Figure 5–50 An angle gauge is used to check the angle of a drive shaft. *Reproduced under license from Snap-on Incorporated. All of the marks are marks of their owners.*

tools are the various drivers used with a press to press the joint in and out of its yoke.

Drive Shaft Angle Gauge

Critical to the durability of universal joints and vibration-free vehicle operation is the angle of the drive shaft. The angle of the drive shaft at the transmission should equal its angle at the drive axle. There are many ways to measure the angle; one way involves the use of an **inclinometer** or drive shaft angle gauge **(Figure 5–50)**.

Hydraulic Pressure Gauge Set

A common diagnostic tool for automatic transmissions is a hydraulic pressure gauge **(Figure 5–51)**. A pressure gauge measures pressure in pounds per square inch (psi) and/or kilopascals (kPa). The gauge is normally part of a kit that contains various fittings and adapters.

Figure 5–51 Pressure gauges are used to diagnose automatic transmissions and power steering systems.

SUSPENSION AND STEERING TOOLS

Suspension and steering repair and diagnostic tools as well as wheel alignment tools and equipment are discussed in the following paragraphs. This discussion does not cover all of the tools you may need; rather, these tools are the most commonly used by the service industry. Details of when and how to use these tools are covered in Section 7 of this book.

Tire Tread Depth Gauge

A tire tread depth gauge measures tire tread depth. This measurement should be taken at three or four locations around the tire's circumference to obtain an average tread depth. This gauge is used to determine the remaining life of a tire as well as for comparing wear of one tire to the other tires. It is also used when making tire warranty adjustments.

Power Steering Pressure Gauge

A power steering pressure gauge is used to test the power steering pump pressure. This test is also important when checking hydraulic boost brake systems. Because the power steering pump delivers extremely high pressure during this test, the recommended procedure in the vehicle manufacturer's service manual must be followed.

A pressure gauge with a shutoff valve is installed between the pump and the steering gear. Adapters are used to make good connections with the vehicle's power steering system.

Control Arm Bushing Tools

A variety of control arm bushing tools are available to remove and replace control arm bushings. Old bushings are pressed out of the control arm. A C-clamp tool can be used to remove the bushing. The C-clamp is installed over the bushing. An adapter is selected to fit on the bushing and push the bushing through the control arm. Turning the handle on the C-clamp pushes the bushing out of the control arm.

New bushings can be installed by driving or pressing them in place. Adapters are available for the C-clamp tool to install the new bushings. After the correct adapters are selected, position the bushing and tool on the control arm. Turning the C-clamp handle pushes the bushing into the control arm.

Tie-Rod End and Ball Joint Puller

Some car manufacturers recommend a tie-rod end and ball joint puller to remove tie-rod ends and pull ball joint studs from the steering knuckle.

Ball joint removal and pressing tools are designed to remove and replace pressed-in ball joints on front

Figure 5–52 A ball joint removal tool.

suspension systems **(Figure 5–52)**. Often these tools are used in conjunction with a hydraulic press. The size of the removal and pressing tool must match the size of the ball joint.

Some ball joints are riveted to the control arm and the rivets are drilled out for removal.

Front Bearing Hub Tool

Front bearing hub tools are designed to remove and install front wheel bearings on FWD cars. These bearing hub tools are usually designed for a specific make of vehicle and the correct tools must be used for each application. Failure to do so may result in damage to the steering knuckle or hub. Also, the use of the wrong tool will waste quite a bit of your time.

Pitman Arm Puller

A pitman arm puller is a heavy-duty puller designed to remove the pitman arm from the pitman shaft **(Figure 5–53)**. These pullers can also be used to separate tie-rod ends and ball joints.

Tie-Rod Sleeve-Adjusting Tool

A tie-rod sleeve-adjusting tool **(Figure 5–54)** is required to rotate the tie-rod sleeves and perform some front wheel adjustments. Never use anything except a tie-rod adjusting tool to adjust the tie-rod sleeves. Tools such as pipe wrenches will damage the sleeves.

