

SECTION 2, CHAPTER 2

PRECISION MEASURING INSTRUMENTS

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Introduction

1. The degree of interchangeability of items which enables a new part to be fitted in the place of an unserviceable part without the need for a considerable amount of shaping or fitting, is dependent upon the consistent dimensional accuracy attained during the process of manufacture. Furthermore, the

dimensional limit to which a part may be permitted to wear is critical and must not be exceeded if the assembly is to maintain continued functional efficiency.

2. This consistency of dimensions and serviceability is secured by the skilful and careful measurement of component parts with the aid of accurate gauges or instru-

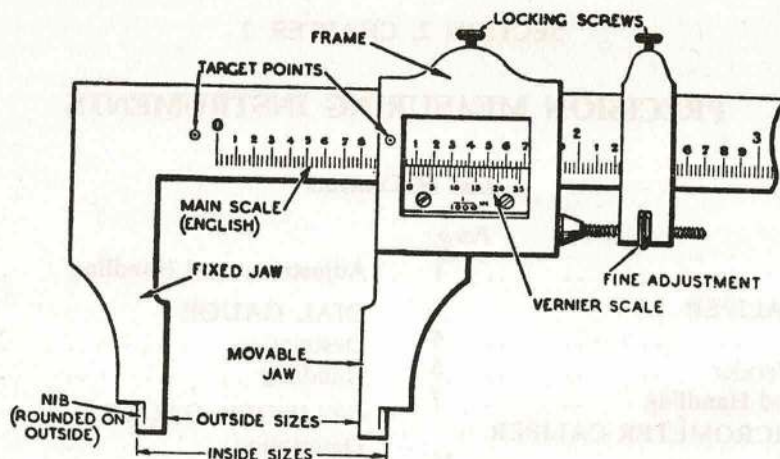


Fig. 1. VERNIER CALIPER

ments which, also being subject to wear, must be periodically checked for accuracy with master gauges or standards. The instruments provide little or no guarantee of a high standard of accuracy, unless they are handled with a skill which is only acquired by frequent practice in their use. Finally, to obtain an accurate measurement, this skill must be combined with careful checks to ensure that an outside influence, such as change of room temperature, does not affect the result.

3. The following paragraphs describe the various precision instruments and gauges used in the workshop and view bay, also the methods of use, checking and adjusting.

VERNIER CALIPER

Description

4. The vernier caliper is an instrument which indicates internal and external dimensions, measured with an accuracy of 0.001 inch or 0.02 millimetre. It consists of a graduated rule with an integral jaw formed at one end, a movable jaw and a frame which slides along the rule. A fitting, attached to the frame by a stud and an adjusting screw, is locked to the rule in any desired position by a locking screw, before the position of the frame is finally adjusted to take a reading. One scale of the rule is used for external measurements and the other scale, which allows for the width of the jaws, is engraved on the reverse side and is used for taking internal measurements. They frequently have two small "target points" which can

be used for setting dividers accurately. Both English and metric scales are often incorporated in the same instrument. The illustrations shows an example of a vernier caliper graduated in English measurements.

Reading the Vernier

5. The English main scale is graduated in inches and tenths, each tenth being numbered and subdivided into four parts (0.025 in.). The length of the "vernier" scale in the frame is equal to the length of 24 main scale subdivisions ($24 \times 0.025 = 0.6$ in.) but it is divided into 25 equal parts ($0.6 \div 25 = 0.024$ in.). Therefore, the difference in size between one main scale subdivision (0.025 in.) and one vernier scale division (0.024 in.) is 0.001 in. Hence, for example, the difference between nine main scale subdivisions and nine vernier scale divisions is 0.009 in. The vernier scale, each fifth division of which is

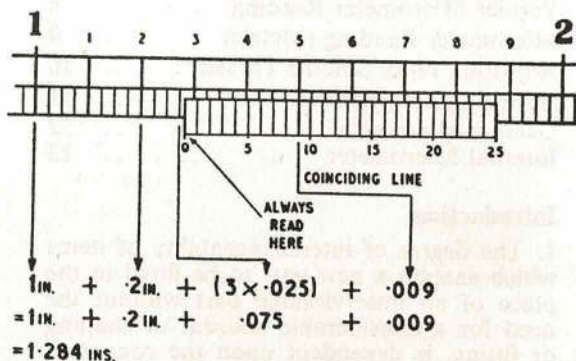


Fig. 2. VERNIER READING (ENGLISH)

numbered, is read in the same direction as the main scale. The main scale is read at the "0" of the vernier scale.

The measurement is indicated by :—

Main Scale :—

- (a) The number of whole inches inches.
- (b) The number of extra tenths tenths.
- (c) The number of extra subdivisions fortieths

Vernier Scale :—

- (d) The value of the line of the vernier scale that coincides with any number on the main scale . . . thousandths.

The vernier scale coincides at the ninth division. The difference between nine vernier and nine main scale subdivisions is 0.009 in., so this is the distance by which the "reading point" (0 on the vernier scale) is to the right of the last main scale subdivision read.

Note.—Some verniers are graduated on a 49/50 system (as per the metric vernier, described later). These are read in a similar way, also to 0.001 in.

