CHAPTER 1

TOOLROOMS AND TOOLS

CHAPTER LEARNING OBJECTIVES

Upon completing this chapter, you should be able to do the following:

- *Describe toolroom organization.*
- *Explain how to inspect tools for damage.*
- *State the process used to issue tools.*
- *Describe the use of measuring tools in shop manufacture.*
- *Describe the procedure used to check the accuracy of measuring instruments.*

Before we discuss toolrooms and tools, we'll give you an overview of the Machinery Repairman (MR) rating.

The official description of the scope of the MR rating is to "perform organizational and intermediate maintenance on assigned equipment and in support of other ships, requiring the skillful use of lathes, milling machines, boring mills, grinders, power hacksaws, drill presses, and other machine tools; portable machinery; and handtools and measuring instruments found in a machine shop." That is a very general statement not meant to define completely the types of skills and supporting knowledge that an MR is expected to have in the different paygrades.

The job of restoring machinery to good working order, ranging from the fabrication of a simple pin or bushing to the complete rebuilding of an intricate gear system, requires skill of the highest order at each task level. Often, in the absence of dimensional drawings or other design information, an MR must depend upon ingenuity and know-how to successfully fabricate a repair part.

One of the important characteristics you will gain from becoming a well-trained and skilled MR is versatility. As you gain knowledge and skill in the operation of the many different types of machines found in Navy machine shops, you will realize that even though a particular machine is used mostly for certain types of jobs, it may be capable of accepting many others. Your imagination will probably be your limiting factor; and if you keep your eyes, ears, and mind open, you will discover that there are many things going on around you that can broaden your base of knowledge. You will find pleasure and pride in developing new and more efficient ways to do something that has become so routine everyone else simply accepts the procedure currently being used as the only one that will work.

The skill acquired by an MR in the Navy is easily translated into several skills found in the machine shops of private industry. In fact, you'd be surprised at the depth and range of your knowledge and skill compared to your civilian counterpart, based on a somewhat equal length of experience. The machinist trade in private industry breaks job descriptions into many different titles and skill levels.

The beginning skill level and one in which you will surely become qualified is machine tool operator, a job often done by semiskilled workers. The primary requirement of the job is to observe the operation, disengage the machine in case of problems, and possibly maintain manual control over certain functions. Workers who do these jobs usually have the ability to operate a limited number of different types of machines.

Another job description found in private industry is layout man. The requirement of this job is to lay out work that is to be machined by someone else. An understanding of the operation and capabilities of the different machines is required, as well as the ability to read blueprints. As you progress in your training in the MR rating you will become proficient in interpreting blueprints and in planning the required machining operations. You will find that laying out intricate parts is not so difficult with this knowledge.

A third job description is set-up man, a job that requires considerable knowledge and skill, all within what you can expect to gain as a MR. A set-up man is responsible for placing each machine accessory and cutting tool in the exact position required to permit accurate production of work by a machine tool operator.

An all-around machinist in private industry is the job for which the average MR would qualify as far as knowledge and skill are concerned. This person is able to operate all machines in the shop and manufacture parts from blueprints. Some MRs will advance their knowledge and skills throughout their Navy career to the point that they can move into a job as a tool and die maker with little trouble. They also acquire a thorough knowledge of engineering data related to design limitations, shop math, and metallurgy. There are many other related fields in which an experienced MR could perform—instrument maker, research and development machinist, toolroom operator, quality assurance inspector and, of course, the supervisory jobs such as foreman or superintendent.

The obvious key to holding down a position of higher skill, responsibility, and pay is the same both in the Navy and in private industry. You must work hard, take advantage of the skills and knowledge of those around you, and take pride in what you do regardless of how unimportant it may seem to you. You have a great opportunity ahead of you as an MR in the Navy; a chance to make your future more secure than it might have been.

Your proficiency as an MR is greatly influenced by your knowledge of tools and your skills in using them. You will need to become familiar with the correct use and care of the many powered and nonpowered handtools, measuring instruments, and gauges you will use in your job.

This training manual will provide information on the tools and instruments used primarily by an MR. You can find additional information on tools used by the many different naval ratings in *USE and CARE of HAND TOOLS and MEASURING TOOLS,* NAVEDTRA 12085.

TOOLROOM SAFETY

The toolroom is relatively small, and a large quantity of different tools are stored there. It can become very dangerous if all items are not kept stored in their proper places. At sea the toolroom can be especially hazardous if you don't secure all drawers, bins, pegboards, and other storage facilities. Fire hazards are sometimes overlooked in the toolroom. When you consider the flammable liquids and wiping rags stored in or issued from the toolroom, you realize there is a real danger present.

As a toolroom keeper, you play a very important part in creating a safe working environment. Several of your jobs are directly connected to the good working order and safe use of tools in the shop. If you issue an improperly ground twist drill to someone who does not have the experience to recognize the defect, the chances of the person being injured if the drill "digs in" or throws the workpiece out of the drill press would be very real. A wrench that has been sprung or worn oversize can become a real "knucklebuster" to any unsuspecting user. An outside micrometer out of calibration can cause trouble when someone is trying to press fit two parts together using a hydraulic press. The list of potential disasters that you can prevent is endless. The important thing to remember is that you as a toolroom keeper contribute more to the mission of the Navy than first meets the eye. If you are ever in doubt concerning toolroom safety, consult your supervisor or *Navy Occupational Safety and Health (NAVOSH) Program Manual for Forces Afloat,* OPNAVINST 5100.19B.

TOOLROOM ORGANIZATION

You may be given responsibility for the operation of the tool crib or tool-issuing room. Make sure that the necessary tools are available and in good condition and that an adequate supply of consumable items (oil, wiping rags, bolts, nuts, and screws) is available.

It's easy to operate and maintain a toolroom if the correct procedures and methods are used to set up the

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Figure 1-1.—Method of tool storage.

system. Some of the basic considerations are (1) the issue and custody of tools; (2) replacement of broken, worn, or lost tools; and (3) proper storage and maintenance of tools.

Shipboard toolrooms are limited in size by the design of the ship. Therefore, the space must be used as efficiently as possible. Since the number of tools required aboard ship is extensive, toolrooms usually tend to be overcrowded. Certain peculiarities in shipboard toolrooms also require consideration. For example, the motion of the ship at sea requires that tools be made secure to prevent movement. The moisture in the air requires that the tools be protected from corrosion.

It's difficult to change permanent bins, shelves, and drawers in the toolroom. However, you can reorganize existing storage spaces by dividing larger bins and relocating tools to provide better use of space.

Hammers, wrenches, and other tools that do not have cutting edges are normally stored in bins. They also may be segregated by size or other designation. Tools with cutting edges require more space to prevent damage to the cutting edges. These tools are stored on shelves lined with wood or felt, on pegboards, or on hanging racks. Pegboards are especially adaptable for tools such as milling cutters. Make provisions to keep these tools from falling off the boards when the ship is rolling. Store precision tools (micrometers, dial indicators, and so forth) in felt-lined wooden boxes in a cabinet to reduce the effects of vibration. This arrangement allows a quick daily inventory. It also prevents the instruments from being damaged by contact with other tools. Use rotating bins to store large supplies of small parts, such as nuts and bolts. Rotating bins provide rapid selection from a wide range of sizes. Figures 1-1,

1-2, and 1-3 show some of the common methods of tool storage.

Place frequently used tools near the issuing door so they are readily available. Place seldom used tools in out of the way areas such as on top of bins or in spaces that cannot be used efficiently because of size and shape. Place heavy tools in spaces or areas where a minimum of lifting is required.

Mark all storage areas such as bins, drawers, and lockers clearly to help locate tools. Make these markings permanent- either stencil them with paint or mark them with stamped metal tags.

TOOL INSPECTION

If you are the toolroom keeper, you'll be responsible for the condition of all the tools and equipment in the toolroom. This is a very important job. Inspect all tools as they are returned to determine if they need repairs or adjustment. NEVER issue damaged tools since they may harm shop equipment or personnel. Set aside a space for damaged tools to prevent issue of these tools until they have been repaired. Send any dull cutting tools to the grind shop for regrinding. Properly dispose of any cutting tools that can't be reground.

Wipe clean all returned tools and give their metal surfaces a light coat of oil. Check all precision tools upon issue and return to determine if they are accurate. Keep all spaces clean and free of dust to prevent foreign matter from getting into the working parts of tools. Plan to spend a portion of each day reconditioning damaged tools. This keeps the tools available for issue and prevents an accumulation of damaged tools.

CONTROL OF TOOLS

There are two common methods of tool issue control: the tool check system and the mimeographed form or tool chit system. Some toolrooms may use a combination of these systems. For example, you may use tool checks for machine shop personnel, and mimeographed forms for personnel outside the shop.

Tool checks are either metal or plastic disks stamped with numbers that identify the borrower. In this system the borrower presents a check for each tool, and the disk is placed on a peg near the space from which the tool was taken. The advantage of this system is that very little time is spent completing the process.

If the tools are loaned to all departments in the ship, printed forms generally are used. The form has a space to list the tools, the borrower's name, the division or department, and the date. This system allows anyone in the ship's crew to borrow tools, and it keeps the toolroom keeper informed as to who has the tools and how long they have been out.

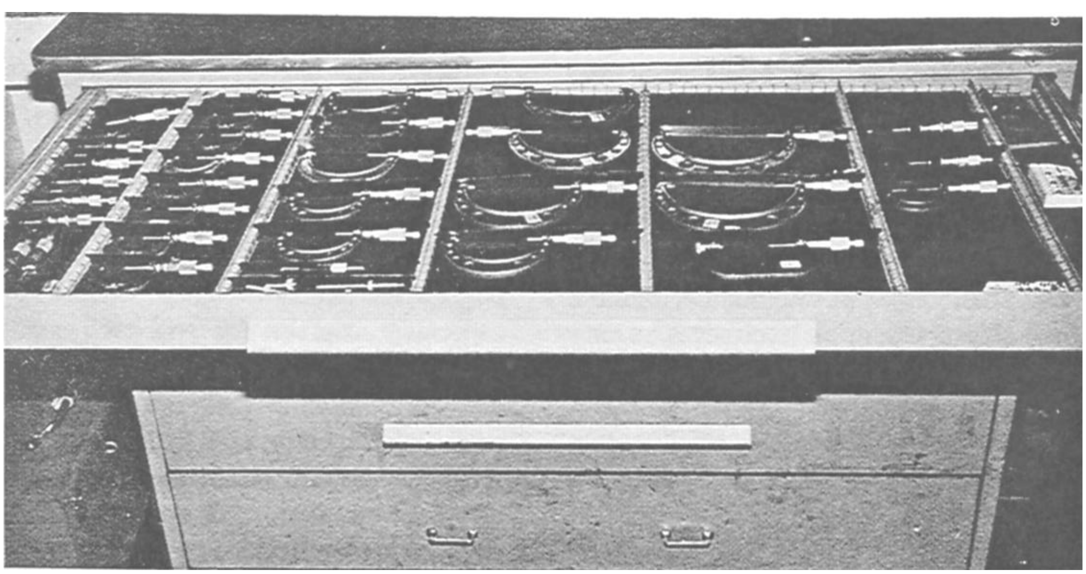

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Figure 1-2.—Method of tool storage.

