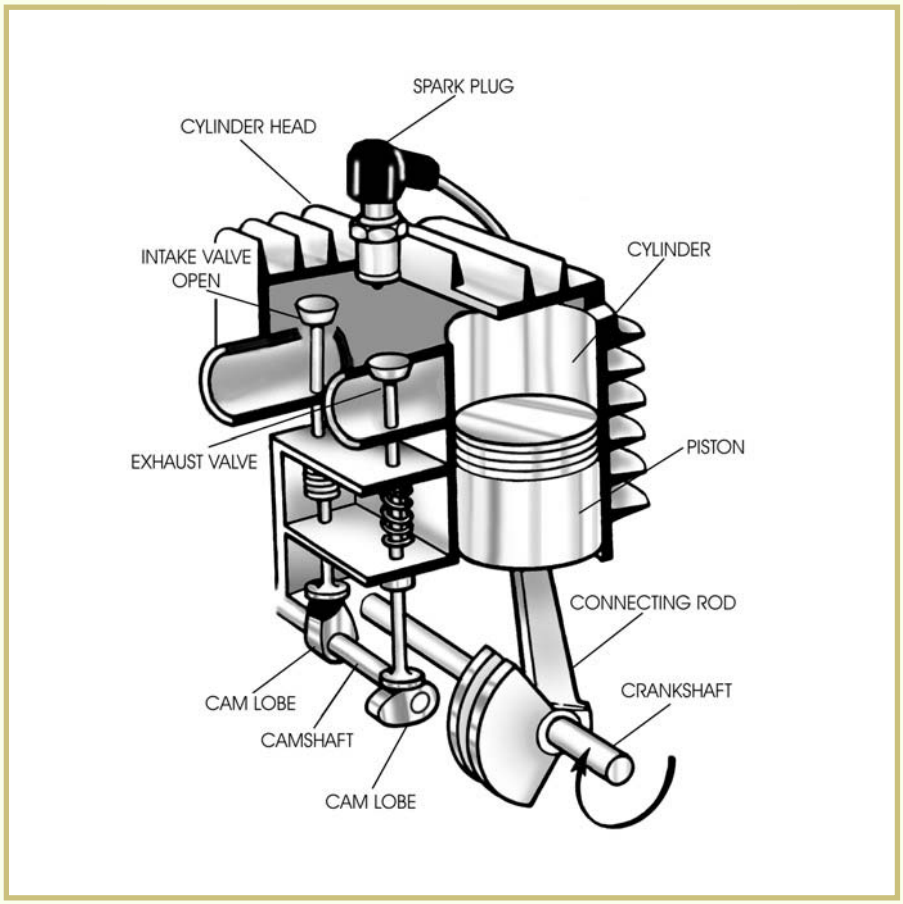


FIGURE 13—The parts of the four-stroke engine are clearly labeled for you in this illustration. During the intake stage, the piston lowers and causes the air-and-fuel mixture to be sucked into the cylinder. The intake valve is open at this time, and the exhaust valve is closed.

As you've learned, a four-stroke engine completes the four stages of engine operation in four piston strokes. During the intake stage, the intake valve opens and the piston moves down in the cylinder. As the piston moves down in the cylinder, a vacuum is created that sucks the air-and-fuel mixture into the cylinder through the open intake valve. (This vacuum is similar to that created when you use a drinking straw to suck a beverage out of a glass.) The intake stage continues until the piston reaches bottom dead center. During the intake stage, the engine's exhaust valve remains closed. The intake stage is illustrated in Figure 13.

When the piston reaches bottom dead center, the intake stage is completed and the compression stage begins. During this stage, both the intake and the exhaust valves are closed. The air-and-fuel mixture is now trapped inside the sealed combustion chamber. At this point, the piston begins to rise, compressing the air-and-fuel mixture tightly. The compression stage is illustrated in Figure 14. Compressing the air-and-fuel mixture tightly will make it ignite easier and burn more efficiently, and thus produce more power.

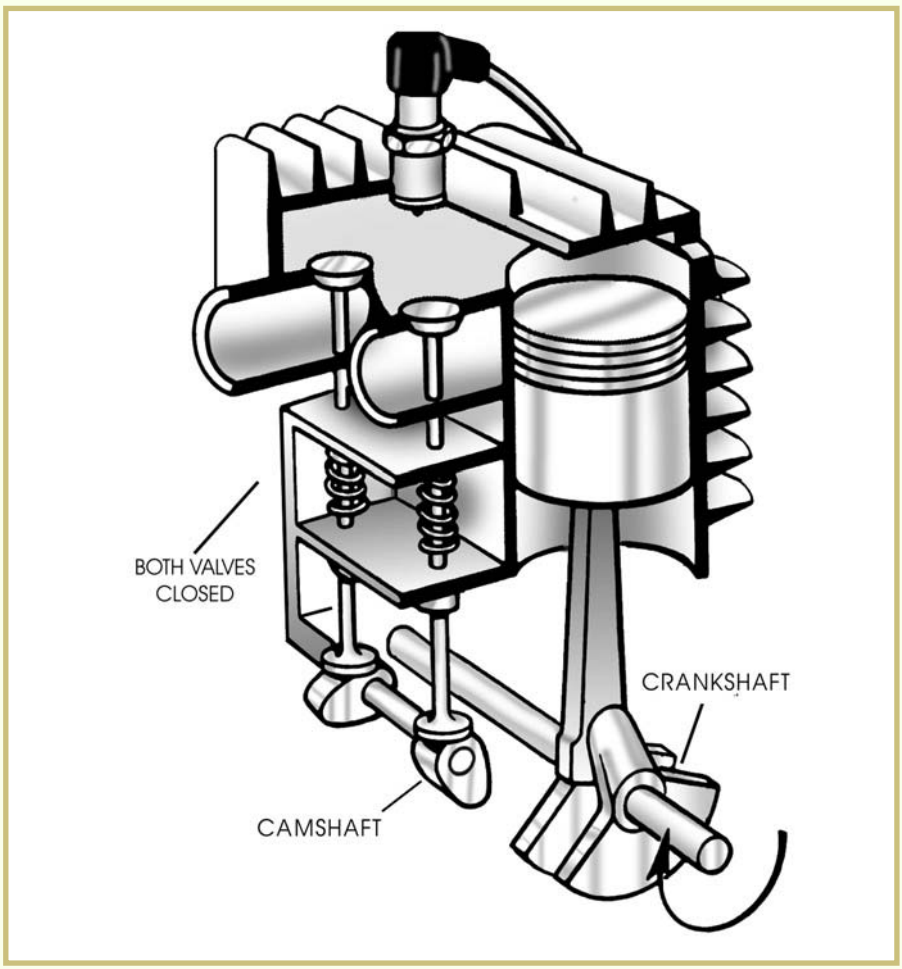


FIGURE 14—During the compression stage, both the intake and exhaust valve are closed. As the piston rises, it compresses the air-and-fuel mixture in the sealed combustion chamber.

The compression stage continues as the piston rises to the top of the cylinder. As the piston approaches top dead center, the engine's ignition system causes the spark plug to create a spark. That is, the ignition system causes the spark plug to "fire." Naturally, when a spark is applied to a compressed mixture of fuel and air, an explosion immediately occurs. The process of burning the air-and-fuel mixture in the cylinder is called *combustion*.

When the air-and-fuel mixture is ignited, the burning gases expand rapidly with great force. Therefore, the contained explosion inside the cylinder forces the piston down hard and fast. Since the piston is connected to the crankshaft through the connecting rod, the piston's downward movement causes the crankshaft to turn around (just like pushing down on the pedals of a bicycle). This stage of burning the mixture in the cylinder and forcing the piston downward is called the *power stage*, and is illustrated in Figure 15.

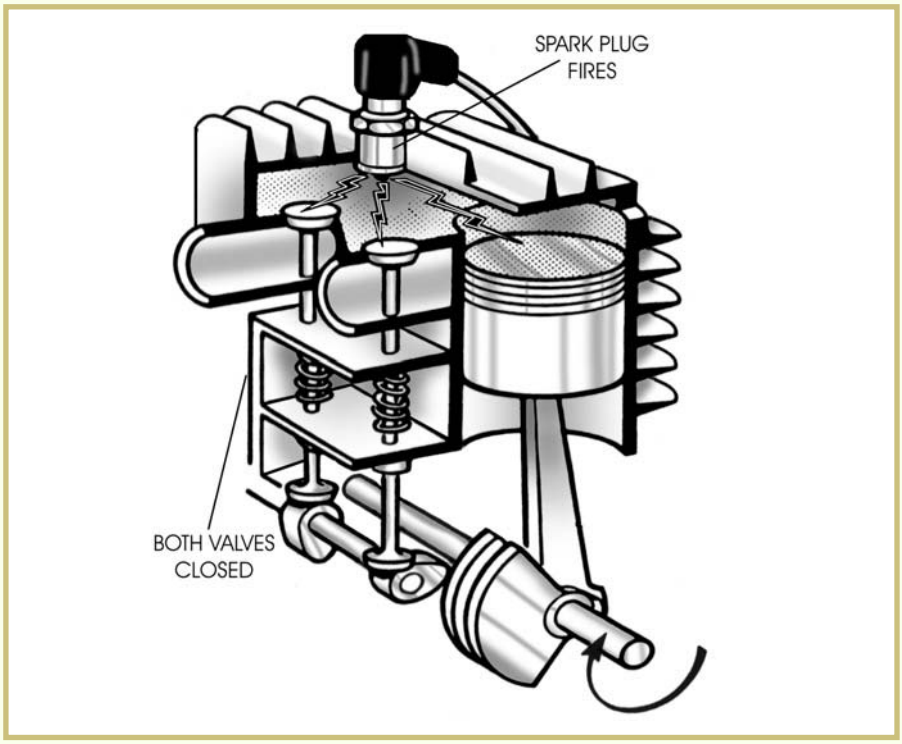


FIGURE 15—When the piston reaches top dead center, the spark plug fires and ignites the air-and-fuel mixture. The force created by the exploding fuel gases pushes the piston down in the cylinder. This is the power stage.

The power stage continues until the piston reaches the bottom of the cylinder (BDC). At this point, the piston begins to move back upward in the cylinder, and the exhaust valve opens. However, the intake valve remains closed at this time. As the piston moves upward in the cylinder, it forces the remaining burned gases in the cylinder out through the open exhaust valve. This is the *exhaust stage*, which is illustrated in Figure 16.

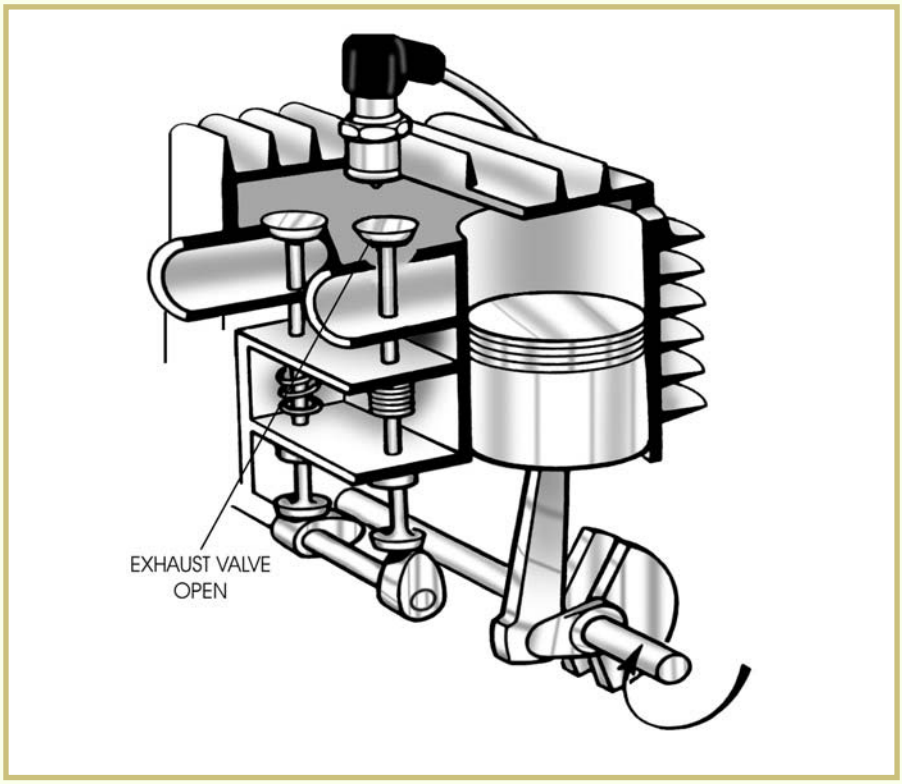


FIGURE 16—During the exhaust stage, the piston rises and the exhaust valve opens. The rising piston pushes the remaining burned gases in the cylinder out through the open exhaust valve.

The exhaust stage continues until the piston reaches the very top of the cylinder (TDC). Once the exhaust stage is completed, the four stages of engine operation are finished, and the cycle begins all over again. The intake valve opens, and the piston moves downward to begin a new intake stage.

The four stages of operation will continue as long as the engine is operating. Also, keep in mind that these cycles are repeated at a very high rate of speed. A typical automobile crankshaft will complete anywhere from 500 to 6,000 revolutions every minute. It's really amazing how fast an engine's components move while it's in operation!

How Engines Are Rated

Now that you understand the four stages of engine operation, let's take a look at how engine manufacturers rate and classify the engines they make. Since so many different engines are produced by so many different manufacturers, what factors can we use to distinguish one

from another? Well, an engine is normally described in one of two ways:

- By the *amount of power* it produces
- By the *size* of the engine

Horsepower

Many years ago, when the first engines were invented, no one knew how to express the amount of work they could do. It was decided that a standard was needed. At that time, horses still provided most of the power for transportation. As a result, the inventors of the first engines compared their engines to horses in order to describe the amount of work the engines could do. It was known that an average horse could do approximately 550 foot-pounds of work in one second (Figure 17). This fact was used to develop the standard unit of *horsepower*.

1 horsepower = 550 foot-pounds per second

Even though horses are seldom used to perform work anymore, we still use the standard unit of horsepower to describe the power output of a gasoline engine. So, the next time you're looking at a car in a showroom and the salesperson tells you it has 150 horsepower, you'll know that the car has as much power as if it was being pulled by 150 horses. Pretty impressive, isn't it?

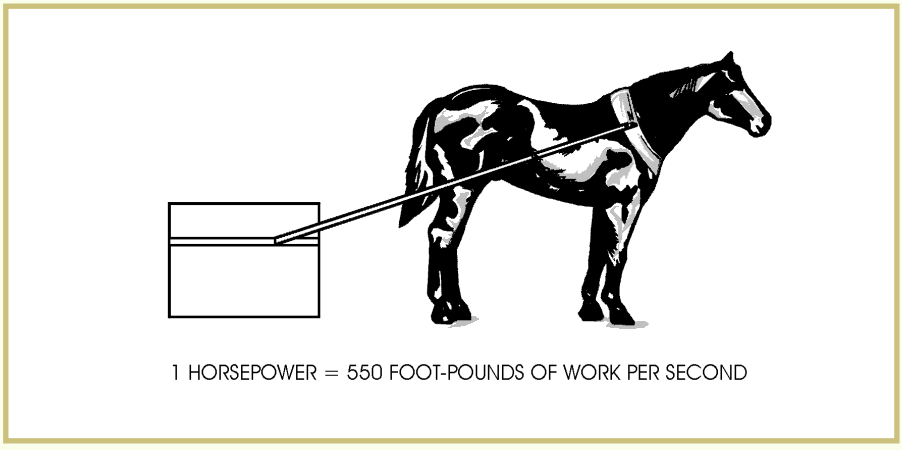


FIGURE 17—An average horse can complete 550 foot-pounds of work in one second. This fact was used to develop the standard unit of horsepower. The more horsepower an engine produces, the more work it can perform.

Today, manufacturers will often list the horsepower output of their engines in their advertising and product information brochures. For a technician, knowing the horsepower of an engine isn't very useful for making repairs. However, this information can be used by consumers

to compare the power of different automobile engines. The more horsepower an engine produces, the stronger the engine is, and the more work it can perform. The amount of horsepower that an engine will produce will depend on many factors. To understand how these factors affect the horsepower, you must first have a complete understanding of how an engine operates. Therefore, we'll look at the various factors that affect horsepower later in the program, after we examine the engine in more detail.

Displacement

When you hear people refer to the size of an engine, they don't mean the physical size of the engine. Rather, they're referring to the size of the space inside the engine where the air-and-fuel mixture is burned. The size of this space is called the engine displacement.

By definition, *engine displacement* is the volume of space that the piston must travel from the very bottom of its path to the very top of its path. The distance that the piston travels up and down in a cylinder is called the *stroke* of the engine. Displacement is measured in units of volume. In the English system of measurement, displacement volume is measured in cubic inches. In the metric system, displacement volume is measured in liters. (Even if you're not too familiar with the metric system, you're probably aware of liters—two-liter plastic bottles are commonly used to hold soft drinks.) So, if an engine has a displacement of 350 cubic inches, this means that it has a total volume of 350 cubic inches inside its cylinders. If an engine has a displacement of 3.1 liters, it has a total volume of 3.1 liters inside its cylinders.

An engine's displacement value has an effect on the amount of power that the engine will develop. In most cases, the larger the displacement, the more power the engine will develop. However, this doesn't mean that a smaller engine can never develop more horsepower than a larger one. As mentioned earlier, there are many factors besides displacement that affect an engine's power. In general, however, an engine that has a larger displacement will develop more horsepower than one with a smaller displacement.

An engine's displacement will usually be stated in the service manual for the engine, or it may be printed on the engine. In some cases, the engine size is even labeled on the outside of the vehicle body itself. A check of the vehicle or manual is all that's usually needed to find the displacement of a particular engine.

Compression Ratio

You've just learned that an engine's displacement is the volume of space inside its cylinders. When a piston is at its lowest point in a cylinder (BDC), the cylinder volume is at its *largest*. When the piston is at

its highest point in the cylinder (TDC), the cylinder volume is at its *smallest*. The ratio of the largest cylinder volume to the smallest cylinder volume is called the *compression ratio*. A *ratio* is simply a comparison between two values. In a compression ratio, the two values are the cylinder volumes at the two different piston positions, BDC and TDC.

The volumes at BDC and TDC can be determined by using a combination of mathematical calculations and special test instruments. Automotive repair technicians will never be required to measure these volumes, so we won't get into the details of how they're determined. (Measuring the volume is a complicated procedure that requires special equipment.) Besides, an engine's compression ratio is usually listed in the vehicle's service manual. However, you should be aware that an engine's compression ratio affects the amount of power that the engine develops, which in turn affects the engine's performance.

The compression ratio is important in an engine because it determines how fuel will be burned in the cylinder. An engine's compression ratio will determine how much the mixture will be compressed when the piston rises. The higher the compression ratio, the more the mixture will be compressed.

So, imagine that a particular engine has a compression ratio of 5 to 1. What exactly does this mean? Well, suppose 5 cubic inches of air-and-fuel mixture enter the cylinder. Because this engine has a compression ratio of 5 to 1, when its piston rises to TDC, the 5 cubic inches of mixture will be compressed into a 1-cubic-inch space.

When the mixture is compressed, the pressure of the mixture will increase dramatically. This large increase in pressure makes the mixture burn more completely and produce more power when it's ignited. In general, the higher an engine's compression ratio, the stronger the fuel mixture burns and the faster the engine will run. However, every engine has its limitations. If an engine's compression ratio is too high, the excessive pressure can damage the engine. If the compression ratio is too low, the engine doesn't develop much power. Different engines have their own particular compression ratios. However, most automobile engines have compression ratios that are between 5 : 1 and 9 : 1.

Now, take a few moments to review what you've learned by completing *Power Check 2*.

Power Check 2

1. *True or False?* In an internal-combustion engine, fuel is burned outside the engine.
2. In the _____ stage of engine operation, the piston rises, compressing the air-and-fuel mixture trapped in the combustion chamber.
3. *True or False?* In an engine, the cylinder is positioned inside the piston.
4. When a piston is at its lowest position in the cylinder, it's said to be at _____.
5. During the _____ stage of engine operation, gases are released from the cylinder.
6. A four-stroke engine will contain at least two mechanical valves called the _____ valve and the _____ valve.
7. In the _____ stage of engine operation, air mixed with fuel is drawn into the cylinder.
8. *True or False?* When the air-and-fuel mixture burns inside the rod and crankshaft assembly, it produces a small explosion.
9. *True or False?* A two-stroke engine completes all four stages of engine operation in four piston strokes.
10. During the _____ stage of engine operation, the mixture of air and fuel is ignited, and the contained explosion of the fuel presses the piston back down in the cylinder.
11. *True or False?* The top of a cylinder is sealed by the cylinder head.
12. *True or False?* Most automotive engines have compression ratios of between 2 to 1 and 3 to 1.

Check your answers with those on page 113.

AUTOMOTIVE TOOLS

This section of your study unit will introduce you to some of the many different types of tools you'll use every day as an automotive technician. Auto technicians use literally thousands of different tools to perform the wide variety of repair jobs they need to complete. In addition to the standard hand and power tools you're probably familiar with, a wide variety of specialized engine repair tools are also available. The type of tools you'll use will depend on the type of vehicles and specific systems on which you work.

All skilled professionals, no matter what their trade or field, know how to use their tools properly and safely. As you gain experience in the automotive repair field, you'll learn how to do jobs faster and more efficiently. By knowing what tool to use for each task, you'll be able to get jobs done quickly, safely, and with the least amount of effort. This will allow you to keep up a fast, skillful pace all day long and, in the long run, increase your earning potential.

Automotive tools can be classified into the following categories:

- Standard hand tools
- Specialized automotive tools
- Measuring instruments
- Testing and diagnostic equipment

It would be impossible for us to discuss every available auto repair tool in this study unit. For this reason, we've limited our discussion to the tools that you'll use most often in your work. You've probably already used many of the standard hand tools that we'll cover. However, you may be unfamiliar with some of the specialized auto repair tools, measuring instruments, and testing instruments. Take your time to read about all the various tools and instruments and familiarize yourself with them. Later in the program, when we cover topics such as engine disassembly and rebuilding, we'll discuss the specialized automotive tools and testing instruments in much more detail.

Now, let's start with a review of standard hand tools.