6. The metric main scale is graduated in millimetres, each tenth division being numbered 1, 2, 3, etc. centimetres. The length of the vernier scale is equal to the length of 49 main scale divisions ($49 \times 1 = 49$ millimetres), but it is divided into 50 equal parts ($49 \div 50 = 0.98$ millimetres). Thus the difference between one main scale division (1.00) and one vernier scale division (0.98) is 0.02 millimetre. The vernier scale has each fifth division numbered 1, 2, 3, etc. Each 5 divisions indicate a difference of ($5 \times 0.02 = 0.1$ millimetre). Thus the number of 5 divisions, plus the number of single divisions read from the vernier scale at the point where the vernier and main scale lines coincide, is added to the main scale reading for the total measurement. For example, the vernier and main scale lines shown in the diagram,

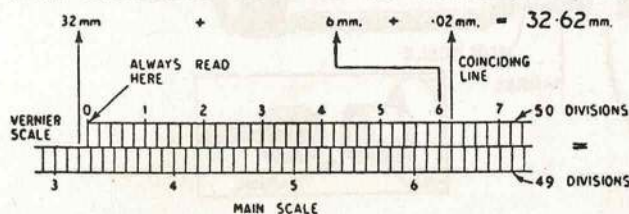


Fig. 3. VERNIER READING (METRIC)

coincide at one subdivision of the vernier scale past the vernier division numbered 6. This indicates 0.62 millimetre difference on main scale, to be added to the main scale reading, giving a total reading of 32.62mm.

Note.—Some metric verniers are graduated on the 24/25 system. They also read to 0.02 millimetres.

Adjustment and Handling

7. The "theoretical accuracy" of a vernier caliper is the difference in length between one main and one vernier division, but its real or practical accuracy may be considerably less. The accuracy of the tool is adversely affected by wear of the gauging faces, dirt on the working faces and unskilled handling.

8. The zero reading of the caliper should be checked before use. To check for accuracy of indicating external dimensions, clean the gauging faces, close them by firm finger pressure and secure the frame by its locking screw. Hold the tool between the eye and a source of light. Uneven wear, strain or dirt causing poor contact of the jaw faces will be evident by the chinks of light passing between the faces. Check the vernier scale locating screws for security. Use a magnifying glass to check that the zero marks on the main scale and the vernier coincide. If the zero marks are not aligned, note the error, but before adjusting the vernier scale, take a measurement of some object with the caliper and compare the reading with a reading of the same dimension taken with an instrument of known accuracy. Adjust the vernier scale to correct the reading if a similar error is noted in the compared readings.

9. A caliper provided with a main and vernier scale for indicating internal dimensions is checked and adjusted in a similar manner. When only one scale is provided for internal and external dimensions, the combined width of the nibs on the jaws must be added to the dimension indicated to obtain the correct internal measurement.

10. Skilful use of the caliper, in common with all other measuring instruments, is acquired only by adopting orthodox methods of handling and developing a sense of touch, which with frequent practice, will enable the operator to attain the necessary standard of accuracy. Whenever possible, the object

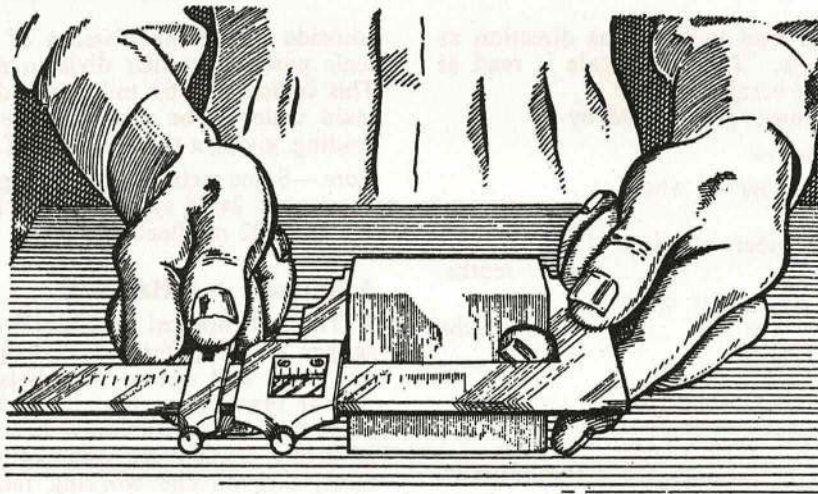


Fig. 4. VERNIER CALIPER IN USE

being measured should be supported by some means, to permit the operator to use both hands for the purpose of holding and manipulating the caliper. Also, more certain results can be obtained when the operator is able to rest his wrists and forearms on a steady support. The illustration shows a typical method of holding the tool when a measurement is being gauged. The maximum area of the gauging faces of the jaws should be in contact with the object, thus reducing to a minimum the error of angularity or lack of parallelism of the contacting faces. The gap between the jaws should be adjusted by the fine adjustment device, before the frame locking screw is finally secured. The jaws should make contact to give the feel of a smooth and easy push fit as the jaws are slowly drawn across the measured faces. Two or three readings should be taken at the same point, to establish the accuracy of the result. In early practice, the results of two or more operators can be compared, or the

measurement can be obtained by the use of other types of instruments for comparison. Finally, always read the vernier in a good light and preferably use a magnifying glass.

OUTSIDE MICROMETER CALIPER

Description

11. An outside micrometer is an instrument used for measuring the external dimensions of an object. It consists of a U-shaped frame, fitted with a barrel internally threaded along a portion of its length with 40 threads per inch, into which screws a spindle attached to and operated by a sleeve. A hardened steel anvil fixed in the other limb of the frame, is contacted by the hardened end face of the spindle when the micrometer is set at a zero reading. A knurled lock-nut can be used to lock the spindle when the instrument is employed as a fixed gauge. Some micrometers have a knurled ratchet stop and spring loaded pawl

