DOCUMENT RESUME

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IDENTIFIERS	*Gages

ABSTRACT

This document contains the materials required by individuals enrolled in a workplace course in basic skills for gages and measurements that was developed by a community college for a St. Louis (Missouri) electric company. The guide begins with an outline of the 12-day course, which covers the types, components, use, and care of the following instruments: dial caliper, English micrometer, vernier scale, vernier height gage, and gage blocks. Presented next are a pre-test and introductory materials devoted to the following topics: process tools (reading, study, and classroom strategies), student responsibilities, basic measurement concepts, and notetaking. The next (and largest) section contains the text materials, vocabulary sheets, diagrams, instruction sheets, and learning activities used during the course's nine lessons and review day. Concluding the guide are a glossary and posttest. (MN)

St. Louis Community College

Basic Skills for Gages & Measurement

Baldor Electric Company
3560 Scarlet Oak Blvd.
St. Louis, MO 63122

NEW PARADIGM for EFFECTIVE WORKFORCE SKILLS

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NEW PARADIGM for EFFECTIVE WORKFORCE SKILLS

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Course Outline

Day 1 Pre-test

Day 2 NWLIS, SLCC Roster, Video Tape, Process Page, Responsibilities, Concepts

Day 3 Content

- Intro to Gages & Measurements
  - Terminology, Identification of Instruments, Care of Instruments

Day 4 Types of Instruments

- Dial Caliper
- Reading Dials/Activity
- Explanation of Dial Caliper
- Exercise 1
- Practice Using Dial Caliper
- Storing the Dial Caliper

Day 5 English Micrometer

- Parts
- How to Handle
- Steps for Reading

Days 6/7 Vernier Scale

- Uses
- Steps for Reading
- Types
- Exercise

Day 8 Vernier Height Gage

- Parts
- Steps
- Ways to Use

Days 9/10 Gage Blocks

- Uses
- Sizes
- Steps for Building Combinations
- Exercise

Glossary

Day 11 Course Review

Day 12 Post-Test

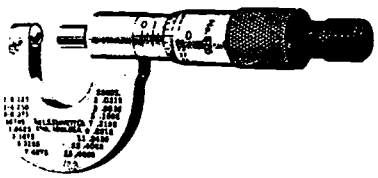
Name_____ Date_____

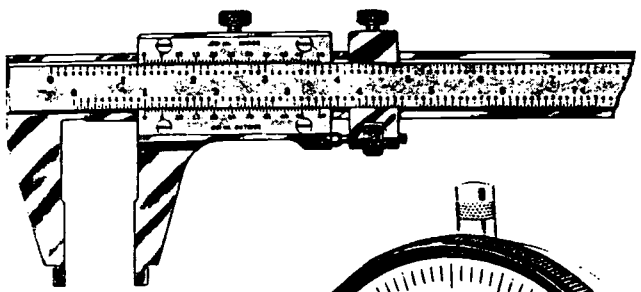
Department_____

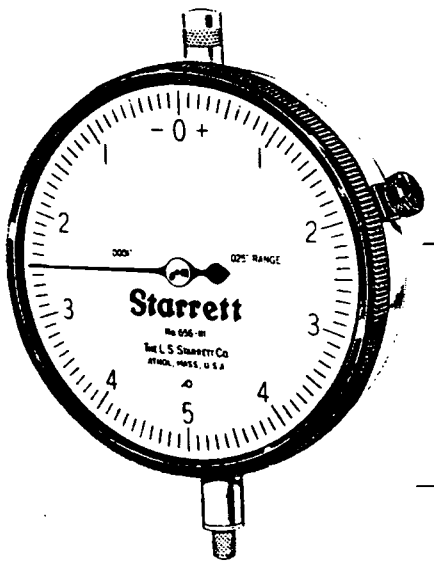
Pre-Test
Precision Measuring Instruments

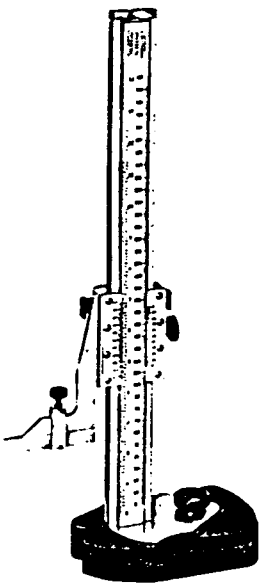
Section 1--Instrument Identification

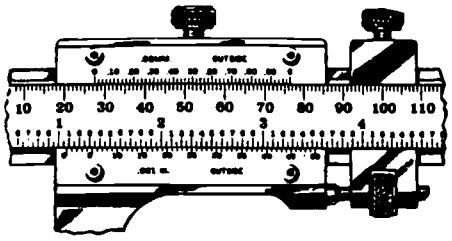
Identify the following precision measuring instruments and record the name of each in the blanks provided.

1.  _____

2  _____

3.  _____

4.  _____

5. 

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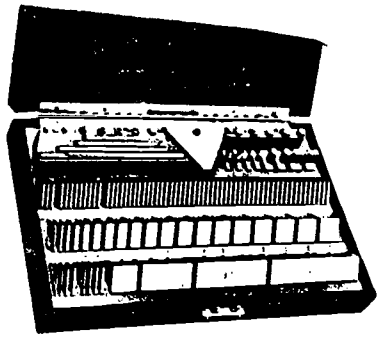
6. 

_____

Section 2--Use of decimals in precision measurement.

1. Add the following decimals:

   3.507 + .021 + .1002 + .07 + .2 + 1.007 = _____

2. Subtract the following decimals:

   3.462 - .0365 = _____

3. Multiply the following decimals:

   .437 x 1.305 = _____

4. Divide the following decimals:

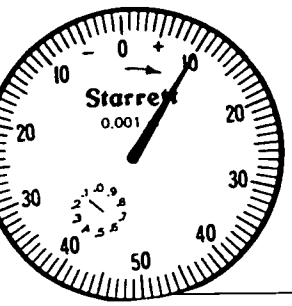
   .750 ÷ .025 = _____

Section 3--

Taking readings from various precision measuring instruments.

Below are some illustrations of readings from precision measuring instruments. Record your answers in the spaces provided.

1. Balanced dial--Look at the arrow on each dial face to see whether the dial is reading positive (+) or negative (-).



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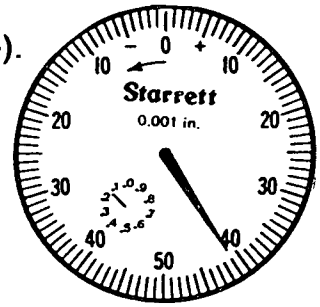
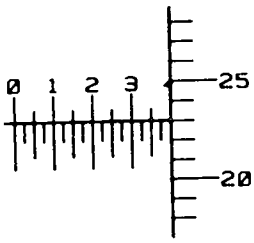


2

3

2. Micrometer--



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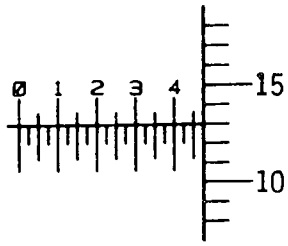

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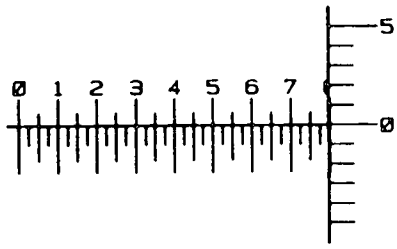

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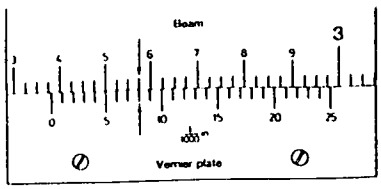
3. Vernier Scale--



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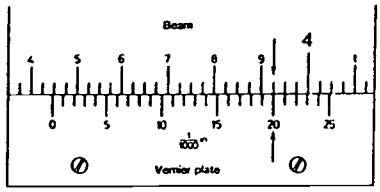

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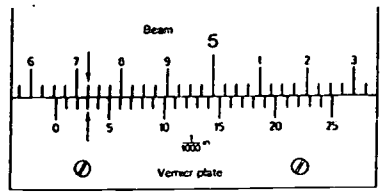


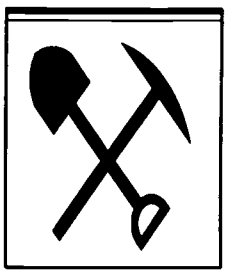
3

4. Below are the dimensions from a standard set of gage blocks (81 pieces).

1.000	.101	.139
2.000	.102	.140
3.000	.103	.141
4.000	.104	.142
	.105	.143
.050	.106	.144
.100	.107	.145
.150	.108	.146
.200	.109	.147
.250	.110	.148
.300	.111	.149
.350	.112	
.400	.113	
.450	.114	.1001
.500	.115	.1002
.550	.116	.1003
.600	.117	.1004
.650	.118	.1005
.700	.119	.1006
.750	.120	.1007
.800	.121	.1008
.850	.122	.1009
.900	.123	
.950	.124	
	.125	
	.126	
	.127	
	.128	
	.129	
	.130	
	.131	
	.132	
	.133	
	.134	
	.135	
	.136	
	.137	
	.138	

Using the minimum number of gage blocks, make up combinations for each total dimension below:

	1.	2.
	_____	_____
	_____	_____
	_____	_____
	_____	_____
	_____	_____
	_____	_____
	_____	_____
Total	1.403	1.976



Tools for Learning

Process Tools

Reading Strategies

1. **Preview**

- Look over text. Look at the title, subtitles, table of contents, index, glossary, and illustrations.

Preview

2. **Question**

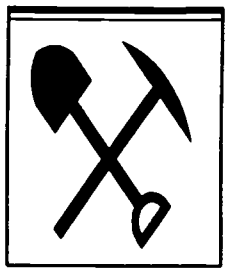
- Ask, "What do I need to know?"—Answer the 5Ws (Who, What When, Where, Why) and How.

Question

3. **Skim**

- Look for words that are **bold**, in *italics*, or <u>underlined</u>.
- Read the first and last sentences in each paragraph.

Skim



Tools for Learning

Process Tools

Study Strategies

1. **Key Words**

- Look for new words, abbreviations, main ideas, and definitions.

Key Words

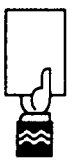
2. **Note Taking**

- Identify your study strengths (use highlighters, abbreviations, shorthand, etc.).
- Develop a system that works for you.

Note Taking

3. **Job Aids**

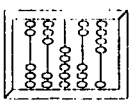
- Use materials to help you on the job.



Job Aids

4. **Estimating**

- Think in round numbers.



Estimating

5. **Memory Aids**

- Use tips, formulas, and memory tricks.

