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INSPECTION OF TAPER THREAD GAGES

CONTENTS

I. INTRODUCTION

The inspection of taper thread gages, which are used largely in the inspection of pipe threads such as the National (American Briggs') or British Standard Pipe Threads, is a somewhat more complicated process than the inspection of straight thread gages and, therefore, requires some modification of the methods applied to the latter. In this circular are presented methods which may be used in measuring taper

thread gages, special attention being given to the description of such adaptions of these methods as may be applied in manufacturing plants where only the ordinary facilities for making such measurements are available.

There are also appended, for reference, tables giving the dimensions of National (American Briggs') and British Standard Pipe Threads and pipe thread gages. The thread forms of National (American Briggs') and British Standard Pipe Threads are illustrated in Figs. 10, 11, and 12; and the forms of pipe thread gages recommended by the National Screw Thread Commission, the American Engineering Standards Committee, and the British Engineering Standards Association are shown in Figs. 13 to 18 inclusive. (See Reference No. 1.)

A complete inspection of a taper thread gage involves:

1. Measurement of length from the small end to the gaging notch, and the total length
2. Measurement of pitch diameter at the gaging notch
3. Measurement of taper
4. Measurement of major diameter of plug gage, or minor diameter of ring gage at the gaging notch
5. Measurement of pitch
6. Measurement of thread angle
7. Examination of the thread form for,
    a. smoothness of surface
    b. straightness of sides of thread
    c. clearance at root
    d. concentricity of pitch and major or minor diameters of plug or ring gages, respectively.

II. MEASUREMENT OF LENGTH TO GAGING NOTCH, AND LENGTH OF THREAD

The determination of the position of the gaging notch with respect to the small end of the gage and of the total length of thread are simple length measurements, and may be accomplished by means of a micrometer caliper checked against precision gage blocks; or by means of the gage blocks themselves, in conjunction with the jaw pieces furnished as accessories.

III. MEASUREMENT OF PITCH DIAMETER

1. Plug Gages

The pitch diameter of a screw thread developed on a cone, that is, of a taper screw thread, is the diameter, at a given distance from a reference plane, of an imaginary cone which would pass through the threads at such points as to make equal the width of the threads, and the width of the spaces cut by the surface

of the cone. The measurement of the pitch diameter, as well as the major diameter (outside diameter) of a thread plug gage is accomplished by means of a micrometer caliper, measuring machine, or other suitable apparatus used in connection with standards of known length. To measure the pitch diameter, it is necessary to provide the micrometer or measuring machine with special contact points, or to apply the usual "wire" methods in which measurements are taken over small cylinders inserted in the thread groove.

The screw thread micrometer, shown in Fig. 1, is the usual adaption of the micrometer caliper for measuring directly the pitch diameter of a screw thread. The spindle of this micrometer has a cone point and the anvil has two parallel wedges formed into one V-shaped piece, which is free to rotate. This instrument gives pitch diameter readings which may be slightly large; however, this excess is usually not over 0.0002 inch provided that the thread angle and the angles of the wedge and cone of the micrometer are equal. The end of the cone point of the spindle is truncated, and the groove in the anvil is cleared at the bottom, thus allowing both the anvil and the spindle to make contact with only the sides of the thread. When the spindle and anvil are in contact, the zero line on the thimble represents the plane XY, Fig. 1. The anvil and spindle are limited in their capacity, and to cover all pitches it is necessary to provide different micrometers for various ranges of pitches. On account of these limitations, and the fact that careful and frequent adjustment are required, this instrument is unsatisfactory for accurate measurement of gages. If used at all in the measurement of thread gages, the thread micrometer should only serve as a means to obtain an approximate check on measurements made by the three-wire method. It is very useful, however, in transferring measurements from a standard gage to the work at hand.

A convenient check for a screw thread micrometer is shown in Fig. 1A. It consists of two pieces, one grooved to fit the spindle and one, which is wedged-shaped, to fit into the anvil. The faces opposite the wedge and groove are lapped flat. A micrometer is checked at various points by inserting precision gage blocks between the two flat faces of the check. The length of the check is determined by measuring over the flat surfaces, the check being assembled with the wedge and groove together as shown.

Of the various methods applied to the measurament of pitch diameter of threaded plugs, the three-wire method has been found to be the most accurate and satisfactory, when properly carried out. It has been in common use for nearly twenty years, and is the standard method used by the Gage Section of the Bureau of Standards. (See Reference No. 2.)

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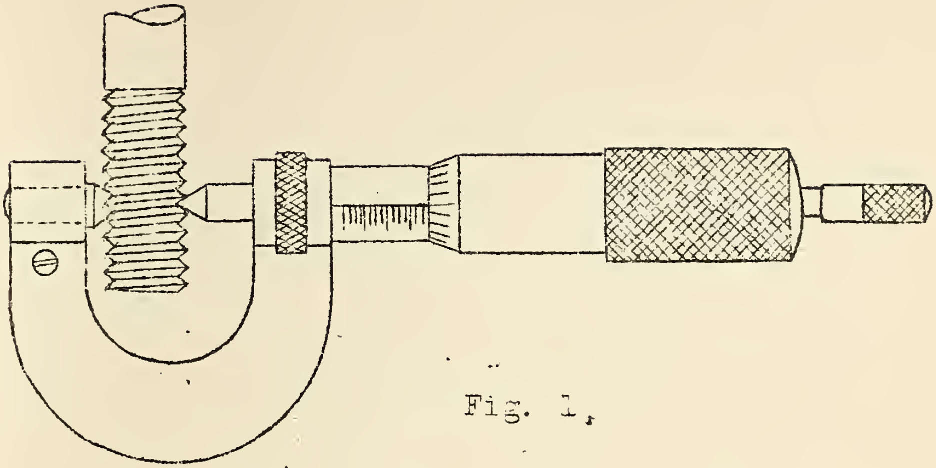


Fig. 1.

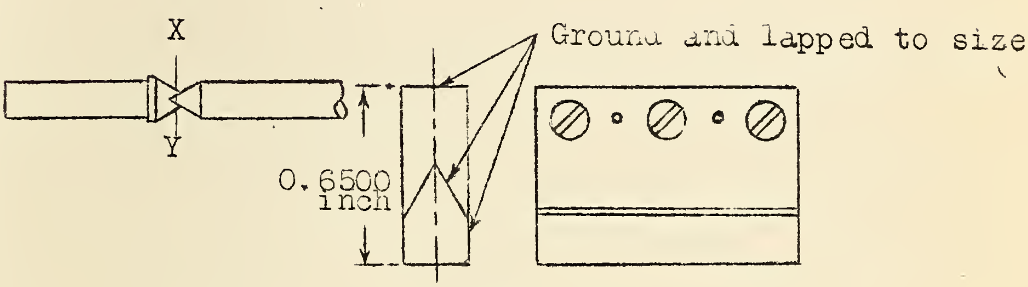


Fig. 1A

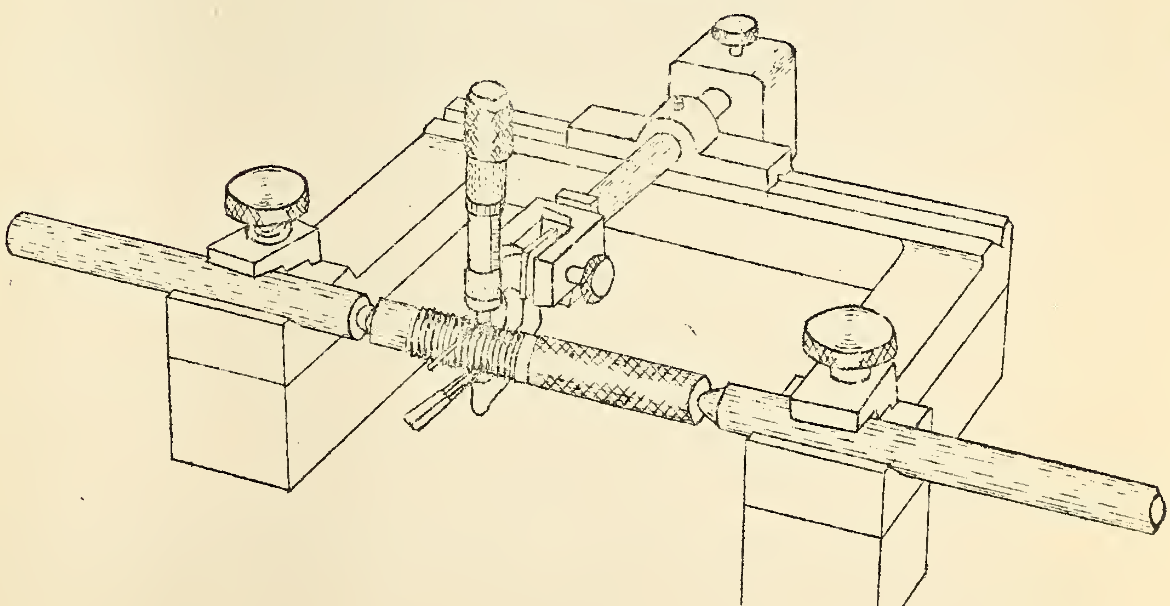


Fig. 2

In the three-wire method of measuring pitch diameter, small hardened steel cylinders, or wires, which have been lapped to correct size, are placed in the thread groove, two on one side of the screw and one on the opposite side as shown in Fig. 3. The contact face of the micrometer anvil or spindle over the two wires must be sufficiently large in diameter to touch both wires, that is, it must be equal to, or greater than, the pitch of the thread. It is best to select wires of such a size that they touch the sides of the thread at the mid-slope, for the reason that the measurement of pitch diameter is least affected by any error in thread angle which may be present when such size is used. The size of wire which touches exactly at the mid-slope of a perfect thread of a given pitch is termed the "best-size" wire for that pitch. Any size, however, may be used which will permit the wires to rest on the sides of the thread and also project above the top of the thread.

The depth at which a wire of given diameter will rest in a thread groove depends primarily on the pitch and included angle of the thread; and secondarily, on the angle made by the helix, at the point of contact of the wire and the thread, with a plane perpendicular to the axis of the screw. Inasmuch as variation in the helix angle has a very small effect in determining the diameter of the wire which touches at the mid-slope of the thread, and as it is desirable to use one size of wire to measure all threads of a given pitch and included angle, the best-size wire is taken as that size which will touch at the mid-slope of a groove cut around a cylinder perpendicular to the axis of the cylinder, and of the same angle and depth as the thread of the given pitch. This is equivalent to a thread of zero helix-angle. The size of wire touching at the mid-slope, or "best-size" wire, is given by the formula:

$$G = \frac{p}{2} \sec a,$$

in which

G = diameter of wire
p = thread interval
a = 1/2 included angle of thread

This formula reduces to:

$$G = 0.57735 \times p \text{ for } 60° \text{ threads}$$
$$G = 0.56369 \times p \text{ for } 55° \text{ threads}$$

It is frequently desirable, as for example when a best-size wire is not available, to measure pitch diameter by means of wires of other than the best size. The minimum size which may be used is limited to that permitting the wire to project above the crest of the thread, and the maximum to that permitting the wire to rest on the sides of the thread just below the crest,

and not ride on the crest of the thread. Tables 4 and 5, which are appended, give the diameters of the best-size, maximum, and minimum wires for National (American Briggs') Pipe Threads and British Standard Pipe Threads.