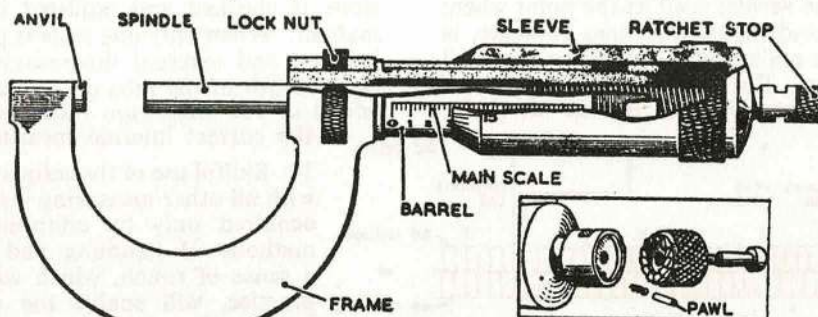


Fig. 5. ENGLISH OUTSIDE MICROMETER CALIPER

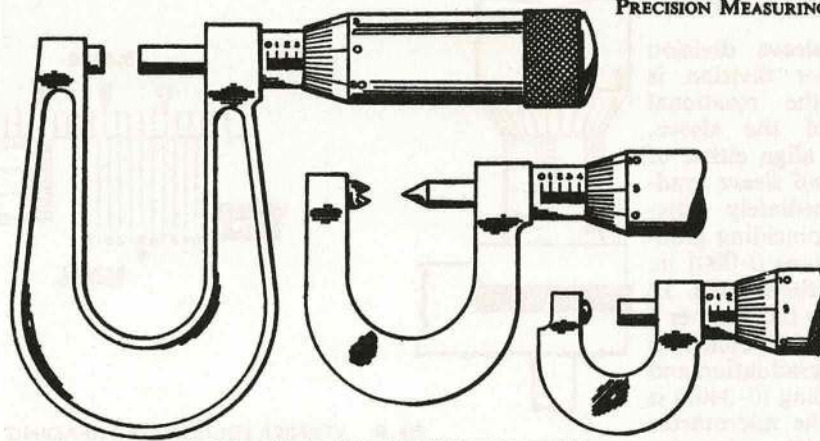


Fig. 6. TYPES OF OUTSIDE MICROMETER

fitted at the outer end of the sleeve, which, when used to rotate the sleeve, eliminates variation of pressure between the contacting measuring faces.

12. The barrel of an English micrometer is marked along its axis with a scale graduated in $1/10$ and $1/40$ of an inch. The bevelled end of the sleeve passing over the barrel is marked with a circumferential scale of 25 divisions, which enables readings to be taken to a limit of $1/1000$ of an inch. Better quality instruments have an additional vernier scale marked around a portion of the barrel, which permits readings to be taken to a limit of $1/10,000$ of an inch.

13. Outside micrometers are made in a variety of shapes and sizes, to meet the requirements of measuring objects where the standard micrometer cannot be satisfactorily used. The illustration shows typical examples of three micrometers. The first is used for measuring the thickness of sheet metal, the second for measuring the pitch diameter of male screw threads and the third for measur-

ing the thickness of metal forming a tube.

14. Excluding micrometers designed for special purposes, the English outside micrometer is supplied in eight sizes, ranging from 0-1 inch to 7-8 inch by one inch steps and the metric version in six sizes from 0-25 mm. to 125-150 mm. by 25 mm. steps. Irrespective of the size of the frame, the axial movement of the spindle is limited to 1 inch. When the reading is set at zero the gap between the anvil and spindle is equal to the low reading limit of that particular instrument.

Reading a Micrometer

15. One revolution of the sleeve of an English micrometer, moves the spindle a distance equal to the pitch of the spindle thread, i.e. $1/40$ (0.025) of an inch which is indicated by one small division on the barrel. As the scale on the sleeve has 25 equal divisions, a rotary movement of the sleeve through the distance of one of these divisions, will move the spindle $1/25$ of $1/40$ of an inch, which equals 0.001 in. The illustration shows the method of reading the measurement indicated on the barrel and the sleeve. If no division on the sleeve coincides with the line on the barrel, read to the nearest division. The zero reading of the micrometer must always be added, e.g. using a 3 in. to 4 in. micrometer, then 3 in. must be added.

16. The vernier scale on the barrel consists of 10 divisions whose total length covers a distance equal to 9 divisions on the sleeve, therefore each vernier division is equal to $9/10$ of a sleeve division. The difference

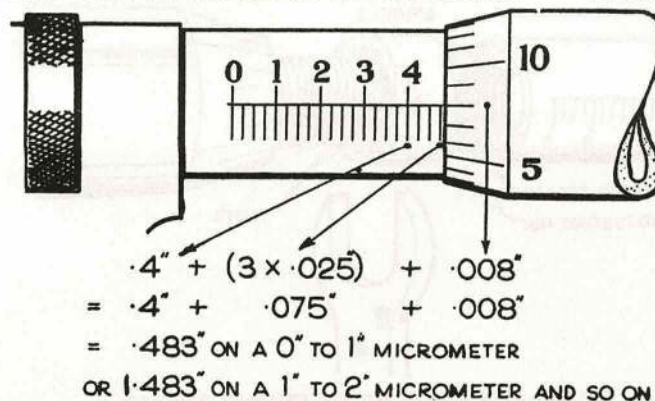


Fig. 7. MICROMETER READING (ENGLISH)

between a sleeve division and a vernier division is such that the rotational movement of the sleeve, necessary to align either of the vernier and sleeve graduations immediately adjacent to the coinciding graduations produces 0.0001 in. movement of the spindle. In the illustration the number 5 vernier division coincides with a sleeve graduation and the total reading (0.3405) is the sum of the micrometer reading (0.340), plus the vernier reading (0.0005 in.).

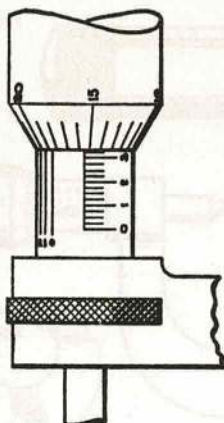


Fig. 8. VERNIER MICROMETER READING

17. The thread of the metric micrometer has a pitch of 0.5 millimetre. The barrel is graduated with two sets of lines to enable millimetre and half-millimetre marks to be easily distinguished and for ease of reading a measure-

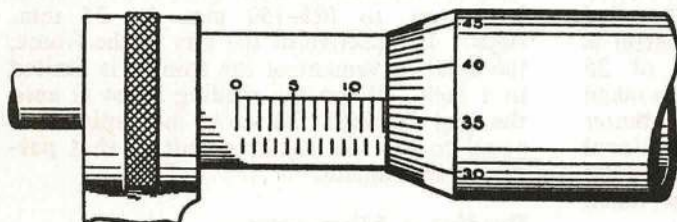


Fig. 9. MICROMETER READING (METRIC)

ment. The sleeve has 50 graduations, so that each represents 1/50th of 0.5 mm., i.e. 0.01 mm. The measurement is indicated as millimetres and half-millimetres on the barrel scale, plus hundredths of a millimetre on the sleeve (e.g. 13 mm. on barrel scale, plus 0.37 mm. on the sleeve equals 13.37 mm.).