Figure 5–53 A pitman arm puller is designed to remove the pitman arm from the pitman shaft. *Courtesy of SPX Service Solutions*

Figure 5–54 A tie-rod sleeve-adjusting tool. *Courtesy of SPX Service Solutions*

Steering Column Special Tool Set

A wheel puller is used to remove the steering wheel from its shaft. Mount the puller over the wheel's hub after the horn button and air bag have been removed. Make sure you follow the recommendations exactly for air bag module removal. Screw the bolts into the threaded bores in the steering wheel. Then tighten the puller's center bolt against the steering wheel shaft until the steering wheel is free.

Special tools are also required to service the lock mechanism and ignition switch.

Shock Absorber Tools

Often shock absorbers can be removed with regular hand tools, but there are times when special tools may be necessary. The shocks are under the vehicle and are subject to dirt and moisture, which may make it difficult to loosen the mounting nut from the stud of the shock. Wrenches are available to hold the stud while attempting to loosen the nut. There are also tools for pneumatic chisels that help to work off the nut.

Spring/Strut Compressor Tool

Many types of coil spring compressor tools are available to the automotive service industry. These tools are designed to compress the coil spring and hold it in the compressed position while removing the strut from the coil spring **(Figure 5–55)**, removing the spring from a short-long arm (SLA) suspension, or performing other suspension work. Various types of spring compressor tools are required on different types of front suspension systems.

One type of spring compressor uses a threaded compression rod that fits through two plates, an upper and lower ball nut, a thrust washer, and a forcing nut. The two plates are positioned at either end of the spring. The compression rod fits through the plates with a ball nut at either end. The upper ball nut is pinned to the rod. The thrust washer and forcing

Figure 5–55 A spring compressor for a strut suspension.

nut are threaded onto the end of the rod. Turning the forcing nut draws the two plates together and compresses the spring.

There is a tremendous amount of energy in a compressed coil spring. Never disconnect any suspension component that will suddenly release this tension. This action could result in serious personal injury and vehicle or property damage.

Power Steering Pump Pulley Special Tool Set

When a power steering pump pulley must be replaced, it should never be hammered off or on. Doing so will cause internal damage to the pump. Normally the pulley can be removed with a gear puller, although special pullers are available. To install a pulley, a special tool is used to press the pulley on without a press or the need to drive the pulley in place.

Brake Pedal Depressor

A brake pedal depressor must be installed between the front seat and the brake pedal to apply the brakes while checking some front wheel alignment angles to prevent the vehicle from moving **(Figure 5–56)**.

Figure 5–56 The technician is installing a brake pedal depressor; also note that a steering wheel lock is in place.

Wheel Alignment Equipment—Four Wheel

Many automotive shops are equipped with a computerized four-wheel alignment machine **(Figure 5–57)** that can check all front- and rear-wheel alignment angles quickly and accurately.

After vehicle information is keyed into the machine and the wheel units are installed, the machine must be compensated for wheel runout. When compensation is complete, alignment measurements are instantly displayed. Also displayed are the specifications for that vehicle. In addition to the normal alignment specifications, the screen may display asymmetric tolerances, different left- and right-side specifications, and cross specifications. (A difference is allowed between left and right sides.) Graphics and text on the screen show the technician where and

Figure 5–57 A computerized four-wheel alignment setup. *Courtesy of RTI Technologies, Inc.*

how to make adjustments. As the adjustments are made on the vehicle, the technician can observe the center block slide toward the target. When the block aligns with the target, the adjustment is within half the specified tolerance.

Tire Changer

Tire changers are used to demount and mount tires. A wide variety of tire changers are available, and each one has somewhat different operating procedures. Always follow the procedure in the equipment operator's manual and the directions provided by your instructor.

