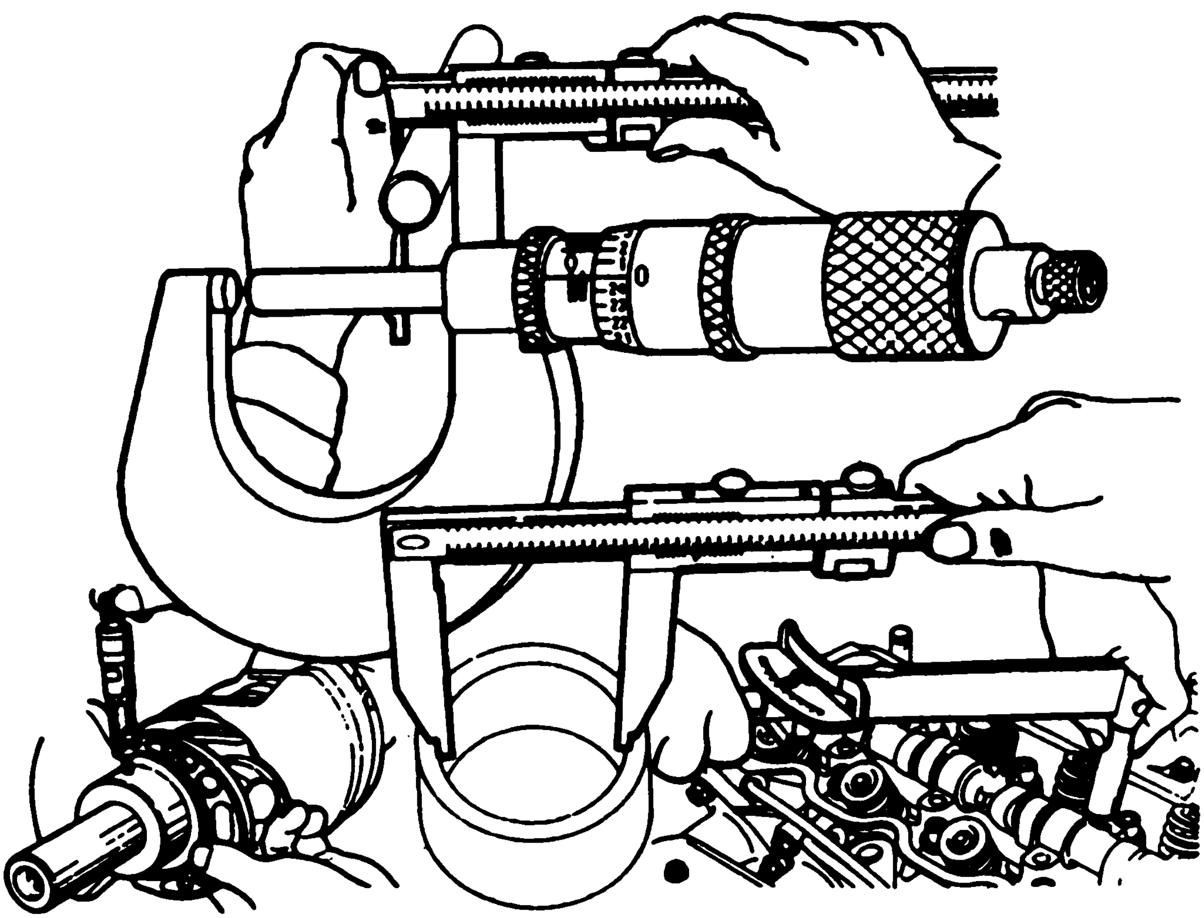
SUBCOURSE EN5264

EDITION 8

US ARMY ENGINEER SCHOOL

ENGINEER CONSTRUCTION EQUIPMENT TEST, MEASURING, AND DIAGNOSTIC EQUIPMENT



THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT

ARMY CORRESPONDENCE COURSE PROGRAM

AIPD

READINESS/PROFESSIONALISM THRU GROWTH

CONSTRUCTION EQUIPMENT REPAIRER

MOS 62B, SKILL LEVEL 2 COURSE

ENGINEER CONSTRUCTION EQUIPMENT
TEST, MEASURING, AND DIAGNOSTIC EQUIPMENT

Training Development Field Office
Directorate of Training and Doctrine

SUBCOURSE NO EN 5264

US ARMY ENGINEER SCHOOL
FORT LEONARD WOOD, MISSOURI

Twelve Credit Hours

GENERAL

This subcourse is designed to teach the knowledge and skills necessary to properly use the various test, measuring, and diagnostic equipment needed to perform various tasks related to the repair of engineer construction equipment. The subcourse is presented in six lessons each of which corresponds to a specific learning objective.

Lesson 1: MICROMETERS

TASK

Identify different types of micrometers, select the proper micrometers for specific jobs, and read the various types of micrometers.

CONDITIONS

You sill be given information describing different types of micrometers, selection of micrometers for specific jobs, and reading different types of micrometers.

STANDARDS

You are expected to demonstrate competency of the task skills and knowledge by responding correctly to 75 percent of the examination questions pertaining to this lesson.

(This objective supports Soldier's Manual (SM) tasks 051-235-1707, Troubleshoot a System Malfunction on Engineer Equipment; 051-235-2290, Replace a Camshaft end Camshaft Gears and Bearings; 051-235-2291, Replace a Crankshaft; 051-235-2600, Replace a Piston Assembly; and 051-235-2234, Repair a Conventional Transmission.)

Lesson 2: CALIPERS AND DIVIDERS

TASK

Identify calipers and dividers by type; transfer measurements using micrometers; select proper calipers or dividers for specific jobs; and read the vernier caliper.

CONDITIONS

You will be given information describing different types of calipers and dividers; the selection of calipers or dividers for specific jobs; and reading vernier calipers.

STANDARDS

You are expected to demonstrate competency of the task skills and knowledge by responding correctly to 75 percent of the examination questions pertaining to this lesson.

(This objective supports SM tasks 051-235-2290, Replace a Camshaft and Camshaft Gears and Bearings; 051-235-2291, Replace a Crankshaft; 051-235-2600, Replace a Piston Assembly; and 051-235-2234, Repair a Conventional Transmission.)

Lesson 3: DIAL INDICATORS

TASK

Identify, set up, and read the dial indicator.

CONDITIONS

You will be given a No. 2 pencil and information on set-up procedures, reading methods, and types of dial indicators.

STANDARDS

You are expected to demonstrate competency of the task skills and knowledge by responding correctly to 75 percent of the examination questions pertaining to this lesson.

(This objective support SM tasks 051-235-2290, Replace a Camshaft and Camshaft Gears and Bearings, and 051-235-2291, Replace a Crankshaft.)

Lesson 4: MEASURING GAGES

TASK

Identify types of measuring gages, select the proper gage for a specific job, and read the graduations on the various gages.

CONDITIONS

You will be given information on different types of gages, gages used for specific jobs, and sizing of gages.

STANDARDS

You are expected to demonstrate competency of the task skills and knowledge by responding correctly to 75 percent of the examination questions pertaining to this lesson.

(This objective supports SM tasks 051-235-2600, Replace a Piston Assembly; 051-235-2601, Replace Engine Valves; and 051-235-2550, Repair an Expanding Shoe Clutch.)

Lesson 5: TORQUE WRENCHES

TASK

Identify torque wrenches by type and size, select the proper torque wrench for a specific job, and use the torque wrench properly.

CONDITIONS

You will be given information describing different types of torque wrenches, torque wrench selection, and proper torque Wrench use.

STANDARDS

You are expected to demonstrate competency of the task skills and knowledge by responding correctly to 75 percent of the examination questions pertaining to this lesson.

(This objective supports SM task 051-235-1703, Use a Torque Wrench.)

Lesson 6: HYDRAULIC FILLER/BLEEDER

TASK

Identify the components and uses of the hydraulic filler/bleeder.

CONDITIONS

You will be given information on the hydraulic filler/bleeder, filler/bleeder components, and filler/bleeder operation.

STANDARDS

You are expected to demonstrate competency of the task skills and knowledge by responding correctly to 70 percent of the examination questions pertaining to this lesson.

(This objective supports SM task 051-235-1704, Use a Hydraulic Filler/Bleeder.)

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***** IMPORTANT NOTICE *****

THE PASSING SCORE FOR ALL ACCP MATERIAL IS NOW 70%.

PLEASE DISREGARD ALL REFERENCES TO THE 75% REQUIREMENT.

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INTRODUCTION

The Army's mission “to perform prompt and sustained combat on land" implies the readiness to go at any time with what we have in manpower and material resources. Effective firepower and mobility depend on our ability to perform the maintenance necessary to keep equipment and material in operating condition. To maintain combat effectiveness, we need to strengthen our entire maintenance system, with emphasis on the user level. Our equipment continually becomes more complex. This all adds to the requirement for improved maintenance at all levels. The growing demands for force readiness mean that we must approach our maintenance responsibility with added enthusiasm. This subcourse teaches the proper use of tools/ equipment necessary to repair and maintain engineer equipment and thus help the supervisor manage and maintain combat readiness.

Lesson 1: MICROMETERS

TASK

Identify different types of micrometers, select the proper micrometers for specific jobs, and reed the various types of micrometers.

CONDITIONS

You will be given information describing different types of micrometers, selection of micrometers for specific jobs, and reading different types of micrometers.

STANDARDS

You are expected to demonstrate competency of the task skills and knowledge by responding correctly to 70 percent of the examination questions pertaining to this lesson.

CREDIT HOURS

2

REFERENCES

TM 9-243

Learning Event 1
IDENTIFY TYPES AND MECHANICS OF MICROMETERS

Micrometers are used for measurements requiring precise accuracy. They are made in various shapes and sizes, depending on their intended purpose. They all have a precision screw adjustment offering great measuring accuracy.

TYPES

Micrometer Caliper (Outside)

The micrometer caliper, Figure 1, is the most common micrometer. It has a range of 0 to 1 inch and is graduated to read in thousandths of an inch or in units of the metric system, from 0 to 25 millimeters by hundredths of a millimeter. It may or may not have--

a. A stainless steel frame to resist corrosion or tarnish.

b. A ratchet for applying a constant measuring pressure.

c. A special vernier scale for reading tenths of thousandths of an inch.

d. A clamp ring or locknut for clamping the spindle to hold a setting.

e. Cemented carbide tips on the measuring anvils to reduce wear.

The frame can be smaller to the extent that the range of the caliper is only 0 to 1/2 inch; or, it can be larger so that the range is 23 to 24 inches. The head has a constant range of 0 to 1 inch. The shape of the frame may be varied to adapt it to the physical requirements of some types of work. For example-

a. The frame back of the anvil may be cut away to allow the anvil to be placed in a narrow slot.

b. The frame may have a deep throat to allow it to reach into the center sections of a sheet (sheet metal or paper gage).

c. The frame may be in the form of a base so that the gage can be used as a bench micrometer.

d. The frame may have a wooden handle and be of extra-heavy construction for use in gaging hot sheet metal in a steel mill.

The design of the spindle and anvil may vary to accommodate special physical requirements. For example-

a. The spindle and anvil may be chamfered so the gage can slide on and off the work easily, as when gaging hot metal.

b. A ball-shaped anvil is convenient in measuring the thickness of a pipe section of small diameter.

c. The V-shaped anvil is necessary on the screw thread micrometer caliper to mesh properly with the screw thread. The spindle of the screw thread micrometer is cone-shaped. This micrometer measures the pitch diameter.

d. Interchangeable anvils of various lengths make it possible to reduce the range of the caliper. A micrometer having a range from 5 to 6 inches can be changed to one having a 4- to 5-inch, or 3- to 4-inch range by inserting a special anvil of the proper length.

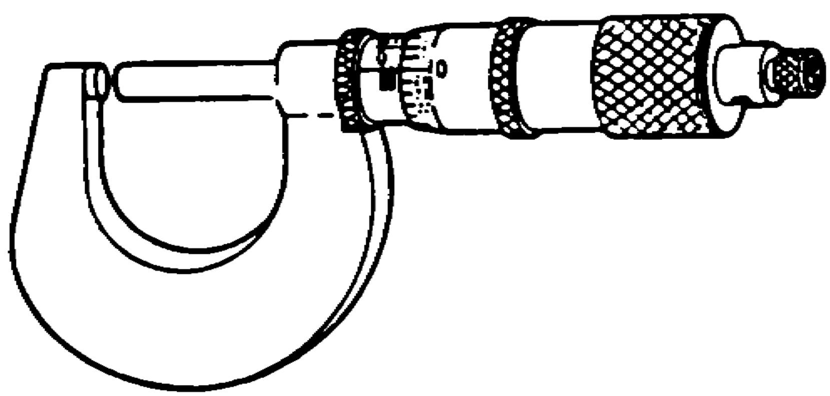


FIGURE 1. OUTSIDE MICROMETER CALIPER

Inside Micrometers

Inside micrometers, Figure 2, are used to measure inside dimensions. The minimum dimension that can be measured is determined by the length of the unit with its shortest anvil in place and the screw set to zero. It consists of an ordinary micrometer head, except that the outer end of the sleeve carries a contact point, attached to a measuring rod.

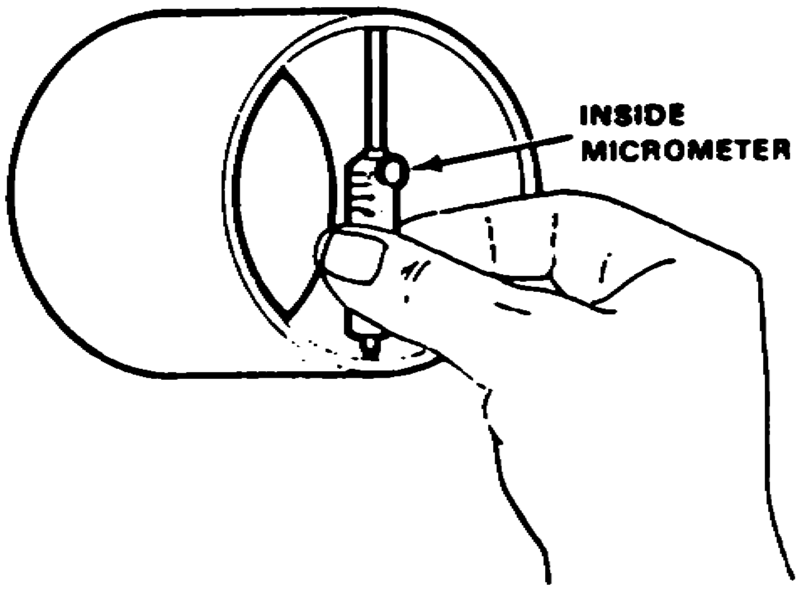


FIGURE 2. INSIDE MICROMETER

The average inside micrometer set, Figure 3, has a range that extends from 2 to 10 inches. The various steps in covering this range are obtained by means of extension rods. The micrometer set may also contain a collar for splitting the inch step between two rods. The collar, which is 1/2 inch long, extends the rod another 1/2 inch so the range of each step can be made to overlap the next. The range of the micrometer screw itself is very short when compared to its measuring range. The smallest models have a 1/4-inch screw, and the largest inside micrometers have only a 1-inch screw.

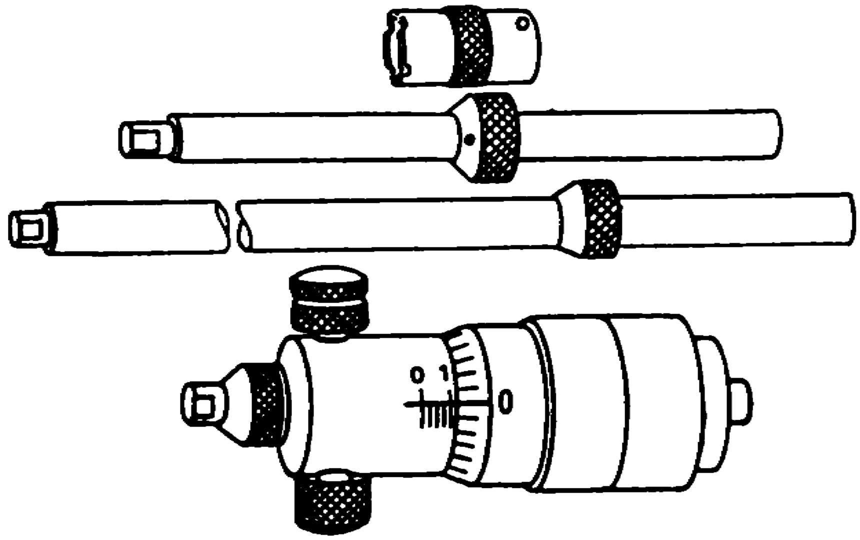


FIGURE 3. INSIDE MICROMETER SET

Depth Micrometers

A depth micrometer, as the name implies, is designed to measure the depth of holes, recesses, keyways, and so forth. The tool consists of a base with a micrometer head, Figure 4. Various length measuring rods can be inserted through a hole in the micrometer screw. The rod protrudes through the base and moves as the thimble is rotated.

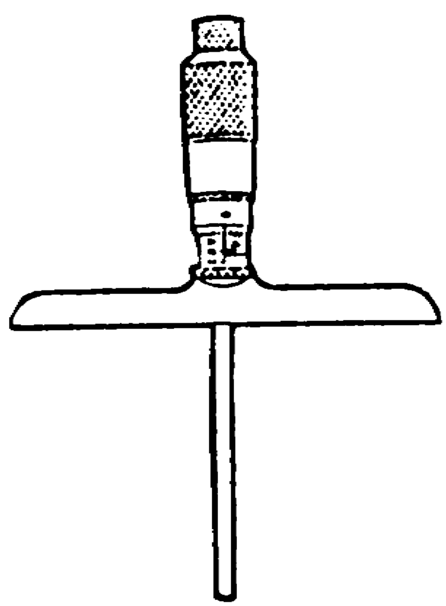


FIGURE 4. DEPTH MICROMETER

MECHANICS

Design

The micrometer, Figure 5, makes use of the relation of the circular movement of a screw to its axial movement. The amount of axial movement of a screw per revolution depends on the thread, and is known as the lead. For example, a circular nut on a screw has its circumference divided into 25 equal spaces. If the nut advances axially 1/40 inch for each revolution and is then turned one division or 1/25 of a revolution, it will move axially 1/25 x 1/40 or 1/1,000 of an inch. In the micrometer, the nut is stationary and the screw moves forward axially a distance proportional to the amount it is turned. The screw on a micrometer has 40 threads to the inch, and the thimble has its circumference divided into 25 parts, so one division on the thimble represents an advancement of 1/1,000 of an inch axially.

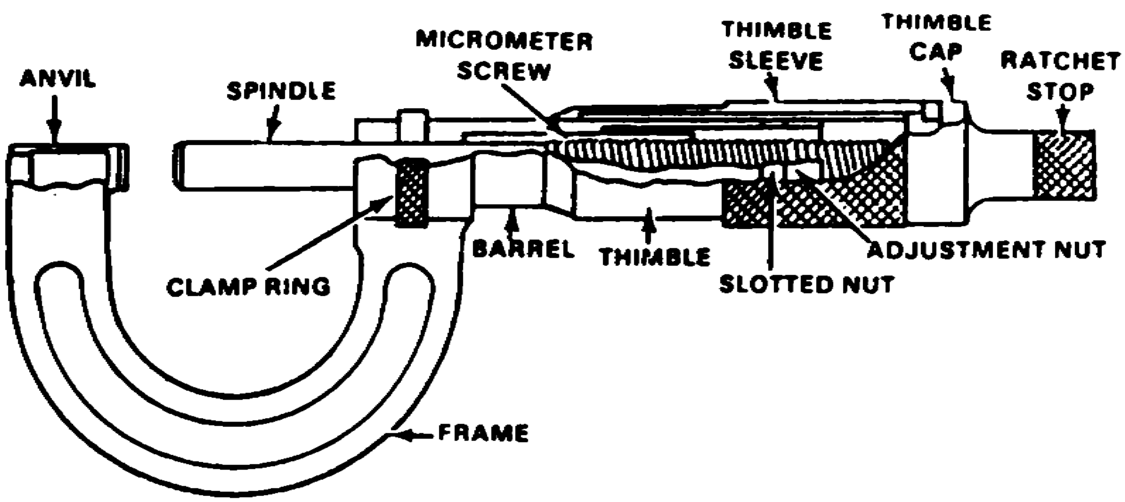


FIGURE 5. MICROMETER CALIPER, CUTAWAY VIEW

Construction

Refer to Figure 5. You can see the various components that make up a micrometer. The following is an explanation of how the components are assembled to make it work:

a. One end of the U-shaped steel frame holds a stationary anvil. The anvil is a hardened button either pressed or screwed onto the frame.

b. The unthreaded part of the screw is the steel spindle. The spindle advances or retracts to open or close the open side of the U-frame. The spindle bearing is a plain bearing and is part of the frame.

c. A hollow barrel extends from this bearing. There is a micrometer scale on the side of the barrel which is graduated in tenths of an inch. These are in turn divided into subdivisions of 0.025 inch. The end of the barrel supports the nut which engages the screw (adjustment nut). This unit is slotted, and its outer surface has a tapered thread and a nut. These make it possible to adjust, within limits, the diameter of the slotted nut to compensate for wear.

d. A thimble is attached to the screw. The thimble is a sleeve that fits over the barrel. The front edge of the thimble carries a scale broken down into 25 parts. This scale indicates parts of a revolution, while the scale on the barrel indicates the number of revolutions. The thimble is connected to the adjustment screw through a sleeve that permits it to be slipped in relation to the screw to allow for adjustment. The inner sleeve is sweated to the screw. The outer sleeve is clamped to the inner one by the thimble cap. Loosening the cap makes it possible to slip one in relation to the other.

e. Sometimes there is a ratchet on top of the thimble cap. This device consists of an overriding clutch held together by a spring in such a way that when the spindle is brought up against the work, the clutch will slip when the correct measuring pressure is reached. The ratchet eliminates the effects of differences in personal touch and thus reduces the possibility of error due to differences in measuring pressure. Not all micrometers have ratchets.

f. Some micrometers have a clamp ring or locknut located in the center of the spindle bearing. This clamping device makes it possible to preserve a setting by locking the spindle in any position desired.

Care

The following rules should be followed to keep micrometers in good condition and to preserve their accuracy:

a. Never store a micrometer with its anvil and spindle closed. Leave a small gap between the anvil and spindle when storing a micrometer since flat surfaces which have been pressed together for any length of time tend to corrode.

b. Oil the micrometer in only one place--the screw. If storing a micrometer for long periods of time, however, cover it with a light film of oil and wrap it in oiled paper.

c. Never roll the thimble along the hand or arm. Likewise, never hold the thimble and twirl the frame to open or close the micrometer. This misuse causes excessive wear on the screw.

d. Before using a micrometer, wipe it off and pull a piece of paper between the anvil and the end of the spindle.

e. The micrometer should operate freely with no play in its travel. If a micrometer has play, or if it binds, it should be returned to the manufacturer for reconditioning. (Play is caused by abuse or uneven wear.)

f. Check the micrometer screw periodically with a precision gage block in at least four places other than zero to verify its accuracy. Simply measure a selected group of blocks ranging from 0 to 1 inch.

g. Clean the micrometer mechanism whenever it becomes gummy, contains abrasive grit, or needs to be adjusted. Use an approved cleaning agent.

h. Test the accuracy of the micrometer periodically. When the faces of the spindle and anvil become worn and are no longer flat and parallel to each other, measurement errors can result. The error tolerance must not exceed 0.0002 inch on a micrometer graduated to control measurements to a limit of 0.001 inch and must not exceed 0.00005 inch in a micrometer which is graduated to control measurements to a limit of 0.0001 inch. Measuring a ball at several points over the surface of the anvil will reveal any error in parallelism. Parallelism can be tested using two balls mounted in an aluminum holder. If the anvils are in error more than the allowable maximum, the micrometer should be returned to the manufacturer for repair.

i. Adjust the micrometer thimble setting periodically. In adjusting a micrometer to read correctly, the thimble is not set to 0 when the anvil is in contact with the spindle, but is set at some dimension to distribute the error. For example, if a micrometer screw has an accumulating error of 0.0003 inch in the length of its travel, and it were set correctly at 0, it would be off 0.0003 at 1 inch. However, if the micrometer were set correctly in the center of its travel, it would be 0.00015 under at 0 and 0.00015 over at 1 inch, which is a much better condition. Micrometers do not always return exactly to 0 when the anvil and spindle contact. This does not mean that it is not adjusted properly. Turn the friction sleeve with a small spanner wrench to compensate for minor wear on the anvil and spindle or on the screw, Figure 6.