Adjustment and Handling

18. Continued use of a micrometer causes the contact surfaces of the anvil spindle and the threads of the spindle and barrel to wear, thus affecting the accuracy of the tool. The methods of adjustment employed to counteract wear may differ with micrometers of different manufacture, but a careful examination of the tool will soon disclose how the adjustments are made.

19. One method used to eliminate slackness of the spindle thread in the barrel, employs an adjusting nut which screws on to an

external tapered thread on the outer slotted end of the barrel. As the adjusting nut is screwed to tighten on the tapered thread, the diameter of the end of the barrel is reduced. The fit of the spindle thread in the barrel is so adjusted that there is no perceptible end float on the spindle, yet the sleeve remains easy to rotate by means of the ratchet stop.

20. When the 0-1 in., or the 0-25 mm. micrometer is closed, the zero mark on the sleeve should coincide with the longitudinal line on the barrel and no portion of the barrel scale should be visible. Gauges or test pieces, from 1 in. to 7 in. in length and accurate to 0.0001 in. are used to close the gap between the anvil and the spindle when the zero setting of larger micrometers is being checked. The test piece is marked with its length in inches and the metric equivalent. To permit adjustment of the zero setting, the part of the barrel carrying the scale is a

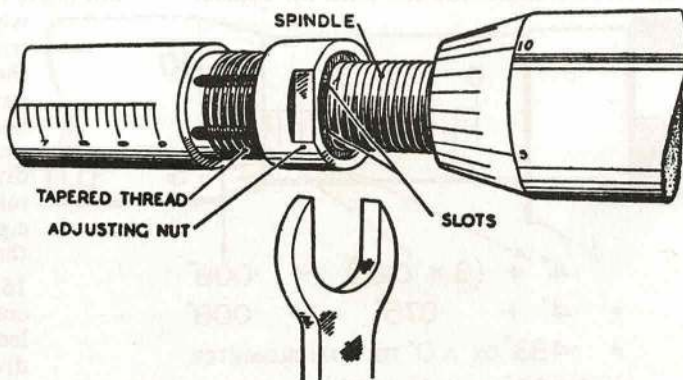


Fig. 10. ADJUSTING FIT OF SPINDLE THREAD

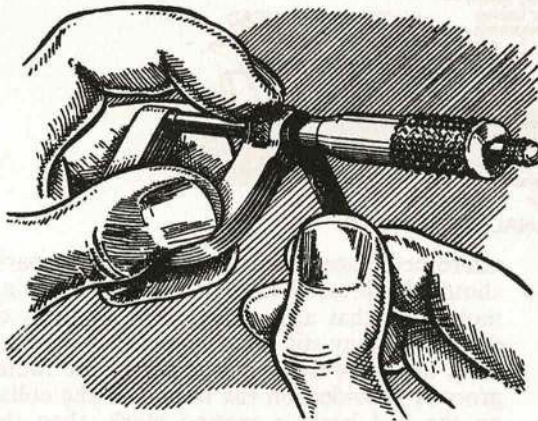


Fig. 11. ADJUSTING ZERO SETTING

tightly fitting sleeve which can be rotated with a "C" spanner, and so by this means, with the micrometer closed, the zero marks can be easily aligned.

21. The accuracy of a dimension obtained with a micrometer which has been correctly adjusted, depends on the handling skill of the operator. Small micrometers should be held in the manner shown in the illustration. The frame lies in the palm of the hand and the sleeve, or ratchet stop if fitted, is rotated by the thumb and forefinger. Both hands should be used to hold large micrometers, one to hold the frame, the other to manipulate the sleeve, whilst the article being measured is suitably supported. More than one reading

should be taken to ensure that any inaccuracy caused by incorrect pressure is made evident by different results. The pressure applied should allow the micrometer to be smoothly withdrawn from the article. When the correct "feel" is obtained, tighten the lock nut before removing the micrometer from the work. Measurements of circular sections are best obtained by holding the anvil stationary against the surface and gently rocking the contacting face of the spindle across the diameter of the section. Never attempt to measure the diameter of an article which is rotating.

INSIDE MICROMETER

Description

22. This instrument is used for measuring internal dimensions. It consists of a micrometer head, a set of detachable extension rods and a distance collar. The micrometer head usually has a range of $\frac{1}{2}$ in., the extension rods increase in length by steps of 1 in. and the distance collar is $\frac{1}{2}$ in. long. The extension rods and collar permit a progressive range of measurement from 2 in. to 12 in. and from 50 mm. to 200 mm. on the respective English and metric types. The principle of operation of the micrometer head, the method of reading and the limits of accuracy are the same as for the outside micrometer. Some inside micrometers are also graduated with a vernier scale.