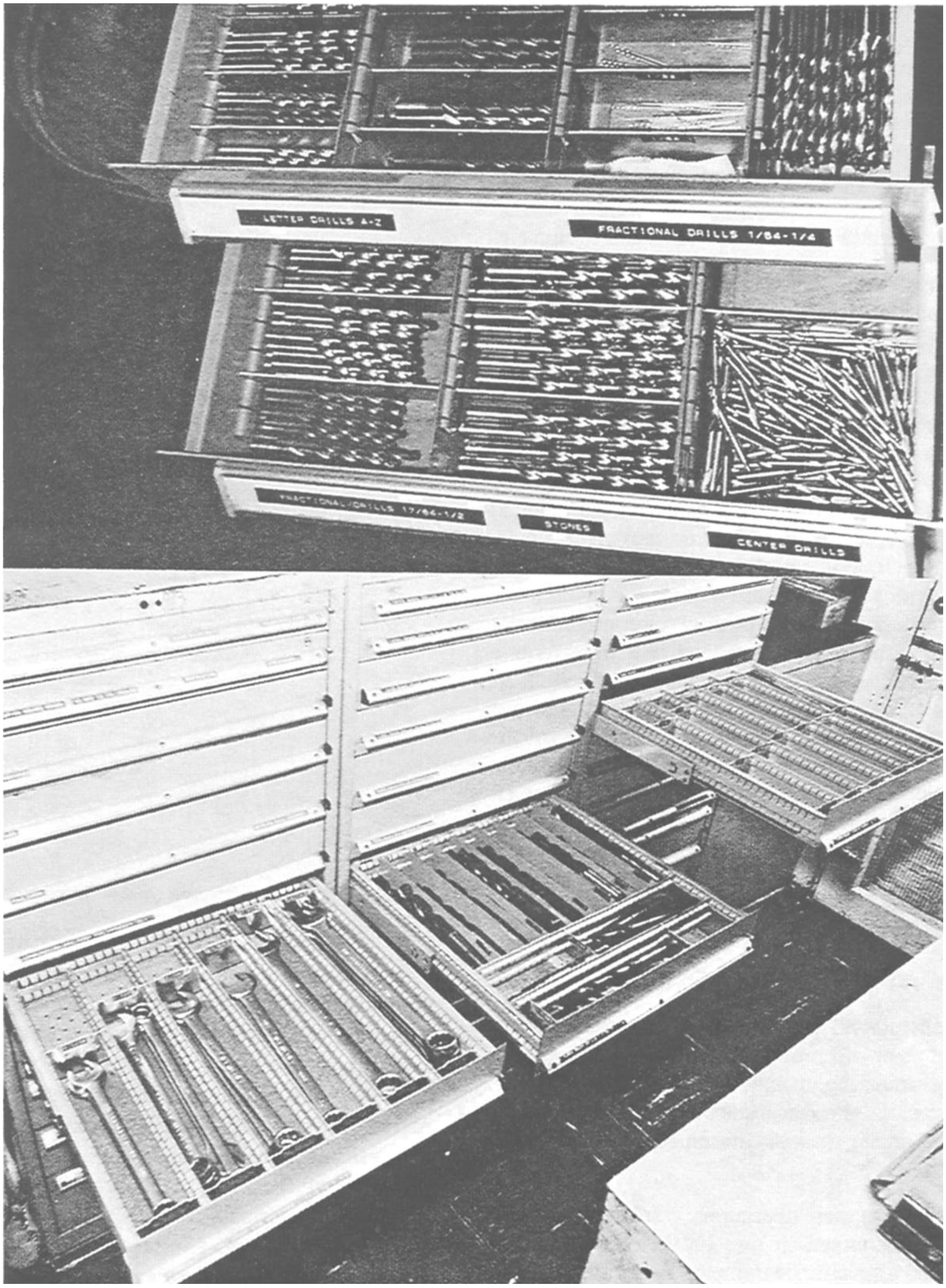

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Figure 1-3.—Method of tool storage.

You must know the location of tools and equipment out on loan, how long tools have been out, and the amount of equipment and consumable supplies you have on hand. To know this, you'll have to make periodic inventories. The inventory consists of a count of all tools, by type, in the toolroom and those out on loan. Inventories help you decide whether more strict control of equipment is needed and if you need to procure more tools and equipment.

Some selected items, called controlled equipage, will require an increased level of management and control due to their high cost, vulnerability to pilferage, or importance to the ship's mission. The number of tools and instruments in this category is generally small. However, it is important that you be aware of controlled equipage items. You can get detailed information about the designation of controlled equipage from the supply department of your activity. When these tools are received from the supply department, your department head will be required to sign a custody card for each item, indicating a definite responsibility for management of the item. The department head will then require signed custody cards from personnel assigned to the division or shop where the item will be stored and used. As a toolroom keeper, you may control the issue of these tools and ensure their good condition. If these special tools are lost or broken beyond repair, you cannot replace them until the correct survey procedures have been completed. Conduct formal inventories of these items periodically as directed by your division officer or department head.

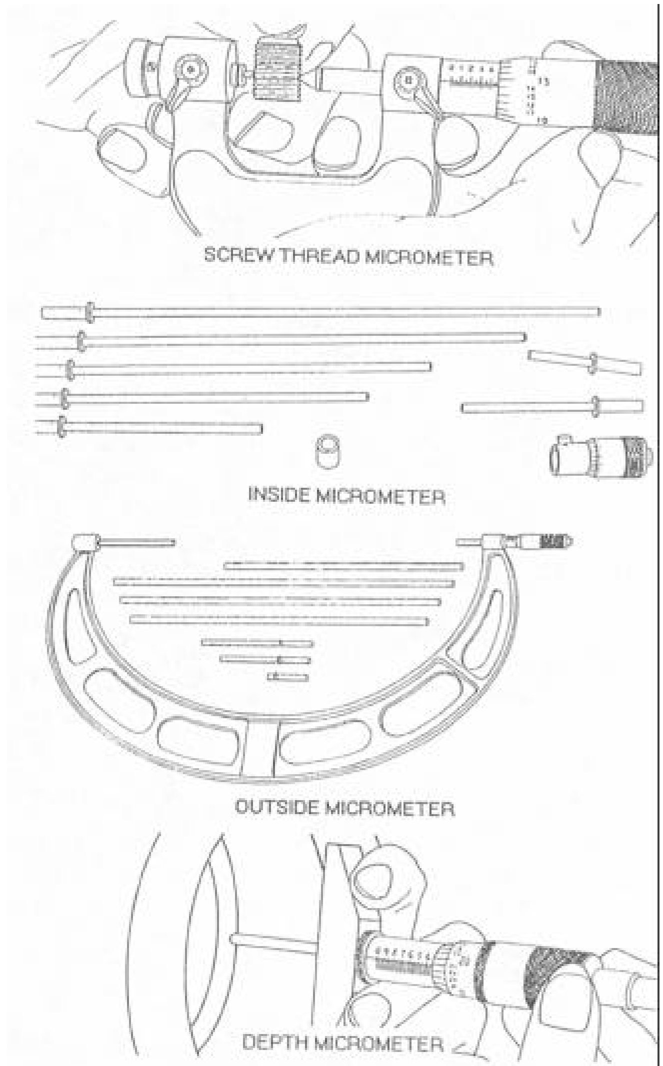

Figure 1-4.—Common types of micrometers.

MEASURING INSTRUMENTS

Practically all shop jobs require measuring or gauging. You will most likely measure or gauge flat or round stock; the outside diameters of rods, shafts, or bolts; slots, grooves, and other openings; thread pitch and angle; spaces between surfaces; or angles and circles.

For some of these operations, you'll have a choice of which instrument to use, but in other instances you'll need a specific instrument. For example, when precision is not important, a simple rule or tape will be suitable. In other instances, when precision is important, you'll need a micrometer.

The term gauge, as used in this chapter identifies any device that can be used to determine the size or shape of an object. There is no significant difference between gauges and measuring instruments. They are both used to compare the size or shape of an object against a scale or fixed dimension. However, there is a distinction between measuring and gauging that is easily explained by an example. Suppose you are turning work on a lathe and want to know the diameter of the work. Take a micrometer, or perhaps an outside caliper, adjust its opening to the exact diameter of the workpiece, and determine that dimension numerically. On the other hand, if you want to turn a piece of work down to a certain size without frequently taking time to measure it, set the caliper at a reading slightly greater than the final dimension; then, at intervals during turning operations, gauge, or "size," the workpiece with the locked instrument. After you have reduced the workpiece dimension to the dimension set on the instrument, you will, of course, need to measure the work as you finish it to the exact dimension.

ADJUSTABLE GAUGES

You can adjust adjustable gauges by moving the scale or by moving the gauging surface to the dimensions of the object being measured or gauged. For example, on a dial indicator, you can adjust the face to align the indicating hand with the zero point on the dial. On verniers, however, you move the measuring surface to the dimensions of the object being measured.

Micrometers

Micrometers are probably the most used precision measuring instruments in a machine shop. There are many different types, each designed to measure surfaces for various applications and configurations of workpieces. The degree of accuracy also varies, with the most common graduations ranging from one-thousandth (0.001) of an inch to one ten-thousandth (0.0001) of an inch. You'll find information on the procedure used to interpret the readings on micrometers in *USE and CARE of HAND TOOLS and MEASURING TOOLS,* NAVEDTRA 12085. We have provided brief descriptions of the more common types of micrometers in the following paragraphs.

OUTSIDE MICROMETER.—Outside micrometers (figs. 1-4 and 1-5), are used to measure the thickness or the outside diameter of parts. They are available in sizes ranging from 1 inch to about 96 inches in steps of 1 inch. The larger sizes normally come as a set with interchangeable anvils that provide a range of several inches. The anvils have an adjusting nut and a locking nut to allow you to set the micrometer with a micrometer standard. Regardless of the degree of accuracy designed into the micrometer, the skill applied by each individual is the primary factor in determining accuracy and reliability in measurements. Training and practice will make you proficient in using this tool.

INSIDE MICROMETER.—An inside micrometer (fig. 1-4) is used to measure inside diameters or between parallel surfaces. They are available in sizes ranging from 0.200 inch to over 100 inches. The individual interchangeable extension rods that may be assembled to the micrometer head vary in size by 1 inch. A small sleeve or bushing, which is 0.500 inch long, is used with these rods in most inside micrometer sets to provide the complete range of sizes. It's slightly more difficult to use the inside micrometer than the outside micrometer-there is more chance that you won't get the same "feel" or measurement each time you check the same surface.

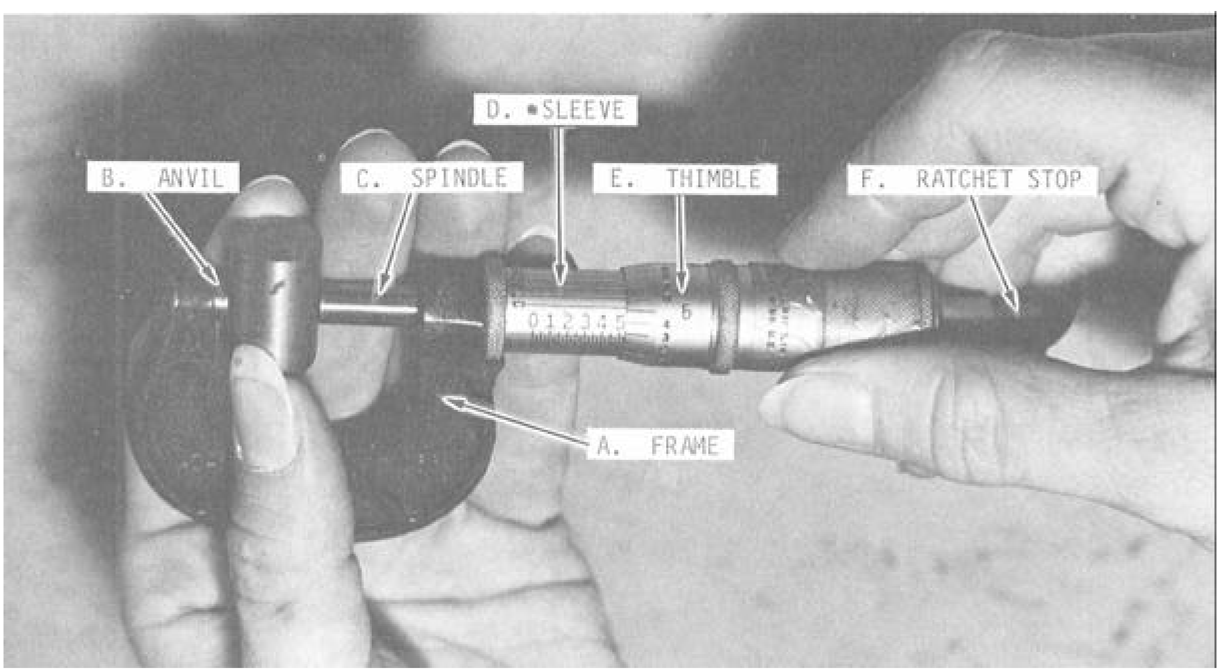

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Figure 1-5.—Nomenclature of an outside micrometer caliper.