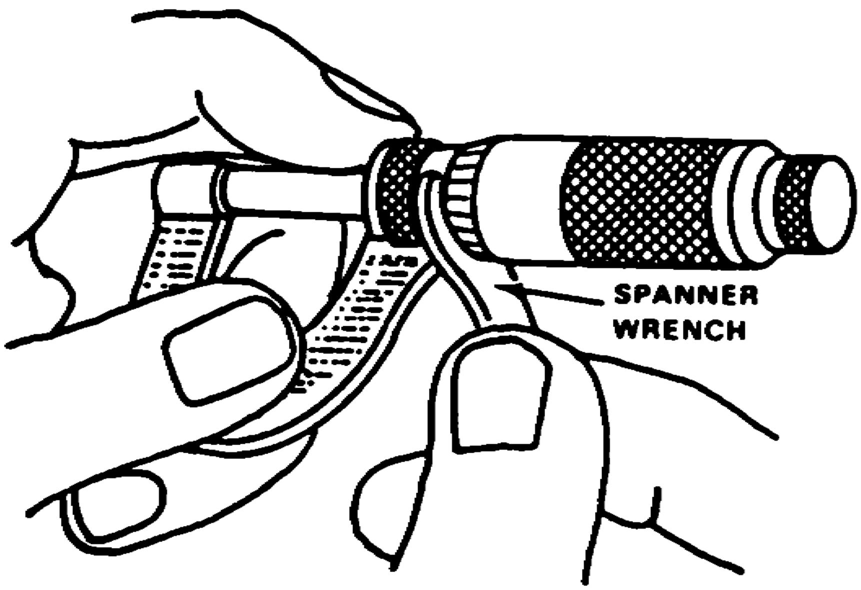


FIGURE 6. MICROMETER ADJUSTMENT

Learning Event 2
MEASURE USING THE MICROMETER

SELECTION

Commonly used micrometers are made so that the longest movement possible between the spindle and the anvil is 1 inch. This movement is called the range. Micrometer frames, however, are available in a wide variety of sizes, from 1 inch up to as large as 24 inches. The range of a 1-inch micrometer is from 0 to 1 inch. In other words, it can be used to measure work that is 1 inch or less. A 2-inch micrometer has a range from 1 to 2 inches. A 6-inch micrometer has a range from 5 to 6 inches, and will only measure work between 5 and 6 inches.

Mechanics must first find the approximate size of the work to the nearest inch, and then select the correct micrometer. For example, to find the exact diameter of a piece of round stock use a rule and find the approximate diameter of the stock. If it is between 3 and 4 inches, a micrometer with a 3- to 4-inch gage would be required to measure the exact diameter. Similarly, when using inside and depth micrometers, rods of suitable lengths must be fitted into the tool to get the approximate inside dimension within an inch. After obtaining the approximate dimensions, an exact measurement is read by turning the thimble. The size of the micrometer indicates the size of the largest work it will measure.

READING STANDARD MICROMETERS

Reading a micrometer consists of simply reading the micrometer scale or counting the revolutions of the thimble and adding to this any fraction of a revolution. The micrometer screw has 40 threads per inch. This means that one complete revolution of the micrometer screw moves the spindle away from or towards the anvil exactly 0.025 inch. The lines on the barrel, Figure 7, conform to the pitch of the micrometer screw with each line being numbered. The bevel edge of the thimble is graduated into 25 parts, each part indicating 0.001 inch or 1/25 of the 0.025 inch covered by a complete revolution. Every fifth line on the thimble is numbered to read a measurement in thousandths of an inch.

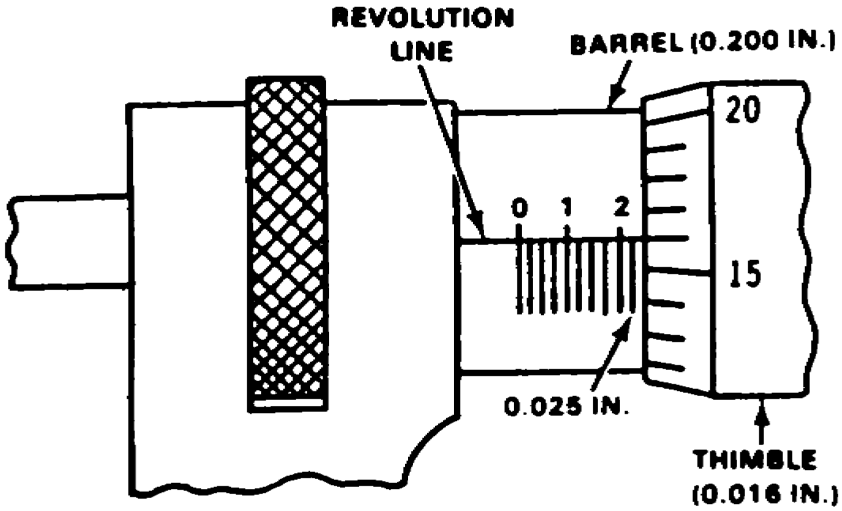


FIGURE 7. STANDARD MICROMETER SCALE

Use the following sequence to read the measurement shown in Figure 7.

a. Highest figure visible on barrel. 2 = 0.200 inch

b. Number of lines visible between the No. 2 and thimble edge. 1 = 0.025 inch

c. Line on the thimble that coincides with or has passed the revolution or long line on the barrel. 16 = 0.016 inch

d. Measurement reading Total = 0.241 inch

READING METRIC MICROMETERS

The same principal applies to reading metric graduated micrometers. But, the following changes in graduation should be noted to avoid confusion:

a. The pitch of the metric micrometer screw is 0.5 millimeter (mm). One revolution of the spindle advances or withdraws the screw a distance equal to 0.5 mm.

b. The barrel is graduated in millimeters, from 0 to 25. It takes two revolutions of the spindle to move 1 mm.

c. The thimble is graduated in 50 divisions with every fifth line being numbered.

d. Rotating the thimble from one graduation to the next moves the spindle 1/50 of 0.5 mm, or 1/100 mm. Two graduations equals 2/100 mm and so forth.

Refer to Figure 8, and follow the same sequence as was used for the standard micrometer and determine the measurement indicated.

a. Highest figure visible on barrel.	20 = 20 mm
b. Number of lines visible between No. 20 and thimble edge.	2 = 2 mm
c. Line on thimble that coincides with or has passed the revolution or long line on the barrel.	36 = .36 mm
d. Measurement reading.	Total = 22.36 mm

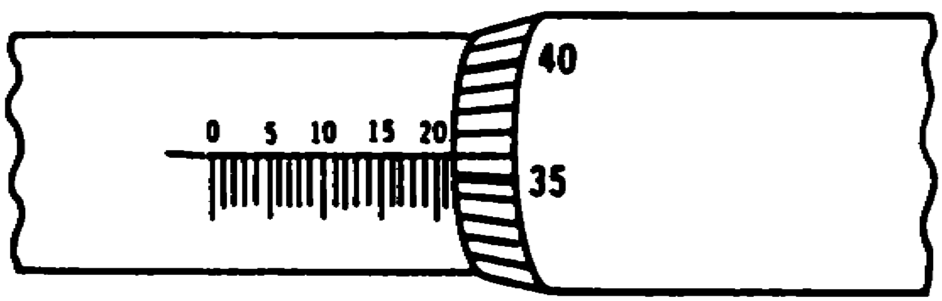


FIGURE 8. METRIC MICROMETER SCALE

READING VERNIER MICROMETERS

Reading vernier micrometers is the same as reading standard micrometers. An additional step must be taken to add the vernier reading to the dimensions. This allows precise measurements accurate to ten thousandths (0.0001) of an inch. This scale furnishes the fine readings between the lines on the thimble rather than making an estimate as you would on a standard micrometer.

The 10 spaces on the vernier scale, Figure 9, (1) are equivalent to 9 spaces on the thimble (2). Therefore, each unit on the vernier scale is equal to 0.0009 inch and the difference between the sizes of the units on each scale is 0.0001 inch.

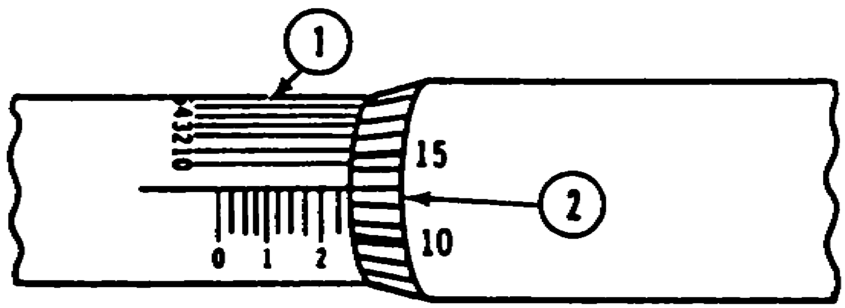


FIGURE 9. VERNIER MICROMETER SCALE

Refer to Figure 10. Read the measurement shown on the vernier micrometer.

a. Highest figure visible on barrel (3).	2 = 0.200 inch
b. Number of lines visible between No. 2 and thimble edge (4).	3 = 0.075 inch
c. Line on the thimble that coincides with or is nearest the revolution or long line in the barrel (5).	11 = 0.011 inch
d. Line on the vernier scale that coincides with the line on the thimble (6).	2 = 0.0002 inch
e. Add all readings together and total.	.2862 inch

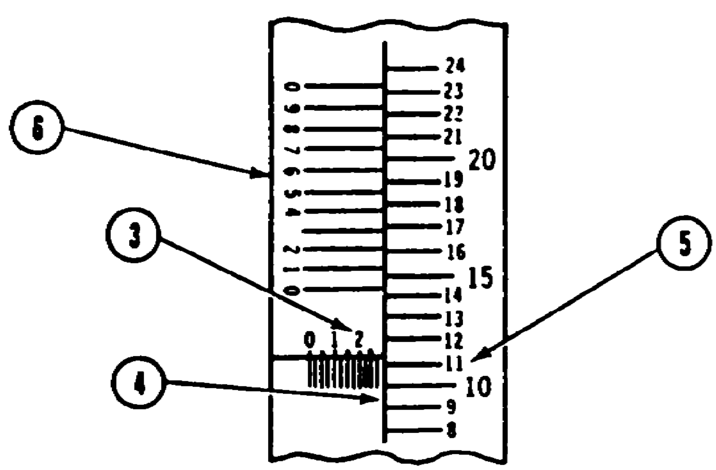


FIGURE 10. VERNIER MICROMETER SCALE

Additional micrometer reading exercises later in this lesson will assist you in understanding how to read micrometers.

ADJUSTING THE MICROMETER CALIPER TO WORK

Figure 11, Part A, shows the proper way to hold a micrometer caliper in checking a small part. Hold the part in one hand. Hold the micrometer in the other hand so that the thimble rests between the thumb and forefinger. The third finger is then in a position to hold the frame against the palm of the hand. When the frame is supported this way it is easy to guide the work over the anvil. The thumb and forefinger are thus in position to turn the thimble either directly or through the ratchet and bring the spindle over against the work.

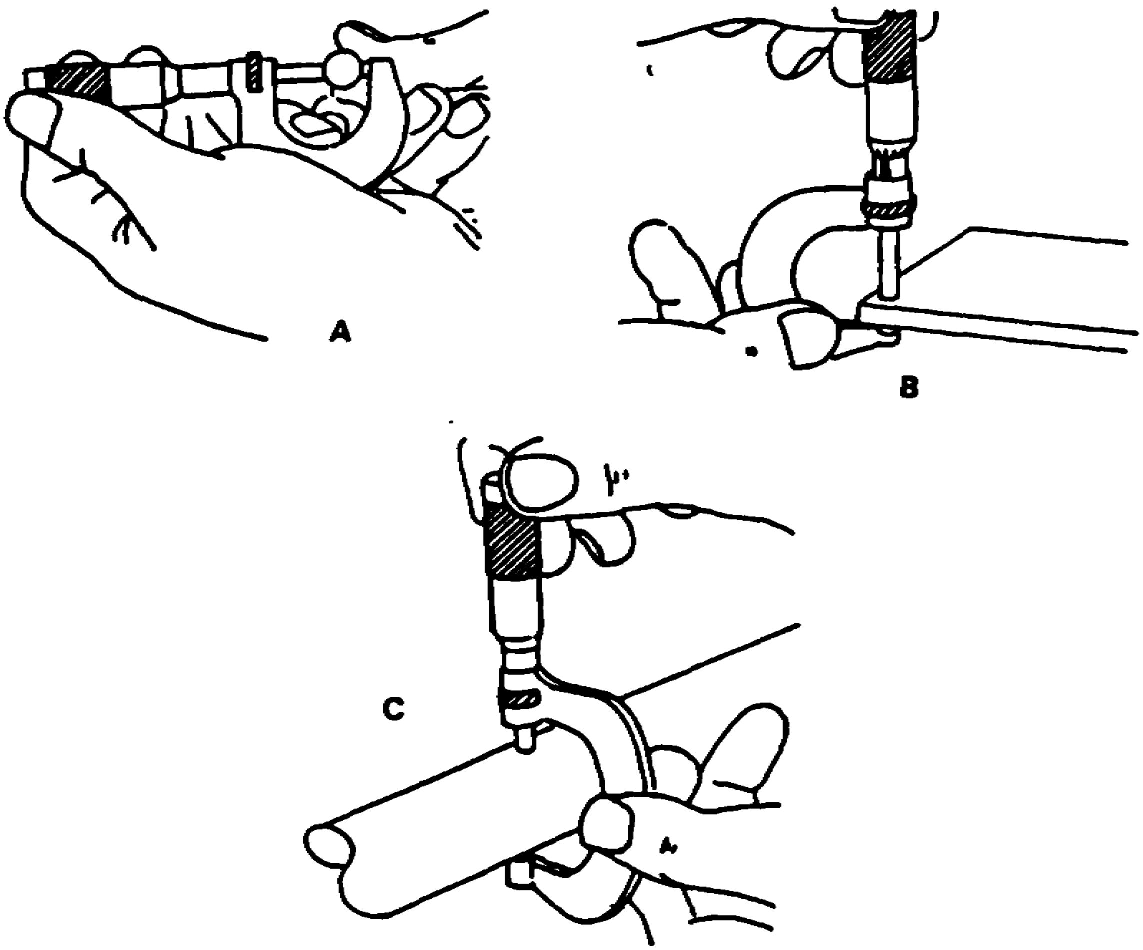


FIGURE 11. USING AN OUTSIDE MICROMETER

On larger work, it is often necessary to have the work stationary and positioned to permit access to the micrometer. Figure 11, Part B, shows the proper method of holding a micrometer when checking a part too large to be held in one hand. The frame is held by one hand to position it and to locate it square to the measured surface. The other hand operates the thimble either directly or through the ratchet. You should check large flat parts in several places to determine the amount of variation.

To gage a shaft, Figure 11, Part C, hold the frame in one hand while operating the thimble with the other. In measuring a cylindrical part with a micrometer, it is necessary to “feel" the setting to be sure that the spindle is on the diameter. You must check the diameter in several places to determine the amount of out-of-roundness.

Micrometer calipers are made in various sizes up to 168 inches. Figure 12 shows a pulley being checked with a micrometer whose range has been reduced by a special anvil screwed into the frame. A set of different length anvils permits this micrometer to be used over a wide range of sizes. Yet, the spindle only moves 1 inch. This micrometer has been lightened in weight by its I-section construction and by boring holes in the frame.

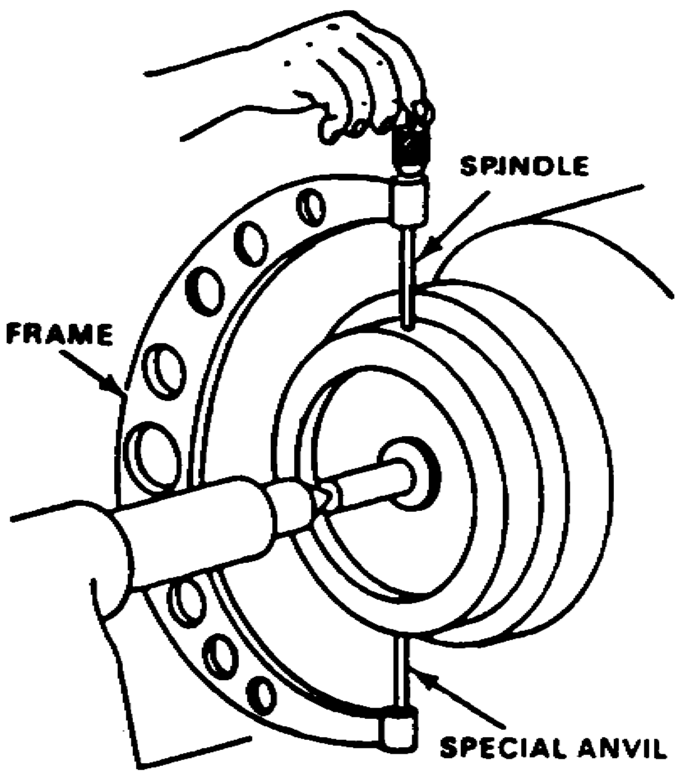


FIGURE 12. CHECKING DIAMETER OF A PULLEY

USING INSIDE MICROMETERS

The normal procedure for using inside micrometers is to set them across diameters or between inside surfaces, remove them, and then read the dimension. For this reason, the thimble on an inside micrometer is much stiffer than the one on a micrometer caliper. Thus, it holds the dimension better. It is good practice to verify the reading of an inside micrometer by measuring it with a micrometer caliper.

Figure 13 shows an inside micrometer with extension rod being used to check the diameter of a bored hole. Note the arrows which indicate the direction the operator is measuring (feeling) for the largest dimension horizontally and the smallest dimension vertically. Inside micrometers have spherical contact points which require more practice to "feel" the full diametral measurement. One contact point is generally held in a fixed position and the other rocked in different directions. This ensures the tool spans the true diameter of a hole or the correct width of a slot.

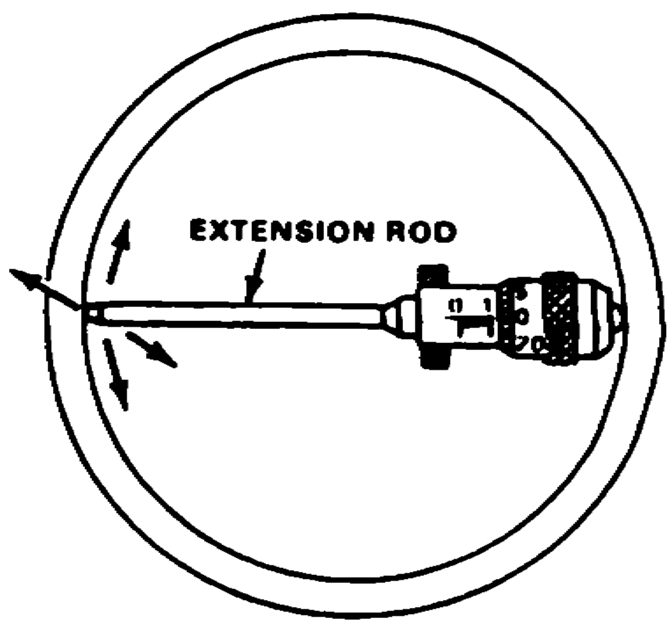


FIGURE 13. USING AN INSIDE MICROMETER
WITH AN EXTENSION ROD

A handle can be clamped onto the body of the micrometer when probing a deep hole or in a restricted place.

Use the following procedures to transfer measurements from inside calipers to micrometer calipers:

a. After setting the inside caliper or inside micrometer to the work, hold the micrometer caliper in one hand and the inside tool in the other hand.

b. Turn the thimble of the micrometer caliper with the thumb and forefinger until you feel the inside tool legs lightly contact the anvil and spindle of the micrometer caliper.

c. Hold the tips of the inside tool legs parallel to the axis of the micrometer caliper.

d. The micrometer caliper will be accurately set when the inside tool will just pass between the anvil and spindle by its own weight.

LESSON 1

PRACTICE EXERCISE

To ensure you understand how to read standard and metric micrometer calipers, complete the following exercise requirements. Requirements 1 through 4 consist of practical application of what you have learned in this lesson. Requirement 5 consists of answering questions about material covered in this lesson.

Requirement 1:

Refer to figure 14, and determine the measurement shown on the standard micrometer.

	A		B
a. Highest figure visible on barrel.	______	=	______
b. Number of lines visible between A above and thimble edge.	______	=	______
c. Line on the thimble that coincides with or has passed the revolution or long line in the barrel.	______	=	______
d. Measurement reading.	Total	=	

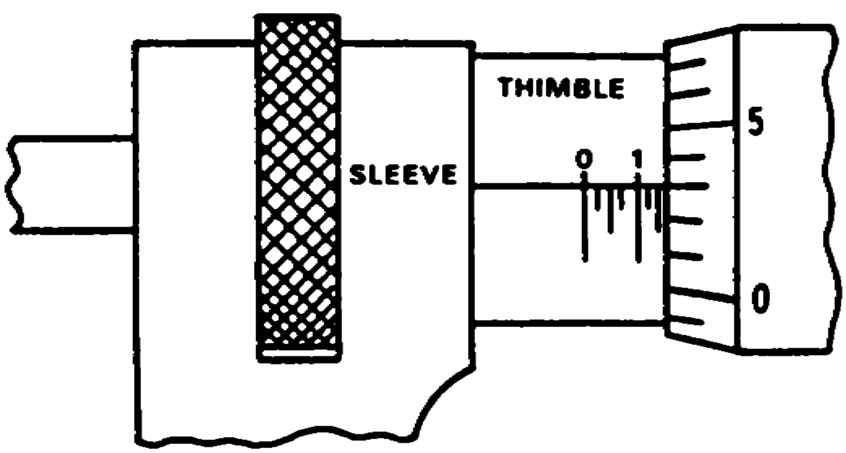


FIGURE 14. STANDARD MICROMETER SCALE

Requirement 2:

Refer to Figure 15, and determine the measurement shown on the metric micrometer.

	A		B
a. Highest figure visible on barrel.	______	=	______
b. Number of lines visible between A above and thimble edge.	______	=	______
c. Line on the thimble that coincides with or has passed the revolution or long line on the barrel.	______	=	______
d. Measurement reading.	Total		

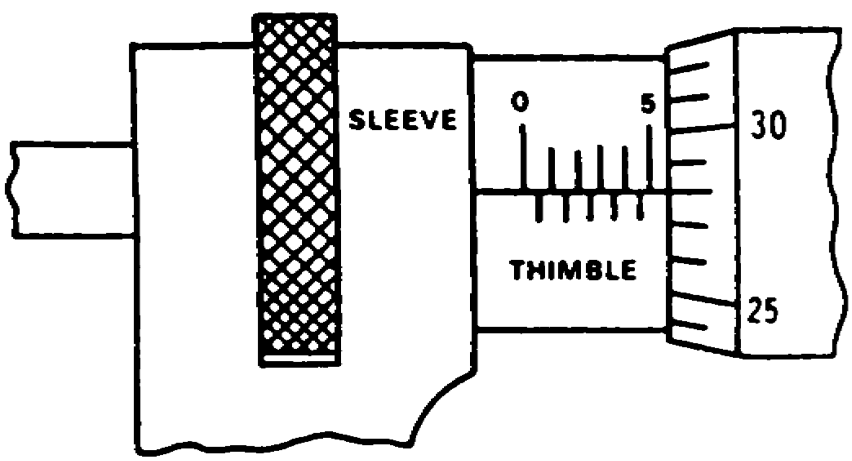


FIGURE 15. METRIC MICROMETER CALIPER SCALE

Lesson 1/Practice Exercise

Requirement 3:

Refer to Figure 16, and determine the measurement shown on the standard micrometer.

	A		B	
a. Highest figure visible on barrel.	______	=	______	in
b. Number of lines visible between A above and thimble edge.	______	=	______	in
c. Line on the thimble that coincides with or has passed the revolution barrel.	______	=	______	in
d. Measurement reading.	Total	=	______	in

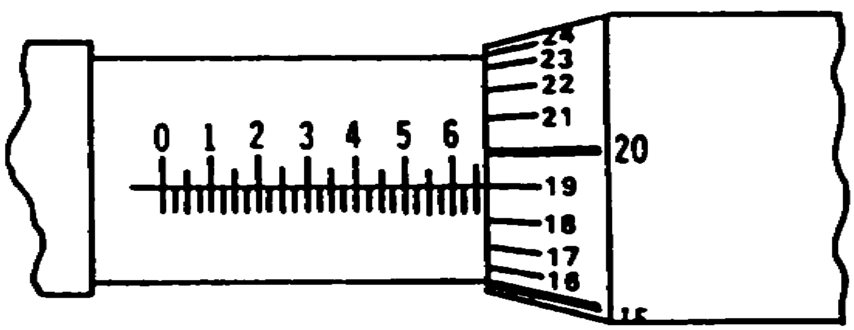


FIGURE 16. STANDARD MICROMETER SCALE

Requirement 4:

Refer to Figure 17, and determine the measurement shown on the vernier micrometer.