Fig. 12. USING A MICROMETER

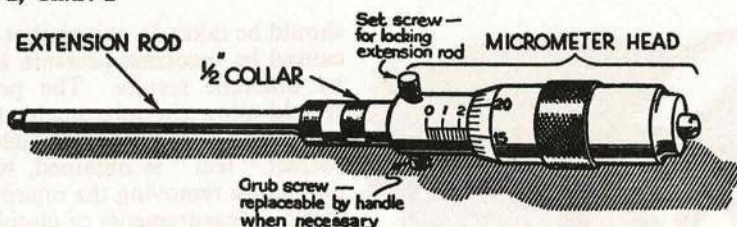


Fig. 13. INTERNAL MICROMETER

Adjustment and Handling

23. When assembling the inside micrometer, the abutting faces of the collar on the extension rod, the distance collar and the

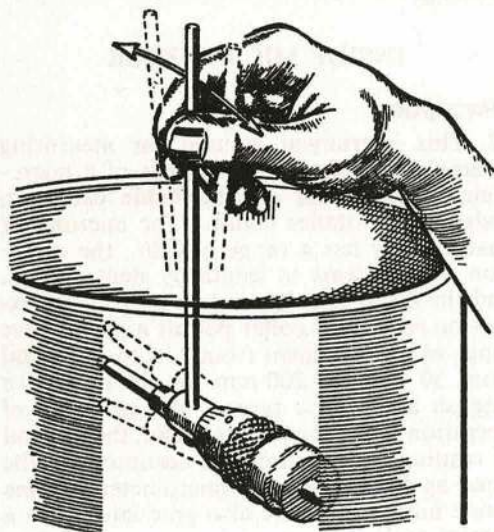


Fig. 14. USING AN INTERNAL MICROMETER

micrometer head must be clean. The parts should be pressed together with a screwing motion so that any oil or small particles of dirt which may still remain on the contacting faces are removed and trapped in the radial grooves provided on the faces. If the collar on the rod bears a mating mark, then the mark must be aligned with the corresponding mark on the micrometer head. The extension rod is secured in the micrometer head by a set screw. The overall dimension of the micrometer is checked with the aid of an external measuring instrument and the zero setting is adjusted by the same method as that used on the outside micrometer.

24. To obtain accurate results, the instrument must be held so that its longitudinal axis is at right angles to the faces between which the measurement is taken. The contacting ends of the extension rod and the micrometer head are convex. Consequently, as the micrometer is generally used with the aid of the handling rod, particular care must be exercised to prevent excessive pressure being applied to the measured faces.

DEPTH GAUGE

Description

25. The depth gauge is used for measuring the depth of holes and recesses or the height of spigots and shoulders from some reference plane on the object. In its simplest form it consists of a graduated blade or rod, fitted with a movable head or stock which can be clamped to the blade in any desired position. More elaborate gauges are made, which are provided with a vernier scale or a micrometer

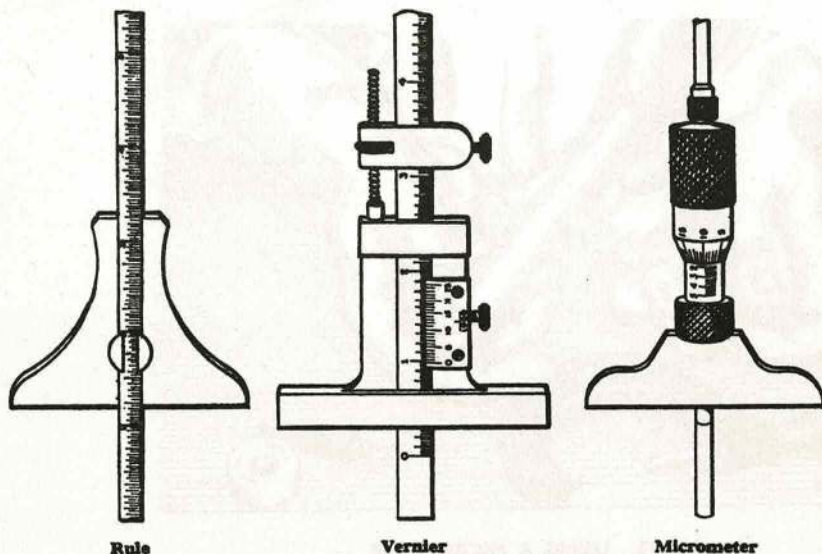


Fig. 15. TYPES OF DEPTH GAUGE

head to measure with an accuracy of 0.001 in. or 0.02 mm. Three types of depth gauge are illustrated.

Adjustment and Handling

26. The zero setting of a vernier depth gauge is tested by the following method. Place the contact face of the stock on a surface plate which has been smeared with a very thin film of "marking." Using the fine adjustment, position the blade in the stock so that the "marking" is transferred to the contacting end of the blade and the stock face, when the gauge is gently rubbed on the surface plate. Tighten the stock locking screw, wipe off the "marking" on the gauge faces and make a second "marking" test. When a satisfactory result is obtained, examine the zero setting of the vernier scale, and adjust the scale position to produce alignment of the zero marks.

27. To take a measurement, the frame and fine adjustment locking screws must first be slackened and the face of the stock placed in contact with the reference plane. The blade is then pushed through the stock until it makes contact with the work. Lock the fine adjustment attachment to the blade and make the final adjustment by using the fine adjustment nut. Care must be exercised to avoid the possibility of the blade projecting too far and so lifting the stock off its seating. Accurate results can only be obtained where there is a satisfactory seating for the stock of the gauge, and the bottom of the hole, recess or shoulder being measured is parallel with the plane of the seating.

VERNIER HEIGHT GAUGE

Description

28. This instrument is similar in construction to the vernier caliper, except that the integral jaw is shaped as a base, the lower face of which is accurately ground to form a contact face at right angles to the rule. The rule is graduated on both sides. The gauge can be converted into a form of scribing block by attaching to the moveable jaw an extension arm which is chamfered to a sharp edge. Variation in height of a plane surface may be measured with the aid of a further attachment and a dial gauge.