Wheel Balancer—Electronic Type

The most commonly used wheel balancer requires that the tire/wheel assembly be taken off and mounted on the balancer's spindle **(Figure 5–58)**. Weights are added to balance the tire/wheel assembly. The wheel assembly is rotated at high speed and the machine indicates the amount of weight to be added and the location where the weights should be placed.

Several electronic dynamic/static balancer units are available that permit balancing while the wheel and tire are on the vehicle. Often a strobe light flashes at the heavy point of the tire and wheel assembly.

Figure 5–58 An electronic wheel balancer.

Figure 5–59 Wheel weight pliers.

Wheel Weight Pliers

Wheel weight pliers are actually combination tools designed to install and remove clip-on lead wheel weights **(Figure 5–59)**. The jaws of the pliers are designed to hook into a hole in the weight's bracket. The pliers are then moved toward the outside of the wheel and the weight is pried off. On one side of the pliers is a plastic hammer head used to tap the weights onto the rim.

BRAKE SYSTEM TOOLS

The repair and diagnostic tools for brake service are discussed in the following paragraphs. This discussion does not cover all of the tools you may need; rather, these tools are the most commonly used by the service industry. Details of when and how to use these tools are presented in Section 8 of this book.

Cleaning Equipment and Containment Systems

Equipment should be used to safely contain asbestos while doing brake work. A negative-pressure enclosure and high-efficiency particulate air (HEPA) vacuum system allow you to clean and inspect brake assemblies while preventing the release of asbestos fibers into the air. A vacuum pump and a HEPA filter keep the enclosure under negative pressure as work is done.

Low-pressure wet cleaning systems wash dirt from the brake assembly and catch the contaminated cleaning agent in a basin. This system uses water mixed with an organic solvent or wetting agent. The brake assembly is gently flooded to prevent any asbestos-containing brake dust from becoming airborne.

Figure 5–60 Brake spring pliers.

Holddown Spring and Return Spring Tools

Brake shoe return springs used on drum brakes are very strong and require special tools for removal and installation. Most return spring tools have special sockets and hooks to release and install the spring ends. Some are built like pliers **(Figure 5–60)**.

Holddown springs for brake shoes are much lighter than return springs, and many such springs can be released and installed by hand. A holddown spring tool **(Figure 5–61)** looks like a cross between a screwdriver and a nut driver. A specially shaped end grips and rotates the spring retaining washer.

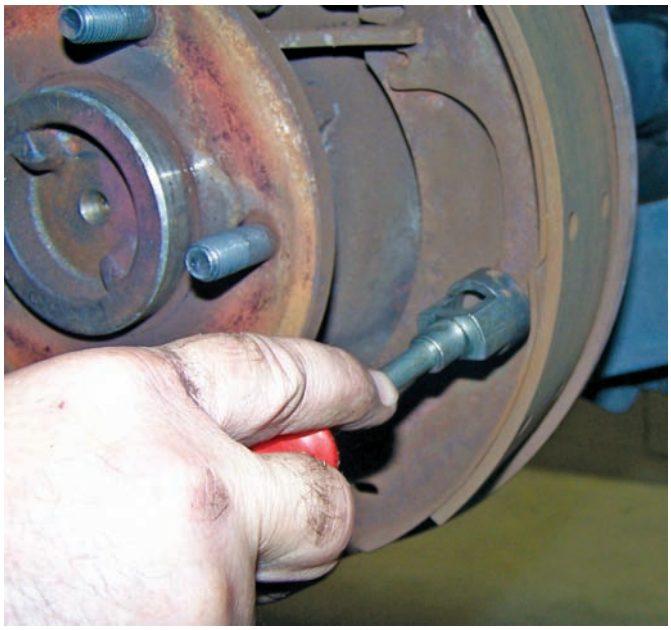

Figure 5–61 A holddown spring compressor tool.

