THE NATIONAL PHYSICAL LABORATORY

NOTES ON SCREW GAUGES

BY THE GAUGE-TESTING STAFF OF THE METROLOGY DEPARTMENT

Third Edition, revised and enlarged
May, 1930

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INTRODUCTION

IN 1916, as a result of experience gained in the testing of screw gauges for use in munitions work, the Metrology Department of the National Physical Laboratory published a pamphlet "Notes on Screw Gauges," with the object of assisting firms who were unfamiliar with the accuracy required in the manufacture and testing of that class of work. A second edition of this pamphlet (Revised Edition II) was published in 1917, and a third revised and enlarged edition is here presented.

In bringing the "Notes" up to date, it was thought that their purpose would be best served by confining them chiefly to brief descriptions of the principles underlying the practice of limit gauging as applied to parallel screw threads, the various types of error met with in screw gauges, and modern methods of testing these gauges, supplemented by the data required for carrying out the measurements. To make these data complete, it has been thought desirable to repeat the information given in the appendices to the former edition of the "Notes," together with some which appeared in the 1921 edition of the Laboratory test pamphlet "Gauge Testing."*

As the methods and measuring instruments described herein may be subject to improvement from time to time, manufacturers and others who contemplate the installation of such instruments, or who have experienced difficulty in measurement, are invited to visit the Laboratory by appointment to discuss their particular problems with members of the staff.

* A revised issue of this publication, which gives particulars as to the accuracy of tests, fees, &c., can be obtained free on application to the Director of the National Physical Laboratory, Teddington, Middlesex.

NOTES ON SCREW GAUGES

I.—Definitions Relating to Screw Threads.

For the purpose of these Notes it is not considered necessary to consider all the terms appertaining to screw threads ; attention will be confined to the more important ones, definitions of which are given below.

Thread Form.—The *form of a thread* is the profile exhibited by a section cut through the axis of a screw.

In the case of the Whitworth thread it is as shown in Fig. 1.

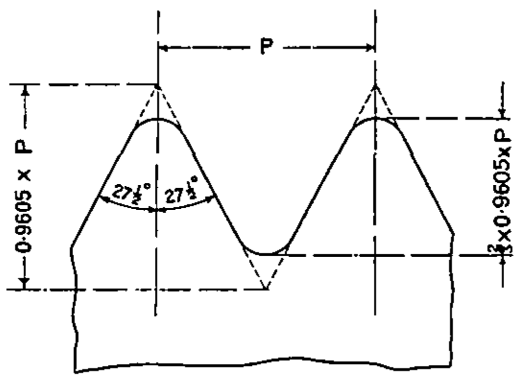


FIG. 1.

The angle between the flanks is 55°, and one-sixth of the sharp Vee is cut off both top and bottom, which are rounded to curves of the same radius (equal to $0 \cdot 137 \times p$).

The depth of the sharp Vee is $\frac{1}{2}\, p \times \cot 27 \cdot 5° = p \times 0 \cdot 96049$, so that the actual depth of thread is two-thirds of this, or $p \times 0 \cdot 64033$.

The numerical values of these and other dimensions are given in Appendix I (p. 52), together with corresponding data for other forms of thread in common use.

Pitch.—The *pitch* is the distance measured parallel to the axis of the screw, between corresponding points on consecutive contours of the thread, in the same axial plane section and on the same side of the axis.

Effective Diameter.—The *effective diameter* of a parallel screw is that of an imaginary coaxial cylinder which intersects the surface of the thread in such a manner that the intercept on a generator of the cylinder, between the points where it cuts the opposite flanks of a groove of the thread, is equal to half the nominal pitch.

In the case of a perfect thread, the effective diameter may be regarded as the length of a line which intersects the axis of the screw at right angles and is terminated by the sloping flanks of the thread. This is illustrated in Fig. 2.

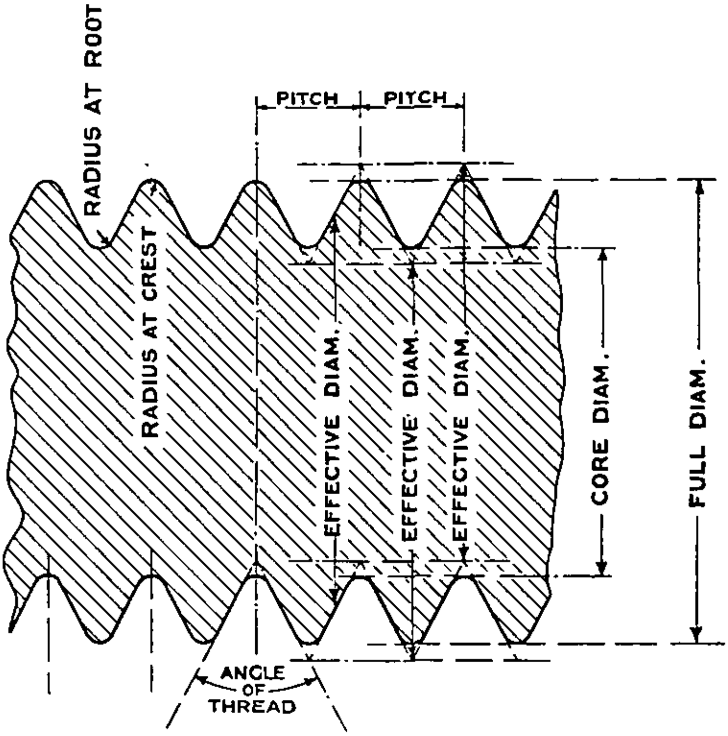


FIG. 2.

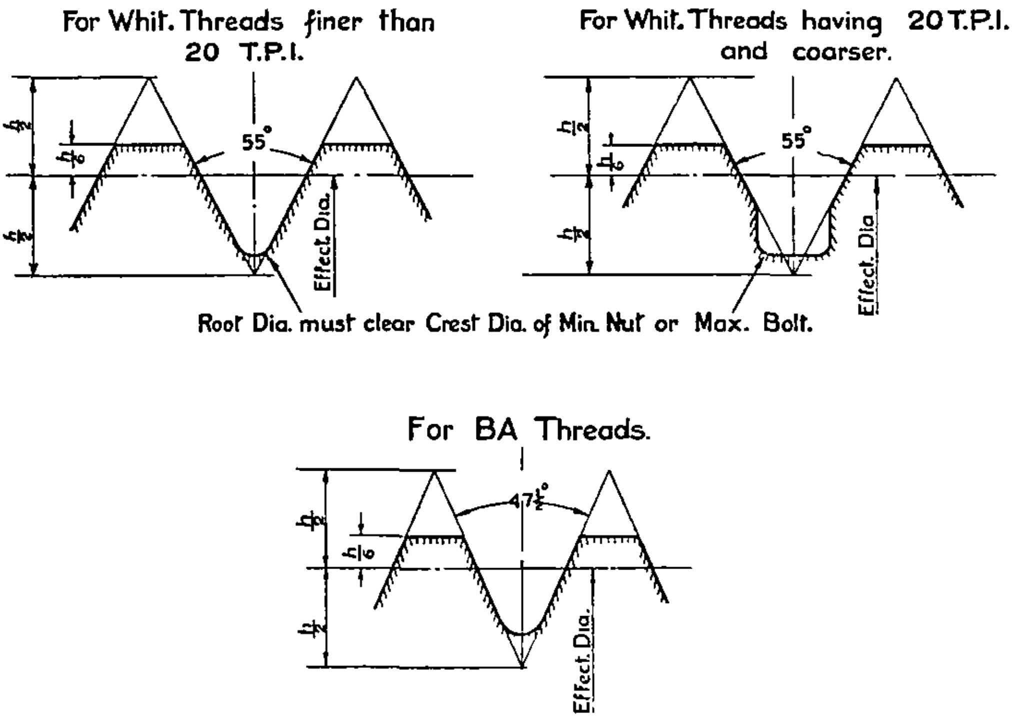
Angle of Thread.—The *angle of thread* is the angle between the flanks, measured in an axial plane section.

Flank Angles.—The *flank angles* are the angles between the individual flanks and the normal to the axis, measured in an axial plane section.

II.—Gauging Screw Threads.

In the manufacture of threaded components, where interchangeability coupled with a reasonable accuracy of fit is desired, it is essential to employ some method of gauging. A common practice is to test each of the components with a " go " screw gauge and to accept only those parts which are considered reasonably good fits to the gauge. If the gauges are correct, this method ensures interchangeability, but, on the other hand, judgment of fit clearly leaves much to the skill and discretion of the inspector. Moreover, it does not necessarily follow that, because two components happen to be good fits to their respective " go " gauges, their fit will also be satisfactory when assembled with each other. The degree of perfection of the thread form obviously plays an important part in the matter, and no system of screw thread gauging will give the desired result in the finished work unless attention is paid to the production of a good form of thread by careful examination of the screwing tools used.

FORM OF THREAD FOR "NOT GO" EFFECTIVE DIA. SCREW GAUGES.



Root Dia. must clear Crest Dia of Min. Nut or Max. Bolt.

Fig. 3.

To secure adequate control, the process of thread gauging should be carried further than the mere use of " go " gauges by the addition of " not go " gauges. In general, the latter gauges take two forms. One type controls the crest diameter (*i.e.*, the full diameter of plug work or the core diameter of ring work), and thus safeguards a certain minimum depth of engagement between the threads of the two components. This type usually consists of either a cylindrical ring or a gap gauge made to the lower limit for the full diameter of the plug work, and a plain plug made to the upper limit of the core diameter of the screwed hole. The other type acts as a check on the effective or flank diameter of the work, and ensures that the threads are not unduly thin ; these are known as " not go " effective diameter gauges, and are in the nature of screw gauges. Their form of thread is such, however, that the crests and roots are cleared, so that the gauge operates only on a short length of the flank of the thread about half-way down. The length is also limited to only two or three turns of the thread so as to avoid complications arising from possible pitch errors. The amount of clearance usually allowed at the crests and roots is shown in Fig. 3.

Where " not go " gauges are adopted in testing screwed work, it is often found that the plain, crest diameter type is alone used. These are cheaper to produce than the effective diameter type, but, on the other hand, it is generally recognised that the latter provide the more valuable test on the work. For complete control, both types are necessary.

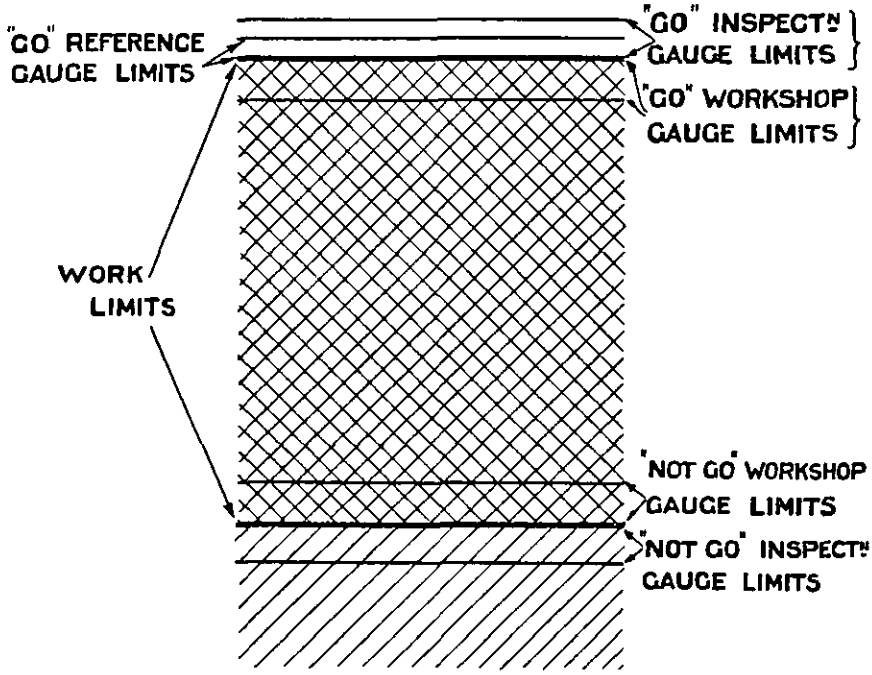


FIG. 4.

The tolerances allocated to screw threads are usually only a few thousandths of an inch, so that the tolerance on the dimensions of the gauges can only be a few ten-thousandths. The Laboratory, in conjunction with the Inspection Departments of the Services, has laid down a schedule of limits for screw gauges classified under the headings, " inspection," " workshop," and " reference." The distinction between these three classes of gauges is as follows :—

Inspection gauges are intended for use during final checking of the work. In order that all work which falls within the prescribed limits shall be passed by the gauges, the directions of the gauge tolerances are such that their limits do not encroach upon the tolerance nominally allowed for the work.

Workshop gauges, as their name implies, are for use either during the production of the work, or at any time prior to final inspection. Since, from the manufacturer's point of view, it is essential that all work passed by these gauges should be accepted without hesitation during the final test with the inspection gauges, it is clear that the limits for the workshop gauges must be made to trespass somewhat upon those laid down for the work.

The relationship between the work limits and those of the inspection and workshop gauges, both " go " and " not go," is set out graphically in Fig. 4. The same diagram also shows the limits for " go " reference gauges. This type of gauge has the same basic dimension as the others, and the tolerance is in the same direction as for " go " inspection gauges, but is only half the amount. Reference gauges can, therefore, be used in place of " go " inspection gauges where the usual tolerance allowed on the latter is considered rather too large in proportion to the tolerance on the work. Their ordinary purpose, however, is for checking the results obtained from inspection gauges, either periodically or in any case of doubt.

It may be useful to summarise in tabular form the relationship between the limits on the work and the tolerances on the different classes of gauges, thus :—

" Go " Gauges.

	For Plug Work.	For Ring Work.
Basic size of " go " gauges	Upper limit for work.	Lower limit for work
Tolerance on reference gauges	+	−
,, ,, inspection gauges	+	−
,, ,, workshop gauges	−	+

" Not go " Gauges.

	For Plug Work.	For Ring Work.
Basic size of " not go " gauges	Lower limit for work.	Upper limit for work.
Tolerance on reference gauges	−	+
,, ,, inspection gauges	−	+
,, ,, workshop gauges	+	−

It is to be noted that in the above scheme, which has been adopted for official inspection purposes by Government Services, the direction of the tolerance on the inspection gauges is such that all work which is within the specified limits would be passed. In addition, owing to the necessary tolerance on the inspection gauges, some small quantity of work will be passed which is slightly outside the nominal limits. For the latter reason it is clearly undesirable to increase the gauge tolerances beyond a figure which will enable the gauges to be produced at a reasonable cost.

In the case of workshop gauges, it is again undesirable to allocate a tolerance beyond that strictly required by the gauge makers, since the direct effect of this tolerance is to reduce the tolerance provided for the actual manufacture of the work.

As mentioned above, the Laboratory has laid down a schedule of tolerances for the three classes of "go" screw gauges. These tolerances are to be found in Tables IV, V and VI (Appendix II, p. 56), from which it will be noted that the tolerances on the diameters increase with the size of the screw. The question of tolerances on the angle, pitch and general form of thread will be dealt with later.

Similar tolerances have been instituted for the diameters of "not go" gauges for screwed work. These are given in Tables VII to X of Appendix II. No figures are given in this case for reference gauges, since this class of gauge serves no useful purpose amongst "not go" gauges.

III.—Errors of Screw Gauges.

The Whitworth thread has seven elements, error on any one of which may be sufficient to cause a gauge to reject work which ought to pass, or *vice versa*. These elements are :—

Full (or major) diameter.
Core (or minor) diameter.
Effective (or pitch) diameter.
Pitch.
Angle.
Radius at crest.
Radius at root.

Of these, pitch, effective diameter and angle are, perhaps, the most important, and are those in which errors most frequently occur.

Effective Diameter.—The importance of accuracy in the effective diameter of a screw gauge becomes evident when it is realised that this diameter determines the relative widths of the threads and the intervening grooves.

If the effective diameter of a screwed plug is less than its nominal value, the threads are thin, and if greater the threads are thick. The reverse holds for a screwed ring.

In a perfect thread, symmetrically formed at root and crest (for example, a true Whitworth thread), the effective diameter is the mean of the full and core diameters.

Pitch.—It is convenient to distinguish between the following types of error in pitch :—

(1) The error in a screw whose pitch is uniform, but longer or shorter than its nominal value, is called *progressive error.*

(2) Errors which vary in magnitude when measured from thread to thread along the screw, and which recur at regular intervals, are called *periodic errors.* A screw having errors which vary in magnitude when measured over equal fractions of one turn of the thread is usually called "*drunken.*"

(3) An error in pitch which varies irregularly in magnitude when measured over equal lengths of the thread, is usually described as "*erratic.*"

It is important to realise that any error in pitch needs to be compensated for by a corresponding, but independent, error in effective diameter. Thus, if an otherwise perfect plug screw has pitch error, it will not screw into a perfect ring screw of the same nominal size. It can only be made to do so by reducing its effective diameter and so making the threads slightly thin. It is, however, only permissible to make use of this compensating effect to a very limited extent in adjusting screw gauges, pitch errors in which must be kept as small as possible.

Error in Pitch in Relation to Effective Diameter.—The amount by which the effective diameter of a plug screw has to be below nominal size, or that of a ring screw above nominal size, to compensate for a given error in pitch, may be determined as follows :—

Suppose the full and dotted outlines in Fig. 5 represent respectively a ring and plug screw, each of correct thread form, but of slightly different pitch. Let the maximum relative axial displacement of any two threads in the length be $2a$. Then these extreme threads will be displaced axially by $+a$ and $-a$ respectively. Fig. 5 shows that in this case the two parts will not go together

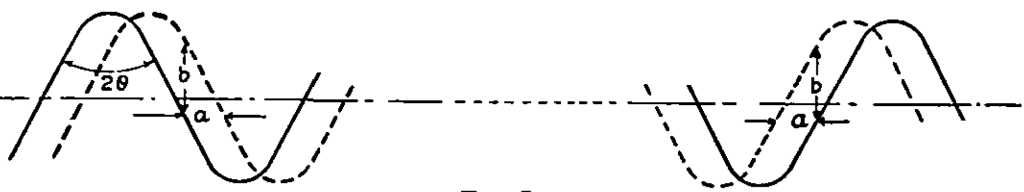


FIG. 5.

unless the axial displacement is accompanied by a radial displacement b, which, calculated from the angle of the thread, is equal to $a \cot \theta$, 2θ being the angle of the thread. This displacement is doubled on the diameter, so that a total error $2a$ (or a periodic error $\pm a$) in pitch requires for compensation an error amounting to $2a \cot \theta$ in the effective diameter. In other words, the allowance required on effective diameter to compensate for error in pitch is $\cot \theta$ times the maximum axial displacement between any two points included within the length of engagement (as compared with their true pitch distance).