	A		B	
a. Highest figure visible on barrel.	______	=	______	in
b. Number of lines visible between A above and the thimble edge.	______	=	______	in
c. Line on the thimble that coincides with or is nearest revolution or long line on the barrel.	______	=	______	in
d. Line on the vernier scale that coincides with the line on the thimble.	______	=	______	in
e. Measurement reading.	Total	=	______	in

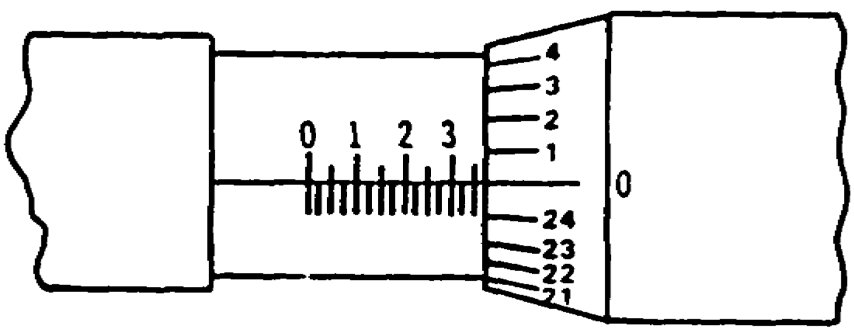


FIGURE 17. VERNIER MICROMETER SCALE

Lesson 1/Practice Exercise

Requirement 5:

1. What is the most common type micrometer?

   A. Inside

   B. Caliper

   C. Depth

   D. Vernier

2. The spindle on a standard micrometer has a travel range of ____________.

   A. 0 to 1 inch

   B. 1 to 2 inches

   C. 2 to 3 inches

   D. All the above

3. What must be changed on a micrometer to bring the range from 4 to 5 inches to 3 to 4 inches?

   A. Spindle

   B. Ratchet

   C. Thimble

   D. Anvil

4. Inside micrometers have a range from 2 to 10 inches. How are these different ranges obtained?

   A. Use of collars

   B. Use of rods

   C. Extending the screw

   D. Changing the anvil

5. How many threads does the micrometer screw have per inch?

A. 20

B. 30

C. 40

D. 50

6. What purpose does the ratchet serve on the standard micrometer caliper?

A. Makes thimble easier to turn

B. Rotates the spindle when tightening

C. Allows spindle to slip when tight

D. Eliminates difference in personal touch

7. All standard micrometer calipers have a clamp ring to lock the spindle in any position.

A. True

B. False

8. To make running the spindle in or out faster you should hold the thimble and spin the frame.

A. True

B. False

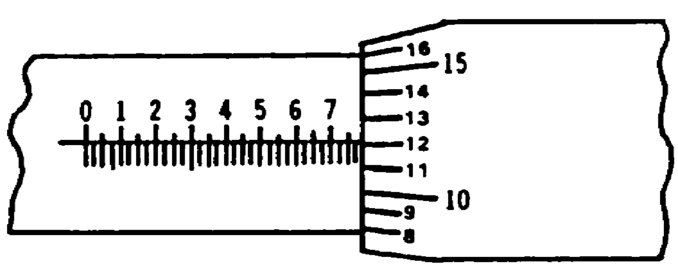
9. What is the correct measurement reading on this standard micrometer caliper?

A. 0.712

B. 0.787

C. 0.812

D. 0.836



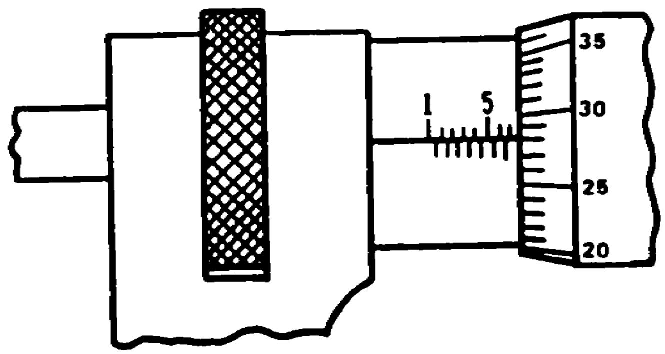
10. What is the correct measurement reading on this metric micrometer?

A. 6.27

B. 6.50

C. 7.28

D. 7.50



LESSON 1

PRACTICE EXERCISE SOLUTIONS

Solution to Requirement 1:

	A		B
a. Highest figure visible on barrel.	1	=	.10 in
b. Number of line visible between A and thimble edge.	3	=	.075 in
c. Line on the thimble that coincides with or has passed the revolution or long line on the barrel.	3	=	.003 in
4. Measurement reading.	Total	=	.178 in

Solution to Requirement 2:

	A		B
a. Highest figure visible on barrel.	5	=	5.0 mm
b. Number of lines visible between A above and thimble edge.	1	=	0.50 mm
c. Line on the thimble that coincides with or has passed the revolution or long line on the barrel.	28	=	0.28 mm
d. Measurement reading.	Total	=	5.78 mm

Solution to Requirement 3:

	A		B
a. Highest figure visible on barrel.	6	=	0.600 in
b. Number of lines visible between A above and thimble edge.	2	=	0.050 in
c. Line on the thimble that coincides with or has passed the revolution or long line on the barrel.	19	=	0.019 in
d. Measurement reading.	Total	=	0.669 in

Lesson 1/Practice Exercise Solutions

Solution to Requirement 4:

	A		B	
a. Highest figure visible on barrel.	3	=	0.300	in
b. Number of lines visible between A above and the thimble edge.	3	=	0.075	in
c. Line on the thimble that coincides with or is nearest revolution or long line on the barrel.	0	=	0	in
d. Line on the vernier scale that coincides with the line on the thimble.	0	=	0	in
e. Measurement reading.	Total	=	0.375	in

Solutions to Requirement 5:

1. B (page 2)

2. D (page 10)

3. D (page 3)

4. B (page 4)

5. C (page 10)

6. D (page 7)

7. B (page 7)

8. B (page 8)

9. B (pages 10 and 11)

10. C (pages 11 and 12)

Lesson 2: CALIPERS AND DIVIDERS

TASK

Identify calipers and dividers by type; transfer measurements using micrometers; select proper calipers or dividers for specific jobs; and read the vernier caliper.

CONDITIONS

You will be given information describing different types of calipers and dividers; the selection of calipers or dividers for specific jobs; and reading vernier calipers.

STANDARDS

You are expected to demonstrate competency of the task skills and knowledge by responding correctly to 70 percent of the examination questions pertaining to this lesson.

CREDIT HOURS

2

REFERENCES

TM 9-243

Learning Event 1
IDENTIFY VARIOUS TYPES OF CALIPERS AND DIVIDERS

Calipers are devices for determining the dimensions of machine parts. Calipers are not usually precision instruments but are sufficiently accurate for the fabrication of many parts. Simple calipers consist of two movable legs joined at one point with the separation between them controlled by a spring-loaded screw.

The ends of the legs of inside calipers turn outward to measure widths of grooves, interior diameters, and similar dimensions. Outside calipers have curved legs with turned-in ends suited to measuring outside diameters. Scribes are calipers with straight legs and sharp points used for marking off distances on flat surfaces. Hermaphrodite (hur maf re dit) calipers have one straight scribing leg. They are used to scribe a line parallel to a curved shoulder. In simple calipers, the opening must be placed against a scale to read the dimension.

Vernier calipers incorporate a scale plus a vernier and are capable of precise measurement. They are shaped something like an adjustable wrench with points at the end of the jaws. These points are suited to both inside and outside surfaces.

CALIPERS

Outside

Outside calipers, Figure 18, are used to measure distances over and around adjacent outside surfaces. They are also used to transfer the measurements to a rule. Several types and sizes are made to accommodate a wide range of measurements. The size of the caliper is expressed in terms of the maximum dimension it is capable of measuring. A 3-inch caliper, for example, will measure a distance of 3 inches. Actually, the maximum capacity of the caliper will be greater, often as much as one-third. This means, for example, that a 3-inch caliper will actually measure up to 4 inches. It is not recommended that you use a 3-inch caliper to measure 4 inches, since that could spring the legs resulting in an inaccurate measurement.

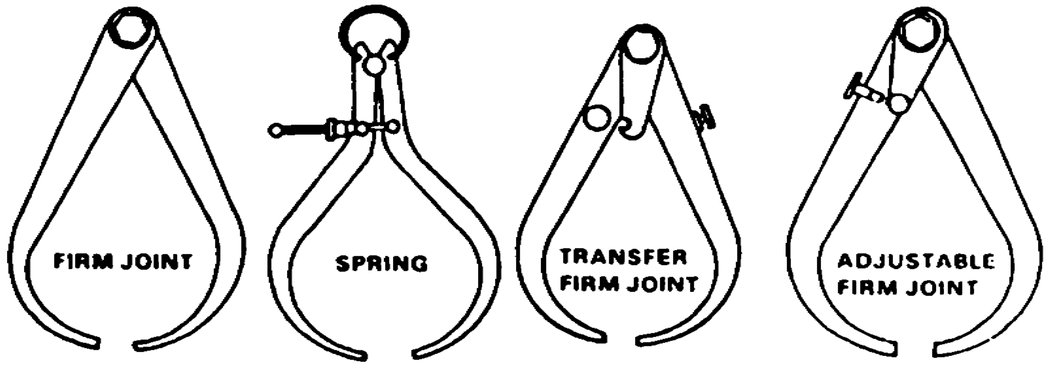


FIGURE 18. OUTSIDE CALIPERS

Inside

Inside calipers, Figure 19, are used to measure distances between inside surfaces. The points are round and slightly ball-shaped. This ball shape establishes the point of contact. Where surfaces are likely to have an inside curvature, error can occur if the radius of the hole being calipered is less than the radius of the ball-shaped points. Some inside calipers are equipped with an adjusting screw on one leg to provide fine adjustment of the caliper legs.

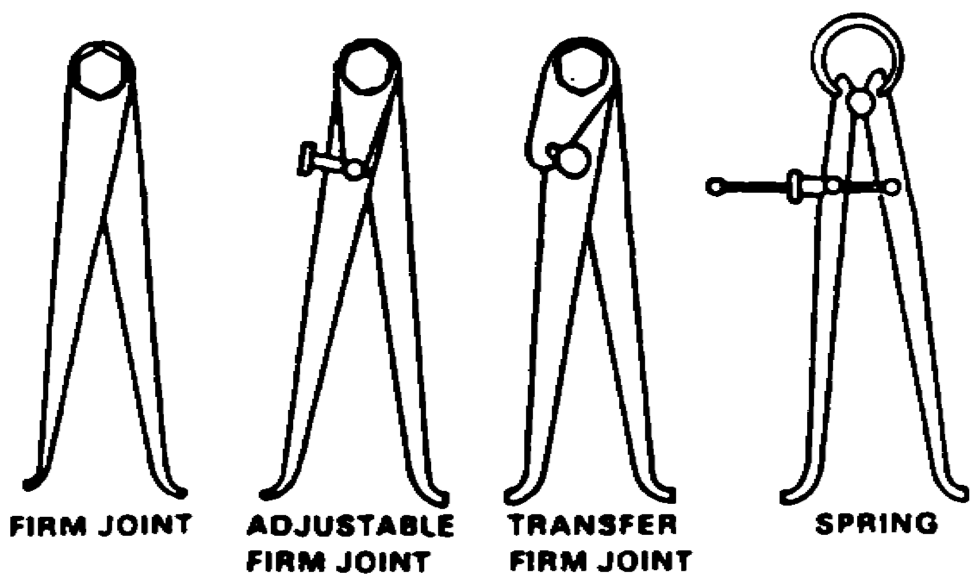


FIGURE 19. INSIDE CALIPERS

Inside and outside calipers have the following design characteristics:

Spring

a. Spring calipers, Figures 18 and 19, are available in sizes from 2 to 8 inches. The friction of the adjusting nut and screw works against the tension of the spring which holds the legs in any set position. This type of caliper is known as the toolmaker's spring caliper.

b. Thread spring calipers are used to measure diameters and distances in tapped holes. The ends of the legs of thread calipers are shaped to a fine point so that exact contact can be made between threads.

Firm Joint

Firm joint calipers are available in a number of sizes from 3 to 24 inches. This type of caliper is equipped with a nut and stud that provides sufficient friction to hold the legs in any set position. Some of these calipers are equipped with an adjusting screw for fine adjustments.

Transfer Firm Joint

Transfer firm joint calipers are shaped for inside measurements and are used for measuring recesses where the setting cannot be transferred to a scale directly because the legs must be collapsed to remove them from the work.

Hermaphrodite Calipers

Hermaphrodite calipers, Figure 20, are a cross between a divider and an inside caliper. They have one leg of each device. These calipers are used for scribing parallel lines from an edge or for locating the center of cylindrical work. Some are equipped with an adjustable point.

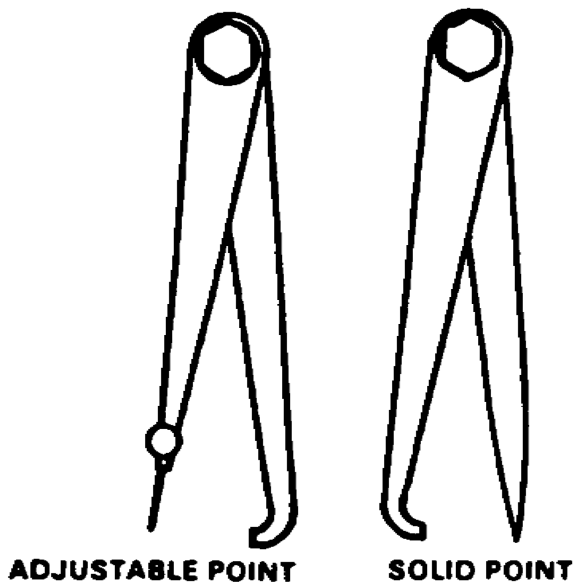


FIGURE 20. HERMAPHRODITE CALIPERS

Slide

Slide calipers, Figure 21, have one fixed jaw and one sliding jaw. When the two jaws are brought in contact with surfaces to be measured, the distance between the surfaces may be read from the scale. The ends of the jaws are shaped so that it is possible to measure both inside and outside surfaces. Slide calipers are normally made in 3-inch sizes, although larger sizes are available. The standard 3-inch slide caliper measures from 0 to 20 inches outside, and from 1/8 inch to a little more than 2 inches inside. The caliper shown has a mark or graduation line on the fixed jaw. This enables the user to read the inside measurement, while the outside measurement can be read directly from the inner edge of the fixed jaw. If these marks were not on the slide caliper, it would be necessary to add the thickness of the nibs to the reading when using it as an inside caliper. All slide calipers are equipped with a locking device which makes it possible to hold the jaws in any desired position. There is an ordinary rule on the other side.

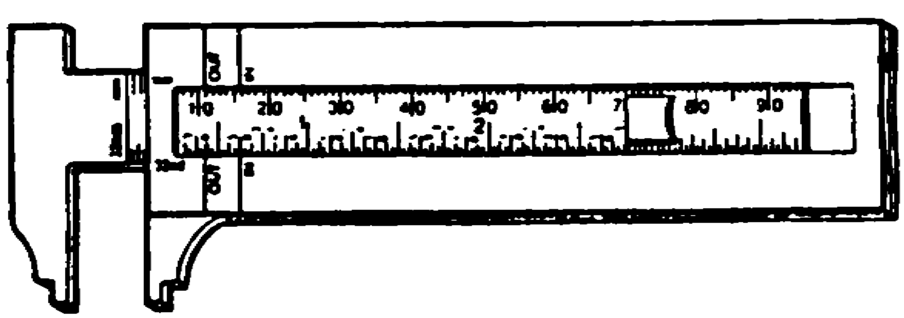


FIGURE 21. SLIDE CALIPER

Vernier

This type of caliper uses a vernier scale. This scale, Figure 22, consists of a short auxiliary scale usually having one more graduation in the same length as the longer main scale.

The vernier caliper consists of a L-shaped frame, the end of which is a fixed jaw. The long arm of the L is inscribed with the main true scale or fixed scale. The sliding jaw carries the vernier scale on either side. The scale on the front side is for outside measurements; the one on the back is for inside measurements. On some vernier calipers, the metric system of measurement is placed on the back side of the caliper in lieu of a scale used for inside measurements. In such cases, add the thickness of the nibs to the reading when making inside measurements.

The tips of the jaws are formed so that inside measurements can be taken. The inside scale automatically compensates for the thickness of the measuring points.

The length of the jaws range from 1 1/4 inches to 3 1/2 inches. The minimum inside measurement, using the smallest caliper, is 1/4 inch or 6 millimeters.

Vernier calipers are made in standard sizes of 6, 12, 24, 36, and 48 inches, and 150, 300, 600, and 900 millimeters. The jaws of all vernier calipers, except the larger sizes, have two center points, which are particularly useful in setting dividers to exact dimensions.

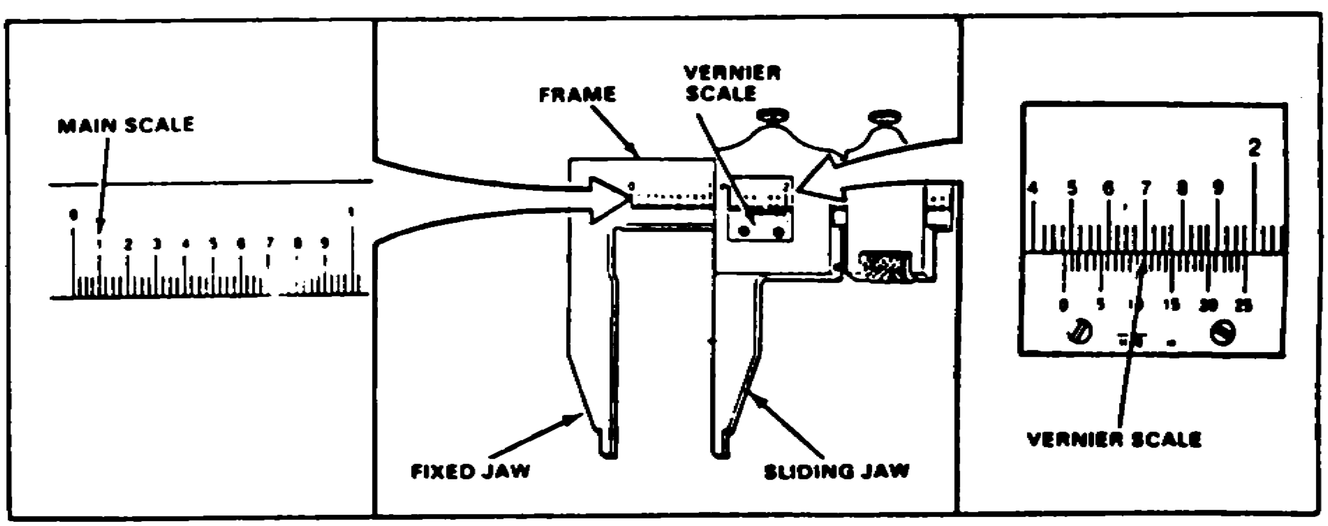


FIGURE 22. VERNIER CALIPER

DIVIDERS

Dividers are used for measuring distances between two points, for transferring or comparing measurements directly from a rule, or for scribing an arc, radius, or circle. Two types of dividers are spring and wing and are described below.

Spring

A spring divider, Figure 23, consists of two sharp points at the end of two straight legs, held apart by a spring and adjusted using a screw and nut. The spring divider is available in lengths from 3 to 10 inches.

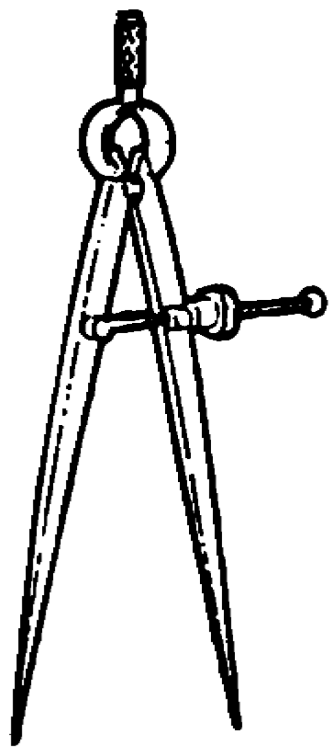


FIGURE 23. SPRING DIVIDER

Wing

Wing dividers, Figure 24, have a steel bar separating their legs, a locking nut for securing a rough measurement, and an adjusting screw for fine adjustments. Wing-type dividers are available in 6-, 8-, and 12-inch lengths. An improved version of this type divider has one leg with a removable tip so a pencil can be inserted.

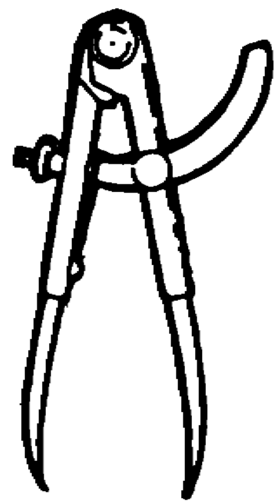


FIGURE 24. WING DIVIDER

Care of Dividers and Calipers

a. Never use a divider or caliper for anything but its intended purpose.

b. Never pile these tools in a drawer.

c. Never force dividers and calipers beyond their capacity or setting.

d. Never use these tools incorrectly. For example, changing settings by hammering instead of loosening a clamping screw or nut, bearing down too hard when scribing with a divider, wearing measuring surfaces unnecessarily by using heavy measuring pressure.

e. Apply a protective film of oil to tools, when not using them.

Care of Vernier Calipers

The accuracy of the vernier caliper depends on the fit of the sliding jaw and the wear and distortion in the measuring surfaces. The sliding jaw should move easily and still not have play. It may be adjusted by removing the gib in the sliding jaw assembly and bending it. The gib holds the adjustable jaw against the inside surface of the blade with just the right pressure to give it the proper friction.

Wear on the jaws of the vernier caliper is mostly at the tips where most measurements are made. A certain amount of this wear may be taken up by adjusting the vernier scale itself. This scale is mounted with screws in elongated holes. This permits slight adjustments to compensate for wear and distortion. When the error exceeds 0.0002 inch, either in parallelism or flatness, the caliper should be returned to the manufacturer for reconditioning. Wear on the jaws can best be checked visually or by measuring rolls or rings of known dimensions.

Learning Event 2
MEASURE USING CALIPERS AND DIVIDERS

DIVIDERS

In setting a divider to a dimension on a scale, the usual procedure is to locate one point in one of the inch graduations of the rule and to adjust the nut or screw so that the other point falls easily into another inch graduation, Figure 25, Part A.

NOTE. Do not set the point to the end of the rule. This could cause an inaccurate measurement.

Make certain the points of the divider are not blunt, Figure 25, Part B.

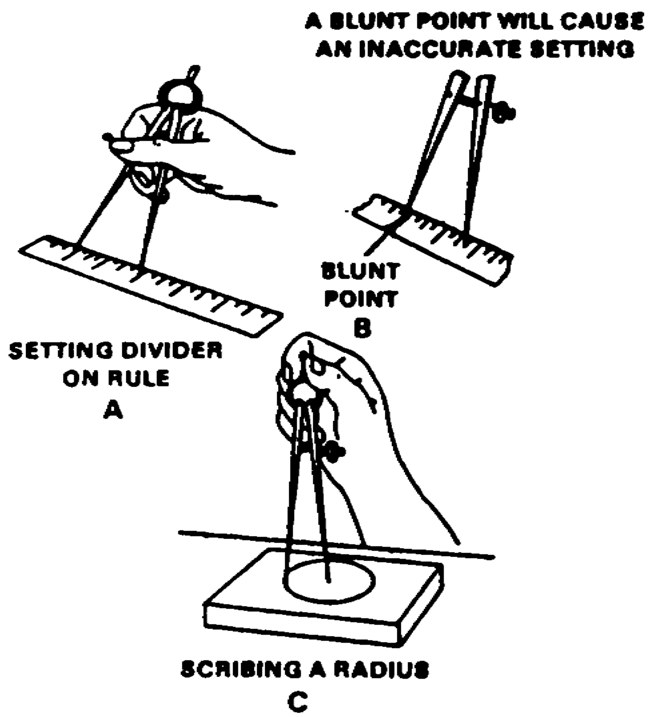


FIGURE 25. USING DIVIDERS (A, B, AND C)

When transferring a dimension from a part or tool to the scale on a rule, use the same care in adjusting the points of the dividers. Make sure there is no excess pressure. Excess pressure tends to spring the points either in or out. Figure 25, Part C, shows a mechanic scribing a radius on a die block he is laying out.

CALIPERS

Outside

These calipers are used in one of two ways. Either the caliper is set to the dimension of the work and the dimension transferred to a scale, or the caliper is set on a scale and the work machined until it checks with the dimension set on the caliper. To adjust an outside caliper to a scale dimension, one leg of the caliper should be held firmly against one end of the scale and the other leg adjusted to the desired dimension, Figure 26, Part A.