Memory Aids

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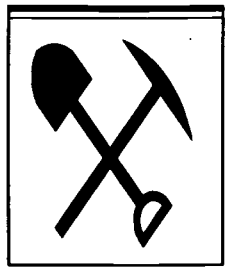
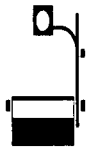


Tools for Learning

Process Tools

Classroom Strategies

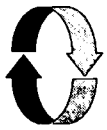
1. **Overheads**



Overheads

2. **Activities**

- Individual, partner, or group skill-building exercises.



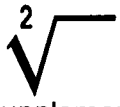
Activities

3. **Listening**

Listening

4. **Supplements**

- Additional learning materials and challenge problems.



Supplements

Your Responsibilities

1. Ask questions.
2. Make mistakes. It's all part of learning.
3. Help each other.
4. Listen.
5. Share ideas.
6. Be skeptical. Don't accept everything that's said.
7. Don't try to stump the facilitator or other participants just to show that we don't have all the answers—we don't.
8. Have a good time learning.

Gages and Measurement Concepts

Before You Start

1. Inadequate precision is expensive.
2. Unnecessary precision is also expensive.
3. Production gages allow parts to be stockpiled and used at random for assembly of the finished product. Almost all parts fit.
4. Production gages can be used to quickly and accurately check a single dimension or several dimensions at one time.
5. Addition, subtraction, multiplication, and division of decimals are required in using gages.

Comment Form

_____

Tool

1. What problems are you having using this tool/instrument? How can we help?

2. How well will you be able to use this tool on the job? How can we help?

3. How can we improve this class?

Name _____

Date/Class Time _____

Note Taking

Note taking means:

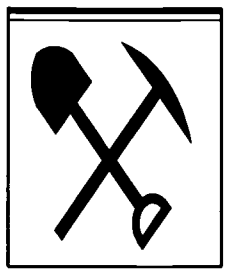
- Identifying your study strengths and creating a system that works for you.
- Deciding if you need to: Draw reminders? Repeat information several times? Ask the speaker to repeat information for clarity? Tape record the information and take notes at a later time? Highlight written material to make ***skimming*** faster?

This is the symbol for note taking in the Basic Blueprint Reading modules. When you see it, use these tips to get the most out of taking notes.

- Note Taking During Lectures = Listening + Analyzing + Selecting + Writing
  TIP: *Develop your own shorthand. Abbreviate w/o losing meaning.*

&.....*AND*	EA ..... *EACH*	2..... *TO*	W/O ..... *WITHOUT*
@ .....*AT*	EX .....*EXAMPLE*	^..... *UP*	U..... *YOU*
$.....*CASH, COST, or MONEY*	/ .....*NO*	WH/..... *WHICH*	
	# .....*NUMBER*	W/.....*WITH*	

- Listening = Tune in 2 the speaker's motions, vocal tone & rhythm 2 know what's important.
  TIP: *Bored? Ask a question or make a comment!*
- Analyzing = Think of the speaker's outline. Practice thinking like the speaker.
  TIP: *Answer the questions who?, what?, where?, when?, why? & how?*
- Selecting = Highlight w/ colors 2 pull headlines & important facts off the page.
  TIP: *Find & highlight the 5 Ws & How.*
- Writing = Divide paper in 2 lengthwise; write notes on the left & headlines on the right.
  TIP: *Make small drawings in the margins 2 lift key ideas off the page. Write legibly.*



Tools for Learning

Introduction

In order for Baldor to improve quality, more and more emphasis is placed on exact dimensions and tolerances. One of the skills necessary for improved quality is precise measurement in all the areas of production. The goal of this course is to be able to efficiently and consistently use measuring devices.

Preview

Upon completion of this class, you will have practiced using a variety of precision measurement instruments. This practice will focus on interpreting the measurements taken from each instrument and the manual skills necessary to take these measurements. Finally, you will know how to maintain and care for these instruments.

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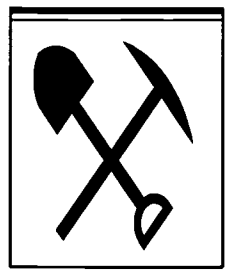


Tools for Learning

Some Vocabulary, Definitions, and Terms

To insure that we are all speaking the same language, we need to use common terms associated with measuring devices.

Key Terms

1. ***Exact number***—A number which has been determined as a result of counting. "There are 14 pump motors ready to be packaged for shipping."

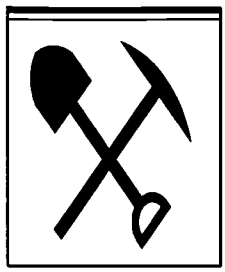
2. ***Approximate number***—A number which has been determined by some measuring process. "That fastener is $3^{1}/_{16}$."

Remember

Remember: Counting gives us exact numbers, while measurements give us approximations.

(counting = exact #s)

(measuring = approximate #s)



Tools for Learning

Key Terms

3. ***Accuracy***—A measurement that gives unbiased true value. (One-hundred percent accuracy is never possible.)

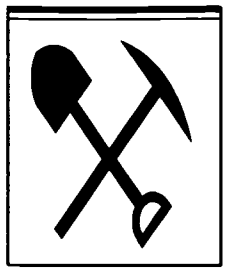
4. ***Attribute Gage***—Designed to either pass or fail the measurement of a part dimension. A plug or a ring gage is an attribute gage.

5. ***Bias***—Distorted reading caused by instrument pressure, viewing angle, etc.

6. ***Bilateral Tolerance***—An allowable variation on either side of the nominal measurement (the call-out measurement).

7. ***Calibration***—The accuracy in the measuring instrument.

8. ***Dial Caliper***—Similar to a Vernier caliper, but the measurement results are read on a dial like the face of a clock.



Tools for Learning

9. ***Dial Indicator***—A circular measurement scale with a pointer that moves like a hand on a clock face.

10. ***Discrimination***—The distance between two lines on a scale. The greatest accuracy that can be achieved on a particular scale. (Also called ***resolution*** or ***sensitivity***.)

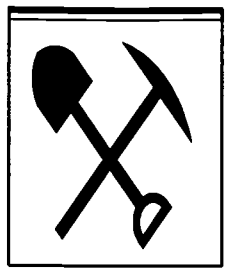
Key Terms

11. ***Manipulation***—The ability to use the instrument without affecting such things as pressure, centering, etc.

12. ***Metrology***—The science of measurement.

13. ***Micrometer***—A precision gage that is designed to measure outside, inside, or depth dimensions on a part. Measurements are read on a sleeve and a thimble.

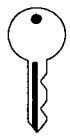
14. ***Parallax Error***—The apparent shifting of an object caused by shifting of the observer; for example, viewing an indicator dial face from an angle instead of directly.



Tools for Learning

15. ***Precision***—Getting consistent results, repeatedly.

16. ***Precision Accuracy***—Accurate to within $^{1}/_{1000}$ (.001) of an inch or less.



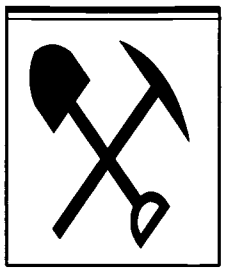
Key Terms

17. ***Semi-Precision Accuracy***—Accurate to within $^{1}/_{64}$ (.015625) of an inch.

18. ***Surface Plate***—A flat, smooth reference surface to support parts for measurements from the surface or surface angle to some point on the part. Surface plates are made of either cast iron or granite.

19. ***Tolerance***—The amount of allowable measured variation from the nominal measurement.

20. ***Unilateral Tolerance***—An allowable variation on only one side of the nominal measurement (the call-out measurement).



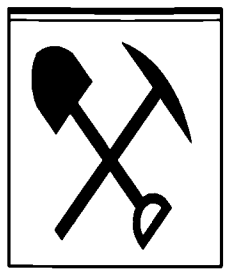
Tools for Learning

21. ***Variable Gage***—Measures a range of dimensions to get the actual size of objects.

22. ***Vernier Height Gage***—Used to measure outside dimensions of parts sitting on a surface plate.

Key Terms

23



Tools for Learning

How to Care for Your Measuring Instruments

1. Keep a light coating of fine-grade machine oil on parts that can rust.

2. Handle tools gently. They are finely manufactured instruments.

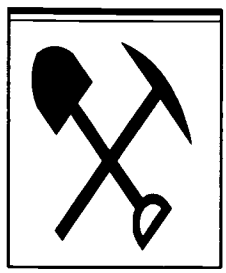
3. Periodically examine instruments for wear, especially on the measuring surfaces.

4. Most instruments come with a container for storage. Use these containers. No piling instruments in a tool box.

5. Read the information that comes with the instrument for special care features.

6. Do not try to measure moving parts.

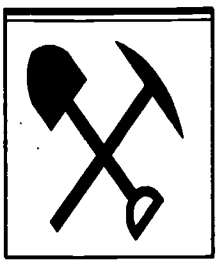
7. Never completely close a micrometer.



Tools for Learning

Rule Of Thumb Regarding The Type Of Instrument To Select

The measuring tool should be ten times more accurate than the total tolerance to be measured. As an example, if you are measuring a part with a 0.010 tolerance, use a tool with a 0.001 discrimination.



Tools for Learning

Types of Instruments

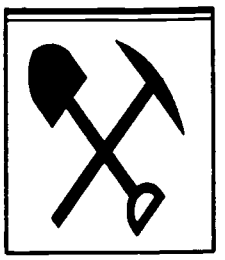
The Dial Caliper

Reading Dials

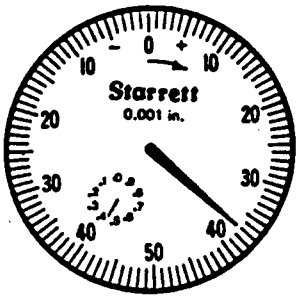
Question

Many measuring instruments rely on dials to display the measurements taken. Dial indicators and dial calipers are a couple of examples. The following example and exercises should familiarize you with one of the more common configurations.

First note that the measurement is taken in thousandths of an inch. (0.001 in.). Second, find the 0 at the top of the dial. To the left of the 0 is a negative sign, to the right, a positive sign. When recording the reading, you do not need to note a positive sign. When the reading is negative, record it as such, i.e., –438. Third, note the small dial in the lower left, which denotes complete revolutions. Read it first.



The following is an example:



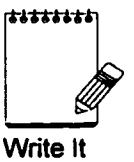
1. Pointer on small dial just past the .4.