Boot Drivers, Rings, and Pliers

Dust boots attach between the caliper bodies and pistons of disc brakes to keep dirt and moisture out of the caliper bores. A special driver is used to install a dust boot with a metal ring that fits tightly on the caliper body. The circular driver is centered on the boot placed against the caliper and then hit with a hammer to drive the boot into place. Other kinds of dust boots fit into a groove in the caliper bore before the piston is installed. Special rings or pliers are then needed to expand the opening in the dust boot and let the piston slide through it for installation.

Caliper Piston Removal Tools

A caliper piston can usually be slid or twisted out of its bore by hand. Rust and corrosion (especially where road salt is used in the winter) can make piston removal difficult. One simple tool that will help with the job is a set of special pliers that grips the inside of the piston and lets you move it by hand with more force. These pliers work well on pistons that are only mildly stuck.

For a severely stuck caliper piston, a hydraulic piston remover can be used. This tool requires that the caliper be removed from the car and installed in a holding fixture. A hydraulic line is connected to the caliper inlet and a hand-operated pump is used to apply up to 1,000 psi of pressure to loosen the piston. Because of the danger of spraying brake fluid, always wear eye protection when using this equipment.

Drum Brake Adjusting Tools

Although almost all drum brakes built during the past 30 years have some kind of self-adjuster, the brake shoes still require an initial adjustment after they are installed. The star wheel adjusters of many drum brakes can be adjusted with a flat-blade screwdriver. Brake adjusting spoons **(Figure 5–62)** and wire hooks designed for this specific purpose can make the job faster and easier, however.

Brake Cylinder Hones

Cylinder hones are used to clean light rust, corrosion, pits, and built-up residue from the bores of master cylinders, wheel cylinders, and calipers. A hone can be a very useful—sometimes necessary—tool when you have to overhaul a cylinder. A hone will not, however, save a cylinder with severe rust or corrosion.

Figure 5–62 A drum brake adjustment tool. *Reproduced under license from Snap-on Incorporated. All of the marks are marks of their owners.*

The most common cylinder hones have two or three replaceable abrasive stones at the ends of spring-loaded arms. Spring tension usually is adjustable to maintain proper stone pressure against the cylinder walls. The other end of the hone is mounted in a drill motor for use, and the hone's flexible shaft lets the motor turn the hone properly without being precisely aligned with the cylinder bore.

Another kind of hone is the **brush** or **ball hone**. It has abrasive balls attached to flexible metal brushes that are, in turn, mounted on the hone's flexible shaft. In use, centrifugal force moves the abrasive balls outward against the cylinder walls; tension adjustment is not required. A brush hone provides a superior surface finish and is less likely to remove too much metal than a stone hone.

Tubing Tools

The rigid brake lines, or pipes, of the hydraulic system are made of steel tubing to withstand high pressure and to resist damage from vibration, corrosion, and work hardening. Brake lines often can be purchased in preformed lengths to fit specific locations on specific vehicles. Straight brake lines can also be purchased in many lengths and several diameters and bent to fit specific vehicle locations. Even with prefabricated lines available, you probably will have many occasions to cut and bend steel lines and form flared ends for installation. The common tools **(Figure 5–63)** you should have are:

Figure 5–63 A typical tubing tool set. *Reproduced under license from Snap-on Incorporated. All of the marks are marks of their owners.*

Figure 5–64 A digital caliper for measuring brake disc thickness. *Courtesy of Honeywell International Inc.*

- A tubing cutter and reamer
- Tube benders
- A double flaring tool for SAE flares
- An International Standards Organization (ISO) flaring tool for European-style ISO flares

Brake Disc Micrometer

A special micrometer should be used to check the thickness of a rotor accurately. A brake disc micrometer has pointed anvils that allow the tip to fit into grooves worn on the rotor. This type of micrometer is read in the same way as other micrometers but is made with a range from 0.300 to 1.300 inches. Digital calipers are also used to measure disc brake thickness **(Figure 5–64)**.