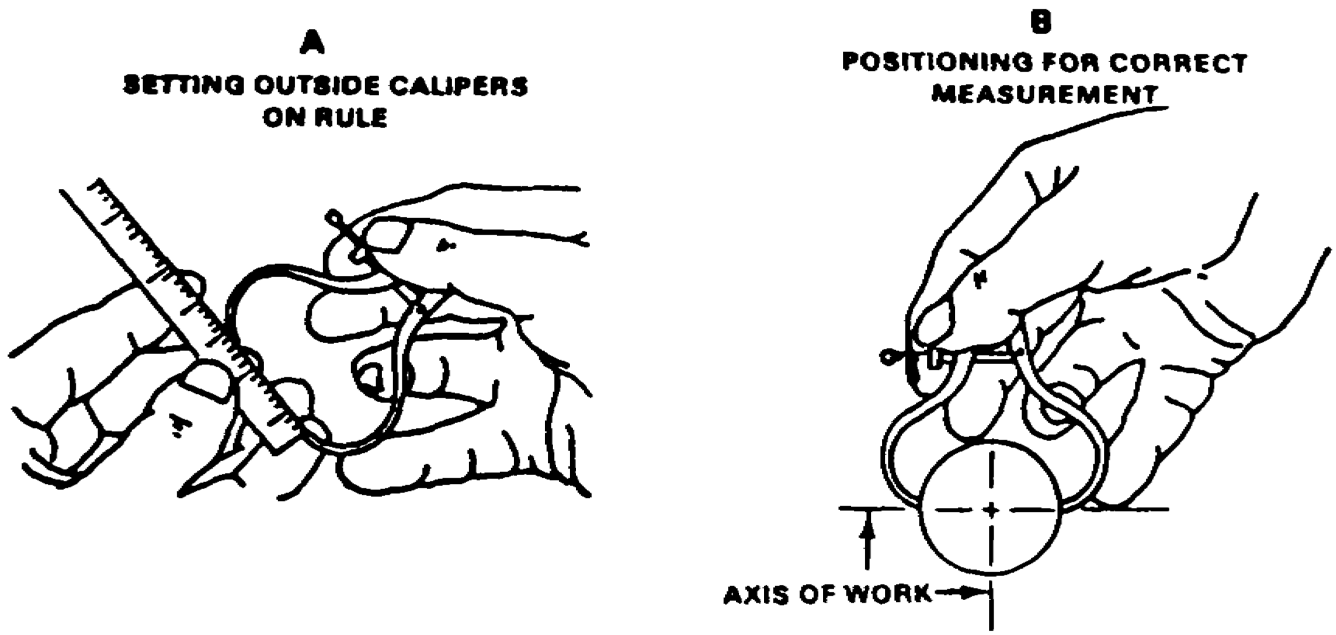


FIGURE 26. USING OUTSIDE CALIPERS (A AND B)

To adjust the outside caliper to the work, open the legs wider than the work and then bring them down to the work. A sense of feel must be acquired to use calipers properly. This comes through practice and care in using the tool to eliminate the possibility of error. Always position the caliper properly on the axis of the work, Figure 26, Part B.

NOTE. Never set a caliper on work that is revolving in a machine. The contact of one leg of a caliper on a revolving surface will tend to draw the other leg over the work because of the friction between the moving surfaces. Only a slight force is necessary to spring the legs of a caliper thus measurements made on moving surfaces are never accurate.

Inside

The inside caliper is set to a dimension by placing the end of a scale and one point of the caliper against a solid surface and adjusting the other leg to the proper graduation, Figure 27, Part A.

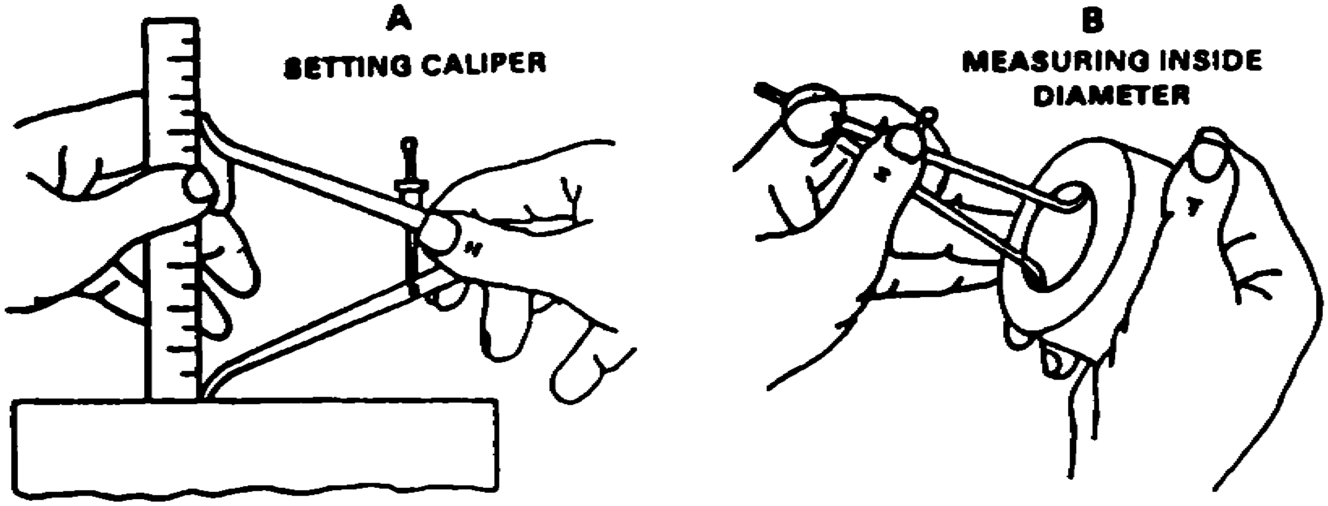


FIGURE 27. SETTING AND USING INSIDE CALIPERS (A AND B)

To adjust the inside caliper to the work, open the legs wider until they touch the work, Figure 27, Part B. Always position the caliper on the axis of the work.

Figure 28 illustrates correct and incorrect positioning of the calipers with relation to the axis of the work.

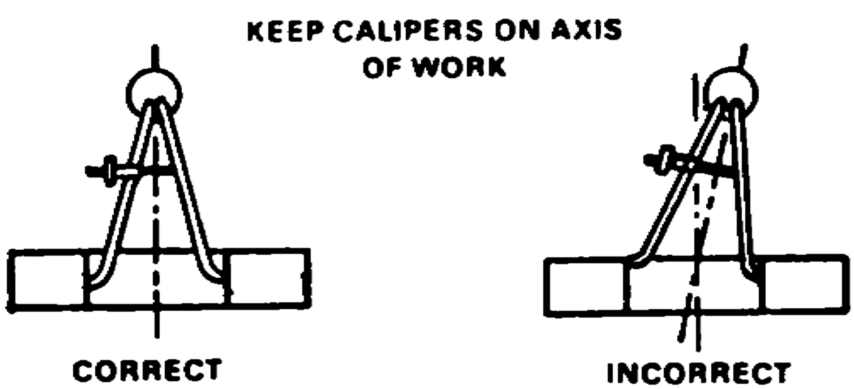


FIGURE 28. POSITIONING OF INSIDE CALIPERS

The transfer feature of the caliper is illustrated in Figure 29. Note that the diameter being measured is recessed and the setting cannot be transferred to a scale directly because the legs must be collapsed to get them out of the work. The setting must be reproduced after the calipers are removed.

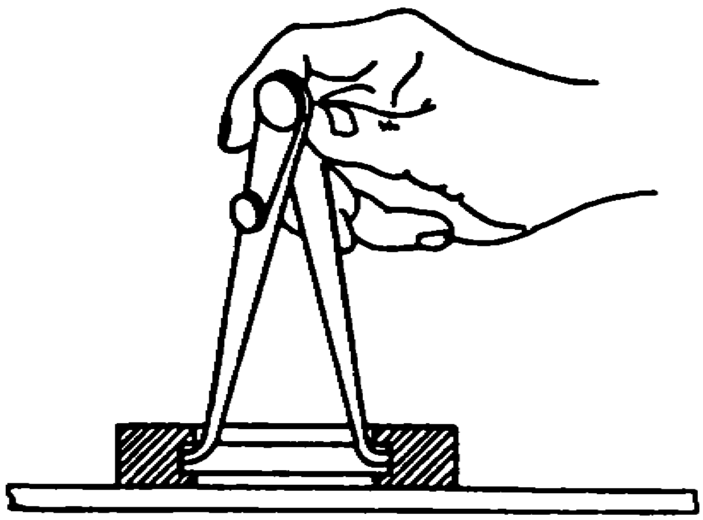


FIGURE 29. USING A TRANSFER CALIPER TO MEASURE A RECESSED DIAMETER

Figure 30 shows how a micrometer can be used to transfer a dimension from an inside spring caliper.

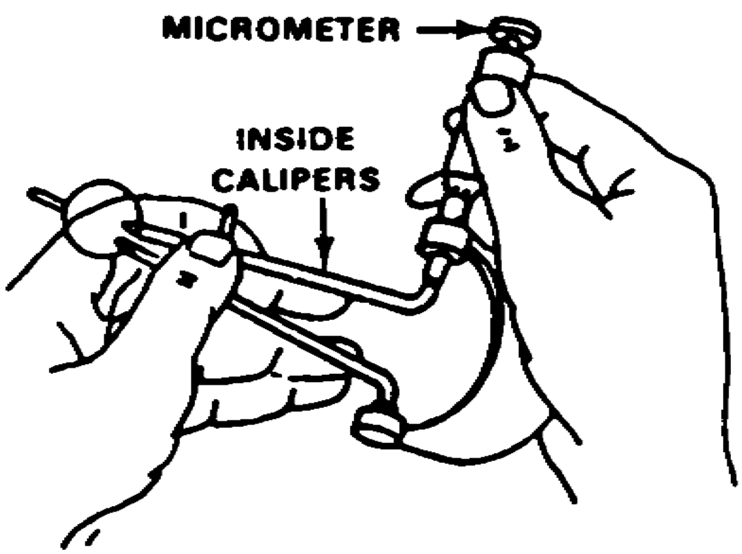


FIGURE 30. TRANSFERRING DIMENSIONS TO A MICROMETER

Hermaphrodite

The hermaphrodite caliper is adjusted and set the same as outside and inside calipers, depending on the position and use of the caliper leg, Figure 31.

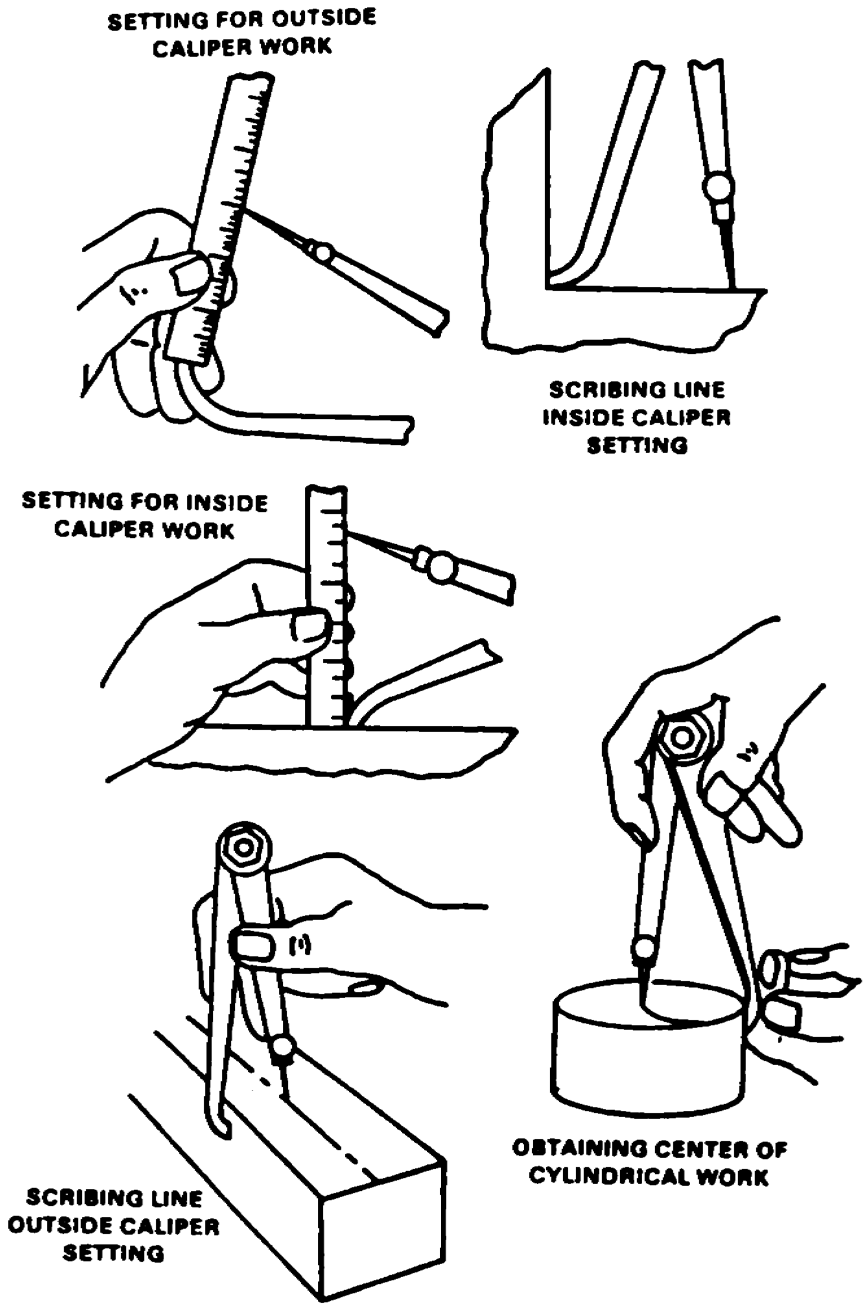


FIGURE 31. SETTING AND USING A HERMAPHRODITE CALIPER

Vernier

Vernier calipers permit precise, accurate readings using a graduated steel rule and a movable jaw with the vernier scale. In order to use the vernier caliper, a thorough vernier scale and the ability to read it are essential. The steel rule of the caliper is graduated in fortieths or 0.025 of an inch. Every fourth division represents a tenth of an inch, and is numbered as shown in Figure 32.

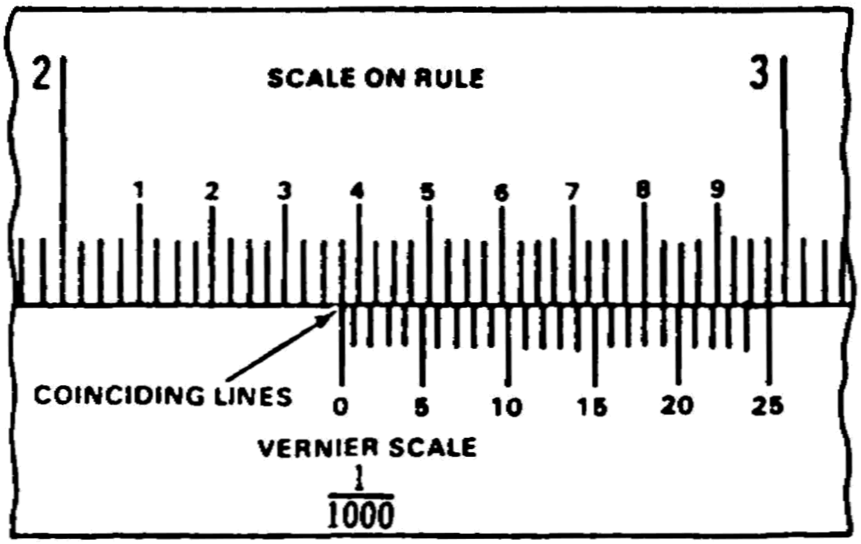


FIGURE 32. READING THE VERNIER SCALE

The vernier scale is divided into 25 parts and numbered 0, 5, 10, 15, 20, and 25. These 25 parts are equal to and occupy the same space as 24 parts on the rule. The difference between the width of one of the 25 spaces on the vernier scale and one of the 24 spaces on the rule is 1/25 of 1/40, or 1/1,000 of an inch. If the tool is set so that the 0 line on the vernier coincides with the 0 line on the rule, the line to the right of 0 on the vernier scale will differ from the line to the right of 0 on the rule by 1/1,000 of an inch; the second line by 2/1,000 of an inch; and so forth. The difference will continue to increase 1/1,000 of an inch for each division until the 25 on the vernier scale coincides with line 24 on the rule. To read the scales, note how many inches, tenths (or 0.100), and fortieths (or 0.025) the mark 0 on the vernier scale is from 0 mark on the rule; then note the number of divisions on the vernier scale from 0 to a line which exactly coincides with a line on the rule.

For example, Figure 32, shows the 0 mark of the vernier scale coinciding with a line on the rule (see arrow). In this case, the vernier scale is not necessary because there is no fractional part of a space to determine. The reading is 2.350.

The 0 mark on the vernier scale, Figure 33, coincides with a fractional part of a space on the rule. The reading is 2.35 plus a fraction of the space on the rule.

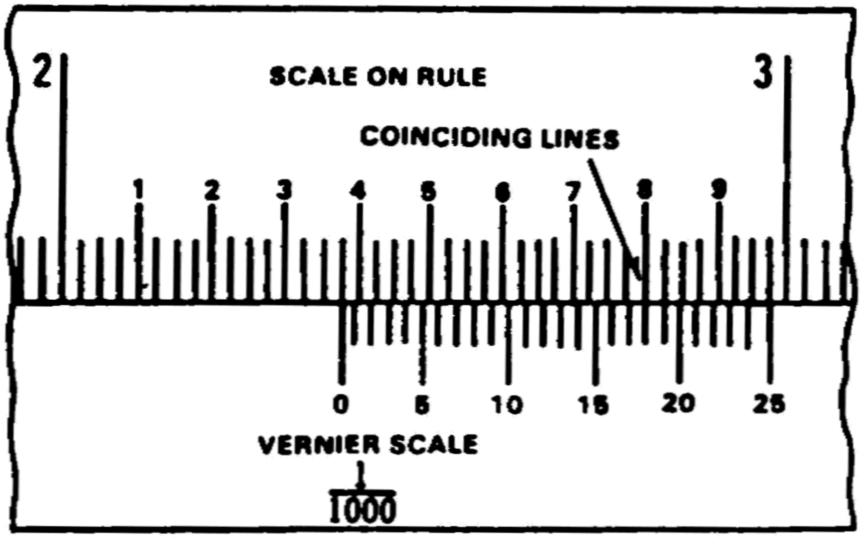


FIGURE 33. READING THE VERNIER SCALE

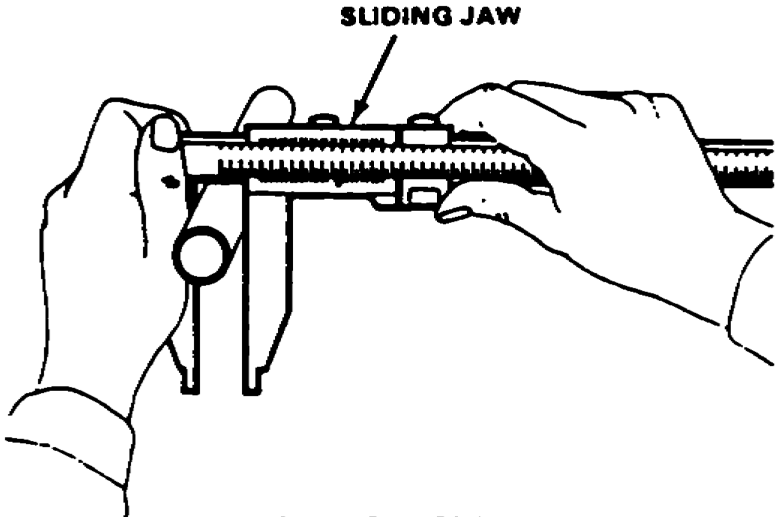
To determine what fractional part of a whole rule division, or how many thousandths are to be added to the 2.35 reading, it is necessary to find the line on the vernier scale that exactly coincides with the line on the rule. In this case the line coincides at the eighteenth mark. This indicates 18/25 of a whole space. Since each space on the rule equals 0.025 inch, this part of a space is equal to 0.018 inch, and the total reading is 2.35 plus 0.018, or 2.368 inches.

NOTE. Vernier scales are not necessarily 25 divisions long; they may have any number of units. For example, the ten thousandths micrometer has a scale of only ten divisions.

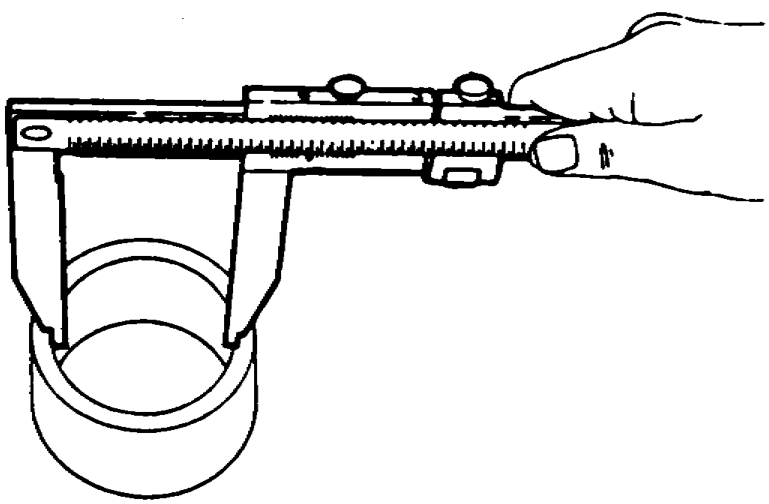
The vernier caliper has a wide range of measurement applications. The shape of the measuring jaws and their position with respect to the scale makes this tool more adaptable than a micrometer. The vernier caliper, however, does not have the accuracy of a micrometer. In any 1 inch of its length a vernier caliper should be accurate within 0.001 inch. In any 12 inches, it should be accurate within 0.002 inch and increase about 0.001 for every additional 12 inches. The accuracy of measurements made with a vernier caliper is dependent on the user's ability to feel the measurement.

Because the jaws are long and may have some play in them (especially if an excessive measuring pressure is used), it is necessary to develop the ability to handle the vernier caliper. This ability (feel) may be acquired by measuring such known standards as gage blocks and plug gages.

Applications of the vernier caliper are shown in Figure 34. Figure 34, Part A, shows a machinist checking the outside diameter of a part. One hand holds the stationary jaw to locate it, while the other hand operates the adjusting nut and moves the sliding jaw to the work. The same procedure is used in checking the inside dimension, Figure 34, Part B.



A—MEASURING OUTSIDE DIAMETER



B—MEASURING INSIDE DIAMETER

FIGURE 34. USING A VERNIER CALIPER

Lesson 2/Learning Event 2

Reading a Metric Vernier Caliper

Refer to Figure 35, the steel rule (1) is divided into centimeters (cm) (2). The longest lines each represent 10 millimeters. Each millimeter is divided into quarters. The vernier scale (3) is divided into 25 parts and is numbered 0, 5, 10, 15, 20, and 25.

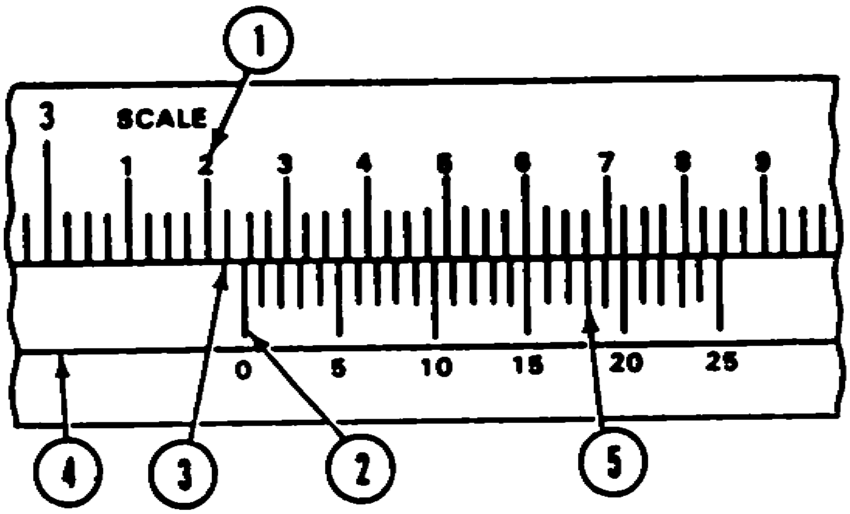


FIGURE 35. METRIC VERNIER CALIPER SCALE

Again refer to Figure 35. The metric vernier caliper would be read as follows:

a. The total number of millimeters (1) to the left of the vernier zero index (2) and record. 32.00 cm

b. The number of quarters (3) between the millimeter mark and the zero index and record. .25 mm

c. The highest line on the vernier scale (4) which lines up with the line on the scale (5) and record. .18 mm

d. Add the three readings. Total 32.43

LESSON 2

PRACTICE EXERCISE

To ensure you understand how to read the English version of the vernier caliper complete the following exercise requirements. Requirements 1 through 4 consist of practical application of what you have learned in this lesson. Requirement 5 consists of answering questions about material covered in this lesson.