   Write: .400

2. Pointer on large dial standing at .037.

   Write: .037

3. Add: .400 + .037 = .437.



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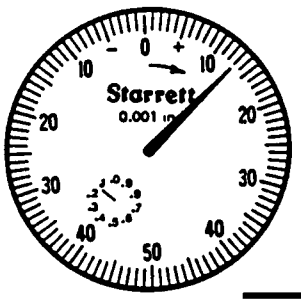
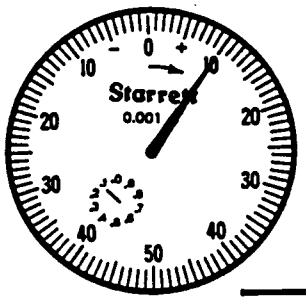
Dial Caliper Activity 1

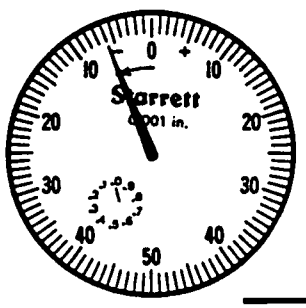
Read and record the measurements from the following dials:

1. 

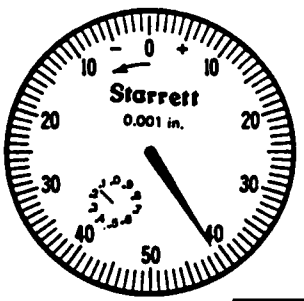
_____

2. 

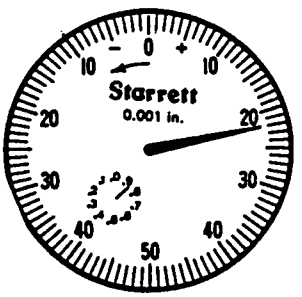
_____

3. 

_____

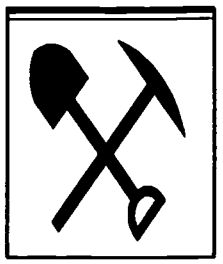
4. 

_____

5. 

_____

NEW PARADIGM for EFFECTIVE WORKFORCE SKILLS



Tools for Learning

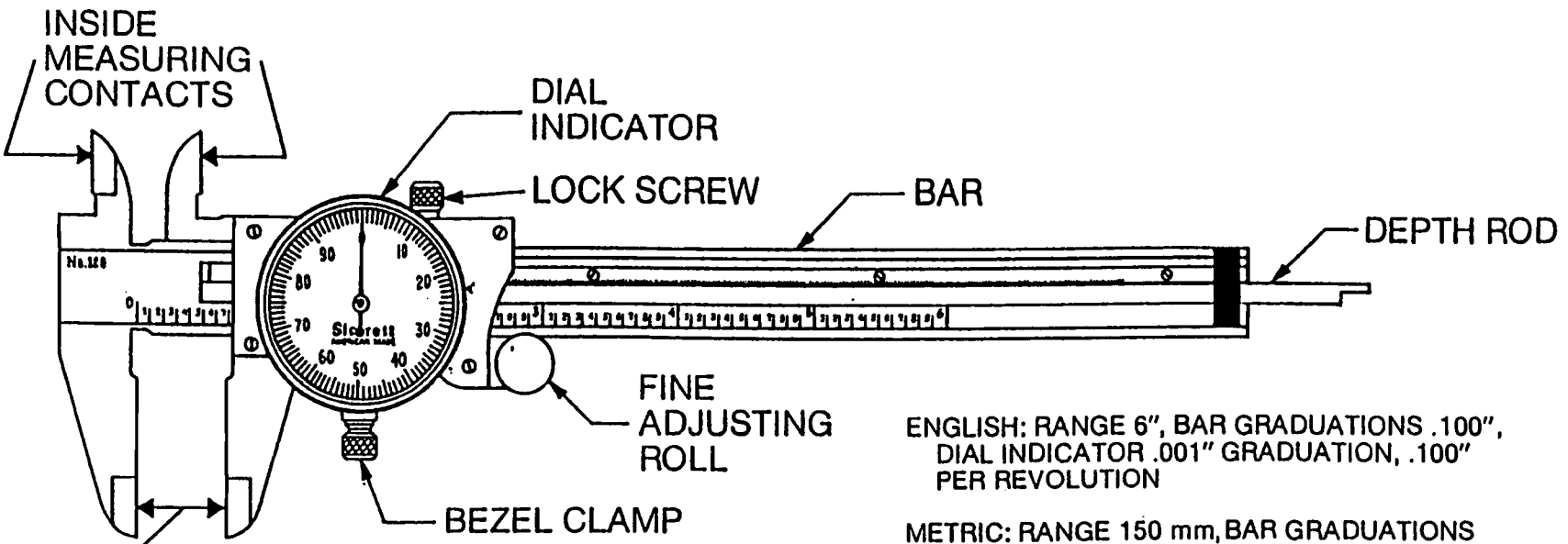
Explanation of the Dial Caliper

The dial caliper is a "three-in-one" tool. It can be used for both internal and external measurements as well as depth gaging. Generally, it is a good instrument to measure dimensions to the thousandths (.000).

The dial caliper is handy and easy to use. It is therefore a good instrument to employ on the shop floor. See Illustration #1, Dial Caliper,[1] with the components pointed out and detail boxes of the functions, i.e., external, internal, and depth.

[1] *Introduction to Fixed Limit Gaging*, Baldor Electric Company, Fort Smith, Arkansas

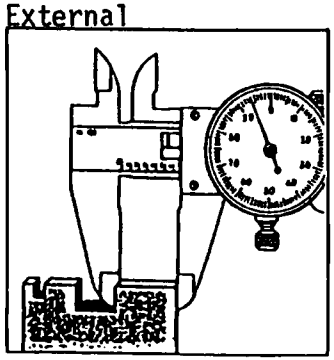
DIAL CALIPER



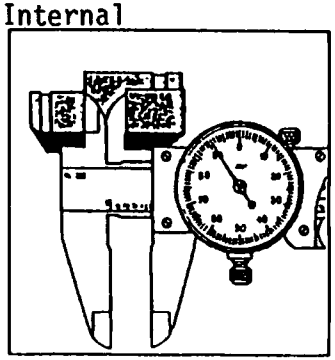
ENGLISH: RANGE 6", BAR GRADUATIONS .100", DIAL INDICATOR .001" GRADUATION, .100" PER REVOLUTION

METRIC: RANGE 150 mm, BAR GRADUATIONS 2 mm, DIAL INDICATOR 0.02 mm GRADUATION, 2 mm RANGE PER REVOLUTION

External



Internal



Depth

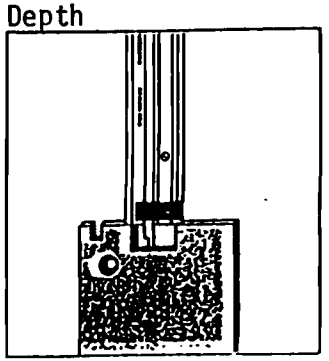
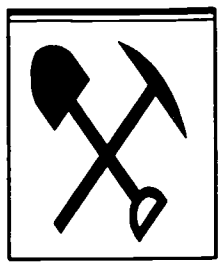


Illustration 1



Tools for Learning

There are variations in calipers, such as some being equipped with ***Vernier*** scales (more about this subject later) and some which are equipped with both ***English measure*** and ***metric measure***. We will be dealing with English measure. This will allow us to take accurate readings to the thousandths (.000).

Key Words

There is also a variation in dials. On some ***Mitutoyo*** instruments, a complete revolution of the dial will record a movement of .2 on the ***bar*** (where the graduations are), whereas on the ***Starrett,*** a complete revolution will only move the beam .1.

Remember

One Caution—No matter what brand of instrument you are using, make sure that the dial is on zero or "zeroed out" before you begin.

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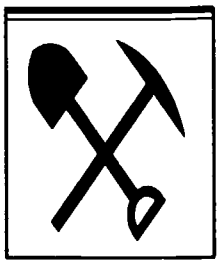


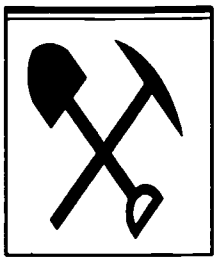
Tools for Learning

Practice Using the Dial Caliper—

Steps for Taking Measurements

1. Grasp the bar in whichever hand you use most often. The thumb should be on the ***fine adjusting roll.***
2. Hold the part to be measured in the other hand or, better yet, place it in a clamping device, so that you have a hand free for recording measurements.
3. As an example, let's say you want to measure the outer diameter (O.D.) of a copper tube. You will select the ***outside measuring contacts.***
4. Open the caliper using the fine adjusting roll to a diameter greater than the diameter of the tube.
5. Make contact with the tube with the ***fixed jaw*** which serves as the reference plane.
6. Move the ***sliding jaw*** toward the closed position using the fine adjusting roll until it also makes contact with the tube. You do not have to force the jaws.

Key Words



Tools for Learning

7. Tighten the lock screw so that the reading you have taken will not change when you remove the caliper from the tube.

8. Remove the caliper from the tube, and you are now ready to record your reading.

Practice Using the Dial Caliper —

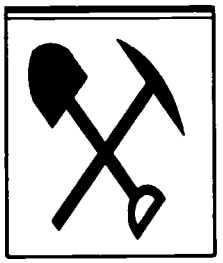
Steps for Reading Measurements

1. Look at the bar. The nominal callout on a drawing was for a $^{5}/_{8}$ O.D. tube. You know that the decimal equivalent of $^{5}/_{8}$ is .625. (Refer to Index.) You notice a 6 showing to the left of the graduations on the sliding jaw.

2. Look at the dial and note that the indicator is past the 20 mark.

3. Count the graduations past the 20 mark to find that there are seven.

4. Record the information by following the directions for recording measurements.



Tools for Learning

Practice Using the Dial Caliper—

Steps for Recording Measurements

1. Reading the bar you see six parts, or .6 of an inch.
   Write: .600.

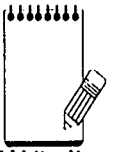
2. From your first reading of the dial, you saw that the indicator had come to and gone past the 20 mark, or .020 of an inch.
   Write: .020.

3. From your second reading of the dial, you counted seven marks past the 20.
   Write: .007.

4. Add: .600 + .020 + .007 = .627.
   You now have the real O.D. measurement of the copper tube. What if the drawing for the copper tube has a callout of .625?

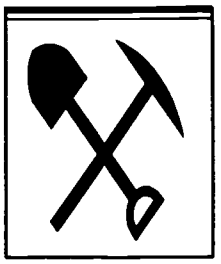
5. To find if your measurement falls within the drawing's tolerance range, you subtract:
   .627 – .625 = .002.

Question



Write It

35



Look on the title block to find the tolerance for thousandths. Unless otherwise specified, it is +.005. So, this tube would fall within the specifications on a drawing (.002 is less than .005).

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Dial Caliper Activity 2

Before going on to some practice readings, we are going to repeat the preceding steps for recording measurement, using a 5/8 O.D. copper tube and the dial caliper.

Measurement 1_____

Measurement 2_____

Measurement 3_____

Measurement 4_____

Measurement 5_____

Measurement 6_____

Summary Exercise 1

Look at each illustration on the following two pages and record the readings.