Standard Hand Tools

Standard hand tools are the common tools that are found in just about any workshop. These tools are used in all fields, not just auto repair. Some of these standard hand tools are screwdrivers, hammers, pliers,

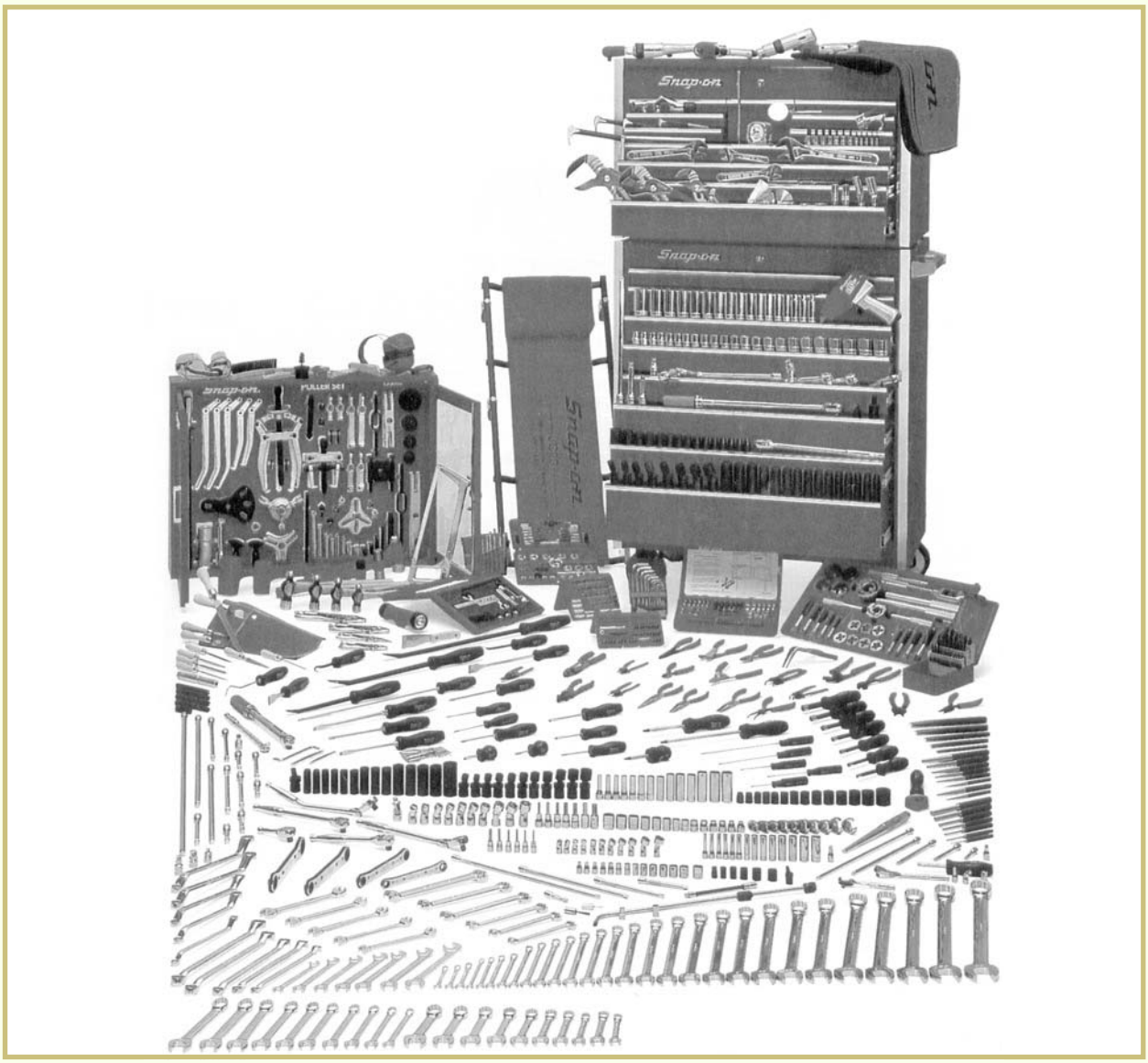


FIGURE 18—This illustration shows a typical set of standard tools that an auto repair technician would be likely to own. These tools can be used for all purposes and aren't limited only to auto repair. (Courtesy of Snap-On Tools Company, Copyright Owner)

wrenches, and socket sets. Since these tools are used so often, most auto repair technicians will want to own a compete set of standard hand tools like the one shown in Figure 18.

Most of these standard tools are probably familiar to you—you've probably used them and may even own them already. However, just to be sure that everyone understands the proper use of these tools, we'll take a brief look at them. We'll begin with the most commonly used automotive hand tool—the wrench.

Open-End, Box-End, and Combination Wrenches

The largest part of your tool collection will probably consist of wrenches. *Wrenches* are used to tighten and loosen nuts and bolts. As you're probably aware, wrenches come in a variety of sizes, from very small to very large. The size of a wrench is determined by the width of the opening at its end (Figure 19).

Note that auto repair technicians use both SAE and metric size wrenches. *SAE* wrenches are sized according to the English system of measurement; that is, SAE wrenches are sized in inches. *Metric* wrenches are designed according to the metric system, so metric wrenches are sized in millimeters. SAE wrenches are commonly used on older vehicles, while metric wrenches are used on most newer vehicles and imported cars.

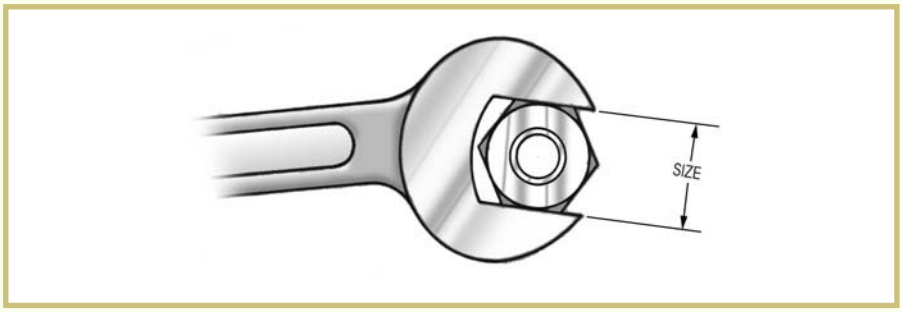


FIGURE 19—The width of the opening in the wrench end determines the wrench's size.

Wrenches not only come in different sizes—they also come in different styles. The three most common styles are the open-end wrench, the box-end wrench, and the combination wrench.

An *open-end wrench* has a U-shaped opening on its end (Figure 20A). An open-end wrench can easily be placed onto a bolt or nut. Because the wrench can be positioned easily, the open-end wrench is commonly used to quickly loosen or tighten bolts or nuts. However, an open-end wrench should only be used when the bolt or nut isn't fastened very tightly.

Because an open-end wrench only contacts the sides of a nut or bolt, the wrench can easily slip. Therefore, it's better to use a box-end wrench to loosen very tight bolts or nuts (Figure 20B). The end of a *box-end* wrench fits completely around a nut or bolt head, providing better contact. Box-end wrenches also have thin heads, so they're useful in tight places where there's limited space around the nut or bolt head.

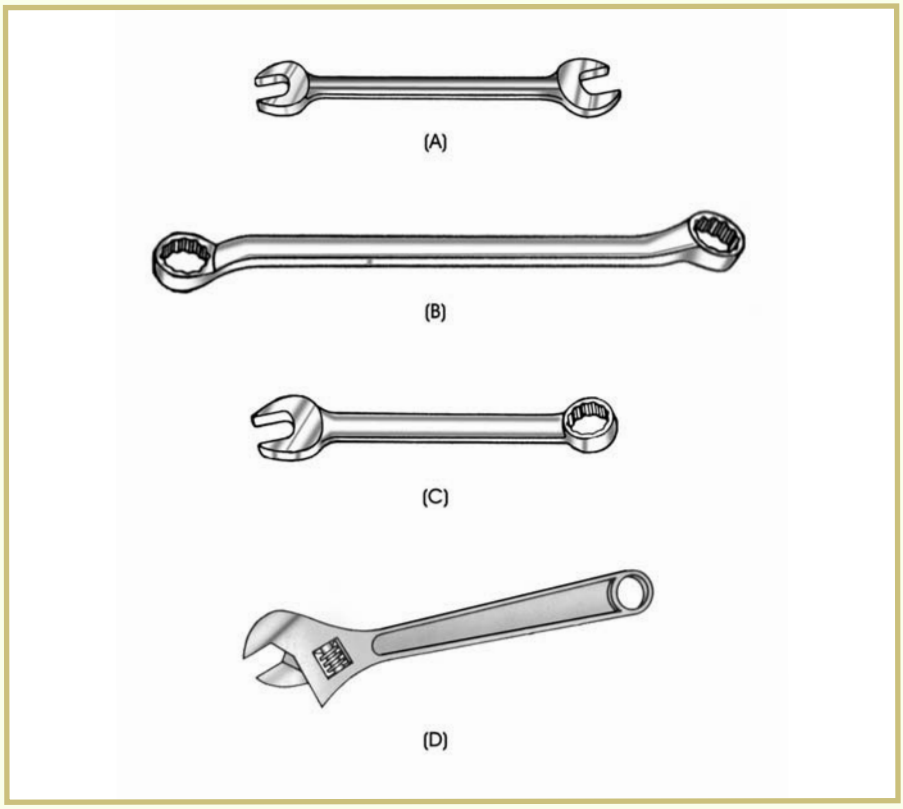


FIGURE 20—Figure 20A shows an open-end wrench, Figure 20B shows a box-end wrench, Figure 20C shows a combination wrench, and Figure 20D shows an adjustable wrench.

The *combination wrench* combines the best features of the open-end wrench and the box-end wrench in one tool (Figure 20C). In most cases, both ends of the combination wrench are the same size. Therefore, you can use the box end to loosen bolts that are tight, and the open end to quickly remove them once they're loosened.

Box-end wrenches are made in two different styles: the *6-point* and the *12-point*. The number of points refers to the shape of the inside of the box end. A 6-point wrench will provide better support to a bolt head than a 12-point wrench. Therefore, 6-point wrenches should be used on bolts that are very tight. When you use a 6-point wrench on tight bolts, the chance of the wrench slipping off the bolt head is greatly reduced.

However, one drawback of the 6-point wrench is that its head is thicker than that of a 12-point wrench. Also, a 6-point wrench can only be placed on a bolt in six positions. For this reason, the 12-point type is the better choice to use in tight places. Its head is thinner, and it can be placed on the bolt head in more positions. Often, in tight places, you can't get enough "swing" on a six-point wrench to move it to the next turning position. However, with a 12-point wrench, the wrench swing

required to turn to the next position is only half that required by the six-point wrench.

Figure 20D shows a typical adjustable wrench. The opening at the end of an adjustable wrench can be adjusted to fit almost any size of bolt or nut. This allows one wrench to be used for a variety of tasks. However, adjustable wrenches don't grip as well as other types of wrenches. They have a tendency to slip, and can wear off the corners of nut and bolt heads. For this reason, adjustable wrenches should only be used to remove bolts or nuts that are already loose. They can also be used in emergencies when the correct size of wrench isn't available. However, adjustable wrenches shouldn't be used when the correct size open-end or box-end wrench is available.

Socket Wrenches

After the ordinary wrenches we just described, the *socket wrench* is probably the most commonly used automotive tool. This type of wrench is actually a separate handle that attaches to different-sized heads called *sockets*. Socket wrenches are manufactured in sets (Figure 21). Individual sockets come in many sizes. The size of the socket refers to the size of the bolt head that the socket fits (Figure 22A).

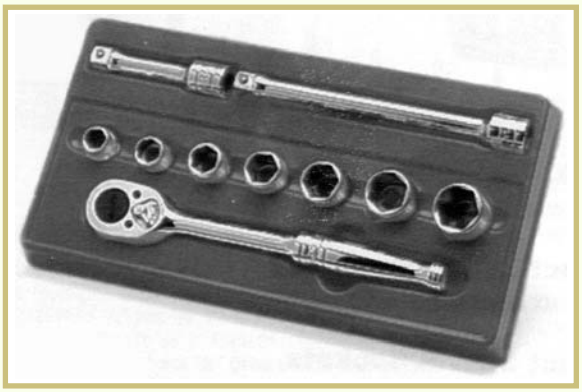


FIGURE 21—A typical set of socket wrenches is shown here. (Courtesy of Snap-On Tools Company, Copyright Owner)

A *drive lug* on the socket handle fits into a *drive hole* on the socket (Figure 22B). Sockets are made with a variety of different-sized drive holes, including ¼-inch, ⅜-inch, and even ½-inch holes. The individual sockets can then be snapped into any type of handle that's appropriate for the job you're doing.

Several different types of handles are used to turn sockets. The most common handle is the *reversible ratchet handle*, shown in Figure 22B. A reversing lever on the handle allows you to change the direction of the handle's rotation to either tighten or loosen bolts. Reversible ratchet handles are great for quickly removing and installing bolts. However, they can be damaged if too much pressure is placed on them. So, when you're using a socket on a tight bolt, you should use a breaker bar to

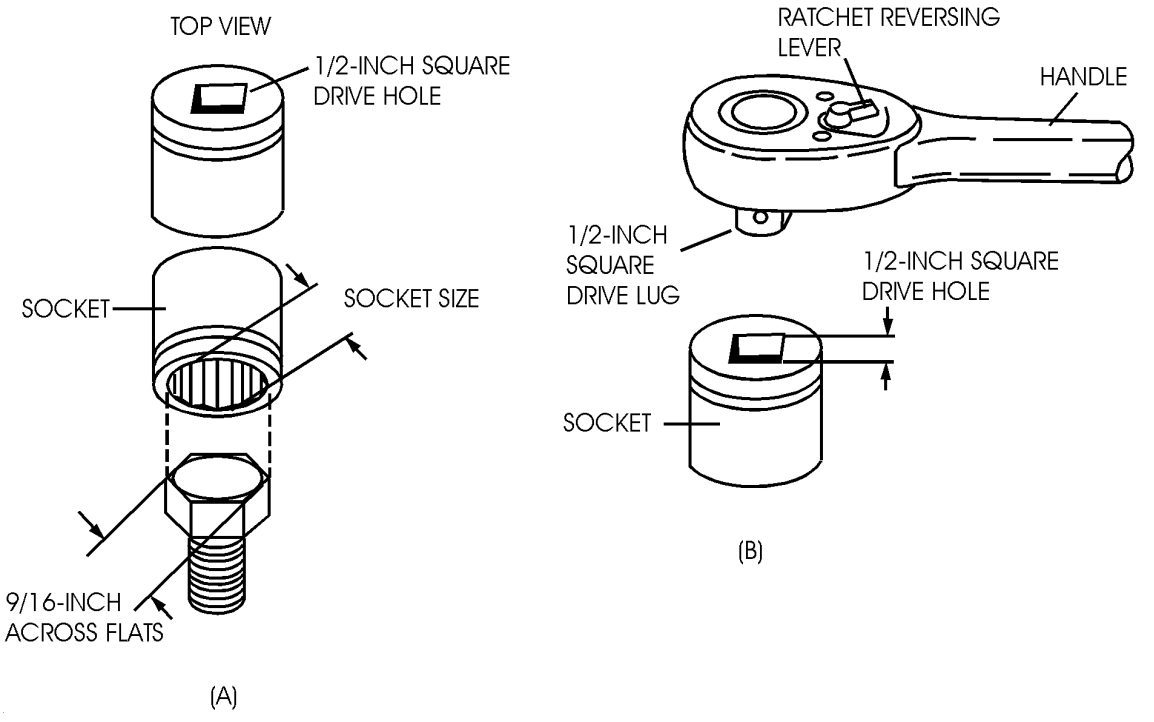


FIGURE 22—In Figure 22A, you can see how the size of a socket refers to the size of the bolt head that the socket fits. Figure 22B shows how the drive lug on a socket handle fits into the drive hole on a socket. This handle is a reversible ratchet handle. Note the shift lever that's used to change the direction of the ratcheting action.

turn the socket. A *breaker bar* is simply a bar with a drive lug on its end. Since a breaker bar has no ratchet mechanism, it can withstand more force than a ratcheting handle.

Along with the handles that are used to turn sockets, most socket sets also contain a variety of extension bars and adapters. These bars allow the sockets to be used in all sorts of different situations. For example, the *speeder handle* shown in Figure 23 is used to turn sockets in tight places.

Allen Wrenches and Torx Wrenches

An *Allen wrench* or *hex wrench* (Figure 24A) is a short, metal, six-sided rod that's used to tighten screws and bolts that contain similar six-sided indentations. A typical Allen wrench has a right-angle bend near one end that forms a handle. Even though most Allen wrenches are shaped with a right-angle bend, tool companies also produce Allen sockets and Allen wrench sets that don't have this bend. Allen wrenches come in many different sizes—you can buy them individually or in sets.

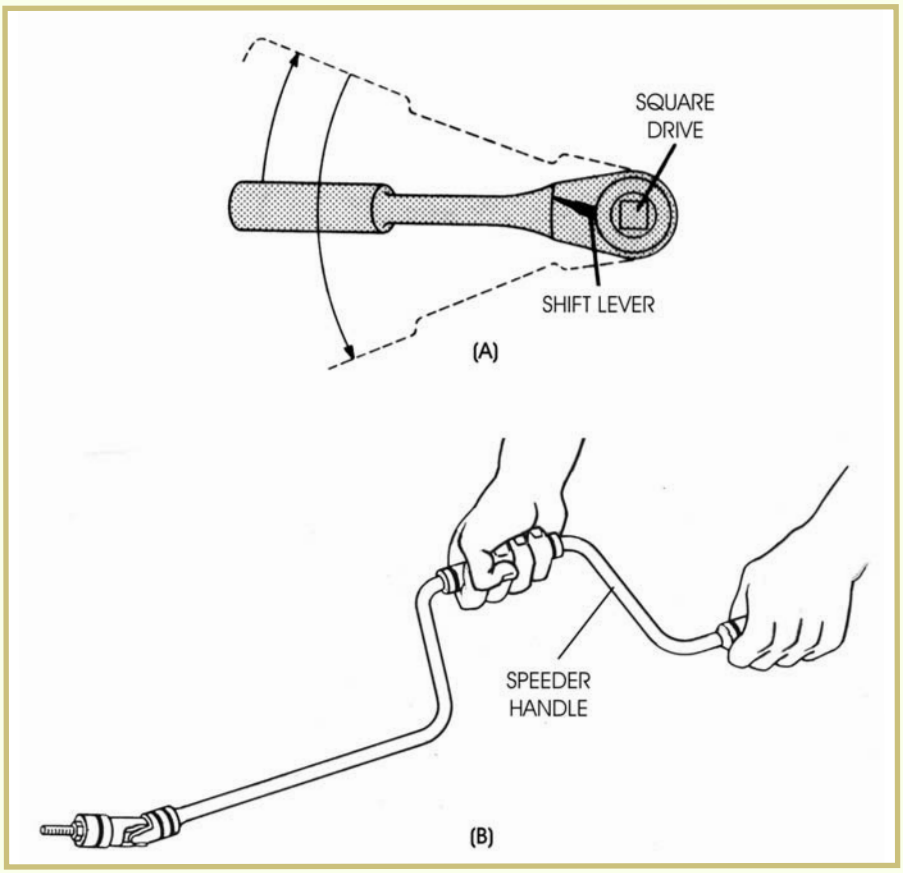


FIGURE 23—The speeder handle shown here is used to turn sockets in tight places.

The *Torx wrench* is similar to the Allen wrench, except that the end of the Torx wrench is star-shaped (Figure 24B). Torx wrenches are used

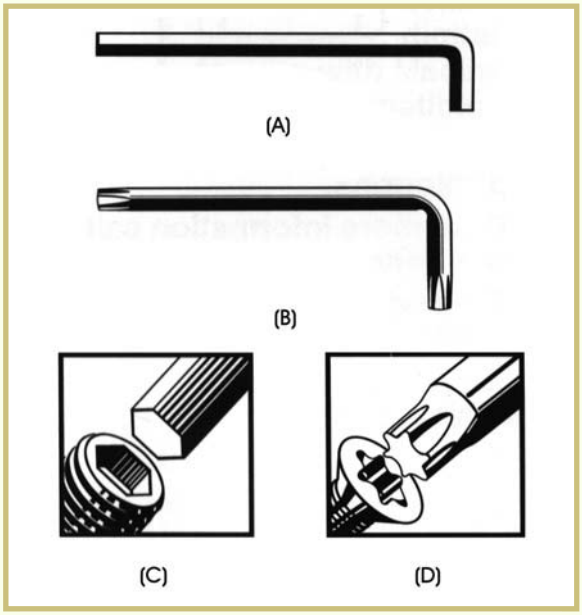


FIGURE 24—Figure 24A shows an Allen wrench, and Figure 24B shows a Torx wrench. Figure 24C shows how the end of an Allen wrench fits into a set screw, and Figure 24D shows the end of a Torx wrench. (Courtesy of Eklind Tool Co.)

when higher fastening strengths are required, because they can handle more turning force without slipping. For this reason, Torx-type bolts are ideal to use with power tools and on assembly lines at manufacturing plants. Therefore, more and more Torx bolts are being used today. Like Allen wrenches, Torx wrenches are also produced as sockets or with screwdriver-type handles on them.

Screwdrivers

Just about everyone is familiar with the standard *screwdriver*. The part you grip is called the *handle*, the steel part that extends from the handle is called the *shaft*, and the end that fits into the slot in the screw is called the *blade*. The size of a screwdriver is normally indicated by its shaft length and blade width. For example, a screwdriver labeled "$\frac{5}{16} \times 4$" would have a blade width of $\frac{5}{16}$ of an inch and a shaft length of 4 inches. Screwdrivers are available in a variety of shaft lengths and blade sizes.

Screwdriver blades are manufactured in different shapes to fit different types of screw heads. A *standard* blade fits a simple slotted-head screw. Figure 25 illustrates this type of screw head as well as several nonstandard head shapes. The main advantage of these nonstandard shapes is that they provide more contact area between the screw head and the blade, ensuring that the blade won't easily slip out when you're turning it. Nonstandard screws are often used to fasten trim materials and moldings on equipment, or wherever the outward appearance of the assembly is important. On such areas, using slotted screws could cause the outer surfaces to become scratched or dented.

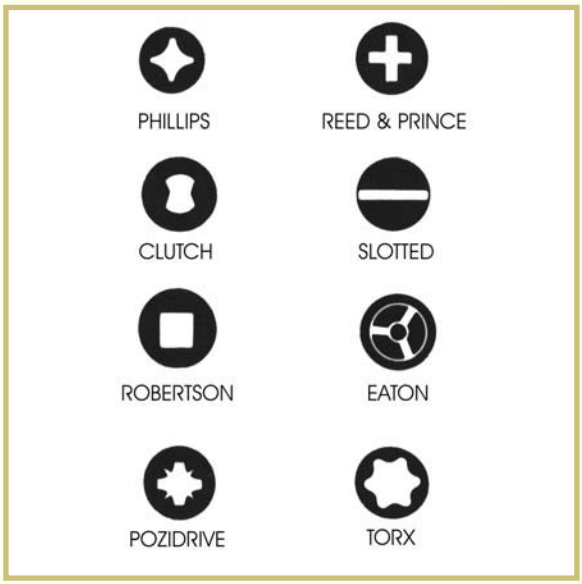


FIGURE 25—These screw head shapes are the most common types used in auto repair applications.

When you tighten or loosen a screw, always use a screwdriver with a blade that fits snugly into the screw head slot. If the screwdriver fits improperly or has a damaged tip, the tool could slip and cause damage to the screwdriver, the screw, or the piece on which you're working.

Observe the following rules when you're using a screwdriver:

- Always clean the slots in a screw head before attempting to remove it.
- Always hold a screwdriver with its blade at a 90-degree angle to the slot of the screw.
- Make sure that the screwdriver blade fits tightly into a screw slot in order to prevent slips.
- When using a nonstandard screwdriver, exert more pressure on the screw head than you would with a standard screwdriver.
- Never use a screwdriver to cut or remove metal, to punch holes, or to pry—it could easily snap.
- Never hammer on the handle of the screwdriver, since this may cause the handle to split or "mushroom."
- Never use a screwdriver to work on an object that you're holding in your other hand. The screwdriver may slip and cause a painful injury. Use a bench vise to hold small objects as you work on them.

Removing old screws can be a problem if a screw is rusted or "frozen" with corrosion, or if the threads are stripped. If you're trying to remove a screw and it won't come out, stop working. Check to make sure the screwdriver blade fits the screw slot perfectly. If the blade fits and the screw is still resistant to turning pressure, try one of the following methods to avoid damaging the screw:

- Clean the screw head to remove dirt, grease, or paint.
- If the screwdriver slot is too narrow or worn to accept a screwdriver blade, try using a hacksaw to widen and deepen the slot.
- Use a penetrating lubricant to help dissolve any rust or corrosion around the screw head. Penetrating lubricants can be purchased at most automotive parts stores.
- Tap the head of the screw lightly with a punch. The rust and corrosion will often be knocked loose from the screw.

If a screw is extremely tight and can't be removed by using any of the methods above, you can use a special tool called an *impact screwdriver*. An impact screwdriver has various tips that can fit into screw heads. Unlike ordinary screwdrivers, an impact screwdriver is designed to be struck with a ball peen hammer. When the end of the impact screwdriver is struck, it produces a twisting motion at the blade that loosens the screw. This turning of the blade occurs at the same time that it's driven into the screw by the impact of the hammer, so the blade won't easily slip out of the screw head.

Pliers

Next to the screwdriver, pliers are probably the most commonly used hand tool. Different types of pliers are used for gripping and cutting functions.