In making measurements over the wires inserted in the thread groove, it has been common shop practice to hold the wires down into the thread by means of elastic bands. This has a tendency to prevent the wires from adjusting themselves to the proper position in the thread grooves; thus a false measurement is obtained. In some cases, it has also been the practice to support the screw being measured on two wires, which are in turn supported on a horizontal surface, and measuring from this surface to the top of a wire placed in a thread over the gage. If the screw is of large diameter, its weight causes a distortion of the wires and an inaccurate reading is obtained. For these reasons these practices should be avoided and subsidiary apparatus for supporting the wires and micrometer should be used. An apparatus for this purpose, known as a balanced micrometer, which is particularly convenient in measuring the smaller sizes of thread gages, is shown in Fig. 2. The screw is supported between centers and the micrometer is supported on a counterbalanced arm as shown. The micrometer clamp is pivoted on its supporting arm, thus allowing a slight movement of the micrometer, in the vertical plane which passes through the axis of the screw, and permitting the micrometer to adjust itself to contact on all wires. Two of the wires are supported on the anvil of the micrometer below the thread and one is supported over the thread. The proper "feel" is obtained by sliding the wires in the thread groove. This apparatus is very simple in construction and is recommended as being very convenient when a large number of gages are to be tested. In measuring gages larger than two inches, it is the practice of this Bureau to make the measurements of both pitch and major diameters on a measuring machine.

The pitch diameter of a taper thread plug gage is measured in much the same manner as that of a straight thread gage, except that a definite position at which the measurement is to be made must be located. A point at a known distance L from the end of the gage is located by means of a combination of precision gage blocks and the cone point furnished as an accessory with these blocks, as shown in Fig. 3A. The gage is set vertically on a surface plate, the cone point is placed with its axis horizontal at the desired height, and the plug is turned until the point fits accurately into the thread. The position of this point is marked by placing a bit of Prussian Blue or wax immediately above it. The gage is placed between centers of the balanced micrometer and a single best-size wire is placed in the thread at this point, and the other two wires are placed in the adjoining threads on the opposite side. Measurement is made over the wires in the usual manner, but care must be taken

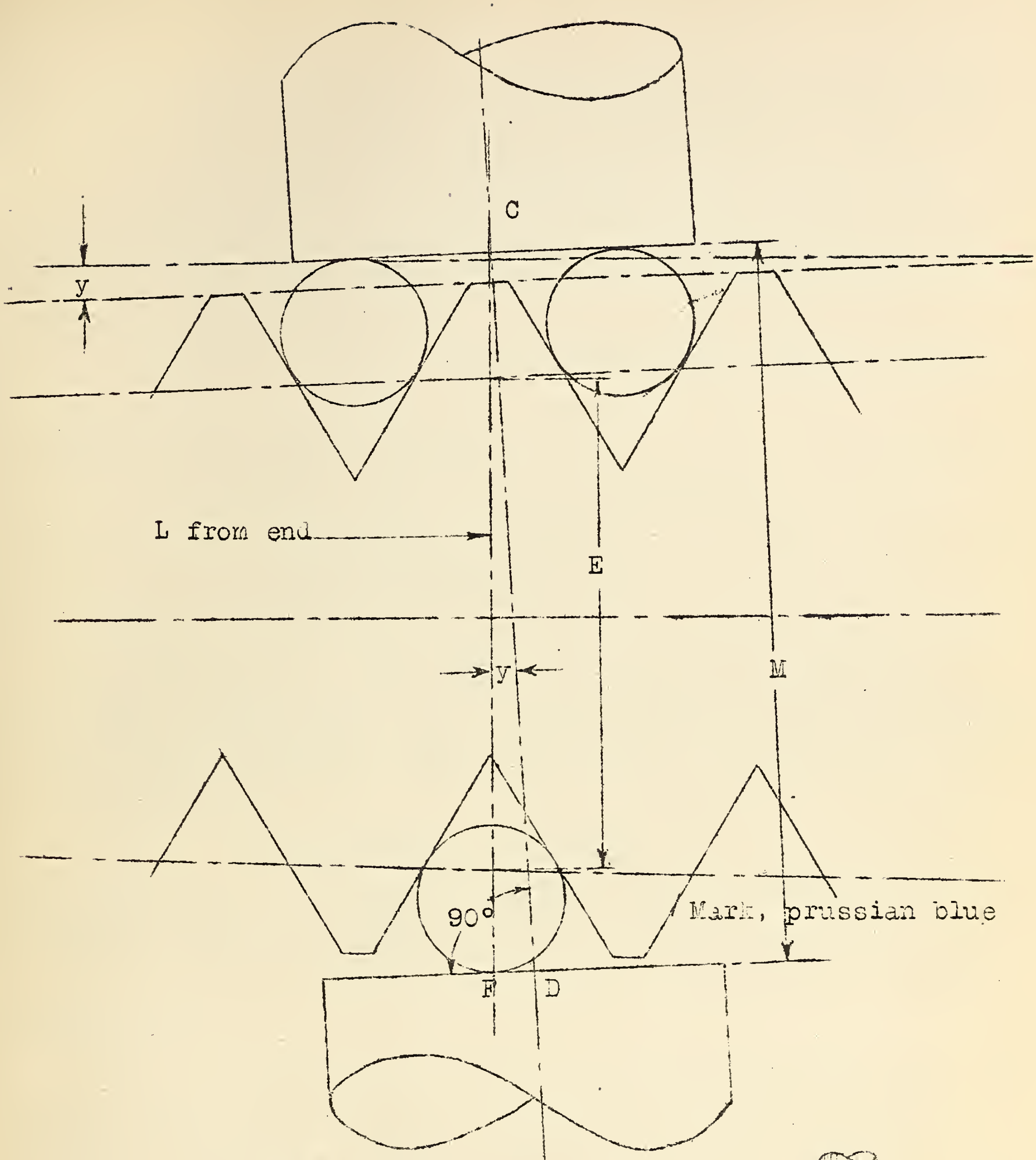


Fig. 3

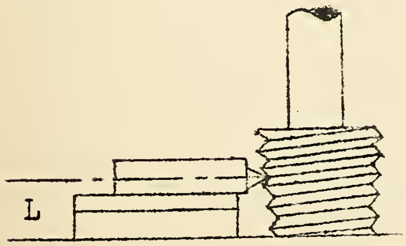


Fig. 3A

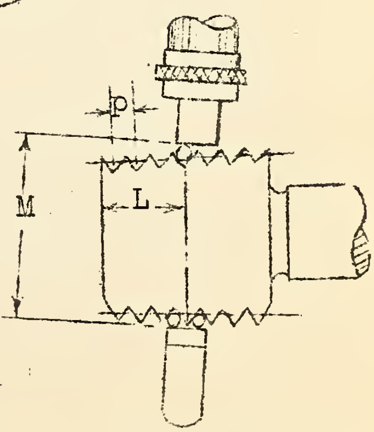


Fig. 3B

that the contact surfaces of the micrometer make contact with all three wires, since the micrometer is not perpendicular to the axis of the screw when there is proper contact. (See Fig. 3.) On account of this inclination, the measurement over the wires must be multiplied by the secant of the half angle of the taper of the thread. The general formula for the pitch diameter of any taper thread plug gage, the threads of which are symmetrical with respect to a line perpendicular to the axis, then has the form:

$$E = M \sec y + \frac{\cot a}{2n} - G\left(1 + \operatorname{cosec} a + \frac{S^2}{2}\cos a \cot a\right),$$

in which
- E = pitch diameter
- M = measurement over wires
- y = half angle of taper of thread
- n = number of threads per inch = $1/p$
- a = half angle of thread
- G = diameter of wires
- S = tangent of helix angle.

As the value of them $\left(\frac{GS^2}{2} \cos a \cot a\right)$ is ordinarily less than 0.00015 inch, it is usually neglected, and the pitch diameter of a National (Briggs') Standard Pipe Thread Gage having correct angle (60°) and taper (3/4 inch per foot) is then given by the formula:

$$E = 1.00048\ M + 0.86603\ p - 3G.$$

This practice is permissible provided that it is uniformly followed, and is observed by this Bureau except in cases when the value of the term $\left(\frac{GS^2}{2} \cos a \cot a\right)$ exceeds 0.00015 inch, which ordinarily occurs only on special threads having large helix angles.

When the threads are not symmetrical with respect to a line perpendicular to the axis of the screw, as is the case for British Standard Pipe Threads, the formula for the pitch diameter of a tapered thread gage, in which the helix angle is not taken into account, has the form:

$$E = M \sec y + \frac{\cos a_1 \cos a_2}{n \sin A} - G\left(1 + \frac{\cos a_1 + \cos a_2}{\sin A}\right),$$

in which, a_1 and a_2 = angles between line perpendicular to axis of thread and sides of thread

$$A = a_1 + a_2 .$$

For a British Standard Pipe Thread, having correct angle (55°) and taper (3/4 in. per ft.), and the bisector of the thread angle perpendicular to the cone, the above formula reduces to:

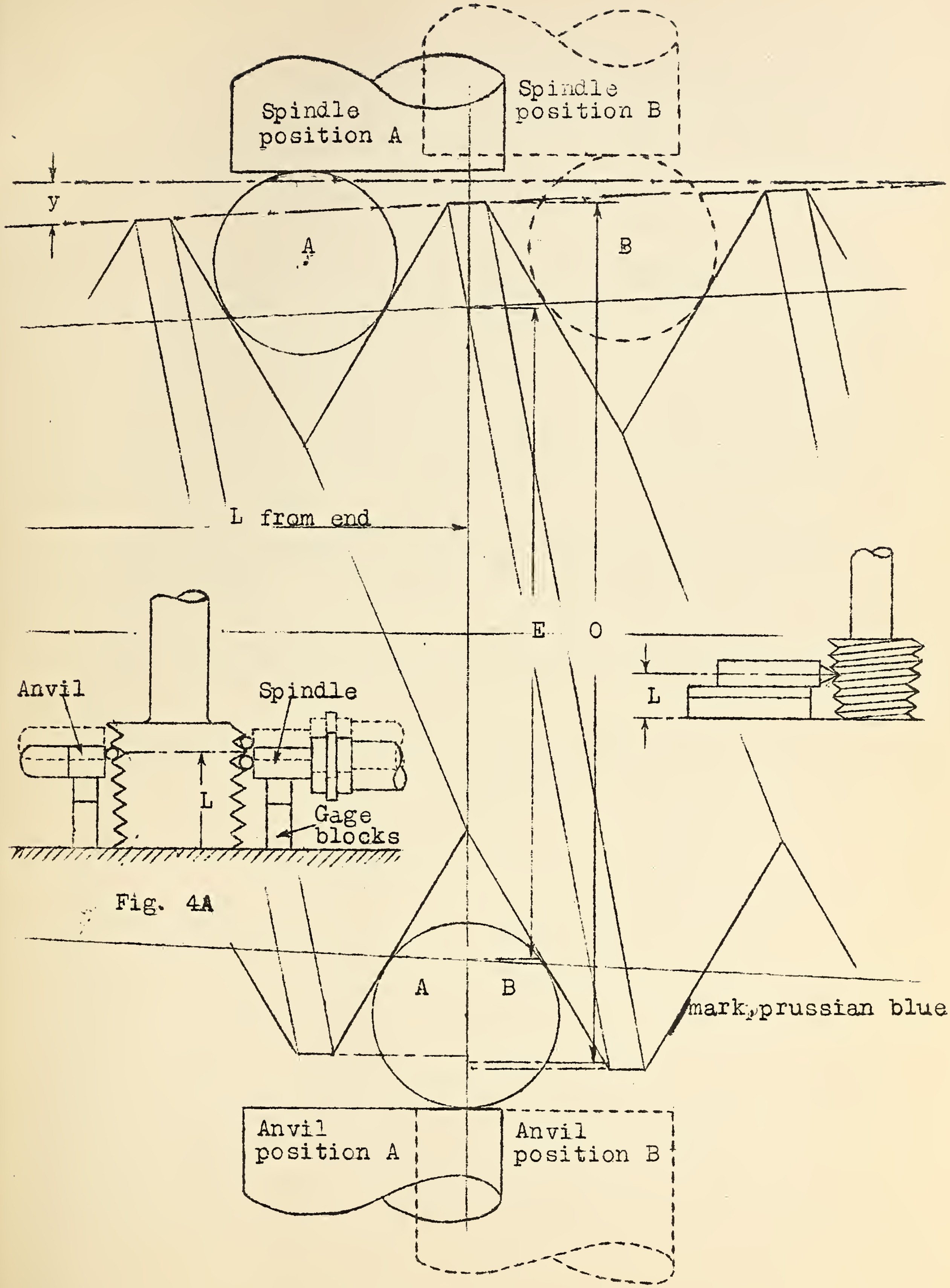
$$E = 1.00048\ M + 0.95931\ p - 3.16463\ G.$$