The numerical values of the factor $\cot \theta$ for the standard forms of thread in common use are as follows :—

		Value of cot θ.
Whitworth thread	$(2\theta = 55°)$	1·921
British Association thread	$(2\theta = 47\frac{1}{2}°)$	2·273
System International .. .. .. / United States Standard, and / Cycle Engineers' Institute Standard thread	$(2\theta = 60°)$	1·732

Table XI in Appendix III (page 61) gives, for screws of various thread forms, the virtual differences in effective diameter corresponding to errors in pitch, rising in steps of 0·00005 inch up to 0·001 inch.

Error in Angle in Relation to Effective Diameter.—Diagrams similar to Fig. 5 can be drawn to illustrate how the presence of errors in the angles of the flanks of a screw thread must be accompanied by a corresponding reduction in the effective diameter, if the screw is to " fit " a perfect ring gauge of the same nominal size. In the case of a ring screw, the effective diameter must be correspondingly enlarged before a perfect plug gauge of the same nominal size will fit into it.

Details of the method of determining the relationship between the angle error and the corresponding difference in the effective diameter will be found in Appendix II of British Engineering Standards Association Report, No. 84 (1918). The final result can be stated in the form :—

$$\delta E = \frac{h}{\sin 2\theta} (\delta\theta_1 + \delta\theta_2), \text{ approximately,}$$

where δE = difference in effective diameter,

h = length of straight portion of flank measured in a diametral direction,

2θ = nominal angle of thread,

$\delta\theta_1$ and $\delta\theta_2$ = errors in the slopes of the two opposite flanks of the thread, regardless of sign.

It is to be noted that, in applying this formula, the errors of the angles of the two flanks of the thread are to be added together irrespective of their signs, and then multiplied by the factor $\frac{h}{\sin 2\theta}$, which will vary, of course, with the form of thread concerned. For the standard forms of threads in common use, the formula reduces to the following, where p is the pitch and $\delta\theta_1$ and $\delta\theta_2$ are now measured in degrees :—

Whitworth thread	$\delta E = 0{\cdot}0105 \times p (\delta\theta_1 + \delta\theta_2)$.
British Association thread..	$\delta E = 0{\cdot}0091 \times p (\delta\theta_1 + \delta\theta_2)$.
System International thread	$\delta E = 0{\cdot}0131 \times p (\delta\theta_1 + \delta\theta_2)$.

Tables XII, XIII and XIV in Appendix III (p. 61) enable the value of δE to be readily determined for any particular case.

It is to be noted that all points on the profile of the thread of a gauge should theoretically fall between two perfect outlines defined by the allowable limits on the diameters. If mechanical measurements, or inspection by an optical projection apparatus, show the thread to be anywhere outside these limiting outlines, then the gauge cannot be considered to be strictly within the limits. From this it would follow that, should the effective diameter, as measured mid-way down the flanks, be on either its upper or lower limit, both the pitch and the angle of each flank would have to be quite free from error. Thus, the maximum errors in pitch or angle, respectively, could occur only with values of the effective diameter mid-way between its limits. In practice, however, gauges are accepted by the Laboratory, as regards pitch, effective diameter and angle of thread, provided (*a*) the actual effective diameter measured at the half depth is within the specified limits, and (*b*) the errors in pitch and/or angle are not so great as to lead to the profile overlapping the correct outline corresponding to the maximum size of the plug, or the minimum size of the ring gauge, at any point. In other words, the gauge is accepted if it would pass a perfect full-form "go" check gauge and a correct "not go" effective diameter check gauge.

If the actual effective diameter is found by measurement to be between limits, and errors are present in pitch and/or angle, it is necessary to compute the maximum virtual effective diameter in order to ascertain whether condition (*b*) is fulfilled. This can be done by application of the Tables in Appendix III, or graphically by the use of a diagram similar to Fig. 4 in B.E.S.A. Report No. 84, but drawn to a suitable scale to represent the finer tolerances allowed on gauges.

Radii at Crest and Root.—Errors in the radii at the crests and roots of gauges are frequently of great importance, as they may be equivalent to leaving the full and/or core diameters large. The most common error is a departure from the circular form, the crests of the threads being partly flat, or the roots somewhat pointed or otherwise ill-formed, so that in either case superfluous metal is left. Such defects would prevent the gauge from functioning satisfactorily, even though the measured values of the full, effective, and core diameters were correct.

IV.—Control of Accuracy in Pitch.

Accuracy in pitch is of special importance where screw gauges are concerned, and particular attention should be paid to this element in the examination of screw gauges. Bearing in mind that the standard tolerance on the effective diameter of screw gauges up to 1½ in. diameter is only 0·0006 in. for inspection and workshop gauges, and but half this amount for reference gauges, it will be realised that the maximum permissible error in pitch (which is about half the tolerance on the effective diameter) is quite small. In addition, it has to be remembered that the maximum error in pitch can only be allowed provided the effective diameter is on its extreme limit and the angle is correct, conditions which still further restrict the amount of pitch error which can be tolerated in any particular case.

Inaccuracy in the pitch of screw gauges is generally due to one or more of the following :—

(*a*) Errors introduced during the process of threading in the lathe.
(*b*) Distortion of the steel during hardening.
(*c*) Errors introduced in the process of final lapping, or grinding, to size.
(*d*) Secular changes in the hardened steel.

If screw gauges are finished by grinding the threads, errors introduced during the initial threading in the lathe or in hardening would be corrected, provided the lead screw of the thread-grinding machine is accurate. Since these machines are generally designed with particular attention to the accuracy of the lead screw and its mountings, gauges finished by this method should be free from any serious pitch errors.

A more general method of finishing screw gauges, however, is to lap them after hardening. This process becomes very tedious and costly if the errors in the pitch of the unlapped gauge are at all large. It is desirable, therefore, to keep the error in pitch within reasonable limits from the beginning, and thus avoid prolonged lapping. With this in view, the initial threading of a gauge should be done on a lathe whose pitch is known to be good, and the steel used should be of a quality which has been found by experiment to withstand the hardening treatment without appreciable distortion. The choice of steel and its correct heat treatment are thus of great importance. It may be mentioned that certain precision lathes, intended primarily for screw-gauge work, have means of adjusting the pitch so that screws made from a particular steel can be threaded with either a long or a short pitch, in order to allow for the changes which are known to occur in the hardening.

Where thread-grinding is not used, it is important to ascertain the accuracy of pitch of the lathe which it is proposed to use for threading the gauges. This is best done by measuring the pitch of a test piece screwed on the lathe. Convenient dimensions for such a test piece are $\frac{3}{4}$ in. diameter, 6 in. long, and screwed for a length of $4\frac{1}{2}$ in. with a pitch of 24 threads per inch. The test screw may have the usual 55° angle, but neither this nor the radius at the core diameter is important. What is essential, is that the flanks of the thread should have a smooth finish straight from the tool. A single-point tool and not a chaser must be used. The tops of the threads may be left flat.*

It often happens that the measurements of such a test screw show the pitch to be satisfactory only over certain limited portions, the lengths of which, however, are sufficient to cover the requirements of most screw gauges. For this reason it is important, when cutting a test screw, to scribe marks on the lathe bed and slide-rest corresponding to the beginning and end of the thread on the test screw. Such marks then serve to identify those regions which, from the measurements of the test screw, may be found to be satisfactory for cutting screw gauges.

It has already been shown on page 10, in the discussion on errors of screws, that pitch errors in a screw may generally be analysed into three types—progressive, periodic and erratic. In lapped screws, the nature of the finishing operation tends to smooth out irregularities in pitch, so that periodic and erratic pitch errors are seldom met in screws finished by this process. Their errors are usually of a progressive nature, and are mostly due to either an extension or contraction of the pitch during hardening, which has not been sufficiently rectified by lapping, or possibly to the use of a lap with incorrect pitch.

Periodic and erratic pitch errors are to be found most frequently in test screws from lathes. If, as the result of the measurements of a trial screw, a lathe is found to have errors of this character exceeding $\pm 0{\cdot}0001$ in. from the general mean, steps should be taken to ascertain the cause of the errors with a view to effecting an improvement before the lathe is used for threading gauges.

* Reports on the pitch measurements of such test pieces can be obtained from the National Physical Laboratory.

Erratic errors may arise from one, or a combination, of a variety of defects in a lathe, such as local irregularities in the pitch of the lead screw itself, inaccurate gears, unsatisfied fit between the saddle and the bed, uneven drive, etc. Irregularities in the hardness and cutting qualities of the steel that is being threaded may also give rise to pitch errors of this nature. For this reason, it is desirable thoroughly to anneal blanks for trial screws and gauges before they are screwed.

When a periodic error of a fairly regular character is found to be present in the pitch of a trial screw, the first thing to note is the period at which the errors recur, as this generally gives a clue to the cause of the error. The most pronounced periodic error is generally found to repeat itself every revolution

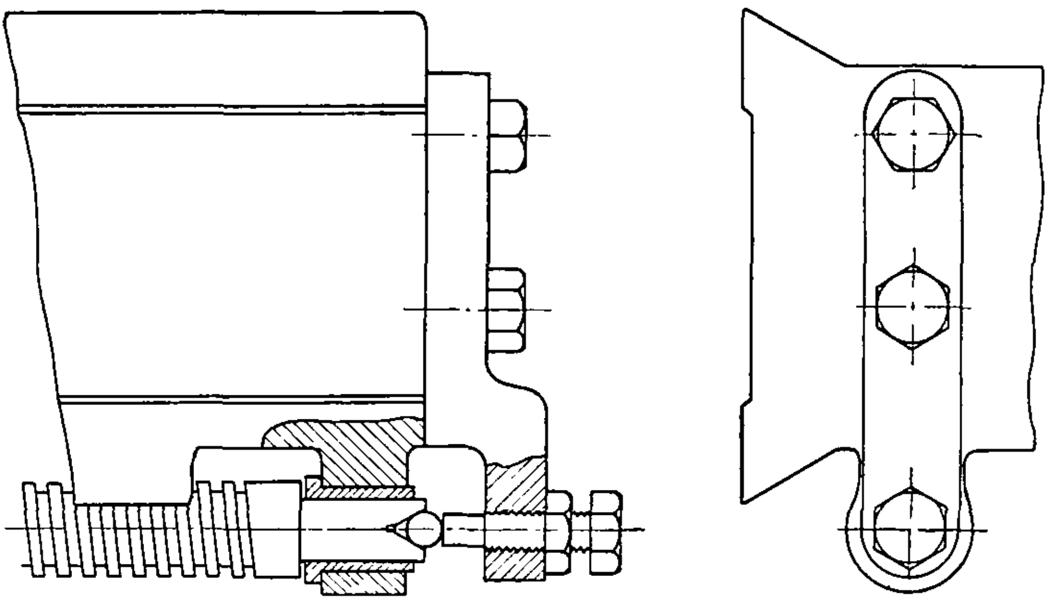


Fig. 6.

of the leading screw of the lathe, If this is the case, it may be due (*a*) to an intrinsic error in the leading screw itself, arising from the fact that the lathe on which it was cut was incorrect, (*b*) to lack of correct centreing of the gear wheel on the leading screw, (*c*) to the leading screw of the lathe not revolving truly about its axis, or (*d*) to imperfect adjustment of the bearings which take the end thrust.

The third cause may arise if the leading screw is slightly bent, so that while it may revolve truly near the ends, it revolves eccentrically near the middle. It is likely that this cause will be more serious in the case of leading screws with other than square threads, such as the Acme thread.

The last of the above enumerated sources of periodic error is the most common. If the thrust-bearing surfaces are even slightly out of square, there will be a to-and-fro motion of the leading screw in the direction of its axis, which is repeated every revolution, and which superposes a periodic error on the regular progression of the tool due to the turning of the screw. The remedy in this case is to square up the surfaces which take the thrust, or to replace the usual abutment by some type of central thrust.

One form of the latter which has proved successful is shown in Fig. 6. The centre in the end of the lead screw is enlarged to form a seating for a hardened steel ball of fair size. The collar thrust-bearing of the lead screw is freed so that the whole of the thrust is taken between the ball and the flat end of a set-screw tapped into a suitable stiff bracket, fixed to the lathe bed. The end face of the set screw should, of course, be hardened and ground square to the axis of the lead screw.

If the lathe is to be used to cut left-hand screws, a ball thrust would also be required at the other end of the lead screw.

V.—Notes on Tools and Methods of Generating Thread Form.

Accurate *single thread* tools designed to complete the whole thread form in one operation are often used in the production of screw gauges on a large scale. All such tools, however, have to be originated in the first instance from single-point tools, which latter consequently form the basis from which all accurate screwed work is ultimately generated.

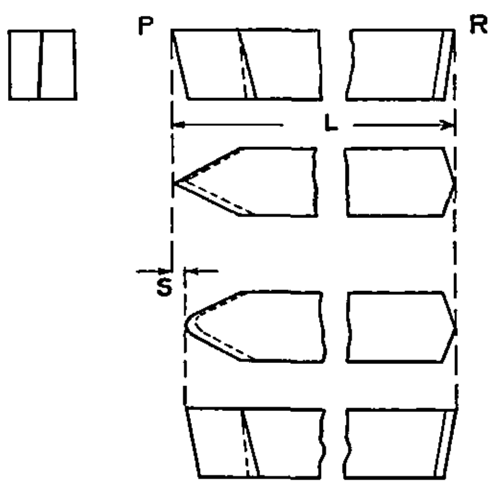


FIG. 7.

One of these single-point tools is shown in Fig. 7, and such tools may be used directly in the production of gauges where only small numbers are required. The tools must have the sides of the Vee at the correct angle and must also have the correct radius at the point. The sides of the tool can be made to the correct angle, and the angle can be measured without special difficulty, but the exact radiusing of the point is not so easy. If the amount of shortening, S, is incorrect, the tool will not cut the core and effective diameters of a screw in correct relation to each other. If, for example, the shortening is insufficient, then, when the tool is fed up to the work so as to make the effective diameter correct, the core diameter will be left too small.

To obtain a tool with the correct shortening, a first approximation at any rate may be obtained by first grinding and lapping it perfectly sharp with an angle of exactly 55° and measuring its length from the sharp point P to a suitable point R at the opposite end with a micrometer. The amount S by which it should be shortened in forming the radius at the point is equal to one quarter of the depth of a Whitworth thread of the particular pitch to be cut, and is given in the table on page 53. If this shortening is carefully done and the point nicely rounded off, it ought to require very little further modification to adjust the tool finally so as to bring both core and effective diameters down simultaneously within the limits allowed. The exact amount of adjustment required can be ascertained from the results of measurements made on a screw cut by the tool.

This method is open to the objection that it is difficult to grind or lap the tool in the first place to a perfectly sharp point, and is recommended only as a means of obtaining a first approximation to the form, in the absence of more elaborate apparatus.

A convenient instrument for measuring the amount that the point has been ground back is illustrated in Fig. 8. The micrometer head is first set to read on a small cylinder of known size wedged in the Vee of the instrument. Preferably the micrometer head is adjusted in position in its seating until this reading is the exact measure of the truncation corresponding to a cylinder of the size employed. If C is the diameter of the cylinder used, this truncation for a 55° Vee is $0 \cdot 583 \times C$. Readings subsequently taken on the point of a screw-cutting tool then give the exact measure of the truncation or shortening of the point of the tool.

The actual cutting part of the tool is, of course, only the extreme tip, and with the smaller sizes this extreme tip will not find a bearing on the sides of the Vee in the instrument, owing to the clearance which has to be provided for the micrometer point. The success of this instrument therefore depends on the absolute flatness of the two surfaces forming the sides of the cutting tool. Subject to this condition, the correctness of the angle of the tool and its truncation can be determined with considerable precision. The tool should have a definite side clearance on each side, as shown in Fig. 7, or the test on angle will fail. Usually, however, owing to the rake, the clearance on one side will be very small, as indicated in the same figure.

It is necessary to reduce the diameter of the measuring point of the micrometer head down to about 0·04 in., as shown, until only a small face is left, and the hole left in the Vee for the passage of the measuring point should be kept as small as possible, having regard to the sizes of tool to be measured. The dimensions indicated are suitable for measuring tools of any size up to 4 threads per inch, and should not be exceeded unless still larger tools are in contemplation.