Combination pliers (Figure 26A) are generally used to hold parts as you work on them, or to twist and bend materials. A combination pliers uses a slip joint to open its jaws wide, allowing it to grip large-diameter items.

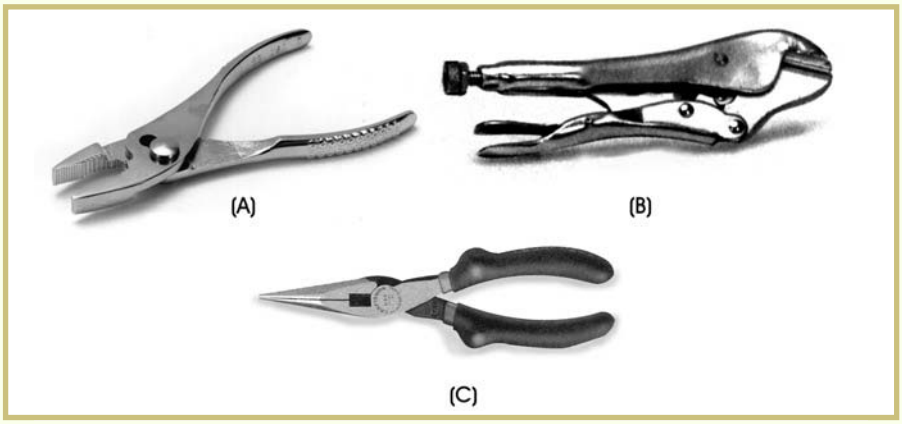


FIGURE 26—Figure 26A shows combination pliers, Figure 26B shows a vise grip or locking pliers, and Figure 26C shows longnose pliers.

Vise grips or *locking pliers* (Figure 26B) are similar to combination pliers in that they're used to grip items. However, vise grips can be locked in place to hold parts tightly while keeping both your hands free. For example, you can use vise grips to hold two metal parts in position while you install screws, washers, or bolts in them.

Longnose and *needlenose pliers* (Figure 26C) are useful for gripping or twisting small parts and for reaching small parts in tight places. The jaws of the needlenose pliers are smaller and thinner than those of the longnose pliers. Parts that are too small to be handled properly with your fingers can easily be moved and positioned with needlenose pli-

ers. Note, however, that you can easily damage these pliers by using them for heavy work.

Snap ring pliers are used to grip and spread snap rings as they're being removed or installed. There are two types of snap ring pliers—external and internal. An *external* snap ring is a small metal ring that fits in a groove that's machined on the outside of a shaft. An *internal* snap ring is a small metal ring that's used to retain components inside a hollow shaft.

Figure 27 illustrates the use of the two types of snap ring pliers. With either type, the jaws of the pliers fit into holes in the snap ring ends. When you use an *internal snap ring pliers* (Figure 27A), the jaws come together when you squeeze the handles. This squeezes the ends of the snap ring together, making it smaller so that it can be drawn out of the hollow shaft. When you use an *external snap ring pliers* (Figure 27B), the jaws spread apart when you squeeze the handles. This spreads apart the ends of the snap ring, making it larger so that it can be removed from the outside of the shaft.

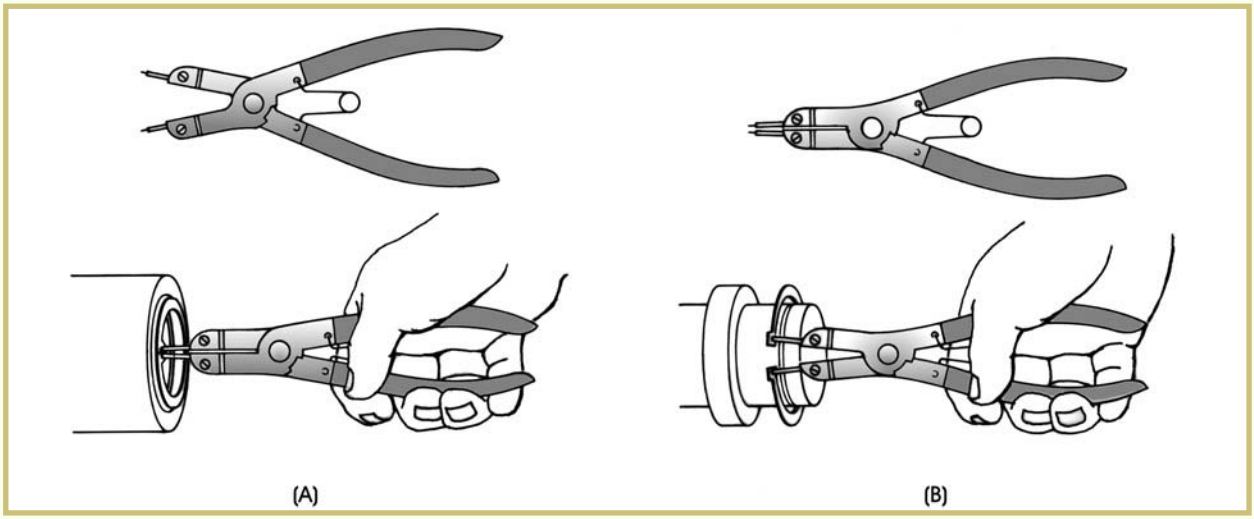


FIGURE 27—Figure 27A shows internal snap ring pliers; Figure 27B shows external snap ring pliers.

Hammers

Engine technicians use a variety of hammers in the shop, but the *ball peen hammer* is the favorite. The head of a ball peen hammer has two opposing hammering surfaces—a flat side and a rounded side. The flat side of the hammer head is used for regular hammering, and the ball end is sometimes used to round off rivets.

In situations where a ball peen hammer could damage the surface being struck, you should use a *soft-faced hammer* made of brass, plastic, or rubber instead. For example, you can use a brass hammer to drive in

pins or align parts. A rubber mallet may be useful for tapping hubcaps or wheel covers into place.

Before you use any type of hammer, make sure the head is securely attached to the handle. Grip a hammer close to the end of the handle to provide better control of the tool and strike a stronger blow. Hammering can send metal particles flying, so wear safety goggles to protect your eyes.

Punches

Punches are used to make indentations in metal. Several common punches are illustrated in Figure 28A. You can use a *center punch* to mark the centers of holes to be drilled. The indentation provided by the punch gives the drill a place to start and bite quickly, which prevents the drill from "wandering." A wandering drill can damage the surrounding metal surface or cause a hole to be incorrectly located. To use a center punch, hold the punch at a 90-degree angle to the metal surface, and strike the other end of the punch squarely with a ball peen hammer.

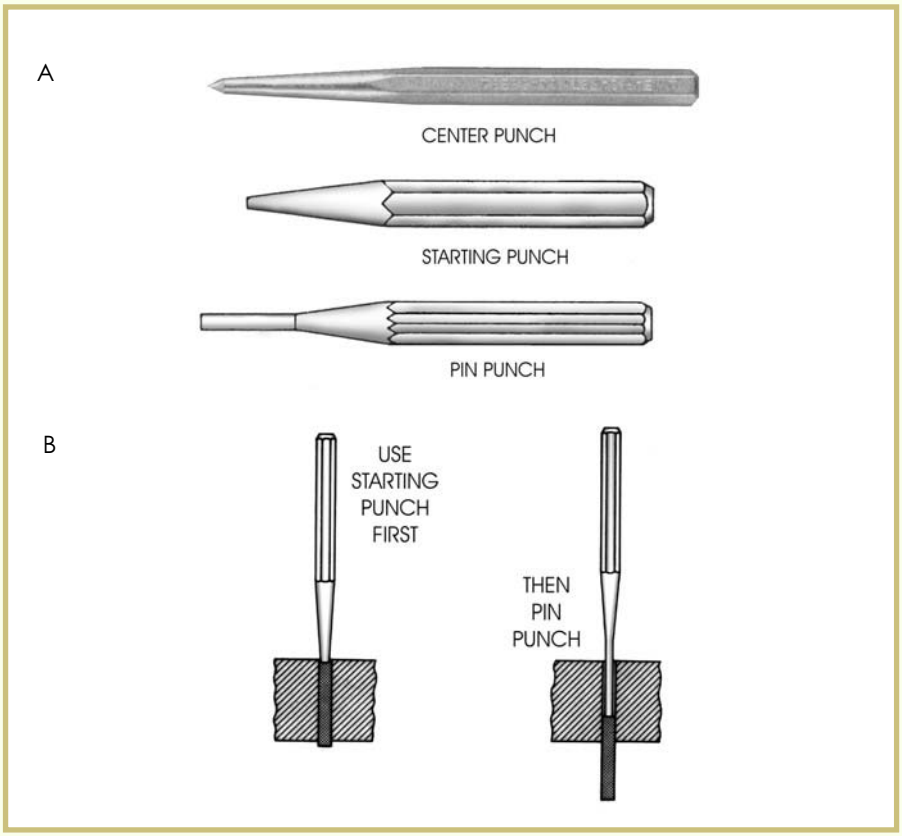


FIGURE 28A—You can use a center punch to mark the spot where a hole will be drilled. Starting punches and pin punches are often used to remove pins and rivets. The two steps used to remove a pin are shown in Figure 28B.

Starting punches and *pin punches* are normally used to remove pins and rivets. Figure 28B shows the removal of a pin. The starting punch is used to drive the pin part of the way out of the hole. The pointed end of the punch is held in place while the other end is struck with a ball peen hammer. Then, the pin punch is used to complete the job of punching out the pin.

Clamps and Vises

Clamps and vises are used to hold workpieces tightly so that both of your hands can be free to work on them. Whenever you're working on automotive parts or components on a workbench, you should always use one of these tools to hold the workpiece firmly in place. Vises can help prevent injuries as well as damage to expensive parts and components.

C-clamps are portable clamps you can use to hold pieces of material together while you work on them. The *bench vise* is a useful holder that clamps onto a workbench or table edge. The underside of the vise usually contains a C-clamp that holds the vise onto the bench. You can open and close the jaws of the vise with a turning handle. The jaws of a bench vise are usually covered with soft metal that protects the surface of the workpiece from scratches and dents.

Taps and Dies

Taps and dies are used to cut threads in metal holes. A *tap* cuts "female" threads (threads in a hole in a piece of metal), and a *die* cuts "male" threads (threads on a screw or bolt). These tools are especially useful when threads have been stripped and you need to cut new ones.

There are three basic types of taps: taper, plug, and bottoming (Figure 29). *Taper taps* have a pointed end. *Plug taps* have a slight taper, and *bottoming taps* have no taper at all. You can turn taps by using a special wrench called a *tap wrench*, as shown in Figure 29. A tap can cut threads in a hole all the way through a piece of metal or cut threads in blind holes (holes that don't go all the way through).

A die is turned by using a *die stock*. The proper size of die is inserted into the die stock, the bolt or screw to be threaded is clamped in a vise, and the die is "screwed" down onto the bolt to cut the threads, as shown in Figure 30.

Extractors

A tool that's similar in operation to the tap and die is the *screw extractor*. When a screw's head has been accidentally sheared off, you can

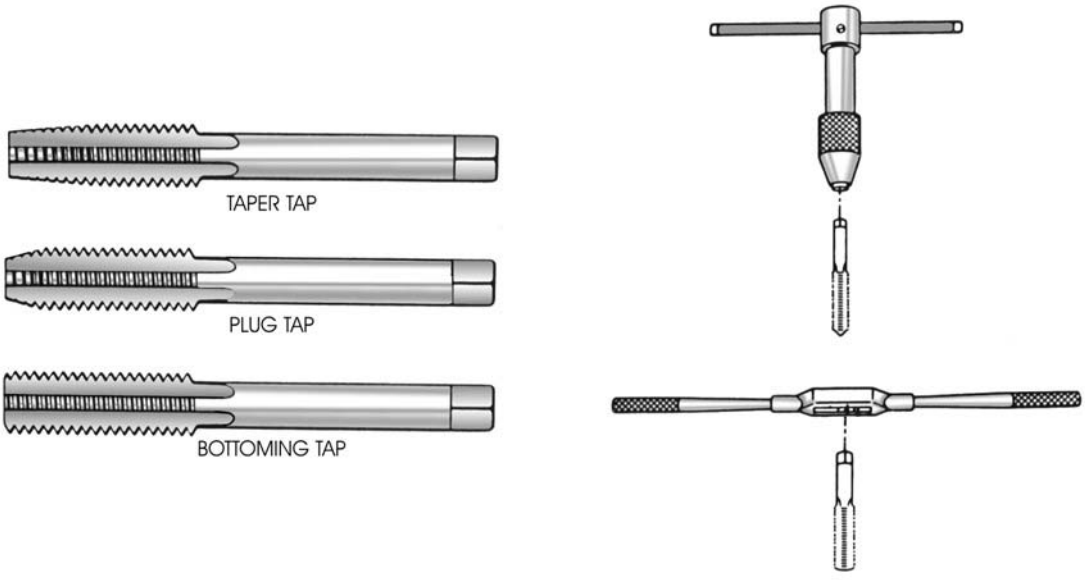
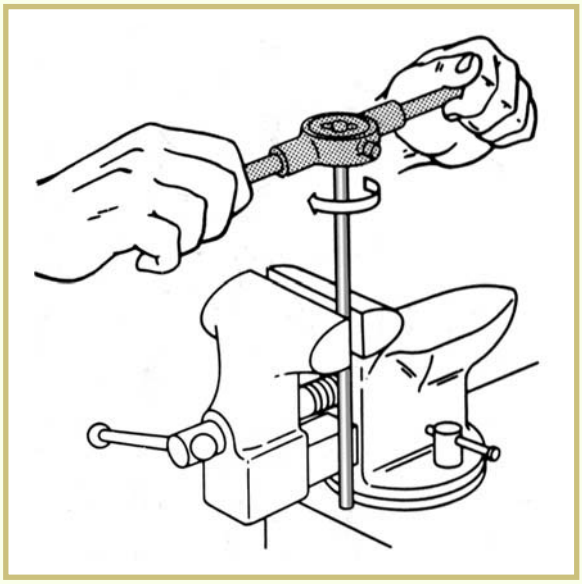


FIGURE 29—The three basic types of taps are the taper tap, the plug tap, and the bottoming tap. Taps are turned by using a tap wrench like the ones shown here.

FIGURE 30—The proper die is inserted into a die stock, the bolt or screw to be threaded is clamped in a vise, and the die is "screwed" down onto the bolt to cut the threads.



use a screw extractor to remove the screw. First, drill a small hole in the center of the broken screw. Then, thread in the screw extractor and twist the tool counterclockwise. As the screw extractor cuts threads into the broken screw, it will begin to twist out the screw.

Specialized Automotive Tools

The standard hand tools we just described are often used in automotive repair. However, many repair situations involve procedures that can't be performed with standard tools. For example, most automobiles contain oil filters that filter dirt out of the engine oil. An *oil filter* is shaped like a small can, and is threaded into a fitting on the engine (Figure 31A). Since oil filters are used to trap dirt, they must be periodically unthreaded from the engine and replaced. However, note that the oil filter has smooth sides, and there's no obvious way to attach a wrench to it. How is the filter unthreaded from the engine? The answer is that a special wrench designed just for this purpose must be used.

Figure 31B shows a *strap-type oil filter wrench*. This wrench has a thin metal strap that's placed around the filter and tightened so that the filter can be removed. Figure 31C shows an *end cap oil filter wrench*. This type of wrench fits over the fluted end of the oil filter and is turned with a square drive handle. The advantage of a strap-type oil filter wrench is that it can be tightened to fit around any size of oil filter. In contrast, the end cap types come in different sizes, and the correct size must be used with each different filter.

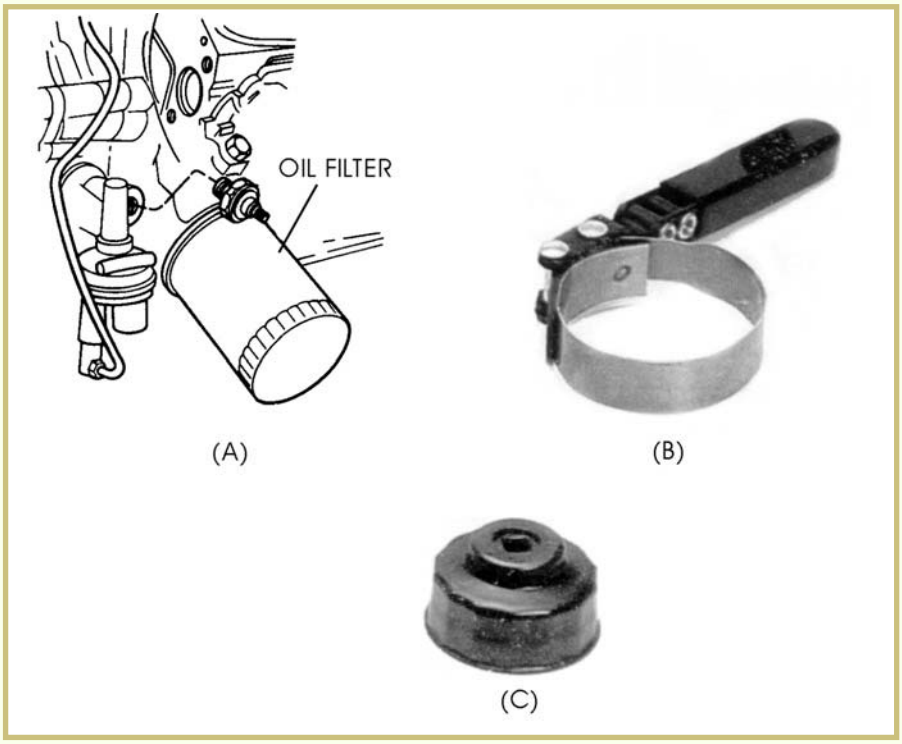


FIGURE 31—Figure 31A shows a typical oil filter. Figure 31B shows a strap-type oil filter wrench. The band can be tightened to fit any size of filter. Figure 31C shows an end cap oil filter wrench. End cap oil filter wrenches come in different sizes to match different filters. (B and C, Courtesy of Snap-On Tools Company, Copyright Owner)

The oil filter wrench is just one example of a specialized auto repair tool. A *specialized tool* is one that's designed to be used for only one limited purpose. Many special tools are required for auto repair, especially to rebuild components like the engine or transmission. Special tools are also used to work on brake and suspension systems. As you learn more about the auto repair field, you'll find that a special tool is made for almost every purpose you can think of. You should also be aware that some special tools are designed to be used on only one make or model of vehicle, while others can be used on a variety of vehicles.

Remember, at this point in the program we'll just be reviewing the names and uses of specialized auto repair tools. We don't expect you to understand exactly how to use all these tools yet—we just want you to be familiar with them. In later study units, the use of specialized tools will be covered in detail as it relates to each lesson topic.

Now, let's start our discussion of specialized automotive tools by looking at some of the most common ones.

Pullers

Pullers are used to help remove gears, pulleys, and various fittings from shafts safely and with little effort. A puller can easily separate machined parts that are tightly pressed together without damaging the parts. The external jaws of the puller apply the pulling force while the center "forcing" screw presses against the stationary part. Standard pullers may be either the two-arm or three-arm type, and they range widely in length. A variety of different pullers are illustrated in Figure 32. For safety reasons and to protect precision parts, you should use pullers whenever possible to separate parts (rather than a hammer and pry bar).

FIGURE 32—A variety of different pullers are illustrated here. (Courtesy of Snap-On Tools Company, Copyright Owner)

Cylinder Hones

A *cylinder hone* is used to recondition the surface of a cylinder wall during an engine rebuild (Figure 33). The hone has several abrasive polishing stones attached to it. The cylinder hone is attached to a power drill and is then inserted into an engine cylinder. When the drill is turned on, the spinning hone will polish and smooth the inside surface of the cylinder.

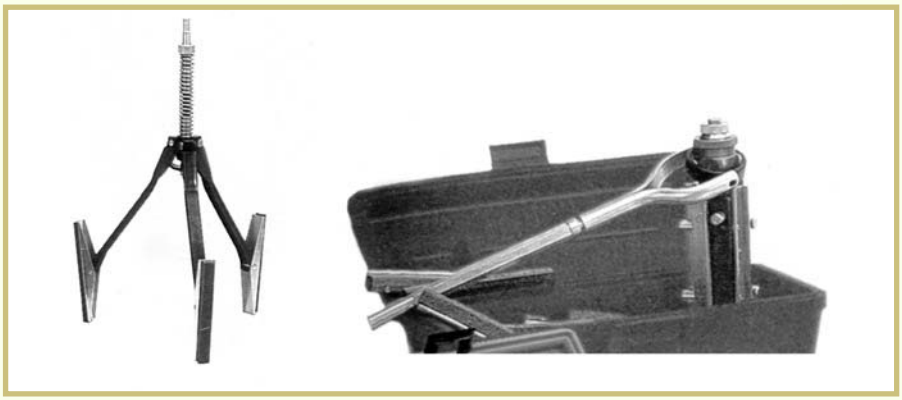


FIGURE 33—A cylinder hone is used to recondition the surface of a cylinder wall during an engine rebuild. The tool has several abrasive polishing stones attached to it. Two types of cylinder hones are shown here. (Courtesy of Snap-On Tools Company, Copyright Owner)

Piston Ring Compressors

Remember from our earlier discussion that a piston has several piston rings installed on it. The piston rings press outward from the surface of the piston to press against the cylinder walls. However, when you're assembling an engine and you need to install a piston in a cylinder, the piston rings get in the way. Because the rings stick out from the surface of the piston, they prevent the piston from sliding smoothly into the cylinder.

For this reason, a piston can't be inserted into an engine cylinder without using a special tool called a *piston ring compressor* (Figure 34). A ring compressor has a thin metal band that's placed around the outside of the piston and then tightened. When the tool is tightened, the piston rings are pressed into their grooves, and the surface of the piston is smoothed. The piston can then be slid into the cylinder. Once the piston is inside the cylinder, the compressor tool is released. The piston rings then spring back into their original positions and press out against the cylinder walls.

FIGURE 34—A ring compressor is a special tool that's used to insert a piston into an engine cylinder. (Courtesy of Snap-On Tools Company, Copyright Owner)

Valve Spring Compressors

In an engine, the intake and exhaust valves are held in the closed position by springs. During an engine rebuild, these valves will need to be removed from the engine for servicing. In order to remove the valves, their springs must first be compressed and held tightly. A *valve spring compressor* is a clamp-like tool that's used to compress and hold a spring (Figure 35).

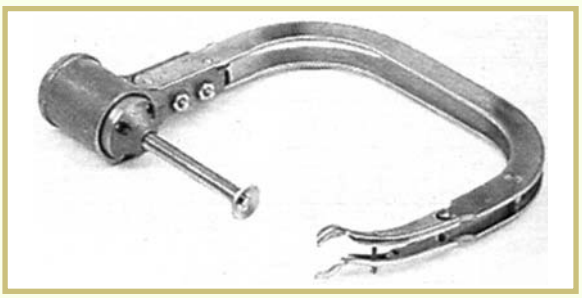


FIGURE 35—A valve spring compressor is used to compress and remove valve springs. (Courtesy of Snap-On Tools Company, Copyright Owner)

Universal Sensor Sockets

A *universal sensor socket* is a special socket that's used to remove sensors from an electronic engine control system. The sensor socket is designed to protect the sensors from damage as they're removed. A typical universal sensor socket is shown in Figure 36. Note that the

FIGURE 36—A universal sensor socket is used to remove sensors from an electronic control system. (Courtesy of Snap-On Tools Company, Copyright Owner)

socket has a slot in its side. Certain sensors (such as oxygen sensors) have wires attached to them, so the slot is provided to hold such a wire as a sensor is being removed.

Brake Spring Pliers

Many automotive brake systems contain springs that release the brakes after they've been applied. Since these springs are always under tension, they have to be stretched slightly in order to remove or install them. There are several special tools designed for removing brake springs. One of the most common is the *brake spring pliers* (Figure 37).