The pitch diameter at any other point along the thread, as at the gaging notch, is obtained by multiplying the distance parallel to the axis of the thread, between this point and the point at which the measurement was taken, by the taper per inch; then adding the product to, or subtracting it from the measured pitch diameter according to the direction in which the second point is located with respect to the first.

The following method, illustrated in Fig. 4, has a theoretical advantage over the first method in that it is independent of the taper of the thread, and, therefore, requires less computation; or if the taper is not measured but assumed to be correct, it is more accurate. The axis of the gage and the line of measurement are constrained perpendicular to each other. This is easily done on a measuring machine if the gage is supported on centers mounted on a slide whose ways are perpendicular to the line of measurement. If a micrometer caliper is used, its spindle is constrained perpendicular to the axis of the screw, either by a solid arm substituted for the swivel arm in the balanced micrometer, or by placing the gage on a surface plate with its axis vertical and supporting the micrometer in a horizontal position with its anvil and spindle resting on two equal combinations of gage blocks as shown in Fig. 4A. A single wire is inserted in the thread at the point located as in the previous method, and one other wire is placed in the upper thread on the opposite side. A measurement is taken over the two wires; the second wire is then moved to the thread immediately below, and a second reading is taken. The mean of these two readings is substituted in any of the above formulas.

2. Ring Gages

For the accurate measurement of the pitch diameter of a taper thread ring gage, the methods described for measuring straight thread ring gages by means of apparatus of special design may be applied, the point at which the measurement is made being carefully located, as in the case of taper thread plug gages. (See Reference No. 3.) As such means are not ordinarily available, the usual procedure is to fit the ring on a Reference Thread Plug Gage, and note the number of turns and fraction of a turn by which the gaging notch of the plug gage fails to match with the corresponding face of the ring gage. It should be remembered that errors in lead and angle of the Reference plug gage, which may be present, affect its fit with the ring gage under inspection, and such errors should be known and taken into consideration in determining whether the ring gage is within the specified tolerances. (See Reference No. 4.)


Spindle
position A
Spindle
position B
y
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L from end
E
O
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mark, prussian blue
Anvil
position A
Anvil
position B
Anvil
Spindle
L
Gage
blocks

Fig. 4A

Fig. 4

There are given in Tables 6 and 7, herein, the diameter equivalents of given errors in lead and angle which are to be added to the measured pitch diameter of the Reference plug gage for a National (American Briggs') Standard Pipe Thread to determine its effective size.

IV. MEASUREMENT OF TAPER

The taper per inch of a taper thread plug gage can be readily determined by measuring over wires, as in the three-wire method, first in any thread near the small end, then in another thread near the large end at a known distance from the first position, and dividing the difference between these measurements by the distance between the positions at which they were taken. The correctness of the taper of a taper thread ring gage can best be checked by fitting it on a concrete taper threaded check plug coated thinly with Prussian Blue and noting after disassembling whether bearing occurred over the entire length of the plug.

The measured taper of a pipe thread gage for either National (American Briggs') or British Standard Pipe Threads is correct when:

Full taper of thread = 1/16 inch on diameter per inch of length, and the following constants relating to taper then apply:

Included angle of taper, Y = 3° 34' 48"
Half-angle of taper, y = 1° 47' 24"
Cosine y = 0.99951
Secant y = 1.00048

V. MEASUREMENT OF MAJOR DIAMETER

Two methods, similar to those described for measuring pitch diameter, may be used for measuring the major diameter of a taper thread plug gage. In either case the anvil of a micrometer caliper or measuring machine is placed in contact with the crest of the thread directly opposite the point located at a known distance, L, from the end of the gage, as shown in Figs. 5 and 6. In one case the axis of the spindle of the micrometer is perpendicular to one side of the conical surface enveloping the thread, and has contact with two or more threads, as in Fig. 5. To obtain the correct value of the major diameter, D, at the distance, L, from the end of the gage, it is necessary to multiply the reading of the micrometer, T, by the secant of the half-angle of the taper. In the case of a thread having a flat truncation, it is also

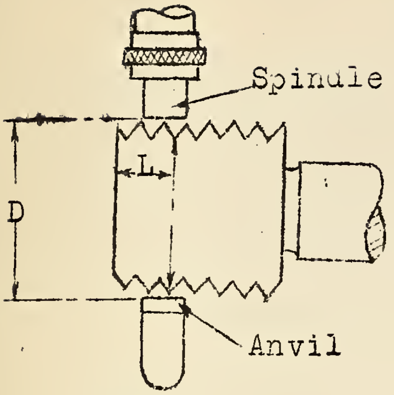


Fig. 5

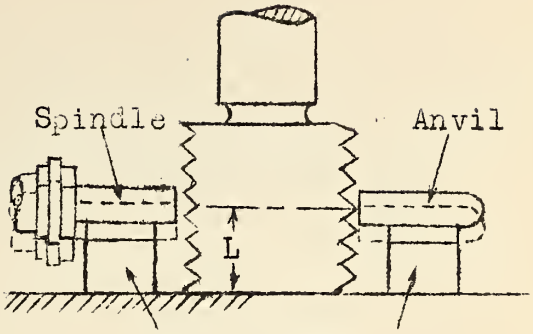
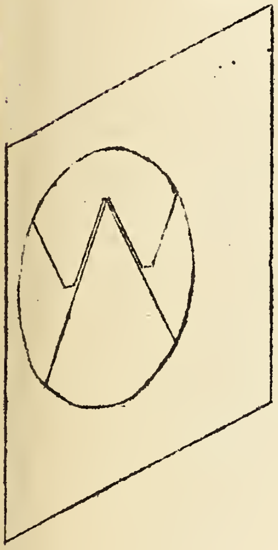


Fig. 6



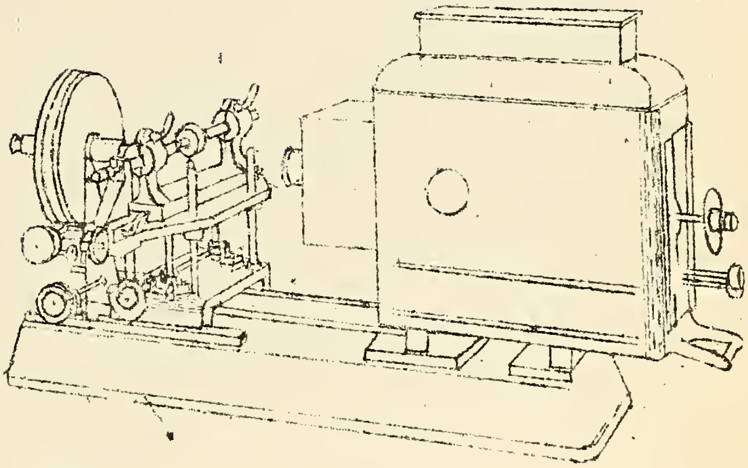


Fig. 8

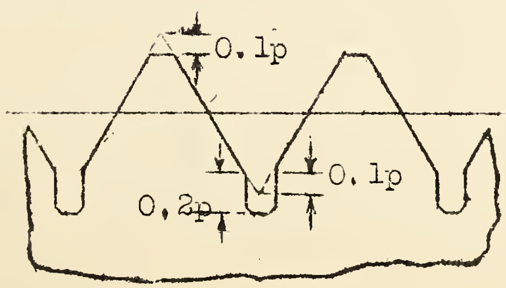


Fig. 9

necessary to subtract a correction on account of the fact that the anvil does not bear flatly on the crest, but on the higher corner, which amounts to the quantity (f tan a tan y), f being the depth of truncation. Thus, the formula for the major diameter, by this method, of a National (American Briggs') Standard Pipe Thread gage, the crests of which are truncated an amount equal to 0.1p, is:

$$D = 1.00048T - 0.00180p;$$

and for a British Standard Pipe Thread gage,

$$D = 1.00048T.$$

In the other method, the axis of the micrometer is constrained perpendicular to the axis of the screw, as shown in Fig. 6, and the anvil of the micrometer again has contact with the single crest at the distance L. Two measurements are made, one, T_1, with the spindle of the micrometer in contact with the crest directly beneath the point at the distance L, and the other, T_2, with the spindle in contact with the crest directly above. To determine the correct value of the major diameter D, at the distance L from the end of the gage, the mean of these readings is taken, and, in the case of a truncated thread, a correction is subtracted equal to the quantity (2f tan a tan y), on account of the fact that both anvil and spindle do not bear flatly on the crests, but on the high corners. Thus, the formula for the major diameter, by this second method, of a National (American Briggs') Standard Pipe Thread gage, the crests of which are truncated an amount equal to 0.1p, is:

$$D = \frac{T_1 + T_2}{2} - 0.00361p;$$

and for a British Standard Pipe Thread gage,

$$D = \frac{T_1 + T_2}{2}.$$

The taper being known, the diameter at any other point on the gage, as at the gaging notch, may then be computed. In determining either pitch or major diameter, it is not good practice to rely on the measurements made at a single point, but check measurements should be made at right angles to the first, and also at different points along the thread. In this way, out-of-roundness and other variations may be detected.