The correct way to measure an inside diameter is to hold the micrometer in place with one hand as you feel for the maximum possible setting of the micrometer by rocking the extension rod from left to right and in and out of the hole. Adjust the micrometer to a slightly larger measurement after each series of rocking movements until you can no longer rock the rod from left to right. At that point, you should feel a very slight drag on the in and out movement. There are no specific guidelines on the number of positions within a hole that should be measured. If you are checking for taper, take measurements as far apart as possible within the hole. If you are checking for roundness or concentricity of a hole, take several measurements at different angular positions in the same area of the hole. You may take the reading directly from the inside micrometer head, or you may use an outside micrometer to measure the inside micrometer.

DEPTH MICROMETER.—A depth micrometer (fig. 1-4) is used to measure the depth of holes, slots, counterbores, and recesses, and the distance from a surface to some recessed part. This type of micrometer is read exactly opposite from the method used to read an outside micrometer. The zero is located toward the closed end of the thimble. The measurement is read in reverse and increases in amount (depth) as the thimble moves toward the base of the instrument. The extension rods come either round or flat (blade-like) to permit measuring a narrow, deep recess or grooves.

THREAD MICROMETER.—The thread micrometer (fig. 1-4) is used to measure the depth of threads that have an included angle of 60°. The measurement obtained represents the pitch diameter of the thread. They are available in sizes that measure pitch diameters up to 2 inches. Each micrometer has a given range of number of threads per inch that can be measured correctly. You'll find additional information on this micrometer in chapter 6.

BALL MICROMETER.—This type of micrometer (not shown) has a rounded anvil and a flat spindle. It's used to check the wall thickness of cylinders, sleeves, rings, and other parts that have a hole bored in a piece of material. The rounded anvil is placed inside the hole and the spindle is brought into contact with the outside diameter. Ball attachments that fit over the anvil of regular outside micrometers are also available. When using the attachments, you must compensate for the diameter of the ball as you read the micrometer.

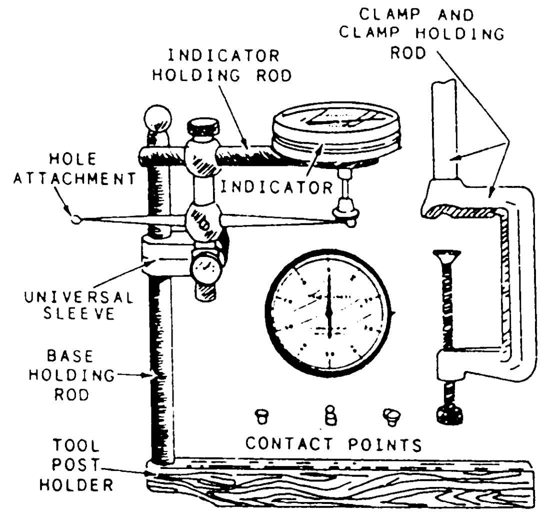

Figure 1-6.—Universal dial indicator.

BLADE MICROMETER.—A blade micrometer (not shown) has an anvil and a spindle that are thin and flat. The spindle does not rotate. This micrometer is especially useful in measuring the depth of narrow grooves, such as an O-ring seat on an outside diameter.

GROOVE MICROMETER.—A groove micrometer (not shown) looks like an inside micrometer with two flat disks. The distance between the disks increases as you turn the micrometer. It is used to measure the width of grooves or recesses on either the outside or the inside diameter. The width of an internal O-ring groove is an excellent example of a groove micrometer measurement.

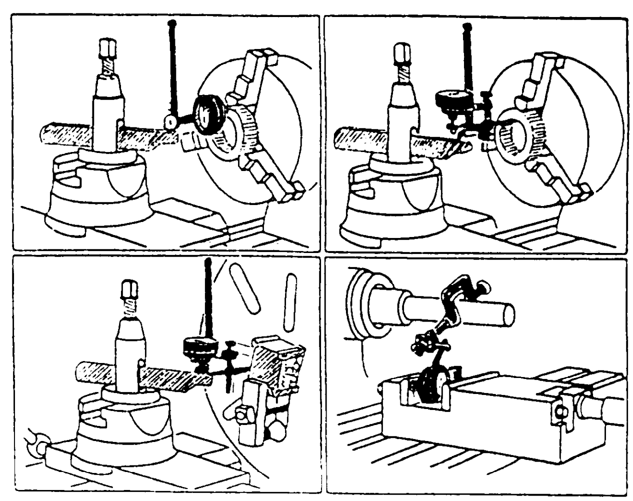

Figure 1-7.—Applications of a dial indicator.

Dial Indicator

MRs use dial indicators to set up work in machines and to check the alignment of machinery. You'll need a lot of practice to become proficient in the use of this instrument. You should use it as often as possible to help you do more accurate work.

Dial indicator sets (fig. 1-6) usually have several components that permit a wide variation of uses. For example, the contact points allow use on different types of surfaces, the universal sleeve permits flexibility of setup, the clamp and holding rods permit setting the indicator to the work, the hole attachment indicates variation or run out of inside surfaces of holes, and the tool post holder can be used in lathe setups. Figure 1-7 shows some practical applications of dial indicators.

Dial indicators come in different degrees of accuracy. Some will give readings to one ten-thousandth (0.0001) of an inch, while others will indicate to only one five-thousandth (0.005) of an inch. Dial indicators also differ in the total range or amount they will indicate. If a dial indicator has a total of one hundred-thousandth (0.100) of an inch in graduations on its face and has a total range of two hundred-thousandths (0.200) of an inch, the needle will only make two revolutions before it begins to exceed its limit and jams up. The degree of accuracy and range of a dial indicator is usually shown on its face. Before you use a dial indicator, carefully depress the contact point and release it slowly; rotate the movable dial face so the dial needle is on zero. Depress and release the contact point again and check to make sure the dial pointer returns to zero; if it does not, have the dial indicator checked for accuracy.

Vernier Caliper

You can use a vernier caliper (fig. 1-8) to measure both inside and outside dimensions. Position the

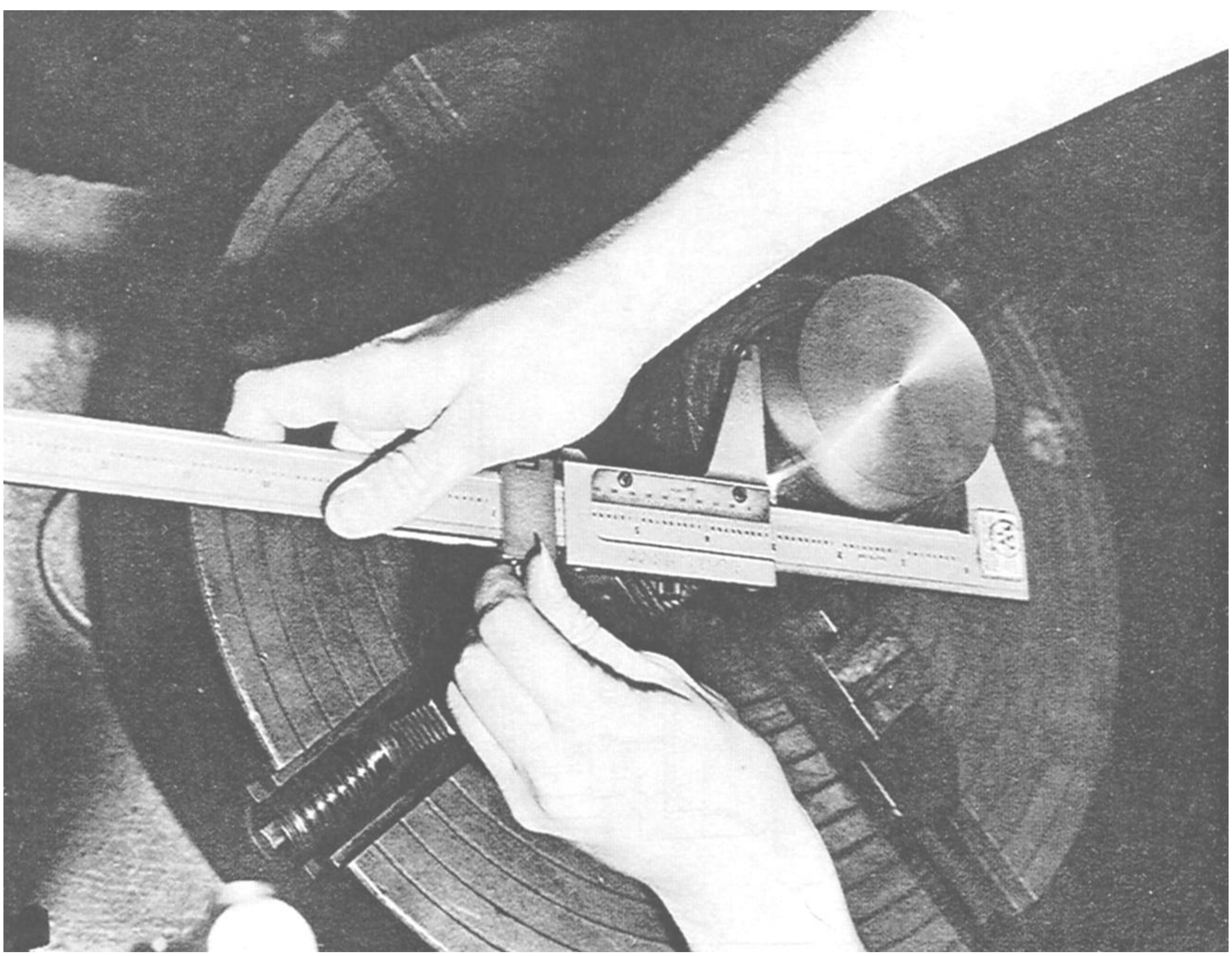

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Figure 1-8.—Vernier caliper.

appropriate sides of the jaws on the surface to be measured and read the caliper from the side marked inside or outside as required. There is a difference in the zero marks on the two sides that is equal to the thickness of the tips of the two jaws, so be sure to read the correct side. Vernier calipers are available in sizes ranging from 6 inches to 6 feet and are graduated in increments of thousandths (0.001) of an inch. The scales on vernier calipers made by different manufacturers may vary slightly in length or number of divisions; however, they are read basically the same way. See *USE and CARE of HAND TOOLS and MEASURING TOOLS*, NAVEDTRA 12085, for instructions on how to interpret the readings.