Adjustment and Handling

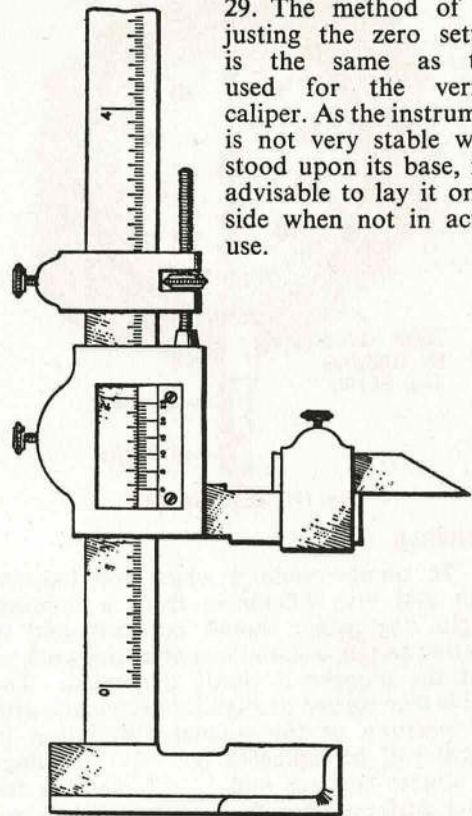


Fig. 16. VERNIER HEIGHT GAUGE

DIAL GAUGE

Description

30. The dial gauge or "clock" gauge is usually employed to indicate small variations in distance from a reference plane, or the limited movement of one component relative to another. The dial of the instrument, which is graduated in quarter thousandths, half thousandths or more generally thousandths of an inch, can be turned by its knurled rim to align the zero mark with any position of the pointer. The gauge can be fitted to a number of accessories and rigs which make it suitable for a variety of tasks involving dimensional examination. The illustrations show one method of assembling a dial test indicator set and a view of a dial gauge of a different pattern to that in use on the indicator set.

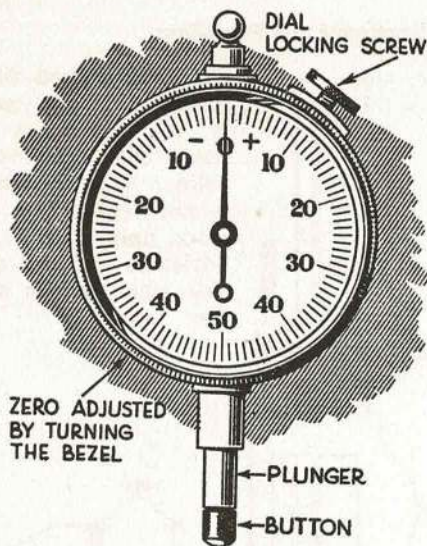


Fig. 17. DIAL GAUGE

Handling

31. To obtain readings which will indicate high and low differences from a nominal height, the gauge should be positioned in relation to the nominal height of the work so that the plunger is partly depressed. The dial is then turned to align the zero mark with the position of the pointer. Variation in height will be indicated by " + " readings for higher surfaces and " - " readings for lower surfaces than the nominal dimension. To ensure accuracy when the gauge is not attached to a static rig, the dial gauge must be firmly secured to its supporting rig and the reference plane must be a tested and true flat.

CYLINDER GAUGE

Description

32. The cylinder gauge is a special form of dial gauge which is used for measuring the amount of wear or machining error in cylinder bores and similar work. The contact face of the dial gauge is operated by a lightly spring-loaded plunger fitted in the " T " shaped head or anvil. The plunger movement is transmitted by a small curved rod, retained in a slide and a long rod housed in the hollow stem of the tool. As the curved rod limits the plunger movement to approximately 1/20 in., a set of washers of different thickness together with a set of spindles of various lengths are supplied, which enable the tool to be used over a range of diameters. The spring loaded anvil centralizes the tool

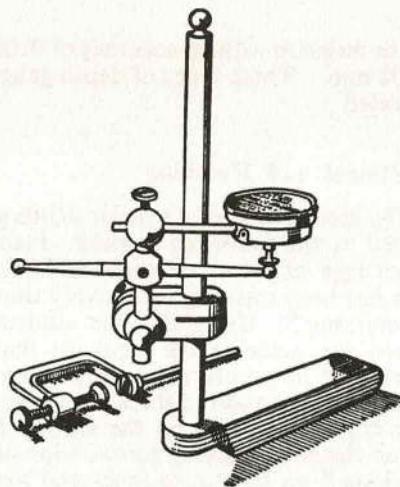


Fig. 18. DIAL TEST INDICATOR

in the cylinder bore so ensuring that the plunger and the spindle make contact with the wall of the cylinder across its diameter.

Adjustment and Handling

33. To adjust the tool to measure a cylinder bore, fit a spindle of suitable length and, if necessary, insert a washer. Set an outside micrometer to the correct diameter of the bore to be tested, then place the ends of the spindle and plunger between the jaws of the micrometer. Adjust the dial gauge to read zero and carefully disengage the micrometer.

34. A reading is taken by inserting the lower end of the instrument into the cylinder bore and rocking the stem gently on the rounded portion of the anvil. As the spindle and plunger pass through the position at right angles to the longitudinal axis of the bore, the dial gauge pointer will approach and then move away from the zero marking on the dial. If the cylinder wall is worn a negative reading will be obtained, the number of divisions indicated being the amount of wear at that point in thousandths of an inch. A zero reading will indicate that no wear has occurred. Several readings taken at various positions within the cylinder barrel will indicate the irregularities of the bore and readings taken at right angles to each other will indicate the amount of ovality.