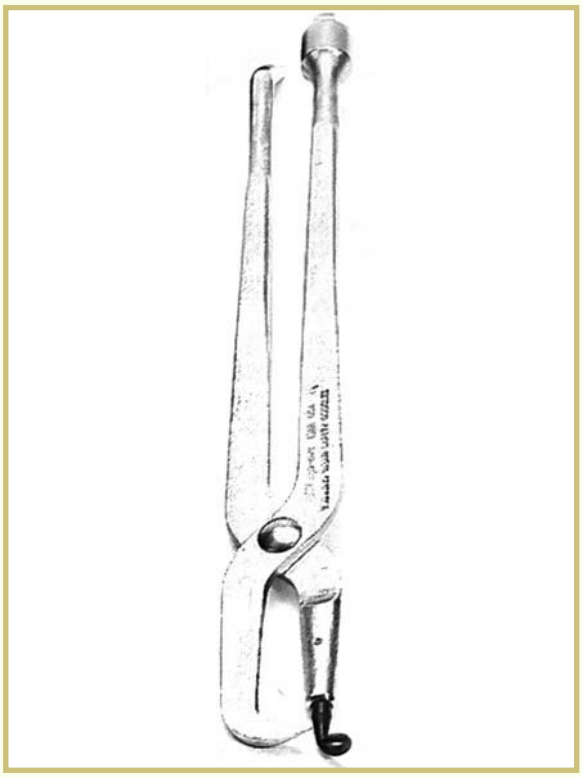


FIGURE 37—A brake spring pliers is used to install and remove brake springs. (Courtesy of Snap-On Tools Company, Copyright Owner)

Measuring Tools

Precision measuring tools are used to make exact measurements of the thicknesses of various auto parts, as well as of the distances between parts. Measuring tools are most commonly used during engine rebuilding, but they have many other applications as well. Many different measuring tools are used during auto repair, including special instruments that are designed to measure thicknesses, clearances, pressure, and the tightness of fasteners.

Let's look at a few examples of precision measurements. During the rebuilding process, an engine is completely taken apart, and all of its components are carefully inspected and measured to see if they're worn or damaged. Several types of precision measurements must be

taken to check the condition of engine components. The two main types of measurements you'll need to take are outside diameters and inside diameters. A *diameter* is simply the length of a line that divides a circle into two equal halves. The line must therefore run through the center of the circle. An *outside diameter (O.D.)* is the diameter measured from the outside walls of a cylinder-shaped object. An *inside diameter (I.D.)* is the diameter measured from points on the inside wall of a hollow, cylinder-shaped object or a hole. Figure 38 illustrates these different types of diameter measurements.

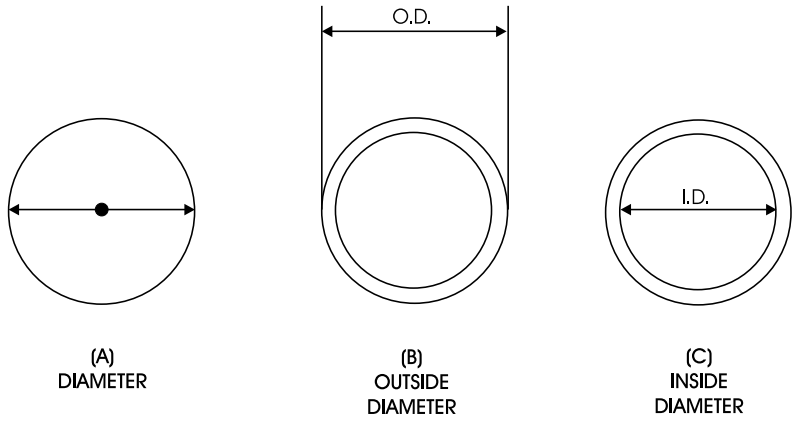


FIGURE 38—The diameter of a flat circle is shown in 38A. Note that the diameter is the width of the circle as measured through the circle's exact center. In 38B, the outside diameter of a hollow metal pipe is shown. The inside diameter of that pipe is shown in 38C.

During rebuilding and other engine repair procedures, you'll need to measure the diameters of numerous engine parts. For example, you'll need to measure the outside diameters of cylinder-shaped components such as the piston and the crankshaft. You'll also need to measure the inside diameter of the cylinder (the hole that's drilled into the cylinder block). All of these measurements must be precise and accurate—you can't use an ordinary household ruler or tape measure for the job. Instead, special measuring tools must be used to make these precision measurements.

Generally, outside diameters are measured with micrometers or calipers, while inside diameters are measured with inside micrometers or dial bore gages. Again, we'll discuss the specific uses of measuring tools later in the program. For now, though, let's take a quick look at some of the common measuring tools you should know about.

Micrometers

The *micrometer* is a tool that's used to measure the exact size of an engine part or component. Micrometers come in various sizes and styles.

Outside micrometers are designed to measure the outer dimensions of an object, such as the diameter of a piston. *Inside micrometers* are made to measure inner dimensions, such as the diameter of a cylinder in the engine block.

Figure 39 shows the parts of a typical outside micrometer. The object to be measured is placed between the anvil and the spindle, and the thimble is then turned until the anvil and spindle grip the object firmly. The measurement is then read off the thimble and sleeve.

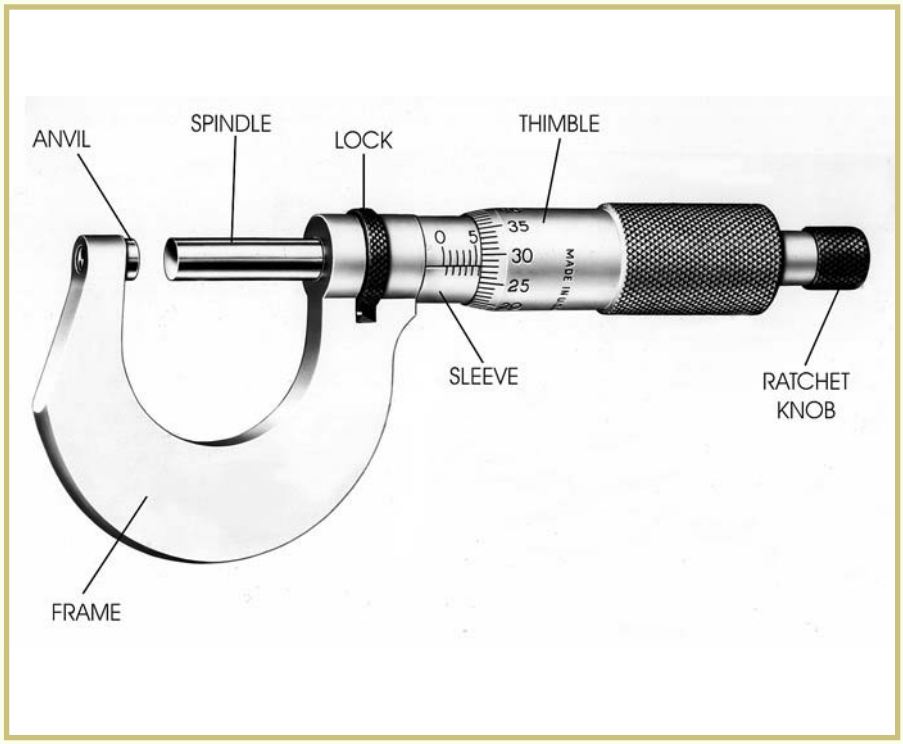


FIGURE 39—A typical micrometer is shown here. The object to be measured is placed between the anvil and the spindle. (Courtesy of L. S. Starrett Company)

Micrometers are often used during the engine rebuilding process. Because a micrometer can measure thicknesses so accurately, it can easily detect the small changes in part sizes that indicate wear. Figure 40 shows a micrometer being used to measure an engine's crankshaft. This is a typical procedure during an engine rebuild.

Calipers

Another tool that's commonly used to measure the size of automobile parts is the *caliper*. Although calipers are quite accurate, they're generally considered to be less accurate than micrometers. However, for most measuring purposes, calipers are more than accurate enough.

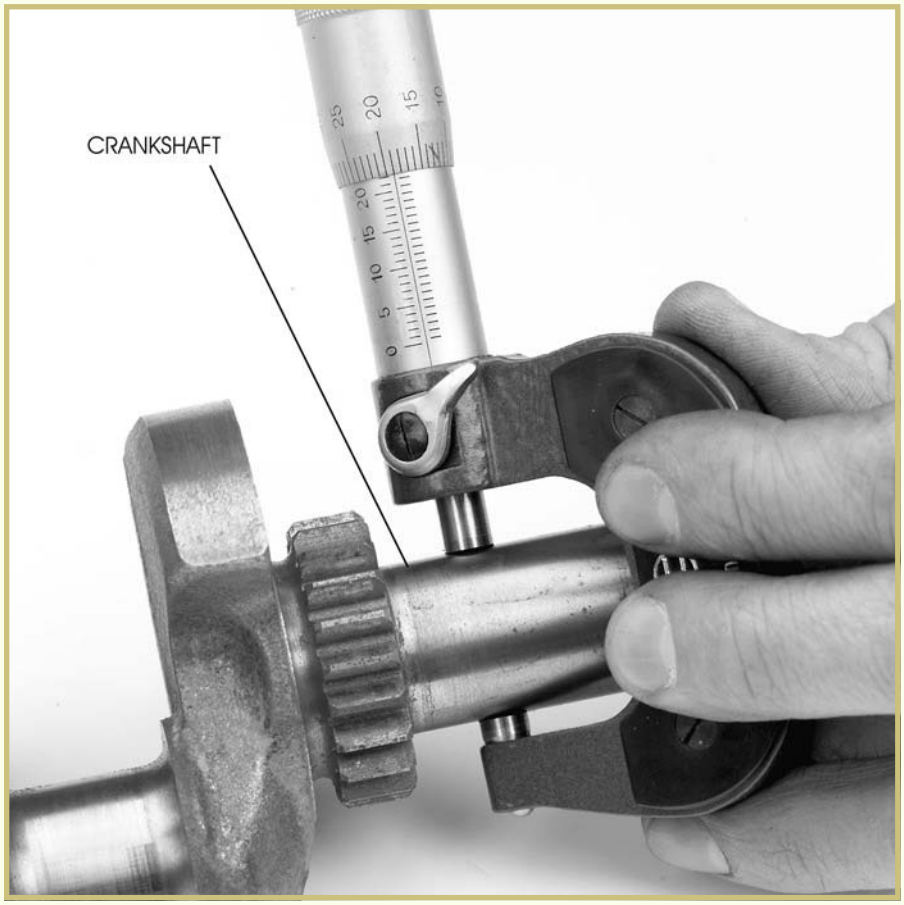


FIGURE 40—One common procedure that you'll need to do during an engine rebuild is to measure the engine's crankshaft with a micrometer.

The most common type of caliper is the *sliding caliper* (Figure 41). Sliding calipers are operated by sliding the jaws of the caliper around the part to be measured. The caliper will then indicate the size of the object

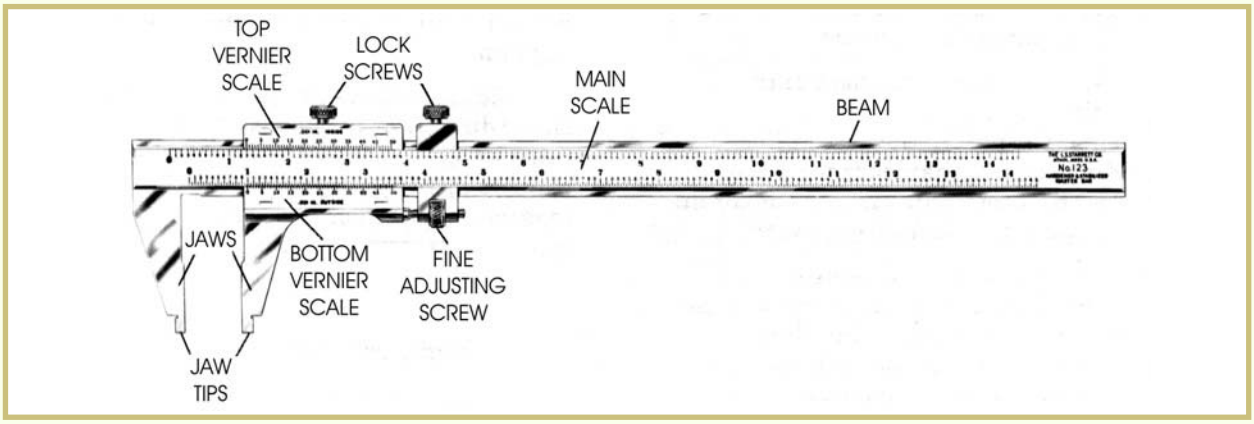


FIGURE 41—A sliding caliper with a vernier scale is shown here. (Courtesy of L. S. Starrett Company)

on its display scales. The jaws on most sliding calipers can be used to measure both outside dimensions and inside dimensions.

Calipers are classified according to the type of measurement display they have. A caliper may display measurements on a printed vernier scale, on a dial gage, or on a digital display. A vernier caliper is shown in Figure 41. The technician must read the numbers off the scale and then perform some simple calculations to determine the measurement. In contrast, the *digital caliper* shown in Figure 42 is easier to use. The caliper displays its measurement directly on the digital display screen.

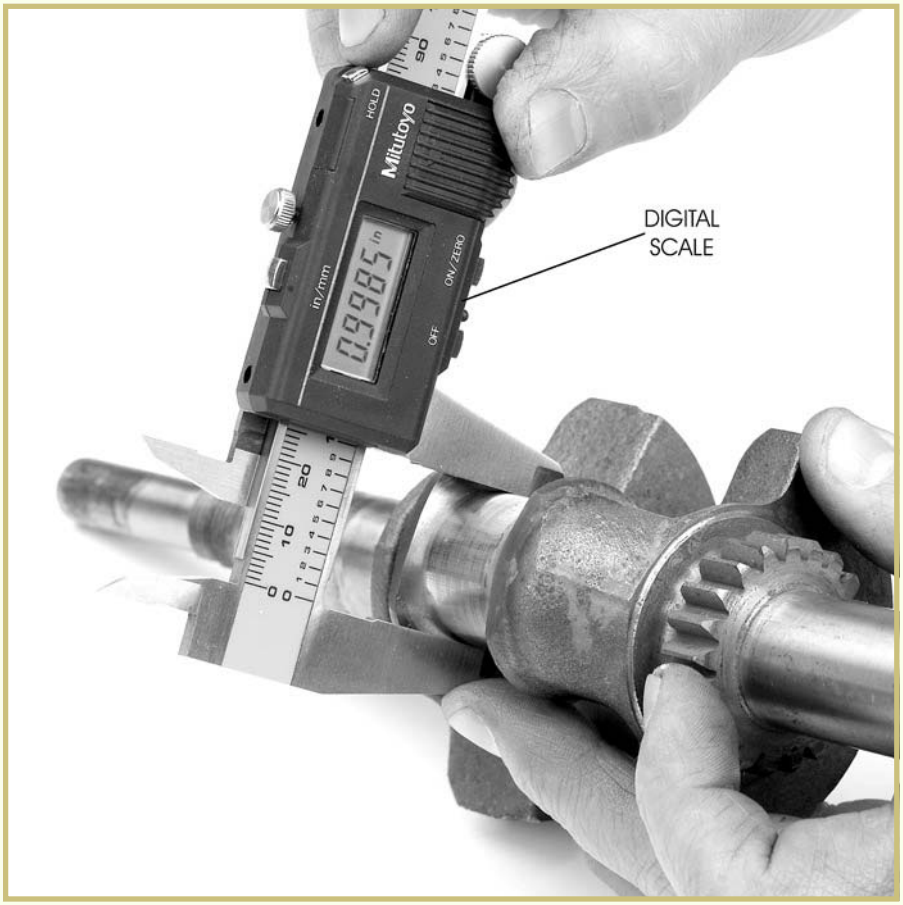


FIGURE 42—A digital caliper is easier to use than a vernier caliper. The digital caliper displays its measurements directly on the display screen.

Dial Indicators

So far, we've looked only at tools that measure the sizes of parts. However, there are times when a technician may need to measure the distance that a part can move freely (such as the amount of movement in and out of a shaft). The most common way to measure this type of movement is with a tool called a *dial indicator*. A dial indicator is simply

a dial gage with a plunger that sticks out from one side (Figure 43). To use the dial indicator, the gage is clamped to a solid object next to the item to be measured, and the plunger is allowed to rest against the end of the object to be measured. The object is then moved back and forth. The dial will then indicate the distance that the plunger moves in and out. Dial indicators are often used during the rebuilding of engines and transmissions.

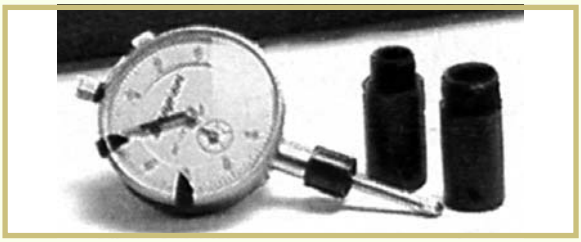


FIGURE 43—A dial indicator is used to measure the distance that a part can move freely. One type of dial indicator is shown here. (Courtesy of Snap-On Tools Company, Copyright Owner)

Torque Wrenches

The correct tightness of fasteners such as nuts and bolts is a key factor in the operation of engines and other automotive systems. In their service manuals, manufacturers will specify the exact amount of turning force (called the *fastening torque*) that should be used to tighten their fasteners. Because it's virtually impossible to accurately tighten a bolt to an exact tightness by hand, special tools called *torque wrenches* are used to tighten important engine fasteners. A torque wrench allows you to apply the exact required amount of fastening torque to a fastener.

In most cases, the torque wrench is simply a handle that's used to turn ordinary sockets. The proper size of socket is attached to the torque wrench, and the socket is placed over the bolt that needs to be tightened. The handle contains a measuring dial or scale. As you tighten the bolt with the wrench, the dial or scale indicates how much twisting force (torque) you're applying to the fastener. The bolt is tightened until the dial or scale on the torque wrench indicates that the desired tightness has been reached. The scale will usually be calibrated in foot-pounds. The three most common types of torque wrenches are the beam type, the "click" type, and the dial type. These three tools are shown in Figure 44.

A *beam-type torque wrench* contains a metal pointer rod (Figure 44A). As a bolt is tightened, the rod points to the measured torque value on the scale. This type of torque wrench is inexpensive, but it's not very accurate.

The *click-type torque wrench* is somewhat easier to use than the beam-type wrench just described (Figure 44C). In a click-type torque wrench, the desired amount of torque is set on the wrench before the bolt is tightened. The wrench is then placed on the bolt and tightened. When

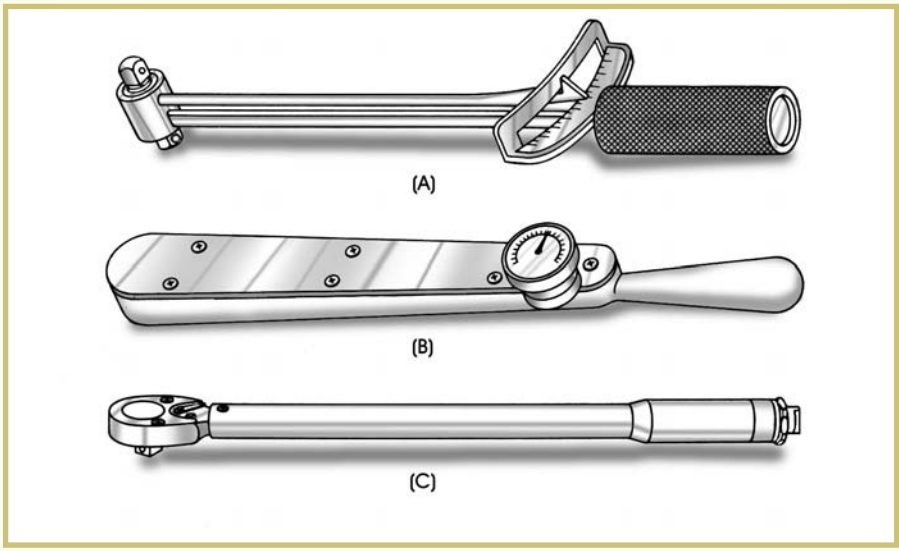


FIGURE 44—The three most common types of torque wrenches are shown here. Figure 44A shows a beam-type wrench, Figure 44B shows a dial-type wrench, and Figure 44C shows a click-type wrench.

the preset torque value is reached, the wrench will produce a clicking sound, which indicates that the bolt is at the desired tightness.

In a *dial-type torque wrench*, the amount of torque being applied is displayed on a dial (Figure 44B). As you tighten a bolt, you watch the dial until the desired torque value is displayed on the dial.

Feeler Gages

A feeler gage is a measuring tool that's used to measure very small spaces between two parts. (These small spaces are often called *clearances*.) A typical feeler gage is made up of a large selection of metal blades that spread open like a fan (Figure 45). The blades vary in thickness to allow a complete range of very precise measurements. Each blade is marked with its thickness, both in fractions of an inch and in millimeters. To measure the distance between two parts, you insert one blade at a time between the parts until you find the blade that's an exact fit. The marked size of that blade indicates the measured clearance between the two parts.

Spark Plug Gapping Tools

As we mentioned earlier, a spark plug is used to create sparks inside an engine's cylinder. The sparks ignite the air-and-fuel mixture in the combustion chamber and cause it to burn. The tip of the spark plug that produces the spark contains two metal terminals called *electrodes* (Figure 46). The small air space between the two electrodes is called the *gap*. The gap is very small and is usually measured in thousandths

FIGURE 45—A blade-type feeler gage is made up of a selection of metal blades that spread open like a fan. Each blade is marked with its thickness, both in thousandths of an inch and in millimeters.

of an inch. When electricity from the engine's ignition system is applied to the spark plug, the electricity will flow into the electrodes, jump across the gap between the two electrodes, and produce a spark.

The gap must be exactly the right size in order for the spark plug to work properly. (The service manual or owner's manual for an engine will list the proper gap for a particular spark plug.) Therefore, before a spark plug can be installed in an engine, its gap must be measured with a special tool called a *gapping tool*. A gapping tool is a device that contains several small wires or prongs of different thicknesses. The wire prongs measure thicknesses in thousandths of an inch, and each one is labeled with its thickness. One by one, the wire prongs are inserted between the spark plug's electrodes until an exact fit is found. If the gap is found to be too large or too small, the metal tab on the side of the gapping tool is used to gently bend the lower electrode into its correct position. Figure 47 shows how a gapping tool is used to measure a spark plug gap.

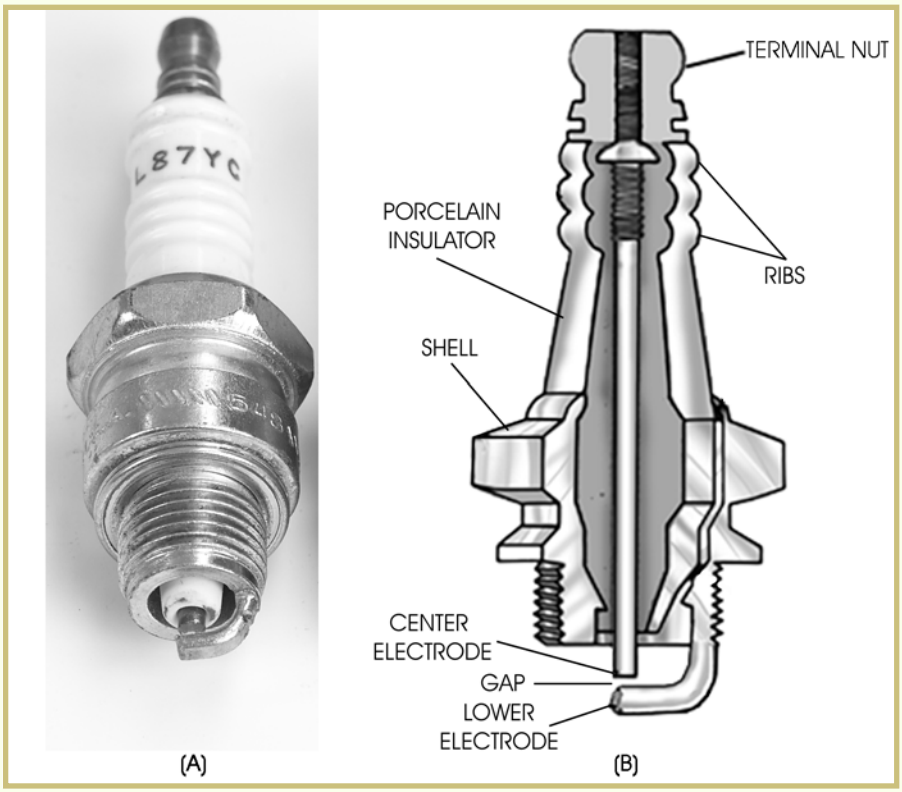


FIGURE 46—Figure 46A shows an external view of a typical spark plug. In the cutaway view shown in Figure 46B, you can see the parts of the spark plug. Note the small gap between the two electrodes.