Vernier Height Gauge

A vernier height gauge (fig. 1-9) is used to lay out work for machining operations or to check the dimensions on surfaces that have been machined. Attachments for the gauge include the offset scribe shown attached to the gauge in figure 1-9. The offset scribe lets you measure from the surface plate with readings taken directly from the scale without the need for calculations. As you can see in figure 1-9, if you were using a straight scribe, you would have to calculate the actual height by taking into account the distance between the surface plate and the zero mark. Some models have a slot in the base for the scribe to move down to the surface and a scale that permits direct reading. Another attachment is a rod that permits depth readings. Small dial indicators that connect to the scribe permit extremely close work when you check or lay out work. Read a vernier height gauge the same way you read a vernier caliper.

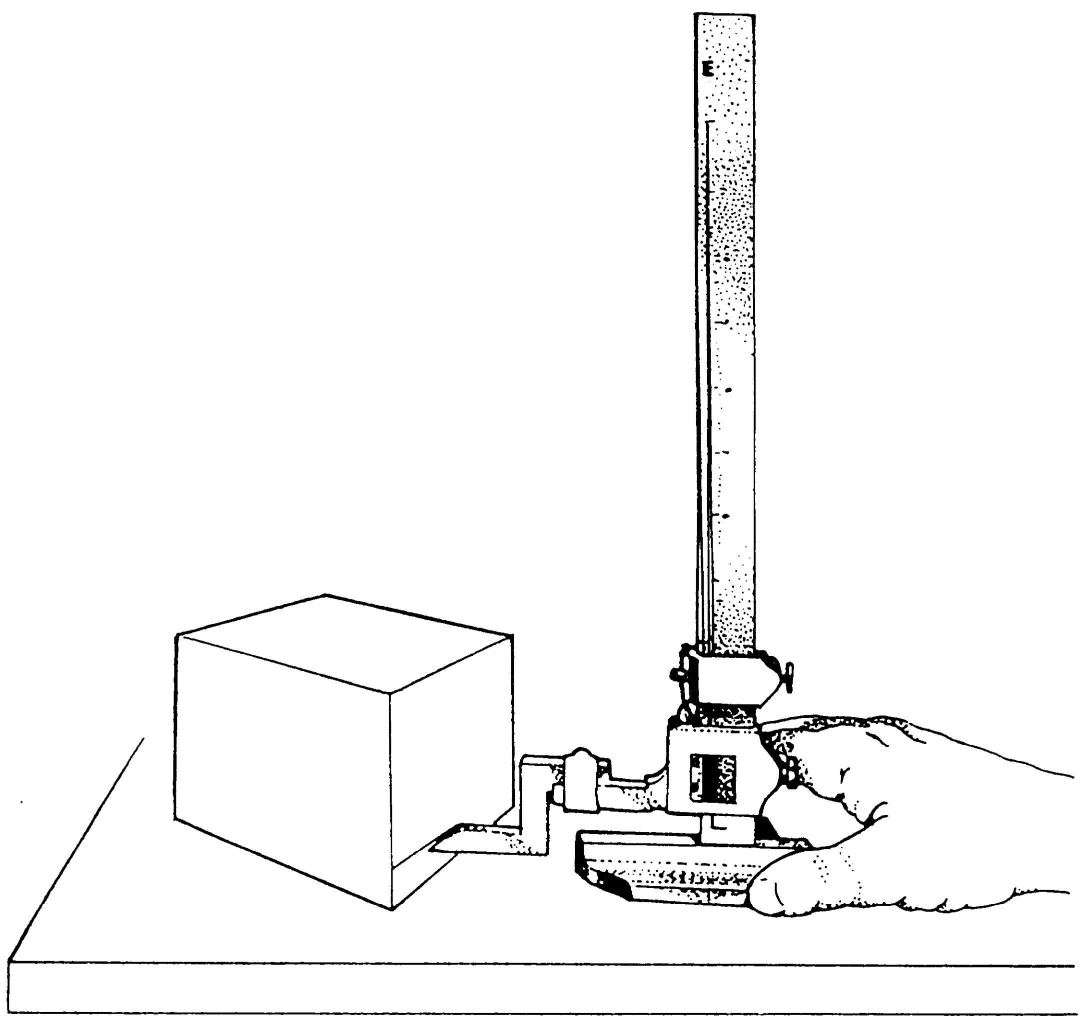
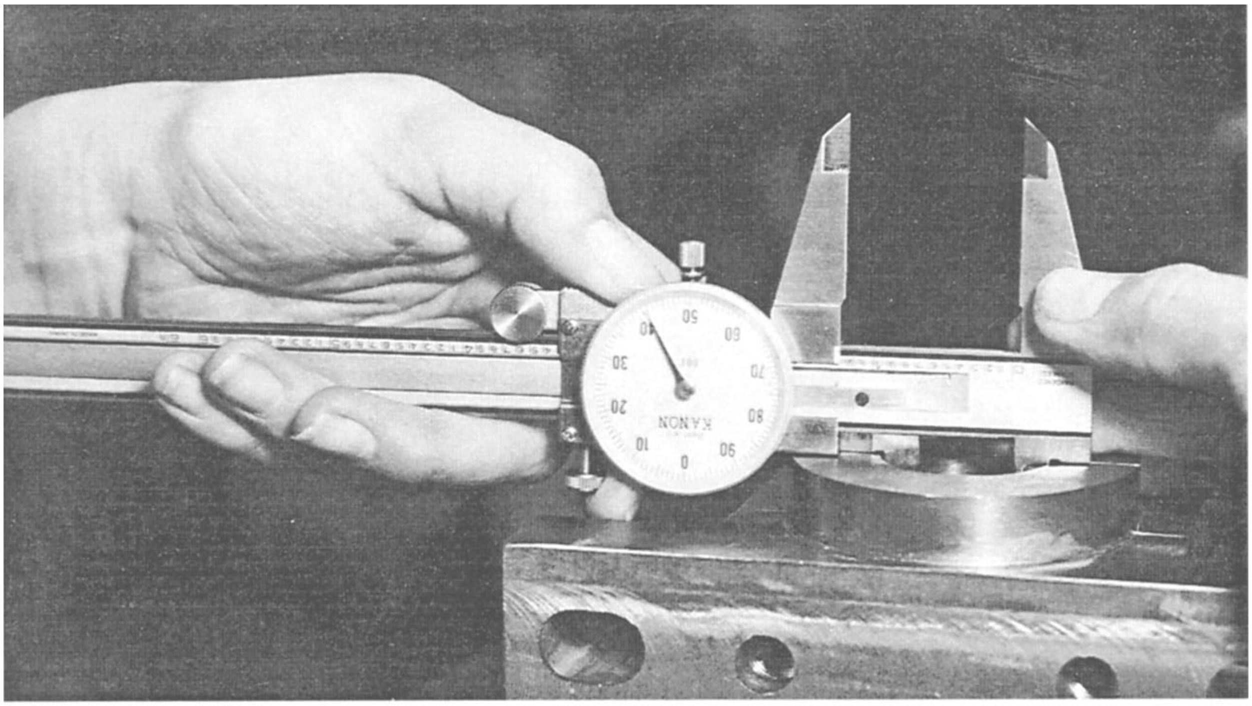


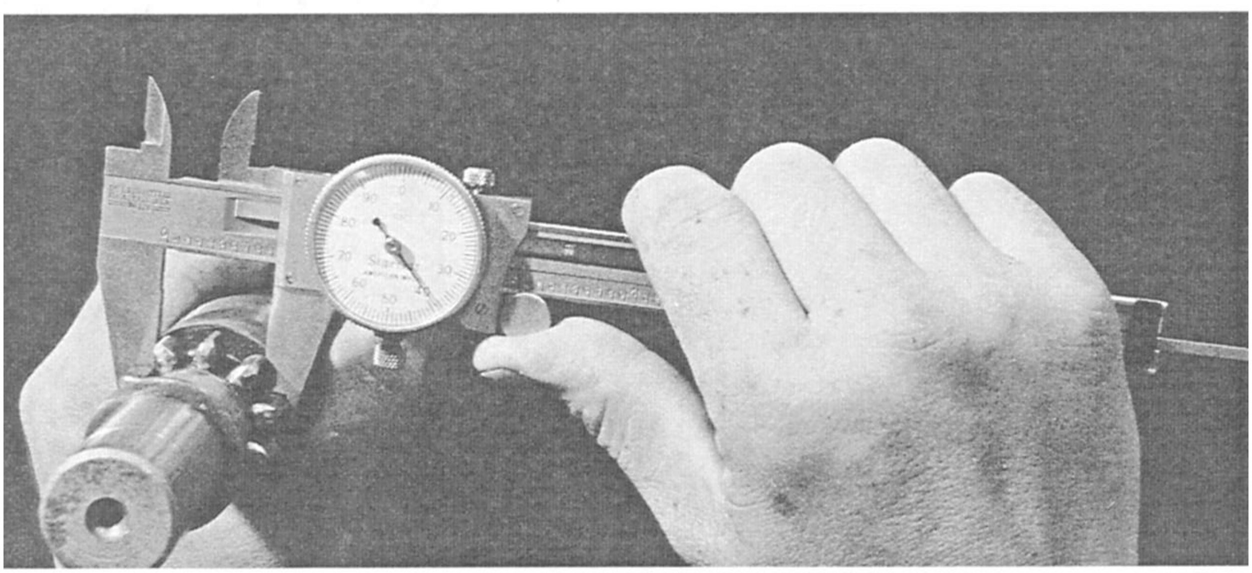
Figure 1-9.—Vernier height gauge.

Dial Vernier Caliper

A dial vernier caliper (fig. 1-10) looks much like a standard vernier caliper and is also graduated in one-thousandths (0.001) of an inch. The main difference is that instead of a double scale, as on the vernier caliper, the dial vernier has the inches marked only along the main body of the caliper and a dial that indicates thousandths (0.001) of an inch. The range of the dial vernier caliper is usually 6 inches.



A. MEASURING THE INSIDE



B. MEASURING THE OUTSIDE

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Figure 1-10.—Dial vernier caliper.

Dial Bore Gauge

The dial bore gauge is one of the most accurate tools used to measure a cylindrical bore or check a bore for out-of-roundness or taper, (fig. 1-11). It does not give a direct measurement; it gives you the amount of deviation from a preset size or the amount of deviation from one part of the bore to another. A master ring gauge is used to preset the gauge. A dial bore gauge has two stationary spring-loaded points and an adjustable point to permit a variation in range. These three points are evenly spaced to allow accurate centering of the tool in the bore. A fourth point, the tip of the dial indicator, is located between the two stationary points. By simply rocking the tool in the bore, you can observe the amount of variation on the dial. Most models are accurate to within one ten-thousandth (0.0001) of an inch.

Internal Groove Gauge

The internal groove gauge (not shown) may be used to measure the depth of an O-ring groove or other recesses inside a bore. This tool lets you measure a deeper recess and one located farther back in the bore than you could with an inside caliper. As with the dial bore gauge, you must set this tool with gauge blocks, a vernier caliper, or an outside micrometer. The reading taken from the dial indicator on the groove gauge represents the difference between the desired recess or groove depth and the measured depth.

Universal Vernier Bevel Protractor

The universal vernier bevel protractor (fig. 1-12) is used to lay out or measure angles on work to very close tolerances. The vernier scale on the tool permits measuring an angle to within 1/12° (5 minutes) and can be used completely through 360°. Interpreting the reading on the protractor is similar to the method used on the vernier caliper.

Universal Bevel

The universal bevel (fig. 1-13) has an offset in the blade. The offset makes it useful for bevel gear work and to check angles on lathe workpieces that cannot be reached with an ordinary bevel. Set and check the universal bevel with the protractor, or another suitable angle-measuring device, to get the angle you need.