It is to be remembered that 55° is to be the angle of the horizontal cutting surface of the tool, which is to be presented to the work exactly at the height of the lathe centres. No cutting lip should be ground in the top face of the finishing tool, which should be left perfectly flat. Whatever the value of the

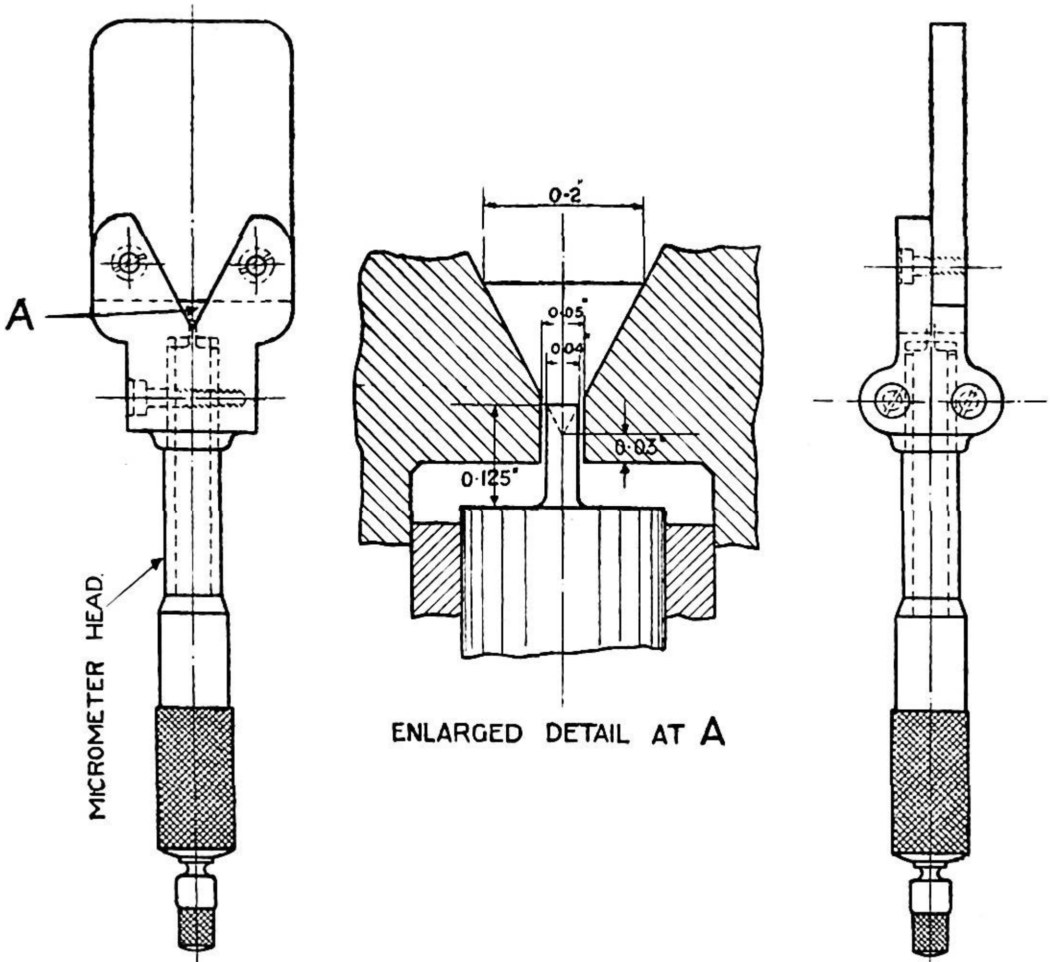


FIG. 8.

clearance angle at which the point of the tool is backed away, and whatever side rake is given to the front edge of the tool for cutting coarse pitches, 55° is to be the angle of the horizontal top face of the tool. If the tool is made to a 55° gauge held square with the backed-off front edge of the tool, the horizontal angle will be too small by an amount depending upon the clearance angle of the tool. It will be seen that the single-point tool used for finishing can only take very light cleaning cuts. The tools used in preparing the threads for the finishing cuts may be given a cutting lip, provided this is not so excessive as to leave a thread of such imperfect form that the final cut with the finishing tool fails to correct it.

The cutting faces of the tool should be finished by lapping. If taken straight from a grinding wheel it is possible for the general angle of the tool to be correct, but for the point, which is the important part in cutting the thread, to be in error owing to elastic deformation during grinding. This error in angle at the point of the tool is fairly frequently found.

To ensure that the tool is satisfactorily radiused, it is best to view it under a microscope, or to project a magnified image on to a screen. If a projection machine such as is described on page 44 is available, it is easy to compare the tool with a drawing of the standard thread form and to make the tool conform to this. Exceptionally good definition can be obtained in projecting a tool owing to the backing off, and it is possible with a high magnification to check the truncation at the same time as the form at the point.

Care bestowed on the production of a tool with correct angle is for the most part wasted if equal precautions are not taken to set up the tool correctly in the lathe. First of all the height of the tool must be adjusted so that its top face is accurately level with the line of the centres. The next step is to set the tool square to the line of centres. The following method has been found satisfactory for doing this. Having arranged the tool approximately square, it is used to cut a 55° circular groove in a short length of rod held between the centres. The rod is then reversed end for end between the centres, and the fit of the nose of the tool to the Vee-groove inspected under a good hand-glass or microscope, against a well illuminated background. Any error in the squareness of the tool clearly becomes doubled by this method, so that to set the tool more closely, it has to be adjusted in the slide-rest so as to halve any visible discrepancy between the tip of the tool and the Vee-groove. The latter is then recut and the angle setting checked again after reversing the rod. It usually only requires two or three attempts before the tip of the tool will exactly fit the groove in the reversed position, in which case the correct setting has been arrived at.

The grooved bar produced in this operation should be kept for reference purposes, since it can be used afterwards as a direct means for setting tools of corresponding angle.

Whatever method of measurement be adopted in preparing a tool, the final test is to cut a screw, measure its effective and core diameters and thread angle, and to examine the rounding at the root. If the shortening of the tool at the point is correct, the difference between the effective and core diameters of the screw will be equal to the standard depth of the thread for the particular pitch concerned. (The standard depths of Whitworth threads are given in Table I in Appendix I, p. 53.) If the difference is found to be too small, then the tool has been shortened too much at the point, and *vice versa*. The shortening at the point should be adjusted by lapping either the sides or the point of the tool until the correct difference is obtained.

Having produced a tool which will cut the effective and core diameters so that both are within the required limits of accuracy, it remains to complete the tops of the threads. The radius of the crest being the same as that at the root, the tool which has been used to cut the screw may be used to cut a suitable groove in the nose of the capping tool, shown in Fig. 9. When in use, this tool is adjusted by eye (or preferably automatically on being placed in the tool holder) so as to fit properly the flanks of the thread already formed.

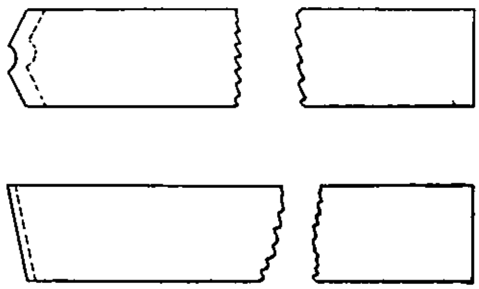


FIG. 9.

If for any reason the gauge has to be taken off the centres after the operation of forming the flanks and roots, care should be taken to see that the screw runs truly in the lathe before the capping tool is used, otherwise an error in concentricity may be introduced between the full diameter and the remaining elements of the screw.

From a pair of single-pointed tools as above described, full-form single-thread tools of various types may be generated.

When making the final cut on a screw gauge, the full, effective and core diameters should be reduced *within* the tolerances allowed. If they are left at full nominal dimensions there is always considerable risk that small errors in pitch, angle, symmetry, etc., may prevent the gauge passing a " go " check ring. It is generally best to aim at the mean of the tolerance on the full and core diameters, and towards the low limit of tolerance on the effective diameter of a plug gauge.

It is sometimes found that it is very difficult to leave a good finish on unhardened tool steel when turning it in the lathe. Various lubricants may be tried with little effect, and sometimes the tool is placed below the lathe centre in the hope of improving the cut: this latter should not be done, as it will cause the form of the screw to be incorrect. Annealing is very likely to produce no improvement. In such cases the cause may sometimes be found in the fact that the material is too soft and ought to be in a harder state to cut satisfactorily. The remedy is to harden and temper the steel sufficiently to enable the tool to cut it smoothly. The amount of the tempering must be determined by experience.

In finishing hardened screw gauges by lapping, it should be remembered that no less care should be bestowed upon the thread form of the laps than is used in screwing the gauge in the unhardened state. A lap with ill-formed threads is useless for producing an accurate screw gauge.

Reference has already been made to methods of grinding the threads of screw gauges. There are several designs of machine for this purpose, each of which has some form of automatic arrangement for quickly restoring the shape of the grinding wheel edge. Whitworth threads as fine as 24 T.P.I. can be satisfactorily produced by grinding, and, it may be mentioned, the process can be applied to ring gauges above about an inch in diameter.

VI.—Mechanical Measurements of Plug Screws.

Full Diameter.—The ordinary micrometer serves for measuring the full diameter, provided a reading is first taken on a cylindrical plug gauge, of known diameter, about the same size as that of the screw to be measured. This precaution eliminates the effect of slight errors in the micrometer screw and the measuring faces. Hoffman " roller " gauges serve as useful standards for this purpose. They are made in sets of sixteen from $\frac{3}{16}$ in. up to $1\frac{1}{4}$ in., and are guaranteed by the makers to be accurate to within $\pm 0{\cdot}0001$ in. on both diameter and length.

Core and Effective Diameters.—It is recommended that the core diameter should be measured by the use of a micrometer and a pair of Vee-pieces (see Fig. 10), and the effective diameter by a micrometer and a pair of small cylinders

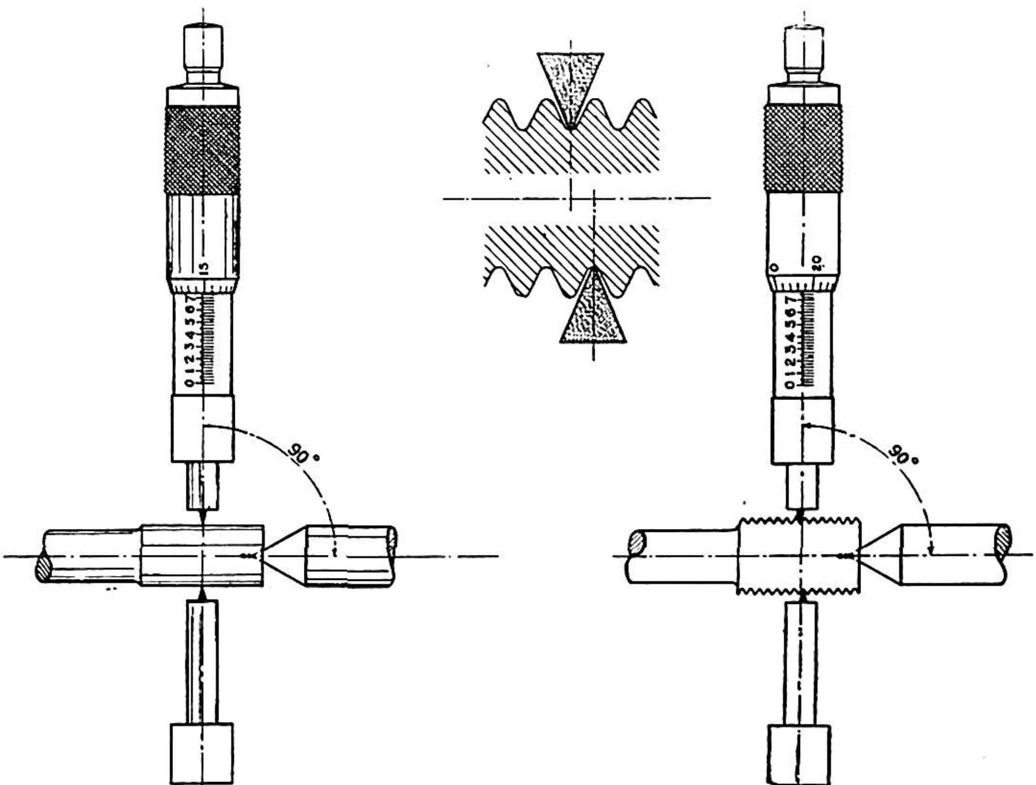


FIG. 10.

(see Fig. 11). The Vees, or small cylinders, are placed one on each side of the gauge, and the micrometer measurement is made over the outside of them.

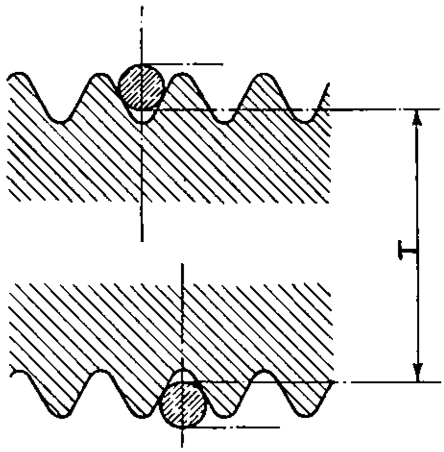


FIG. 11.

With this method, it is essential that the micrometer should be held at right angles to the axis of the screw being measured. This is best secured by using a machine of the type shown in Fig. 12. The screw is mounted between a pair of centres carried on a base A, which has two Vee grooves machined in its upper surface parallel to the line of the centres. These Vee grooves form run-ways for a saddle B, having on one side two projecting conical pegs C which rest in one of the grooves. The other end of the saddle rests on a steel ball placed in the other Vee groove. A micrometer carriage D, with a Vee groove and a flat on its underside, can move freely on steel balls resting in two Vee grooves cut in the upper surface of the saddle in a direction at right angles to the line of centres. This micrometer carriage is provided on one side with a micrometer head graduated to 0·0002 in. and capable of being read to 0·00005 in., and on the other with an adjustable anvil. The common axis of the micrometer and anvil is at the same height as the line of centres.

The shank of one of the conical pegs C is made eccentric, so that by turning it in its hole, it is possible to adjust the axis of the micrometer truly square with the line of centres. After making this setting, the position of the peg can be maintained by a clamping screw.

Taken as a whole, the machine therefore consists of a micrometer having a free motion at right angles to the line of centres, and capable also of being traversed along the bed of the machine so as to measure at any desired position along a screw mounted between the centres.

The Vee-pieces and small cylinders used with the machine during the measurements of core and effective diameters respectively, are suspended by

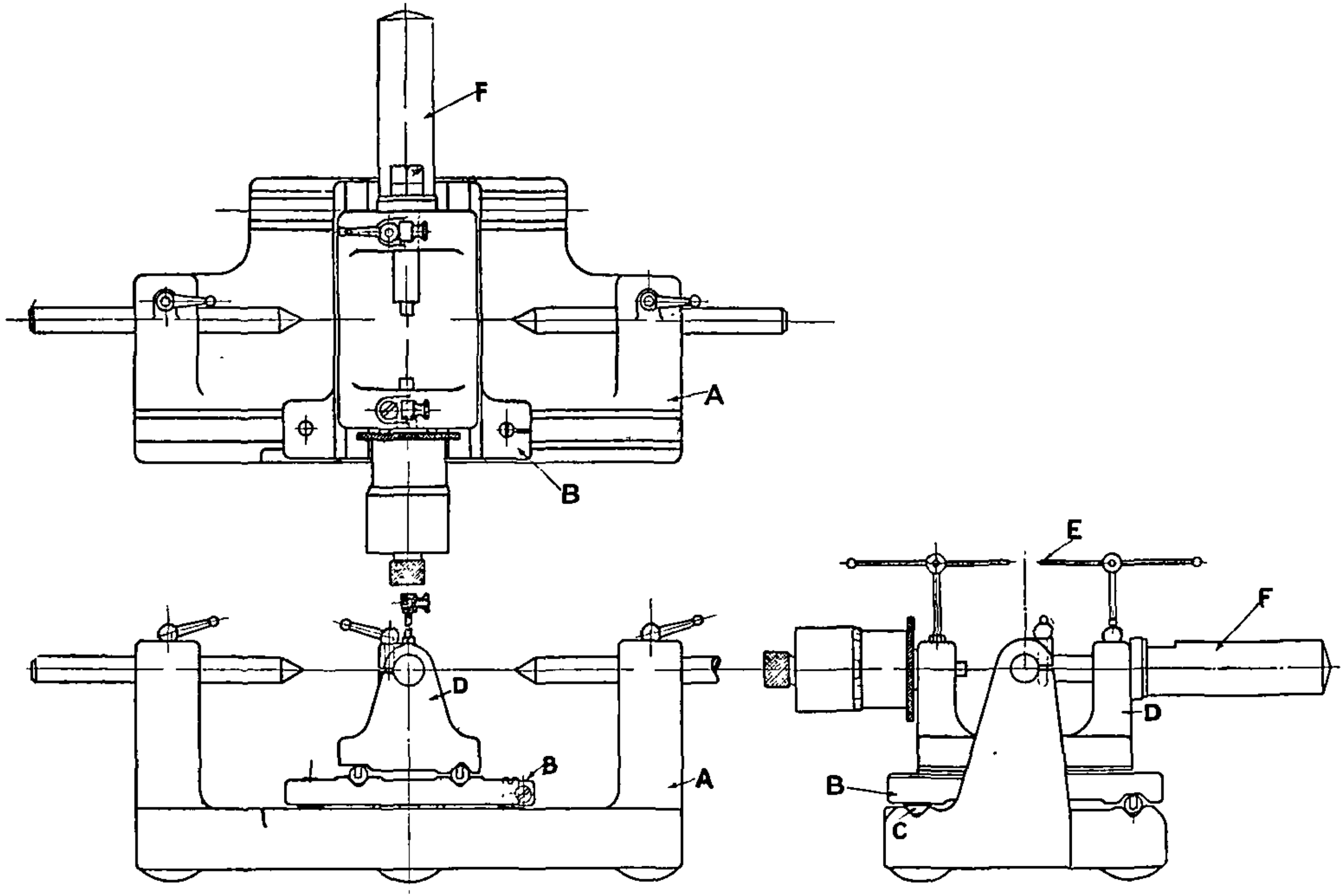


FIG. 12.

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B 4

threads from light rods E fixed to the micrometer carriage. In order to eliminate entirely the personal element as regards the " feel " of the micrometer, and also to obtain a control on the measuring pressure, the adjustable anvil is fitted with a fiducial indicator F* which operates under a pressure of about 8 oz., or less if desired.

The above type of machine, which was designed and is used at the Laboratory, is obtainable commercially in two or three sizes to accommodate screws up to ten inches in diameter.

The Vee-pieces used for core diameter measurements consist of hardened steel prisms having an angle of about 45°, with the front edge finished to a radius somewhat smaller than that of the curvature at the roots of the finest thread which it is desired to measure. It is found useful to have such Vees made in a series of different sizes, in order to cover the range of screws usually met. Details of the sizes of the Vees will be found in Appendix IV, page 65.