Requirement 1:

Refer to Figure 36 and determine the measurement shown on the English vernier caliper.

a. Number of whole inches on the top scale to the left of the vernier zero index. _____ in

b. Number of tenths to the left of the vernier zero index. _____ in

c. Number of twenty-fifths between the tenths mark and zero index. _____ in

d. Highest line on the vernier scale which lines up with the lines on the top scale and record. _____ in

Total

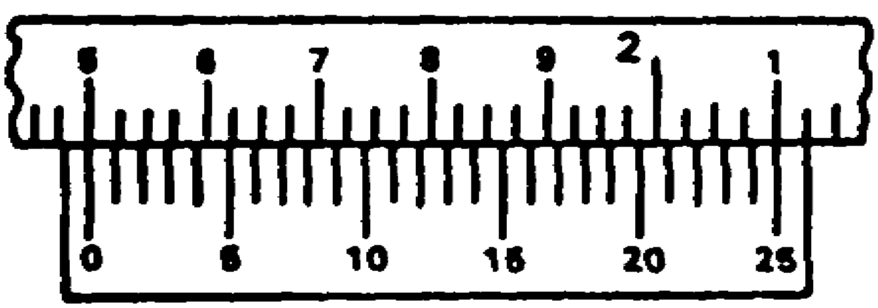


FIGURE 36. ENGLISH VERNIER CALIPER SCALE

Lesson 2/Practice Exercise

Requirement 2:

Refer to Figure 37 and determine the measurement shown on the English vernier caliper.

a. Number of whole inches on the top scale to the left of the vernier zero index. ______ in

b. Number of tenths to the left of the vernier zero index. ______ in

c. Number of twenty-fifths between the tenths mark and zero index. ______ in

d. Highest line on the vernier scale which lines up with the lines on the top scale and record. ______ in

Total

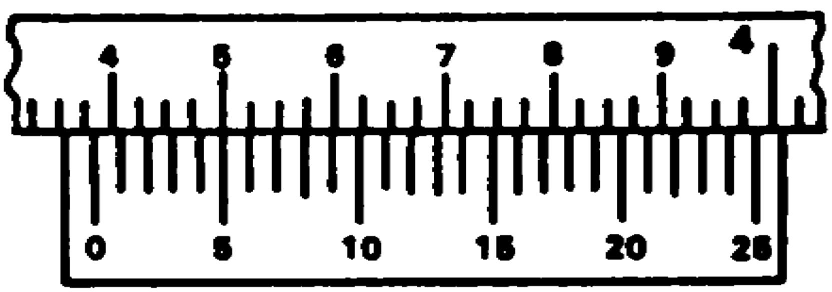


FIGURE 37. ENGLISH VERNIER CALIPER SCALE

Requirement 3:

Refer to Figure 38 and determine the measurement shown on the English vernier caliper.

a. Number of whole inches on the top scale to the left of the vernier zero index. _____ in

b. Number of tenths to the left of the vernier zero index. _____ in

c. Number of twenty-fifths between the tenths mark and zero index. _____ in

d. Highest line on the vernier scale which lines up with the lines on the top scale and record. _____ in

Total

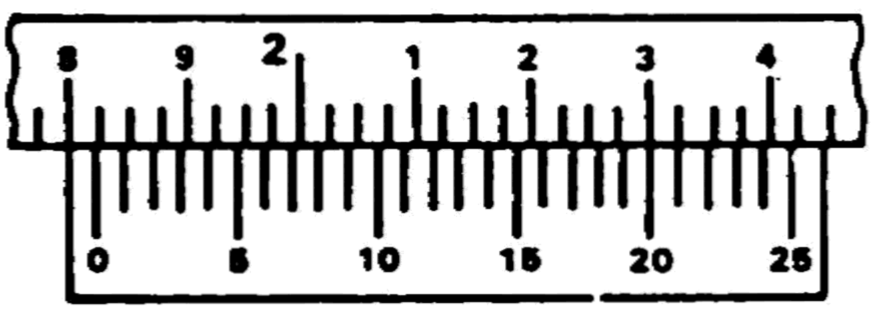


FIGURE 38. ENGLISH VERNIER CALIPER SCALE

Lesson 2/Practice Exercise

Requirement 4:

Refer to Figure 39 and determine the measurement shown on the English vernier caliper.

a. Number of whole inches on the top scale to the left of the vernier zero index. ______ in

b. Number of tenths to the left of the vernier zero index. ______ in

c. Number of twenty-fifths between the tenths mark and zero index. ______ in

d. Highest line on the vernier scale which lines up with the lines on the top scale and record. ______ in

Total

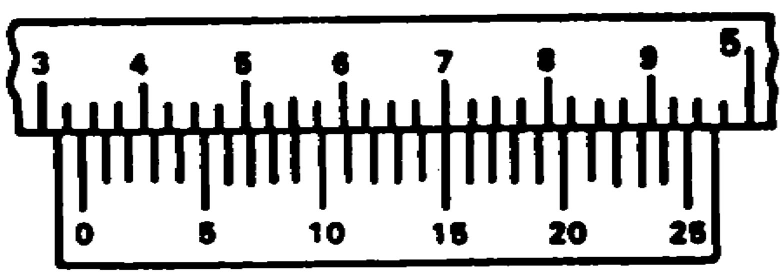


FIGURE 39. ENGLISH VERNIER CALIPER SCALE

Requirement 5:

1. What are calipers used for?

   A. Measure lengths

   B. Measure heights

   C. Measure machined parts

   D. Scribe lines for new work

2. In what terms are caliper sizes expressed?

   A. Measuring capabilities

   B. Lengthening of the leg

   C. Shaping of the legs

   D. Scribing distance

3. What purpose does the ball shape on the points of inside calipers serve?

   A. Allows caliper to fit in smaller area

   B. Establishes point of contact for inside measurements

   C. Provides a fine adjustment for the caliper

   D. Provides a keen sense of feel

4. Inside and outside calipers have the same basic design characteristics.

   A. True

   B. False

5. Hermaphrodite calipers are used for scribing a parallel line from an edge.

   A. True

   B. False

6. The standard 3-inch caliper can measure from _____ to _____ inch(es) outside.

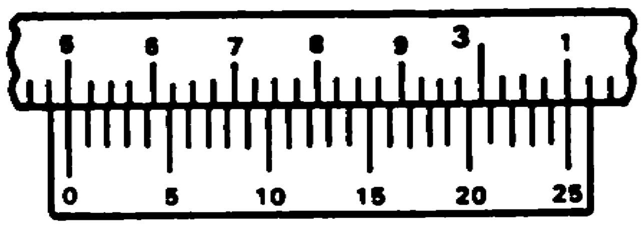
   A. 0 to 1

   B. 0 to 2

   C. 0 to 3

   D. 0 to 4

7. What is the correct measurement reading on this English vernier caliper?



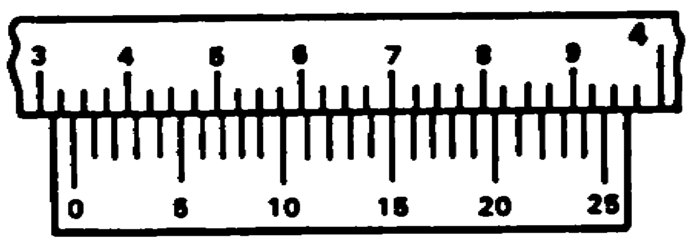
   A. 1.5

   B. 1.55

   C. 2.505

   D. 2.55

8. What is the correct measurement reading on this English vernier caliper?



   A. 3.3

   B. 3.335

   C. 3.360

   D. 3.375

9. What is the importance of NOT setting the point of a divider at the end of a rule when adjusting to make a measurement?

   A. Damages the divider points

   B. Can give an inaccurate measurement

   C. Makes the divider harder to adjust

   D. Points of divider will become blunt

10. It is permissible to set a caliper on revolving work.

   A. True

   B. False

LESSON 2

PRACTICE EXERCISE SOLUTIONS

Solution to Requirement 1:

a. Number of whole inches on the top scale to the left of the vernier zero index.			1.000 in
b. Number of tenths to the left of the vernier zero index.		5	0.500 in
c. Number of twenty-fifths between the tenths mark and zero index.		0	0.000 in
d. Highest line on the vernier scale which lines up with the lines on the top scale and record.		0	0.000 in
	Total		1.500 in or 1.5 in

Solution to Requirement 2:

a. Number of whole inches on the top scale of the left of the vernier zero index.			3.000 in
b. Number of tenths to the left of the vernier zero index.		3	0.300 in
c. Number of twenty-fifths between the tenths mark and zero index.		3	0.075 in
d. Highest line on the vernier scale which lines up with the lines on the top scale and record.		5	0.005 in
	Total		3.380

Solution to Requirement 3:

a. Number of whole inches on the top scale to the left of the vernier zero index.			1.000 in
b. Number of tenths to the left of the vernier zero index.		7	0.800 in
c. Number of twenty-fifths between the tenths mark and zero index.		3	0.025 in
d. The highest line on the vernier scale which lines up with the lines on the top scale and record.		20	0.020 in
	Total		1.845

Solution to Requirement 4:

a. Number of whole inches on the top scale to the left of the vernier zero index.			4.000 in
b. Number of tenths to the left of the vernier zero index.		3	0.300 in
c. Number of twenty-fifths between the tenths mark and zero index.		1	0.025 in
d. Highest line on the vernier scale which lines up with the lines on the top scale and record.		15	0.015 in
	Total		4.340

Solutions to Requirement 5:

1. C (page 28)

2. A (page 28)

3. B (page 29)

4. A (page 30)

5. A (page 30)

6. C (page 28)

7. C (pages 45 through 48)

8. C (pages 45 through 48)

9. B (page 36)

10. B (page 37)

Lesson 3: DIAL INDICATORS

TASK

Identify, set up, and read the dial indicator.

CONDITIONS

You will be given a No. 2 pencil and information on set-up procedures, reading methods, and types of dial indicators.

STANDARDS

You are expected to demonstrate competency of the task skills and knowledge by responding correctly to 70 percent of the examination questions pertaining to this lesson.

CREDIT HOURS

2

REFERENCES

TM 9-243

Learning Event 1
IDENTIFY DIAL INDICATORS BY TYPE AND CONSTRUCTION

The dial indicator, Figure 40, is a precision measuring instrument. It is used in machine shops to check size variations of machined parts from the desired size. It is also used to measure the runout of a flywheel, the end play of a crankshaft, the lift of a camshaft lobe, the alignment accuracy of work, and the machine in machine setups.

Dial indicators range in diameter from about 1 inch to 4 1/2 inches. Each important part has been named and is indicated in the illustration (Figure 40).

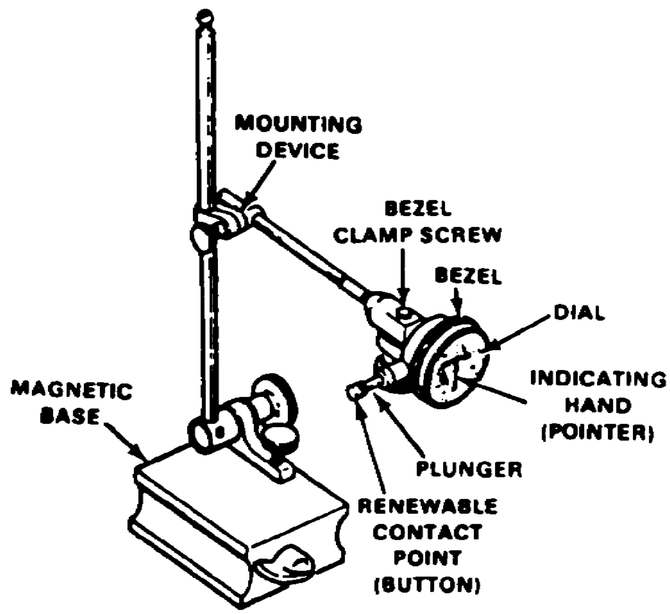


FIGURE 40. THE DIAL INDICATOR

Dial indicators are usually classified as either 1/1,000 indicators or 1/10,000 indicators. This is marked on the dial face, just below the hand, Figure 41. The dial may be of the balance type, Figure 41, in which the figures read both to the left or to the right of the zero. Or, it may be of the continuous reading type, Figure 42, in which the figures read from zero only in the clockwise direction. The dial is marked off (graduated) so that each graduation (space between to adjacent lines) represents a definite movement of the plunger, which is designed so that it will slide in and out.

On 1/1,000-type indicators, each graduation may represent a plunger movement of one-thousandth, one-half thousandth, or one-quarter thousandth of an inch. On 1/10,000 indicators, each graduation may represent a plunger movement of one ten-thousandth, one-half of one ten-thousandth, or as small as one-quarter of one ten-thousandth of an inch.

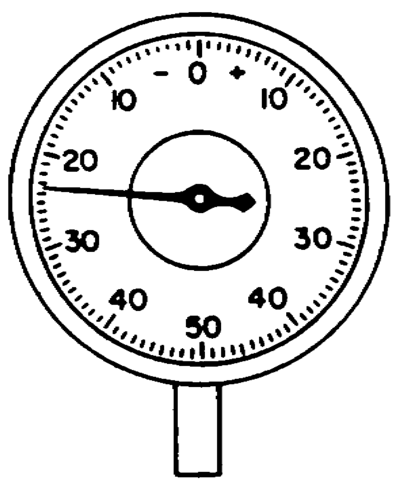


FIGURE 41. DIAL INDICATOR WITH A BALANCE DIAL

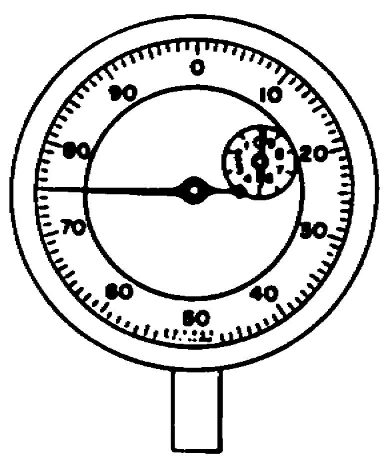


FIGURE 42. DIAL INDICATOR WITH A CONTINUOUS READING DIAL

Learning Event 2
MEASURE USING DIAL INDICATORS

The dial indicator can be used for detecting differences in the size of various parts of a workpiece. For example, assume we have a 6-inch long shaft of 3/4-inch diameter which we wish to check for concentricity (roundness) and taper. To check or indicate for concentricity, you must use the setup shown in Figure 43. The V-block clamp screws (not shown) must be adjusted just enough to permit you to rotate the end of the shaft by hand as it rests in the blocks. Loosen the spindle lockscrew of the pedestal, so you can position the indicator at the proper height. Determine the proper height by watching the pointer of the indicator. Bring the bottom of the indicator to bear on the workpiece between the V-blocks until the pointer moves clockwise .015. At that point, lock the indicator to the spindle of the pedestal by turning the spindle lockscrew. Now loosen the bezel clamp and turn the bezel until the 0 on the face of the dial lines up directly under the pointer of the indicator. After this, clamp the dial in place by turning the bezel clamp screw.

To check the shaft for concentricity, simply turn the end of the shaft by hand and note the amount of variation detected by the deflection or movement of the pointer as the workpiece is revolved.

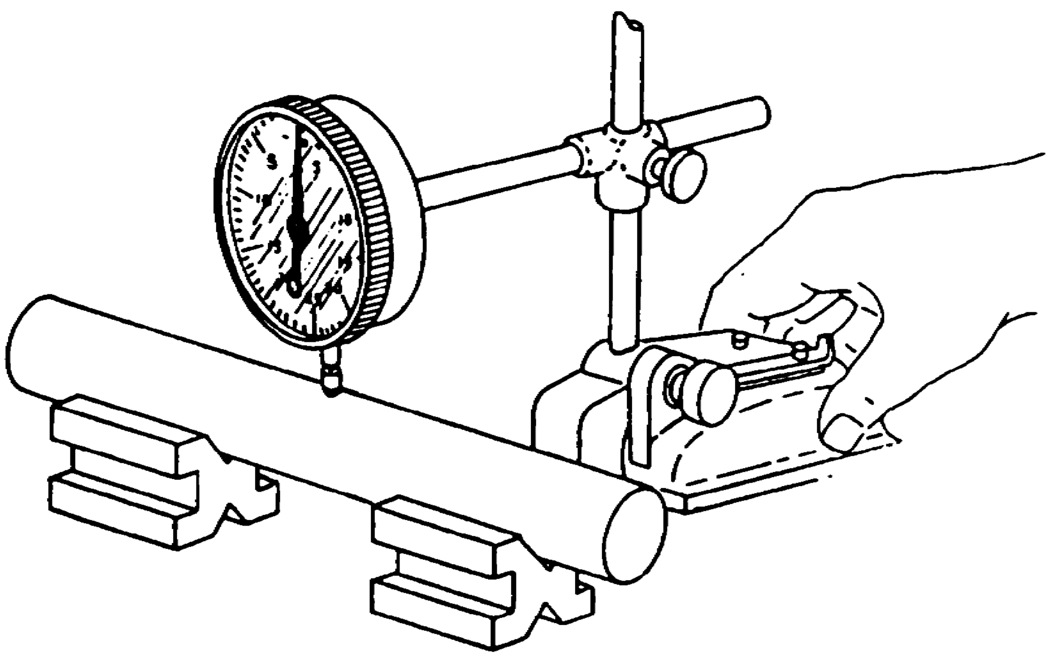


FIGURE 43. USING DIAL INDICATOR TO TEST CONCENTRICITY (ROUNDNESS)

To check this same piece for taper, first remove the V-block clamps. It is only necessary to lay the piece in the blocks. Then follow the procedures outlined above. Adjust the indicator to the proper height on the pedestal and bring the button of the indicator to bear on one end of the workpiece. Adjust the dial so the 0 on the dial lines up with the pointer of the indicator. Now move the indicator pedestal base so the button of the indicator is brought to bear on the opposite end of the workpiece. By noting the deflection of the needle from 0, you can readily see the amount of taper in the shaft.

Always mount the dial indicator with the plunger at right angles to the object being measured. Failure to do this can result in inaccurate readings.

The value of the graduations on the indicator dial of the dial indicator is easily determined. Using Figure 44 as an example, first look at the figure on the dial face which identifies the indicator as a 1/1,000 type. (The figure is just below the center of the hand.) Then count the number of spaces between the 0 and the first numeral to the left of the 0. The first numeral is a 10, indicating .010 of an inch (10/1,000) of plunger travel. Since there are 10 spaces between the 0 and the 10, the value of each graduation is equal to one-thousandth inch.

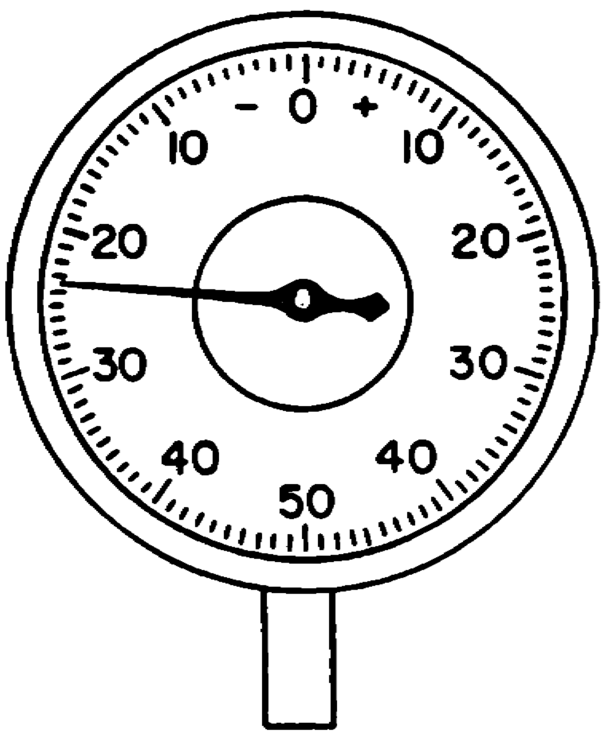


FIGURE 44. DIAL INDICATOR

Since it is obvious that such small movements of the plunger cannot be seen, the plunger is linked to the indicator hand or pointer through a train of small gears or through a set of linking levers which multiply any small movement of the plunger into a larger, sore easily seen movement of the indicator hand. This is why the dial indicator must be mounted rigidly to some support (magnetic base), Figure 45. Thus only the plunger can move. Any movement of the indicator body, in relation to the plunger, would cause an error in the reading.

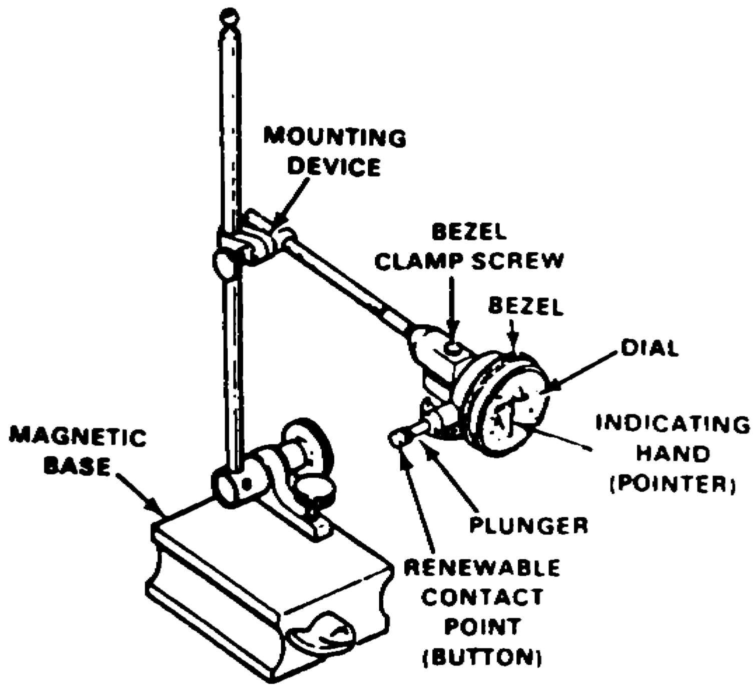


FIGURE 45. DIAL INDICATOR MOUNTED ON A MAGNETIC BASE

When not in use, the plunger spring naturally pushes the plunger outward, away from the indicator body, to the limit of plunger travel. On most standard indicators, the indicator hand comes to rest as shown in Figure 40. From this position, the hand could only travel to the right, or clockwise. When you use the indicator properly, the pointer could move either to the right or left of the 0 (to indicate plus or minus). The indicator must be set up for use so the plunger has been pushed inward far enough to allow equal travel to the right or to the left of 0. When using the indicator, remember that as the plunger moves toward the indicator body, the pointer moves clockwise, and as it moves away from the indicator body, the pointer moves counterclockwise.

Handle dial indicators carefully, and store them in their proper cases when you finish using then.

As stated earlier, the dial indicator is used to make measurements of flywheel runout, crankshaft end play, and lift of camshaft lobes. They my also be used to measure runout of disk brake rotors, cylinder bores of an engine, and so forth.

LESSON 3

PRACTICE EXERCISE

To ensure you understand how to read dial indicators, complete the following exercise requirements. Requirements 1 and 2 consist of practical application of what you have learned in this lesson. Requirement 3 consists of answering questions about material covered in this lesson.

Requirement 1:

Determine the measurement reading on the dial indicator shown below.

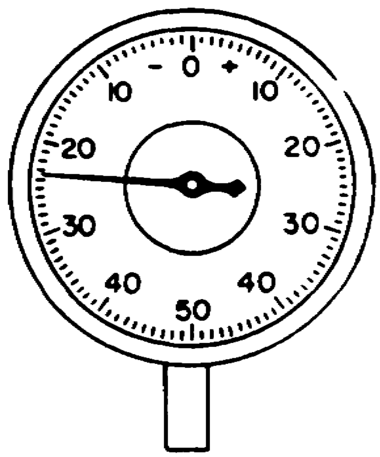


FIGURE 46. DIAL INDICATOR

Requirement 2:

Determine the measurement reading on the dial indicator shown below.

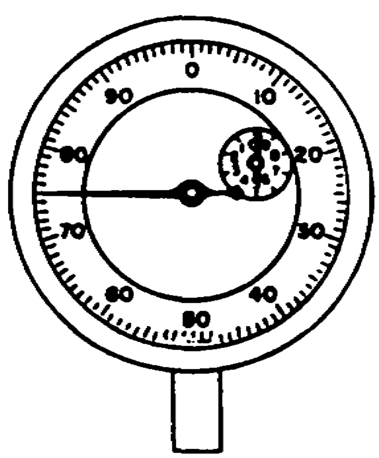


FIGURE 47. DIAL INDICATOR

Lesson 3/Practice Exercise

Requirement 3:

1. What does a dial indicator use to register its measurements?

   A. Hub and thimble
   B. Steel scale
   C. Dial face with a needle
   D. Caliper

2. What is the dial indicator used to measure?

   A. Shaft diameters
   B. Shaft length
   C. Shaft out-of-round
   D. Weight

3. What part of the dial indicator indicates its classification?

   A. Bezel
   B. Plunger
   C. Magnetic base
   D. Dial face

4. In which direction(s) do the figures read on a continuous reading type dial indicator?

   A. Counterclockwise
   B. Clockwise
   C. Both clockwise and counterclockwise

5. What happens if the indicator is NOT mounted with the plunger at right angles to the object to be measured?

   A. Plunger will not operate
   B. Bezel will not turn
   C. Measure will not be accurate
   D. Indicator hand will not move

6. What direction will the plunger move if the pointer is moving counterclockwise?

   A. Away from the indicator body
   B. Toward the indicator body
   C. Toward the bezel
   D. Away from the magnetic mount

7. All dial indicators are graduated in 1/1,000 inches.

   A. True
   B. False

8. To use the dial indicator properly it must be rigidly mounted to a support.

   A. True
   B. False

9. What is the measurement reading shown on the dial indicator below?

   A. -.025
   B. +.035
   C. +.125
   D. -.135

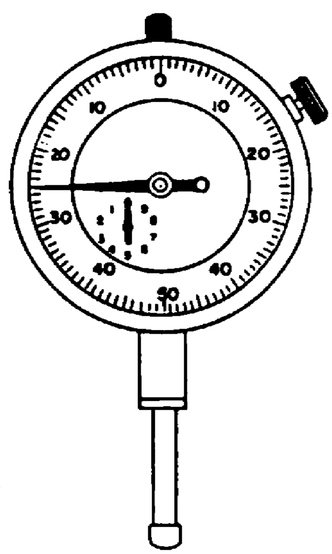


FIG ATOR

LESSON 3

PRACTICE EXERCISE SOLUTIONS

Solution to Requirement 1.