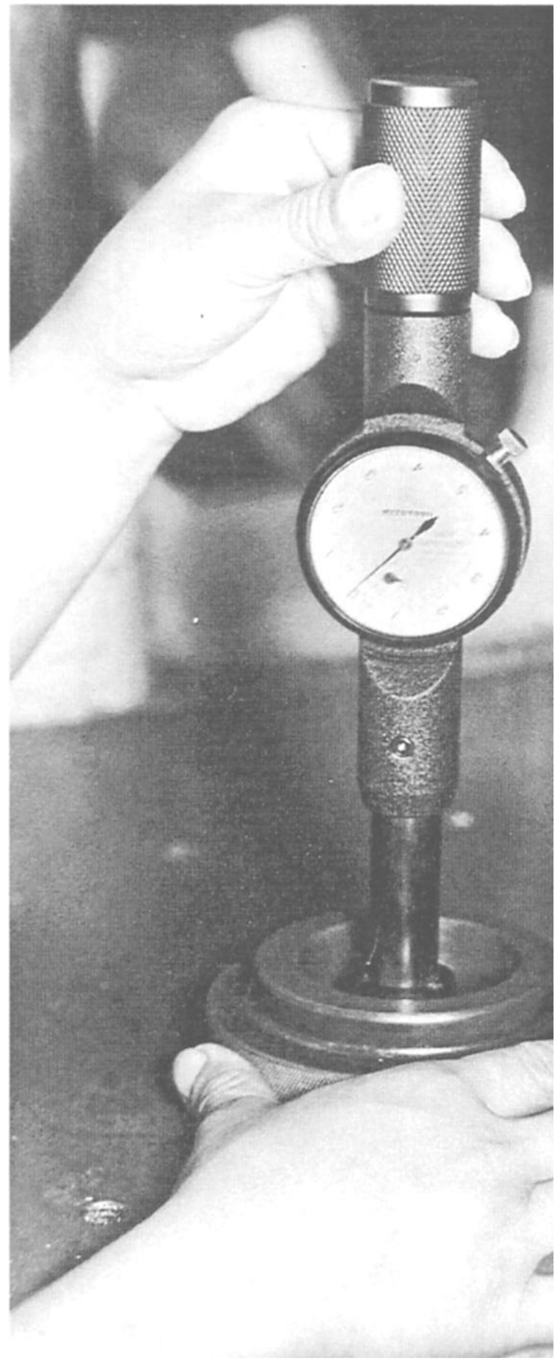

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Figure 1-11.—Dial bore gauge.

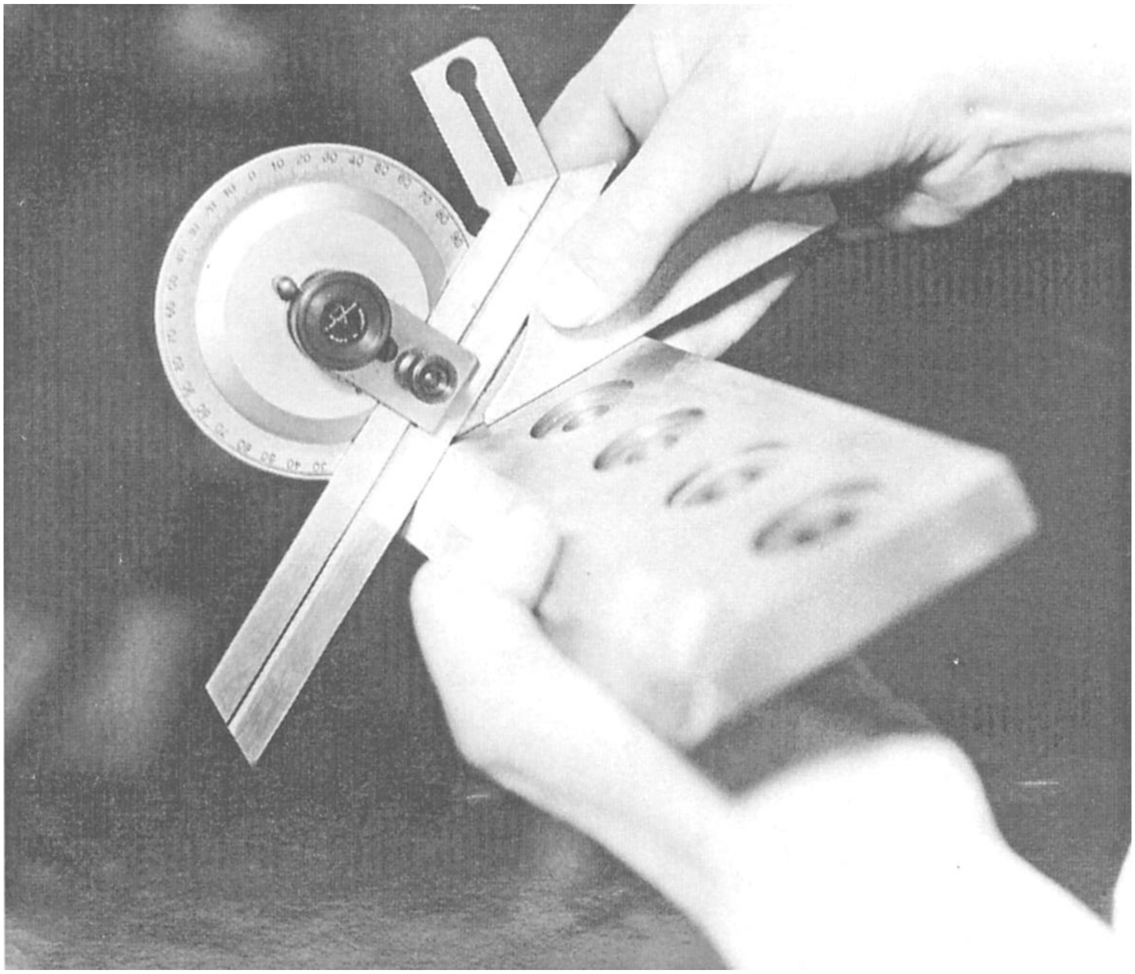

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Figure 1-12.—Universal vernier bevel protractor.

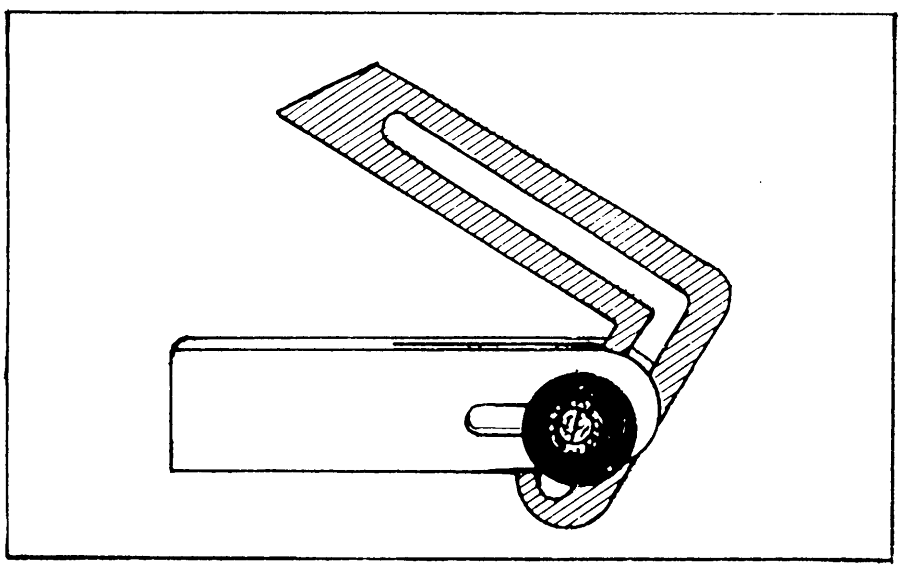

Figure 1-13.—Universal bevel.

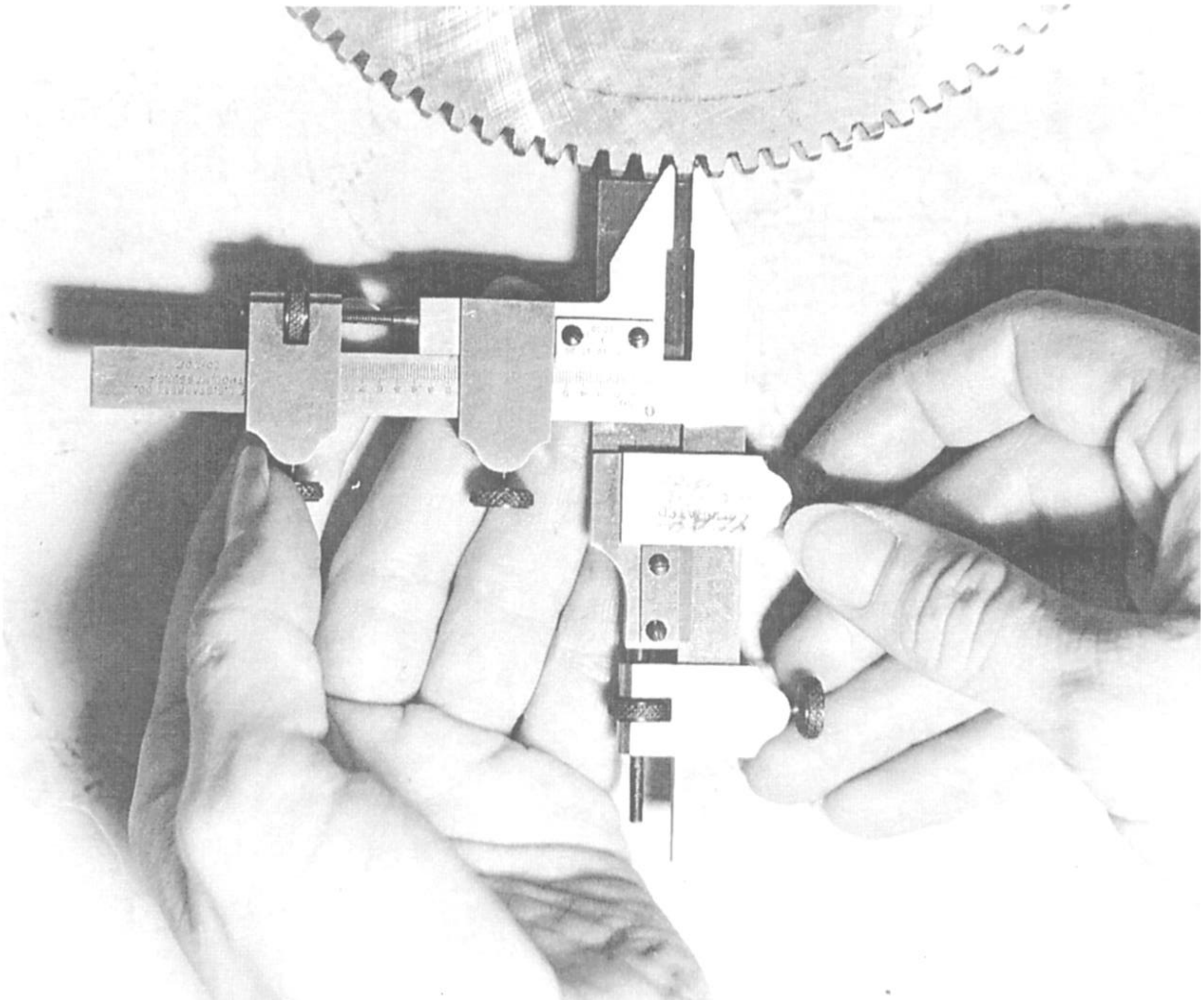

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Figure 1-14.—Gear tooth vernier.

Gear Tooth Vernier

Use a gear tooth vernier (fig. 1-14) to measure the thickness of a gear tooth on the pitch circle and the distance from the top of the tooth to the pitch chord, at the same time. Read the vernier scale on this tool in the same way as other verniers, but note that graduations on the main scale are 0.020 inch apart instead of 0.025 inch.