Having selected a suitable pair of Vees for the screw to be measured, they are placed one on each side, with their bases against the micrometer faces. The micrometer head is then advanced until the pointer of the indicator arrives opposite the fiducial mark. The reading is then noted. To complete the measurement, the screw is replaced between the centres by a plain cylindrical standard plug gauge of diameter approximately equal to the core diameter of the screw, and a second reading is taken. The core diameter of the screw is then readily obtained from the difference between the readings and the known size of the standard plug gauge; thus if :—

Micrometer reading on—

Screw gauge with Vee-pieces = R_G.
Plain plug with Vee-pieces = R_S.

Size of plain plug = D.

Then, core diameter of screw gauge = $D + R_G - R_S$.

It is important to realise that the actual sizes of the Vee-pieces do not require to be known, nor do they need to be equal in size. It is essential, however, that each Vee-piece should be uniform along its length, *i.e.*, the front measuring edge must be parallel to the back face, and both must be straight.

The procedure adopted in measuring effective diameter is the same as that just described for the core diameter, except that two small cylinders are used instead of Vee-pieces. The cylinders should be chosen so that, when placed between the threads, as in Fig. 11, they make contact about half-way down the flanks. Suitable sizes of cylinders for various threads will be found in Appendix V, page 66.

It is essential that the small cylinders should be cylindrical to within 0·00003 in. over the working portions, and their actual diameters should be known to well within the same accuracy. They should be hardened and their surfaces highly polished. If used in a floating micrometer machine, such as

* For description of this indicator see the Report of the Laboratory for 1928, p. 181.

the type described above, only two cylinders are required, and these need not be of exactly the same size, although it is desirable that they should not differ by more than a few ten-thousandths of an inch.

Failing a floating micrometer machine, the necessary squareness of the micrometer to the axis of the screw can be obtained by the use of three small cylinders, two being used on one side of the screw (in adjacent threads for coarse pitches, or separated by two or three threads in finer pitches), and one cylinder on the other side. In this case it is necessary for the three cylinders forming a set to be equal in diameter to 0·0001 in.

The dimension T (Fig. 11), under the small cylinders in contact with the screw, is determined by comparison with the corresponding dimension with the cylinders in contact with a standard plug (without reference to the zero reading of the micrometer or to the diameters of the small cylinders used), in exactly the same way as for the measurement of core diameter ; thus if :—

Micrometer reading on—

Screw with small cylinders $= R_G$.

Standard plug with small cylinders $= R_S$

Size of plain plug $= D$.

Then, value of $T = D + R_G - R_S$.

The expression usually adopted for connecting the measurement T with the desired effective diameter E is

$$E = T + P - c,$$

where P is a constant depending upon the pitch and angle of the screw and the mean diameter of the small cylinders used, and c a small quantity depending mainly upon the rake angle of the screw. Formulae for calculating P and c are given in Section VII, page 29.

The small cylinders obtainable commercially in this country for screw thread measurement are always accompanied by a National Physical Laboratory certificate giving their actual diameters, the screw threads for which they are suitable, and the corresponding constants, P.

Attention to pressure is even more important in the measurement of effective diameter than for core diameter, owing to the wedging action on the flanks of the threads. Its importance, especially in the case of small screws, is referred to on page 34.

Pitch.—As a pitch error of 0·0001 in. between any two points on a screw gauge is equivalent to an error in effective diameter of approximately 0·0002 in., the pitch of screw gauges should be measured with corresponding accuracy. If the error is periodic or variable, the greatest error can only be found with certainty by taking measurements from one point to every other point on the same spiral. For screw gauges of ordinary types, having fairly fine pitch, it is usual, however, to measure the pitch along a line parallel to the axis, measuring from the first thread (or space) to every thread (or space) in turn. The test is repeated along another line at 180° round the screw, and the mean of the two sets of measurements is taken in order to eliminate the effect of any slight eccentricity of the " centres " with respect to the thread. Unless the screw is " drunken," the maximum error which exists in the pitch can then be seen from the mean result.

It is this maximum error which has to be used in estimating the virtual effective diameter (*see* p. 11).

If a screw gauge has been carefully cut with a single-point tool and with the headstock-mandrel and centres in good order, drunkenness is not likely to occur unless the gauge has been cut from a lead screw of the same pitch as the gauge. This is not very likely to be the case with fine-pitch gauges, but if, for instance, a 10 thread per inch lead screw were used to cut a 10 thread per inch screw gauge, want of truth in the lead screw collars, a common cause of pitch error, would produce drunkenness in the gauge. A properly lapped screw is very unlikely to be drunken.

Fig. 13 shows one of the types of machine designed and used at the Laboratory for measuring the pitch of both plug and ring screws. This machine will accommodate plug screws up to 6 in. in diameter with a maximum overall length of 9 in., and ring screws up to 6 in. outside diameter.

The three main portions of the machine are the bed A, the sliding bar B carrying the micrometer, and the indicator and saddle K.

Plug screws are held between centres C_1 and C_2, while ring gauges are clamped to a vertical face-plate which is fitted on to the projecting, parallel portion of the centre C_1. The measurements are made by using a hardened steel feeler-piece or stylus P, with a rounded nose. This is arranged so as to engage with the thread, and is made to travel in a direction parallel to the axis of the screw, riding in and out of the threads in turn.

The stylus is fixed to the end of the first lever l_1 of an indicator K. This lever is attached to the body of the indicator by a flexible steel strip which can both bend and twist under the action of the stylus in the thread. The indicator is clamped to the bar B, which is supported on balls in Vee grooves, and can be traversed over a range of an inch by the micrometer M, which usually has a pitch of 40 threads per inch. The thrust of the latter is taken by an anvil rod L, fixed to the bed.

As the stylus is traversed along the screw being measured, the second lever l_2 of the indicator is deflected from side to side, and when brought repeatedly opposite a fixed fiducial mark, ensures that the stylus is resting centrally in the successive threads, as in Fig. 14. Readings of the micrometer are taken at the points of indication, and from these the pitch of the screw can be obtained.

For ring screws the same indicator is used, but an additional attachment is provided to carry the stylus P inside the ring.

Although the micrometer has a run of only an inch, screws of longer lengths can be measured in successive inch lengths by moving the saddle K along the bar B and reclamping it in other positions.

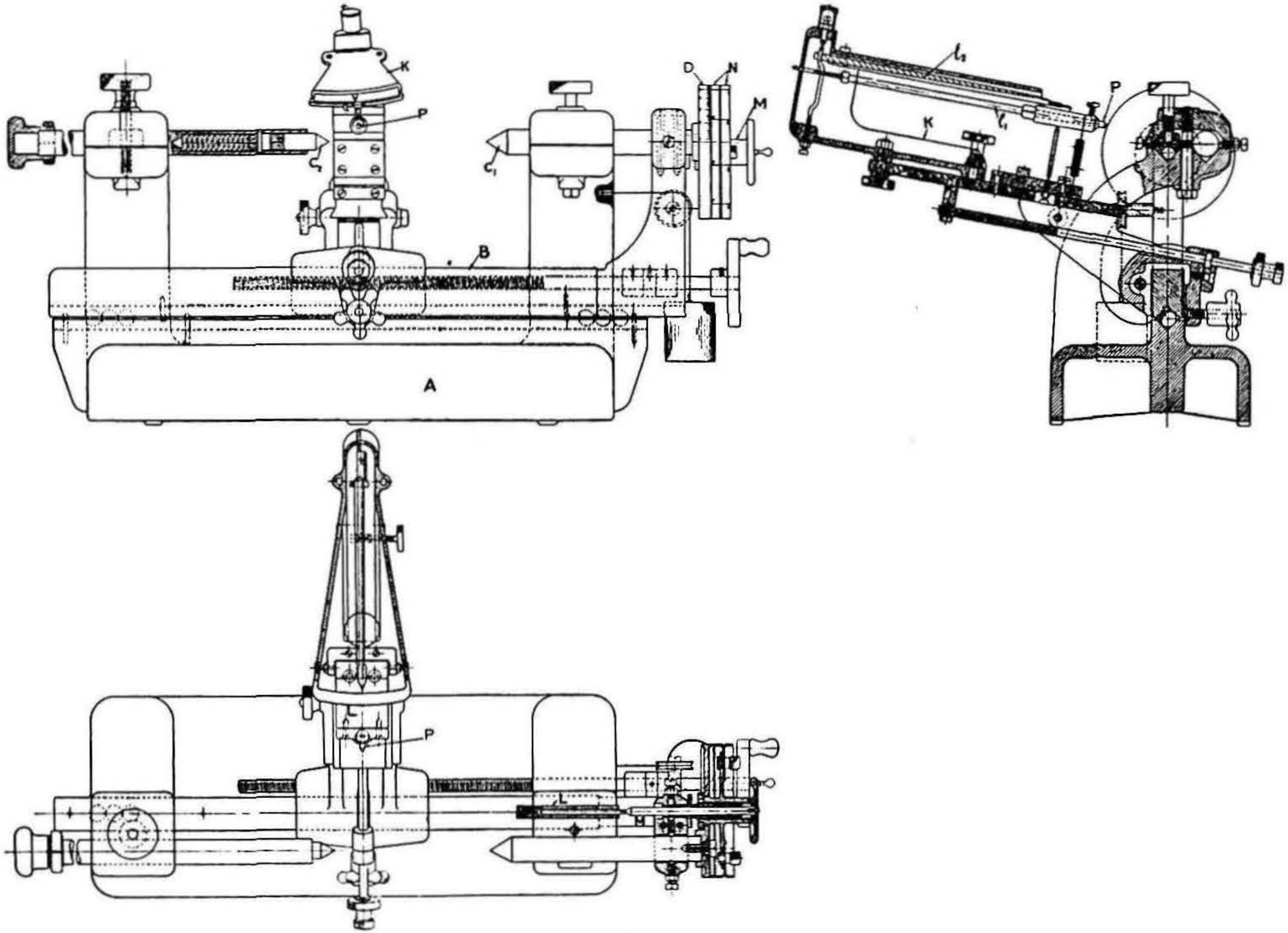


FIG. 13.

To allow rapid measurements of the commoner pitches to be made, a number of specially graduated dials N are provided for attachment to the thimble of the micrometer. These dials are divided according to the whole number and fraction of a revolution of the micrometer screw necessary to move the stylus a distance equal to the nominal pitch of the screw under test. The actual errors

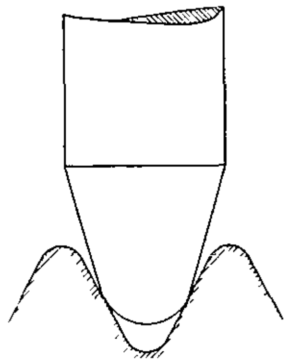


FIG. 14.

of the successive threads are then readily obtained from a fixed dial D graduated to read direct to 0·0001 in.

In addition to these special dials, the machine is also provided with another which is fully divided into 250 parts. This is used for measuring the pitch of screws for which the special dials are unsuitable, as for example B.A. and S.I. screws.

To assist in the measurement of the latter screws, Tables XX and XXI, given in Appendix VI (page 68), have been prepared, showing the nominal B.A. and metric pitches, respectively, in inches. Alternatively, the measurement of S.I. screws can be facilitated by using a machine fitted with a metric micrometer in place of the usual one in inch units.

Each machine is provided with a set of feeler-pieces having a graded series of radii. The feeler-piece, or stylus, is selected which touches about half-way down the flanks of the thread of the screw whose pitch is to be measured, as illustrated in Fig. 14.

A detailed description of the machine outlined above, and another of rather smaller capacity, will be found in Glazebrook's " Dictionary of Applied Physics," Vol. 3, page 322 (Macmillan, London, 1923).

Thread Form and Angle.—The angle and the form of thread of plug screws are most conveniently examined by optical projection methods. Machines suitable for the purpose are described in Section IX, page 44.

VII.—Formulae and Corrections for use in the Measurement of Effective Diameter of Plug Screws by means of Small Cylinders.*

(*a*) Value of the Constant "P," and Corrections required on account of the Rake of the Thread.

If E = required effective diameter,
T = measured dimension under the cylinders, see Fig. 11, page 22,
p = pitch of thread,
d = mean diameter of cylinders used,
θ = semi-angle of thread,
c = a correction due to the tilting of the cylinders on account of the rake,

then

$$E = T + P - c \quad \text{(1)}$$

where

$$P = \tfrac{1}{2}\, p \cot\theta - (\operatorname{cosec}\theta - 1)\, d. \quad \text{(2)}$$

For Whitworth threads, where $\theta = 27\tfrac{1}{2}°$, this becomes

$$P = 0{\cdot}96049 \times p - 1{\cdot}16568 \times d. \quad \text{(3)}$$

For B.A. threads, where $\theta = 23{\cdot}75°$,

$$P = 1{\cdot}13634 \times p - 1{\cdot}48295 \times d. \quad \text{(4)}$$

For the System International, U.S.S., or C.E.I. threads, where $\theta = 30°$,

$$P = 0{\cdot}86602 \times p - d. \quad \text{(5)}$$

Note.—The formulae given above for the constant P are for use with parallel screw threads.

The values of c for standard Whitworth and System International screws, for any size of cylinder, can be found by means of the nomograms shown in Figs. 15 and 16. These nomograms also serve for determining c for non-standard screws of average rake.

For screws belonging to the British Standard Whitworth (B.S.W.) series, the values of c are of the order of 0·00015 in. when the " best size " cylinders (see page 66) are used, but the correction reaches values between 0·0002 in. and 0·00025 in. if cylinders approaching the maximum size are employed.

For British Standard Fine (B.S.F.) and British Standard Pipe (B.S.P.) screws, the values of c are within 0·0001 in. for all cylinders.

The correction is practically constant for all sizes of B.A. screws down to No. 8 ; e.g., for No. 0 it amounts to 0·00007 in. and for No. 8, 0·00005 in.

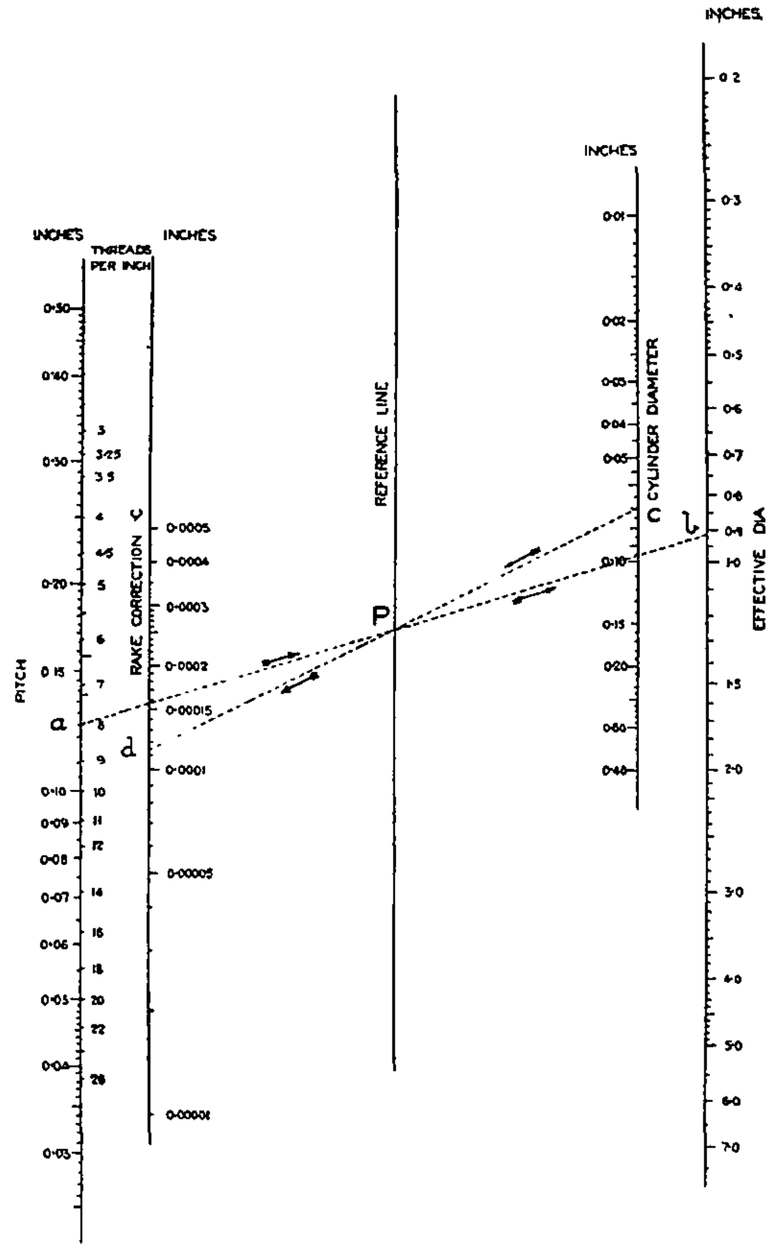
For screws with large rake angle, as, for instance, those having double- or quadruple-start threads, and screws with Acme threads, the value of c can be found as follows :—

First calculate the approximate distance r', from the axis of the screw to the centre of either cylinder, from the formula :—

$$r' = \tfrac{1}{2} E + \frac{d}{2} \operatorname{cosec}\theta - \frac{p}{4} \cot\theta. \quad \text{(6)}$$

* For method of measurement, see page 24.

RAKE CORRECTION FOR WHITWORTH THREADS OF MODERATE RAKE ANGLE.