VI. MEASUREMENT OF PITCH

The presence of error in lead or pitch between any two threads of a thread gage is of importance because of its

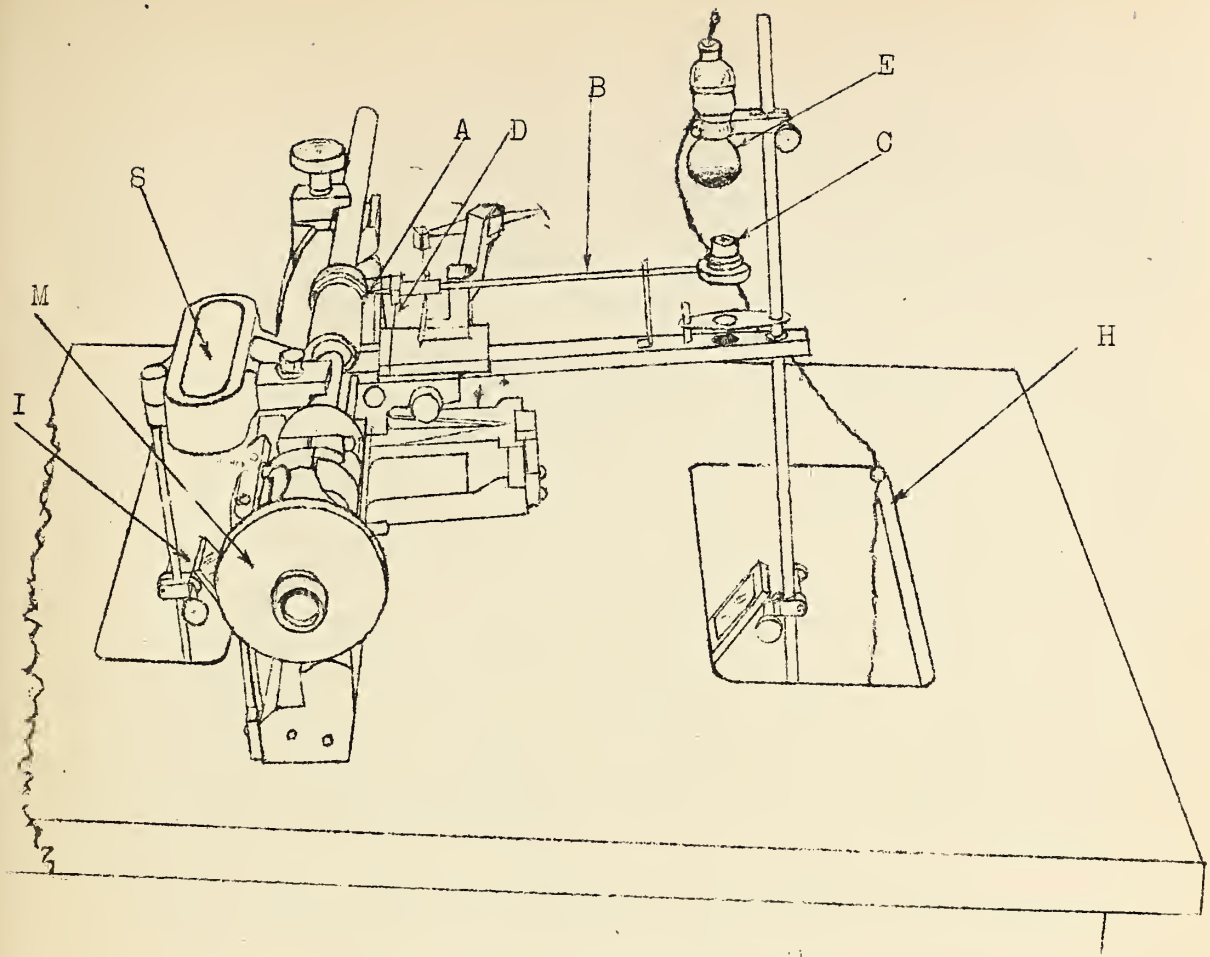
effect on the effective size, or fit, of the gage. For this reason the pitch of a thread gage must be measured to determine the magnitude of such errors. (See Reference No. 4.) Various commercial devices for determining error in pitch are available and usually take the form of comparators for comparing the screw with a standard over 1/4, 1/2, or 1 inch intervals.

The machine found most satisfactory for this purpose by the Bureau of Standards is of a design similar to that of a device used by the National Physical Laboratory, England. Two types of this machine were developed by the Gage Section of the Bureau of Standards, one, type "A", to measure the pitch of straight or cylindrical thread gages, the other, type "B", to measure taper thread gages having a taper of 1/16 inch per inch. (See Reference No. 5.)

By means of this machine, shown in Fig. 7, direct measurements of pitch between any two threads may be made; a special micrometer screw, having a straight line calibration curve to within 0.00002 inch and provided with an aluminum head graduated directly to 0.0001 inch, being the means of measurement. The method of operation of this machine is as follows:

A ball pointed stylus A, Fig. 7, rests in the groove of the thread to be measured and is supported at the end of a floating arm B, which carries a lens C, at the other end. The arm B is supported by a flexible flat steel spring D, and the movable support upon which the spring is carried is so adjusted that the spring D exerts a slight pressure on the floating arm B, which tends to cause the stylus A to bear firmly against the sides of the thread. When the stylus is resting evenly on both sides of the thread, the lens C is directly beneath the lamp E, and the image of the straight filament in the lamp E is projected by the lens C downward to a prism H, by which it is reflected under the machine to the prism I, and is again reflected by this second prism to the screen S. When the image of the filament coincides with a reference line on the screen S, the micrometer M is read and the reading recorded. The turning of the micrometer head M causes the carriage supporting the micrometer, stylus, lens, lamp, prisms, and screen to move with reference to the thread, which remains stationary. Upon moving the micrometer head an amount corresponding to one thread interval, the stylus comes to a position in the next thread similar to the position in the preceding thread and the micrometer setting is adjusted until the image of the filament coincides with the index line as before. The micrometer reading is again recorded and the difference between the two micrometer readings indicates directly the pitch interval traversed.

In a similar manner each thread interval along the gage may be measured, and the maximum variation in lead over the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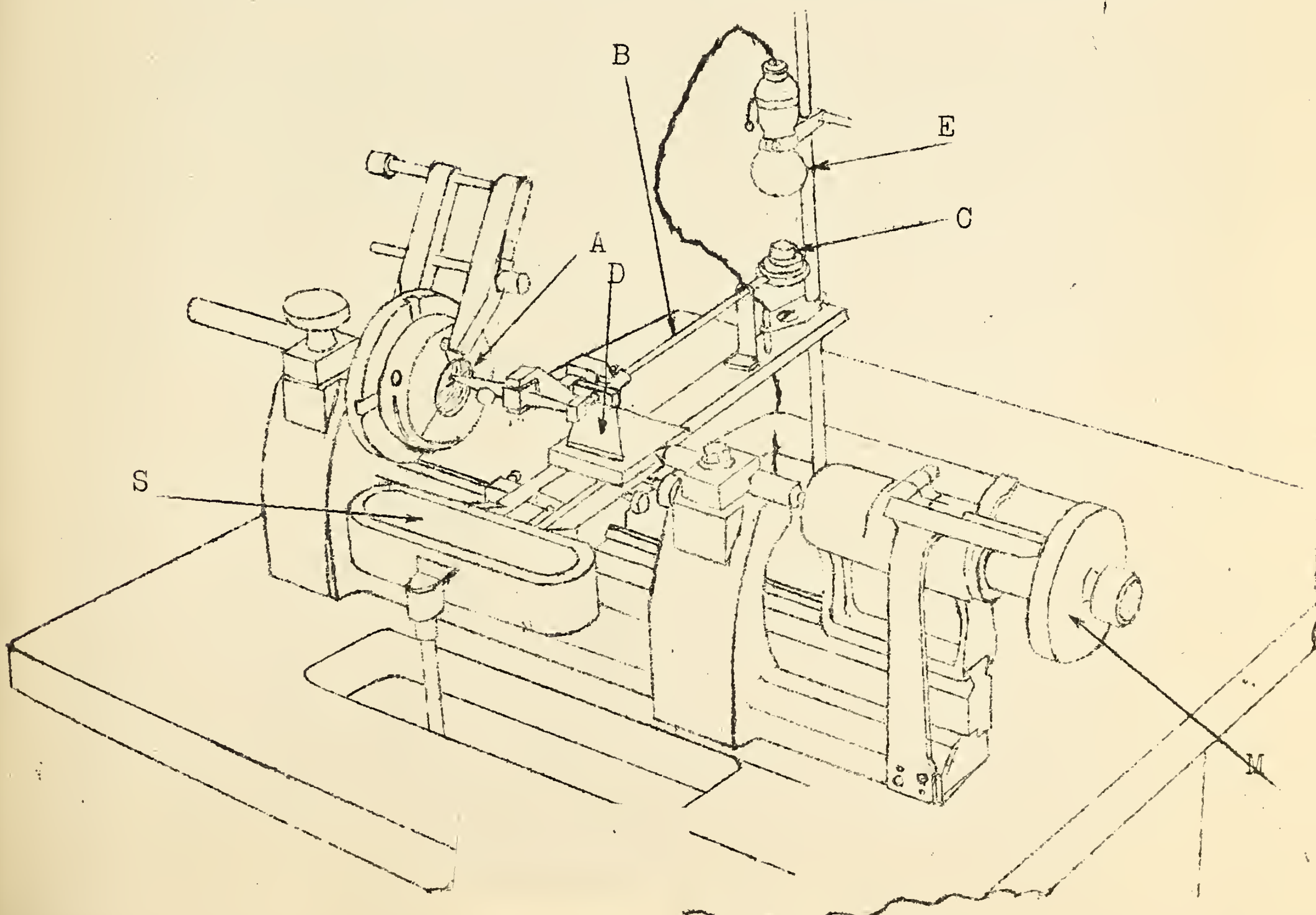
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entire threaded portion may be determined. The stylus, lens, lamp, reflectors and screen merely form a sensitive optical indicator for the micrometer settings. For the measurement of thread ring gages, a swivel arm attachment, shown in Fig. 7A, serves to introduce the stylus point into the thread. A face plate, on which the ring gage may be clamped, is provided.

In the type "B" machine used for measuring National (American Briggs') or British Standard Pipe Thread Gages, the line of travel of the carriage bearing the stylus and micrometer head is at an angle, horizontally, to the axis of the centers bearing the gage, of 1° 47'. This is necessary in order that the stylus point, and thus the image of the filament, will occupy the same relative position for successive threads. Otherwise the lens would move progressively forward or backward with the movement of the stylus along the thread. The lead is thus measured along the taper and the values obtained must be multiplied by the cosine of the half-angle of the taper of the thread to reduce them to values equivalent to those parallel to the axis of the thread. The correction is made for National (American Briggs') or British Standard Pipe Threads by multiplying the measurements obtained by 0.99951, or by subtracting the amount 0.00049 inch per inch.

VI. MEASUREMENT OF THREAD ANGLE AND EXAMINATION OF THREAD FORM

For both accuracy and rapidity, the optical projection method of measuring the thread angle of a thread gage is found to be superior to other methods, and it also affords a means of easy examination of the thread form. The projection apparatus developed and used by the Gage Section of the Bureau of Standards is illustrated in Fig, 8. It consists essentially of an approximate point source of light, as an electric arc, a condensing lens, a system of projection lenses, a screen, a gage support provided with means for adjusting the gage vertically, longitudinally (focally), and transversely; and a device for measuring the thread angle of the projected shadow-image of the thread.