Cutter Clearance Gauge

The cutter clearance gauge (fig. 1-15) is one of the simplest to use. You can gauge clearance on all styles of plain milling cutters that have more than 8 teeth and a diameter range from 1/2 inch to 8 inches. To gauge a tooth with this instrument, bring the surfaces of the "V" into contact with the cutter and lower the gauge blade to the tooth to be gauged. Rotate the cutter sufficiently to bring the tooth face into contact with the gauge blade. If the angle of clearance on the tooth is correct, it will correspond with the angle of the gauge blade. Cutter clearance gauges that have an adjustable gauge blade to check clearance angles of 0° to 30° are also available.

Adjustable Parallel

The adjustable parallel in figure 1-16 consists of two wedges connected on their inclined surfaces by a sliding dovetail. An adjustable parallel can be locked at any height between its maximum and minimum limits. This instrument, constructed to about the same accuracy of dimensions as parallel blocks, is very useful to level and position setups in a milling machine or in a shaper vise. You should normally use an outside micrometer to set the adjustable parallel for height.

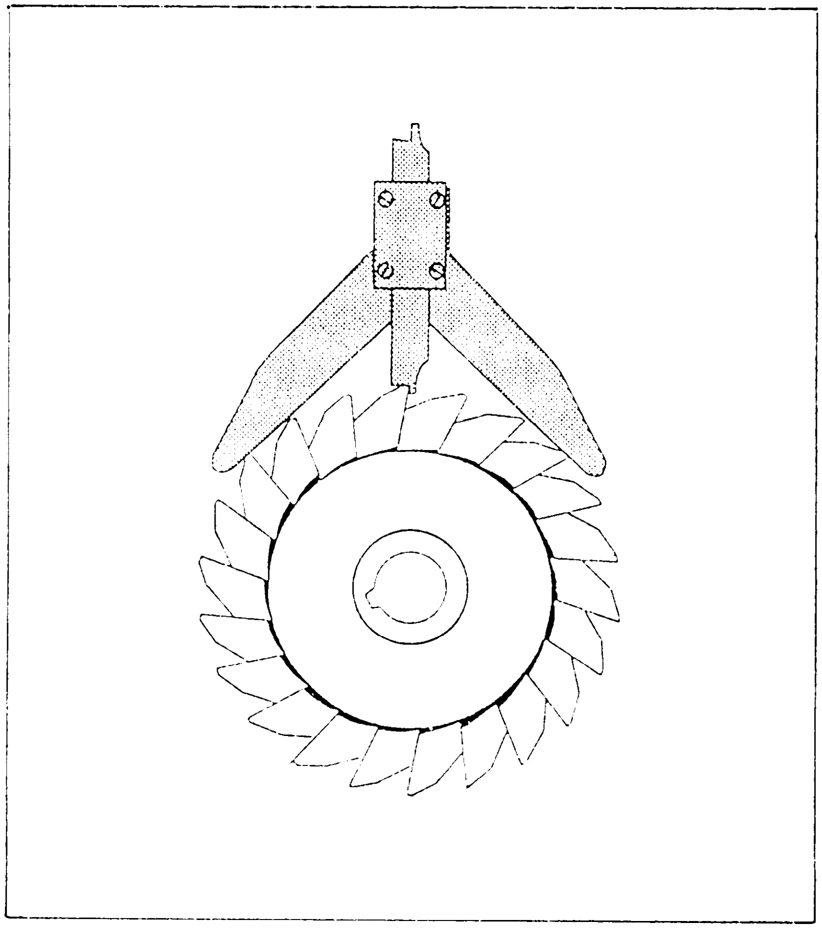

Figure 1-15.—Cutter clearance gauge.

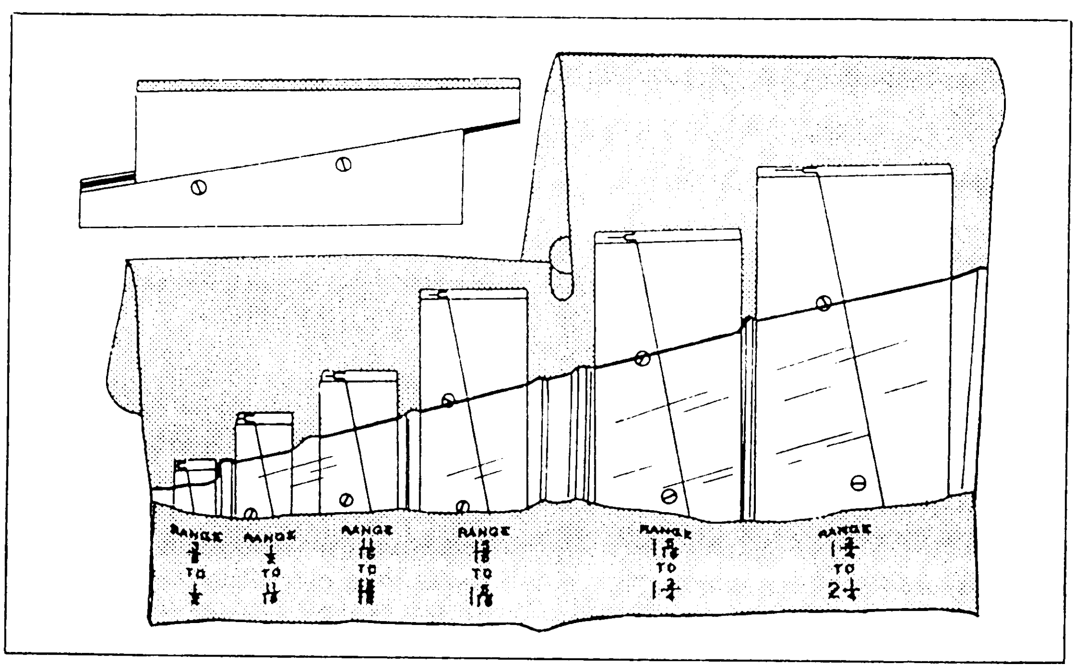

Figure 1-16.—Adjustable parallel.

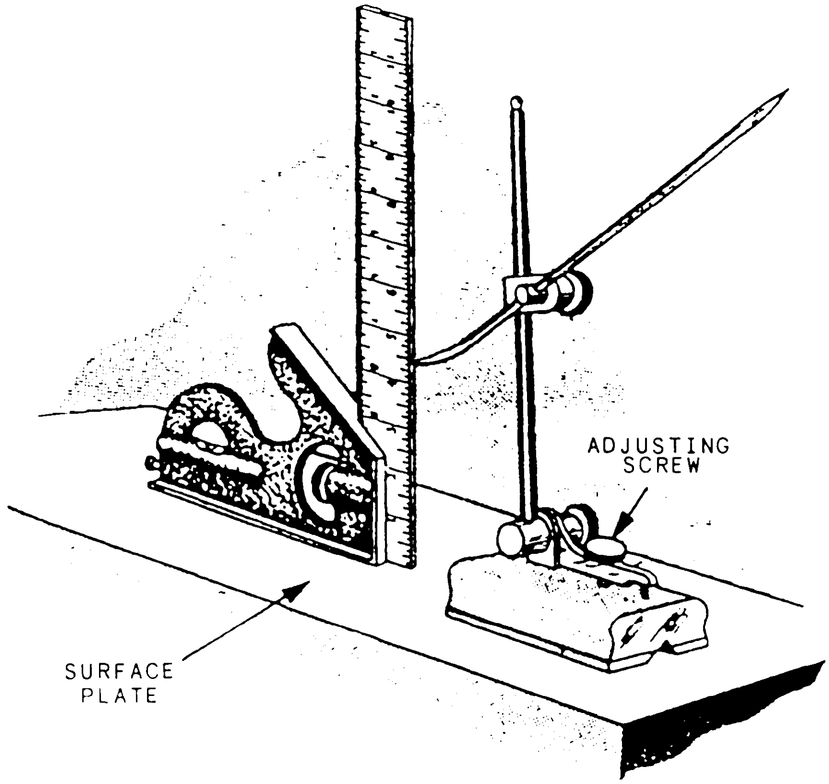

Figure 1-17.—Setting a dimension on a surface gauge.

Surface Gauge

A surface gauge (fig. 1- 17) is useful in gauging or measuring operations. It is used primarily in layout and alignment work and it is used with a scribe to transfer dimensions and layout lines. In some cases a dial indicator is used with the surface gauge to check trueness or alignment.

FIXED GAUGES

Fixed gauges cannot be adjusted. Generally, they can be divided into two categories, graduated and nongraduated. The accuracy of your work, when you use fixed gauges, will depend on your ability to compare between the work and the gauge. For example, a skilled machinist can take a dimension accurately to within 0.005 of an inch or less using a common rule. Experience will increase your ability to take accurate measurements.

Graduated Gauges

Graduated gauges are direct reading gauges that have scales inscribed on them, enabling you to take a reading while using the gauge. The gauges in this group are rules, scales, thread gauges, center gauges, feeler gauges, and radius gauges.

RULES.—The steel rule with holder set (fig. 1-18, view A) is convenient for measuring recesses. It has a long tubular handle with a split chuck for holding the ruled blade. The chuck can be adjusted by a knurled nut at the top of the holder, allowing the rule to be set at various angles. The set has rules ranging from 1/4 to 1 inch in length.

The angle rule (fig. 1-18, view B) is useful in measuring small work mounted between centers on a lathe. The long side of the rule (ungraduated) is placed even with one shoulder of the work. The graduated angle side of the rule can then be positioned easily over the work.

Another useful device is the keyseat rule (fig. 1-18, view C). It has a straightedge and a 6-inch machinist's-type rule arranged to form a right angle square. This rule and straightedge combination, when applied to the surface of a cylindrical workpiece, makes an excellent guide for drawing or scribing layout lines parallel to the axis of the work. This device is very convenient when making keyseat layouts on shafts.

You must take care of your rules if you expect them to give accurate measurements. Do not allow them to become battered, covered with rust, or

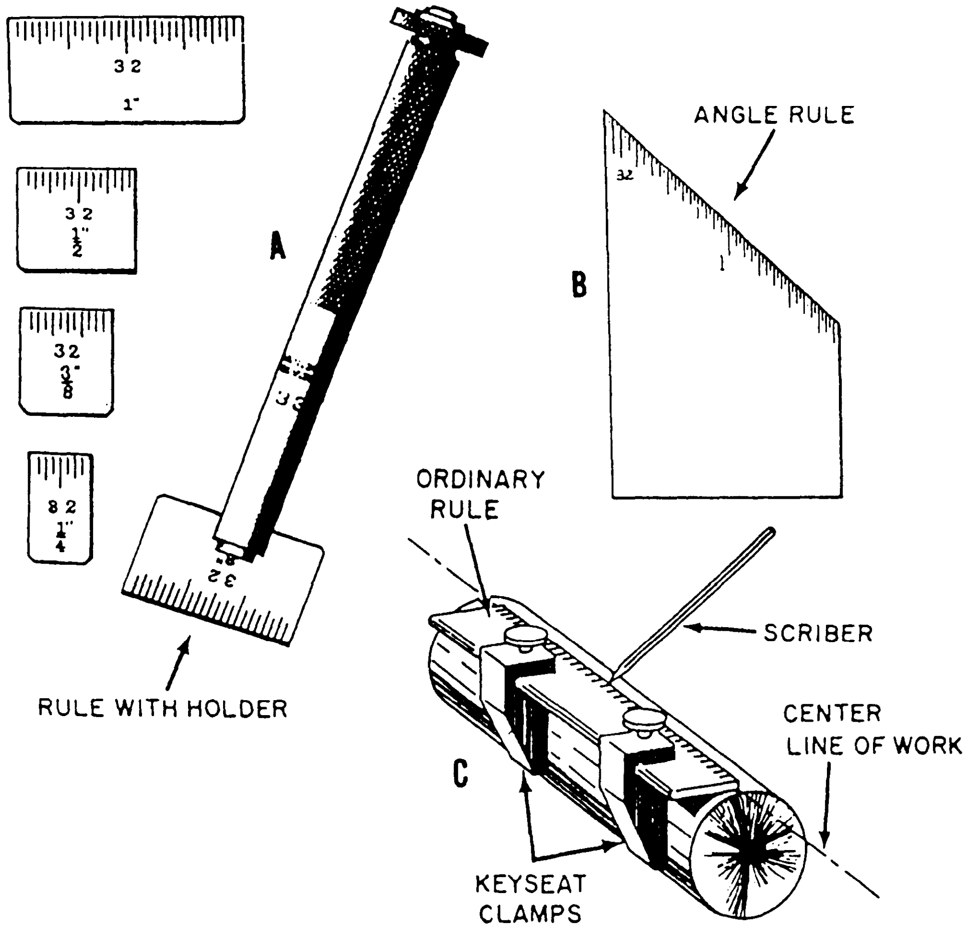

Figure 1-18.—Speclal rules for shop use.

otherwise damaged so that the markings cannot be read easily. Never use rules for scrapers. Once rules lose their sharp edges and square corners, their accuracy is decreased.