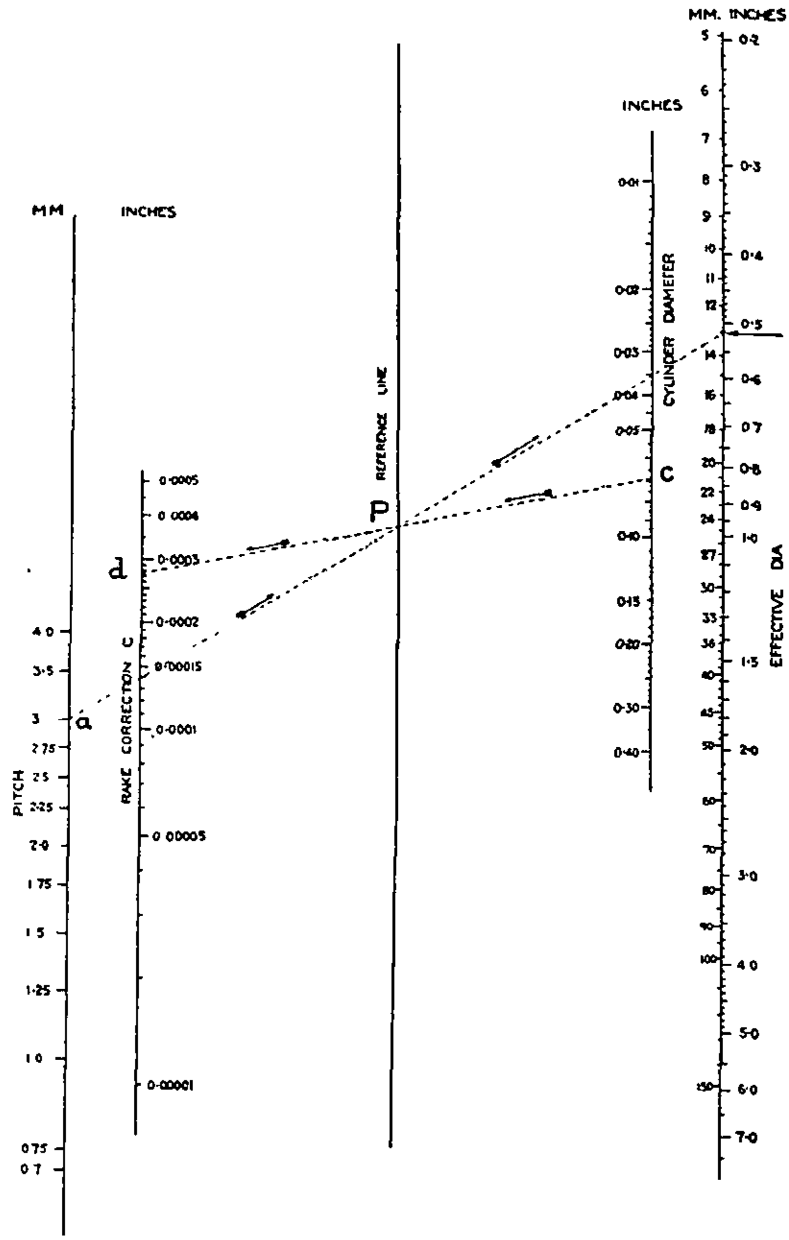


Example :—Screw 1 in. × 8 T.P.I. (effective dia. 0·9200 inch).
Dia. of cylinders, 0·070 inch.

Join appropriate point *a* on " Pitch " line to *b* on " Effective Dia." line and obtain a point P on " Reference Line." Required correction (0·00011 inch) is found where line from point *c* on " Cylinder Dia." line passing through P strikes " Rake Correction " line at *d*.

FIG. 15.

Rake Correction for System International Threads of Moderate Rake Angle.



Example :—Screw 15 mm. × 3 mm. (effective dia. 13·05 mm.).
Dia. of cylinders, 0·068 inch.

Join appropriate point *a* on "Pitch" line to *b* on "Effective Dia." line and obtain a point P on "Reference Line" Required correction (0 00027 inch) is found where line from point *c* on "Cylinder Dia." line passing through P strikes "Rake Correction" line at *d*.

Fig. 16.

Next calculate the approximate rake correction, c', given by

$$c' = \frac{l^2 d \cos\theta \cot\theta}{8\pi^2 r'^2}, \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

where l is the lead of the thread, and is equal to p for single-start threads.

A more exact value of r', denoted by r, is that obtained from the equation

$$r = r' + \tfrac{1}{2} c'.$$

A sufficiently close value of the rake correction c can then be calculated from the formula

$$c = \frac{l^2 d \cos\theta \cot\theta}{8\pi^2 r^2}\left\{1 + \frac{d \sin\theta}{2r} + \left(\frac{d \sin\theta}{2r}\right)^2\right\}. \qquad \ldots\ldots\ldots\ldots\ldots \quad (8)$$

The following example illustrates the application of the above formulae for determining the rake correction c. The screw to be considered is $1\frac{1}{2}$ in. in diameter with a double-start Acme thread of $\frac{1}{2}$ in. pitch and 1 in. lead. The mean diameter of the cylinders used is assumed to be 0·25822 in.

$$\begin{aligned} \text{The nominal value of E} &= 1{\cdot}5 - \text{depth of thread} \\ &= 1{\cdot}5 - 0{\cdot}25 \\ &= 1{\cdot}25 \text{ in.} \\ d = 0{\cdot}25822\,;\ p &= 0{\cdot}5\,;\ \theta = 14\tfrac{1}{2}^\circ. \end{aligned}$$

Then from equation (6), r' is found to be 0·65732 in. Substituting the appropriate values in equation (7), l being 1 in., the approximate rake correction c' becomes 0·02834 in.

The more exact value (r) of r' is found to be

$$\begin{aligned} r &= 0{\cdot}65732 + \frac{0{\cdot}02834}{2}, \\ &= 0{\cdot}67149 \text{ in.} \end{aligned}$$

Substituting finally in equation (8), and showing the values of the three terms separately, we obtain—

$$\begin{aligned} c &= 0{\cdot}02715 + 0{\cdot}00131 + 0{\cdot}00006 \\ &= 0{\cdot}0285 \text{ in.} \end{aligned}$$

For more extreme cases, such as worm screws, reference should be made to a paper, by G. A. Tomlinson, entitled "Correction for Rake in Screw Thread Measurement," Proc. Inst. Mech. Eng., Vol. 2, p. 1031, 1927.

(*b*) **Measurements of Effective Diameter using Cylinders other than those of "Best Size."**—In Section VI (page 24) the measurement of the effective diameter of a plug screw is described, and it is there stated that the cylinders chosen should preferably make contact about half-way down the flanks. This is recommended in view of the effect upon the measurement of any error which may be present in the thread angle. Should the angle be correct, then any size of cylinders can be used provided they make contact somewhere on the straight flanks. The appropriate value of P would be calculated from the formulae on page 29 by substituting the actual diameter of the cylinders employed. On the other hand, if the thread angle of the screw is incorrect, the true effective diameter is most readily obtained by using the "best size" wires, since for these wires the values of P calculated on the assumption that the angle is correct can still be used. Other sizes of wires can be employed to obtain the effective diameter, but it becomes necessary to know the actual thread angle of the screw, and either to substitute this angle, as well as the actual diameter of the wires, in the formulae for P, or alternatively to apply a correction to the "P" value, as calculated from the formulae assuming the angle to be nominal. The formulae for such corrections are given below :—

Form of thread.	Correction to "P" value.
Whitworth	$(0{\cdot}036 \times d - 0{\cdot}020 \times p) \times \delta\,(2\,\theta)$
B.A.	$(0{\cdot}049 \times d - 0{\cdot}027 \times p) \times \delta\,(2\,\theta)$
S.I. (Metric)	$(0{\cdot}030 \times d - 0{\cdot}017 \times p) \times \delta\,(2\,\theta)$

Where d = mean diameter of cylinders used,
p = pitch of thread,
$\delta\,(2\theta)$ = error in total angle of thread expressed in degrees.

The sign of the correction is given by the formula if the proper sign of $\delta\,(2\theta)$ be introduced.

EXAMPLE.

Plug screw 2 in. × 14 T.P.I. Whitworth.
Mean diameter of cylinders, $d = 0{\cdot}05117$ in.
Note.—Diameter of best size cylinders = 0·0403 in.
Case I.—Angle error, $\delta\,(2\theta) = +1°$.
Case II.—Angle error, $\delta\,(2\theta) = -1°$.

Case I.

From the formula on page 29,

$P = \frac{1}{2}\,p \cot \theta - (\operatorname{cosec} \theta - 1)\,d.$

By substituting $\theta = 28°$, $p = \frac{1}{14}$, and $d = 0{\cdot}05117$, the value for P, taking into account the error in angle, is found to be 0·00935 in.

If, instead of 28°, we give to θ the nominal value $27\frac{1}{2}°$, we obtain a value for P equal to 0·00896 in.

The correction to this value on account of angle error is

$$\left\{(0{\cdot}036 \times 0{\cdot}05117) - \frac{0{\cdot}020}{14}\right\} \times (+1)$$
$$= +\,0{\cdot}00041 \text{ in.}$$

Thus, the corrected value for P = 0·00896 + 0·00041
= 0·00937 in.

The insignificant difference between the values of P found by the two methods is due to the approximate nature of the factors 0·036 and 0·020 in the correction formula.

Case II.

By the first method, substituting $\theta = 27°$,
$P = 0{\cdot}00855$ in.

Using the nominal angle,

$$P = 0 \cdot 00896 \text{ in.}$$

$$\text{Correction to this P value} = \left\{(0\cdot036 \times 0\cdot05117) - \frac{0\cdot020}{14}\right\} \times (-1)$$

$$= -\,0\cdot00041 \text{ in.}$$

$$\text{Hence the proper P value} = 0\cdot00896 - 0\cdot00041$$

$$= 0\cdot00855 \text{ in.}$$

In this case the two methods agree exactly to the fifth decimal place.

(*c*) **Measurement of Thread Angle using Cylinders of Different Sizes.**—From what has been said above, it is clear that, provided the flanks of the thread are straight, it is possible to determine accurately the error in the *total* thread angle by obtaining values for the effective diameter with two different pairs of cylinders, preferably approaching the maximum and minimum sizes, respectively, for the particular thread concerned. In calculating the appropriate values of P for the two sets of cylinders, the thread angle is assumed correct.

If E_1 = apparent effective diameter as obtained with the larger pair of cylinders (mean diameter d_1),

E_2 = apparent effective diameter as obtained with the smaller pair of cylinders (mean diameter d_2),

Then the error in *total* thread angle is given by the following formulae :—

$$\delta\,(2\theta) = \frac{(E_2 - E_1)}{0\cdot036\,(d_1 - d_2)} \text{ for Whitworth } (55^\circ) \text{ threads.}$$

$$\delta\,(2\theta) = \frac{(E_2 - E_1)}{0\cdot049\,(d_1 - d_2)} \text{ for B.A. } (47\cdot5^\circ) \text{ threads.}$$

$$\delta\,(2\theta) = \frac{(E_2 - E_1)}{0\cdot030\,(d_1 - d_2)} \text{ for S.I. } (60^\circ) \text{ threads.}$$

It is to be noted that only the *total* error in the thread angle is obtained by this method : it provides no information as to the individual errors of the two sets of flanks. These errors can best be measured by optical means in some such manner as is described in Section IX.

Measurements with a series of cylinders of different diameters afford a means of confirming any want of straightness of the flanks observed during the examination of the thread form on the projection apparatus.

(*d*) **Correction for Elastic Compression in the Measurement of Screws with Small Cylinders.***—In measuring the effective diameter of screws by placing small cylinders in spaces between the threads, since each cylinder makes two " point " contacts with the screw and, in addition, a wedging effect occurs between each cylinder and the flanks of the threads, it will be readily understood that, unless precautions are taken to apply only slight pressures, the measurement of effective diameter is likely to be appreciably small on account

* Reprinted, by courtesy of the Editor of " Machinery," from an article by G. A. Tomlinson of the National Physical Laboratory, " Machinery," Vol. 28, p. 616, 1926.

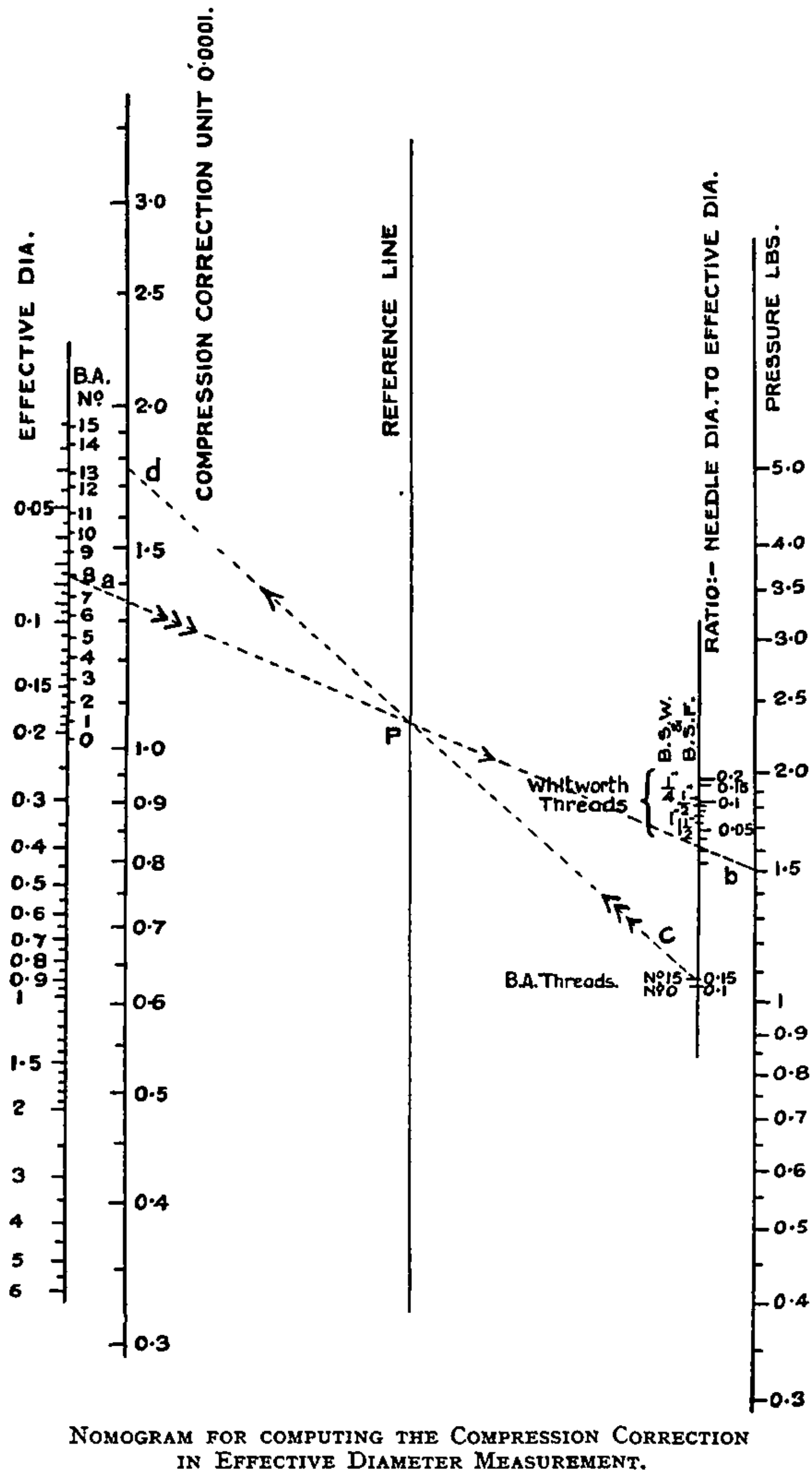
of elastic deformation at the various contacts. Experiment has shown that about half of the error due to this cause can be eliminated if a comparative measurement is first made on a plain plug of known size with the small wires included. Nevertheless; it has been found that, even with this precaution, the error due to compression in the measurement of small screws up to about ¼ in. diameter generally amounts to between 0·0001 in. and 0·0002 in. when the measurements are made under the ordinary pressure exerted by a micrometer, where reliance is placed on feel or touch. In this connexion it may be of interest to mention that tests made with six different observers showed that the average measuring pressure exerted was of the order of 14 oz., the maximum and minimum pressures being 22 and 11 oz.

It is evident, therefore, in the accurate measurement of small screws (especially the finer sizes of the B.A. series, where the tolerance on inspection gauges is only 0·0004 in., and on reference gauges only half this amount) that a correction should be applied on account of the compression which ordinarily occurs.

The amount of the correction depends upon the diameter, pitch and angle of the screw, and on the pressure applied during the measurement. The problem of determining the correction to suit any given case has been investigated at the Laboratory both mathematically and experimentally. In the latter case, various screws were measured with reference to cylindrical plug standards under a series of known pressures, and the results obtained confirmed the general formula deduced from theoretical considerations. At first sight it did not appear an easy matter to reduce this formula to one which could be quickly applied to any particular case. Eventually it was found possible to summarise it by a nomogram (Fig. 17), from which, as will be seen later, the correction can be read off without any difficulty.

In using this nomogram it is to be understood that a reading is first taken with the micrometer on a standard cylindrical plug of known size, and of approximately the same diameter as the screw to be measured, the small cylinders being inserted one on each side between the plug and the micrometer faces. The reading thus obtained is compared with that on the screw in order to obtain the size under the small wires when the latter are resting in the thread, and from this the measurement of the effective diameter, uncorrected for compression, can be readily deduced in the usual manner.

The method of using the nomogram will be seen from the example shown, which is a No. 8 B.A. screw measured under 1½ lb. pressure. The scale on the left is for the effective diameter and covers a range from No. 15 B.A. up to 6 in. ; the one on the right is for the pressure in lb. from 0·3 to 6 lb. The points *a* and *b* chosen on these scales corresponding to the case in hand are joined by a straight line, which cuts the " reference line " in the middle of the diagram at a point denoted by P. Attention is then directed to the scale marked " ratio: needle diameter to effective diameter," which is to be found towards the right-hand side of the diagram. This scale is graduated at the right-hand side of the line, two sets of graduations being given, for 55° and 47½° thread angle respectively. To save time in calculating the ratio of the diameters when needles of the " best "



NOMOGRAM FOR COMPUTING THE COMPRESSION CORRECTION IN EFFECTIVE DIAMETER MEASUREMENT.

FIG. 17.

diameter are being used, certain graduations are shown at the left-hand side of the line, by means of which the appropriate point on the scale can be immediately located for most standard screws. A point *c* is taken in the region marked " B.A. threads No. 15—No. 0," corresponding to the No. 8 size under consideration, and a line drawn through it and the point P. The point *d* where the continuation of this line intersects the scale to the left-hand side of the diagram marked " compression correction " gives the required value for the correction, the unit of the latter scale being 0·0001 in. The correction in this particular instance is found to be 0·00018 in.