Drum Micrometer

A drum micrometer is a single-purpose instrument used to measure the inside diameter of a brake drum. A drum micrometer has two movable arms on a shaft **(Figure 5–65)**. One arm has a precision dial indicator; the other arm has an outside anvil that fits against the inside of the drum. In use, the arms are secured on the shaft by lock screws that fit into grooves every 1/8 inch (0.125) on the shaft. The dial indicator is graduated in 0.005-inch increments.

Metric drum micrometers work the same way except that the shaft is graduated in 1 cm major increments and the lock screws fit in notches every 2 mm.

Figure 5–65 A drum micrometer.

Brake Shoe Adjusting Gauge (Calipers)

A brake shoe adjusting gauge is an inside-outside measuring device **(Figure 5–66)**. This gauge is often called a brake shoe caliper. During drum brake service, the inside part of the gauge is placed inside a newly surfaced drum and expanded to fit the drum diameter. The lock screw is then tightened and the gauge moved to the brake shoes installed on the backing plate. The brake shoes are then adjusted until the outside part of the gauge just slips over them. This action provides a rough adjustment of the brake shoes. Final adjustment must still be done after the drum is installed, but the brake shoe gauge makes the job faster.

Figure 5–66 A drum brake shoe adjusting gauge.

Figure 5–67 A bench brake lathe.

Brake Lathes

Brake lathes are special power tools used only for brake service. They are used to turn and resurface brake rotors and drums. Turning involves cutting away very small amounts of metal to restore the surface of the rotor or drum. The traditional brake lathe is an assembly mounted on a stand or workbench. The bench lathe requires that the drum or rotor be removed from the vehicle and mounted on the lathe for service **(Figure 5–67)**.

As the drum or rotor is turned on the lathe spindle, a carbide steel cutting bit is passed over the drum or rotor friction surface to remove a small amount of metal. The cutting bit is mounted rigidly on a lathe fixture for precise control as it passes across the friction surface.

An on-car lathe **(Figure 5–68)** is bolted to the vehicle suspension or mounted on a rigid stand to provide a stable mounting point for the cutting tool. The rotor may be turned by either the vehicle's engine or drive train (for a FWD vehicle) or by an electric motor and drive attachment on the lathe. As the rotor is turned, the lathe cutting tool is moved across both surfaces of the rotor to refinish it. An on-car lathe not only has the obvious advantage of speed, it also rotates the rotor on the vehicle wheel bearings and hub so that these sources of runout, or wobble, are compensated for during the refinishing operation.

Bleeder Screw Wrenches

Special bleeder screw wrenches often are used to open bleeder screws. Bleeder screw wrenches are small, 6-point box wrenches with strangely offset handles for access to bleeder screws in awkward

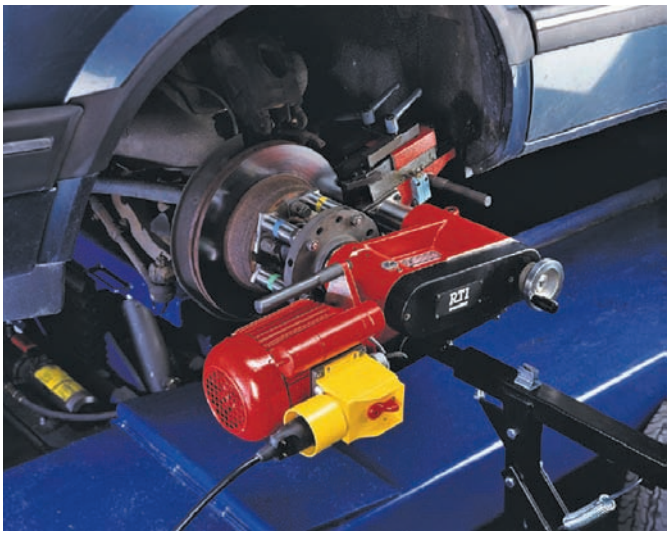

Figure 5–68 An on-vehicle disc brake lathe.
Courtesy of RTI Technologies, Inc.

locations. The 6-point box end grips the screw more securely than a 12-point box wrench can and avoids damage to the screw.