SCALES.—A scale is similar in appearance to a rule, since its surface is graduated into regular spaces. The graduations on a scale, however, differ from those on a rule because they are either larger or smaller than the measurements indicated. For example, a half-size scale is graduated so that 1 inch on the scale is equivalent to an actual measurement of 2 inches; a 12-inch long scale of this type is equivalent to 24 inches. A scale, therefore, gives proportional measurements instead of the actual measurements obtained with a rule. Like rules, scales are made of wood, plastic, or metal, and they generally range from 6 to 24 inches.

ACME THREAD TOOL GAUGE.—The thread gauge (fig. 1-19) is used to both grind the tool used to machine Acme threads and to set the tool up in the lathe. The sides of the Acme thread have an included

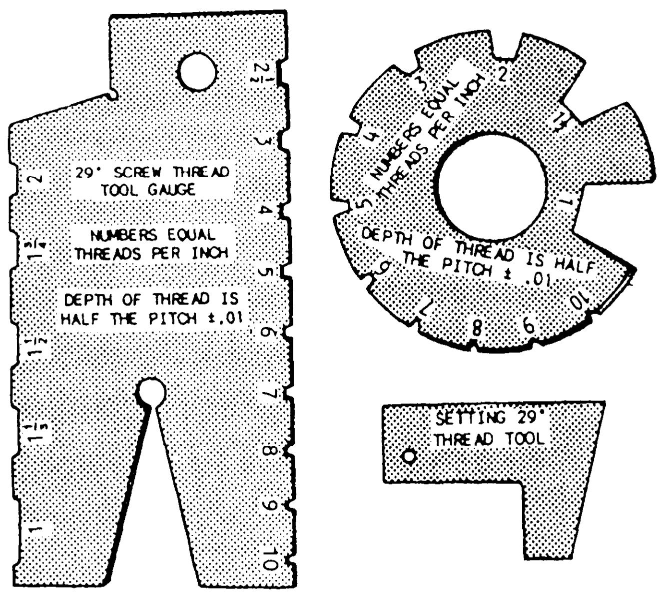

Figure 1-19.—Acme thread gauges.

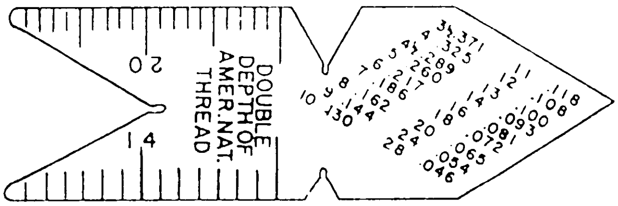

Figure 1-20.—Center gauge.

angle of 29° (14 1/2° to each side), and this is the angle made into the gauge. The width of the flat on the point of the tool varies according to the number of threads per inch. The gauge provides different slots for you to use as a guide when you grind the tool. It's easy to set up the tool in the lathe. First, make sure that the tool is centered on the work as far as height is concerned. Then, with the gauge edge laid parallel to the centerline of the work, adjust the side of your tool until it fits the angle on the gauge very closely.

CENTER GAUGE.—Use the center gauge (fig. 1-20) like the Acme thread gauge. Each notch and the point of the gauge has an included angle of 60°. Use the gauge primarily to check and to set the angle of the V-sharp and other 60° standard threading tools. You may also use it to check the lathe centers. The edges are graduated into 1/4, 1/24, 1/32, and 1/64 inch for ease in determining the pitch of threads on screws.

FEELER GAUGE.—Use a feeler (thickness) gauge (fig. 1-21) to determine distances between two closely mating surfaces. When you USC a combination of blades to get a desired gauge thickness, try to place the thinner blades between the heavier ones to protect the thinner blades and to prevent their kinking. Do not force blades into openings that are too small; the blades may bend and kink. To get the feel of using a feeler gauge, practice with it on openings of known dimensions.

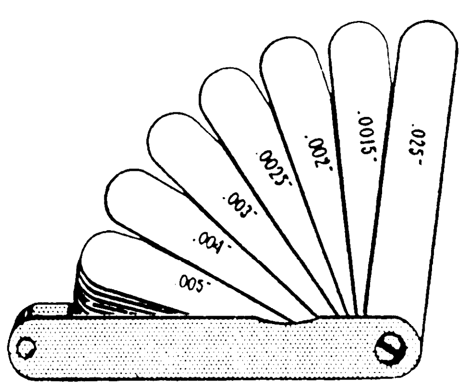

Figure 1-21.—Feeler (thickness) gauge.

RADIUS GAUGE.—The radius gauge (fig. 1-22) is often underrated in its usefulness to the machinist. Whenever possible, the design of most parts includes a radius located at the shoulder formed when a change is made in the diameter. This gives the part an added margin of strength at that particular place. When a square shoulder is machined in a place where a radius should have been, the possibility that the part will fail by bending or cracking is increased. The blades of most radius gauges have both concave (inside curve) and convex (outside curve) radii in the common sizes.

Nongraduated Gauges

Nongraduated gauges are used primarily as standards, or to determine the accuracy of form or shape. They include the straightedge, machinist square, sine bar, parallel blocks, gauge blocks, ring and plug gauges, and thread-measuring wires. We'll explain the use of these gauges in the following paragraphs.

STRAIGHTEDGES.—Straightedges look very much like rules, except they are not graduated. They are used primarily to check surfaces for straightness; however, they can also be used as guides to help draw or scribe straight lines. Two types of straightedges are shown in figure 1-23. View A shows a straightedge made of steel that is hardened on the edges to prevent wear; it is the one you will probably use most often. The straightedge shown in view B has a knife edge and is used for work requiring extreme accuracy.

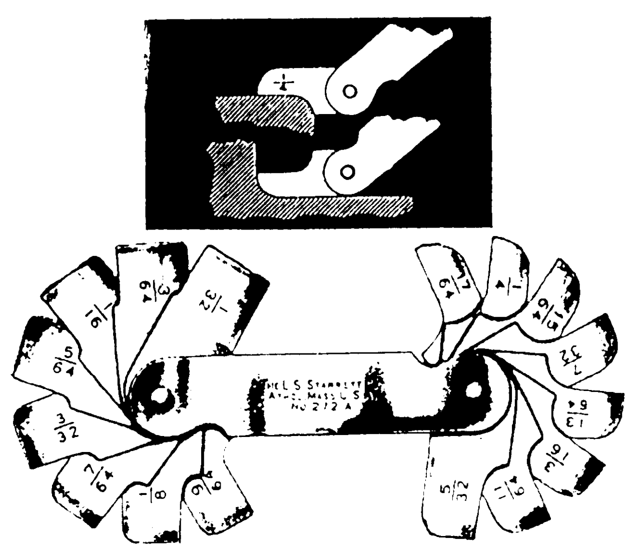

Figure 1-22.—Radius gauges.

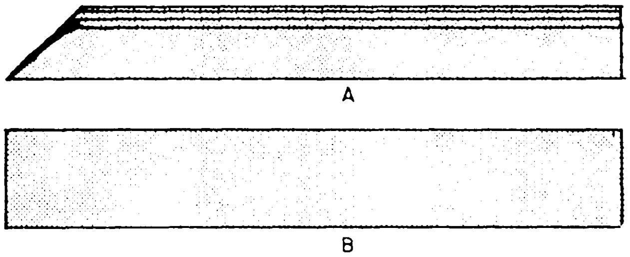

Figure 1-23.—Straightedge.

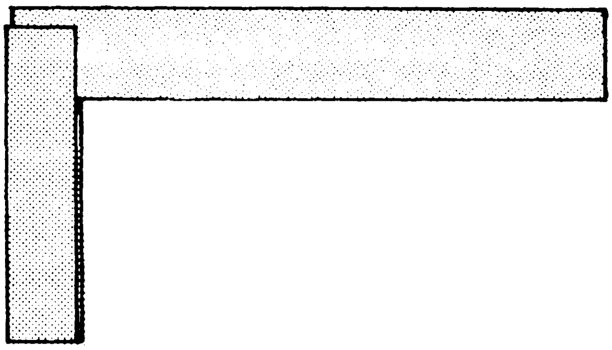

Figure 1-24.—Machinist's square.

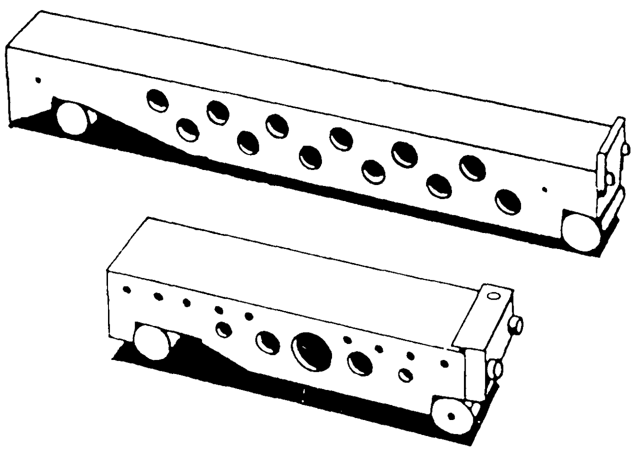

Figure 1-25.—Sine bars.

Always keep a straightedge in a box when it is not in use. Some straightedges are marked with two arrows, one near each end, which indicate balance points. When a box is not provided, place resting pads on a flat surface in a storage area where no damage to the straightedge will occur from other tools. Then, place the straightedge so the two balance points sit on the resting pads.

MACHINIST'S SQUARE.—The most common type of machinist's square has a hardened steel blade securely attached to a beam. The steel blade is NOT graduated. (See fig. 1-24.) This instrument is very useful in checking right angles and in setting up work on shapers, milling machines, and drilling machines. The size of machinist's squares ranges from 1 1/2 to 36 inches in blade length. You should take the same care of machinist's squares, in storage and use, as you do with a micrometer.

SINE BAR.—A sine bar (fig. 1-25) is a precision tool used to establish angles that require extremely close accuracy. When used in conjunction with a surface plate and gauge blocks, angles are accurate to 1 minute (1/60°). The sine bar is used to measure angles on work and to lay out an angle on work to be machined, or work may be mounted directly to the sine bar for machining. The cylindrical rolls and the parallel bar, which make up the sine bar, are all precision ground and accurately positioned to permit such close measurements. Be sure to repair any scratches, nicks, or other damage before you use the sine bar, and take care in using and storing the sine bar. Instructions on using the sine bar are included in chapter 2.