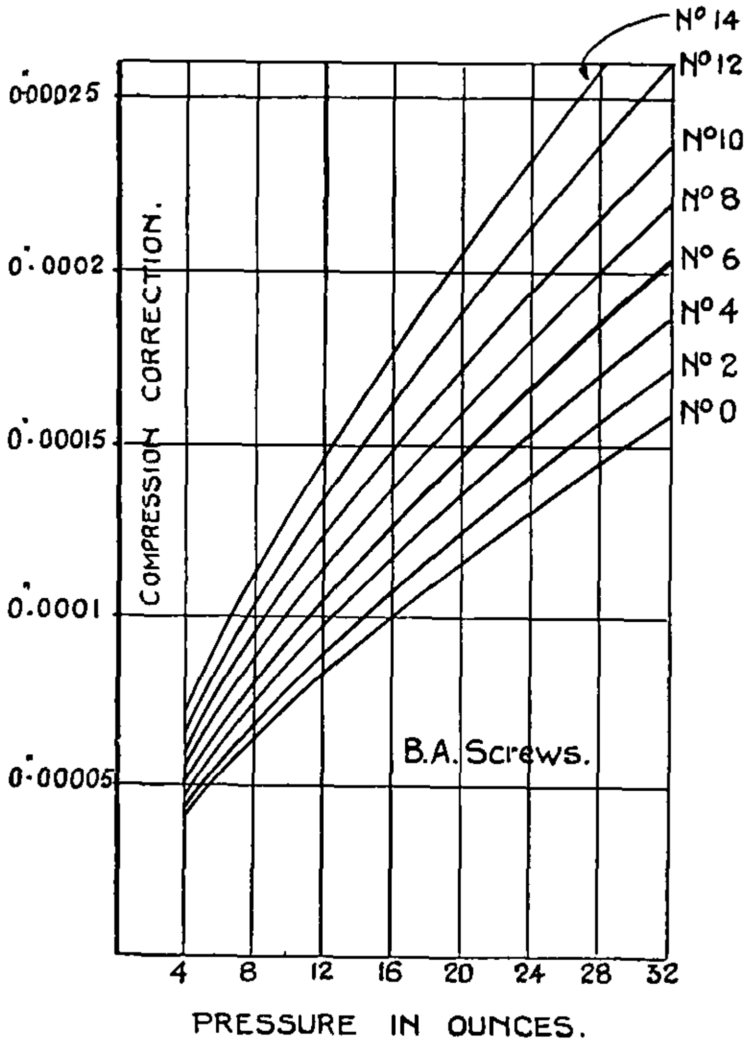
In the case of B.S.W. and B.S.F. screws up to 1½ in. diameter, the same procedure is adopted, using the short scale of B.S.W. and B.S.F. sizes to be found on the third scale. It will be obvious by inspection that the exact location of the point *c* on the third scale is not at all important, and if desired a single mean graduation might be used for all B.A. screws, and another for all Whitworth screws, without materially affecting the accuracy of the final computed correction.

With a Whitworth thread of non-standard pitch, such as, for example, ½ in.×26 T.P.I., it would be necessary to calculate the approximate ratio of the needle diameter to the effective diameter. If needles of the "best" size were being used, the ratio in this particular case would be 0·05, and the point on the third scale corresponding to this ratio would be joined to the point determined on the reference line from the effective diameter and pressure scales in order to obtain the intersection on the correction scale. For a pressure of 1 lb. the correction in this case would be a little greater than 0·00005 in.

It will be evident that the application of the correction is of the most importance in the B.A. series of screws, and the curves shown in Fig. 18 illustrate this point. These curves give the magnitude of the correction with measuring pressures from 4 to 32 oz., for the even numbers from No. 0 to No. 14, the " best " size of needles being assumed. The compression may thus under quite average conditions amount to 0·0001 to 0·0002 in., and the necessity for making the correction in precise measurements is clear from the curves. The curves may be used for these particular screws in preference to the nomogram if desired.

It has been mentioned that the size of the plain cylindrical standard should approximate to the effective diameter of the screw. In the B.A. series down to No. 15, it is sufficient to use a series of standards having diameters 0·05, 0·1, 0·15 and 0·20 in. Thus, for example, in measuring a No. 14 B.A. screw with a 0·05 in. standard at 8 oz. pressure, the correction for compression, as shown by the nomogram or curves, in which a standard exactly equal to the effective diameter is assumed, is 0·00011 in. Actually with the standard used the true value is 0·00012 in., the discrepancy being negligible.

Before this method can be used to determine the compression, it is clearly necessary to know the amount of pressure which is applied during the measurements of the screw and its corresponding cylindrical plug. When using a micrometer with a solid anvil, this will depend, as mentioned above, upon the touch or " feel " of the particular operator. It is possible, by loading the face of the micrometer spindle, to obtain a fairly close idea of the pressure exerted in any particular case, but it is preferable, when measuring small screws, to replace the solid anvil of the micrometer with one controlled by a spring and fitted with an



Curves showing Magnitude of Corrections with various Measuring Pressures on B.A. Screws.

Fig. 18.

indicator, as mentioned on page 24. Each measurement is then made under a definite measurable pressure, so long as the pointer attached to the plunger of the indicator is brought up each time to a fixed fiducial mark.

VIII.—Measurement of Ring Screws.

The Use of Check Plugs.—The diameters of ring screw gauges may be tested between limits by means of check plugs, or measured directly by mechanical means provided the gauges are not less than ¼ in. in diameter.

To test the diameters of a ring screw gauge completely during manufacture the following check plugs are desirable :—

(1) A " Go " Full Diameter screw check plug with thin threads and small angle, cleared on core diameter, and having its full diameter on the lower limit of size of the ring.

(2) A " Not-go " Full Diameter screw check plug, similar to No. (1), but whose full diameter is made to the upper limit.

(3) A " Go " *Effective Diameter* screw check plug, cleared on full and core diameters, with correct angle and pitch, and with its effective diameter made to the lower limit of size for the ring.

(4) A " Not-go " Effective Diameter screw check plug, similar in form to No. (3), but with an effective diameter made to the upper limit size.

(5) A " Go " Core Diameter cylindrical check plug made to the lower limit size.

(6) A " Not-go " Core Diameter cylindrical check plug made to the upper limit.

(7) A " Go " Full Form screw check plug made to the lower limit size on all diameters and correct in angle, pitch and form of thread.

Screw plugs numbers (1), (2) and (4) need be only a few threads long, but numbers (3) and (7) must be at least as long in the thread as the ring gauge.

If small errors in angle and pitch are present in checks numbers (3) and (7), they must be compensated for by a corresponding reduction in effective diameter. (See Section III on errors in plug screw gauges.)

Of the check plugs enumerated above, numbers (1), (3) and (5) are practically essential in producing ring screw gauges ; check No. (7) must also be used as a final test on the finished gauge. The " not-go " check plugs numbers (2), (4) and (6) are of value in the workshop for indicating the stage at which a gauge may be accidentally spoilt. For the purposes of the test room, only the check plugs (2), (4), (6) and (7) are needed.

The method of testing ring screw gauges by means of check plugs is very convenient when a large number of gauges of the same size have to be examined. When, however, only a limited number of screws have to be tested, the expense and delay involved in the production of a set of check plugs become prohibitive. In such cases, therefore, it is desirable that means should be available for carrying out direct measurements of ring screw gauges.

Measurements on Internal Diameter Machines.—The core diameter is usually measurable by inserting into the ring a pair of cylinders of suitable size and fitting slip gauges between them. For small gauges, a pair of accurately made folding wedges can be used, as in Fig. 19, the core diameter being obtained by micrometer measurement over the projecting portions of the wedges.

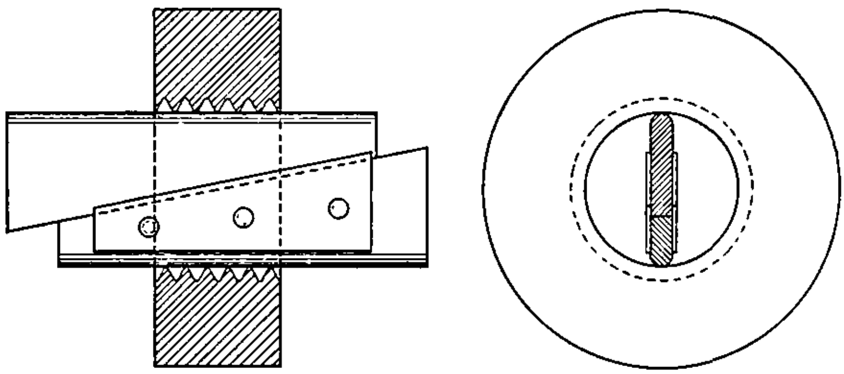


FIG. 19.

The effective and full diameters are not so easily measured. Two entirely different machines have been designed and are used at the Laboratory for the measurement of the effective diameter. One of these also enables the full diameter to be obtained.

The first machine, known as the displacement type, is shown diagrammatically in Fig. 20, and enables the effective diameter to be found by comparison with a circular Vee-groove of known diameter cut on a cylindrical plug. This Vee-groove is previously standardised by measurement with a suitable pair of small cylinders, in the same manner as is used for determining the effective diameter of plug screws.

The standard Vee-groove and the ring to be measured are placed in turn on a carriage C, whose position is controlled in the diametral direction by two micrometers M_1 and M_2. A short, double-ended stylus S, the radius of whose ends is so chosen that they will bear at about the middle of the flanks of the thread, is mounted on the carriage D at the end of the lever arm E of a fiducial indicator, which serves to record the position of the stylus in the diametral direction of the gauge. This carriage is supported on balls on a bracket F at the back of the machine, so as to have free motion in the direction of the axis of the gauge. A screw adjustment operated by the handwheel G is provided for raising or lowering the bracket, so as to adjust the position of the stylus to the horizontal plane containing the axis of the gauge.

The two positions of the carriage C, corresponding to the stylus being brought into contact in turn with each side of the standard groove, are first recorded by

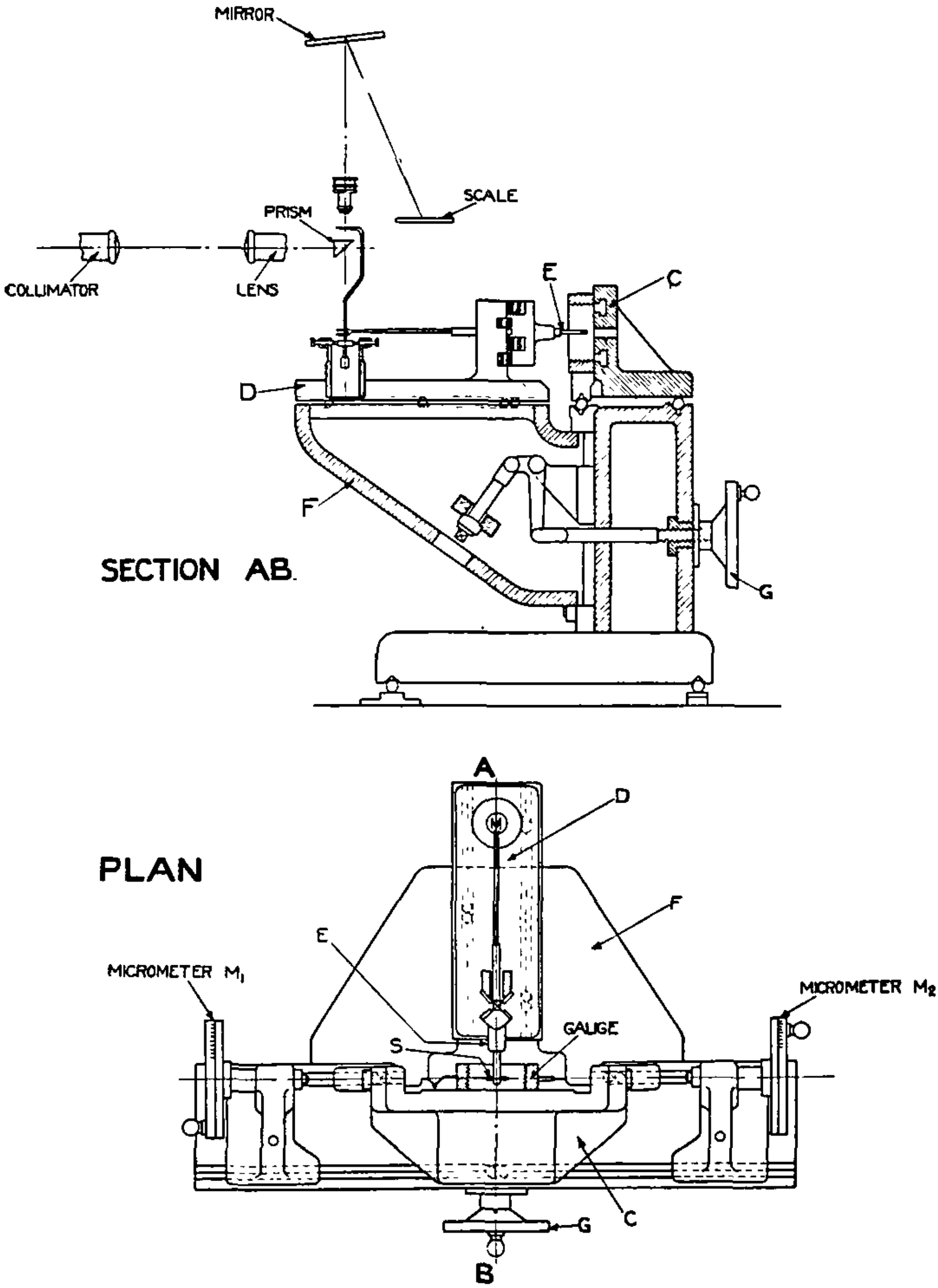

MIRROR
SCALE
PRISM
COLLIMATOR
LENS
E
C
D
F
G
SECTION AB.
A
D
PLAN
F
E
MICROMETER M1
MICROMETER M2
GAUGE
S
C
G
B

FIG. 20.

means of the micrometers. Similar readings are then obtained on the ring gauge. In all the four positions of the carriage, the stylus is brought to exactly the same position by means of the indicator. From the four readings thus obtained, the effective diameter of the ring can be readily calculated with reference to the known diameter of the Vee-groove.

For measuring the full diameter, a stylus having smaller radii is used, contact being made on the roots of the thread. In this case, the comparative reading

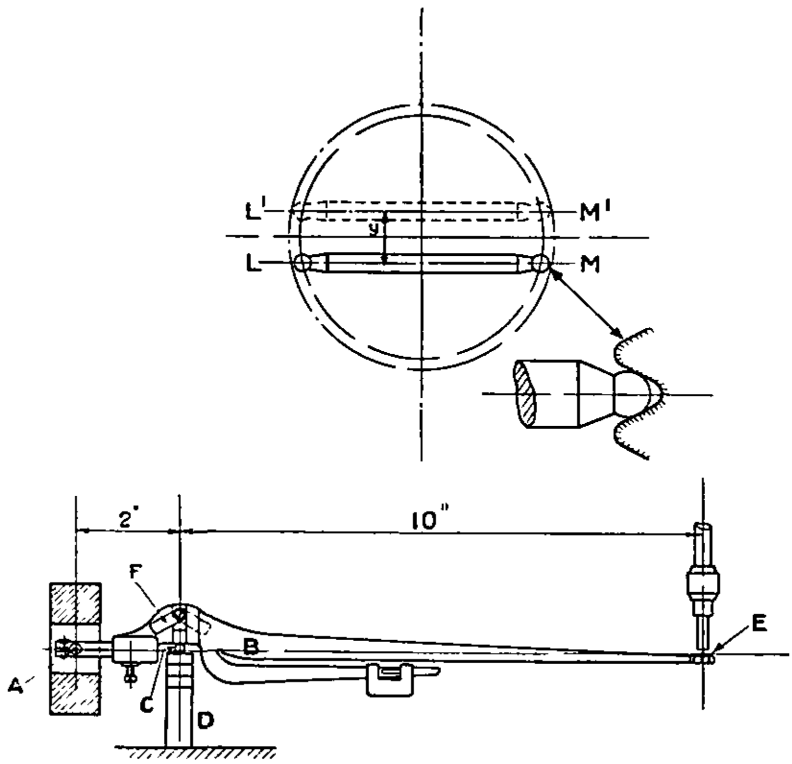


FIG. 21.

is made on a cylindrical plug of known diameter. A complete description of this machine, which will accommodate gauges up to about 6 in. outside diameter, will be found on page 118 of the Report of the National Physical Laboratory for the year 1921, published by H.M. Stationery Office, price 6*s*. 11*d*. post free.

The second machine, known as the chordal type, operates on the principle shown in Fig. 21. The ring is held with its axis horizontal, and the effective diameter is measured by means of a double ball-ended rod LM. This rod is made of such a length that, when placed horizontally with the ball-ends lying in a groove of the ring, it is possible to move it vertically through a distance y, which depends on the effective diameter of the ring, the length of the rod and the diameter of the balls. With a knowledge of the last two dimensions, all that is necessary is to measure y, and from this the effective diameter can be calculated.

The measurement of y is carried out by mounting the ball-ended rod on the short arm A of a five-to-one lever, as shown diagrammatically in the lower part of Fig. 21. This lever B is supported on two steel balls C on a pile of block gauges D, so as to be approximately horizontal when the rod is resting in its lower position in the ring. A reading of a fixed micrometer is then taken by sighting the contact between its measuring face and a thin curved sector E mounted at the end of the long arm of the lever. The lever is raised by increasing the pile of slip gauges D by the calculated value of y, and the rod is brought into contact with the upper portion of the ring by means of the throw-over weight F. A second micrometer reading is then taken. From the micrometer readings and the known displacement of the fulcrum, the actual distance y is determined.

For a complete description of the machine, and the calculations involved, see "*Engineering*," Vol. *112*, page 558, *1921*, or Glazebrook's "Dictionary of Applied Physics," Vol. 3, page 304.

Pitch.—The method of measuring the pitch of ring screws is similar to that used for plug screws, and is mentioned in Section VI.