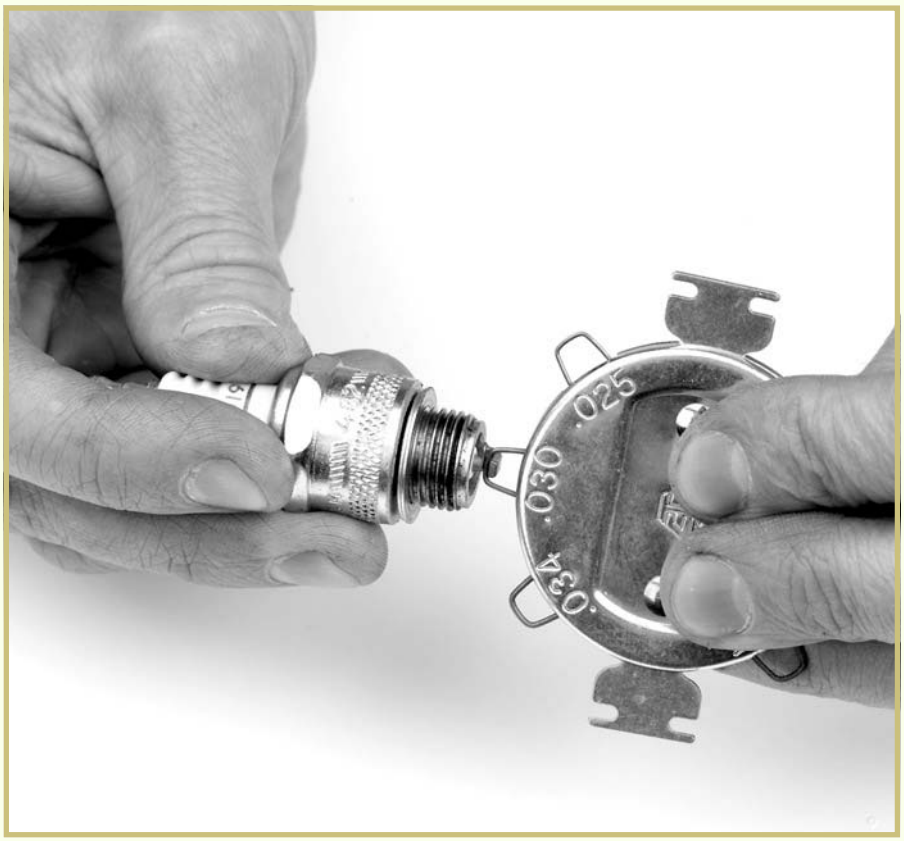


FIGURE 47—One by one, the gapping tool's wires are slid between the spark plug's electrodes until an exact fit is found.

Testing and Diagnostic Equipment

A wide variety of special test instruments are used to troubleshoot and repair automobiles. These test instruments are specially designed to test the condition of various automotive systems. For example, several different instruments can be used to test the condition of an engine's ignition and electrical system. Other testing devices are used to measure compression and pressure. Let's take a brief look at some of the most common test instruments.

Multimeters

Several different special instruments are used to measure electrical quantities in a vehicle's ignition system and electrical system. The most common electrical testing instrument is the *multimeter* (also called a *volt-ohm-meter* or *VOM*). This one instrument can measure voltage, current, or resistance. The multimeter is a boxlike device that has two wire *test leads* connected to it (Figure 48). The ends of the wire leads hold *probes* that are used to make the actual tests. The probes are touched to different areas in a car's electrical system to measure electrical quantities. The multimeter displays the circuit information it reads on its display face. Depending on the type of multimeter, the display may be a moving metal needle or a digital display. The circuit information read by the multimeter can help a technician determine where problems may exist in the electrical system, such as broken wires, faulty connections, or malfunctioning components.

Note that this is just a very basic description of the operation of a multimeter. The actual operation of a multimeter is somewhat more involved, and electrical safety precautions must be observed. You could destroy a multimeter if you use it improperly; more importantly, you could receive a serious electrical shock. We'll discuss how to use and operate a VOM in detail in a later study unit.

Timing Lights

Earlier, we discussed the basic operation of a spark plug. In very simple terms, an engine's ignition system sends electricity to the spark plug in order to make it fire a spark. The timing of these sparks is very important to efficient engine operation. For this reason, if a technician suspects that an engine's spark timing is incorrect, a special device called a *timing light* will be used to test the system. The type of timing light shown in Figure 49 is connected between the spark plug and the ignition system. The spark plug is left in the cylinder head. The engine is then turned on, and the timing light is watched. Each time the spark plug fires, the timing light will produce a flash of light.

FIGURE 48—A typical multimeter is shown here.

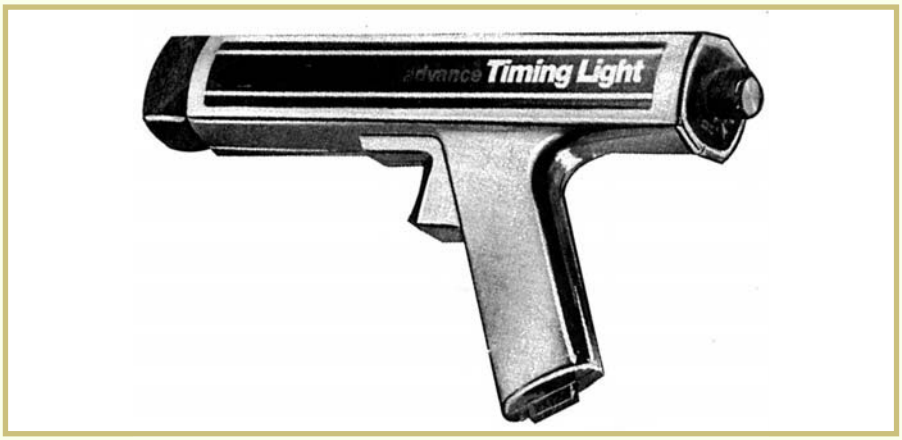


FIGURE 49—The timing light shown here is used to test ignition timing with the engine running. The timing light will flash each time the spark plug fires.

Tachometers

A *tachometer* is a testing instrument that's used to measure engine speed (rpm). These readings are used during an engine tune-up or problem diagnosis. The tachometer is connected to an engine's ignition system to count the number of ignition pulses. (Modern tachometers

often have clamp-on leads that fit over an engine's spark plug wires.) The tachometer then converts its count of ignition pulses to an rpm reading.

Engine Analyzers

An *engine analyzer* is a complex, computerized testing instrument that combines several tools into one unit (Figure 50). An analyzer can be used to run a complete engine performance analysis on many different vehicle models. A technician can use an engine analyzer to test a vehicle's battery, ignition system, starting system, charging system, fuel system, electronic controls, emissions, compression, and speed. These units are expensive and are usually owned only by larger repair shops.

FIGURE 50—A typical engine analyzer is shown here. (Courtesy of Snap-On Tools Company, Copyright Owner)

Scan Tools

The electronic control systems in a modern automobile are used to control everything from the amount of fuel the engine receives to the temperature inside the vehicle. Special tools called *scan tools* are used

to diagnose problems in these electronic systems. The most common type of scan tool allows the technician to connect into a vehicle's electronic system and scan or monitor the signals produced by the system (Figure 51). By comparing these readings to the specifications for the system, the technician can quickly pinpoint problems.

FIGURE 51—A scan tool allows the technician to connect into a vehicle's electronic system and scan or monitor the signals produced by the system. (Courtesy of Snap-On Tools Company, Copyright Owner)

Tire Pressure Gages

Proper tire pressure is an important factor in both vehicle handling and tire wear. For this reason, it's important to regularly check a vehicle's tire pressure with a tire pressure gage. Tire pressure gages come in a variety of styles, from simple pencil-type gages to electronic digital display gages (Figure 52). To use a tire pressure gage, you simply place the gage over the tire stem and press the tool inward. The pressure inside the tire is then displayed on the gage.

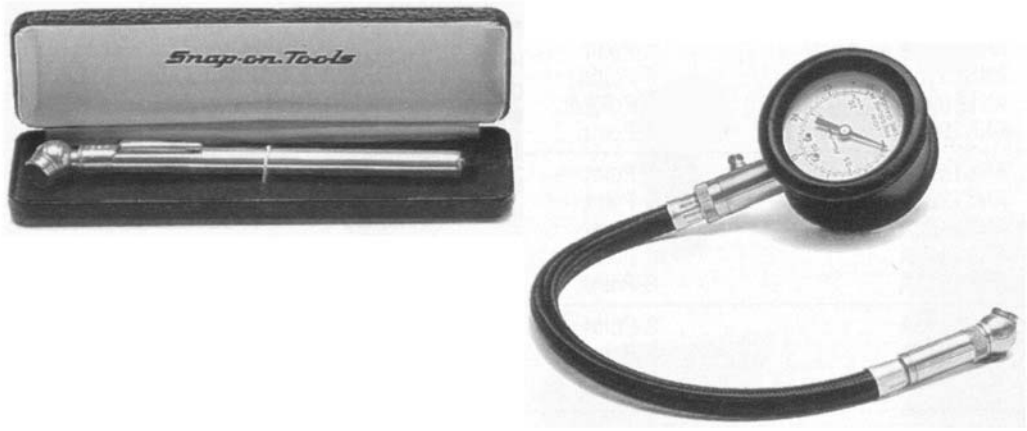


FIGURE 52—Two common types of tire pressure gages are shown here. (Courtesy of Snap-On Tools Company, Copyright Owner)

Compression Testers

In our discussion earlier in this lesson, you learned that a mixture of air and fuel must be compressed inside an engine's cylinder before it's burned. The stronger the compression in the cylinder, the better the fuel will burn. However, as engine components wear out, the compression in the cylinder will start to get weaker. So, by measuring the amount of pressure inside the cylinder during the compression stage, you can get a good idea of how much the engine is worn. A special gage called a *compression tester* is used for this purpose (Figure 53). To use a compression tester, a spark plug is unscrewed from the vehicle's cylinder head. Then, the compression tester gage is inserted into the cylinder head in place of the spark plug, and the engine is then cranked. The amount of pressure that develops in the cylinder is then displayed on the gage.

FIGURE 53—A typical compression tester is shown here. (Courtesy of Snap-On Tools Company, Copyright Owner)

Vacuum Gages

From our earlier discussion of the four stages of engine operation, you'll remember that a vacuum develops in the cylinder during the intake stage. This vacuum draws the air-and-fuel mixture into the cylinder. The correct amount of suction is needed in order for the engine to work properly. If the suction is weak, it may indicate an engine problem or worn components.

The amount of suction produced during the intake stage can be measured by using a special gage called a *vacuum gage*. A vacuum gage is simply a dial gage with a rubber hose attached to it (Figure 54). To use the gage, the hose is attached to the engine. The engine is then turned on, and the amount of vacuum suction in the engine will be indicated on the gage.

A vacuum gage can reveal a number of problems in an engine, including the following:

- Worn piston rings
- Worn cylinder
- Leaking cylinder head gasket
- Incorrectly adjusted carburetor
- Stuck or damaged valves

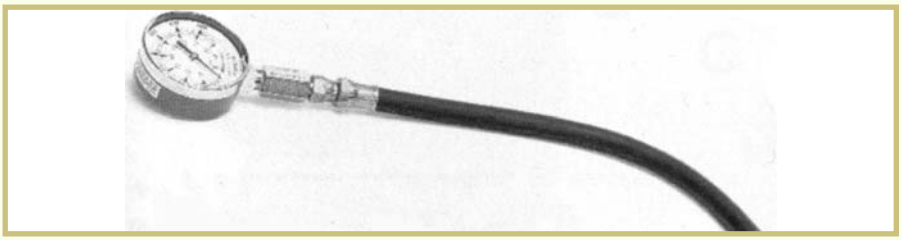


FIGURE 54—The amount of suction produced during the intake stage can be measured by using a vacuum gage. (Courtesy of Snap-On Tools Company, Copyright Owner)

Oil Pressure Gages

The moving parts of an automotive engine must be kept properly lubricated with oil in order to run properly. Usually, an engine will contain an *oil pump* that circulates oil throughout the engine as it operates. The oil must be pumped with the correct amount of pressure in order to reach all the engine components. An *oil pressure gage* is used to check the oil pressure in an engine's lubricating system.

Fuel Pressure Gages

An oil pump isn't the only pump that a typical vehicle contains. Usually, an automobile will also contain a *fuel pump* that delivers gasoline from the fuel tank to the engine. The gasoline must be pumped under the correct amount of pressure in order for the engine to run properly. Therefore, a tool called a *fuel pressure gage* is used to measure the amount of pressure that's being developed by the fuel pump (Figure 55). The amount of fuel pressure is very important to engine operation, especially in engines that use fuel-injection systems.

Note that many modern electronic control systems have the ability to self-diagnose their own problems. So, when a problem develops, the system will detect it and display a trouble code to indicate what the problem is. When a scan tool is attached to the system, the trouble code can be accessed by the technician. The trouble code will give the technician some idea of where to look for the problem in the system.

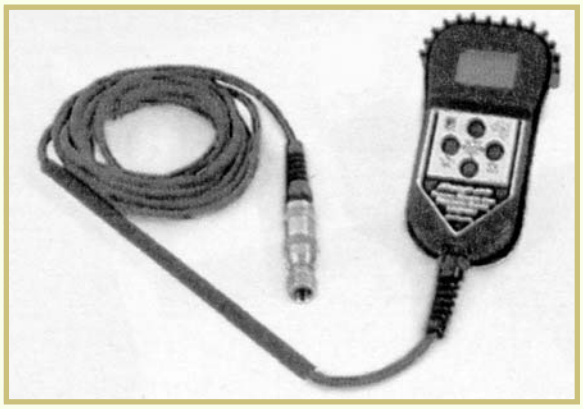


FIGURE 55—A fuel pressure testing kit is shown here. This type of kit is used to test the fuel pressure in fuel-injected systems. (Courtesy of Snap-On Tools Company, Copyright Owner)

Exhaust Analyzers

An *exhaust analyzer* is used to measure the quantities of certain gases in an engine's exhaust. Most modern exhaust analyzers are designed to measure the levels of hydrocarbons, carbon monoxide, carbon dioxide, and oxygen in the exhaust. The word *hydrocarbons* refers to raw, unburned fuel in the exhaust. *Carbon monoxide* is a toxic, odorless gas that's produced when fuel doesn't burn completely in an engine. *Carbon dioxide* and *oxygen* are gases that are normal products of combustion.

To analyze an engine's exhaust, the technician uses the exhaust analyzer to take a sample of exhaust gas from the vehicle. The analyzer then produces readings that indicate the levels of various gases in the exhaust. These readings are compared to a chart to make a diagnosis of the engine's condition. If an engine is working properly, certain percentages of each of these gases will be present in its exhaust. If the level

of a particular gas in the exhaust is higher or lower than normal, it may indicate a problem in the engine.

In addition to diagnosing engine problems, a vehicle's exhaust may also be analyzed to make sure that it complies with federal emission laws. These emission laws determine the amounts of pollutants that a car can safely release into the environment. All new cars and light trucks must meet the specific exhaust requirements that are defined by the federal government.

Purchasing Tools

Very few (if any) automotive technicians own every tool that's available. The reason is that most technicians don't perform every type of repair, so there are a lot of tools they would never use. Just what tools will you need? Well, that will depend on the type of work that you do and the shop at which you work. In most auto repair shops, technicians are required to buy their own basic hand tools, and perhaps some simple testing tools. However, specialized tools and expensive test equipment will usually be provided by employers.

When buying tools, keep in mind that you'll use your tools every day, so you'll want to be able to depend on them. For this reason, the tools you buy should be of good quality so that they can provide many years of service. It's a good idea to buy professional brand-name tools, since these tools are usually of the highest quality and are often backed with lifetime warranties. A "lifetime warranty" is a guarantee of the tool's quality for the owner's entire lifetime. If a tool under such a warranty gets damaged, you can return it at any time to the tool manufacturer for a replacement at no charge.

You can purchase most tools individually or in sets. In most cases, purchasing tools in sets is cheaper than buying them one by one. If you already own a lot of tools, however, you may only need to purchase a few additional items to meet your needs. If you definitely intend to enter the auto repair field, it may be a good idea to purchase a complete starter set of tools rather than individual tools. A basic auto technician's tool kit was shown earlier in Figure 18. The kit contains all the standard tools that you'll need to use every day. Later, as you gain experience and start performing more repairs, you can add individual tools to your basic set, one at a time.

Remember, it's better to avoid buying too many tools until you're somewhat settled in your field. For example, a technician who works in a shop that specializes in brake and suspension work won't need a set of engine rebuilding tools. Therefore, before you buy a lot of tools that you may not ever use, stop and carefully examine your personal work situation. Once you determine the types of repairs that you'll be

doing regularly, you can purchase tools based on your specific needs and avoid spending a lot of money on tools that you may not need in the future.

Storing Tools

Proper tool maintenance and storage is an important responsibility. Professional technicians always respect and take proper care of their equipment. Since an automotive technician will usually own a large number of tools, it's very important to organize them so that you can find them easily. (You don't want to spend a lot of time looking for a tool each time you need it.) Also, because tools are an expensive investment, they should be locked up securely when you're not using them. A sturdy, professional toolbox with drawers and a lock is the best way to store and organize your tools. Toolboxes come in all sizes and price ranges. They may be small and portable like the one shown in Figure 56A, or large, floor-standing units with wheels like the one shown in Figure 56B.

When choosing a toolbox or storage unit, always consider your future needs. As a professional technician, you'll always continue adding tools to your collection as you need them. So, when you choose a toolbox or cabinet, select one that will allow room for future expansion.

Service Manuals

Whenever you're repairing and rebuilding a vehicle's systems, you must have the *service manual* for the vehicle on hand. Because each vehicle make and model is slightly different, you'll often need to look up manufacturer's information about a particular automotive system. Service manuals contain a variety of helpful information, such as engine identification guidelines, engine specifications, rebuilding specifications, and recommended repair procedures. Service manuals, like tools, are essential to your work. Most auto technicians keep a variety of service manuals on hand for reference, and their collections keep growing all the time.

Note that the term *specifications* refers to certain precision measurements that are made on certain parts of the vehicle (particularly in the engine). These ideal measurements are determined by the manufacturer and are listed in a vehicle's service manual. If an engine is to function properly, it must exactly conform to its specifications. Therefore, many engine specifications will need to be checked with precision measuring instruments when you're doing repairs. You would then compare your measurements to the specifications printed in the service manual, and correct any problems that you found.

FIGURE 56—A portable toolbox is shown in Figure 56A, and a floor-standing tool storage unit is shown in Figure 56B. (Courtesy of Snap-On Tools Company, Copyright Owner)

Some common engine specifications are the *spark plug gap* (the width of the gap between the spark plug's electrodes), the *cylinder bore* (the inside diameter of the engine's cylinder), and *torque requirements* (the specific tightness of fasteners, usually measured in foot-pounds). All of these specifications must be correct in order for an engine to function properly.

Service manuals are available for both engines and entire vehicles. Most service manuals are published by vehicle manufacturers and can be purchased from any dealer or parts supplier. Most manuals are inexpensive, and some cover a wide variety of vehicles and engine models. Some manuals are also published by educational companies. These educational manuals can often be purchased at local bookstores, at an auto parts store, or directly from publishers.

Service manuals are an invaluable resource when you're doing repairs. Some technicians will attempt to make repairs to a vehicle without using service manuals, but this isn't a good practice for several reasons.

First, even the most experienced technicians can't remember every specification for every vehicle make and model. If you work on only one particular make and model all the time, you could probably make many repairs without the use of outside references. However, in most repair shops, technicians work on a large variety of cars made by many different manufacturers. Working without proper reference manuals is like trying to assemble an appliance you just bought without first reading the instructions. You may be able to do it, but it's not the best method to make sure that the job gets done properly and quickly.

Second, manufacturers may make changes and improvements to their vehicles from year to year. Each year, more and more new vehicles are introduced, and more features are added to existing models. Having a supply of good service manuals will help you to keep up-to-date on the latest changes in the vehicles you service.

Third, manuals are often necessary in those cases where you weren't the person who took apart a particular component. For example, suppose a customer brings in a vehicle component that he or she took apart and tried to fix. In such a situation, you'll probably need to refer to a service manual to determine how the part should be reassembled, or even to determine whether certain small parts are missing. With a service manual at hand, you can quickly determine how the component should be assembled and how it should be adjusted once it's installed.

Service manuals are very useful tools. However, you should realize that manuals can't tell you everything. Most manuals are written under the assumption that you already know the basics of auto repair—how engines operate, how the various automotive systems operate, how to disassemble and reassemble engines, and how to use the proper tools and measuring instruments required to make repairs. Most service manuals concentrate on specifications for particular vehicle makes and models, such as torque specifications and recommended engine settings. Therefore, service manuals can never take the place of good

training. They're merely supplements that can provide you with specific information about particular vehicles.

Now, take a few moments to review what you've learned by completing *Power Check 3.*

Power Check 3

Fill in the blanks in each of the following statements.

1. A measuring tool that's used to measure very small clearances between parts is called a _____.
2. Screws that are extremely tight can be removed using a special tool called a/an _____.
3. The size of a _____ is determined by the width of the opening of its end.
4. A _____ is attached to a power drill and used to recondition the surface of a cylinder wall during an engine rebuild.
5. A tool that can be locked in place to hold parts very tightly is called a _____.
6. A tool that's useful for gripping small parts and for reaching small parts in tight places is the _____.
7. When an engine is being assembled, a tool called a _____ must be used to insert the piston into the cylinder.
8. A _____ is used to cut "female" threads in a hole in a piece of metal.
9. The tool that's used to measure the small air space between a spark plug's electrodes is called a _____.
10. The tool that's used to test an engine's spark timing is called a _____.
11. A die is turned by using a _____.
12. A _____ is used to tighten a nut or bolt with the exact required amount of fastening torque.

Check your answers with those on page 113.

KEY SAFETY ISSUES IN YOUR SHOP

The Safety Attitude

Most people are very concerned about safety in their homes, because they want to protect their families from injury. However, accidents in the workplace are actually much more dangerous than home accidents because workplaces contain many more hazards than the average home. Workplace accidents can injure dozens of people and cause tremendous financial and property losses. For this reason, workers should make every effort to use safe work practices at all times.

Safety is more than just the absence of an accident. Safety is an *attitude* that helps you prevent injury to yourself and others. Safe working practices should be a way of life, as natural as putting on a seat belt or looking both ways before you cross the street. Safety isn't a matter of good or bad luck. Instead, it's a matter of planning to work safely, recognizing potential hazards, and following proper work procedures.

You should be aware that the *Occupational Safety and Health Administration (OSHA)* is the federal agency that publishes safety standards for business and industry. OSHA's regulations affect every business that has employees and sells its products or services. OSHA requires every employer to provide employees with workplaces that are free from all recognized hazards that can cause injury or death. Employers are motivated to adopt and use safe working procedures through the strict enforcement of the regulations. Safety violators receive stiff penalties and fines.