First, you should determine that the reading is a minus (-) reading. The next step is to read the number which the indicator hand has passed to the left. In this case, the number is 20 indicating a reading of .020 inch. Now you must read the number of marks the indicating hand has passed. If the indicating hand is aligned with a mark, that mark must also be counted. In this case, the hand has passed three marks which gives a reading of .023 inch. Since the indicating hand past the third mark you must now divide the distance between the third and fourth marks and make an estimate as to how far past the third mark the hand has gone. Example: one-quarter, one-half, or three-quarters of the way. In this case, the hand is approximately halfway between the third and fourth mark which now gives you a reading of -.0235.

Solution to Requirement 2:

First, you should determine that this dial indicator is a continuous dial type and will only read plus readings. Next you should go to the small dial on the face of the large dial and read the number to the left (counterclockwise). In this case, the hand has passed the numeral 9 which gives a reading of .900 inch. Next you should have gone to the large dial and read the number the indicating hand has passed to the right (clockwise). In this case it had passed the 70, which now gives you a reading of .970 inch. Now to complete the reading, you count the number of lines the indicating hand had passed clockwise from 70. In this case, it has passed 4 and was aligned with the fifth which also must be counted for a total of 5 which now gives a reading of .975 inch.

Solution to Requirement 3:

1. C (page 56)

2. C (page 58)

3. D (page 56)

4. B (page 56)

5. C (page 58)

6. A (page 59)

7. B (page 56)

8. A (page 59)

9. A Shown on Figure 48 in question

Lesson 4: MEASURING GAGES

TASK

Identify types of measuring gages, select the proper gage for a specific job, and read the graduations on the various gages.

CONDITIONS

You will be given information on different types of gages, gages used for specific jobs, and sizing of gages.

STANDARDS

You are expected to demonstrate competency of the task skills and knowledge by responding correctly to 70 percent of the examination questions pertaining to this lesson.

CREDIT HOURS

2

REFERENCES

TM 9-243

Learning Event
IDENTIFY TYPES AND USES OF MEASURING GAGES

In this lesson we will discuss the following measuring gages:

GAGES

Thickness (Feeler)

These gages are fixed in leaf form which allows you to check and measure small openings such as valve clearances, narrow slots such as point gaps, and so forth. They are widely used to check the flatness of parts in straightening and grinding operations and in squaring objects with a try square.

Wire and Drill

Wire gages are used for gaging metal wire. A similar gage is also used to check the size of hot and cold rolled steel, sheet and plate iron, and music wire. Drill gages determine the size of a drill and indicate the correct size of drill bit to use for a given tap size. Drill number and decimal size are also shown on this type gage.

Thread

Among the many gages used in machining and inspecting threads are center gages and screw pitch gages.

a. The center gage is used to set thread tools. Four scales on the gage are used for determining the number of threads per inch.

b. Screw pitch gages are used to determine the pitch of an unknown thread. The pitch of a screw thread is the distance between the center of one tooth to the center of the next tooth.

Small Hole Set

This set of four or more gages is used to check dimensions of small holes, slots, grooves, and so forth. The set can measure diameters from approximately 1/8 to 1/2 inch.

Telescoping

These gages are used for measuring the inside size of slots or holes up to 6 inches in width or diameter.

Fillet and Radius

These gages are used to check convex and concave radii in corners or against shoulders.

Drill Point

These gages are used to check the accuracy of drill cutting edges after grinding. They are also equipped with a 6-inch hook rule. This tool can be used as a drill point gage, hook rule, plain rule, and a slide caliper for taking outside measurements.

TYPES OF GAGES

Thickness (Feeler)

Thickness (feeler) gages are made in many shapes and sizes. Usually 2 to 26 blades are grouped into a single tool and graduated in thousandths of an inch. Most thickness blades are straight. Others are bent at the end at 45-degree and 90-degree angles. Some thickness gages are grouped so that there are several short and several long blades together. Thickness gages are also available in single blades and in strip form for specific measurements. For convenience, many groups of thickness gages are equipped with a locking screw in the case. This screw locks the blade to be used in the extended position. Figure 49 shows several types of thickness gages available through the Army Supply System.

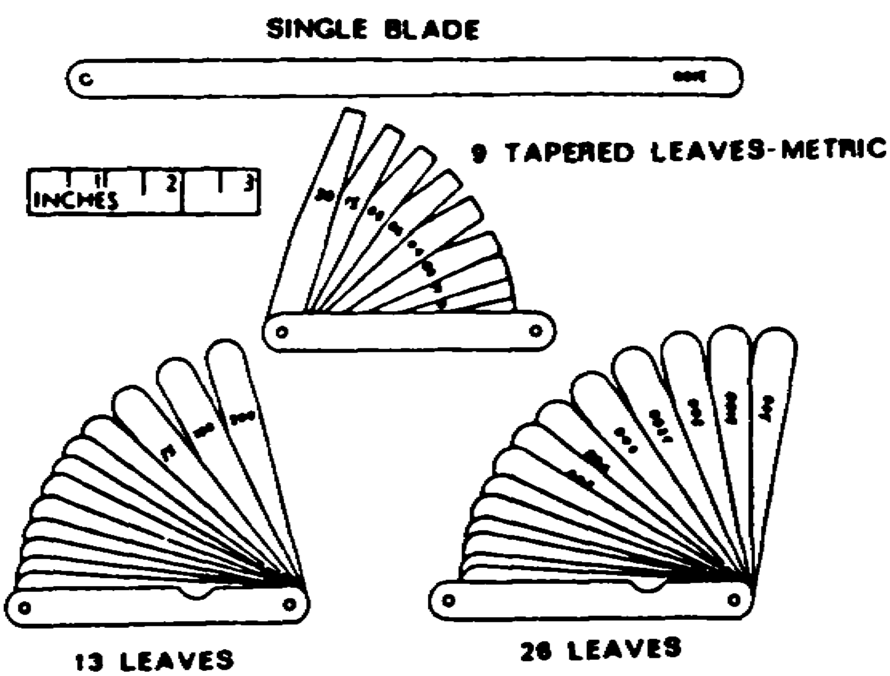


FIGURE 49. THICKNESS FEELER GAGES

Wire and Drill

a. The twist drill and drill rod gages, Figure 50, Part A, each have a series of holes with size and decimal equivalents stamped adjacent to each hole. One gage measures drill sizes numbers 1 to 60; the other gage measures drill sizes 1/16 to 1/2 inch by 1/64-inch intervals.

b. Wire gages, Figure 50, Part B, are circular in shape with cutouts in the outer perimeter. Each cutout gages a different size wire, from 0 to 36 of the English standard wire gage. A separate gage is used for American standard wire and another for US standard sheet and plate iron and steel.

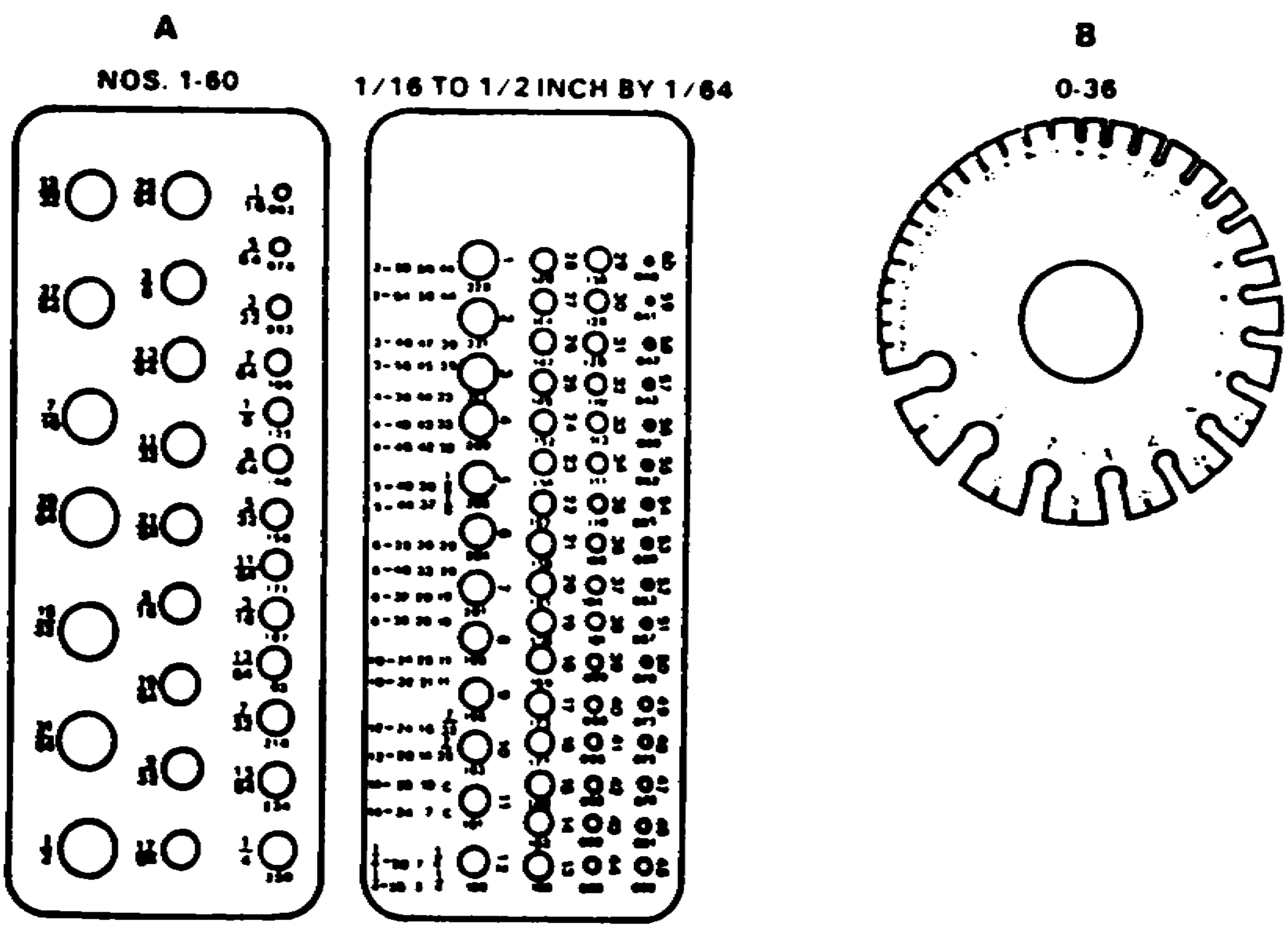


FIGURE 50. WIRE AND DRILL GAGES (PARTS A AND B)

Thread

a. Center gages, Figure 51, Part A, are graduated in fourteenth, twentieth, twenty-fourth, and thirtieth of an inch. The back of the center gage has a table giving the double depth of thread in thousandths of an inch for each pitch. This information helps you determine the size of tap drills. Sixty-degree angles in the shape of the gage are used for checking Unified and American threads or US standard threads and for checking thread cutting tools.

b. Screw pitch gages, Figure 51, Part B, are made for checking the pitch of US standard, metric, national form, V-form, and whitworth cut threads. These gages come grouped in a case or handle, like thickness gages. The number of threads per inch is stamped on each blade. Some types have blade locks. The triangular shaped gage has 51 blades covering a very wide range of pitches, including 11 1/2 and 27 threads per inch for V-form threads.

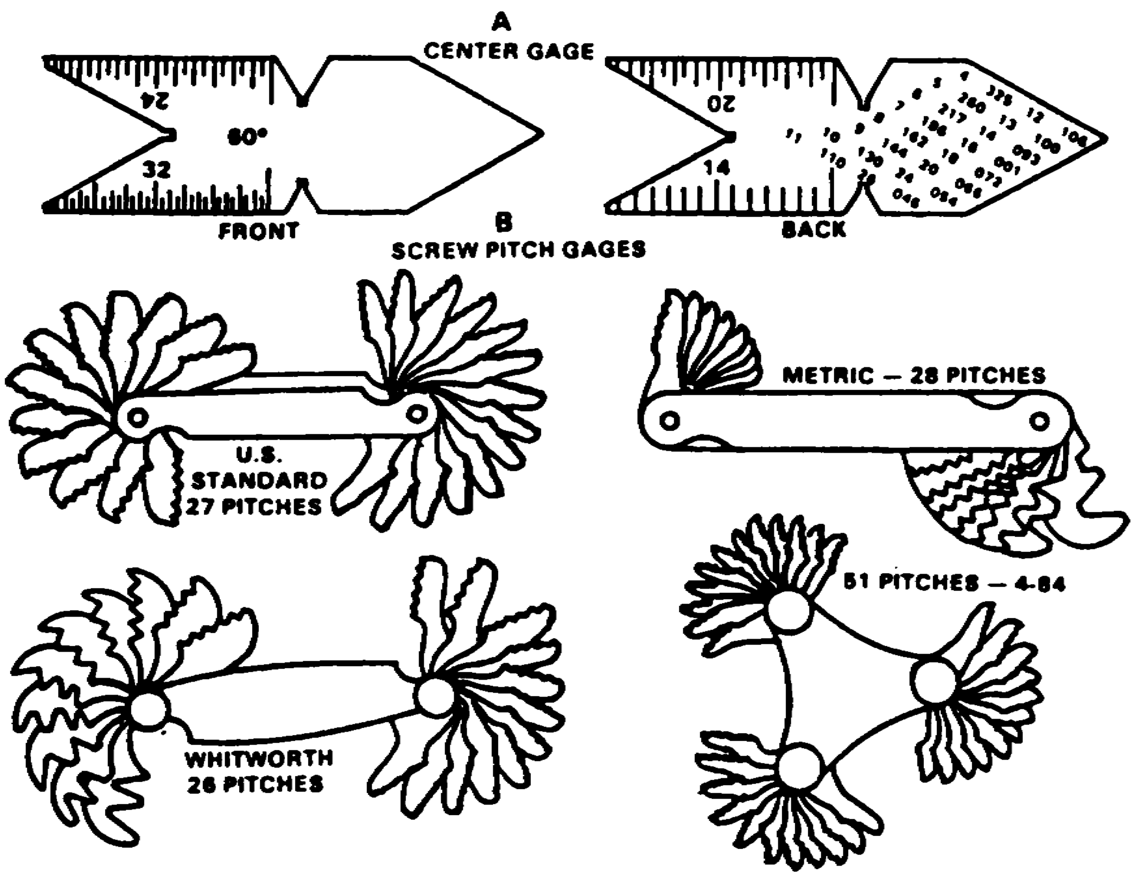


FIGURE 51. CENTER AND SCREW PITCH GAGES (PARTS A AND B)

Small Hole and Telescoping

a. Small hole gages, Figure 52, Part A, are adjustable, having a rounded measuring member. A knurled screw in the end of the handle is turned to expand the ball-shaped end in small holes and recesses. A micrometer caliper is used to measure the ball end. Maximum measuring capacity is 1/2 inch.

b. Telescoping gages, Figure 52, Part B, are used to gage larger holes and to measure inside distances. A knurled screw in the end of the handle locks the plunger in the measuring position. Maximum measuring capacity is 6 inches. As with small hole gages, measurements must be calipered on the gage using a micrometer.

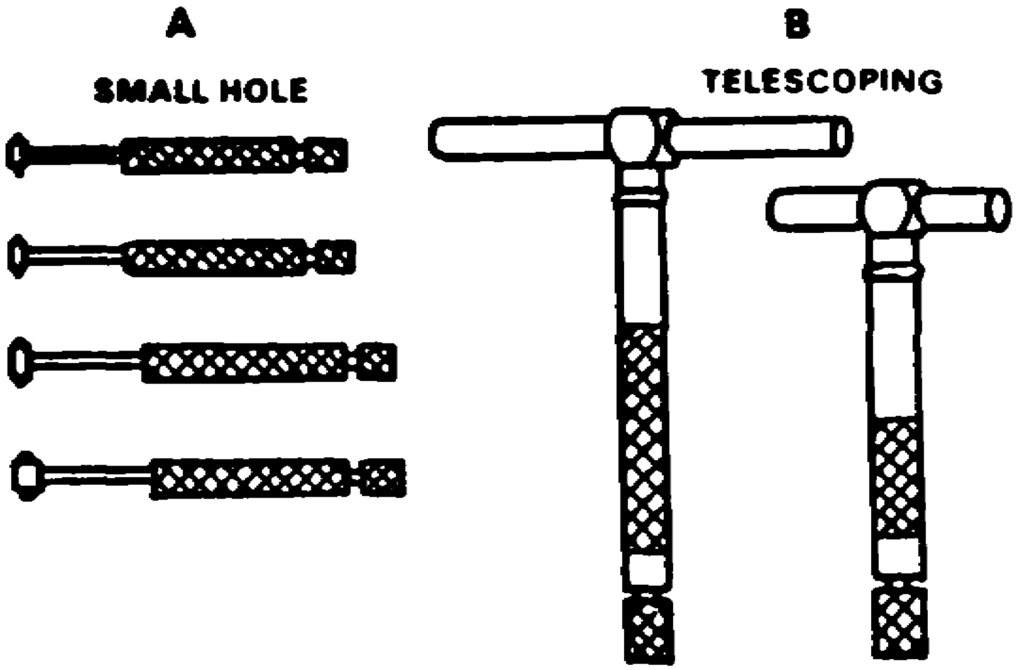


FIGURE 52. SHALL HOLE AND TELESCOPING GAGES (PARTS A AND B)

Fillet and Radius

The blades of fillet and radius gages are made of hard rolled steel. Double-ended blades, Figure 53, Part A, have a lock which holds the blades in position. Inside and outside measurements are made with the same blade. The other gage, Figure 53, Part B, has separate blades for inside and outside measurements. Each blade of each gage is marked in sixty-fourth. Gage A, Figure 53, has a range of sizes from 17/64 to 1/2 inch. Gage 3, Figure 53, ranges in size from 1/32 to 17/64 inch. Each gage has 16 blades.

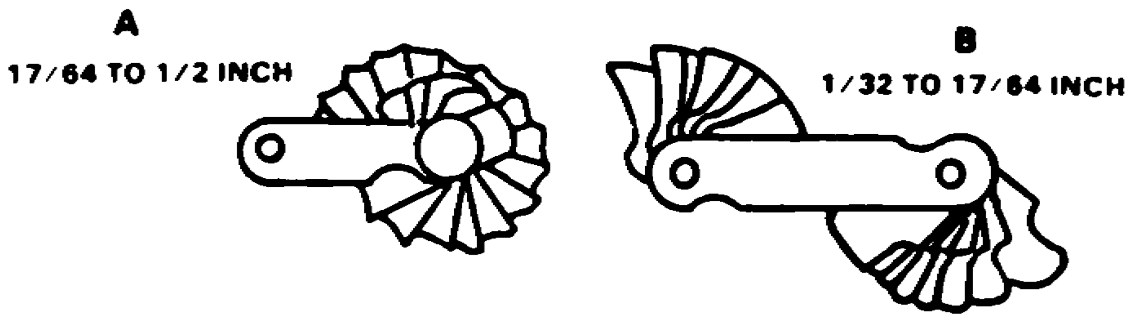


FIGURE 53. FILLET AND RADIUS GAGES (PARTS A AND B)

Drill Point

Drill point gages, Figure 54, consist of a 6-inch hook rule with a 59-degree sliding head that slides up and down the rule. The sliding head can be locked at any position on the rule. The sliding head is graduated in 1/32 inch increments.

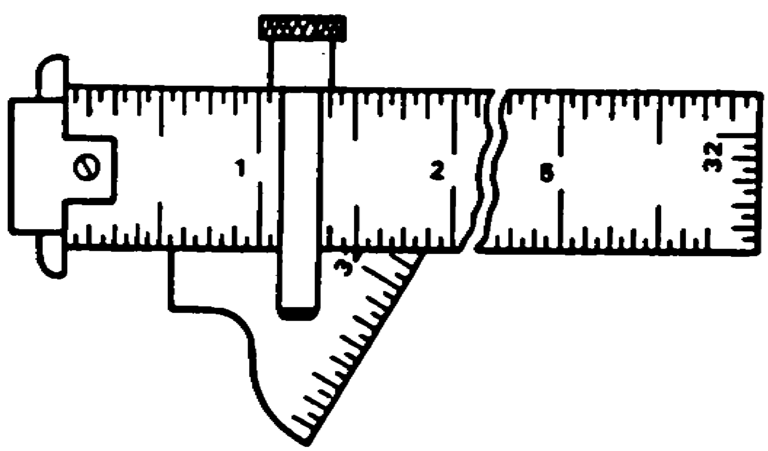


FIGURE 54. DRILL POINT GAGE

Care of Gages

a. Exercise care when using thickness gages to measure clearance of knives and cutters on machines. Do not lower a knife on a thickness blade and then try to remove the gage since the blade may be shaved off if it is too tight.

b. Never use gages for cleaning slots or holes.

c. When blades are damaged or worn, replace them.

d. Blades in cases are removed by loosening the clamp and sliding out the damaged blade. Install a new blade and tighten the clamp.

e. To prevent rust when storing gages, always coat the metal parts with a light film of oil.

f. Store gages in separate containers.

g. Do not stack or pile gages.

h. Always return blades of leaf-type gages to their cases after use.

i. Keep graduations and markings on gages clean and legible.

j. Do not drop gages. Minute scratches or nicks will result in inaccurate measurements.

GAGE USES

Thickness (Feeler)

Thickness (feeler) gages are used in one of two ways, as a means for determining a measure or as a means for adjusting to a definite limit. Figure 55, Part A, shows a thickness gage being used to check piston ring gap clearance in a cylinder bore. A long blade thickness gage is being used to determine the fit between large mating surfaces in Figure 55, Part B. By combining blades, it is possible to measure a wide variation of thicknesses.

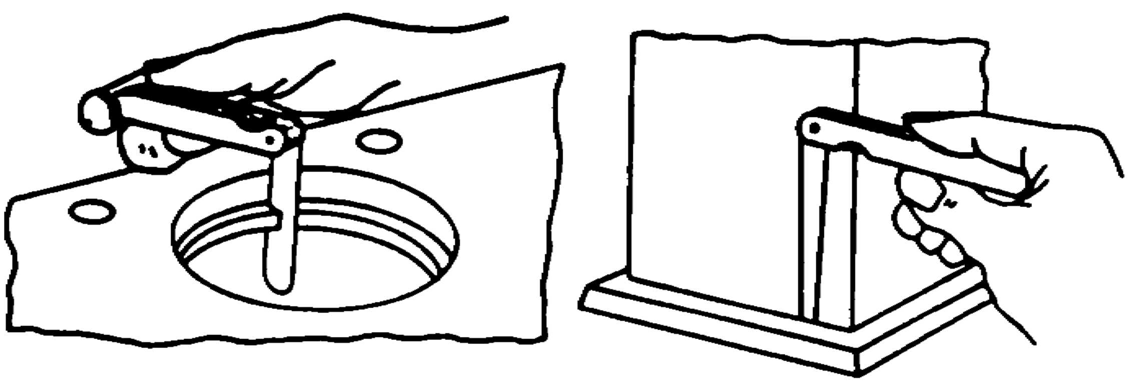


FIGURE 55. USING THICKNESS (FEELER) GAGES

Wire and Drill

The use of a drill gage is illustrated in Figure 56, Part A. The size of a drill is being determined. The drill size or number and decimal size are stamped on the gage beside each hole. A chart on the gage indicates the correct size of drill to use for a given tap size. To determine the size of both sheet stock and wire, you can use the wire gage shown in Figure 56, Part B.

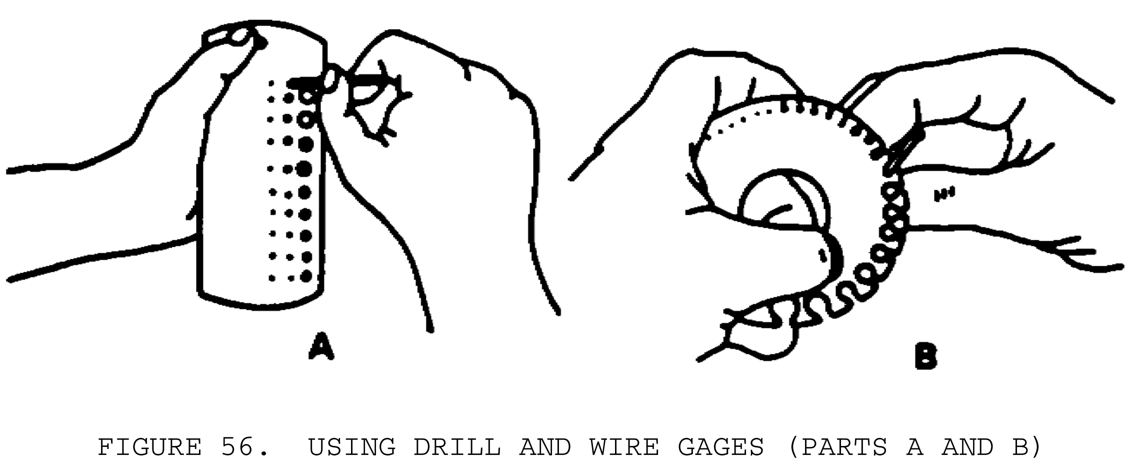


FIGURE 56. USING DRILL AND WIRE GAGES (PARTS A AND B)

Thread

a. Center gages check the angle of thread cutting tools, Figure 57. The gage is also used to check cut threads and the scales are used to measure the number of threads per inch.

b. Screw pitch gages measure the pitch of screws. If the pitch of a screw is not known, it can be determined by comparing it with the standards on various screw pitch gages as shown in Figure 58. Place a blade of a gage over the threads, and check to see whether it meshes; if not, successively check each blade of the gage against the thread until it matches. The pitch can be read off the correct blade. The blades are made pointed so they can be inserted in small nuts to check inside threads as well as outside threads.