It may be pointed out that, in the case of a ring gauge tested by means of check plugs and found to be satisfactory, it is really unnecessary to measure its pitch independently, for if a ring gauge accepts completely a full form "go" screw check and refuses to allow the "not go" effective diameter check to enter, it cannot be in error on pitch by an amount which is outside acceptable limits. Should, however, a ring gauge fail to accept the full form check completely, a knowledge of its pitch error proves very useful in attempting to ascertain the cause, and for this reason it is usual, in the routine testing of ring screw gauges, to measure their pitches independently.

Angle and Thread Form.—The angle and thread form of ring screws are examined through the medium of a cast of the thread either in plaster or dental wax. The finest plaster of Paris is found to give the most satisfactory results for gauges over about ½ in. in diameter; for smaller gauges a dental wax which softens in hot water is most serviceable.

To obtain good results with plaster, the gauge must be scrupulously clean, and the screwed surface coated with a very thin and uniform film of grease so as to prevent the cast adhering to the gauge. A thin solution of vaseline in petrol is found to be suitable for this purpose. The plaster is mixed with water to form a very thin, creamy liquid, and is poured into a sector of the ring gauge, which is held with its plane vertical as in Fig. 22. The sector used should be considerably less than a semicircle, so as to allow of the removal of the cast from the ring without having to unscrew it—an operation which would destroy its accuracy. The cast should be removed before the plaster sets quite hard.

For very small rings dental wax softened in hot water is pressed into a sector of the gauge, which is slightly heated to prevent sudden chilling of the wax.

Some experience is usually necessary before satisfactory casts can be obtained, but when properly carried out, the method of examining the form of thread by

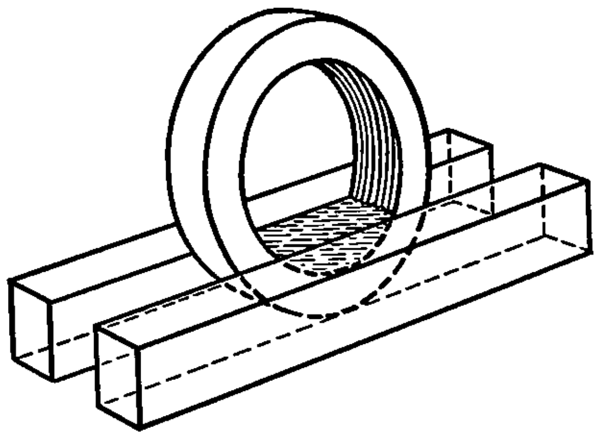


FIG. 22.

optical projection of casts has been found to be quite reliable. The type of apparatus upon which the examination is made is described in the next Section.

IX.—Optical Projection Apparatus.

The examination of the thread form of screw gauges, both plugs and rings, and of complicated profile gauges, is most conveniently carried out by means of an optical projection apparatus.

(*a*) **Horizontal Projector.**—The standard horizontal, large-field type of gauge projection apparatus designed at the Laboratory is illustrated in Fig. 23. The optical system consists of an electric arc or 100 c.p. " pointolite " lamp L, used in conjunction with a condenser C to give an illuminating beam of parallel light, and a compound projection lens P. The object to be projected is mounted on the horizontal slide S, either between the centres or in the clamp B, and is placed in the path of the beam in front of the projection lens. In addition to its horizontal motion, the slide S can be raised or lowered by means of the screw V, so that the position of the object can be readily adjusted in the field of the lens. The image, which is usually arranged to be enlarged exactly 50 times, is formed on a screen situated about 20 feet away, and is focussed by fine adjustment of the position of the gauge with respect to the projection lens. The image is compared with a standard diagram carefully drawn to the correct scale.

The chief feature of the horizontal projector is the large area of the field, from 6 to 7 ft. in diameter, over which the distortion is negligible. This is attained by using a suitable combination of lenses in the compound projection lens P. Suitable lenses for the purpose are the 6-in. focus Dallmeyer " Serrac " and Ross " Tessar " photographic lenses, combined with suitable field lenses.

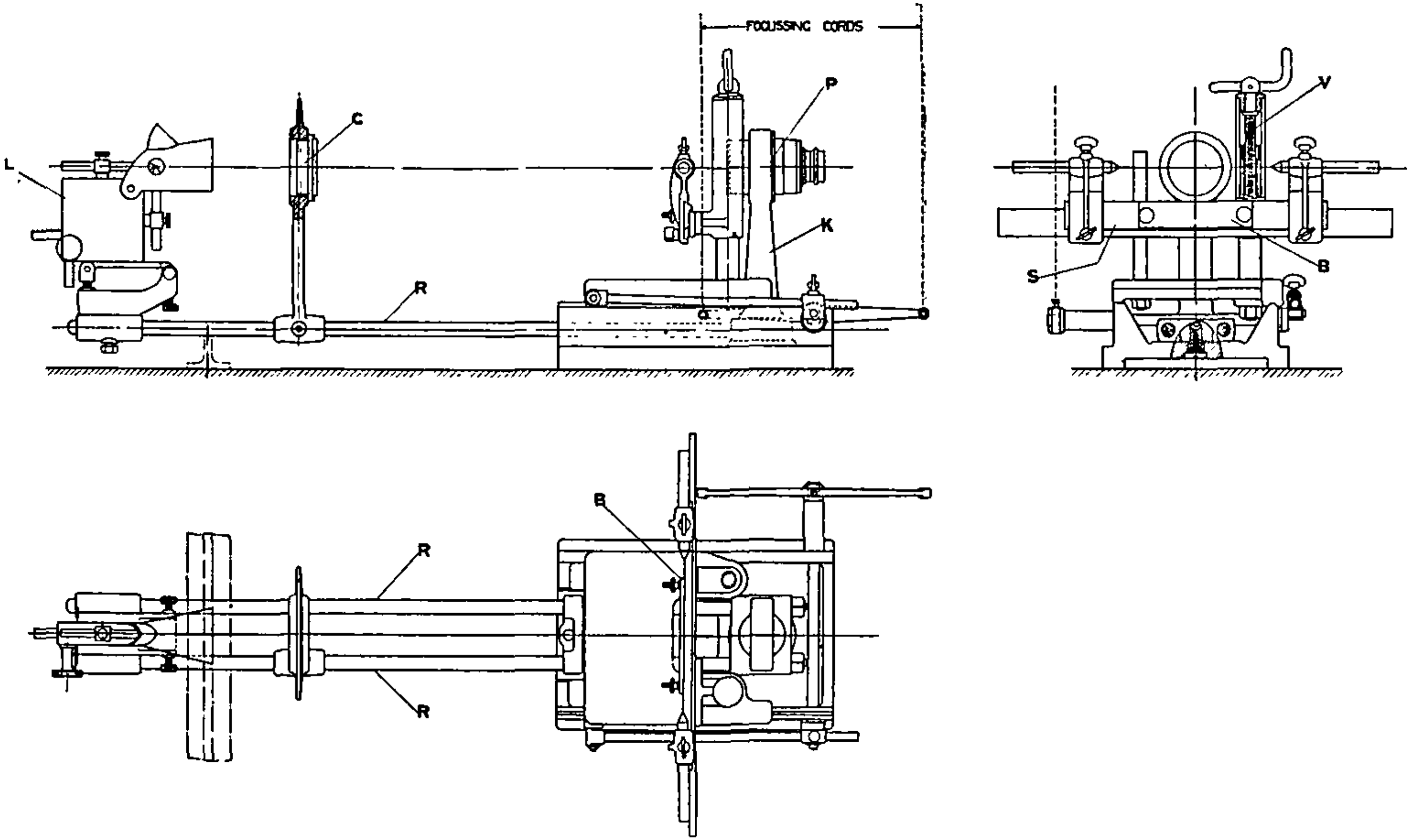


Fig. 23.

The setting-up of the apparatus is a simple matter. With the screen set truly vertical and the bed of the machine carefully levelled, the next step is to set the apparatus at the correct distance from the screen to obtain the desired magnification. This is done by adjusting the distance until the correct width is obtained for the image of, say, a ½-in. diameter cylinder, the diameter of which is known to $\pm$ 0·0001 in. Squareness of the optical axis of the apparatus to the screen in the horizontal plane is ensured if the apparatus is finally set so that the width of the image is the same on the two sides of the screen.

For some purposes it is desirable to have facilities for altering the magnification of the projected image without disturbing in any way the squareness of the optical axis with the screen. To do this, the trestle supporting the apparatus is sometimes mounted on flanged wheels, running on a pair of straight rails extending from the screen to the back of the room. By means of a scale fixed along one of the rails, it then becomes a simple matter to set the apparatus to give any desired magnification within the compass of the room.

This projector, while particularly adapted for the examination of comparatively large objects up to about 1½ in. in size, can also be used for examining the angle and thread form of screw gauges. For this purpose it is necessary that the direction of the parallel illuminating beam should be adjusted to coincide with the mean inclination of the threads to the axis of the screw; in other words, parallel to the rake angle of the threads. To effect this adjustment, the rods R which support the lamp and condenser are capable of rotation in a horizontal plane through about 5° on each side of the centre line, about an axis passing through the centre of the post K, which carries the projection lens.

The flank angles of a screw are measured by means of the shadow protractor shown in Fig. 24. This rests against the screen on an adjustable straight-edge, which permits of it being moved sideways without tilting. After setting up the protractor by means of the adjustable straight-edge, so that its edge A is parallel to the crests of the screw, the pivoted arm B is rotated, first to one side and then to the other, so as to bring the edge of its shadow on the white background parallel to the sloping flanks of the thread in turn. The angles of the two sets of flanks are then read off in degrees from the circular scale. From these measurements, any error in the squareness of the thread with the axis of the screw, as well as in the total angle, is readily deduced.

The thread form of the screw is examined by meshing the image with a standard diagram, such as is shown in Fig. 25. The diagram consists of a profile of the thread form of the screw, 50 times true size, on a metal plate fitted with suitable handles. It is of a greyish or light-blue colour on a white background. Since, in a partially darkened room, the projected image is of a grey tint, the presence of excess metal at any point of the thread produces an overlapping of the grey image and the tinted diagram, which is indicated at once by the appearance of a black patch at the point concerned. Where metal is missing, a corresponding white space is seen. The two effects are illustrated in Fig. 26, which shows the image B of a screw having an unsymmetrical thread angle, meshed with the standard outline A.

Standard thread-form diagrams to a magnification of 50 are obtainable commercially for all the usual pitches of Whitworth, B.A., and S.I. threads.

For the examination of the form of thread of a screw gauge, the projection lens as ordinarily used in the horizontal projector is unnecessarily large. A vertical type of apparatus is available for dealing with such gauges in a more convenient manner.

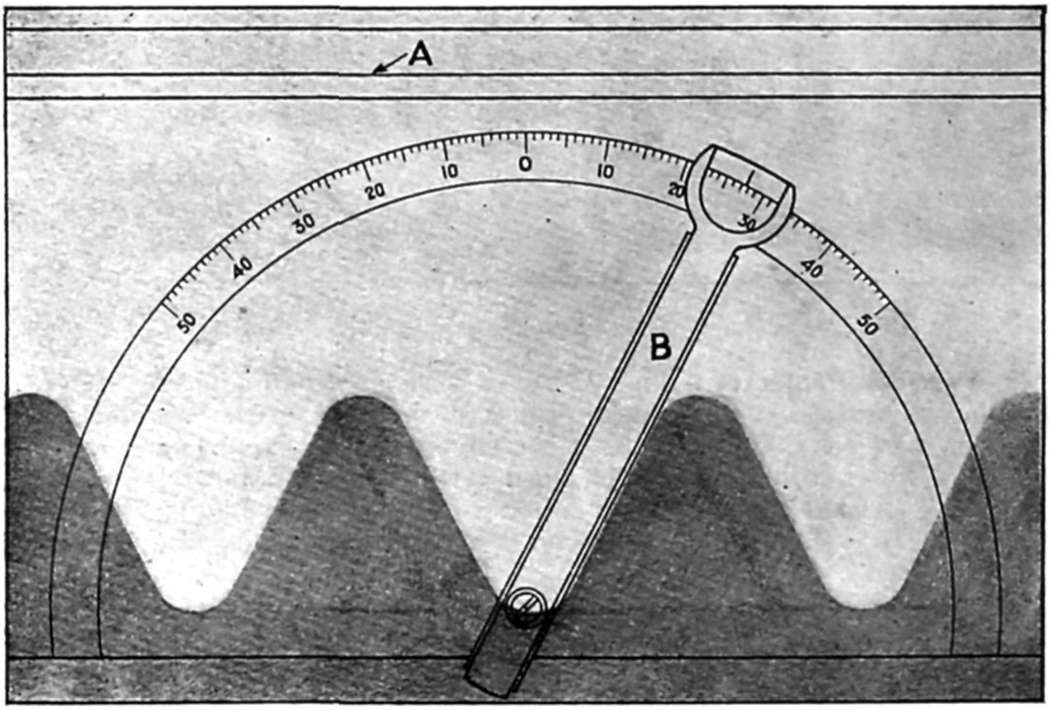


Fig. 24.

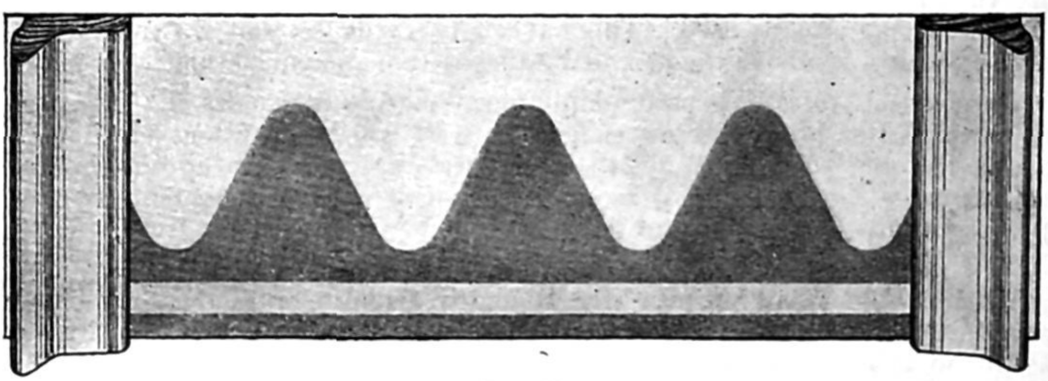


Fig. 25.

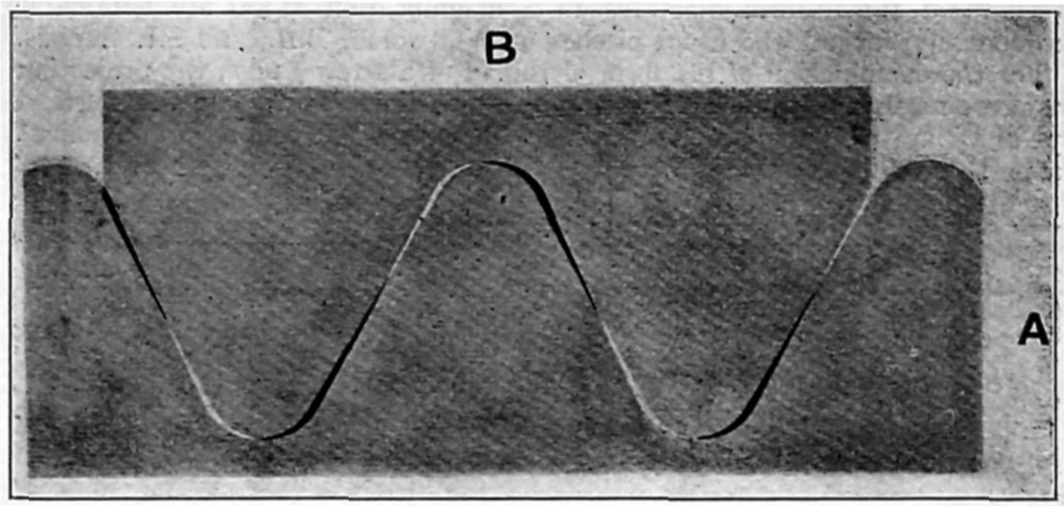


FIG. 26.

(*b*) **Vertical Projector.**—Fig. 27 shows skeleton front and side views of the standard vertical type of gauge projector, the body of the machine being shown in more detail in Fig. 28. Generally speaking, the machine may be regarded as the horizontal projector stood vertically on end, but instead of the image being formed on the ceiling, it is reflected, by means of a horizontal mirror placed overhead, on to a table carried on the bed of the machine near the object being examined.

The source of illumination is either an arc or a 100 c.p. " pointolite " lamp, and the parallel beam, which is at first horizontal, is reflected upwards past the gauge by means of a 45° glass prism situated in the body of the machine. By slight tilting, this prism also serves to adjust the beam to the " rake " of the thread. The projection lens ordinarily used is known as the No. 4 Dallmeyer Gauge Projection lens, and the magnification, which varies according to the height of the mirror, is usually set to 50 times true size. With this 3-in. focus lens, the mirror is about 6 ft. above the lens. A No. 1 Dallmeyer Gauge Projection lens can also be used. This has a 2-in. focus, so that the mirror need only be about 4 ft. above the lens to obtain the same magnification.

The vertical projector is used mainly for measuring the angles and inspecting the thread forms of plug screw gauges, both of which operations are done in exactly the same manner as on the horizontal projector. In addition, actual measurements can be made, if required, of the pitch and diameters of screws up to 2 in. in diameter, by means of micrometers provided for traversing the screw in directions parallel and at right angles to its axis respectively.