Remember—some of the readings may exceed an inch. The inch(es) must also be recorded.

Measurement 1_____

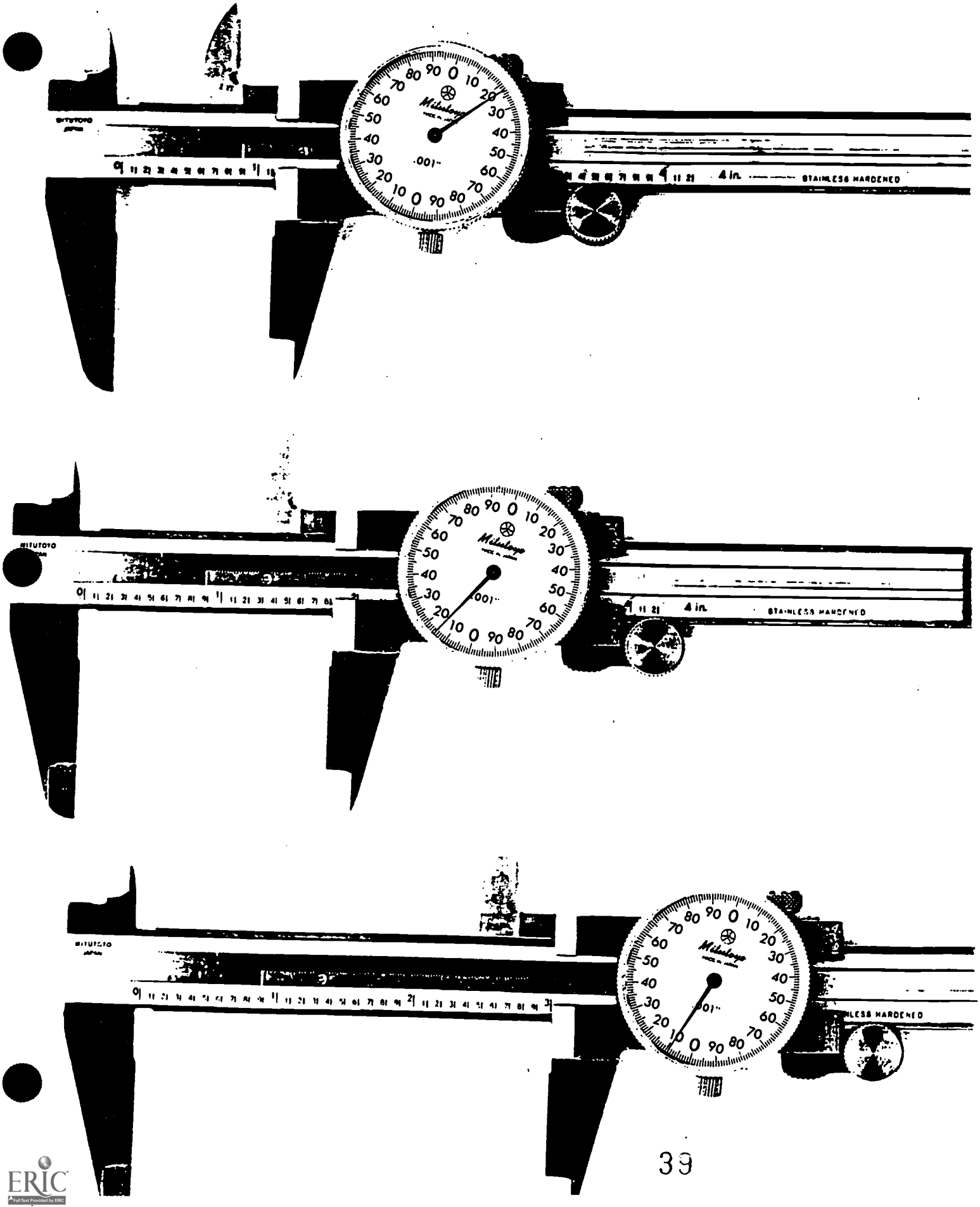
Measurement 2_____

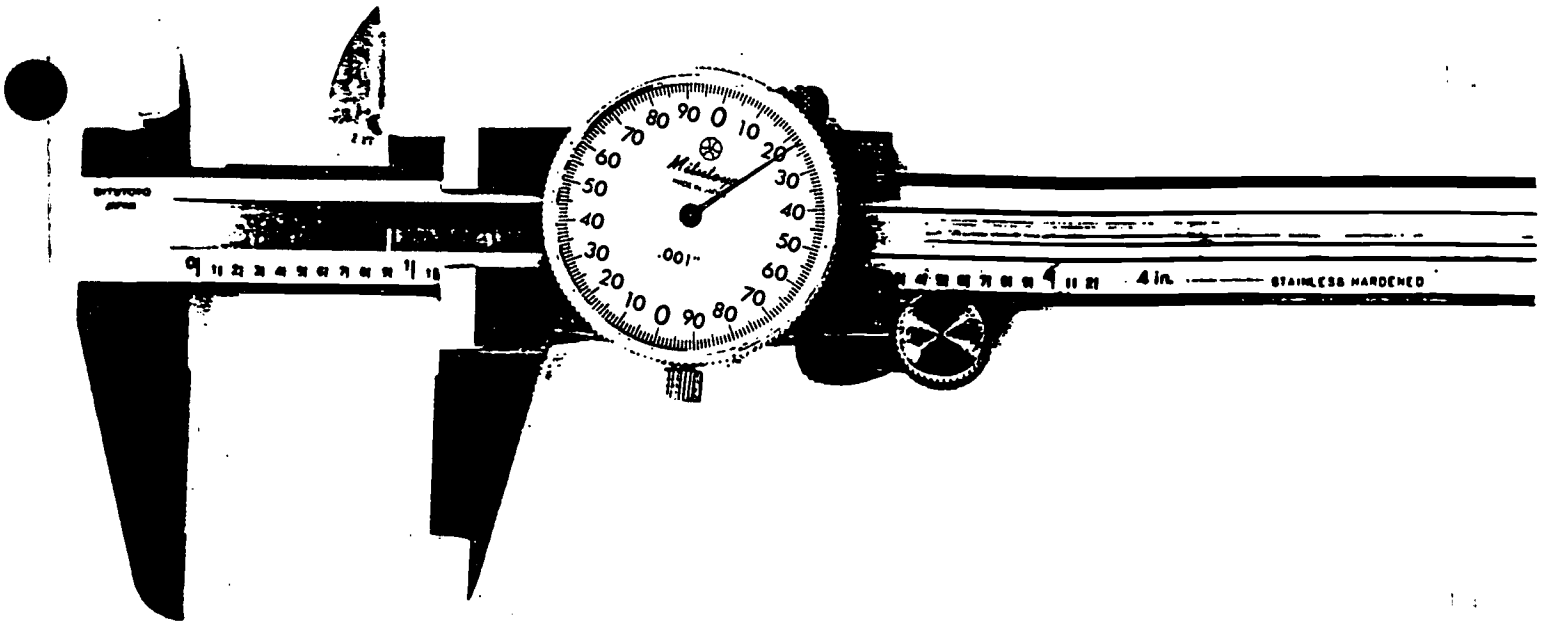
Measurement 3_____

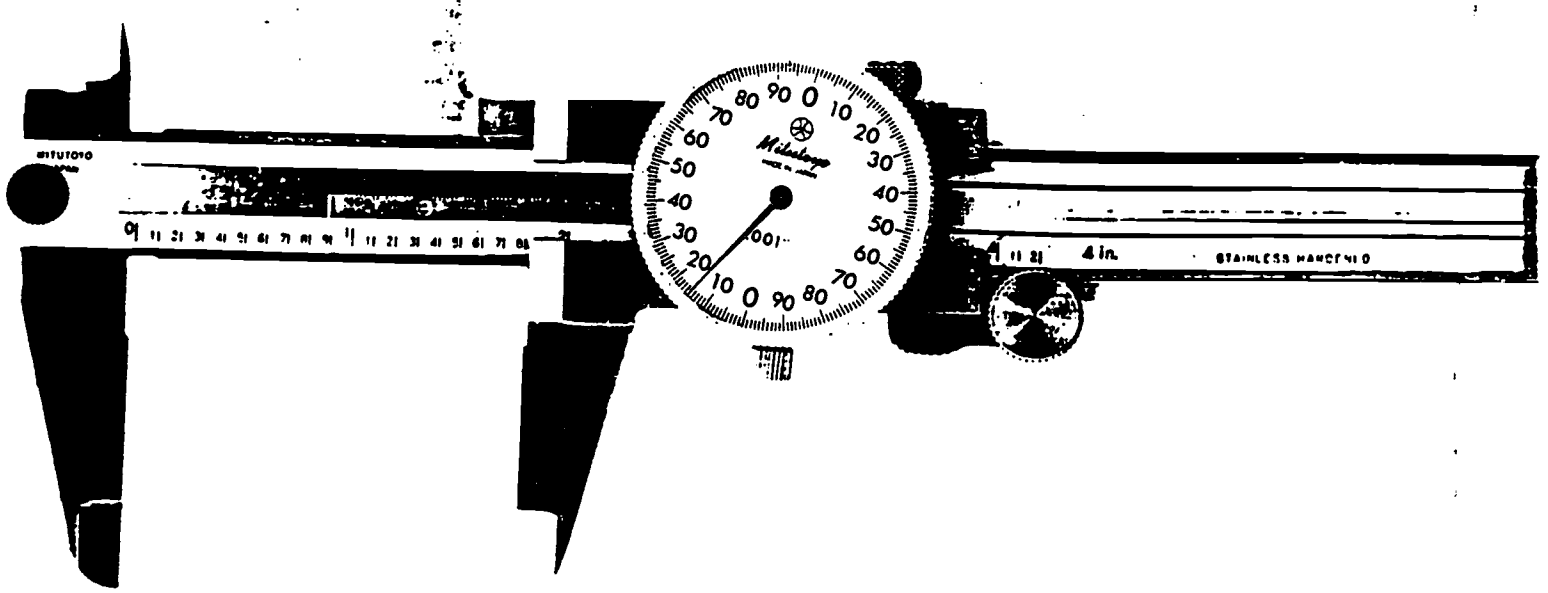
Measurement 4_____

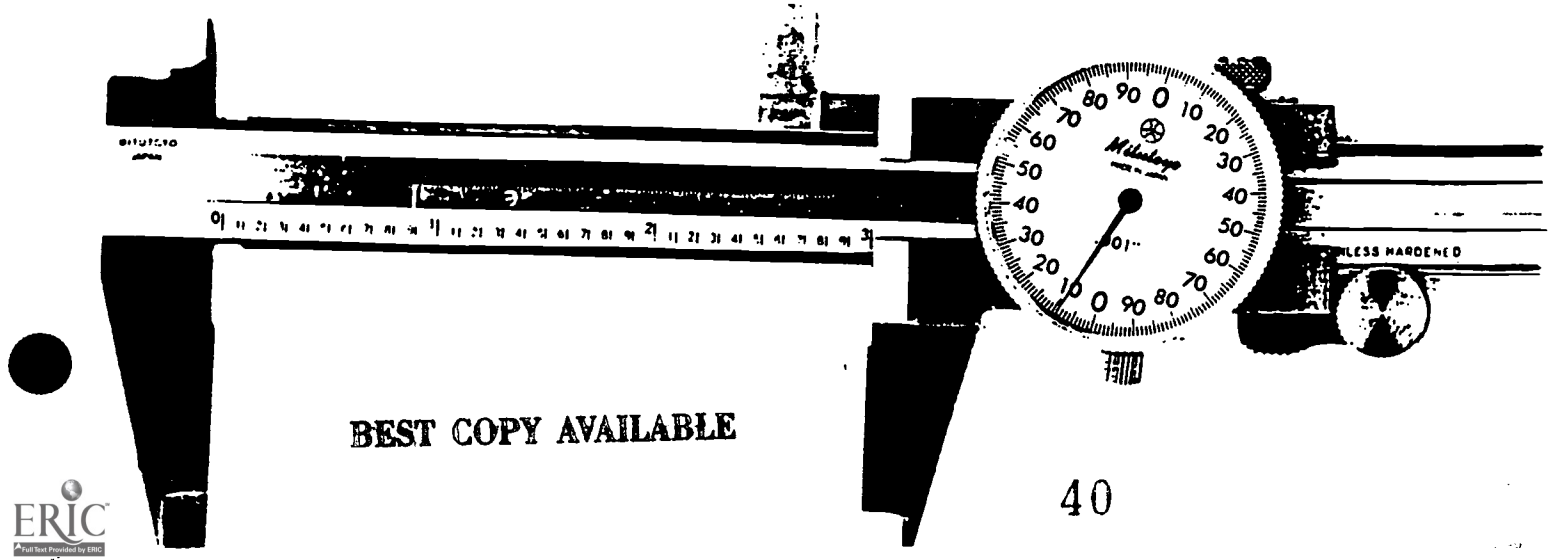
Measurement 5_____

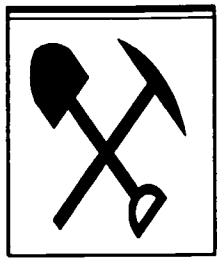
Measurement 6_____


Mitutoyo
.001"
4 in.
STAINLESS HARDENED





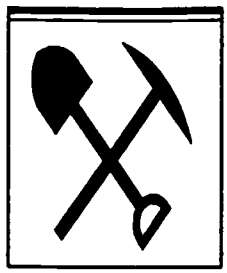




Tools for Learning

Storing the Dial Caliper

Close the caliper so that the fixed and sliding jaws are together. Next, turn the bezel clamp until the indicator on the dial points directly to the 0.



Tools for Learning

The English Micrometer Caliper

Different micrometers serve a wide range of industrial functions. The "mike" we will concentrate on is the ***English micrometer caliper.*** ("English" because it is graduated in inches and fractions of inches.) The term "micrometer" means that it is designed to make small (micro) measurements (meter). "Caliper" indicates that it is part of that family of measuring instruments which operates with a combination of a fixed and moving parts for taking measurements.

Key Words

The "mike" we will use in class is designed for taking outside measurements. Dial and digital calipers, however, combine three functions: outside, inside, and depth.

Remember to handle a micrometer carefully. Never twirl a micrometer. The ***spindle*** colliding with the ***anvil*** will cause distortion.

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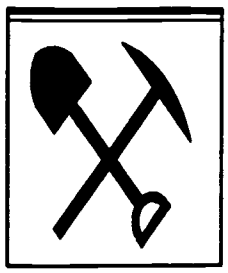
NEW PARADIGM for EFFECTIVE WORKFORCE SKILLS



Tools for Learning

Take a look at Illustration #2. Like the dial and digital calipers, the micrometer has both fixed and moving parts. The technique for taking measurements is also similar. Measurements are taken from two sources.

Key Words

The "mike" also has a locking device which is referred to as either the ***thumb nut*** or ***lock nut.*** This allows you to "hold" the measurement while it is being recorded. When you want to hold a measurement, move the thumb nut to a vertical position. The cylinder where the numbers appear horizontally is called the ***sleeve.*** The cylinder where the numbers appear vertically is called the ***thimble.*** Revolving the ***thimble*** clockwise moves the spindle toward the ***anvil.*** The shape of the ***frame*** allows the ***measuring surface*** (object to be measured) to be inserted between the spindle and the anvil.