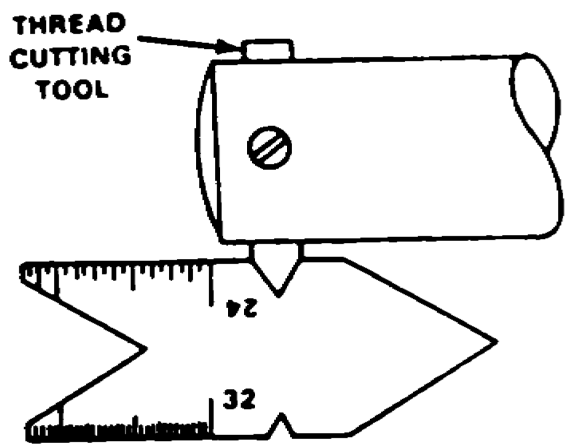


FIGURE 57. USING CENTER GAGE

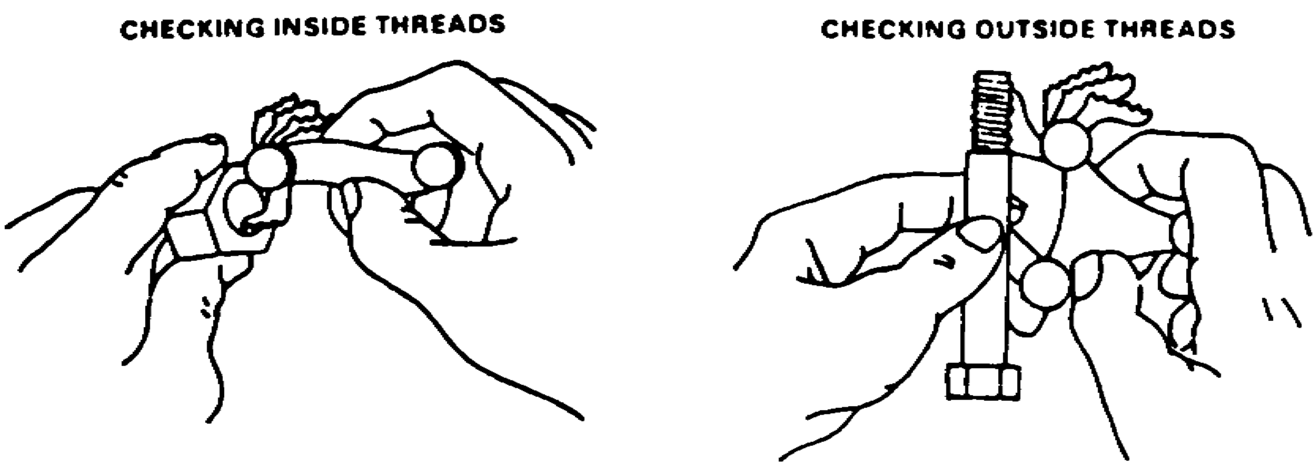


FIGURE 58. USING SCREW PITCH GAGES.

Small Hole and Telescoping

a. Use these gages when measurements cannot be taken with a standard micrometer, or when no plug gages are available.

b. Telescoping gages are particularly adaptable for rough bored work and odd sizes and shapes of holes.

c. Use compress plungers and lock by turning the handle screw. Insert the gage in the hole, Figure 59. Release the lock and the plunger expands to the exact size of the hole. Lock the plunger by turning the handle. After locking the plunger, remove the gage and check the measurement with a micrometer.

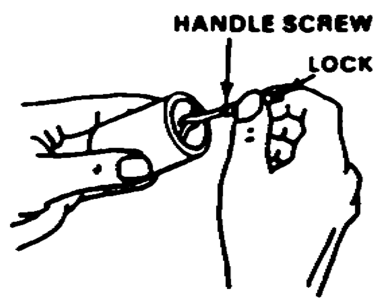


FIGURE 59. USING TELESCOPING GAGE

d. Small hole gages perform the same function as telescoping gages except that they are used in small work.

e. To use the small hole gage, fit the ball-shaped point into the hole or slot, Figure 60, Part A. Expand the ball-shaped end by turning the screw at the end of the handle.

f. Use a micrometer to gage the measurement, Figure 60, Part B.

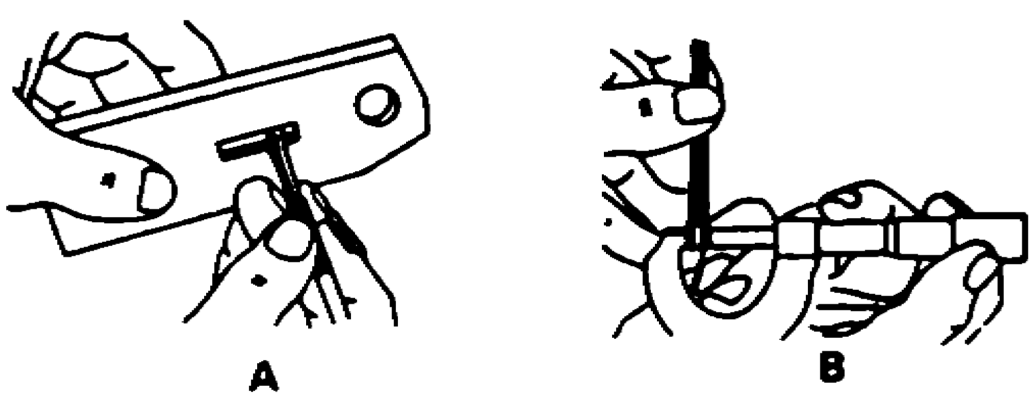


FIGURE 60. USING SMALL HOLE GAGE (PARTS A AND B)

Thread Cutting Tool

To check the correct form of a thread cutting tool, place the proper gage over the tool, Figure 61. (The Acme standard gage is used here.) The tool must mesh properly with no light showing between the tool and the gage. Use a 29-degree angle as a guide when grinding a cutting tool.

When the tool fits the angle, grind the point to fit the proper place on the gage. This indicates the number of threads per inch to be cut.

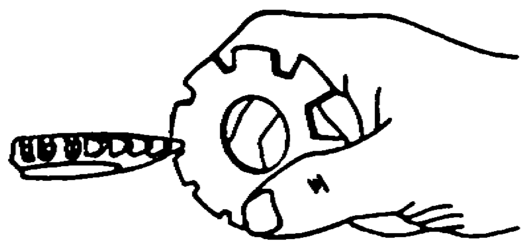


FIGURE 61. USING THREAD CUTTING TOOL GAGE

Fillet and Radius

A double ended radius gage blade is used to check the inside corner or fillet of a machine part, Figure 62, Part A. Each blade can be locked in any position and at any angle for both inside and outside radii, Figure 62, Part B.

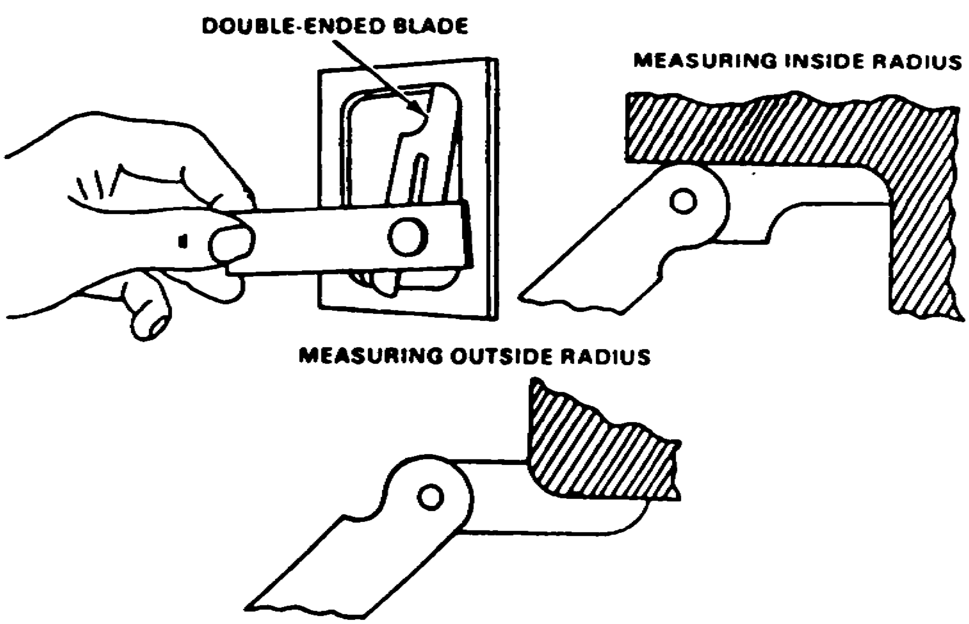


FIGURE 62. USING FILLET AND RADIUS GAGES

Lesson 4/Learning Event

Drill Point (Rod)

Sharpen the cutting edges of a drill one lip at a time. Each lip must have the same length and angle in relation to the axis of the drill. Set the sliding head securely on the rule at the mark equal to the length of the drill. Place the drill vertically against the rule so that the drill lip contracts the 59 degrees angle of the sliding head. Hold the drill and gage up to light. The correct angle is obtained when no light is seen between the gage and drill.

LESSON 4

PRACTICE EXERCISE

1. Which measurement would NOT be made using a thickness gage?

   A. Value clearance

   B. Squaring objects with a try square

   C. Roundness of a shaft

   D. Point gap of ignition system

2. What gage would be used to find the tap size before drilling a hole?

   A. Drill

   B. Wire

   C. Thread

   D. Small hole

3. What type of measurements are center gages used for?

   A. Depth of threads in thousandths of an inch

   B. Number of threads per inch

   C. Gage of the wire used

   D. Screw pitch

4. Which gage is used to check the dimensions of grooves and slots?

   A. Telescoping

   B. Radius

   C. Center

   D. Small hole

5. What gage of the miscellaneous group can also be used as a slide caliper?

   A. Drill point

   B. Telescoping

   C. Small hole

   D. Radius

6. Thickness gages are graduated in what portion of an inch?

   A. Tenths

   B. Hundredths

   C. Thousandths

   D. Ten-thousandths

7. The drill gage lists both the drill size and the decimal equivalent.

   A. True

   B. False

8. The English Standard wire gage measures wire sizes from 0 to 45.

   A. True

   B. False

9. What is the maximum measuring capacity of the telescoping gage, in inches?

   A. 2

   B. 4

   C. 6

   D. 8

10. What is the maximum measuring capacity of small hole gages, in inches?

    A. 1/8

    B. 1/4

    C. 1/2

    D. 3/4

LESSON 4

PRACTICE EXERCISE SOLUTIONS

1. C (page 70)
2. A (page 77)
3. B (page 70)
4. D (page 70)
5. A (page 76)
6. C (page 68)
7. A (page 70)
8. B (page 69)
9. C (page 71)
10. B (page 73)

Lesson 5: TORQUE WRENCHES

TASK

Identify torque wrenches by type and size, select the proper torque wrench for a specific job, and use the torque wrench properly.

CONDITIONS

You will be given information describing different types of torque wrenches, torque wrench selection, and proper torque wrench use.

STANDARDS

You are expected to demonstrate competency of the task skills and knowledge by responding correctly to 70 percent of the examination questions pertaining to this lesson.

CREDIT HOURS

2

REFERENCES

TM 9-243
TM 5-3805-251-34

Learning Event
IDENTIFY TORQUE WRENCHES BY TYPES AND USE

A torque wrench is used for work requiring a particular force (torque). It has a measuring device that indicates the amount of torque or twist being applied to a nut or bolt. In much of today's machinery, engineers have carefully worked out the degree of tightness to which nuts or bolts should be tightened. If they are not tightened enough, they may loosen in service. If they are tightened too much, the bolts or machine parts may be strained excessively and break. In either case, the result could severely damage the machine. The torque wrench allows nuts and bolts to be tightened just the right amount.

Torque can be defined as a twisting force. A one-pound pull on a 1-foot wrench (center of bolt to point of pull) equals 1 foot-pound. Force times distance equals torque. The formula for determining torque would be as follows:

(F x D = T) or 1 pound x 1 foot = 1 foot-pound of torque

When an extension (adapter) is used to lengthen a torque wrench, the effective length is increased. Increasing the effective length of the wrench changes the actual torque reading on the dial. To calculate the actual torque, the following formula may be used:

A - Torque reading on dial

B - Length of torque wrench without adapter

C - Length of adapter

$$\frac{A \times B + C}{B} = \text{Actual Torque}$$

TYPES OF TORQUE WRENCHES

Dial Indicating

The dial-indicating torque wrench, Figure 63, indicates the amount of torque applied at any given moment. Dial-indicating wrenches are especially suited for jobs requiring many different torque values because the dial does not have to be reset each time. To measure bearing or preload, use a dial-indicating torque wrench.

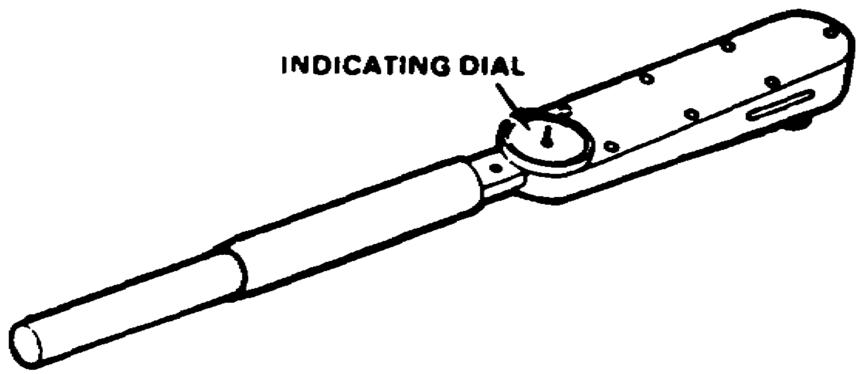


FIGURE 63. DIAL-INDICATING TORQUE WRENCH

Deflecting Beam

Beam-type torque wrenches, Figure 64, are made of flexible alloy steel which deflects when torque is applied. A pointer attached to the end of the beam indicates the torque reading on a scale. This type torque wrench has the advantage of simple design. It does not use a multiplying device or a cam mechanism that can be ruined easily.

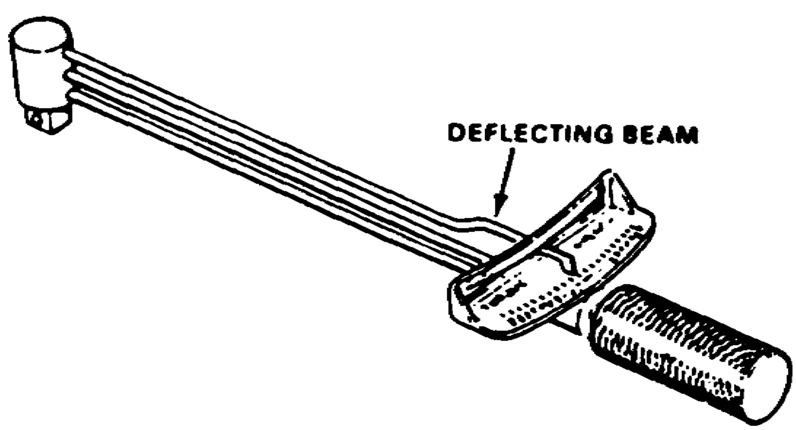


FIGURE 64. DEFLECTING BEAM TORQUE WRENCH

Micrometer or Clicker

The micrometer-type torque wrench, Figure 65, has a built-in micrometer at the end of the handle where a specified torque can be set by turning the handle. When the specified torque is reached, a loud click is heard. This type torque wrench permits very accurate tightening of nuts and bolts.

FIGURE 65. MICROMETER TORQUE WRENCH

Regardless of their type, most torque wrenches measure torque in foot-pounds (ft-lb). However, some torque wrenches (mainly those used for more accurate readings on smaller nuts and bolts) measure torque in inch-pounds (in-lb). Twelve inch-pounds equal 1 foot-pound. To convert foot-pounds to inch-pounds, multiply the foot-pound by 12. To convert inch-pounds to foot-pounds, divide the inch-pounds by 12.

Example of converting foot-pounds to inch-pounds:

75 foot-pounds x 12 inch-pounds = 900 inch-pounds.

Example of converting inch-pounds to foot-pounds:

1,260 inch-pounds ÷ 12 inch-pounds = 105 foot-pounds.

Torque wrenches are issued in several sizes; they may have a 1/4-, 1/2-, or 3/4-inch square drive to receive socket wrenches, and the capacity may range up to 600 foot-pounds.

SELECTING A TORQUE WRENCH FOR A SPECIFIC JOB

Before selecting a torque wrench for a job, note the torque specification. Then select and use a torque wrench that will read about midrange for the specified torque. For example, a typical 1/2-inch drive micrometer torque wrench measures from 30 to 200 foot-pounds. It would be the best torque wrench for a job requiring about 100 foot-pounds of torque. Typically, a 3/8-inch-drive torque wrench reads from 15 to 100 foot-pounds. A 1/4-inch-drive torque wrench measures from 30 to 300 inch-pounds.

USING THE TORQUE WRENCH

To use a torque wrench, set the specification on the micrometer handle or note the specification on the scale or dial. Attach the proper socket to the torque wrench. Place the socket on the nut or bolt to be tightened.

If an assembly containing many bolts or nuts is to be torqued, it is good practice to use the following three-step procedure:

1. First, torque all the bolts to about three-quarters of the specification.

2. Recheck the specification and the torque wrench setting. Then, apply the specified torque to each bolt.

3. Finally, retorque all bolts to the specification, to be sure that none were missed in the final torquing.

Use a smooth, steady pulling motion with a torque wrench. A fast or a jerky motion will cause the fastener to be tightened to an incorrect torque. Be sure to follow the torque specification for each fastener. Look for footnotes, in the specification charts, that indicate whether the threads are to be dry or lubricated with an antiseize compound. When you are tightening parts such as cylinder heads or intake manifolds, always find and follow the recommended bolt tightening pattern, Figure 66.

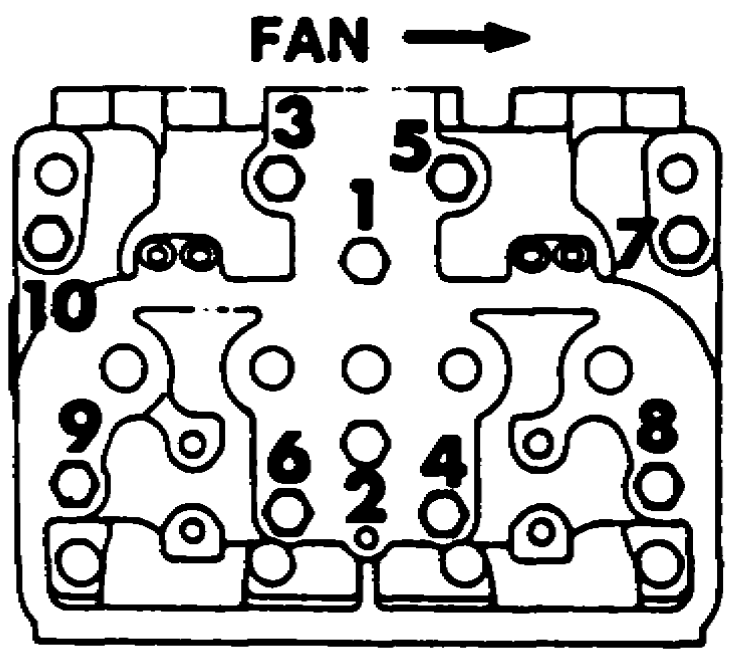


FIGURE 66. MW24 B CYLINDER HEAD BOLT TORQUE SEQUENCE

CARE OF TORQUE WRENCHES

A torque wrench is a precision measuring instrument that accurately limits the torque applied to a fastener. Do not use the torque wrench as a general purpose turning tool. When using a torque wrench, observe the following rules:

1. Never use a micrometer torque wrench in a position below the minimum torque setting on the scale. However, when storing a micrometer torque wrench, always adjust the handle to its lowest setting.

2. Never use the torque wrench to tighten a fastener to a higher torque than the maximum reading on the scale.

3. Never use a torque wrench on a fastener that has been tightened with a wrench or socket. For an accurate torque reading, the final tightening must be done with the torque wrench.

4. A torque wrench has a recommended calibration interval. Most torque wrenches are guaranteed to be accurate within four percent. To ensure that the wrench is always this accurate, have it checked at specified intervals by the manufacturer.

5. Examine and try torque wrenches. Note how varying amounts of pull on the wrench handle register on the wrench dial. A torque wrench should be pulled evenly and steadily; it should not be jerked.

6. Threads should be cleaned and lubricated before a nut or a bolt is tightened. This reduces thread friction and results in more accurate tightening.

7. Take special care of the torque wrench to avoid damaging it or ruining its adjustment. Keep it clean and oiled; put it away in a protected place after each use.

METRIC SYSTEM VERSUS US CUSTOMARY SYSTEM

Today, knowing how to convert measurements from the US customary system to the metric system is very important.

Kilograms (kiloponds) or newtons express force in the metric system.

Use the appropriate type of torque wrench for specifications given. If specifications are given in centimeters-kilograms, then a torque wrench with a centimeter-kilogram scale should be used. If torque values stated do not match the valves on your torque wrench, the following formulas can be used to convert the values given:

- **Foot-pounds** = $\frac{\text{centimeters-kilograms}}{13.8}$

  Example: 54 centimeters-kilograms / 13.8 = 3.9 foot-pounds

- **Inch-pounds** = $\frac{\text{centimeters-kilograms}}{1.15}$

  Example: 108 centimeters-kilograms / 1.15 = 93.9 inch-pounds

- **Centimeters-kilograms** = **inch-pounds x 1.15**

  Example: 70 inch-pounds x 1.15 = 80.5 centimeters-kilograms

- **Centimeters-kilograms** = **foot-pounds x 13.8**

  Example: 20 foot-pounds x 13.8 = 276 centimeters-kilograms

NOTE: The newton-meter is a measurement of torque used by any countries using the metric system. One newton-meter is equal to .7375 foot-pounds.

To convert newton-meters to foot-pounds, you multiply the total newton-meters by .7375.

Example: 150 newton-meters x .7375 = 110.6 foot-pounds

To convert foot-pounds to newton-meters, you would divide the total foot-pounds by .7375.

Example: 80 foot-pounds ÷ .7375 = 108.5 newton-meters

LESSON 5

PRACTICE EXERCISE

To insure you understand how to use a torque wrench, complete the following exercise requirements. Requirements 1 through 5 consist of practical application of what you have learned in this lesson. Requirement 6 consists of answering questions about material covered in this lesson.

Requirement 1:
Determining Torque Values

a. Using the formula F x D = T, determine the torque value for a torque wrench 2 feet long.

10 lb-force =

20 lb-force =

40 lb-force =

80 lb-force =

b. Using the formula F x D = T, determine the torque value for a torque wrench 1 1/2 feet long.

15 lb-force =

30 lb-force =

60 lb-force =

120 lb-force =

Requirement 2:

Determining Torque Value when the Torque Wrench has been Lengthened.

a. Using the following formula, determine the actual torque for a torque wrench 2 feet long and an extension 1 foot long:

$$\frac{A \times B + C}{B}$$

Dial reading of 40 ft-lb =

Dial reading of 53.5 ft-lb =

Dial reading of 65 ft-lb =

Dial reading of 87 ft-lb =

Dial reading of 109 ft-lb =

b. Using the following formula, determine the actual torque for a torque wrench 1 foot long with a 2-foot extension:

$$\frac{A \times B + C}{B}$$

Dial reading of 35 ft-lb =

Dial reading of 47 ft-lb =

Dial reading of 59 ft-lb =

Dial reading of 63 ft-lb =

Dial reading of 77 ft-lb =

Requirement 3:

a. Convert the following foot-pounds to inch-pounds.

29 ft-lb =

32 ft-lb =

38 ft-lb =

43 ft-lb =

50 ft-lb =

b. Convert the following inch-pounds to foot-pounds.