PARALLEL BLOCKS.—Parallel blocks (fig. 1-26) are hardened, ground steel bars that are used to lay out work or set up work for machining. The surfaces of the parallel block are all either parallel or perpendicular, as appropriate, and can be used to position work in a variety of setups with

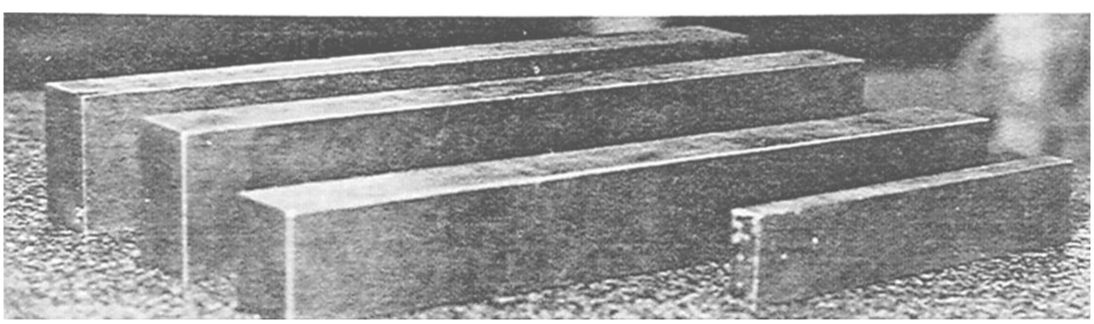

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Figure 1-26.—Parallel blocks.

accuracy. They generally come in matched pairs and in standard fractional dimensions. Use care in storing and handling them to prevent damage. If it becomes necessary to regrind the parallel blocks, be sure to change the size stamped on the ends of the blocks.

GAUGE BLOCKS.—Gauge blocks (not shown) are used as master gauges to set and check other gauges and instruments. Their accuracy is from two-millionths (0.000002) of an inch to eight-millionths (0.000008) of an inch, depending on the grade of the set. To visualize this minute amount, consider that the average thickness of a human hair divided 1,500 times equals 0.000002 inch. This degree of accuracy applies to the thickness of the gauge block, the parallelism of the sides, and the flatness of the surfaces. To attain this accuracy, a fine grade of hardenable alloy steel is ground and then lapped. The gauge blocks are so smooth and flat that when they are "wrung" or placed one atop the other you cannot separate them by pulling straight out. A set of gauge blocks has enough different size blocks that you can establish any measurement within the accuracy and range of the set. As you might expect, anything so accurate requires exceptional care to prevent damage and to ensure continued accuracy. A dust-free temperature-controlled atmosphere is preferred. After use, wipe each block clean of all marks and fingerprints, and coat it with a thin layer of white petrolatum to prevent rust.

RING AND PLUG GAUGES.—A ring gauge (fig. 1-27, views C and D) is a cylindrically-shaped disk that has a precisely ground bore. Ring gauges are used to check machined diameters by sliding the gauge over the surface. Straight, tapered, and threaded diameters can be checked by using the appropriate gauge. The ring gauge is also used to set other measuring instruments to the basic dimension required for their operation. Normally, ring gauges are available with a GO and a NOT GO size that represents the tolerance allowed for the particular size or job.

A plug gauge (fig. 1-27, views A and B) is used for the same types of jobs as a ring gauge. However, it is a solid shaft-shaped bar that has a precisely ground diameter used to check inside diameters or bores.

THREAD MEASURING WIRES.—These wires provide the most accurate method of measuring the fit or pitch diameter of threads, without going into the expensive and sophisticated optical and comparator equipment. The wires are accurately sized, depending on the number of threads per inch. When they are laid over the threads in a position that allows an outside micrometer to measure the distance between them, the pitch diameter of the threads can be determined. Sets are available that contain all the more common sizes. Detailed information on computing and using the wire method for measuring is covered in chapter 6.

CARE AND MAINTENANCE OF MEASURING INSTRUMENTS

The proper care and maintenance of precision instruments is very important to a conscientious MR. To help you maintain your instruments in the most accurate and reliable condition possible, the Navy has established a calibration program. It provides calibration technicians with the required standards and procedures, and a schedule of how often an instrument must be calibrated to be reliable. When an instrument is calibrated, a sticker is affixed to it showing the date the calibration was done and the date the next calibration is due. Whenever possible, you should use the Navy calibration program to verify the accuracy of your instruments. Some repair jobs, due to their sensitive nature, demand the reliability provided by the program. Information concerning the procedures that you can use in the shop to check the accuracy of an instrument is contained in the following paragraphs.

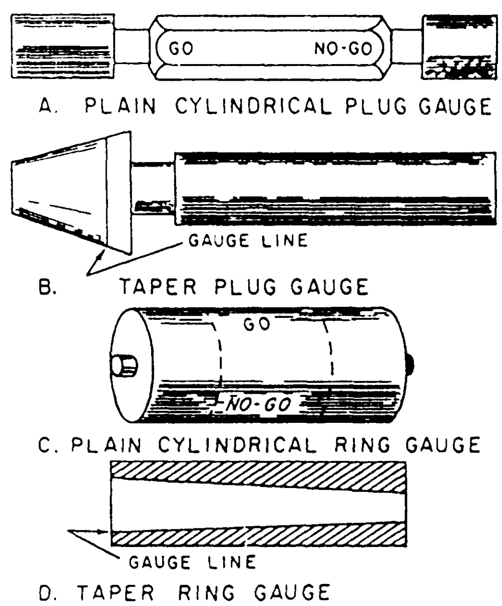

Figure 1-27.—Ring gauges and plug gauges.

MICROMETERS

The micrometer is one of the most used, and often one of the most abused, precision measuring instruments in the shop. Careful observation of the do's and don'ts in the following list will enable you to take proper care of the micrometer you use:

- Always stop the work before taking a measurement. Do NOT measure moving parts because the micrometer may get caught in the rotating work and be severely damaged.

- Always open a micrometer by holding the frame with one hand and turning the knurled sleeve with the other hand. Never open a micrometer by twirling the frame, because such practice will put unnecessary strain on the instrument and cause excessive wear of the threads.

- Apply only moderate force to the knurled thimble when you take a measurement. Always use the friction slip ratchet if there is one on the instrument. Too much pressure on the knurled sleeve will not only result in an inaccurate reading, but may also cause the frame to spring, forcing the measuring surfaces out of line.

- When a micrometer is not in actual use, place it where it is not likely to be dropped. Dropping a micrometer can cause the frame to spring; if dropped, the instrument should be checked for accuracy before any further readings are taken.

- Before a micrometer is returned to stowage, back the spindle away from the anvil, wipe all exterior surfaces with a clean, soft cloth, and coat the surfaces with a light oil. Do not reset the measuring surfaces to close contact because the protecting film of oil in these surfaces will be squeezed out.

- A micrometer caliper should be checked for zero setting (and adjusted when necessary) as a matter of routine to ensure that reliable readings are being obtained. To do this, proceed as follows:

1. Wipe the measuring faces, making sure that they are perfectly clean, and then bring the spindle into contact with the anvil. Use the same moderate force that you ordinarily use when taking a measurement. The reading should be zero; if it is not, the micrometer needs further checking.

2. If the reading is more than zero, examine the edges of the measuring faces for burrs. Should burrs be present, remove them with a small slip of oilstone; clean the measuring surfaces again, and then recheck the micrometer for zero setting.

3. If the reading is less than zero, or if you do not obtain a zero reading after making the correction described in step 2, you will need to adjust the spindle-thimble relationship. The method for setting zero differs considerably between makes of micrometers. Some makes have a thimble cap that locks the thimble to the spindle; some have a special rotatable sleeve on the barrel that can be unlocked; and some have an adjustable anvil.

- To make adjustments to micrometers follow these steps:

1. To adjust the THIMBLE-CAP TYPE, back the spindle away from the anvil, release the thimble cap with the small spanner wrench provided for that purpose, and bring the spindle into contact with the anvil. Hold the spindle firmly with one hand and rotate the thimble to zero with the other; after zero relation has been established, rotate the spindle counterclockwise to open the micrometer, and then tighten the thimble cap. After tightening the cap, check the zero setting again to be sure the thimble-spindle relation was not disturbed while the cap was being tightened.

2. To adjust the ROTATABLE SLEEVE TYPE, unlock the barrel sleeve with the small spanner wrench provided for that purpose, bring the spindle into contact with the anvil, and rotate the sleeve into alignment with the zero mark on the thimble. After completing the alignment, back the spindle away from the anvil, and retighten the barrel sleeve locking nut. Recheck for zero setting, to be sure you did not disturb the thimble-sleeve relationship while tightening the lock nut.

3. To set zero on the ADJUSTABLE ANVIL TYPE, bring the thimble to zero reading, lock the spindle if a spindle lock is provided, and loosen the anvil lock screw. After you have loosened the lock screw, bring the anvil into contact with the spindle, making sure the thimble is still set on zero. Tighten the anvil setscrew lock nut slightly, unlock the spindle, and back the spindle away from the anvil; then lock the anvil setscrew firmly. After locking the setscrew, check the micrometer for zero setting to make sure you did not move the anvil out of position while you tightened the setscrew.

- The zero check and methods of adjustment of course apply directly to micrometers that will measure to zero; the PROCEDURE FOR LARGER

MICROMETERS is essentially the same except that a standard must be placed between the anvil and the spindle to get a zero measuring reference. For example, a 2-inch micrometer is furnished with a 1-inch standard. To check for zero setting, place the standard between the spindle and the anvil and measure the standard. If zero is not indicated, the micrometer needs adjusting.

- Inside micrometers can be checked for zero setting and adjusted in about the same way as a micrometer caliper; the main difference in the method of testing is that an accurate micrometer caliper is required for transferring readings to and from the standard when an inside micrometer is being checked.

- Micrometers of all types should be disassembled periodically for cleaning and lubrication of internal parts. When this is done, each part should be cleaned in noncorrosive solvent, completely dried, and then given a lubricating coat of watchmaker's oil or a similar light oil.

VERNIER GAUGES

Vernier gauges also require careful handling and proper maintenance if they are to remain accurate. The following instructions apply to vernier gauges in general:

- Always loosen a gauge into position. Forcing, besides causing an inaccurate reading, is likely to force the arms out of alignment.

- When taking a measurement, use only gentle pressure on the fine adjustment screw. Heavy pressure will force the two scales out of parallel.

- Before putting a vernier gauge away, wipe it clean and give it a light coating of oil. (Perspiration from hands will cause the instrument to corrode rapidly.)

Dials

Dial indicators and other instruments that have a mechanically operated dial as part of their measurement features are easily damaged by misuse and lack of proper maintenance. The following instructions apply to dials in general:

- As previously mentioned, be sure the dial you have selected to use has the range capability required. When a dial is extended beyond its design limit, some lever, small gear, or rack must give to the pressure. The dial will be rendered useless if this happens.

- Never leave a dial in contact with any surface that is being subjected to a shock (such as hammering a part when dialing it in) or an erratic and uncontrolled movement that could cause the dial to be overtraveled.

- Protect the dial when it is not being used. Provide a storage area where the dial will not receive accidental blows and where dust, oil, and chips will not contact it.

- When a dial becomes sticky or sluggish in operating, it may be either damaged or dirty. You may find that the pointer is rubbing the dial crystal or that it is bent and rubbing the dial face. Never oil a sluggish dial. Oil will compound the problems. Use a suitable cleaning solvent to remove all dirt and residue.