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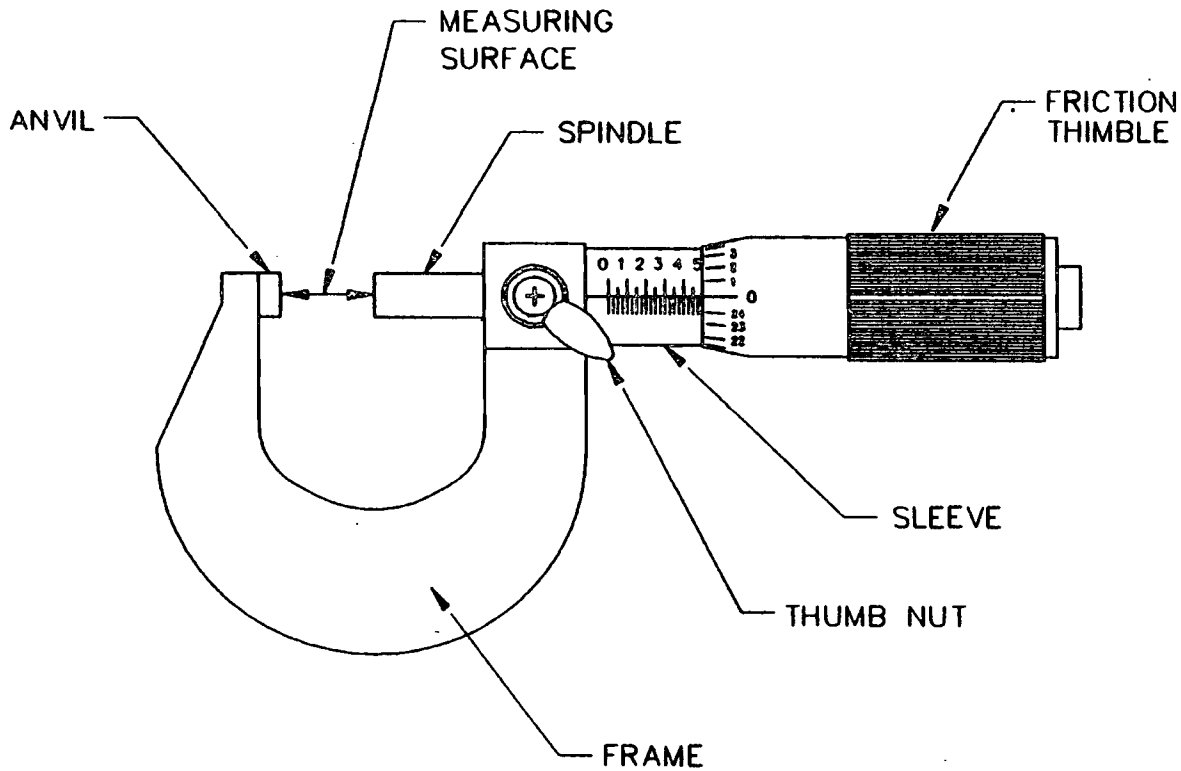


Illustration #2

STANDARD TOLERANCE		
00	±	015
.000	±	.005
.0000	±	.0005
ANGULAR	±	0°30'0"
FRACTION	±	1/32

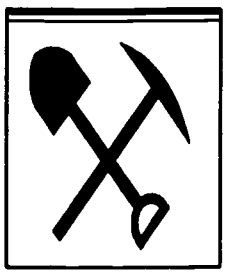
UNLESS OTHERWISE SPECIFIED

KEY	DATE	BY	REMARKS

BALDOR ELECTRIC MOTOR CO.
WESTVILLE, OK. PLANT

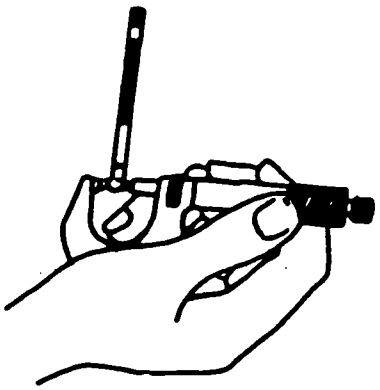
PRINCIPLE MICROMETER PARTS

DWG FILE: DWSMICRO	MATERIAL:	
MACHD BY:	SCALE: FULL	HARDNESS:
DATE CREATED:	DATE: 01 27 94	

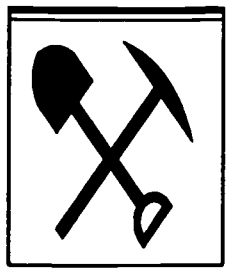


Although there are variations in calipers, the above components are common to all of them. Some have additional ratcheting capability and some are equipped with Vernier scales, an attachment we'll discuss later.

Steps



1. Grasp the micrometer as illustrated.
2. Turn the thimble counterclockwise until the space between the spindle and the anvil is larger than the part being measured. Try to secure the part in a clamping device if possible.
3. Make contact with the part on the anvil.
4. Rotate the thimble clockwise so that it makes contact with the other side of the part. Don't apply a great deal of pressure. The faces of the anvil and the spindle must touch and be parallel to the surfaces.
5. Turn the lock nut and take your reading.



Tools for Learning

Reading The Micrometer

Again we will use the $^{5}/_{8}$-inch O.D. of a copper tube. Follow the steps on the previous page to measure the copper tube.

1. Note that the 6 is the highest number visible on the sleeve. That 6 represents .6 of an inch. Write it as .600 in order to add the measurements.

2. You see that there is another short line immediately to the right of the 6 line. Each mark between the numbers on the sleeve represents .025 of an inch. Notice there are four .025 spaces between the sleeve numbers. Count the spaces visible. Multiply the number of complete spaces by .025. Write this number below .600.

3. Now look at the numbers on the thimble. Each number represents .001 of an inch. Record the number which lines up with the sleeve center line. In this example the 2 on the thimble lines up with the horizontal line on the sleeve. This constitutes .002.