You can find a list of all of OSHA's proven safety methods, practices, and regulations in one convenient resource called the *Code of Federal Regulations*. Even if your shop has no employees, you should understand and follow OSHA's safety guidelines for your own protection.

The *National Fire Protection Association (NFPA)* is the largest and most important national group dedicated to fire prevention and protection. Its mission is to safeguard people, property, and the environment from fires. The NFPA also publishes the *National Electrical Code (NEC),* which is the national standard used for all residential and industrial electrical installations (both in the United States and Canada). As you begin to plan a fire safety program for your business, the NFPA can provide much useful information.

In an automotive repair shop, the safety matters of primary concern are the following:

- Fire safety
- Chemical safety
- Basic electrical safety
- Ventilation of exhaust gases
- Safe operation of engines and equipment
- Good housekeeping practices
- Safe handling of heavy objects and materials
- Safe use of jack stands and lifts
- Proper use of personal protective equipment
- Safe use of tools

Now, let's look at each of these important safety issues individually.

Fire

The primary safety concern in any auto repair business is *fire prevention*. Statistically, many fires occur annually in private garages, and more than a few are started by the mishandling of gasoline. Unsafe practices (such as storing gasoline in unapproved containers, or failing to clean up gasoline spills) have caused many serious fires. Since automotive engines run on gasoline, and since gasoline is one of the most flammable liquids in existence, fire is a serious threat in the auto repair shop.

Gasoline won't be the only flammable liquid in your shop. Oils, cleaning solvents, and other chemicals can cause serious injury or damage when handled improperly. Carbon monoxide and other gases produced by engine exhaust are also flammable. However, in spite of the fire risk, a repair shop *can* be run safely. By following basic safety procedures, the danger of fire can be all but eliminated.

The information we've provided here is designed to teach you what you need to know, both to prevent fires and to safely put them out if they start.

The Fire Triangle

There are three conditions that must be present in order for a fire to start. These conditions are grouped together to form the *fire triangle*. The three components of the fire triangle are *fuel* (such as wood or gasoline), *oxygen*, and a *heat source* (such as a spark). Once a fire starts, the supply of fuel and oxygen must stay at certain levels in order to keep the fire going. To extinguish a fire (or to prevent one from starting), you must remove at least one of the legs of the triangle. Thus, you can put out a fire in one of three ways: (1) by removing the fuel source, (2) by removing the oxygen, or (3) by removing the ignition source.

You must always be aware of heat sources in your work area that may be potential fire hazards. When we think of heat sources, most of us would first think of open flames, sparks, and furnaces. However, there are several other dangerous heat sources that aren't so obvious.

For example, one common source of heat in a garage is *engine exhaust*. A car's exhaust system becomes very hot during operation. This heat will remain in the exhaust system for some time after the vehicle is shut off. Therefore, if a vehicle's engine is still warm when you begin to make repairs, you must take extra care to prevent fires at that time.

Another dangerous source of heat is the *cigarette*. The open flames of lighters and matches, sparks from lit cigarettes, and heat from discarded cigarette butts can all start fires in flammable and combustible materials. Smoking-related ignitions are a leading cause of fires. Therefore, smoking should be strictly controlled in your repair shop. Clearly mark smoking and nonsmoking areas with easily recognizable symbols. Also, equip smoking areas with adequate receptacles to provide for the safe disposal of smoking materials.

Spontaneous combustion is another source of ignition you should be aware of. In this type of fire, the heat for ignition is created by a chemical reaction in combustible materials. One common type of spontaneous combustion occurs when rags or papers that are soaked in solvents end up in a garbage can. The decomposition of the solvent will often create enough heat to ignite the rags and papers. To prevent this type of fire, discard rags or papers that contain oil or solvents in metal safety cans with lids.

The Four Fire Classes

Now, let's take a look at the different types of fires. The NFPA classifies fires in four groups: Classes A, B, C, and D. Each fire class involves a different fuel source.

Class A fires involve the burning of wood, paper, cardboard, fabrics, and other similar materials. These materials ignite easily, burn rapidly,

and produce large amounts of heat during burning. Some examples of Class A combustible materials that are commonly found in workplaces are cardboard boxes, paper business forms, company files or records, cleaning and polishing cloths, coveralls or work aprons, dust covers, and work area partitions.

Class A fires can be extinguished with water or with dry chemical agents. These agents extinguish the fire by quickly cooling the burning material and lowering the temperature in the combustion zone. The symbol used to identify Class A extinguishing equipment is a letter A inside a green triangle.

Class B fires involve flammable liquids, gases, and other chemicals. Many flammable and combustible liquids and solvents are used in automotive repair. Some common flammable liquids are gasoline, cleaning solvents, oils, greases, turpentine, oil-based paints, and lacquers. Common flammable gases are natural gas, propane, and carbon monoxide.

Fires involving flammable liquids produce tremendous amounts of heat. For this reason, water is a poor extinguishing agent for a Class B fire. The heat of a burning flammable liquid will boil any water that's applied to it, turning it into steam before it can extinguish the fire. Also, most flammable liquids are lighter than water, so they simply float on top of the water and continue to burn.

For these reasons, the best way to extinguish a Class B fire is to suffocate it by removing its source of oxygen. Dry foams, dry chemicals, and carbon dioxide are therefore the best extinguishing agents to use on a Class B fire. (Small Class B fires can also be smothered with fire blankets or noncombustible containers.) The symbol used to identify Class B extinguishing equipment is a letter B inside a red square. If you routinely keep gasoline (even in small amounts) in your shop, you should have at least one Class B fire extinguisher in the area.

Class C fires involve live electric equipment, such as electrical boxes, panels, circuits, appliances, power tools, machine wiring, junction boxes, wall switches, and outlets. Electrical fires are usually caused by loose contacts, frayed wire insulation, improper installations, faulty equipment, or overloaded circuits. Electrical system overloads can easily produce arcs, sparks, and heat that could ignite nearby combustible materials (such as wire insulation, plastic components, or wall insulation).

Water or water-based solutions must *never* be used on a Class C fire. Water is a good conductor of electricity, and if it's applied to an electrical fire, the person holding the extinguisher could be electrocuted. Instead, dry extinguishing agents such as carbon dioxide, dry chemicals, and halon should be used on Class C fires. Carbon dioxide is the most

widely used because it's nonconductive, it penetrates around electric equipment well, and it leaves behind no residue that must be cleaned up afterward. (Dry chemicals leave behind a residue that can damage electric equipment.) The symbol used to identify Class C extinguishing equipment is the letter C inside a blue circle.

Class D fires involve combustible metals such as magnesium, titanium, zirconium, sodium, lithium, and potassium. Small chips and shavings of these metals can be ignited at relatively low temperatures. Metal particles are most often produced by cutting or grinding operations, so Class D fires don't commonly occur in the typical auto repair shop. However, you should be aware of this type of fire. Dry powder compounds are used to extinguish metal fires. Note that dry powder compounds are completely different from dry chemicals. Dry powder compounds are usually scooped onto a fire rather than sprayed. The symbol used to identify Class D extinguishing equipment is the letter D inside a yellow star.

The most important reason to know about the four classes of fires is to be able to protect yourself properly against them. Knowledge of the fire classes is also important in assessing your work area and evaluating the type of fire hazards present. Because of the nature of your work, the two fire types that are most likely to occur in an auto repair shop are Class A fires and Class B fires. The symbols that are used to identify the four fire extinguisher classes are shown in Figure 57.

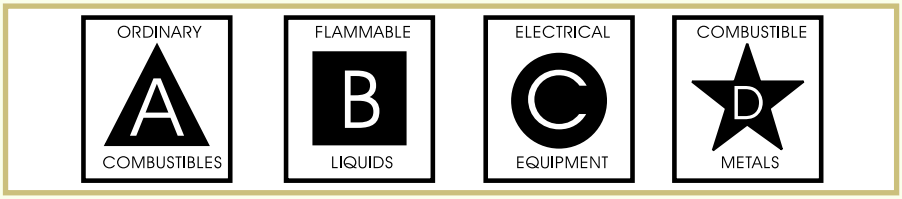


FIGURE 57—These symbols are placed on fire extinguishers to indicate the types of fires the extinguishers can be used on.

Using a Fire Extinguisher

Fire extinguishers must be activated and applied properly in order to be effective. Before a fire starts, you should become familiar with the various extinguishers installed at your facility for the following reasons:

- Practice is required to operate a fire extinguisher safely and efficiently. You'll lose valuable firefighting time if you have to stop and read instructions.

- You could injure yourself or others by using an extinguisher improperly.

- An average fire extinguisher discharges all its contents in only 12 to 60 seconds, so you need to make the best use of every bit of the agent.

In order to be effective, portable fire extinguishers must be readily available during a fire emergency. Thus, extinguishers must be installed close to all potential fire hazards, they must contain the proper type of extinguishing agent for those hazards, and they must be large enough to protect the designated area. The fire hazards present in a shop will need to be evaluated carefully so that the proper number and type of fire extinguishers can be installed.

Before you attempt to extinguish any fire, take these actions:

- *Quickly evaluate the size of the fire*. You must be aware of the size of the fire and its rate of spread before you attempt to put it out with an ordinary extinguisher. A fire in its beginning stages is called an *incipient fire*. A fire is considered to be incipient if it covers an area of 2 to 4 square feet, has flames that are fewer than 2 feet in height, and produces low levels of smoke. Fire extinguishers can be effective for extinguishing or suppressing incipient fires. However, it's no longer safe to use a fire extinguisher after a fire passes the incipient stage. Instead, evacuate the building and call the fire department.

- *Locate the exit and the escape route you'll need to take*. Keep the location of the exit in mind as you fight the fire to prevent yourself from getting trapped.

- *Look at the fire to determine which way the flames are moving, and approach the fire from the opposite direction*. The flaming side of the fire will throw off too much heat and the fire could overtake you before you have a chance to escape. By approaching from the opposite side, you'll be safer and able to get closer to the combustion zone.

Once you've taken these preliminary steps, you're ready to use an extinguisher. A standard self-expelling fire extinguisher is shown in Figure 58. To operate such an extinguisher, follow these steps:

Step 1: Remove the extinguisher from the wall.

Step 2: Grasp the handle of the extinguisher and pull out the safety pin.

Step 3: Free the hose and aim the nozzle at the fire.

Step 4: Squeeze the handle.

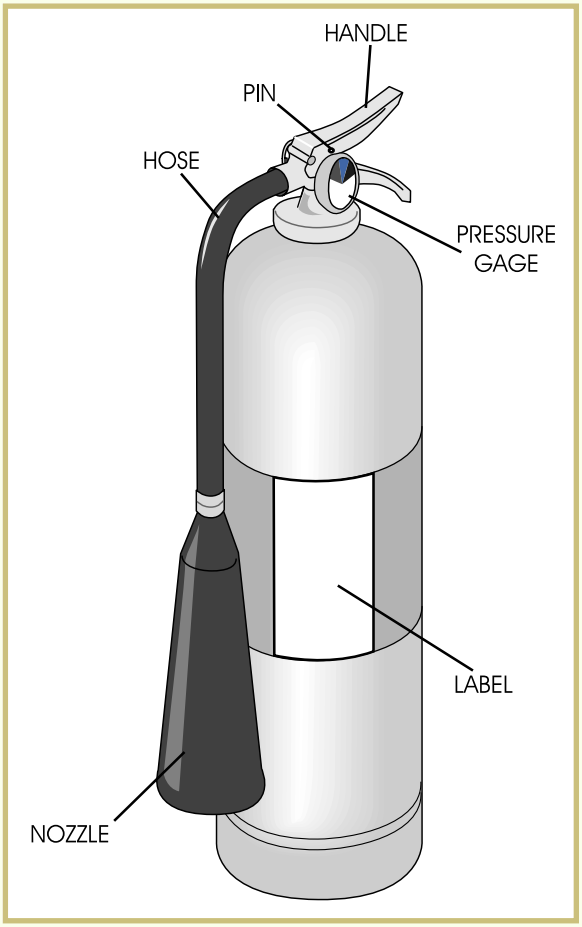


FIGURE 58—The basic parts of a typical self-expelling fire extinguisher are shown here. The label lists the types of fires that the extinguisher can put out.

Step 5: Move the nozzle in a sweeping motion to distribute the extinguishing agent.

You can use the keyword PASS to help you remember how to operate an extinguisher. The letters in PASS stand for Pull (pin), Aim, Squeeze, and Sweep. These words will help remind you of the steps needed to operate an extinguisher.

Always direct the stream of extinguishing agent at the base of the flames. This area is called the *combustion zone*, and cooling this area will extinguish the fire quickly. Sweep the stream from side to side, and work your way around the fire until it's completely extinguished. Remember, never turn your back on a fire until you're absolutely sure it's extinguished. Heat can remain inside partially burned materials and reignite the material later if enough oxygen reaches it.

Portable fire extinguishers should undergo a complete maintenance check every 12 months. Maintenance may include recharging or pressure-testing the extinguisher. Most fire extinguishers require pressure-testing every five years. Fire extinguishers should also be inspected at least once every 30 days to answer the following questions:

- Is the extinguisher in its designated place, close to possible fire hazards?
- Is the extinguisher clearly visible?
- Is the access to the extinguisher free of all obstacles?
- Is the extinguisher full?

It's also a good idea to install battery-operated smoke detectors and carbon-monoxide detectors in any type of building. Remember, smoke detectors require some maintenance. Check the detectors and their batteries frequently to be sure they're in working order. Replace batteries yearly, and replace your detector if it shows any signs of malfunction.

The following are some important fire evacuation procedures that you should be aware of. It's a good idea to practice these procedures in regularly scheduled fire drills.

- *Get out fast*. Believe the alarm when you hear it. Don't waste time trying to verify that there's a fire or trying to gather things before you leave.
- *Stay low to the floor to avoid smoke and toxic gases in the air.* The clearest air is found close to the floor, so crawl if you have to. If necessary, cover your mouth and nose with a damp cloth to help you breathe.
- *Don't open a closed door without feeling the surface first*. If you open a door and flames are present on the other side, they could flare up through the open door and burn you. Instead, use the back of your hand to feel the door (to avoid burning your palm). If the door feels warm on your side, the temperature is probably far above the safety level on the other side. Use an alternate escape route.
- *Never enter a burning building*. The deteriorating conditions inside could be fatal. Professional firefighters are equipped with special protective equipment and breathing devices that allow them to enter a burning building safely, and they're trained in search and rescue techniques. Leave these tasks to them.
- *If your clothing catches fire, don't panic*. Stop, drop to the ground, and roll around to smother the flames. If a coworker's clothing catches fire, quickly wrap the person in a blanket, rug, or carpet to smother the flames.

Chemicals

Do you work with or around any chemicals? Don't answer until you read further. Many people are unaware that some familiar, everyday materials and products in their work areas are dangerous chemicals. Common materials such as paints, lubricants, degreasers, cleaners, solvents, oils, and gasoline are all potentially dangerous chemicals.

The label on a chemical container usually lists the name of the chemical and any hazards associated with it. It also highlights health hazards, such as whether the chemical can irritate eyes and skin, or whether the chemical's fumes are dangerous to the lungs. Many labels also include first aid procedures, the name and address of the chemical manufacturer or importer, and specific ingredients of the chemical that may cause problems.

Chemicals can cause a variety of serious health problems (or even death) when humans are exposed to them. For example, chemicals can produce gases and vapors that are poisonous when inhaled. Some chemicals are highly flammable or even explosive when exposed to sparks. Others can cause temporary or permanent blindness if splashed in the eyes. Everyone should take the potential hazards of chemicals seriously. So, when working with chemicals in your shop, always follow the safety precautions on the chemical's label and protect yourself when necessary with gloves and eyewear.

Naturally, most chemicals in the workplace aren't life-threatening, although they can cause minor injuries or illnesses. For example, one common problem that chemicals can cause is a skin ailment called *contact dermatitis* or *eczema*. Contact dermatitis usually starts as redness in the area of contact, and may progress into blistering, scaling, and cracking of the skin surface. People who regularly expose their hands to solvents such as detergents, cleaners, degreasers, oil, and gasoline are especially likely to develop dermatitis. While contact dermatitis isn't a life-threatening condition, it's highly uncomfortable and could lead to other health complications such as infection. The condition is much easier to prevent than to cure, so it's important to wear gloves when you're using chemicals.

Exposing the skin to stronger chemicals can cause more serious injuries. For example, exposure to acids and strong bases can cause immediate burns to the skin. The storage batteries that are used in most automobiles contain strong and dangerous acids. Sulfuric acid, which is found in storage batteries, is a particularly dangerous acid you should be aware of. Such acids can eat through clothing, burn your skin, or even cause blindness if they're splashed in the eyes. In addition, batteries give off dangerous hydrogen gases when they're being charged. Always use extreme caution when handling, storing, replacing, charging, or adding water to storage batteries.

Follow these safety guidelines when handling batteries:

- Keep batteries upright to prevent acid from spilling or leaking out.
- Always use a battery strap to move a battery.
- Never charge a frozen battery—it could explode.
- Always wear gloves and goggles when handling a battery to protect your skin and eyes.

Electricity

Electricity is all around us, but we sometimes forget that it has the potential to cause serious injury or even death under certain circumstances. The main hazards of electricity are electric shocks and burns. Electric shocks and burns result from faulty power tools or equipment, a disorderly work environment, or a worker's error. Even if you don't work with electric installations or equipment on an everyday basis, you should be aware of how shocks can occur.

Usually, for an electric shock to occur, you must be standing on or near a conductor or a conductive surface. (*Conductors* are metallic materials that allow electricity to pass through them easily.) If you're standing near a conductor and you come in contact with a source of electricity, the electricity can pass through your body to the conductive material and then to ground (the earth). In such a situation, your body has acted as a "switch," closing and completing an electric circuit. The sensation you feel is an electric shock. The shock could be mild or severe, depending on the circumstances and the source of the electricity. If you're lucky, you may just experience a brief unpleasant sensation. If you're unlucky, you could be seriously injured.

The important thing to remember about electricity is that it will always find the quickest, easiest path to ground. That is, electricity always travels on the path of *least resistance*. Normally, electricity travels through its regular circuit of conductor wires. However, if you touch a piece of electric equipment or a conductor that contains *live electricity* (that is, the power source is on), the electricity may find it easier to travel through your body than through its normal circuit. As a result, you'll receive a powerful electric shock that could injure or even kill you.

The type of power source involved greatly affects the severity of an electric shock. There are two types of electric power sources: *alternating current (AC)* and *direct current (DC).* AC current flows in alternating cycles, from on to off. DC current is continuous and steady. AC current is

used to run lighting circuits and appliances in most households and workplaces. DC current is used in storage batteries and battery-powered electric systems, such as automotive electrical systems.

As an automotive technician, it's important to be aware that DC current can cause more serious shocks than AC. Remember, DC current is continuous while AC current cycles on and off. So, if you're shocked by AC current, you'll be able to pull your hand away at the moment the current hits the "off" cycle. However, a shock from a DC power source can hold you and prevent you from pulling your hand away. This can result in a more serious injury.

To prevent electrical accidents, always keep your work area clean and orderly. Floors should be kept clean and dry, since a wet or damp floor will make anyone standing on it more conductive. All portable electric equipment (machines that have plugs and cords) should be inspected before each use to ensure that the equipment, cord, and plug are in good condition. If you feel a slight tingle or shock while using a piece of equipment, stop using it immediately. This is an indication that electric energy is escaping from the machine.

To further prevent injury to yourself, avoid wearing conductive metals on your person (such as watches, chains, and rings) when working with electricity. These metal objects make the risk of shock greater. Increase your resistance to electric current by wearing gloves, standing on an insulating rubber mat, and using tools with insulated handles that are designed to be used with electric equipment.

Exhaust Gases

Whenever an engine is running, it creates exhaust gases that are hazardous when inhaled. The most dangerous of these gases is carbon monoxide. Carbon monoxide is a product of burning and is often present in garages and around heating equipment. It's colorless, odorless, and tasteless, so you can't see it or smell it when it's present in the air. When inhaled, carbon monoxide passes into the bloodstream and prevents red blood cells from carrying oxygen. As a result, the body will suffocate. Even small amounts of carbon monoxide can make you ill (or even kill you).

To prevent a buildup of dangerous carbon monoxide fumes, adequate venting is necessary. In addition, carbon monoxide detectors should be installed in the work area. These devices are much like smoke detectors and can be purchased at most hardware stores. In addition, always follow these precautions when operating an engine:

- Never operate an engine in an enclosed area. Make sure that your workshop has proper ventilation, and pipe exhaust gases to the

outside if necessary. OSHA can provide detailed information about ventilation safety requirements for buildings and work areas.

- When you're operating an engine (even if your shop is well ventilated), avoid directly breathing in the fumes.

- Never operate an engine too close to a residential building. Exhaust gases could seep in through cracks under a door or through an open window and suffocate those inside. If your workshop is located in an attached garage, you'll need special ventilation precautions.

Operation of Equipment

All automobiles have moving parts and other components that can present hazards to the technician. The careless operation of equipment can not only cause serious injuries, but it can also damage your workshop and your tools. To avoid accidents when operating equipment, follow these safety guidelines:

- Read the manufacturer's instruction manual carefully before operating any unfamiliar piece of equipment.

- Never start a vehicle unless the machine has been shifted into park or neutral and the emergency brake is applied.

- To prevent the machine from starting by accident when you're working on it, disconnect the ignition system before starting work.

- Keep your hands, fingers, and sleeves away from any moving parts that could catch them and cause an injury.

- Keep visitors and customers (especially children) away from work areas. Post appropriate signs to warn customers of hazards.

- Remember that the exhaust areas of a machine get very hot during operation. Keep hands, feet, and loose clothing away from this area when an engine is operating, and for a while after the engine stops.

Good Housekeeping Practices

Now that we've discussed some of the hazards that may be present in an automobile repair shop, let's look at some of the ways you can prevent accidents. One of the most important parts of any safety and accident prevention program is good housekeeping. This means more

than just tidying up. The most important functions of housekeeping are the control of material handling and storage, and the control of waste disposal.

Workbenches and work areas should be kept clean and organized at all times. You should clean your work area every day or after each job is completed. Keep any workbenches or tables clean, and don't allow combustible debris such as paper, cardboard, string, or rags to accumulate on or under the bench. If you need to use combustible materials or flammable liquids, use only the amount of material you need to complete a task and return the rest to its proper storage area. Immediately clean up any spilled materials from floors and benches. Sweep floors daily to eliminate buildups of combustible dirt, dust, and lint.

Store flammable liquids such as gasoline and solvents in a cool, dry area away from heat and ignition sources. Avoid storing flammable liquids or other chemicals in direct sunlight, heat, or humidity, and make sure that the storage area is well ventilated. Check storage areas frequently for container deterioration, corroded caps, and leaks.

Properly label all flammable liquids and other hazardous materials. If a substance is transferred from its original container to another container, the second container must also be properly labeled. Use portable *safety cans* for transporting small quantities of flammable liquids (Figure 59). These cans are fire-resistant and have self-closing lids.

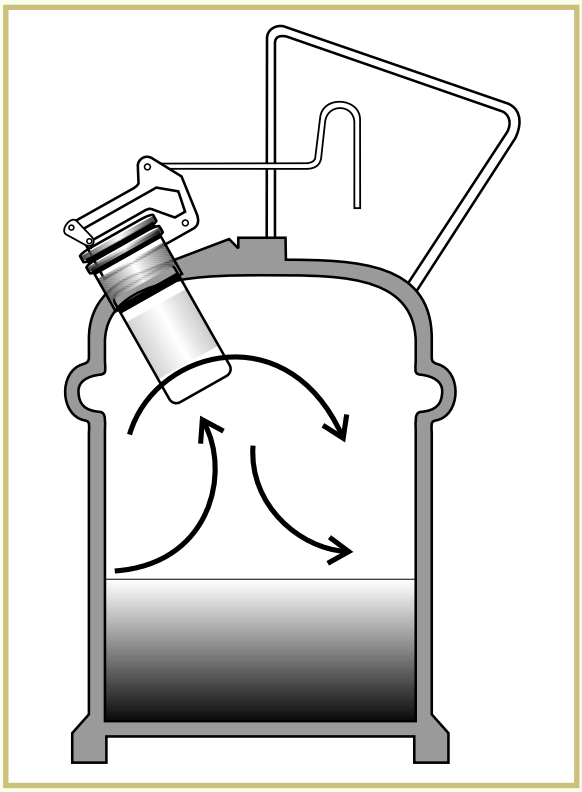


FIGURE 59—Use safety cans to transport small quantities of flammable liquids.