The point source of light is at the principal focus of the condensing lens, and the resultant beam of parallel light, which is incident on the gage, may be directed parallel to the helix angle of the thread by rotating the lamp and condensing lens about a point beneath the gage and in the vertical axial plane of the projection lens. The gage and the screen are at conjugate focal distances from the projection lens. The projection lens system consists of a 32 or 48 mm. microscope objective and a Ramsden eyepiece of magnification 5. At the focal plane of the eyepiece a 60° template is mounted inside of a graduated drum by means of which the amount of rotation of the template may be measured. The slow-motion adjustment for this rotation consists of a worm gear on the drum, and a worm shaft, which carries a graduated head at its end for reading minutes of angle.

In measuring the angle of a screw thread, the edges of the shadow images of the template and thread are made to coincide. The gage is then moved transversely by operating an adjusting screw on the gage holder, and the template is rotated until the other edges of the shadow-images of template and screw coincide. The angle through which the template was rotated is the measure of the difference between the thread angle of the sorew and the angle of the template.

The angle and thread form of a thread ring gage may be inspected by projecting the shadow-image of a cast of the thread, made by pouring a fused mixture of about 90% sulphur and 10% graphite into the thread.

The straightness of the sides of the thread is examined by matching the shadow-images of thread and template in the same manner as in the measurement of thread angle. The smoothness of the surface of the thread may be examined visually or with the aid of a magnifying glass. The wearing life of a gage depends as much upon the smoothness of its surface as upon its hardness, and it is therefore very desirable that the surface be made as smooth as possible by finish-lapping with a very fine abrasive.

A proper clearance at the root of the thread, of a thread gage, is necessary to insure bearing upon the sides of the threads, rather than at the crests and roots, and thus to secure satisfactory fit of the product gaged. For this reason, and to facilitate grinding and lapping, the root of the thread of a pipe thread gage should be undercut, as shown in Figs. 9 and 13. A visual examination of the projected shadow-image will show whether proper clearance at the root of the thread has been provided.

When the major and pitch diameters of a thread plug gage have been determined by readings taken at right angles to each other, and at different points along the thread, the concentricity of these diameters at a few places should be checked. This is important if these diameters were finished separately, by using different laps, or in different set-ups in grinding, since in these cases the diameters might be eccentric. The eccentricity may be readily determined in the case of a plug gage by measuring over one wire placed in the thread, with the anvil of the micrometer in contact with the wire and the spindle in contact with the crest of the thread. Observations are made on the variation in the readings obtained during one revolution of the gage, keeping on the same thread, due allowance being made for the taper. Another method, whereby eccentricity may be detected, consists on rotating the gage in the projection lantern and observing the presence of any pronounced variations in the width of the flat at the crest of the thread. In the case of ring gages, sulphur-graphite casts made on opposite sides of the thread in the ring may be examined in the projection lantern in a similar manner.

In case special facilities for measuring the included angle of a thread are not available, the angle of a plug gage may be determined approximately by means of two sets of wires of different diameters. Measurement is made over the wires, which are inserted in the thread, in the same manner as when the pitch diameter is measured. One measurement is taken over the minimum or best-size wires and a second is taken over the maximum wires. The sizes of maximum and minimum wires which may be used with National (American Briggs') or British Standard Pipe Threads are given in Tables 4 and 5. The angle may be computed from the measurements by applying the formula, derived in Appendix 4 of Letter Circular LC 23:

$$\text{Sin } a = \frac{(G_1 - G_2)\left(1 + \frac{S^2}{2}\right)}{(M_1 - M_2) - (G_1 - G_2)}$$

in which
G_1 = diameter of large set of wires
G_2 = diameter of small set of wires
M_1 = measurement over large wires
M_2 = measurement over small wires
a = half-angle of thread
S = tangent of helix angle of thread

This method cannot be relied upon to give results as accurate as measurements made by means of an optical projection apparatus and shadow protractor. A variation of this method is to use a single wire of each size and make the measurement with the spindle of the micrometer in contact with the crest of the thread. In this case the formula has the form:

$$\text{Sin } a = \frac{(G_1 - G_2)\left(1 + \frac{S^2}{2}\right)}{2(M_1 - M_2) - (G_1 - G_2)}$$

Values of S^2 for various helix angles are given in Table 12 of LC 23. Since the value of S^2 is small for small helix angles, the term $(1 + S^2/2)$ in the above formula may be neglected when the helix angle is less than two degrees.

VIII. REFERENCES

1. Further information regarding pipe thread standards and methods of gaging pipe threads may be obtained from the "Progress Report of the National Screw Thread Commission", Bureau of Standards Miscellaneous Publication No. 42, or "American Standard Pipe Thread", Report No. 3-1919 of the American Engineering Standards Committee; and "Report on British Standard Pipe Threads for Iron or Steel Pipes and Tubes", No. 21-1919, of the British Engineering Standards Association.

2. The three-wire method, as applied to all types of thread gages, is described and discussed in considerable detail in Bureau of Standards Letter Circular No. LC 23.

3. Two different types of machines for measuring the pitch diameter of thread ring gages have been developed at the National Physical Laboratory of Great Britain, which are described in Engineering (London), Vol. 112, October 21, 1921, pp. 558-560, and Vol. 114, August 18, 1922, pp, 213-214. A universal screw measuring machine for measuring the pitch diameter, lead, and other thread elements of both thread plug and thread ring gages is described in Engineering (London) Vol. 107, January 24, 1919, pp. 104-108, and Vol. 108, December 19, 1919, pp. 816-817.

4. The mathematical relations between effective size and lead and angle errors are discussed in Appendix 3 of Bureau of Standards Letter Circular No. LC 23.

5. Detailed designs of both types of lead measuring machine are available in Bureau of Standards Letter Circular No. LC 17.

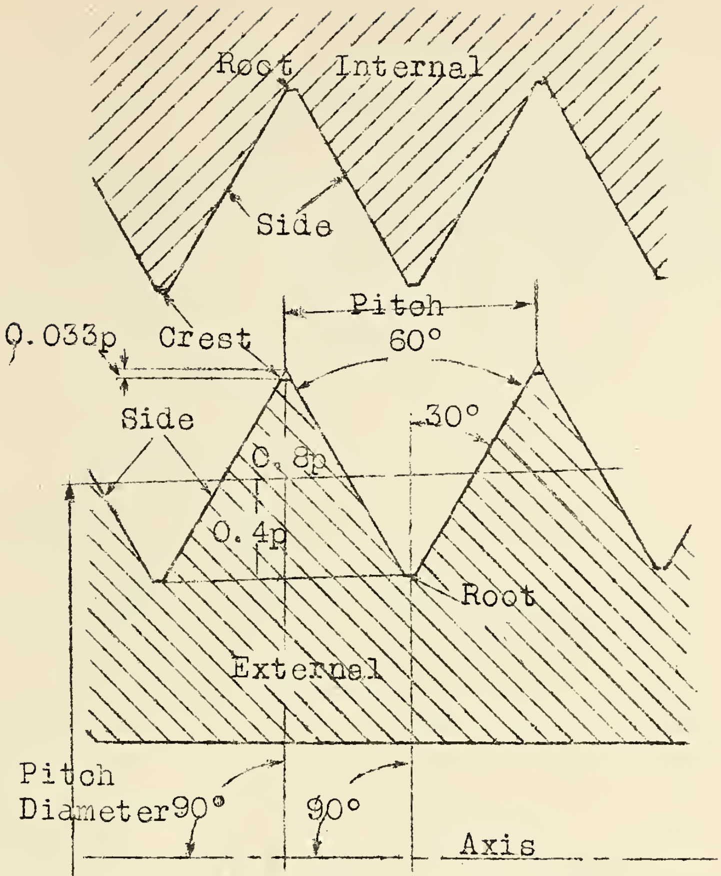

Fig. 10. - Form of National Taper Pipe Thread

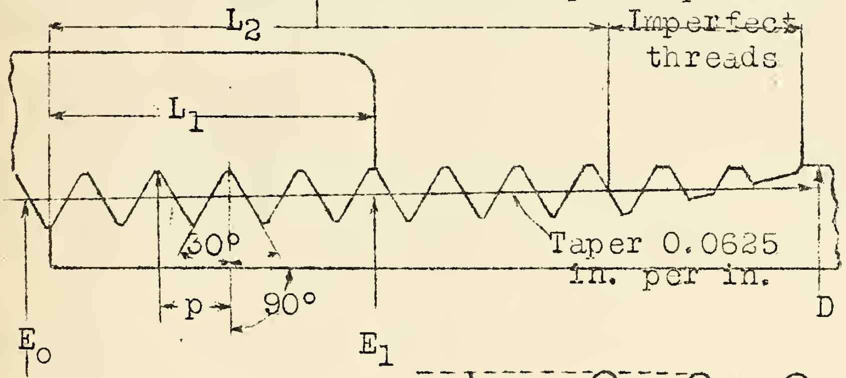

Fig. 11. - National Taper Pipe Thread Notation

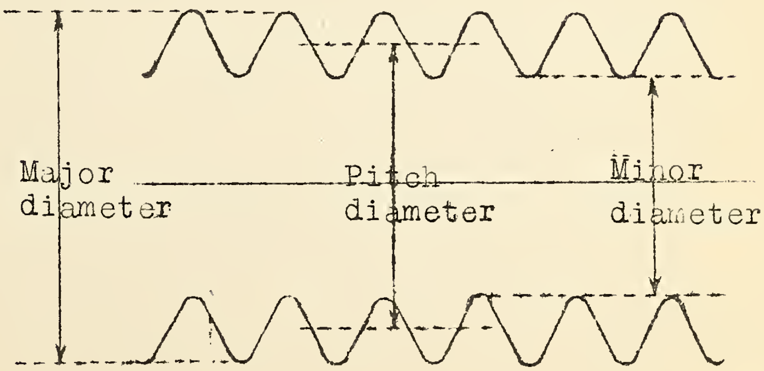

Fig. 12. - Form of British Standard Pipe Threads.