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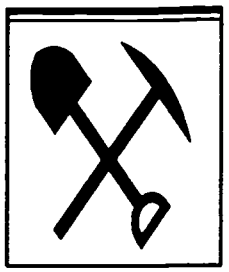


Tools for Learning

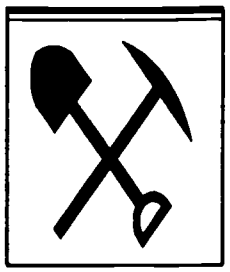
Now add the three measurements to find the O.D. of the copper tube:

.600 + .025 +.002 =.627

MACH. TOL UNLESS SPEC.
2 PLC DECIMALS = ±.020 3 PLC DECIMALS = ±.005
ANG=±.5° RADII=.015

Question

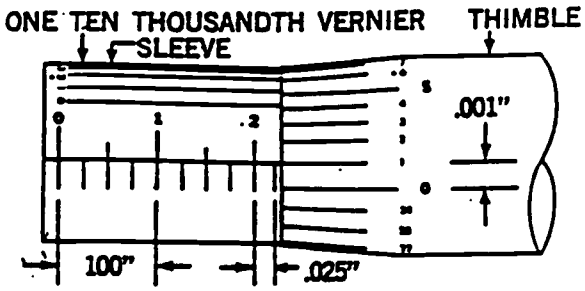
Does the measurement from the copper fall within the allowable tolerance?



Tools for Learning

Key Word

How to Read a Micrometer to Ten-Thousandths[2]



To read to one ten-thousandth requires an additional scale called the ***Vernier scale,*** named after the inventer, Pierre Vernier.

In the case of a regular micrometer, the Vernier consists of ten divisions, marked on the sleeve, which are spaced within nine divisions on the thimble scale.

Each division on the Vernier, therefore, is one-tenth shorter than that of the thimble's, thus representing .0001 inch. It is important to note that when finding the Vernier (ten-thousandths) reading, the correct figure is *ALWAYS* taken from the number at the Vernier scale and *NEVER* from the thimble.

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[2]*"How to Read a Micrometer,"* Starrett Company Catalog, 1989.

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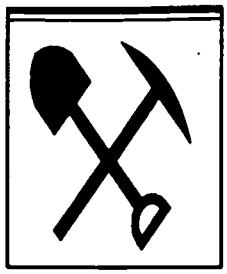
NEW PARADIGM for EFFECTIVE WORKFORCE SKILLS



Tools for Learning

Reading Example

1. Read to the thousandth of an inch in the same manner as shown on the left. When the center line of the sleeve falls between the lines of the thimble, or when the line of the thimble does not correspond to the center line of the sleeve, the unknown amount is read by using the Vernier scale provided on the sleeve.

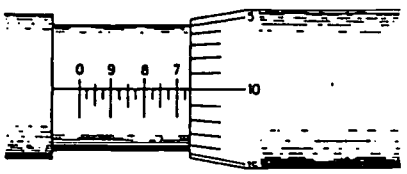
2. The Vernier on the sleeve reads to one-tenth of a thousandth of an inch, or .0001 inch.

3. To read the Vernier, find which line on the Vernier scale coincides with the line on the thimble and read the number off the Vernier scale.

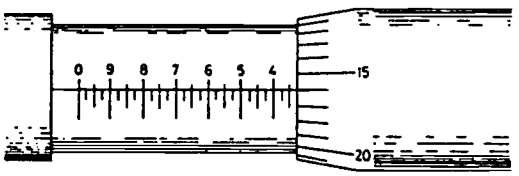
4. Note that the Vernier line numbered "2" coincides exactly with a thimble line indicating .0002 inch.

Exercise 1 On Micrometers

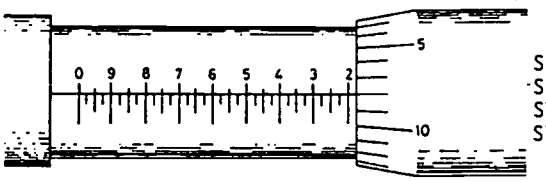
Complete the following exercises by recording your measurement readings, then add them up for the answer.



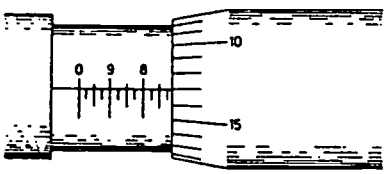
STEP 1
STEP 2
STEP 3 _____
STEP 4



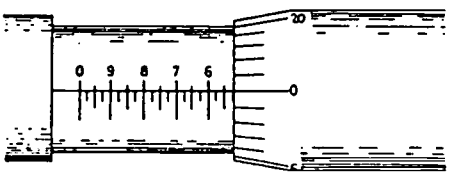
STEP 1
STEP 2
STEP 3 _____
STEP 4



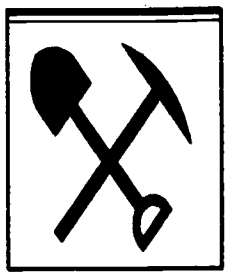
STEP 1
STEP 2
STEP 3 _____
STEP 4



STEP 1
STEP 2
STEP 3 _____
STEP 4



STEP 1
STEP 2
STEP 3 _____
STEP 4



Tools for Learning

The Vernier Scale

The ***Vernier scale*** is not a separate measuring instrument but a supplementary device which may be included on calipers, micrometers, height gauges, or other measuring devices.

Key Word

The Vernier scale allows the user to take fractional measurements from the primary gradations on the instrument, and it requires that the user "line up two numbers," one from the main scale and one from the supplementary or Vernier scale.

It is necessary to make sure that the measurement taken from the Vernier plate is the first number that perfectly "lines up." See Illustration 3, Vernier Plate.

Finally, this scale does not increase the capability from thousandths to ten-thousandths but does allow the user to record smaller measurements. Refer to the example on the previous page and note that the .009 is taken from Vernier plate.

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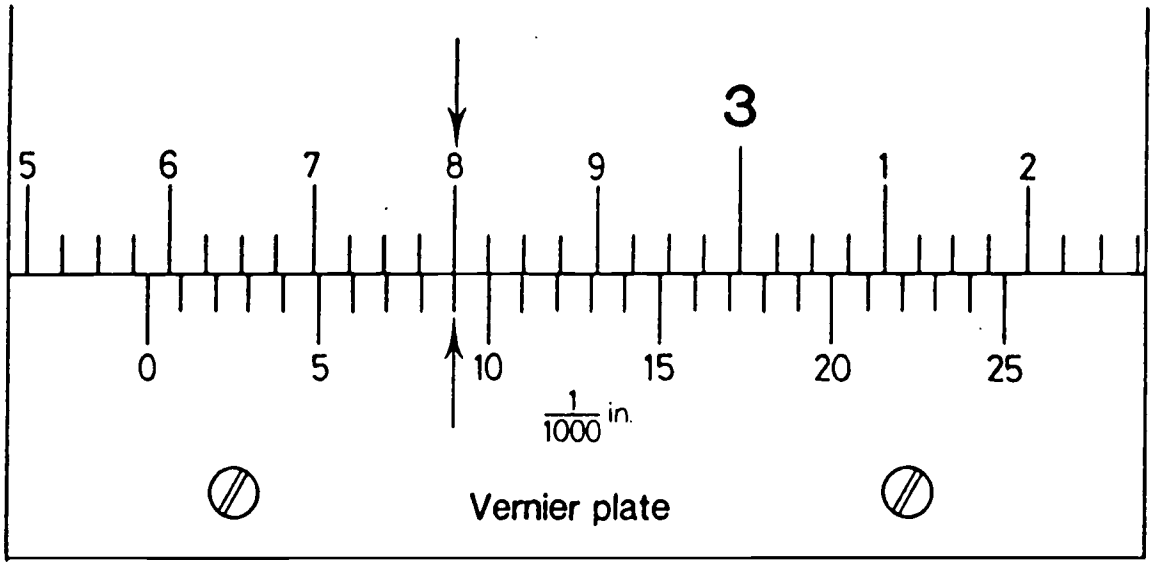
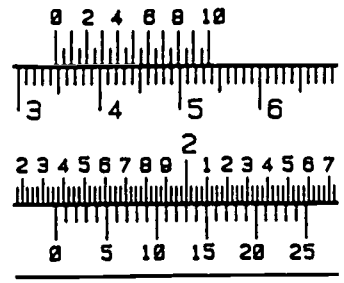


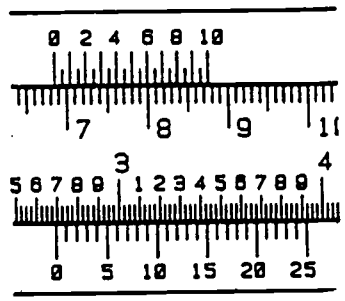
Step 1:		2.000 inch
Step 2:		.500
Step 3:		.075
+ Step 4:		.009
Step 5:		2.584 inch

Exercise 4

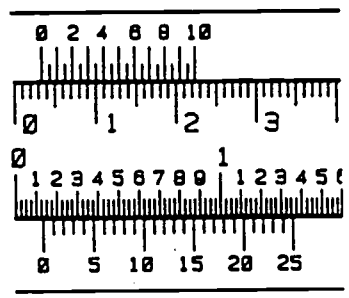
Now try your hand at reading some of the samples below. Refer back to the steps, if necessary.



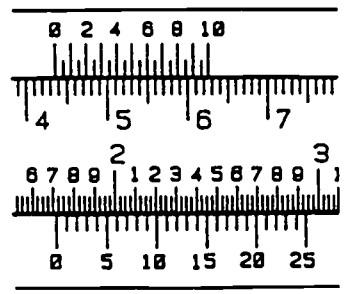
1. _____
   Outside



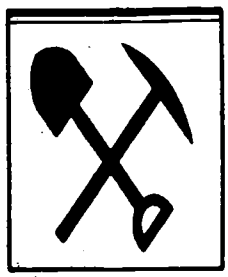
2. _____
   Outside



3. _____
   Outside



4. _____
   Outside

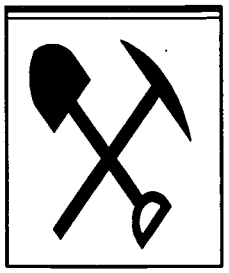


Tools for Learning

By now you can probably see how useful a Vernier scale can be when there is a need for finer measuring capability than the primary scale will allow.

Remember

Just remember, the Vernier scale is a supplementary tool. Use it when there is a real need for finer gradations.



Tools for Learning

The Vernier Height Gage

Vernier height gages are used to measure outside dimensions of parts. You can measure the height, length, and width of parts, as well as lay out dimensions on parts.

Key Terms

Very flat and smooth surfaces called ***surface plates*** must be used to both measure parts and lay out parts with the Vernier height gage.

The Vernier height gage and the part are placed on the surface plate. Make sure that both the surface plate and the height gage are clean. Dimensions will be measured between the ***scriber*** and the surface plate. (Illustration 4, Vernier Height Gage.)