Never leave cans of flammable liquids lying around when they're not in use.

Small amounts of flammable liquids sometimes leak or spill around machines and equipment. For this reason, drip pans should be placed under motors and vehicles that leak cutting oils or lubricants. Drip pans should be made of noncombustible materials and should be large enough to contain the expected amount of liquid. If a vehicle has a persistent leak, place an absorbent, noncombustible material in the pan to soak up the liquid. Empty drip pans and dispose of oil-soaked compounds regularly.

Proper garbage disposal is another important concern for auto repair shops. Dry combustibles should be discarded on a regular basis and never allowed to accumulate in one area. Place combustibles in metal containers, preferably with lids. These lids help to contain and snuff out any fire that may start inside the containers. When smaller containers are emptied, the accumulated waste should be stored in a large metal dumpster with a lid. Dumpsters should be located in a remote area away from heat sources.

It's a good housekeeping practice to separate clean combustible wastes from dirty combustible wastes. Examples of "dirty" combustibles include papers, rags, and work clothes that are soaked with oil, grease, or solvents. These materials are more flammable than clean materials and should therefore be placed in separate metal containers with tight-fitting lids (Figure 60). Have oily rags and work clothes laundered by professional industrial cleaners.

FIGURE 60—Place oily rags and other combustible wastes in metal safety cans to await disposal.

Note that used liquids that are contaminated with dirt, grease, oils, solvents, or degreasers are classified as hazardous wastes and must be disposed of accordingly. *Never* empty such liquids into a sink or dump them on the ground! The handling and disposal of hazardous wastes are regulated by the federal, state, and local laws. Always follow these rules when disposing of waste liquids.

Handling Heavy Objects and Materials

Material handling (moving materials from one place to another) is a concern for all occupations, since this task has serious hazards associated with it. Every workplace requires some sort of material handling. In an auto repair shop, you may need to move or lift whole engines, packages of supplies, pieces of equipment, and so on. Some of these items may be very heavy. Poor material handling techniques can lead to a variety of injuries, including back injuries, twisted or sprained muscles and joints, hand injuries, and foot injuries. Faulty material handling can also result in damaged equipment, tools, and facilities.

Back injuries are the most expensive of all injuries, and they're most commonly caused by poor material handling techniques. Most back injuries occur when workers aren't used to lifting, don't know the proper techniques to use when lifting, or have back muscles that are out of shape. Some workers know how to lift heavy items properly, but they ignore proper techniques in an effort to get a job done more quickly. In order to prevent injuries, always use the following lifting techniques:

- Be sure that the weight of the load isn't beyond your capacity to lift. Usually, loads of more than 50 pounds require the assistance of a second person.
- Check that the path of travel from pick-up to drop-off is clear of obstacles.
- Get a good grip on the item to be lifted. Wear gloves to improve your grip if necessary.
- Stand close to the load to be lifted.
- Bend from the knees (squat) when lifting a load and setting it down. Bending from the waist places more stress on the lower back.
- Lift with a smooth, controlled motion.
- Don't twist from the waist to place the load after lifting. Instead, turn your entire body and walk to set a load in place.

FIGURE 61—Heavy loads should always be lifted using the legs rather than the back. Get close to the object to make lifting easier.

- Use caution when placing a load above chest height or below knee height. You put more strain on the lower back in those positions.

Figure 61 illustrates the proper technique to use when lifting a heavy load.

Other methods can also be used to properly lift loads of different sizes and shapes. Other pointers to prevent back injury when lifting materials include the following:

- Use chain hoists, cranes, hand trucks, carts, or dollies to lift or move heavy items. These lifting aids take the burden of the weight off you and protect you from injury.
- Try wearing a back support belt to protect the back muscles.
- Always get help to move loads that are heavy or of an awkward size or shape.
- Stretch your back and arm muscles before lifting. Stretching warms up the muscles and helps prevent muscle strains, pulls, and tears.
- Keep your back and stomach muscles in good shape. Workers who regularly lift materials at work need to have strong back and stomach muscles. Lack of muscle tone could lead to a severe injury.

Jacking and Lifting

To make repairs on an automobile, it's often necessary to lift the car up off the floor so that you can work underneath it. Special equipment is used to lift vehicles and to support them safely once they're raised. In

this section of your text, we'll look at some of the different devices that are used to jack up or lift vehicles off the floor.

Ramps

One of the most basic devices you can use to raise a vehicle off the floor is a set of ramps. Ramps are placed in front of the vehicle's wheels. Then, the vehicle is simply driven up onto the ramps to raise the vehicle and provide access to the underside of the car. Car ramps are very easy to use, but they do have some limitations. For example, car ramps can only be safely used on level, paved surfaces. Ramps should never be used on dirt or grass, since they may sink down into the ground and be unable to support the vehicle safely. The other limitation is that a vehicle's wheels or tires can't be removed when it's on ramps, because the vehicle's tires are resting directly on the ramps.

Hydraulic Jacks

The most common method of lifting a car is to use a *hydraulic jack* (Figure 62). A hydraulic jack uses hydraulic pressure to raise a vehicle. The lifting plate of the jack is placed under the proper lift point of the ve-

FIGURE 62—The hydraulic jack is the most common device used to raise a car off the floor for servicing.
(Courtesy of Snap-On Tools Company, Copyright Owner)

hicle, and the jack handle is then pumped up and down to raise the vehicle off the floor.

The point where the jack is placed under the vehicle is very important. If the jack is improperly placed, the vehicle may fall off the jack when you try to lift a car, causing serious damage to the vehicle, or worse, injuries to workers. The locations where a jack can be safely placed under a car are called the *lift points*. In most cases, the lift points are located on a vehicle's frame or under the suspension system. The location of the lift points will vary depending on the make and model of each vehicle and will usually be listed in the vehicle's service manual.

Note that the jack pictured in Figure 62 isn't the only type of jack in use. There are many different types of hydraulic jacks, from very small to very large. Some jacks operate on air pressure, while others use hydraulic pressure. Jacks that operate on air pressure are activated using a machine called an *air compressor*. Air compressors are electric or gas-powered machines that produce the pressurized air needed to operate lifts, inflate tires, and run impact wrenches and other shop tools.

Small jacks have some disadvantages. For example, they only allow one area of the car to be lifted at a time. In addition, the jack can only raise the vehicle a few feet off the ground, which allows a limited amount of work space.

Safety Stands

A car that's supported only by a jack isn't safe—it could easily slip off the jack and cause serious injury or death. For this reason, no matter what type of jack you use to lift a vehicle, *safety stands* (also called *jack stands*) must be placed under the vehicle after it's jacked up. After the safety stands are placed under the vehicle, the jack is lowered to allow the weight of the vehicle to rest on the safety stands.

Before you attempt to move underneath a raised vehicle, always make sure that jack stands are in place. It's also a good idea to shake the vehicle slightly to be sure that the stands are properly in place. Only then should you consider it safe to move underneath the vehicle.

A typical set of automotive safety stands is shown in Figure 63. These stands are rated according to the amount of weight that they can support. Never exceed the rated weight of the stand. If you try to place more weight on the stands than they're designed to hold, they could collapse. Also, never use anything to support a car except safety stands that are designed specifically for this purpose. For example, never substitute boxes, bricks, wooden blocks, or any other objects for safety stands. Objects such as these can slide, collapse, or break, and therefore fail to support the vehicle.

FIGURE 63—A typical set of safety stands is shown here. (Courtesy of Snap-On Tools Company, Copyright Owner)

To safely support a vehicle, safety stands must be carefully placed in the proper support locations. In most cases, safety stands should be placed under a vehicle's frame. The car manufacturer's service manual will indicate the best location to place safety stands.

Vehicle Lifts

The small hydraulic jacks we described earlier can only lift one part of a vehicle off the floor at a time. In order to lift an entire vehicle, a special piece of equipment called a *lift* must be used. Lifts can raise an entire vehicle very high in the air—high enough so that a technician can simply walk underneath to make repairs.

Lifts are definitely the best way to lift a vehicle; however, they're very large and quite expensive. A lift can cost thousands of dollars and must be permanently mounted to the floor of a garage. In addition, the garage must have a high enough ceiling to allow the vehicle to be raised up. For these reasons, lifts are usually found only in larger repair shops. Most smaller shops simply use small jacks to raise vehicles for repairs.

When using a lift, be sure to follow the manufacturer's directions. Each type of lift is operated differently, but in general, the following procedure is used. First, the vehicle is driven over the lift. The lifting pads are then placed to pick the vehicle up at its proper lift points. The lift control is then used to lift the vehicle up to the desired height. In most cases, a lift will have its own built-in safety support, so safety stands aren't needed.

Using Personal Protective Equipment (PPE)

One of the most important ways you can prevent injury in the workplace is to use *personal protective equipment (PPE).* PPE includes items such as dust masks, safety glasses, gloves, and special footwear. Remember that any task can be hazardous, even if equipment is operated properly and safety procedures are followed. Personal protective equipment should be worn wherever the potential for injury exists. The type of PPE you need will vary depending on the tasks you perform.

Protecting Your Eyes and Face

Protective safety glasses and goggles come in a wide variety of styles to meet specific worker needs. Safety glasses with *side shields* provide more protection from impact and flying particles. Most safety glasses and goggles may be worn alone or over a worker's own prescription eyeglasses.

Splash goggles protect the eyes from dust, particles, and chemicals. They may contain ventilation holes that allow air circulation. *Welding glasses* are tinted or darkened lenses that protect the eyes from the bright flashes of welding arcs. A *face shield* is a cap-like device that holds a clear plastic shield over the face. A face shield provides protection for the entire face against chemical splashes and flying particles. Figure 64 shows several types of eye protection devices.

In recent years, many people have begun wearing contact lenses to work instead of eyeglasses. Contact lens wearers must determine when it's appropriate for them to wear their contacts based on their workplace environment. If the workplace contains a lot of flying dirt or dust particles or if chemical fumes are present, wearing contact lenses isn't a good idea. In any case, remember that the only function of contact lenses is to correct your vision. Contact lenses *do not* protect the

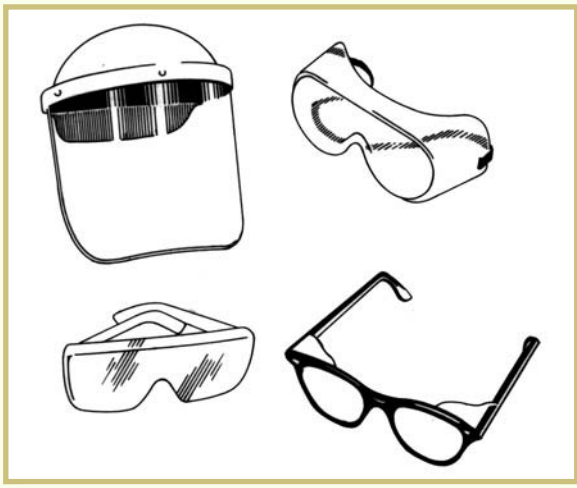


FIGURE 64—These are some of the most common types of eye protection devices in use.

eyes in any way from dust, impact, or splashes. You must still wear eye protection devices such as goggles or face shields over the eyes.

Protecting Your Lungs

Respiratory protection devices can prevent you from inhaling harmful dusts, gases, or vapors. Any employee who could be exposed to chemical fumes, dust, or any other irritants in the air should wear respiratory protection. A typical *dust mask* is a small, fabric-like filter with straps that slip over the face to cover the nose and mouth. Dust masks are designed only to shield the mouth and nose from dust particles.

Respirators are more substantial devices than masks. Respirators are made of heavy plastic, metal, and safety glass. They offer a higher level of protection than dust masks and come in a variety of styles. Respirators are designed for use where chemical fumes or vapors are present, or where the oxygen supply is insufficient for humans to breathe.

Protecting Your Hearing

Without using a sound-level meter, how can you tell when you're in a high-noise area? Well, if another worker is standing three feet away from you and you can't have a conversation unless you shout, the work area is too noisy.

Hearing protection should always be worn in areas with a high noise level. If you work eight hours a day in such an environment without wearing hearing protection, over a period of years you'll experience a hearing loss. If the noise level is severe, you may suffer a hearing loss more quickly. You should always wear earplugs or headsets in noisy areas or when you're using noisy tools. Remember, there's no cure for noise-induced hearing loss. The prevention of excessive noise exposure is the only way to avoid hearing damage.

Some earplugs are disposable, to be used once and thrown away. Others are intended to be cleaned and used repeatedly. Preformed or molded plugs should be individually fitted by a professional.

Protecting Your Feet and Legs

Injuries to the toes and feet can also occur during material handling, usually when heavy materials or tools are dropped. To prevent these injuries, it's a good idea to wear steel-toed shoes or boots whenever you're working in your shop. Various types of steel-toed shoes are available to provide different levels of protection. You can also attach *metatarsal guards* (special covers that go over the instep) to your shoes to protect your feet.

Protecting Your Hands and Arms

Gloves, *gauntlets*, and *sleeves* protect the arms and hands from chemical splashes, heat, cuts, and tool-related injuries. Gloves are made from a variety of plastics and rubbers such as nitrile, natural rubber, and neoprene, as well as from leather and heavy cotton. Special gloves may also be designed to resist tearing, cuts, and punctures. Gloves come in a variety of lengths to cover the hand, wrist, elbow, or entire arm, depending on the function required.

Using Tools Safely

According to the National Safety Council, more than 500,000 disabling, work-related finger and hand injuries occurred in a recent year. The careless use of simple hand tools like screwdrivers, wrenches, and hammers is responsible for many of these injuries. The most common hand and finger injuries are impact injuries (bruises, sprains, broken bones), cuts, and puncture wounds caused by the improper use of hand tools. This "improper use" may mean using the wrong tool for the job, holding or using the tool incorrectly, or using a damaged tool.

Auto repair technicians use dozens of different hand tools daily. By caring properly for your tools, you'll extend their useful life and also prevent accidents and injuries. To keep your tools in top working order and to prevent injury to yourself and your fellow workers, observe the following safety precautions:

- Always use the right tool for a job. Don't try to substitute one tool for another.
- Inspect hand tools often for defects. If you find a defective tool, repair it or replace it.
- Comply with the manufacturer's instructions when using a tool. Follow instructions for the tool's use and maintenance.
- Never toss a tool to someone. Hand tools should be passed from one person to another by hand.
- Keep tools clean. Protect the tools from corrosion by wiping them clean when finished with them. Regularly lubricate all tools with moving parts, such as pliers or adjustable wrenches, to prevent wear. Store tools in a dry and secure location.
- Keep the cutting edges on tools sharp. Sharp tools are more accurate, and they save time.

Power tools also have certain hazards associated with them. Common power tools that are used by an auto repair technician include drills, impact wrenches, and grinding wheels. Electric power tools have three properties that can make them dangerous: electrical charge, high-speed movement, and momentum. The most important area of concern when using power tools is *electric charge*. To avoid an electric shock when using a power tool, you must isolate and insulate yourself from electric current. Do this by taking the following precautions:

- Make sure that power tools are properly grounded.
- Inspect power tools often for faults in their wires. Visually inspect all cords, plugs, receptacles, and any equipment connected to them. Have qualified electricians replace all faulty cords and plugs.
- Always unplug tools before replacing bits, blades, or grinder wheels.
- Never operate a power tool in a wet or damp area.
- Wear gloves to protect yourself from shocks. If you ever feel a shock or "tingle" when using a power tool, stop using it immediately.
- Use extension cords that can carry the rated current of the power tools. An undersized extension cord can cause damage to the tool.

High-speed movement is another area of concern when operating power tools. Avoid contact with any rotating tool part, since the part could grab and tear or trap your hands, hair, or clothing. To prevent this, keep all safety guards in their proper positions when operating power tools such as saws, grinders, and drills. When drilling metal, be aware that friction from the high speed will produce sharp, hot shavings. Also, note that if a drill becomes jammed in a workpiece, the momentum of its moving parts may cause it to spin out of control. To avoid being injured by a tool's momentum, you should remember the following guidelines:

- Hold all tools firmly. Pay attention to any sounds that may indicate a tool is about to jam.
- Use only sharp cutting bits on all tools. A dull bit will frequently jam.
- Clamp or block all workpieces tightly to a firm work surface. Don't use your hands to hold the materials in position.
- Wear the appropriate personal protective equipment when operating electric tools.

- Check tools for potential mechanical failure. For example, check for broken drill bits, broken saw blades, and faulty triggers that cause unexpected start-ups and stops. Make sure the tools have all their guards in place.

Now, take a few moments to review what you've learned by completing *Power Check 4.*

Power Check 4

1. *True or False?* One way to extinguish a fire is to cool the area around it.
2. The two types of electric power sources are alternating current (AC) and direct current (DC). Of these two types, _____ power sources cause more severe shocks.
3. The three elements of the fire triangle are _____, _____, and _____.
4. How often should the batteries in a smoke detector be changed?

   _____
5. Electricity always follows the path of least _____.
6. *True or False?* A Class B fire involves live electrical equipment.
7. How often should a portable fire extinguisher undergo a complete maintenance check?

   _____
8. Water and water solutions are best used to extinguish a Class _____ fire.
9. Poor lifting techniques are a frequent cause of _____ injuries.
10. *True or False?* A Class C fire involves combustibles such as paper, wood, and cloth.

Check your answers with those on page 114.

YOUR CAREER OPPORTUNITIES

What Career Opportunities Are Available?

As an automotive technician, you'll have many opportunities for employment, with each type offering its own advantages. You may choose to work in someone else's shop, your own shop, as a subcontractor, for a dealership, or even as an instructor. Keep in mind that the automotive repair field tends to be "recession-proof," meaning that business tends to be good whether overall economic conditions are good or bad. This paints an optimistic picture for the skilled automotive technician.There are several reasons why the auto repair field presents so many attractive career opportunities. Let's take a look at some of these reasons.

First of all, the universal use of automobiles creates career opportunities for repair technicians in all regions, both urban and rural. Cities that have large populations will have many cars that require maintenance and service. In rural areas, there are fewer vehicles; however, people must travel longer distances to reach workplaces and stores, so they'll use their vehicles more often and rely on them more. Since the average rural automobile is used more often, it will require more maintenance and repairs. Therefore, even though there are fewer vehicles in rural areas, the overall employment opportunities for auto repair technicians are about the same as in larger cities.

Auto repair technicians also have the advantage of being able to pursue their trade year-round. Unlike some seasonal industries (such as construction), automobiles are used and serviced every day of the year. Both hot and cold weather places stress on vehicles, causing them to break down more frequently and require special seasonal servicing. These services include, for example, winterizing in cold weather and more frequent oil changes in hot weather. Thus, the auto repair technician's services are needed during all seasons.

Another factor that affects employment in the auto repair field is new technology. Every year, the new vehicle models offered for sale become more complex. New electronic control systems and components are continually being developed that improve vehicle performance and reliability. However, over the years, some auto mechanics have been unwilling to learn new repair techniques, and some shop owners have been unwilling to invest in the new diagnostic equipment that's needed to service today's vehicles. As a result, more career opportunities have been created for those technicians who are willing to learn new technology. Technicians who can troubleshoot and diagnose problems accurately are particularly in demand.

All of these factors contribute to the growing demand for skilled auto repair technicians. As a result, most auto technicians have the advantage of being able to choose whom they work for. Some technicians prefer to work for someone else, while others run their own businesses. Those technicians who do work for someone else will have many opportunities for advancement. For example, many larger repair shops employ managers who oversee the work of other technicians, schedule the workload, and deal directly with customers. There are also management opportunities in parts departments and vehicle sales.

Many technicians find it helpful to start by working in an established repair business in order to gain valuable experience. As they gain experience, they may gradually take on more responsibility and eventually move to the management level. Other technicians prefer to use their experience to open businesses of their own. No matter where you decide to seek employment, however, you'll be able to draw on the many different skills you'll learn in this program.

Now, let's take a closer look at some of the different places automotive technicians work.

Working for an Established Shop

As a beginning automotive mechanic, you may choose to work in an established auto repair business for a while to gain experience. An established auto repair shop may be independently owned, or it may be part of an automotive dealership. Automotive repair shops vary in size, depending on the type of services that are offered. Some larger shops may have a dozen employees who are assigned to specialized tasks, while smaller shops may be run by just one or two people. No matter what the size, however, most auto repair shops can offer either part-time or full-time employment.

The type of work you'll do will depend on the type of shop you work at and the experience you have. If you have no past repair experience, your first job will probably be at the entry level. Your first assignments may be simple, such as cleaning parts, doing oil changes, and answering the phone. As you gain experience, you'll quickly begin to do service and repair jobs. Later on, depending on your level of skill, you may work your way up to the position of master technician. Or, you may decide to specialize in a particular type of work that you excel at, such as brake repair, transmission repair, engine rebuilding, or collision repair. (A check of your local Yellow Pages listings will give you some idea of the types of specialized shops there are in your area.) Finally, if you so desire, you may advance into a management position, overseeing the work of others in the shop.

General Service Technicians and Specialty Technicians

Automobile repair technicians are often classified by the type of jobs they perform. These two job classifications are called general service technician and specialty technician.

A *general service technician* is a person who can repair just about any type of mechanical problem that occurs in a vehicle. This job will include everything from simple oil changes to complete engine rebuilds. A general service technician will therefore need to have a complete knowledge of all automotive systems. For this reason, general service technicians are often certified as master automotive technicians.

In contrast, a *specialty technician* will specialize in repairing only one type of automotive system. The specialty technician, therefore, is often able to diagnose and service the system faster and more economically than a general service technician. For example, a technician who specializes in repairing only brake systems will gain a lot more experience in this area than a typical general service technician. Therefore, the specialty technician will usually be able to diagnose brake problems faster. However, a specialty technician's expertise may be limited to only one system. Therefore, a specialty technician will often not have the experience or working knowledge to efficiently repair all auto systems quickly and efficiently.

The following are some common types of automotive specialists who are employed in larger repair shops and auto dealerships:

- *Lubrication specialist.* A lubrication specialist will lubricate all the moving parts of an automobile and check the oil levels in the engine, transmission, and differential. He or she will also typically check the general condition of the battery, radiator, steering system, shock absorbers, and tires.

- *Tune-up specialist.* A tune-up specialist inspects, adjusts, and repairs automotive ignition systems, carburetors, and fuel injection systems. This specialist may also check electrical system components, such as alternators, starters, wiring, headlights, and so on.

- *Diagnostic technician.* A diagnostic technician is a specialist who uses a written checklist to inspect each vehicle system and record its condition. The diagnostic technician then reviews the overall results of the checks and estimates the cost of needed repairs. These specialty technicians are often employed in shops called diagnostic centers that specialize in this type of repair estimating.

- *Parts specialist.* Larger garages and dealerships that need to maintain a large inventory of parts frequently employ parts specialists.

These specialty technicians are responsible for ordering, inventorying, and distributing parts to other repair technicians in the shop.

- *Brake specialist*. Brake specialists troubleshoot, repair, and replace all types of brake systems. This job requires a lot of experience as well as special training.

- *Transmission specialist*. Transmission specialists troubleshoot, repair, and rebuild all types of transmission systems. This job generally requires extensive practical experience.

- *Front end specialist.* A front end specialist services and repairs steering systems, and also performs wheel balancing and alignment jobs.

- *Electrical system specialist*. This technician will handle repairs on alternators, starters, and electrical wiring, and will also work on electrical accessories such as seat controls, door locks, window controls, and sound systems. An electrical system specialist typically has a strong background in electricity and electronics as well as in auto repair.

- *Passenger comfort specialist*. A passenger comfort specialist installs, troubleshoots, and repairs heating and air conditioning systems in automobiles. This job typically requires special training, but is highly lucrative.