NON-ADJUSTABLE GAUGES

Description

35. In reconditioning practice, it is often necessary to measure a number of components of one type to ascertain that the dimensions

being made to the large dimension or "high limit," and the other to the small dimension or "low limit"; the difference between the two dimensions being the "tolerance"

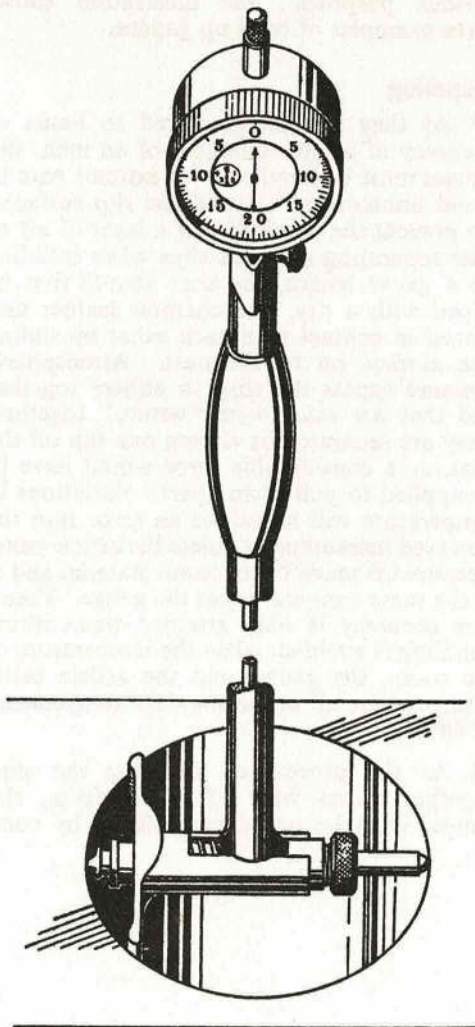


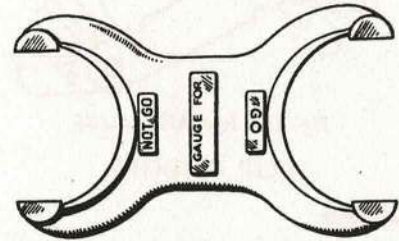
Fig. 19. CYLINDER GAUGE

of each component are within the serviceable working limits. To perform such a task with adjustable measuring instruments is laborious and tedious, but by using various types of gauges of fixed sizes the examination is simplified and each component is measured with the same degree of accuracy.

(a) **Limit Gauges.** Limit gauges, such as plate, gap, caliper, plug and ring gauges, which are more generally termed "GO" and "NOT GO" gauges are used to determine that an internal or external dimension of a component lies between two specified dimensional limits. The gauges are usually double ended; one end



Plug Gauge



Caliper or Gap Gauge

Fig. 20. LIMIT GAUGES

allowed on the nominal dimension. In use, the "GO" end of the gauge should fit into or over the work, and the "NOT GO" end should not. Plug gauges usually have flats machined on the gauging surfaces to enable them to be used for checking ovality of a bore.

(b) **Screw Pitch Gauges.** Screw pitch gauges are used to determine the number of threads per inch of a given thread. A gauge consists of a number of blades, each blade being cut with a certain number of teeth per inch, the teeth being accurately

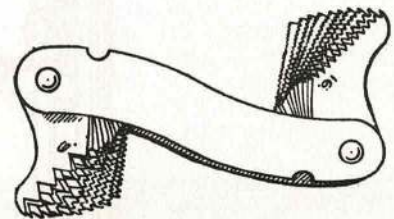


Fig. 21. SCREW PITCH GAUGE

shaped to the profile of a standard thread form. Four types are available in the Service to check B.A., Whitworth, U.S. Standard and Metric threads. The gauges

are suitably marked, and each blade is marked with the number of threads per inch which it represents.

(c) **Radius Gauges.** These are used to check the size and accuracy of the form of small radii. The gauges are usually provided as a set of blades, each blade being shaped with a convex and concave radius of the size stamped on it.

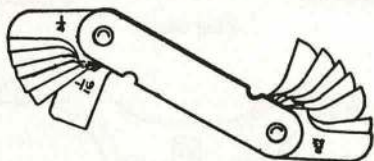


Fig. 22. RADIUS GAUGE
SLIP GAUGES

Description

36. Slip gauges or Johansson blocks are mainly used as standards for checking the accuracy of working gauges. They consist of rectangular blocks of hardened and polished steel, which are ground to a high degree of accuracy in length, flatness and parallelism. The set of slips comprises 81 pieces, graduated in size, to enable any length from 0.1001 in. to over 10 ins. to be built up in steps of 0.0001 in. The slips are used in conjunction with a set of accessories to produce gauges for

various purposes; the illustration shows three examples of built up gauges.

Handling

37. As they are manufactured to limits of accuracy of a few millionths of an inch, slip gauges must be handled with extreme care to avoid unnecessary wear of the slip surfaces. To prevent the possibility of a layer of air or dust separating adjacent slips when building up a gauge length, the slips should first be wiped with a dry, fine chamois leather and placed in contact with each other by sliding one surface on to the next. Atmospheric pressure causes the slips to adhere together and they are said to be "wrung" together. They are separated by sliding one slip off the next, as a considerable force would have to be applied to pull them apart. Variations in temperature will introduce an error into the observed measurement unless the article being measured is made of the same material and is at the same temperature as the gauge. Therefore accuracy is only attained when direct handling is avoided, when the temperature of the room, the gauge, and the article being measured are all at the standard temperature of 68° F.