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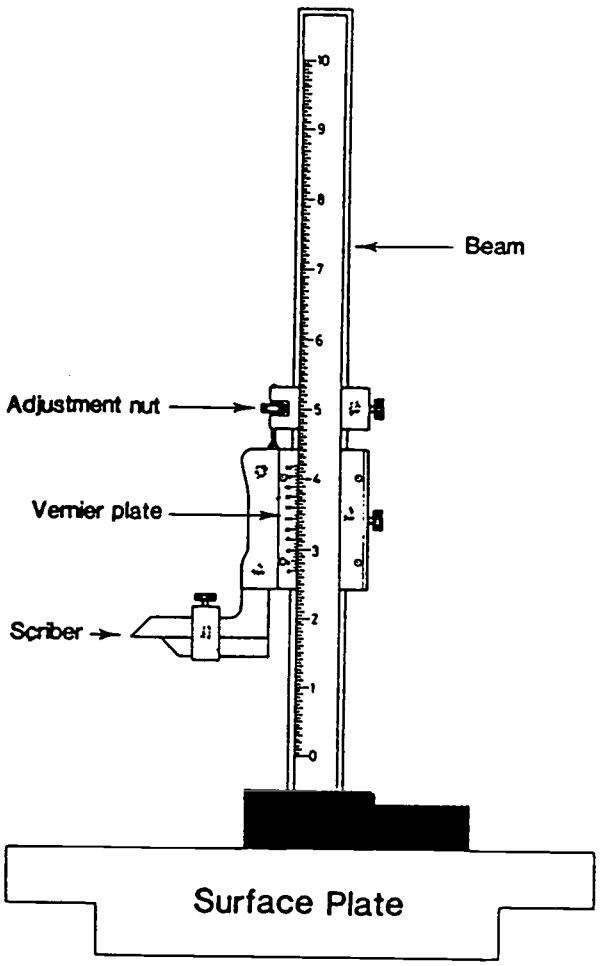
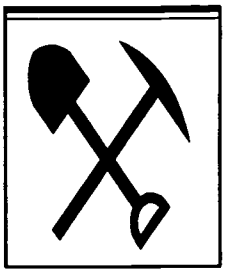
Parts of the Vernier Height Gage





Tools for Learning

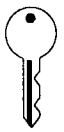
Steps for Reading a Vernier Height Gage

Underline or highlight the following:

1. Set up the Vernier height gage according to your needs. (See the three following illustrations.)

Note Taking

2. Adjust the scriber of the Vernier height gage with the ***adjustment nut*** to the measurement you need.



Key Terms

3. Read three measurements on the beam:

- Read 1.000 in., 2.000 in., ... (the ***inch measurement)***
- Read .100 in. to .900 in. on beam (the ***tenth of an inch measurement.)***
- Read .025 in., .050 in., or .075 in. on the beam (the ***thousandths of an inch*** from .025 to .075.)

4. Read the following measurement on the Vernier plate.

- Read .001 in. to .024 in. on the Vernier plate.

5. Add the four measurements to find the dimension.

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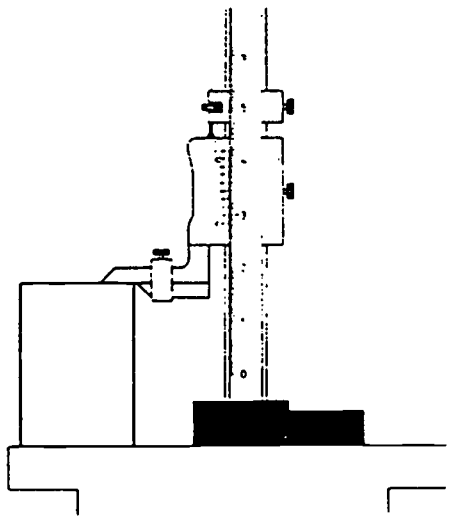
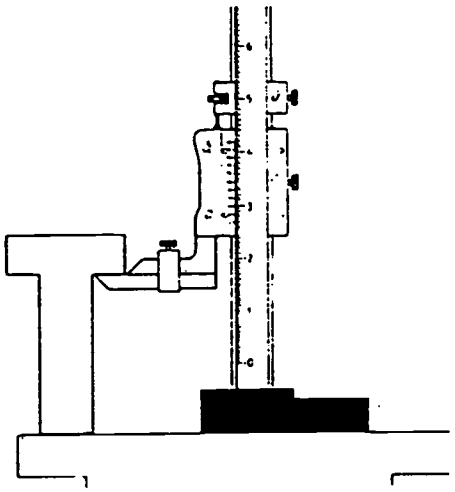
Three Uses of the Vernier Height Gage

You can use the Vernier Height Gage in three ways according to your needs.

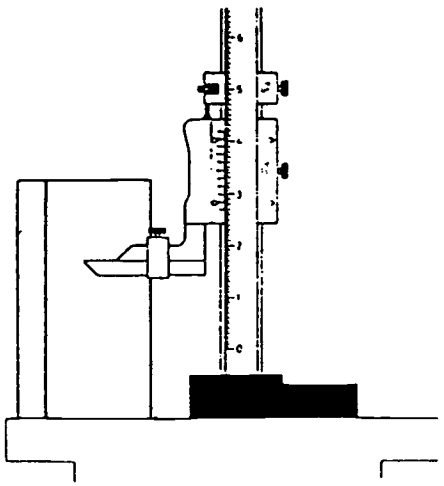
1. **Measuring Over a Surface.** Set the scriber on the Vernier height gage *to measure over a surface* on a part.

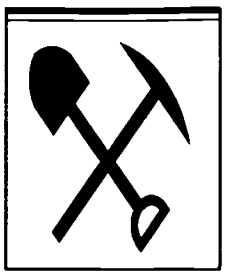


2. **Measuring Under a Surface.** Set the scriber on the Vernier height gage *to measure under a surface* on a part.



3. **Laying Out a Correct Dimension.** Set the scriber on the Vernier height gage *to lay out a correct dimension* on a part.

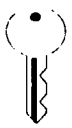




Tools for Learning

Gage Blocks

Gage blocks come under the general classification of ***fixed gages.*** Gage blocks are a ***secondary standard*** based upon units controlled by the National Institute of Standards and Technology.



Key Terms

Gage blocks are of different grades depending on how they are used. Those we will be working with are ***industrial grade.*** Tool & die makers and machinists use industrial grade gage blocks. These gage blocks come in sets of different sizes and shapes, the most common being rectangular. A typical set of gage blocks will have dimensions in inches and fractional parts of inches. A set of gage blocks, like the one in the next illustration[3], uses combinations of different lengths.

[3]Ford Motor Company, 1944

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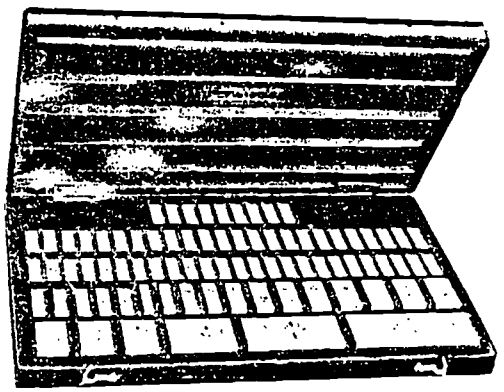
A full set of gage blocks consists of 81 blocks, which have surfaces flat and parallel within .000008 of an inch. This set consists of four series.



Sizes Composing a Set of 81 Blocks

FIRST SERIES

.1001" .1002" .1003" .1004" .1005" .1006" .1007" .1008" .1009"

SECOND SERIES

.101"	.102"	.103"	.104"	.105"	.106"	.107"	.108"	.109"	.110"
.111"	.112"	.113"	.114"	.115"	.116"	.117"	.118"	.119"	.120"
.121"	.122"	.123"	.124"	.125"	.126"	.127"	.128"	.129"	.130"
.131"	.132"	.133"	.134"	.135"	.136"	.137"	.138"	.139"	.140"
.141"	.142"	.143"	.144"	.145"	.146"	.147"	.148"	.149"	

THIRD SERIES

.050"

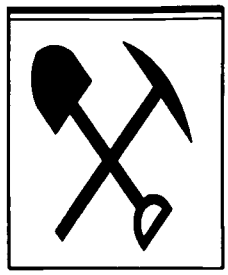
.100"	.200"	.300"	.400"	.500"	.600"	.700"	.800"	.900"
.150"	.250"	.350"	.450"	.550"	.650"	.750"	.850"	.950"

FOURTH SERIES

1.000" 2.000" 3.000" 4.000"

It is possible to make many combinations to obtain any required size.

1.2721	1.2721	1.2721	1.2721	1.2721
.1001	.1009	.1008	.1006	.1007
.149	.1002	.1003	.1005	.1004
.123	.147	.139	.138	.141
.900	.124	.132	.133	.130
1.2721	.800	.100	.500	.600
	1.2721	.700	.300	.200
		1.2721	1.2721	1.2721



Tools for Learning

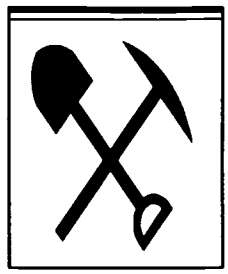
Compared to micrometers and calipers, even the industrial-grade gage blocks are "super" accurate, i.e., to 0.000010 inch. They are usually used with a surface plate so that the greatest amount of accuracy possible may be assured.

Because the degree of accuracy is so precise, gage blocks are usually "wrung" together. That is, the surfaces are rubbed against one another to assure that no air is left between the blocks. This technique will be illustrated later.

Key Terms

To cut down even further the possibility of error, always use as few blocks as possible when making up the length you desire. Gage block sets come with ***wear blocks*** which protect the gage blocks. Always use them on both ends of the stack.

One or two missing blocks can cut down on the usefulness of the set. Always be sure that the blocks are cleaned after their use and replaced in the correct slots in the storage box.



Tools for Learning

Instructions For Building A Combination of Gage Blocks

Underline or highlight the following instructions:

1. Select from the set the first two blocks of the combination.

2. Wipe each of the contacting surfaces of the blocks on the palm of the hand, on the wrist, or on a piece of chamois, and then place the contacting surfaces together.

3. With a slight inward pressure, slide one block on the other. If the contacting surfaces are clean, they will cling together as though they were magnetized.

4. Continue in this manner until the required combination is completed.

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Summary Exercise

Using the *minimum* number of gage blocks, make up combinations for each total dimension below:

1.000
2.000
3.000
4.000

.050
.100
.150
.200
.250
.300
.350
.400
.450
.500
.550
.600
.650
.700
.750
.800
.850
.900
.950

.101
.102
.103
.104
.105
.106
.107
.108
.109
.110
.111
.112
.113
.114
.115
.116
.117
.118
.119
.120
.121
.122
.123
.124
.125
.126
.127
.128
.129
.130
.131
.132
.133
.134
.135
.136
.137
.138

.139
.140
.141
.142
.143
.144
.145
.146
.147
.148
.149

.1001
.1002
.1003
.1004
.1005
.1006
.1007
.1008
.1009

1. \+ _____ 1.240 TOTAL DIMENSION

2. \+ _____ .3015 TOTAL DIMENSION

3. \+ _____ 1.1221 TOTAL DIMENSION

4. \+ _____ .4502 TOTAL DIMENSION

Glossary

Six-Inch Rule — A short steel ruler marked in 32nds of an inch on one side and 64ths of an inch on the other. Decimal equivalents of fractions are also shown on one side.