600 in-lb =

750 in-lb =

825 in-lb =

930 in-lb =

1,120 in-lb =

Requirement 4:

a. Convert the following centimeters-kilograms to foot-pounds:

200 centimeters-kilograms =

225 centimeters-kilograms =

233 centimeters-kilograms =

242 centimeters-kilogram =

261 centimeters-kilograms =

b. Convert the following centimeters-kilograms to inch-pounds:

90 centimeters-kilograms =

87 centimeters-kilograms =

75 centimeters-kilograms =

63 centimeters-kilograms =

54 centimeters-kilograms =

c. Convert the following foot-pounds to centimeters-kilograms:

25 ft-lb =

30 ft-lb =

32 ft-lb =

44 ft-lb =

56 ft-lb =

d. Convert the following inch-pounds to centimeters-kilograms:

75 in-lb =

79 in-lb =

83 in-lb =

86 in-lb =

94 in-lb =

Lesson 5/Practice Exercise

Requirement 5:

a. Convert the following newton-meters to foot-pounds:

265 newton-meters =

254 newton-meters =

240 newton-meters =

190 newton-meters =

175 newton-meters =

b. Convert the following foot-pounds to newton-meters:

80 ft-lb =

87 ft-lb =

93 ft-lb =

98 ft-lb =

106 ft-lb =

Requirement 6:

1. What term best describes torque?

   A. A jerking force

   B. A twisting force

   C. A reversing force

   D. A rotating force

2. What type tool/device is a torque wrench?

   A. Turning

   B. Cutting

   C. Fastening

   D. Precision measuring

3. When storing a micrometer torque wrench, what setting do you adjust the handle to?

   A. Highest reading

   B. Most used position

   C. Lowest setting

   D. Off-scale position

4. What procedure is best to use when torquing the bolts in an assembly?

   A. One-step

   B. Two-steps

   C. Three-steps

   D. Four-steps

5. To convert foot-pounds to inch-pounds, you multiply the foot-pounds by:

   A. 12.0

   B. 0.138

   C. 0.7375

   D. 1.15

6. To convert foot-pounds to centimeters-kilograms, you multiply the foot-pounds by:

   A. 1.15

   B. 13.8

   C. 12.0

   D. 0.138

7. To convert newton-meters to foot-pounds, you multiply the newton-meters by:

   A. 0.138

   B. 13.8

   C. 1.15

   D. 0.7375

8. To convert centimeters-kilograms to inch-pounds, you multiply the centimeters-kilograms by:

   A. 1.15

   B. 13.8

   C. 12.0

   D. 0.138

9. Which torque wrench is best suited for jobs requiring more than one torque value?

   A. Deflecting beam

   B. Dial indicating

   C. Micrometer

   D. Ratchet

LESSON 5

PRACTICE EXERCISE SOLUTIONS

Solutions to Requirement 1a.

10 lb-force = 20 ft-lb

20 lb-force = 40 ft-lb

40 lb-force = 80 ft-lb

80 lb-force = 160 ft-lb

Solutions to Requirement 1b.

15 lb-force = 12.5 ft-lb

30 lb-force = 45 ft-lb

60 lb-force = 90 ft-lb

120 lb-force = 180 ft-lb

Solutions to Requirement 2a:

40 ft-lb = 40.5 ft-lb

53 ft-lb = 53.5 ft-lb

65 ft-lb = 65.5 ft-lb

87 ft-lb = 87.5 ft-lb

109 ft-lb = 109.5 ft-lb

Solutions to Requirement 2b:

35 ft-lb = 37 ft-lb

47 ft-lb = 49 ft-lb

59 ft-lb = 61 ft-lb

63 ft-lb = 65 ft-lb

77 ft-lb = 79 ft-lb

Lesson 5/Practice Exercise Solutions

Solutions to Requirement 3a:

29 ft-lb = 384 in-lb

32 ft-lb = 348 in-lb

38 ft-lb = 456 in-lb

43 ft-lb = 516 in-lb

50 ft-lb = 600 in-lb

Solutions to Requirement 3b:

600 in-lb = 50 ft-lb

750 in-lb = 62.5 ft-lb

825 in-lb = 68.7 ft-lb

930 in-lb = 77.5 ft-lb

1,120 in-lb = 93.3 ft-lb

Solutions to Requirement 4a:

200 centimeters-kilograms = 14.49 ft-lb

225 centimeters-kilograms = 16.3 ft-lb

233 centimeters-kilograms = 16.8 ft-lb

242 centimeters-kilograms = 17.5 ft-lb

261 centimeters-kilograms = 18.9 ft-lb

Solutions to Requirement 4b:

90 centimeters-kilograms = 78.26 in-lb

87 centimeters-kilograms = 75.6 in-lb

75 centimeters-kilograms = 65.2 in-lb

63 centimeters-kilograms = 54.8 in-lb

54 centimeters-kilograms = 47.0 in-lb

Solutions to Requirement 4c:

25 ft-lb	=	345	centimeters-kilograms
30 ft-lb	=	414	centimeters-kilograms
32 ft-lb	=	441.6	centimeters-kilograms
44 ft-lb	=	607.2	centimeters-kilograms
56 ft-lb	=	772.8	centimeters-kilograms

Solutions to Requirement 4d:

75 in-lb	=	86.25	centimeters-kilograms
79 in-lb	=	90.85	centimeters-kilograms
83 in-lb	=	95.45	centimeters-kilograms
86 in-lb	=	98.9	centimeters-kilograms
94 in-lb	=	108.1	centimeters-kilograms

Solutions to Requirement 5a:

265 newton-meters	=	195.4	ft-lb
254 newton-meters	=	187.3	ft-lb
240 newton-meters	=	177	ft-lb
190 newton-meters	=	140.1	ft-lb
175 newton-meters	=	129	ft-lb

Solutions to Requirement 5b:

80 ft-lb	=	108.4 newton-meters
87 ft-lb	=	117.96 newton-meters
93 ft-lb	=	126.1 newton-meters
98 ft-lb	=	132.88 newton-meters
106 ft-lb	=	143.7 newton-meters

Lesson 5/Practice Exercise Solutions

Solutions to Requirement 6:

1. B (page 83)
2. D (page 86)
3. C (page 87)
4. C (page 86)
5. A (page 85)
6. B (page 88)
7. D (page 88)
8. A (page 88)
9. B (page 83)

Lesson 6: HYDRAULIC FILLER/BLEEDER

TASK

Identify the components and uses of the hydraulic filler/bleeder.

CONDITIONS

You will be given information on the hydraulic filler/bleeder, filler/ bleeder components, and bleeder/filler operation.

STANDARDS

You are expected to demonstrate competency of the task skills and knowledge by responding correctly to 70 percent of the examination questions pertaining to this lesson.

CREDIT HOURS

2

REFERENCES

EIS Division - Parker Hannifin Corporation - Middletown, CT 06457 Form #F1128-79

Learning Event
USING THE HYDRAULIC FILLER/BLEEDER

The hydraulic filler/bleeder is used to purge (remove trapped air) a hydraulic system such as a hydraulic brake or a hydraulic clutch system.

When a hydraulic brake or clutch system must have a component repaired or replaced, the system must be opened. This allows air to enter the system. Air in the system results in spongy pedal feel and action. Since air in the system is compressible, reduced pressure and force result in poor braking action when the brakes are applied.

Although you can bleed a hydraulic brake or clutch system without a filler/bleeder, using it simplifies the job, and allows you to accomplish the task without assistance.

The hydraulic filler/bleeder can be used to bleed hydraulic brake systems, hydraulic clutch systems, dual safety cylinders, dual clutch and brake cylinders, all power brake systems, and any master cylinder with or without a check valve.

DESCRIPTION

The filler/bleeder, Figure 67, is a round cylinder divided into two chambers by a tank diaphragm. The top chamber holds hydraulic brake fluid. The bottom holds pressurized air. The filler/bleeder is mounted on casters (rollers) which allow it to be moved easily around the shop.

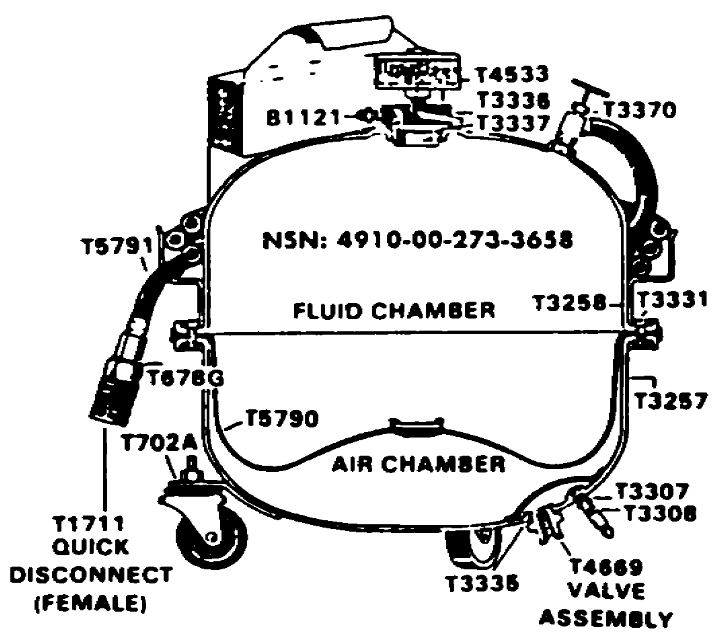


FIGURE 67. HYDRAULIC FILLER/BLEEDER

The filler/bleeder comes with seven bleeder adapters, Figure 68. They are designed to fit most master cylinders on the market at this time.

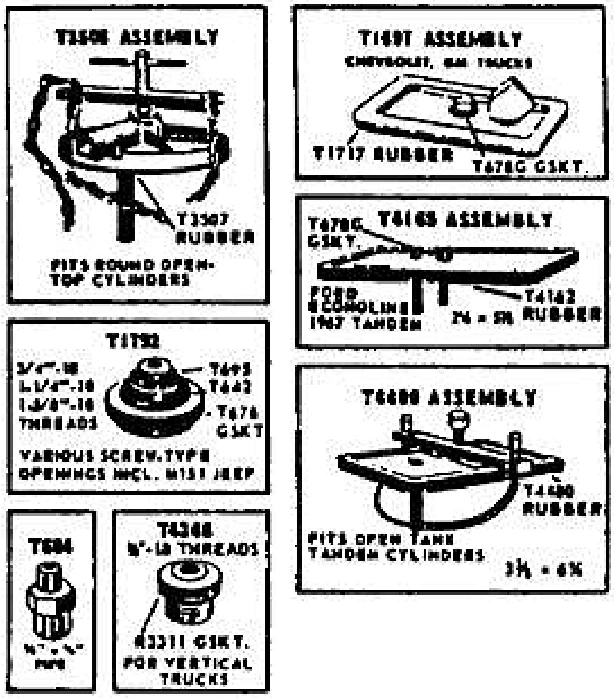


FIGURE 68. BLEEDER ADAPTERS

In addition to the adapters, the filler/bleeder comes with bleeder hoses, elbows, male and female quick-disconnects, and a spare gasket set, Figure 69.

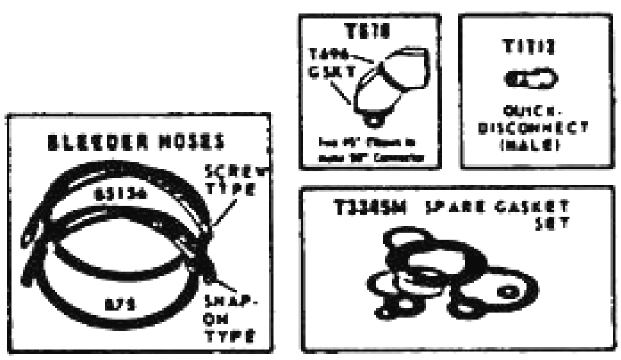


FIGURE 69. ADDITIONAL COMPONENTS

The numbers that appear on the filler/bleeder and its adapters are parts numbers which correspond to the parts list in Figure 70.

PARTS LIST

MANUF. PART NO.	NOMENCLATURE
075	- Bleeder Hose (Snap on type)
T642	- Rubber Gasket for T1792 (1¼" I.D.)
T670	- Rubber Gasket for T1792 (1⅜" I.D.)
T678	- 45° Elbow (2 supplied for 90° angle)
T678G	- Fibre Gasket for Adapters T1697 & T4165 and T5791 Hose End
T684	- Combination Adapter (⅜" x ⅜" I.P.)
T695	- Rubber Gasket for T1792 (⅞" I.D.)
T698	- Rubber Gasket for T678 & T1712
T702A	- Caster
B1121	- Bleeder Screw
F1120	- Instruction Manual
T1697	- Adapter for GMC & Chev. Truck
T1711	- Quick Disconnect Coupler-Female
T1712	- Quick Disconnect Coupler-Male
T1717	- Rubber for T1697
T1792	- 3 Thread Adapter ([illegible])
T3257	- Tank Shell -16 Hole (Bottom)
T3258	- Tank Shell -16 Hole (Top)
T3307	- Air Stem
T3308	- Air Chuck (Std. Schrader No. 610)
T3311	- Rubber Gasket for T4348
T3331	- No. 12-24 Oven Hd. Screw & Nut
T3335	- "O" Ring for Safety Release Valve
T3336	- Tank Filler Plug
T3337	- "O" Ring for Filler Plug
T3345M	- Spare Gasket Set
T3370	- Shut-Off Valve
T3506	- Adapter Universal for Open Round Tanks & 1¼"- 1½" Threaded Inlets
T3507	- Rubber for T3506 (Diam. 3¼")
T4182	- Rubber for T4165
T4165	- Adapter-Ford Econoline Tandem 1967
T4348	- Adapter-Vertical Truck (Cl. & Br.) 1961 & up (⅞" - 18 Thds.)
T4400	- Adapter for all Open-Tank Tandem Cyls
T4480	- Rubber for T4400
T4533	- Pressure Gage (2" Diam.)
T4669	- Safety Valve-Complete Assembly
B5156	- Bleeder Hose (Screw type)
T5790	- Diaphragm -16 Hole
T5791	- Hose Assembly - 84" long with T1711

FIGURE 70. PARTS LIST

PREPARING THE FILLER/BLEEDER FOR OPERATION

Filler Unit

a. Refer to Figure 67. Loosen valve cap A to exhaust the air chamber. Leave valve A open. Also, ensure that valve B is fully open.

b. Wipe dirt from the top of the tank and open filler plug C, Figure 67. Fill the fluid chamber to the brim of the inlet with brake fluid (silicone, automotive all weather, operation and preservative, military specification Mil-B-46176).

c. Close plug C, Figure 67, hand tight. Tighten air cap A securely and fill the unit with air through cap A until the gage reads in the black, 20 to 30 psi (20 psi is sufficient to bleed all vehicles).

WARNING

DO NOT CHARGE THE UNIT WITH AIR IN EXCESS OF 50 PSI.

DO NOT USE SHARP TOOLS OR OTHER PROBES TO RETURN DIAPHRAGM TO ITS NORMAL DOWN POSITION.

d. Open bleeder screw D, Figure 67, to bleed any air that may be trapped in the fluid section of the filler/bleeder.

e. On the initial filling only, the hose should be bled using the male quick-disconnect fitting, part number T1712, Figure 69.

Connecting Filler/Bleeder to Master Cylinder

a. Clean the top of the master cylinder to keep dirt from dropping into the opening. Remove the filler cap from the master cylinder and clean the gasket seat thoroughly.

b. Refer to Figure 68. Select and install the proper adapter and gasket. On most adapters, hand tightening is sufficient with clean surfaces and the proper gaskets. Others may require a wrench to tighten enough to hold the proper pressure.

c. Screw the quick-disconnect male fitting, part number T1712, Figure 69, into the adapter on the master cylinder and hand tighten.

d. Connect the female quick-disconnect, Figure 71 (the female disconnect is attached to the end of a long hose), directly to the male adapter on the master cylinder.

e. Be sure valve B, Figure 67, is open. The system is now ready for bleeding.

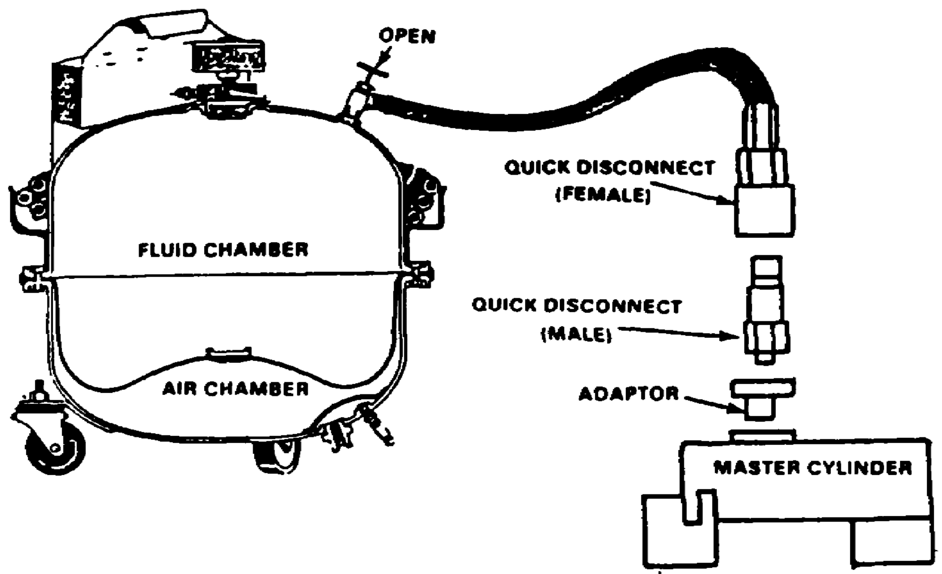


FIGURE 71. FILLER/BLEEDER CONNECTION TO MASTER CYLINDER

General Procedures

a. Check for leaks at all line, hose, and cylinder connections you made on the vehicle.

b. Bleed units in the following order: master cylinders (some have bleeder screws), booster or power units, line bleeder screws, and, finally, all wheel cylinders.

c. Refer to Figure 72. Attach the bleeder hose, part number B75 or B5156, to each bleeder screw in turn and insert the open end of the hose into the bottom of a glass container. The end of the hose should be submerged in the fluid. Open the screw to permit all air to escape. Watch for air bubbles in fluid for a positive check. When fluid flows clear without air bubbles, close the bleeder screw and tighten it securely.

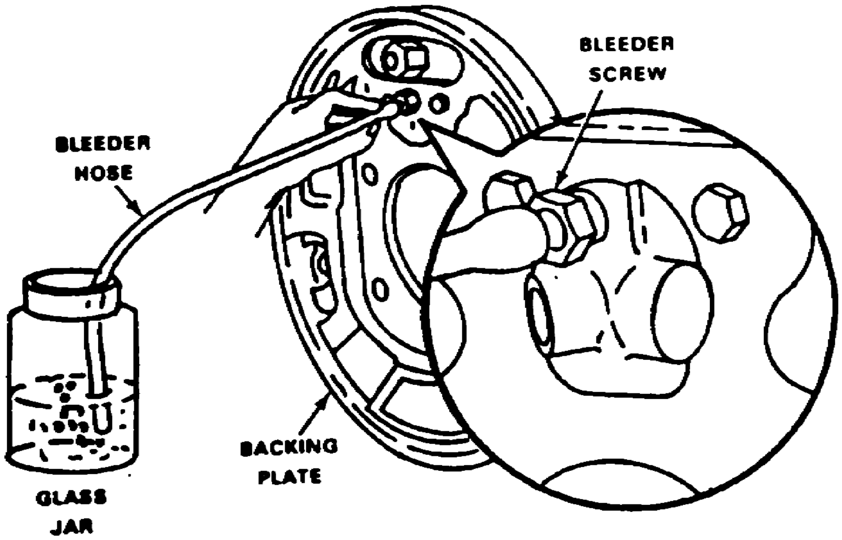


FIGURE 72. ATTACHING BLEEDER HOSE

d. To remove most of the air from the master cylinder quickly, you should bleed the left front wheel cylinder first, then the right rear, the left rear, the right front, and the left front again. It is good practice to rebleed the four wheels again to ensure a perfectly air-free system.

e. To disconnect the bleeder, always cover the quick-disconnects with cloth before disconnecting them. This avoids fluid spilling onto the vehicle finish. Just uncouple the quick-disconnect, and remove the adapter from the cylinder. Be sure the reservoir is filled to within 1/2 inch or less of the top and replace the gasket and filler cap.

<u>Caution</u>

Always cover fenders and keep hoses clean to avoid damaging finish.

Power Brakes

a. Follow the general procedures above, except DO NOT bleed with the motor running.

b. If the power unit has a bleeder screw, bleed it first. Some have two bleeder screws. When there are two, bleed at the highest screw first.

c. When bleeding the treadle valve, use only low pressure, 10 to 12 psi, in the bleeder tank.

d. When bleeding the hydro-vac double stage control valve, rebleed the highest bleeder screw three or four times to ensure complete air removal.

Clutch Systems

a. Follow general bleeding procedures.

b. Clutch controls will always lose pressure and will not build up like brake pedals do since pumping will not help.

Vertical Type Wheel Cylinders

a. Cylinders with an internal cross connecting line should be prefilled before installing. Connect cylinders with the cross-line hand tightened on the bench and prefill the cylinders. Moving the pistons slightly will help to assure complete filling.

b. Hoses and lines should be pressure bled before connecting the wheel cylinders. Rebleed units after installing.

Surge Bleeding

Some vehicles have diagonal or vertical wheel cylinders which require surge bleeding. On such cylinders, the bleeder screw is not always the highest point to allow air to escape, therefore, complete bleeding is difficult. Surge bleeding will help:

a. Bleed each wheel with the pressure bleeder.

b. Open one bleeder screw at a time and have someone kick the brake pedal vigorously a few times. This will cause turbulence in the cylinder forcing additional air out.

<u>Caution</u>

Before allowing the vehicle or equipment to be operated, check the following:

Always check connections for leaks by applying heavy pressure on the pedal or treadle. If the system is vacuum or air assisted, start the engine to create a vacuum, or to build air pressure.

Always check the by-pass part in the master cylinder to be sure it is clear when the system is at rest. Never probe in the small by-pass hole. When applying the brakes, there should be a ripple in the fluid in the master cylinder reservoir. After applying brakes a few times, there should also be a ripple caused by returning fluid. Checking visually with a bright light is advisable.

WARNING

IF THE BY-PASS PART IS NOT CLEAR, BRAKE SYSTEM LOCK UP COULD OCCUR AND CAUSE SERIOUS DAMAGE.

Caution

Always check the brake pedal or linkage for free travel. Adjust in accordance with the appropriate technical manual as needed.

FILLER/BLEEDER MAINTENANCE

Bleeder/Filler Tank

The tank and fittings should be kept clean at all times. Never allow the tank or fittings to come into contact with mineral oil products such as kerosene, motor oil, and thinners. Do not use water to clean the tank at anytime.

Fittings

Fittings cleaned in anything other than brake fluid should be thoroughly dried inside and out before use.

Air Chamber

Periodically clean out the air chamber in order to remove any water, oil, and dirt sludge that may enter from the air system used to fill the tank. Remove and rinse the safety valve (part number T4669) with clean alcohol. Be sure to drain and dry it completely to avoid contaminating the next fluid fill.

Fluid Chamber

The fluid chamber needs no attention unless dirt or improper fluid has to be removed. Rinse it with clean alcohol, and drain and dry the chamber completely to avoid contaminating the next fluid fill.

Safety Valve

The safety valve (part number T4669), Figure 70, on the bottom of the tank is set to blow off at about 50 psi. When pressure is relieved, it will reseat itself at about 30 psi.

LESSON 6

PRACTICE EXERCISE

1. When referring to a hydraulic clutch or brake system, what does the term <u>purged</u> mean?

   A. The system is sealed against leaks

   B. A valve is opened allowing air to enter

   C. Seals and gaskets are damaged

   D. Air has been removed from the system

2. What is the maximum air pressure, in psi, the filler/bleeder is designed to hold?

   A. 20

   B. 30

   C. 40

   D. 50

3. How full should the brake fluid chamber be filled?

   A. To the fill mark indicator

   B. One inch below the brim of chamber

   C. One-half inch from the top of the filler cap

   D. To one-half of the tank's capacity.

4. Prior to filling the fluid chamber, what must be opened?

   A. Valve in the bottom of the tank

   B. Water trap at the bottom of the tank

   C. Oil reservoir at the top of the tank

   D. Pressure cap on the upper left of the tank

5. What is the proper pressure, in psi, to charge the air chamber to?

   A. 10 to 20

   B. 20 to 30

   C. 30 to 40

   D. 40 to 50

6. When bleeding a wheel or clutch cylinder, one end of a short hose is connected to the bleeder screw. What is the other end placed in?

   A. Can of brake fluid

   B. Glass container of fluid

   C. Can of gasoline

   D. Master cylinder

7. When bleeding a master cylinder, which wheel cylinder should be bled first?

   A. Nearest to master cylinder

   B. Farthest from master cylinder

   C. Right front

   D. Left front

8. When cleaning the fluid chamber of the filler/bleeder, what is used to rinse it?

   A. Water

   B. Mineral oil

   C. Cleaning solvent

   D. Alcohol

9. How many chambers does a filler/bleeder have?

   A. One

   B. Two

   C. Three

   D. Four

10. When removing the filler/bleeder from the master cylinder, what should you cover the quick-disconnects with?

   A. Rubber hose coupling

   B. Cloths

   C. Wood plug

   D. Plastic plug

LESSON 6

PRACTICE EXERCISE SOLUTIONS

1. D (page 100)

2. D (page 104)

3. B (page 104)

4. A (page 104)

5. B (page 104)

6. B (page 104)

7. D (page 105)

8. D (page 107)

9. B (page 105)

10. B (page 105)