Fig. 13. - Gages for British Standard Pipe Threads

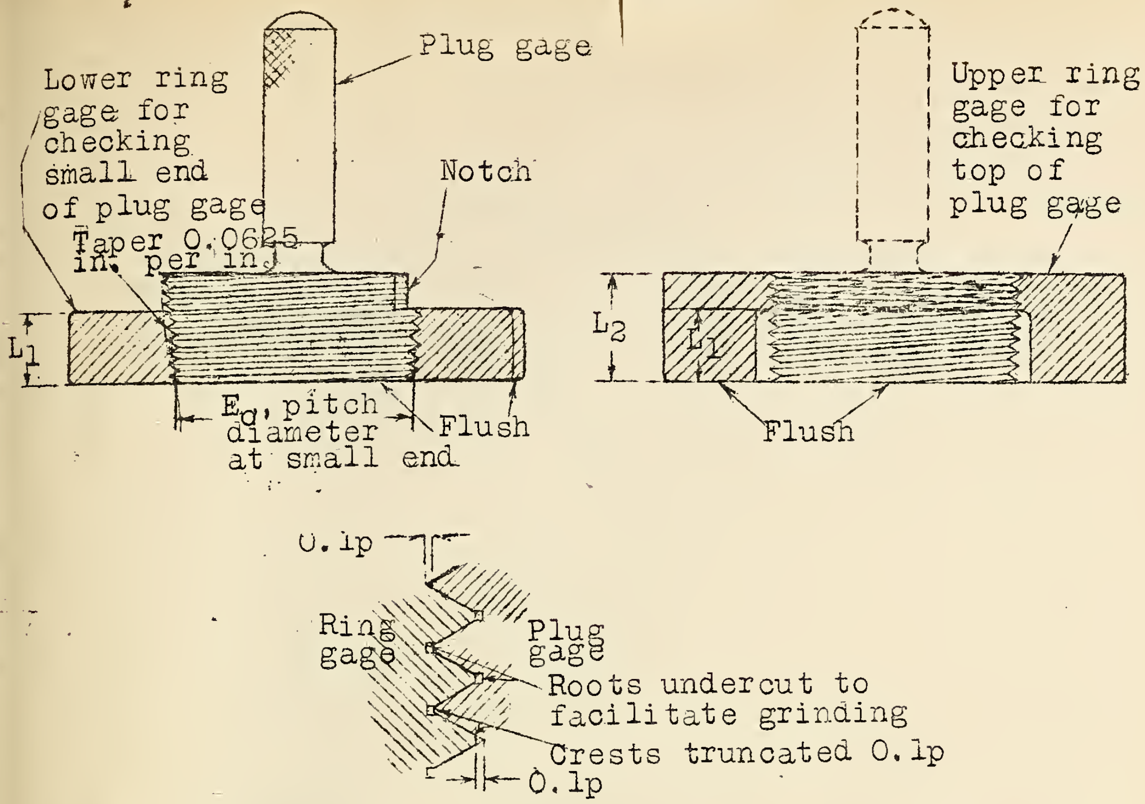

Fig. 13. - Reference Gages for Checking Working Gages

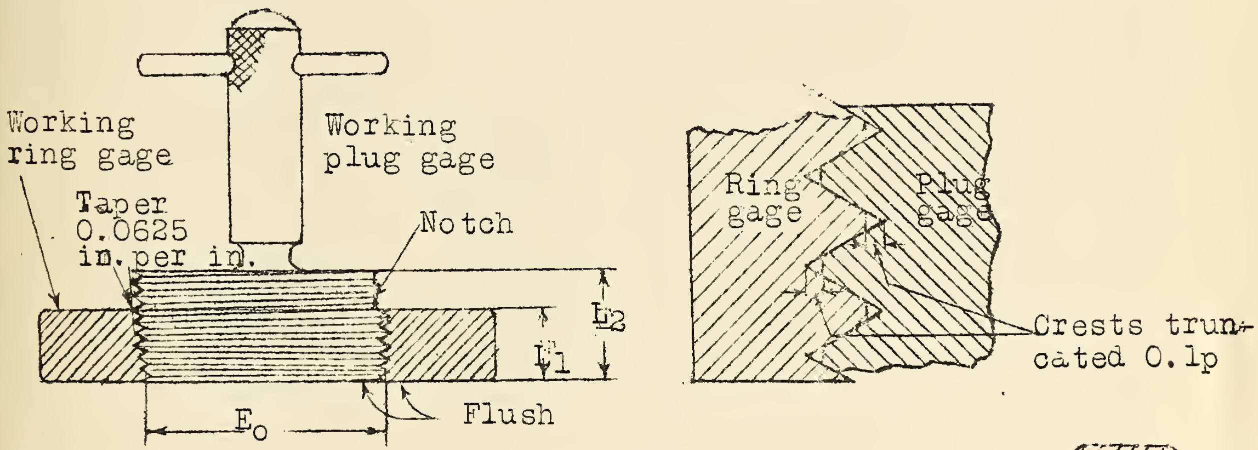

Fig. 14. - Working Gages for Checking Product

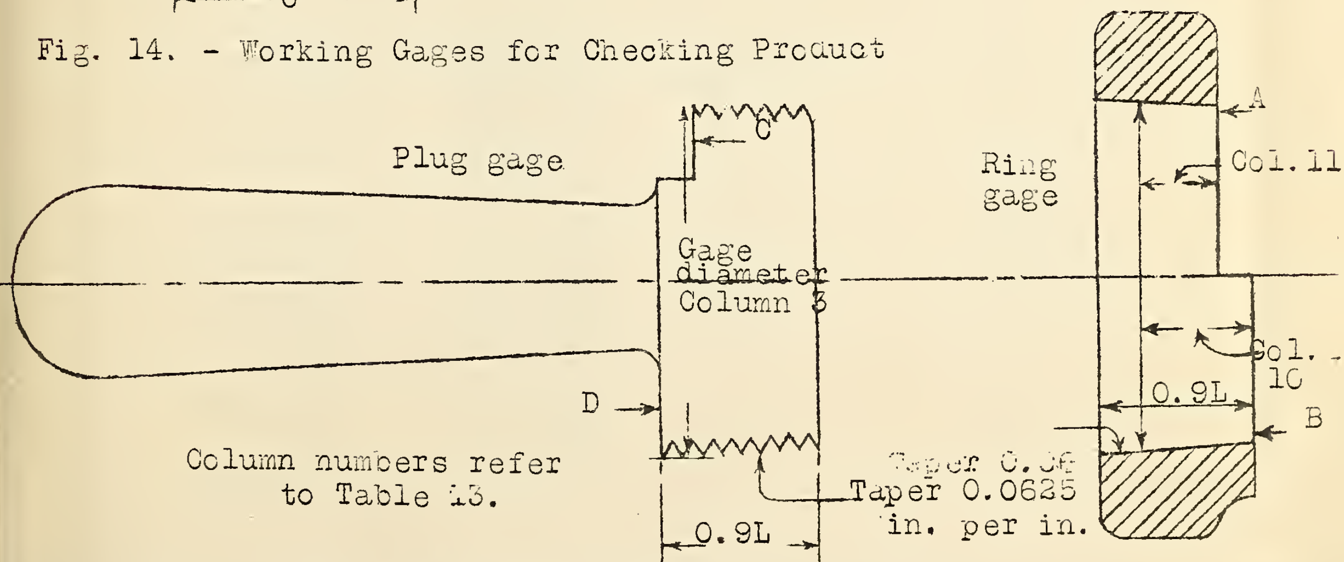

Fig. 15. - Gages for British Standard Pipe Threads

Table 1.-Basic Dimensions of National (Briggs') Taper Pipe Threads

1	2	3	4	5	6	7	8
Nominal size of pipe	Number of threads per inch n	Pitch p	Depth of thread	Outside dia. of pipe D	Length of normal engagement by hand L_1	Length of effective thread L_2	Increase in dia. per thd. $\frac{0.0625}{n}$
Inches		Inches	Inches	Inches	Inches	Inches	Inches
1/8	27	0.03704	0.02963	0.405	0.180	0.26385	0.00231
1/4	18	.05556	.04444	.540	.200	.40178	.00347
3/8	18	.05556	.04444	.675	.240	.40778	.00347
1/2	14	.07143	.05714	.840	.320	.53371	.00446
3/4	14	.07143	.05714	1.050	.339	.54571	.00446
1	11 1/2	.08696	.06957	1.315	.400	.68278	.00543
1 1/4	11 1/2	.08696	.06957	1.660	.420	.70678	.00543
1 1/2	11 1/2	.08696	.06957	1.900	.420	.72348	.00543
2	11 1/2	.08696	.06957	2.375	.436	.75652	.00543
2 1/2	8	.12500	.10000	2.875	.682	1.13750	.00781
3	8	.12500	.10000	3.500	.766	1.20000	.00781
3 1/2	8	.12500	.10000	4.000	.821	1.25000	.00781
4	8	.12500	.10000	4.500	.844	1.30000	.00781
4 1/2	8	.12500	.10000	5.000	.875	1.35000	.00781
5	8	.12500	.10000	5.563	.937	1.40630	.00781
6	8	.12500	.10000	6.625	.958	1.51250	.00781
7	8	.12500	.10000	7.625	1.000	1.61250	.00781
8	8	.12500	.10000	8.625	1.063	1.71250	.00781
9	8	.12500	.10000	9.625	1.130	1.81250	.00781
10	8	.12500	.10000	10.750	1.210	1.92500	.00781
11	8	.12500	.10000	11.750	1.285	2.02500	.00781
12	8	.12500	.10000	12.750	1.360	2.12500	.00781
14 O.D.	8	.12500	.10000	14.000	1.562	2.25000	.00781
15 O.D.	8	.12500	.10000	15.000	1.687	2.35000	.00781
16 O.D.	8	.12500	.10000	16.000	1.812	2.45000	.00781
17 O.D.	8	.12500	.10000	17.000	1.900	2.55000	.00781
18 O.D.	8	.12500	.10000	18.000	2.000	2.65000	.00781
20 O.D.	8	.12500	.10000	20.000	2.125	2.85000	.00781
22 O.D.	8	.12500	.10000	22.000	2.250	3.05000	.00781
24 O.D.	6	.12500	.10000	24.000	2.375	3.25000	.00781
26 O.D.	8	.12500	.10000	26.000	2.500	3.45000	.00781
28 O.D.	8	.12500	.10000	28.000	2.625	3.65000	.00781
30 O.D.	8	.12500	.10000	30.000	2.750	3.85000	.00781