Alpha Risk—An error in the measuring process that causes the rejection of an acceptable dimension.

Attribute Gage—Designed to either pass or fail the measurement of a part dimension. A plug or a ring gage is an attribute gage.

Balanced Dial—A measurement indicator that can be read directly in either direction (negative or positive) from zero, to measure variations along a surface.

Bilateral Tolerance—An allowable variation on either side of the nominal measurement.

Blind Hole—A hole that does not go all the way through a part.

Combination Square—A steel rule with a moveable hook that often includes a bubble level, scribe, and a standard 45° angle.

Continuous Dial—A measurement indicator that can be read directly in only one direction from zero. It is used mostly to measure dimensions with unilateral tolerances.

Cosine Error—The error that occurs when an indicator tip is at an angle to the measured surface. This error is considered an alpha risk.

Depth Micrometer—Used to make precision measurements of the depth of slots or blind holes.

Depth Rule—Used to measure the depth of slots or blind holes with semiprecision.

Dial Caliper—Used as a Vernier caliper is used, but the measurement results are read on a dial like the face of a clock.

Dial Indicator—A circular measurement scale with a pointer that moves like a hand on a clock face.

Drawing Call-Out—The allowable tolerance for a dimension shown on a drawing. For example, a hole with a nominal diameter of no less than .500 inch could be shown on the call-out as .500/.504 or .500 +.004., -.0.

Fixed-Limit Gage—Indicates whether a dimension on a part is above or below a fixed limit.

Force Fit—A gage forced into the measurement position and not easily removed.

Go-No-Go Gage—A production gage that only tells you if a measurement is good or bad. It does not tell you what the actual measurement is.

Hook Rule—A steel ruler having a hook aligned with the 0-inch mark that can be used for measuring "around" rounded edges.

Inside Caliper—Used to measure the inside diameter of a hole. The caliper locks on the measured distance and is held against a six-inch rule to get the reading.

Inside Micrometer—A precision gage that reads inside dimensions on a part.

Insulating Grips—Plastic grips on a gage to prevent the heat of the user's hand from expanding the gage.

Iso Metric System— A standard system of measurement for screw threads in which the millimeter is the unit of measurement.

Master Disk—A reference gage for the snap gage. The master disk is used to periodically check the snap gage for incorrect tolerances due to slippage or wear. A new master disk is also used to reset a snap gage to new tolerances.

Mechanical Indicator—A variable gage, such as a dial indicator, that displays the actual variation between a dimension and a reference standard.

Micrometer—A precision gage that is designed to measure outside, inside, or depth dimensions on a part. Measurements are read on a sleeve and a thimble that has been rotated to the measurement position.

Nominal Size—The name size of a dimension, such as a 1/2-inch shaft, but not the actual measured size of the part.

Outside Caliper—Used to measure the outside diameter of a part. The caliper locks on the measured distance and is held against a six-inch rule to get the reading.

Outside Micrometer—A precision gage that reads outside dimensions on a part.

Plug Gage—A go-no-go gage that checks the size of a hole but not the shape of the hole.

Precision Accuracy—Accuracy to within .001 of an inch or less.

Production Gage—Used in assembly line production to quickly check one or several dimensions on a production part.

Progressive Gage—A "go" gage followed immediately by an in-line "no-go" gage

Revolution Counter—A small, built-in indicator on a larger indicator that counts the number of revolutions of the larger indicator.

Ring Gage—A go-no-go gage that will check the diameter of a shaft but will not check the overall shape of the shaft.

Running Fit—A gage that can be shaken slightly as it runs through or over a part.

Scribe—A sharp tool for placing a measurement mark on metal or other materials.

Semiprecision Accuracy—Accuracy to within $^1/_{64}$ of an inch.

Snap Gage—A set of fixed calipers that can be used to check most outside dimensions that a micrometer can check. No adjustment time for the gage is required.

Standard Tolerance Gage—Runs from the coarsest Class Z to the finest Class XX as follows:

Class XX	.00002	(twenty millionths)
Class X	.00004	(forty millionths)
Class Y	.00007	(seventy millionths)
Class Z	.0001	(one-hundred millionths)

Surface Plate—A flat, smooth reference surface to support parts for measurements from the surface or surface angle to some point on the part. Surface plates are made of either cast iron or granite.

Tape Rule—Used to measure long pieces of stock and usually accurate to the nearest $^1/_{16}$ inch.

Tolerance—The amount of allowable measured variation from the nominal measurement.

Unified System—A standard system of measurement for screw threads in which the inch is the unit of measurement.

Unilateral Tolerance—An allowable variation on only one side of the nominal measurement.

Variable Gage—Measures a range of dimensions to get the actual sizes of objects.

Vernier—A small, moveable, straight-line, graduated scale.

Vernier Beam—The larger scale on a Vernier caliper.

Vernier Caliper—Used to measure outside and inside dimensions of parts to the nearest .001 (thousandth) of an inch.

Vernier Height Gage—Used to measure outside dimensions of parts sitting on a surface plate.

Vernier Plate—The small scale on a Vernier caliper that moves along a larger scale.

Wear Allowance—Limits the wear that can be tolerated on a gage.

Work Gage—A production gage that is designed to check a dimension or several dimensions quickly and easily.

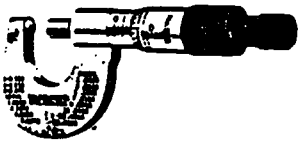
Name_____ **Date**_____

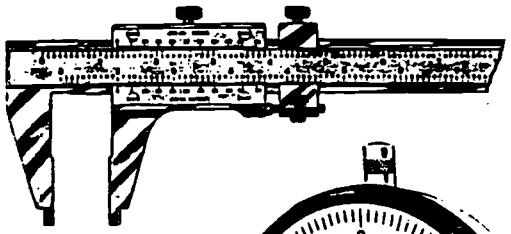
Department _____

Post-Test

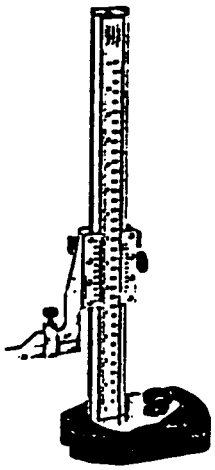
Instrument Identification

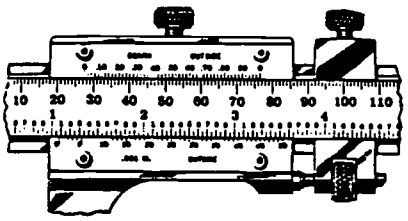
Identify the following precision measuring instruments and record the name of each in the blanks provided.

1.  _____

2  _____

3.  _____

4.  _____

5. 

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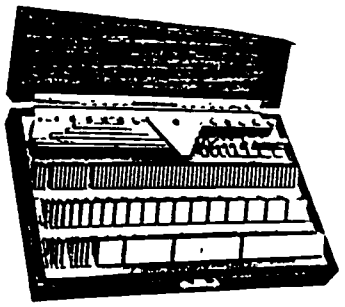
6. 

_____

Use of Decimals in Precision Measurement

Record your answers in the spaces provided.

1. Add the following decimals:

   3.507 + .021 + .1002 + .07 + .2 + 1.007 = _____

2. Subtract the following decimals:

   3.462 – .0365 = _____

3. Multiply the following decimals:

   .437 x 1.305 = _____

4. Divide the following decimals:

   .750 – .025 = _____

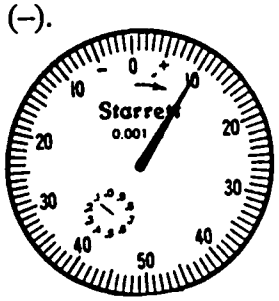
Taking Readings from Precision Measuring Instruments

Below are some illustrations of readings from precision measuring instruments.

Record your answers in the spaces provided.

Balanced Dial.

Look at the arrow on each dial face to see whether the dial is reading positive (+) or negative (–).

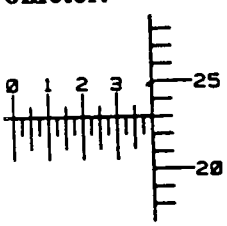


1

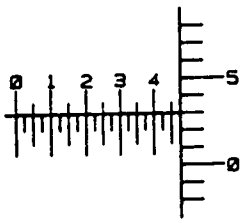
2

3

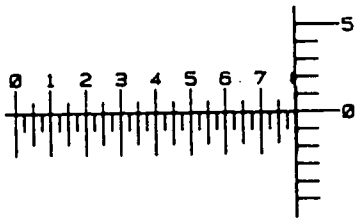
Micrometer.



1

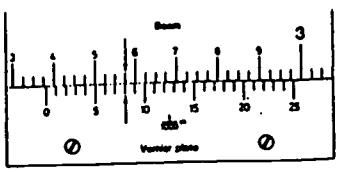


2

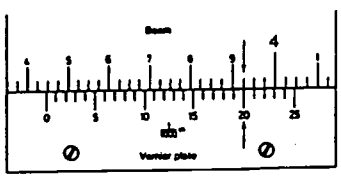


3

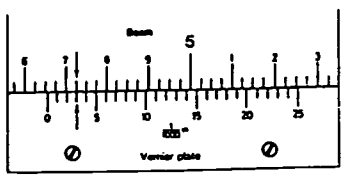
Vernier Scale.



1



2



3

Summary Exercise

Using the *minimum* number of gage blocks, make up combinations for each total dimension below:

1.000
2.000
3.000
4.000

.050
.100
.150
.200
.250
.300
.350
.400
.450
.500
.550
.600
.650
.700
.750
.800
.850
.900
.950

.101
.102
.103
.104
.105
.106
.107
.108
.109
.110
.111
.112
.113
.114
.115
.116
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.122
.123
.124
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.127
.128
.129
.130
.131
.132
.133
.134
.135
.136
.137
.138

.139
.140
.141
.142
.143
.144
.145
.146
.147
.148
.149

.1001
.1002
.1003
.1004
.1005
.1006
.1007
.1008
.1009

1. \+ _____ 1.240 TOTAL DIMENSION

2. \+ _____ .3015 TOTAL DIMENSION

3. \+ _____ 1.1221 TOTAL DIMENSION

4. \+ _____ .4502 TOTAL DIMENSION

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