Bleeding Tools

Removing the air from the closed hydraulic brake system is very important. This is done by bleeding the system. Bleeding can be done manually, with a vacuum pump, or with a pressure bleeder. The latter two are preferred because they are quick and very efficient, and the technician can do without an assistant.

HEATING AND AIR-CONDITIONING TOOLS

The repair and diagnostic tools for the heating, ventilation, and air-conditioning (A/C) systems are discussed in the following paragraphs. This discussion does not cover all of the tools you may need; rather, these tools are the most commonly used by the service industry. Details of when and how to use these tools are covered in Section 9 of this book.

Manifold Gauge Set

A **manifold gauge set** **(Figure 5–69)** is used when discharging, charging, evacuating, and for diagnosing trouble in an A/C system. With the new legislation on handling refrigerants, all gauge sets are required to have a valve device to close off the end of the hose so that the fitting not in use is automatically shut.

The low-pressure gauge is graduated into pounds of pressure from 1 to 120 (with cushion to 250) in 1-pound graduations, and, in the opposite direction, in inches of vacuum from 0 to 30. This is the gauge that should always be used in checking pressure on the low-pressure side of the system. The high-pressure gauge is graduated from 0 to 500 pounds pressure in 10-pound graduations. This gauge is used for checking pressure on the high-pressure side of the system.

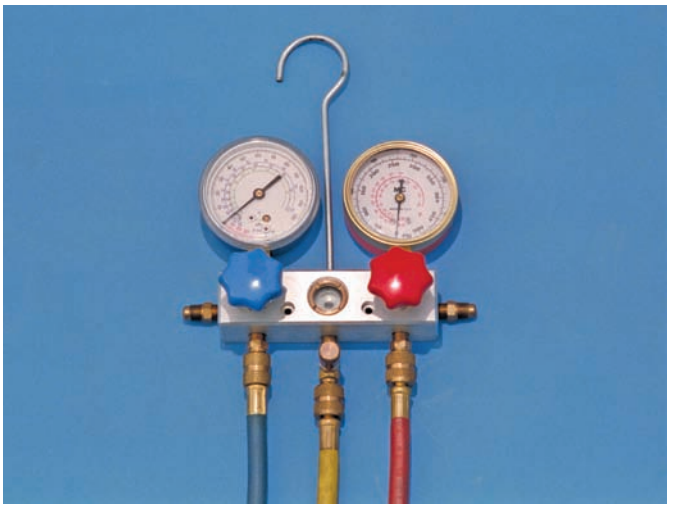

Figure 5–69 A manifold gauge set.

The gauge manifold is designed to control refrigerant flow. When the manifold test set is connected into the system, pressure is registered on both gauges at all times.

Because R-134a is not interchangeable with R-12, separate sets of hoses, gauges, and other equipment are required to service vehicles. All equipment used to service R-134a and R-12 systems must meet SAE standard J1991. The service hoses on the manifold gauge set must have manual or automatic backflow valves at the service port connector ends to prevent the refrigerant from being released into the atmosphere during connection and disconnection. Manifold gauge sets for R-134a can be identified by labels on the gauges and/or have a light blue color on the face of the gauges.

For identification purposes, R-134a service hoses must have a black stripe along their length and be clearly labeled. The low-pressure hose is blue with a black stripe. The high-pressure hose is red with black stripe and the center service hose is yellow with a black stripe. Service hoses for one type of refrigerant will not easily connect into the wrong system, as the fittings for an R-134a system are different than those used in an R-12 system.

Service Port Adapter Set

To connect a manifold gauge set to an A/C system, adapters are sometimes needed **(Figure 5–70)**. The high-side fitting on many vehicles with an R-12 system may require the use of a special adapter to connect the manifold gauge set to the service port. The service hoses of some manifold gauge sets are not