- *Light repair technician*. A light repair technician is often employed by car dealerships to check out and prepare new cars for delivery to their owners. This job involves testing and operating all the car systems to be sure that everything works properly. A light repair technician will also perform checkups that are offered by the dealership or manufacturer after a certain mileage is reached.

Management Opportunities

There are several management positions available in larger repair shops. The most common of these are the positions of service writer and service manager.

A *service writer* (also commonly referred to as a *service advisor*) is the employee who deals directly with customers. In larger shops, it isn't practical for customers to meet directly with the service technicians. For this reason, the shop will employ a service writer whose job is to interact with the customer. The service writer isn't directly involved in repairs; instead, he or she will talk to the customer and then relay the problem to the shop technician. This procedure allows the technicians

to concentrate completely on the repair work and use their time more efficiently. The service writer must have a background in auto repair so that he or she can understand the nature of the customer's complaint and correctly relay the information to the technician who will make the repairs. The service writer may also be responsible for scheduling the workload in the shop.

A *service manager* is in charge of a repair shop's entire service department, and is responsible for the overall operation of the shop. The service manager is usually in charge of hiring, training, and purchasing shop equipment. The service manager's primary duty is to see that the shop is run efficiently and that customers are satisfied with the services performed.

Working as a Fleet Technician

A *fleet technician* is employed by a company to service all the vehicles owned by that company. The fleet technician will have a workshop or garage on company property and will be on call to immediately provide services whenever they're needed. Fleet technicians are often employed by delivery companies, taxi services, rental car agencies, corporate headquarters, and government installations.

Operating a Mobile Business

Some technicians who can't afford to open a shop at a permanent location, but who already own a van or pickup truck, may choose the alternative of opening a *mobile business*. In a mobile automotive repair business, the technician takes service calls from customers and then travels to each job. The technician's van or truck is outfitted with all the tools, parts, and materials needed to repair vehicles right on the scene. This type of business is becoming more popular as customers find it harder to find the time to take their cars in for routine maintenance and repairs (such as oil changes, tire rotation, and so on). A technician with a mobile business can perform many of these services right at the customer's home. In addition, mobile auto technicians can easily perform roadside repairs when breakdowns occur. Often, repairing a vehicle on the side of the road is cheaper than paying for both towing and repairs in a garage.

A telephone is a vital part of any mobile operation. Since there's no walk-in business, a mobile shop will be almost entirely dependent on telephone requests for service. The owner may use an answering service or take calls on a cell phone, whichever is more convenient.

A mobile business has the advantages of low operating costs (although there is an investment in tools and supplies) and the ability to help

customers whenever and wherever needed. Since many automotive breakdowns and problems occur on the road away from home, mobile businesses present an excellent profit potential.

Working in Automotive Sales

Automotive repair skills are invaluable if you're interested in a position in sales. The automotive field offers several different types of sales employment opportunities. For example, you may choose to work in vehicle sales in an automotive dealership. Lucrative sales positions are also available in the parts and accessories industries.

Working for Manufacturers and Distributors

Vehicle manufacturers and automotive parts manufacturers often employ automotive technicians in their factories, warehouses, or offices to sell merchandise, stock inventory, and serve industrial clients. The expertise of the skilled professional technician is invaluable in helping customers purchase the right parts and vehicles that they need for a particular purpose. Some creative and talented automotive technicians even work in consulting or designing departments, where they help develop new products for the industry. In addition, a skilled and experienced automotive technician may be in charge of continuing education or training programs for company employees. These company trainers may travel, for example, to local automotive dealerships to train other technicians in how to service the company's products.

Teaching, Instructing, and Writing

Some experienced automotive technicians find employment training others on a full-time basis. You may be hired, for example, by a vocational school to lead classes; or, you may conduct private seminars or lectures for a fee. Also, many automotive publications accept articles and stories from professional contributors. If you enjoy writing, this type of work could provide you with a lucrative source of additional income.

Now, take a few moments to review what you've learned by completing *Power Check 5*.

Power Check 5

1. *True or False?* The auto repair trade is seasonal and can be practiced only at certain times of the year.

2. A technician who is employed by car dealerships to check out and prepare new cars for delivery to their owners is called a _____.

3. In larger auto repair shops, the employee who deals directly with customers and then explains their problems to the repair technician is called the _____.

4. In an auto repair business, the employee who is responsible for hiring, training, purchasing shop equipment, and overseeing the operation of the shop is called the _____.

5. An auto repair technician who performs overall checks of vehicle systems, evaluates their condition with written checklists, and estimates the cost of needed repairs is called a _____.

Check your answers with those on page 114.

BECOMING A PROFESSIONAL

What are the qualities that separate an excellent technician from one who isn't so skilled? The answer is knowledge, training, and certification. The skills you'll learn in this program, combined with some hands-on experience, will be all you'll need to get started in the field. It will also be helpful to obtain certification from a professional organization. Let's look at how you'll go about achieving your goal.

First of all, a technician should have a fairly broad knowledge of all types of automotive systems. This should include an understanding of automotive operation, proper service procedures, and troubleshooting. Most successful automotive technicians have had some formal training in the repair field and, after gaining some experience, have mastered the skills needed to repair all types of vehicle systems.

Just about anyone can learn to replace defective parts. However, a professional training program can change a person from a "parts changer" into a skilled troubleshooter. Troubleshooting skills are the most valuable skills a professional technician can have. The key to learning how

to diagnose problems is the completion of a thorough training program (such as the program you're now taking). By successfully completing such a program, you'll have earned a diploma that tells everyone you're a true professional.

Obtaining Certification

Another excellent way to demonstrate your skills as a repair technician is to complete a certification program. Most such programs are simply "practical exams" that are sponsored by manufacturers or professional associations. These exams are designed to test your skills in various areas of the repair field. When you successfully pass a certification exam, you'll be awarded a certificate that indicates you've met the professional qualifications set by the organization.

In most cases, you won't need to pass a certification exam in order to be successfully employed. When you're just starting out in the field of auto repair, you'll still be learning your trade, and you won't be expected to become certified right away. In fact, many certification organizations require that you have a certain amount of work experience before you can take their exams. Later on, when you gain some experience, you may choose to take a certification exam. A certificate from a professional association is an enhancement to your job skills, and a good way to prove your abilities to customers and prospective employers.

Employers tend to favor certified technicians for employment and job advancement. There are several reasons for this. First, a professional certificate clearly shows that you have knowledge and skills in the repair field. The certificate shows that no matter what your age, level of schooling, training, or experience, you have the hands-on, professional skills needed to do a good job. Certification allows an employer to compare the skills of different job applicants, so a certificate may give you a strong advantage over other candidates for a job. Also, customers tend to be impressed by certified technicians. As a certified technician, you're entitled to wear an insignia on your uniform or coveralls that clearly shows that you're certified. Customers tend to favor businesses that employ certified technicians, so those businesses want to hire certified technicians.

It's important to remember that all the information in this training program has been designed to reflect the content of the *National Institute for Automotive Service Excellence (ASE)* certification exams. The ASE is the largest professional certification body in the United States for automotive technicians. The ASE has worked for many years to improve the quality of automotive service offered and to improve the public's impression of the automotive service field.

The ASE certification system uses voluntary testing and an evaluation of on-the-job experience to confirm that a technician meets professional standards of excellence. A person who successfully achieves ASE certification is considered to carry a professional "seal of approval." The certification provides customers with proof of a technician's ability, as well as a commitment to quality service. An ASE certificate is a nationally recognized symbol of excellence, and employers will view a person who has this certificate as a first-class professional. In fact, some shops will only employ technicians who have ASE certification. These shops will display the blue ASE seal of excellence on their sign. Whether you intend to obtain full-time employment in the auto repair field or not, you may want to consider taking the ASE exam just to obtain this valuable certificate.

To become ASE certified, a technician must pass one or more examinations. The exam questions are based on actual situations, scenarios, and problems that would be seen every day in an auto repair shop. Each separate examination covers a particular automotive service area. You can elect to obtain certification in any or all of the areas. The exams cover some of the following topics:

- Engine repair
- Automatic transmissions and transaxles
- Manual drive trains and axles
- Brakes
- Suspension and steering
- Electrical and electronic systems
- Heating and air conditioning
- Engine performance

In addition, there are ASE exams that cover other special topics, including the following:

- Medium and heavy truck repair
- Diesel engines
- Collision repair and refinishing
- Engine machinist
- Advanced automotive performance specialist

- School bus repair
- Alternative fuels

The ASE sponsors automotive repair certification exams several times a year throughout the entire United States. The ASE recognizes two levels of professional qualification and ability: *automotive technician* and *master auto technician*. You must pass at least one exam to obtain the automotive technician certificate. If you successfully pass all the auto servicing exams, you'll receive a master technician certificate. Every five years after you pass an exam, you must be retested to retain your certificate.

Each ASE test contains between 40 and 80 multiple-choice questions. The exams are written by working auto technicians, instructors, domestic and imported vehicle manufacturers, parts manufacturers, and other industry professionals. The questions are designed to measure your knowledge of troubleshooting and repair skills that you use on the job every day. The questions are practical and completely job-related.

In order to be eligible to take ASE exams, you must have two or more years of hands-on working experience as an automotive technician. However, formal training may be substituted for hands-on experience according to the following guidelines:

- *High school training*. Three full years of high school training in either auto repair or auto body repair and refinishing may be substituted for one year of work experience.
- *Post-high school training*. Two full years of post-high school training in a public or private trade school, technical institute, community or four-year college, or in an apprenticeship program may substitute for one year of work experience.
- *Short training programs*. For other formal training programs, two months of training may be substituted for one month of work experience.

So, if you're just starting out in the automotive field and want to achieve ASE certification, you can see how formal training can be very useful in reaching your goal.

You should be aware that some states and local municipalities have their own licensing requirements for automotive technicians. Since these regulations are now in place in only a few areas and the requirements change frequently, we suggest that you contact the appropriate agencies in your state and local area to see if there are any special requirements for automotive technicians.

Personal Skills

Qualified automotive technicians come from all walks of life and from a variety of age groups. Anyone who is willing to learn the job can become a professional auto technician. However, you can develop a personal advantage in the job market by being energetic, ambitious, and self-confident. If you want to be self-employed, you'll also need to develop a commitment to making it on your own. There are challenges in being your own boss! However, if you have ambition, communicate well, and are willing to work hard, we have no doubt you'll succeed.

Virtually anyone who is willing to work hard to learn the job can become an automotive technician. However, learning to communicate with other people isn't always as easy. Developing what are known as "people skills" is as much a part of automotive repair as any other business. People skills are communication skills that strengthen understanding between persons.

High on the list of these skills are consideration, sincerity, courtesy, patience, and the ability to relate to and understand the problems of others. Any previous experience you've had in dealing with the public will be a definite asset to your automotive repair career. You'll use your communication skills every day when dealing with customers, prospective employers, manufacturers' representatives, employees, and phone callers. Good communication skills are as much of an asset to your career as excellent technical skills.

Professional Image and Conduct

Did you know that a person will, upon meeting you, form an opinion of you within just a few minutes? Once their opinion is formed, whether good or bad, it will be hard to change it. For this reason, it's very important that you always look and act like a professional. That way, you'll make an excellent impression that inspires confidence in both prospective employers and your customers.

The pursuit of excellence sets a fine technician apart from an average one. Paying attention to detail is one important way to provide excellent service. You'll inspire confidence and loyalty in your customers when they perceive you to be honest and skilled in the way you conduct your business. Let your excellent work and professional manner speak for themselves, and you'll get all the business you can handle.

Remember, as a skilled professional, you should always make an effort to maintain a professional appearance. No one is saying that you need to look like a fashion model, but you should make it a habit to dress neatly, practice good grooming, speak pleasantly, and keep your tools neatly organized. If you own your own shop, keep your work areas and office well-organized and attractive. These qualities are very important

to prospective employers, especially in larger businesses that have many customers. An unkempt appearance detracts from your professional image and may even cause you to lose business. No matter how good your work is, your customer may think that you neglect your job as much as your appearance, and it will be difficult to change the customer's impression of you.

Offering Outstanding Service

When you begin your career as a professional, remember this old saying: "Customers are not an interruption of our business; they are the reason for it." For this reason, the most important part of your job as an automotive technician will be to provide excellent service to your valuable customers. Let's look at a few ways that you can offer outstanding service.

1. *Offer immediate service.* Speedy and efficient service is essential in the automotive repair field. Very few businesses provide such a need to get things done quickly. When a car won't run, its owner can't get to work or to any of the other places they need and want to go. Long delays in repairs don't fit in well with today's busy schedules. A technician or business who can get a job done quickly and properly will get more business than he or she can handle.

2. *Use quality parts and supplies.* Build your reputation as an excellent technician by using reliable parts and supplies. Good quality parts are durable and dependable. Even if you're the best automotive technician in town, if you use cheap or poorly made parts, your jobs will return to haunt you later! Always do a job right the first time.

3. *Be knowledgeable about vehicles and related products.* As a professional technician, you'll frequently be called upon to offer advice to your customers. In order to do this, you must be knowledgeable about the variety of vehicles that are on the road today. Take some time to study manufacturers' catalogs, popular automotive magazines, and professional journals. Visit automotive dealerships to look at new vehicles and judge their quality and features for yourself. This knowledge will be invaluable to you when you're making recommendations to your customers. Keep current on new developments in automotive technology, performance, and safety features.

4. *Set competitive prices.* Your prices will depend on two factors: the economic conditions in the area where you conduct business and what the competition charges. The public may be willing to pay more for excellent service. However, make sure that you always give customers their money's worth if you want to attract repeat business.

5. *Offer more services than your competitors.* A knowledgeable automotive technician who knows how to do a wide variety of jobs (and who has the tools needed to do them) is invaluable. Because of the many different makes and models of vehicles on the road today, many professional automotive technicians offer only a limited number of services. This is particularly true in larger cities where many automotive technicians are available. In a smaller community, however, you may need to offer more than just basic maintenance and repair services. Your customers may have nowhere else to turn if you're unable to help them. Every time that you turn down a job that you don't know how to do, you're losing a valuable customer. For this reason, you should take the extra time to learn more and improve your existing skills. The sweetest words a customer can hear are: "Yes, I can fix it for you. No problem!"

Case Studies

Now, let's take a look at three case studies that illustrate the goals of some typical students. Although they started out with very different educational goals, all three of these students were able to take the knowledge they gained from the automotive repair program and quickly put it to good use.

Case Study #1: Professional Certification for Career Advancement

Ramon Palacio is a 45-year-old automotive technician who has worked in the auto repair field for more than twenty years. Ray learned his trade on his own years ago and has never had any formal training. Today, however, he is beginning to see an increasing emphasis on formal education and professional certification. More and more of the employees at the shop where he works are getting ASE certifications, and his supervisor is strongly encouraging him to do the same. Ray's supervisor feels that customers will have more confidence in the shop's work if all the technicians are ASE certified.

Ray realizes that he can't put it off any longer—he must look into becoming certified. However, he begins to wonder if he has the skills needed to pass the certification exam. Sure, he has years of on-the-job experience, but without any formal training, Ray worries that he won't be able to demonstrate his knowledge on paper. In addition, Ray feels that he could really use some additional training to bring him up-to-date with the latest computer control systems. Currently, another technician in the shop does most of the repairs to computer control systems—Ray doesn't have a lot of experience working with them.

Knowing that he wants to be fully prepared before he tries to take the ASE certification exams, Ray decides to look into formal training. He quickly decides that a home study program on auto repair will give him just the training he needs, especially since the program includes all the topics that will be covered in the ASE exam.

Ray begins working on the home study program during his spare time. He discovers that he can move quickly through the topics that he knows well, but slow down and take his time to carefully study the material that he needs to learn better. The program helps him to pinpoint his weak areas so that he can improve them. This flexibility allows him to quickly update his skills.

After completing the program, Ray is pleased to find that even with his years of experience, he has learned many things he didn't know before. The program has given him new confidence in his skills, because he knows that he learned about topics that will be covered in the ASE exams. He has gained valuable experience in taking exams, and has a program diploma that he can show to his supervisor.

With his newfound knowledge, Ray decides that he is ready to take the ASE tests. He registers to take several exams in the automotive series at a local testing center. Although the tests were challenging, Ray passes with flying colors. Over time, he completes all of the core ASE exams and becomes a certified master automotive technician. Ray's supervisor is impressed, and so are his customers.

What's the moral? On-the-job experience, a training program diploma, and a professional certification will go a long way in proving your skills to others, as well as to yourself.

Case #2: Auto Repair for a Career Change

Chris McGrath is a 34-year-old factory worker who currently works for a large manufacturing company. For a single person, her income is good—even in hard economic times, her company has always had more business than it can handle. Although Chris likes her job and her boss respects her abilities, she is beginning to get tired of doing the same old tasks day after day. She would like to have more responsibility and a better variety of jobs to choose from in the future. For these reasons, Chris feels that now is an excellent time to consider a career change.

Many years ago, Chris spent many Sundays helping her dad work on the family car, and today, she still enjoys tinkering when she has the time. After giving it some thought, Chris decides that the field of automobile repair is just what she is looking for. After all, what could be better than earning a living doing something you really enjoy? A check of classified ads in the local newspaper quickly shows her just how many job opportunities are available for trained automotive repair technicians.

With this knowledge, Chris is decided. All that's left to do is to get some formal training to prepare for a job in the field of auto repair.

Chris finds out that there are many ways to get formal training in auto repair. There are resident colleges that offer auto programs, technical or trade schools, and distance education programs, like this program. However, the resident colleges and trade schools require daily class attendance during the day. Since Chris is working full-time and needs her income, she can't afford to take time off to attend a lengthy training program during the day. Therefore, she chooses a distance education program that will allow her to study in her spare time.

After completing her distance education training program, Chris set her sights on a job in her new career field. Knowing that she will need to get some more hands-on experience, Chris accepts a part-time job at a local garage, and begins by working on weekends. By starting out in a part-time position, Chris is able to keep her full-time job at the factory while she gains some experience in auto repair. She starts out by doing minor maintenance and repairs; however, she quickly learns to apply the valuable knowledge she gained from her training program to real-life situations.

After just a few weeks, Chris' boss notices her excellent diagnostic and troubleshooting skills, and begins assigning some of the more difficult repair jobs to her. Before long, other technicians are coming to her to ask for advice! Chris is soon offered a full-time job at the shop, which enables her to finally leave the factory job that she had grown to dislike.

This marks the end of Chris' job boredom. She now looks forward to work each day because she really enjoys her work and knows that she is respected by her employer for the quality of work she does. She expects to be promoted to master shop technician very soon. Many exciting possibilities have opened to her, and she can hardly wait to cash in on them!

What's the moral? By obtaining some formal training and applying yourself to your work, you can be successful in almost any field you choose. In addition, by continuing to improve your skills, you can increase your value as an employee, increase the amount of responsibility you're given, and earn more money as a result.

Case Study #3: Automotive Mechanics and the Small Business

Frank Ayers is a graduate of Landmark Community College, where he studied business management. During his college years, Frank supported himself and paid his tuition by doing carpentry work, home repairs, and other odd jobs. When he graduated, Frank found a good job with a local building contractor. In his job, he gained wide experience in carpentry, electrical work, and a variety of other areas. He also rose

within the business to become a construction supervisor. Frank enjoys working with his hands, but he also feels that his training in management has been important to his employer's business.

For several years, the construction business was up and down in Frank's area. However, at the present time, new construction in the area is experiencing a serious downturn. Frank's company begins to experience financial difficulties. For the first time ever in his company, it appears that several employees may be laid off due to a lack of available work. Although Frank is loyal to his employer, he can't help wondering if he should be looking for another job. And, unless the new construction market changes dramatically, he isn't too optimistic about getting a job in another company in the same field.

In his spare time, Frank enjoys tinkering. He has always been talented at fixing things—small appliances, machines, all kinds of devices. One day, while reading a technical magazine, Frank finds an article about the growing field of automotive maintenance and servicing. He is particularly interested by the idea that auto repair is a service that everyone needs, year-round, no matter what economic conditions are.

Frank decides to do a little research into this field. He looks into the possibility of taking a program to learn auto repair in his spare time. Then, he feels, if he is laid off soon, he will have the skills needed to get a different job. He also checks with local employment agencies, job placement services, and classified ads, and finds out that there's a shortage of trained auto technicians in his area. Frank figures that even if he decides not to work in the field, he will save a lot of money over the long run by repairing his own car.

Frank enrolls in an auto repair program and spends some of his evenings and weekends studying. He quickly learns that he has a natural aptitude for the work; he enjoys the program so much that it hardly seems like work.

Since Frank's original educational background was in business management, and since he learned that auto technicians are at a premium in his city, Frank wonders if he should think of starting his own auto repair business. In the long run, this could offer him more security than working for someone else. He doesn't think he can afford to rent or buy a shop. However, he does already own a van. Could he open a mobile business, that is, run a shop from his van?

Frank decides to take the plunge. He invests some of his savings in tools, supplies, business cards, and a small ad in the Yellow Pages. He makes a trip to the local county office to file his new business name, Superior Auto Service. With energy and enthusiasm, Frank embarks on a campaign to let everyone know that he is open for business. His business cards start appearing all over town, even in such places as supermarket

bulletin boards and church vestibules. Soon, Frank's auto repair van is a familiar sight to local residents, and the phone number painted on the side of the van lets them know how to contact him when they need him.

Frank is on his way to a better future! Although he started out on a small, part-time scale, his business is growing quickly. Frank hopes that Superior Auto Service will expand into a full-time business that will provide him with a secure, long-term income.

What's the moral? Matching your skills to the things you enjoy doing is an excellent way to achieve success and personal satisfaction through a career change.

Now, take a few moments to review what you've learned by completing *Power Check 6*.

Power Check 6

1. The ASE recognizes two levels of professional qualification and ability. These two levels are called _____ and _____.

2. *True or False?* ASE certification exams are offered once every two years at different locations throughout the United States.

3. What must you do in order to become ASE certified as an automotive technician?

   _____

4. *True or False?* Employers tend to favor certified technicians for employment and job advancement.

5. What must you do in order to become ASE certified as a master automotive technician?

   _____

   _____

   _____

Check your answers with those on page 114.

Power Check Answers

1

1. False
2. Three or four
3. automatic transmission, manual transmission
4. antilock
5. False
6. technicians
7. Four-wheel drive
8. front-wheel drive
9. Four or five
10. steering
11. True
12. The engine, the brake system, the suspension and steering system, the transmission, the drive train, the electrical and electronic system, the heating and air conditioning system

2

1. False
2. compression
3. False
4. bottom dead center (BDC)
5. exhaust
6. intake, exhaust
7. intake
8. False
9. False
10. power
11. True
12. False

3

1. feeler gage
2. impact screwdriver
3. wrench
4. cylinder hone
5. vise grip or locking pliers
6. longnose or needlenose pliers
7. piston ring compressor
8. tap
9. gapping tool
10. timing light
11. die stock
12. torque wrench

4

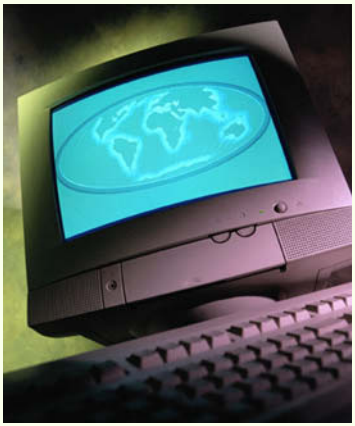
1. True
2. DC
3. fuel, oxygen, a heat source
4. At least once a year
5. resistance
6. False
7. Every 12 months
8. A
9. back
10. False

5

1. False
2. light repair technician
3. service writer
4. service manager
5. diagnostic technician

6

1. automotive technician, master auto technician
2. False
3. In order to become ASE certified as an automotive technician, you must pass at least one of the ASE auto servicing exams.
4. True
5. To become an ASE-certified master automotive technician, you must pass all of the ASE auto servicing exams.



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