1	9	10	11	12	13	14	15	16
	Major diameters		Pitch diameters			Minor diameters		
Nominal size of pipe	At end of pipe, or at length L_1 from end of coupling $E_o + \frac{0.8}{n}$	At length L_1 on pipe, or at end of coupling $E_1 + \frac{0.8}{n}$	At end of pipe, or at length L_1 from end of coupling $E_o = D - \frac{.05D + 1.1}{n}$	At length L_1 on pipe, or at end of coupling $E_1 = E_o + \frac{L_1}{16}$	At length L_2 on pipe $E_2 = E_o + \frac{L_2}{16}$	At end of pipe, or at length L_1 from end of coupling $E_o - \frac{0.8}{n}$	At length L_1 on pipe, or at end of coupling $E_1 - \frac{0.8}{n}$	At length L_2 on pipe $E_2 - \frac{0.8}{n}$
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1/8	0.39314	0.40439	0.36351	0.37476	0.38000	0.33388	0.34513	0.35037
1/4	.52183	.53433	.47739	.48989	.50250	.43294	.44544	.45806
3/8	.65646	.67146	.61201	.62701	.63750	.56757	.58257	.59306
1/2	.81557	.83557	.75843	.77843	.79179	.70129	.72129	.73464
3/4	1.02482	1.04601	.96768	.98887	1.00179	.91054	.93172	.94464
1	1.28320	1.30820	1.21363	1.23863	1.25630	1.14406	1.16906	1.18674
1 1/4	1.62670	1.65295	1.55713	1.68338	1.60130	1.48756	1.51382	1.53174
1 1/2	1.86565	1.89190	1.79609	1.82234	1.84130	1.72652	1.75277	1.77174
2	2.33859	2.36584	2.26902	2.29627	2.31630	2.19946	2.22671	2.24674
2 1/2	2.81953	2.86216	2.71953	2.76216	2.79062	2.61953	2.66216	2.69062
3	3.44062	3.48850	3.34062	3.38850	3.41562	3.24062	3.28850	3.31562
3 1/2	3.93750	3.98881	3.83750	3.88881	3.91562	3.73750	3.78881	3.81562
4	4.43438	4.48712	4.33438	4.38712	4.41562	4.23438	4.28712	4.31562
4 1/2	4.93125	4.98594	4.83125	4.88594	4.91562	4.73125	4.78594	4.81562
5	5.49073	5.54929	5.39073	5.44929	5.47862	5.29073	5.34929	5.37862
6	6.54609	6.60597	6.44609	6.50597	6.54062	6.34609	6.40597	6.44062
7	7.53984	7.60234	7.43984	7.50234	7.54062	7.33984	7.40234	7.44062
8	8.53359	8.60003	8.43359	8.50003	8.54062	8.33359	8.40003	8.44062
9	9.52734	9.59797	9.42734	9.49797	9.54062	9.32734	9.39797	9.44062
10	10.64531	10.72094	10.54531	10.62094	10.66562	10.44531	10.52094	10.56562
11	11.63906	11.79138	11.53906	11.61938	11.66562	11.43906	11.51938	11.56562
12	12.63281	12.71781	12.53281	12.61781	12.66562	12.43281	12.51781	12.56562
14 O.D.	13.87500	13.97262	13.77500	13.87262	13.91562	13.67500	13.77262	13.81562
15 O.D.	14.86875	14.97419	14.76875	14.87419	14.91562	14.66875	14.77419	14.81562
16 O.D.	15.86250	15.97575	15.76250	15.87575	15.91562	15.66250	15.77575	15.81562
17 O.D.	16.85625	16.97500	16.75625	16.87500	16.91562	16.65625	16.77500	16.81562
18 O.D.	17.85000	17.97500	17.75000	17.87500	17.91562	17.65000	17.77500	17.81562
20 O.D.	19.83750	19.97031	19.73750	19.87031	19.91562	19.63750	19.77031	19.81562
22 O.D.	21.82500	21.96562	21.72500	21.86562	21.91562	21.62500	21.76562	21.81562
24 O.D.	23.81250	23.96094	23.71250	23.86094	23.91562	23.61250	23.76094	23.81562
26 O.D.	25.80000	25.95625	25.70000	25.85625	25.91562	25.60000	25.75625	25.81562
28 O.D.	27.88750	27.95165	27.68750	27.85156	27.91562	27.58750	27.75156	27.81562
30 O.D.	29.77500	29.94688	29.67500	29.84688	29.91562	29.57500	29.74688	29.81562

Table 2.-Basic Dimensions of Threaded Plug and Ring Gages for National (Briggs') Taper Pipe Threads

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
			Major diameters of plug gages*			Pitch diameters of plug & ring gages			Minor diameters of ring gages*					
Nominal size of pipe	No. of thds. per in. n	Pitch p	At small end, $E_0 + \frac{.666025}{n}$	At gaging notch, $E_1 + \frac{.666025}{n}$	At large end, full ring, $E_2 + \frac{.666025}{n}$	At small end, E_0	At gaging notch, E_1	At large end, full ring, E_2	At small end, $E_0 - \frac{.666025}{n}$	At gaging notch, $E_1 - \frac{.666025}{n}$	At large end, full ring, $E_2 - \frac{.666025}{n}$	Increase in dia. per thd. $\frac{0.0625}{n}$	Thickness of thin ring, L_1	Thickness of full ring, L_2
Inches		Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1/8	27	0.03704	0.38818	0.39943	0.40467	0.36351	0.37476	0.38000	0.33884	0.35009	0.35533	0.00231	0.180	0.26385
1/4	18	.05556	.51439	.52689	.53950	.47739	.48989	.50250	.44039	.45289	.46550	.00347	.200	.40178
3/8	18	.05556	.64902	.66402	.67450	.61201	.62701	.63750	.57501	.59001	.60050	.00347	.240	.40778
1/2	14	.07143	.80600	.82600	.83936	.75843	.77843	.79179	.71086	.73086	.74421	.00446	.320	.53371
3/4	14	.07143	1.01525	1.03644	1.04936	.96768	.98887	1.00179	.92011	.94129	.95421	.00446	.339	.54571
1	11½	.08696	1.27155	1.29655	1.31422	1.21363	1.23863	1.25630	1.15571	1.18071	1.19839	.00543	.400	.68278
1 1/4	11½	.08696	1.61505	1.64130	1.65922	1.55713	1.58338	1.60130	1.49921	1.52546	1.54339	.00543	.420	.70678
1 1/2	11½	.08696	1.85400	1.88025	1.89922	1.79609	1.82234	1.84130	1.73817	1.76442	1.78339	.00543	.420	.72348
2	11½	.08696	2.32694	2.35419	2.37422	2.26902	2.29627	2.31630	2.21111	2.23836	2.25839	.00543	.436	.75652
2 1/2	8	.12500	2.80278	2.84541	2.87388	2.71953	2.76216	2.79062	2.63628	2.67890	2.70737	.00781	.682	1.13750
3	8	.12500	3.42388	3.47175	3.49888	3.34062	3.38850	3.41562	3.25737	3.30525	3.33237	.00781	.766	1.20000
3 1/2	8	.12500	3.92075	3.97207	3.99888	3.83750	3.88881	3.91562	3.75425	3.80556	3.83237	.00781	.821	1.25000
4	8	.12500	4.41763	4.47038	4.49888	4.33438	4.38712	4.41562	4.25112	4.30387	4.33237	.00781	.844	1.30000
4 1/2	8	.12500	4.91450	4.96919	4.99888	4.83125	4.88594	4.91562	4.74800	4.80268	4.83237	.00781	.875	1.35000
5	8	.12500	5.47398	5.53255	5.56188	5.39073	5.44929	5.47862	5.30748	5.36604	5.39537	.00781	.937	1.40630
6	8	.12500	6.52935	6.58922	6.62388	6.44609	6.50597	6.54062	6.36284	6.42272	6.45737	.00781	.958	1.51250
7	8	.12500	7.52310	7.58560	7.62388	7.43984	7.50234	7.54062	7.35659	7.41909	7.45737	.00781	1.000	1.61250
8	8	.12500	8.51685	8.58328	8.62388	8.43359	8.50003	8.54062	8.35034	8.41678	8.45737	.00781	1.063	1.71250
9	8	.12500	9.51060	9.58122	9.62388	9.42734	9.49797	9.54062	9.34409	9.41472	9.45737	.00781	1.130	1.81250
10	8	.12500	10.62857	10.70419	10.74888	10.54531	10.62094	10.66562	10.46206	10.53768	10.58237	.00781	1.210	1.92500
11	8	.12500	11.62232	11.70263	11.74888	11.53906	11.61938	11.66562	11.45581	11.53612	11.58237	.00781	1.285	2.02500
12	8	.12500	12.61607	12.70107	12.74888	12.53281	12.61781	12.66562	12.44956	12.53456	12.58237	.00781	1.360	2.12500
14 O.D.	8	.12500	13.85825	13.95588	13.99888	13.77500	13.87262	13.91562	13.69175	13.78937	13.83237	.00781	1.562	2.25000
15 O.D.	8	.12500	14.85200	14.95744	14.99888	14.76875	14.87419	14.91562	14.68550	14.79093	14.83237	.00781	1.687	2.35000
16 O.D.	8	.12500	15.84575	15.95900	15.99888	15.76250	15.87575	15.91562	15.67925	15.79250	15.83237	.00781	1.812	2.45000
17 O.D.	8	.12500	16.83950	16.95825	16.99888	16.75625	16.87500	16.91562	16.67300	16.79175	16.83237	.00781	1.900	2.55000
18 O.D.	8	.12500	17.83325	17.95825	17.99888	17.75000	17.87500	17.91562	17.66675	17.79175	17.83237	.00781	2.000	2.65000
20 O.D.	8	.12500	19.82075	19.95357	19.99888	19.73750	19.87031	19.91562	19.65425	18.78706	19.83237	.00781	2.125	2.85000
22 O.D.	8	.12500	21.80825	21.94888	21.99888	21.72500	21.86562	21.91562	21.64175	21.78237	21.83237	.00781	2.250	3.05000
24 O.D.	8	.12500	23.79575	23.94419	23.99888	23.71250	23.86094	23.91562	23.62925	23.77768	23.83237	.00781	2.375	3.25000
26 O.D.	8	.12500	25.78325	25.93950	25.99888	25.70000	25.85625	25.91562	25.61675	25.77300	25.83237	.00781	2.500	3.45000
28 O.D.	8	.12500	27.77075	27.93482	27.99888	27.68750	27.85156	27.91562	27.60425	27.76831	27.83237	.00781	2.625	3.65000
30 O.D.	8	.12500	29.75825	29.93013	29.99888	29.67500	29.84688	29.91562	29.59175	29.76362	29.83237	.00781	2.750	3.85000

*These dimensions are based on a crest truncation of 0.1 p for pipe thread gages, which insures bearing of the gage on the sides of the thread, when cut with a slightly dull tool, instead of at the roots, as specified in the Progress Report of the National Screw Thread Commission, Bureau of Standards Miscellaneous Publication No. 42. For tolerances on pipe thread gages see pages 81 and 82 of this progress report.