38. As the process of wringing the slips together causes wear of the surfaces, slip gauges must be tested periodically by com-

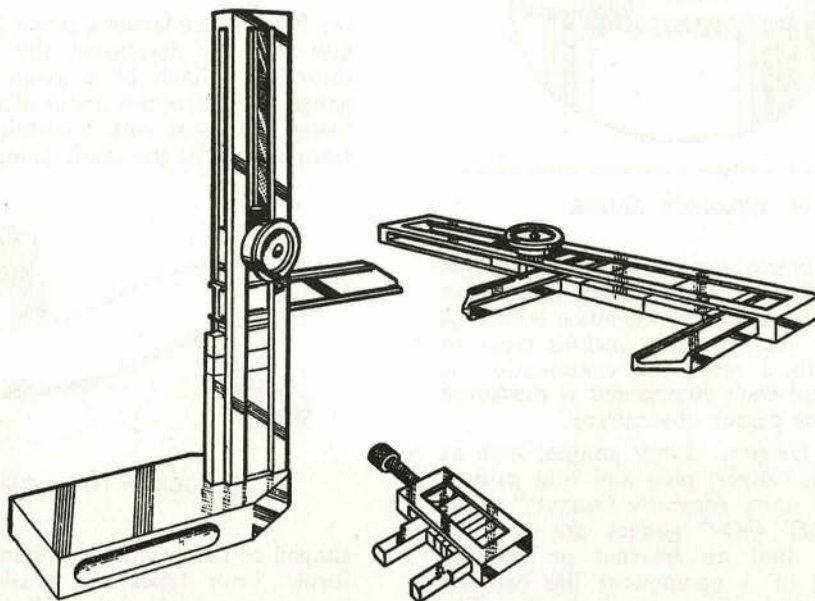


Fig. 23. TYPICAL USES OF SLIP GAUGES

parison with "calibration" slips or by other methods to ensure that they remain within the prescribed limits of accuracy.

VERNIER BEVEL PROTRACTOR

Description

39. The vernier bevel protractor enables angles to be measured to an accuracy of 5 minutes (60 minutes = 1 degree). The tool

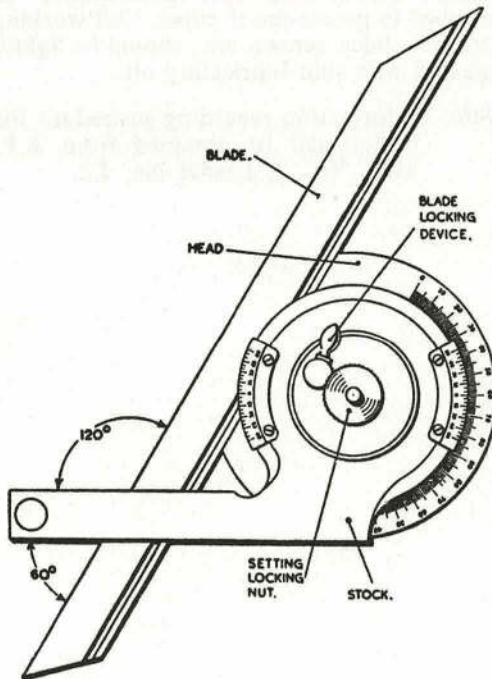


Fig. 24. VERNIER BEVEL PROTRACTOR

consists of a blade, a graduated protractor head and a stock which has an integral straight edge. The protractor head can be slid along the length of the blade to any required position and locked. The stock rotates about the centre of the protractor and can be locked in any position by the setting lock nut. The angles formed by the stock straight edge relative to the blade are indicated on the protractor by an index mark "0" on the vernier scale attached to the rim of the stock disc.

Reading and Adjusting

40. The protractor scale is graduated in degrees from 0 at each end, meeting at 90 degrees in the centre of the scale. The vernier scale is graduated with two groups of 12 divisions set on either side of the index mark "0". The angle included by each group of 12 vernier divisions is equal to 23 main scale divisions (23 degrees), therefore one vernier division equals $(23 \div 12)$ 1 degree 55 minutes. Thus the angular difference between two protractor scale divisions (2 degrees) and one vernier scale division is 5 minutes. The vernier scales have each third division numbered consecutively 15, 30, 45 and 60, indicating minutes, enabling an angle or its supplement to be read directly from the tool.

41. To read an angular measurement, note the number of whole degrees on the protractor scale passed by the vernier index mark and then, *continuing to read in the same direction*, add the number of minutes indicated by the line on the vernier which coincides with a

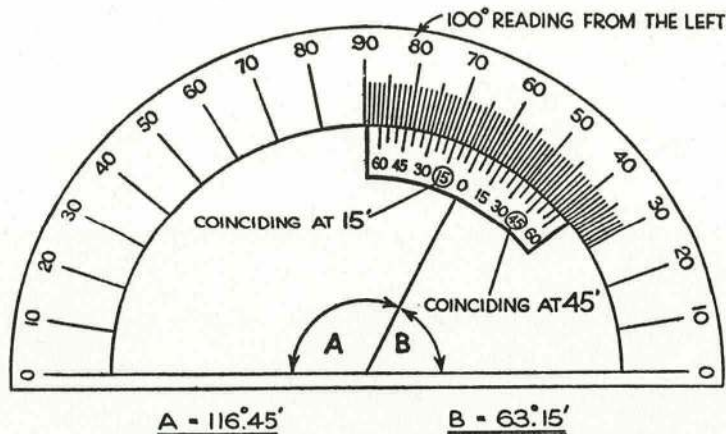


Fig. 25. BEVEL PROTRACTOR VERNIER READING

main scale line. Before an angle is measured, the accuracy of the bevel protractor should be tested by setting the blade and straight edge to a right angle with the aid of a master square and then checking the position of the vernier index mark in relation to the protractor scale. Any error can be corrected by adjusting the vernier scale position.

Serviceability and Care

42. The descriptions and illustrations are not to be taken as authority for dismantling precision instruments. Adjustments should only be undertaken in exceptional circumstances and when experienced personnel and full facilities for such are available. Periodic checks should be carried out at the Standards

Room to which the particular station is zoned. Standards Rooms are manned by qualified A.I.S. personnel and these periodic checks will ensure the continued serviceability of all precision measuring equipment. It is also essential that these delicate instruments should not be left lying around, but should be replaced in their respective containers immediately after use. If the instruments are not in continual use, they should be lightly coated with rust preventative or wrapped in grease-proof paper. All working surfaces, slides, screws, etc., should be lightly smeared with thin lubricating oil.

Note. Information regarding procedure for testing can be obtained from A.P. 3158, Vol. 2, Leaflet No. J.2.

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