Table 3. - Dimensions of British Standard Pipe Threads

1	2	3	4	5	6	7	8	9	10	11
Nominal size of pipe	Outside diameter of pipe	Gage diameter (basic major diameter)	Number of threads per inch	Depth of thread	Minor diameter corresponding to gage diameter	Minimum length of thread "L" on pipe-end	Minimum length of thread In coupling	Distance of gage diameter from pipe-end (Class I, taper screw) Standard	Distance of gage diameter from pipe-end (Class I, taper screw) Maximum	Distance of gage diameter from pipe-end (Class I, taper screw) Minimum
Inches	Inches	Inches		Inches	Inches	Inches	Inches	Inches	Inches	Inches
1/8	13/32	0.383	28	0.02285	0.3373	3/8	3/4	5/32	0.1823	0.1302
1/4	17/32	.518	19	.03370	.4506	7/16	7/8	3/16	.2188	.1562
3/8	11/16	.656	19	.03370	.5886	1/2	1	1/4	.2917	.2083
1/2	27/32	.825	14	.04575	.7335	5/8	1 1/4	1/4	.2917	.2083
5/8	15/16	.902	14	.04575	.8105	5/8	1 1/4	1/4	.2917	.2083
3/4	1 1/16	1.041	14	.04575	.9495	3/4	1 1/2	3/8	.4375	.3125
7/8	1 7/32	1.189	14	.04575	1.0975	3/4	1 1/2	3/8	.4375	.3125
1	1 11/32	1.309	11	.05820	1.1926	7/8	1 3/4	3/8	.4375	.3125
1 1/4	1 11/16	1.650	11	.05820	1.5336	1	2	1/2	.5833	.4167
1 1/2	1 29/32	1.882	11	.05820	1.7656	1	2	1/2	.5833	.4167
1 3/4	2 5/32	2.116	11	.05820	1.9996	1 1/8	2 1/4	5/8	.7292	.5208
2	2 3/8	2.347	11	.05820	2.2306	1 1/8	2 1/4	5/8	.7292	.5208
2 1/4	2 5/8	2.587	11	.05820	2.4706	1 1/4	2 1/2	11/16	.8021	.5729
2 1/2	3	2.960	11	.05820	2.8436	1 1/4	2 1/2	11/16	.8021	.5729
2 3/4	3 1/4	3.210	11	.05820	3.0936	1 3/8	2 3/4	13/16	.9479	.6771
3	3 1/2	3.460	11	.05820	2.3436	1 3/8	2 3/4	13/16	.9479	.6771
3 1/4	3 3/4	3.700	11	.05820	3.5836	1 1/2	3	7/8	1.0208	.7292
3 1/2	4	3.950	11	.05820	3.8336	1 1/2	3	7/8	1.0208	.7292
3 3/4	4 1/4	4.200	11	.05820	4.0836	1 1/2	3	7/8	1.0208	.7292
4	4 1/2	4.450	11	.05820	4.3336	1 5/8	3 1/4	1	1.1667	.8333
4 1/2	5	4.950	11	.05820	4.8336	1 5/8	3 1/4	1	1.1667	.8333
5	5 1/2	6.450	11	.05820	5.3336	1 3/4	3 1/2	1 1/8	1.3125	.9375
5 1/2	6	5.950	11	.05820	5.8336	1 7/8	3 3/4	1 1/4	1.4583	1.0417
6	6 1/2	6.450	11	.05820	6.3336	2	4	1 3/8	1.6042	1.1458
7	7 1/2	7.450	10	.0640	7.3219	2 1/8	4 1/4	1 3/8	1.6042	1.1458
8	8 1/2	8.450	10	.06405	8.3219	2 1/4	4 1/2	1 1/2	1.7500	1.2500
9	9 1/2	9.450	10	.06405	9.3219	2 1/4	4 1/2	1 1/2	1.7500	1.2500
10	10 1/2	10.450	10	.06405	10.3219	2 3/8	4 3/4	1 5/8	1.8958	1.3542
11	11 1/2	11.450	8	.08005	11.2899	2 1/2	5	1 5/8	1.8958	1.3542
12	12 1/2	12.450	8	.08005	12.2899	2 1/2	5	1 5/8	1.8958	1.3542
13	13 3/4	13.680	8	.08005	13.5199	2 5/8	5 1/4	1 5/8	1.8958	1.3542
14	14 3/4	14.680	8	.08005	14.5199	2 3/4	5 1/2	1 3/4	2.0417	1.4583
15	15 3/4	15.680	8	.08005	15.5199	2 3/4	5 1/2	1 3/4	2.0417	1.4583
16	16 3/4	16.680	8	.08005	16.5199	2 7/8	5 3/4	1 7/8	2.1875	1.5625
17	17 3/4	17.680	8	.08005	17.5199	3	6	2	2.3333	1.6667
18	18 3/4	18.680	8	.08005	18.5199	3	6	2	2.3333	1.6667

Table 4. -- Wire Sizes and Constants, National (Briggs') Pipe Threads -- 60°

1	2	3	4	5	6	7
Wire Sizes*			Threads per inch n	Pitch $p = \frac{1}{n}$	Pitch/2 $\frac{p}{2} = \frac{1}{2n}$	Depth of V-thread $\frac{\cot 30°}{2n}$
Best 0.577350p	Maximum 1.010363p	Minimum 0.505182p				
Inches	Inches	Inches		Inches	Inches	
0.02138	0.03742	0.01871	27	0.03704	0.01852	0.03208
.03208	.05613	.02807	18	.05556	.02778	.04811
.04124	.07217	.03608	14	.07143	.03571	.06186
.05020	.08786	.04393	11 1/2	.08696	.04348	.07531
.07217	.12630	.06315	8	.12500	.06250	.10825

* For zero helix angle.

Table 5. -- Wire Sizes and Constants, British Standard Pipe Threads - 55°

1	2	3	4	5	6	7
Wire Sizes*			Threads per inch n	Pitch $p = \frac{1}{n}$	Pitch/2 $\frac{p}{2} = \frac{1}{2n}$	Depth of V-thread $\frac{\cot 27°30'}{2n}$
Best 0.563692p	Maximum 0.852727p	Minimum 0.505679p				
Inches	Inches	Inches		Inches	Inches	
0.02013	0.03045	0.01806	28	0.03571	0.01786	0.03430
.02967	.04488	.02661	19	.05263	.02632	.05055
.04026	.06091	.03612	14	.07143	.03571	.06861
.05124	.07752	.04597	11	.09091	.04545	.08732
.05637	.08527	.05057	10	.10000	.05000	.09605
.07046	.10659	.06321	8	.12500	.06250	.12006

* For zero helix angle.

TABLE 6. -- Corrections in Diameter for Errors in Angle, National (American Briggs') Taper Pipe Thread Gages.

1	2	3	4	5	6	7	8	9	10	11
a'	Correction in diameter, E"									
	8 threads		11 1/2 threads		14 threads		18 threads		27 threads	
Minutes	Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm
1	0.00006	0.0014	0.00004	0.0010	0.00003	0.0008	0.00002	0.0006	0.00002	0.0004
2	.00011	.0028	.00008	.0020	.00006	.0016	.00005	.0013	.00003	.0008
3	.00017	.0043	.00012	.0030	.00010	.0024	.00007	.0019	.00005	.0013
4	.00022	.0057	.00016	.0040	.00013	.0032	.00010	.0025	.00007	.0017
5	.00028	.0071	.00019	.0049	.00016	.0041	.00012	.0032	.00008	.0021
6	.00034	.0085	.00023	.0059	.00019	.0049	.00015	.0038	.00010	.0025
7	.00039	.0099	.00027	.0069	.00022	.0057	.00017	.0044	.00012	.0029
8	.00045	.0114	.00031	.0079	.00026	.0065	.00020	.0051	.00013	.0034
9	.00050	.0128	.00035	.0089	.00029	.0073	.00022	.0057	.00015	.0038
10	.00056	.0142	.00039	.0099	.00032	.0081	.00025	.0063	.00017	.0042
11	.00062	.0156	.00043	.0109	.00035	.0089	.00027	.0069	.00018	.0046
12	.00067	.0170	.00047	.0119	.00038	.0097	.00030	.0076	.00020	.0051
13	.00073	.0185	.00051	.0128	.00042	.0106	.00032	.0062	.00022	.0055
14	.00078	.0199	.00054	.0138	.00045	.0114	.00035	.0088	.00023	.0059
15	.00064	.0213	.00058	.0148	.00048	.0122	.00037	.0095	.00025	.0063
16	.00089	.0227	.00062	.0158	.00051	.0130	.00040	.0101	.00027	.0067
17	.00095	.0241	.00066	.0168	.00054	.0138	.00042	.0107	.00028	.0072
18	.00101	.0256	.00070	.0178	.00058	.0146	.00045	.0114	.00030	.0076
19	.00106	.0270	.00074	.0188	.00061	.0154	.00047	.0120	.00031	.0080
20	.00112	.0284	.00076	.0198	.00064	.0162	.00050	.0126	.00033	.0084
21	.00117	.0298	.00082	.0208	.00067	.0170	.00052	.0133	.00035	.0088
22	.00123	.0313	.00086	.0217	.00070	.0179	.00055	.0139	.00036	.0093
23	.00129	.0327	.00089	.0227	.00074	.0187	.00057	.0145	.00038	.0097
24	.00134	.0341	.00093	.0237	.00077	.0195	.00060	.0152	.00040	.0101
25	.00140	.0355	.00097	.0247	.00080	.0203	.00062	.0158	.00041	.0105
26	.00145	.0369	.00101	.0257	.00083	.0211	.00065	.0164	.00043	.0109
27	.00151	.0384	.00105	.0267	.00086	.0219	.00067	.0170	.00045	.0114
28	.00157	.0398	.00109	.0277	.00089	.0227	.00070	.0177	.00046	.0118
29	.00162	.0412	.00113	.0287	.00093	.0235	.00072	.0183	.00048	.0122
30	.00168	.0426	.00117	.0296	.00096	.0244	.00075	.0189	.00050	.0126
45	.00252	.0639	.00175	.0445	.00144	.0365	.00112	.0284	.00075	.0189
60	.00336	.0852	.00233	.0593	.00192	.0487	.00149	.0379	.00099	.0253

a' = error in half included angle of thread
E" = correction in diameter

$$E'' = \frac{1.53612}{n} \tan a'$$

TABLE 7. -- Correction in Diameter for Errors in Lead, National (American Briggs') Taper Pipe Thread Gages.

Error in lead p'	Correction in diameter, E'									
	0.00000	0.00001	0.00002	0.00003	0.00004	0.00005	0.00006	0.00007	0.00008	0.00009
0.00000	0.00000	0.00002	0.00003	0.00005	0.00007	0.00009	0.00010	0.00012	0.00014	0.00016
.00010	.00017	.00019	.00021	.00023	.00024	.00026	.00028	.00029	.00031	.00033
.00020	.00035	.00036	.00038	.00040	.00042	.00043	.00045	.00047	.00048	.00050
.00030	.00052	.00054	.00055	.00057	.00059	.00061	.00062	.00064	.00066	.00068
.00040	.00069	.00071	.00073	.00074	.00076	.00078	.00080	.00081	.00083	.00085
.00050	.00087	.00088	.00090	.00092	.00094	.00095	.00097	.00099	.00100	.00102
.00060	.00104	.00106	.00107	.00109	.00111	.00113	.00114	.00116	.00118	.00120
.00070	.00121	.00123	.00125	.00126	.00128	.00130	.00132	.00133	.00135	.00137
.00080	.00139	.00140	.00142	.00144	.00145	.00147	.00149	.00151	.00152	.00154
.00090	.00156	.00158	.00159	.00161	.00163	.00165	.00166	.00168	.00170	.00171
.00100	.00173	.00175	.00177	.00178	.00180	.00182	.00184	.00185	.00187	.00189
.00110	.00191	.00192	.00194	.00196	.00197	.00199	.00201	.00203	.00204	.00206
.00120	.00208	.00210	.00211	.00213	.00215	.00217	.00218	.00220	.00222	.00223
.00130	.00225	.00227	.00229	.00230	.00232	.00234	.00236	.00237	.00239	.00241
.00140	.00242	.00244	.00246	.00248	.00249	.00251	.00253	.00255	.00256	.00258
.00150	.00260	.00262	.00263	.00265	.00267	.00268	.00270	.00272	.00274	.00275
.00160	.00277	.00279	.00281	.00282	.00284	.00286	.00288	.00289	.00291	.00293
.00170	.00294	.00296	.00298	.00300	.00301	.00303	.00305	.00307	.00308	.00310
.00180	.00312	.00313	.00315	.00317	.00319	.00320	.00322	.00324	.00326	.00327
.00190	.00329	.00331	.00333	.00334	.00336	.00338	.00339	.00341	.00343	.00345
.00200	.00346	.00348	.00350	.00352	.00353	.00355	.00357	.00359	.00360	.00362

$$E' = 1.732\ p'$$