When used for this purpose, the standard diagram takes the form shown towards the bottom left-hand corner of Fig. 28. It comprises two outlines of the thread, spaced exactly half an inch apart in the diametral direction, together with parallel bands of the same width. The images of opposite sides of the

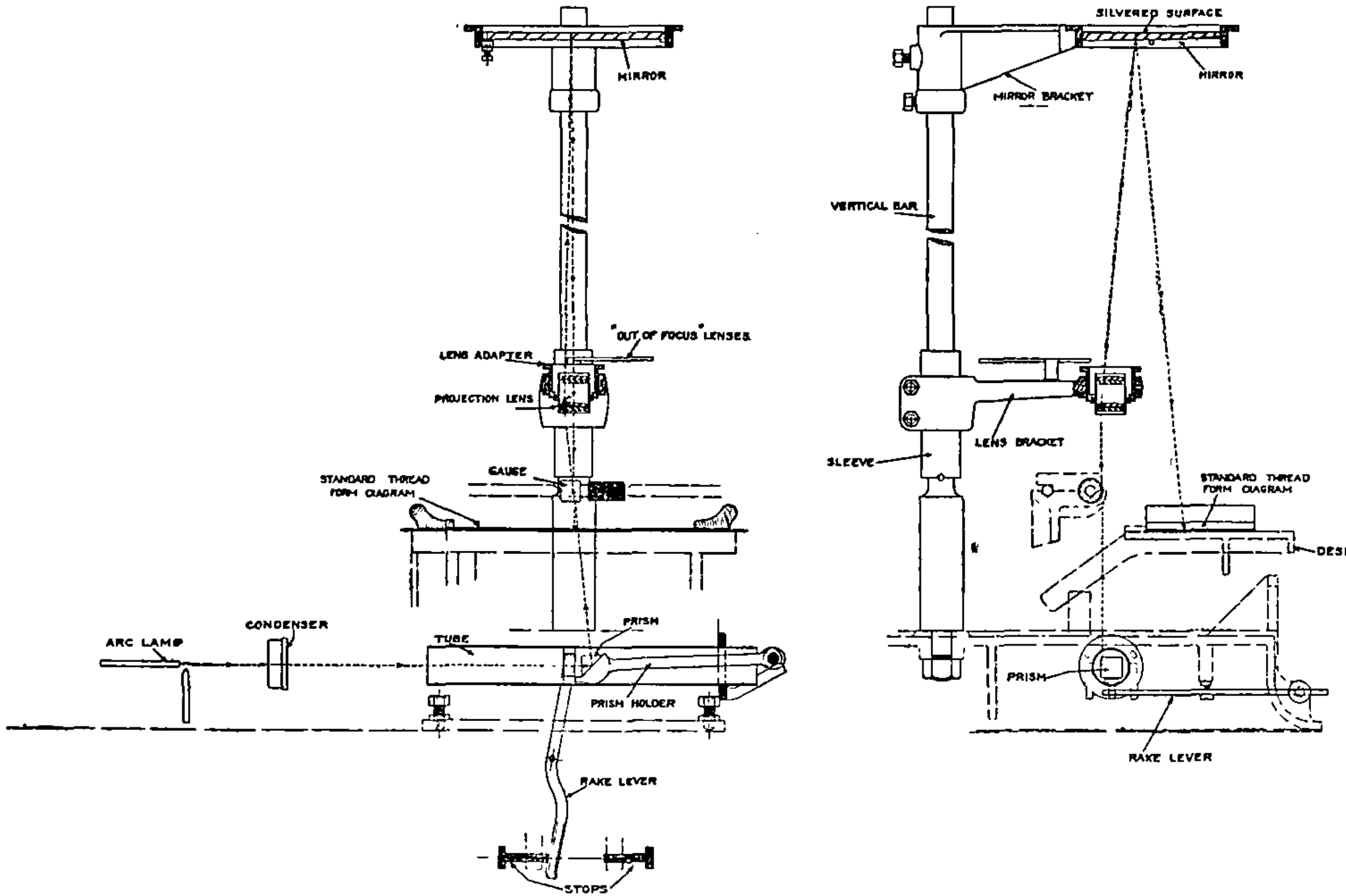

MIRROR
"OUT OF FOCUS" LENSES
LENS ADAPTER
PROJECTION LENS
GAUGE
STANDARD THREAD FORM DIAGRAM
CONDENSER
ARC LAMP
TUBE
PRISM
PRISM HOLDER
RAKE LEVER
STOPS
SILVERED SURFACE
MIRROR
MIRROR BRACKET
VERTICAL BAR
LENS BRACKET
SLEEVE
STANDARD THREAD FORM DIAGRAM
DESK
PRISM
RAKE LEVER

FIG. 27.

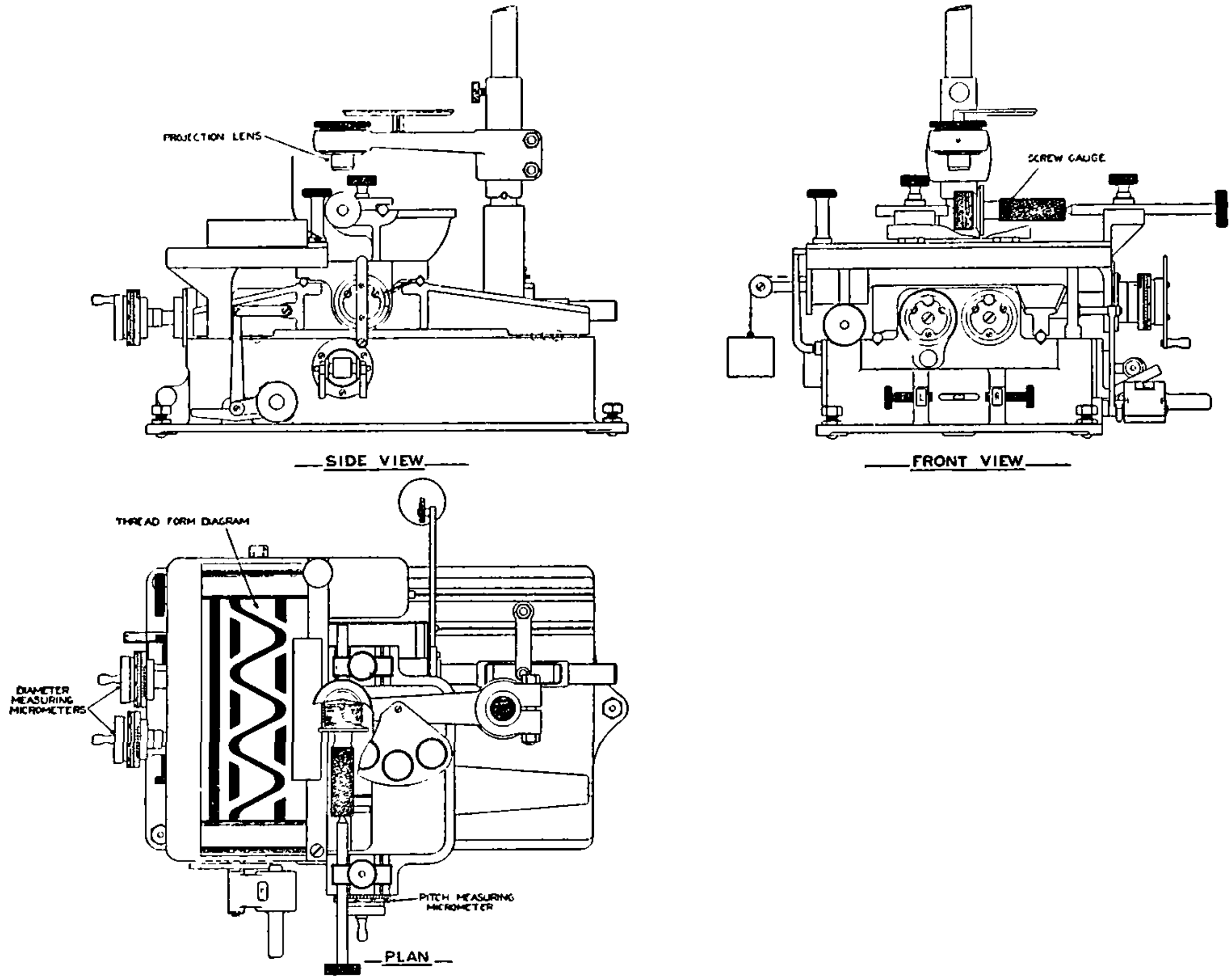

PROJECTION LENS
SCREW GAUGE
SIDE VIEW
FRONT VIEW
THREAD FORM DIAGRAM
DIAMETER MEASURING MICROMETERS
PITCH MEASURING MICROMETER
PLAN

Fig. 28.

screw under test are brought up in turn, by means of the micrometers, until they fit the corresponding outline on the diagram. By comparing the micrometer readings with those obtained after substituting a plain cylindrical plug gauge for the screw, and setting the edges of its image to those of the parallel band on the diagram, the diameters of the screw can be readily obtained.

Screws up to about 6 in. in diameter can be examined for form of thread on this vertical type of apparatus; screws up to 2 in. can in addition be measured, if desired.

Screws larger than 6 in. in diameter can be dealt with on the horizontal projector if the usual projection lens is replaced by one having a greater working distance between the gauge and the back of the lens. An additional pair of higher centres is provided for mounting such gauges. A suitable lens for the purpose is a Dallmeyer 5-in. focus Gauge Projection lens. This lens gives a satisfactory field about 3 ft. in diameter, the distance between the back of the lens and the plane of projection being about 3 in. With this arrangement, plug screws up to 8 in. in diameter can be projected, but with the larger sizes the definition of the image falls off appreciably.

For a detailed description of the projectors, together with an account of other purposes for which they have been found useful, reference should be made to a paper by G. A. Tomlinson entitled "Measurement by Optical Projection,"* or to Glazebrook's "Dictionary of Applied Physics," Vol. 3, pp. 352 *et seq*.

* "N.P.L. Collected Researches," Vol. 20, Paper 30, p. 429, 1928. Published by H.M. Stationery Office, price 10d.

APPENDIX I.

Particulars of Standard Screw Threads.

WHITWORTH THREADS.

The Whitworth form of thread has been standardised by the British Engineering Standards Association, and is defined in their Reports Nos. 84 and 92. These Reports give the Standard Limits for screws in the B.S.F. and B.S.W. series respectively.

The form of thread is as follows :—

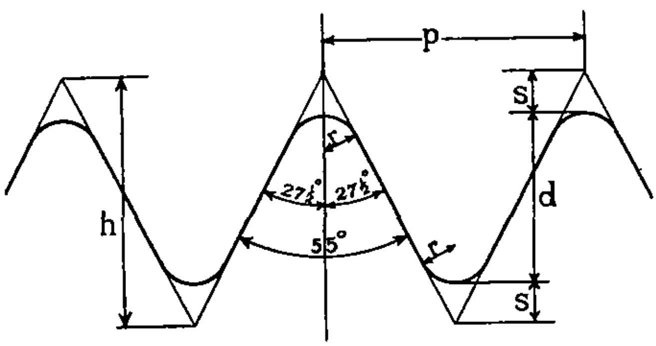


FIG. 29.

$h = 0{\cdot}9605 \times p.$ $\qquad$ $s = \frac{1}{6}h = 0{\cdot}160 \times p.$

$d = \frac{2}{3}h = 0{\cdot}6403 \times p.$ $\qquad$ $r = 0{\cdot}137 \times p.$

TABLE I.

Threads per Inch.	Depth of Thread.	Double depth of Thread.	Shortening.	Radius of Tool.
n	d	$2d$	S	r
	In.	In.	In.	In.
40	0·0160	0·0320	0·0040	0·0034
36	0·0178	0·0356	0·0044	0·0038
32	0·0200	0·0400	0·0050	0·0043
28	0·02285	0·0457	0·0057	0·0049
26	0·02465	0·0493	0·0062	0·0053
24	0·0267	0·0534	0·0067	0·0057
22	0·0291	0·0582	0·0073	0·0062
20	0·0320	0·0640	0·0080	0·0069
19	0·0337	0·0674	0·0084	0·0072
18	0·03555	0·0711	0·0089	0·0076
16	0·0400	0·0800	0·0100	0·0086
14	0·04575	0·0915	0·0114	0·0098
12	0·05335	0·1067	0·0133	0·0114
11	0·0582	0·1164	0·0146	0·0125
10	0·06405	0·1281	0·0160	0·0137
9	0·07115	0·1423	0·0178	0·0152
8	0·08005	0·1601	0·0200	0·0172
7	0·0915	0·1830	0·0229	0·0196
6	0·1067	0·2134	0·0267	0·0229
5	0·12805	0·2561	0·0320	0·0275
4·5	0·1423	0·2846	0·0356	0·0305
4	0·1601	0·3202	0·0400	0·0343

BRITISH ASSOCIATION THREADS.

The British Association (B.A.) series of threads is recommended by the B.E.S.A. for sizes below ¼ in. diameter. This series is dealt with in the B.E.S.A. Report No. 93, which includes standard limits for the screws.

The form of thread is as follows :—

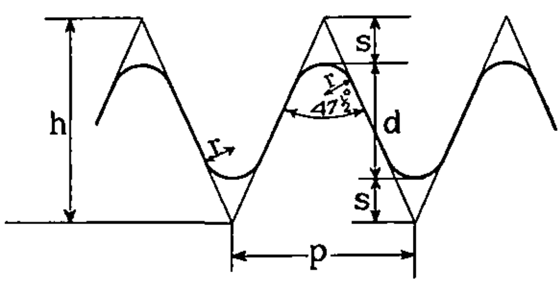


FIG. 30.

$h = 1 \cdot 13634 \times p$

$d = 0 \cdot 6 \times p$ (approximately)

$r = \frac{2}{11} \times p$ (approximately)

$s = 0 \cdot 27 \times p$ (approximately)

This thread has rounded crests and roots as is the case with the Whitworth thread. The angle of the thread is 47·5°.

The following are the nominal sizes and pitches :—

TABLE II.

Designating Number.	Full Diameter.	Effective Diameter.	Core Diameter.	Pitch.
	mm.	mm.	mm.	mm.
0	6·0	5·40	4·80	1·00
1	5·3	4·76	4·22	0·90
2	4·7	4·215	3·73	0·81
3	4·1	3·66	3·22	0·73
4	3·6	3·205	2·81	0·66
5	3·2	2·845	2·49	0·59
6	2·8	2·48	2·16	0·53
7	2·5	2·21	1·92	0·48
8	2·2	1·94	1·68	0·43
9	1·9	1·665	1·43	0·39
10	1·7	1·49	1·28	0·35
11	1·5	1·315	1·13	0·31
12	1·3	1·13	0·96	0·28
13	1·2	1·05	0·90	0·25
14	1·0	0·86	0·72	0·23
5	0·9	0·775	0·65	0·21

METRIC THREADS (SYSTEM INTERNATIONAL).

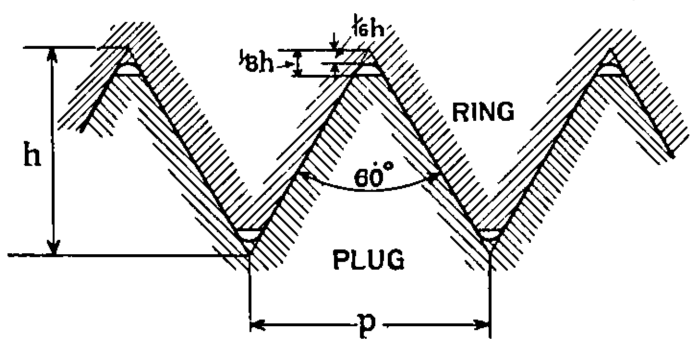


FIG. 31.

The principal feature of the thread form of the International System is the provision of a definite clearance at the top and bottom of the thread between the plug and the ring.

The angle of the thread is 60°. The crests of the threads are flat, as shown in Fig. 31 above, being truncated by one-eighth of the total height of the fundamental triangle. The actual amount of the clearance at the core diameter of the plug and at the full diameter of the ring is immaterial, but it is convenient that the thread form at these points should follow reasonably closely the nominal outline as shown in the figure.

The following Table III will be found useful in calculating the standard sizes of the effective and core diameters of a plug gauge from the pitch and the full diameter.

TABLE III.

p	h	$\frac{1}{16}h$	$\frac{1}{8}h$	Full dia. − Effective dia. = $\frac{3}{4}h$.	Full dia. − Core dia. = $1\frac{5}{8}h$.
mm.	mm.	mm.	mm.	mm.	mm.
0·5	0·4330	0·0271	0·0541	0·3247	0·7036
0·75	0·6495	0·0406	0·0812	0·4871	1·0555
1·0	0·8660	0·0541	0·1082	0·6495	1·4073
1·25	1·0825	0·0677	0·1353	0·8119	1·7591
1·5	1·2990	0·0812	0·1624	0·9743	2·1109
1·75	1·5155	0·0947	0·1894	1·1366	2·4627
2·0	1·7320	0·1082	0·2165	1·2990	2·8146
2·5	2·1651	0·1353	0·2706	1·6238	3·5182
3·0	2·5981	0·1624	0·3247	1·9486	4·2219

CYCLE ENGINEERS' INSTITUTE (C.E.I.) THREADS.

This thread is not a standard adopted by the B.E.S.A., but since it is still used to some extent by the automobile and cycle trades, particulars of the generally accepted profile of the thread are given in Fig. 32.

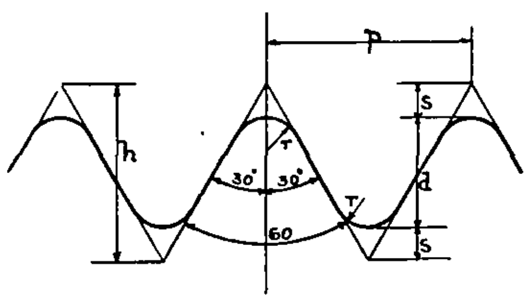


FIG. 32.

$h = 0 \cdot 8660 \times p.$ $s = \frac{1}{6}p.$
$d = 0 \cdot 5327 \times p.$ $r = \frac{1}{8}p.$

APPENDIX II.

Table IV.

Limits of Tolerance for "Go" Plug Screw Gauges.

Size of gauge :—	Up to and including 1·5 in.*	Above 1·5 and up to 3 in.	Above 3 and up to 6 in.	Over 6 in.
Reference.				
	In.	In.	In.	In.
Full diameter	+ 0·0000 − 0·0003	+ 0·0000 − 0·0005	+ 0·0000 − 0·0007	+ 0·0000 − 0·0010
Effective diameter ..	+ 0·0000 − 0·0003	+ 0·0000 − 0·0005	+ 0·0000 − 0·0007	+ 0·0000 − 0·0010
Core diameter	+ 0·0000 − 0·0005	+ 0·0000 − 0·0007	+ 0·0000 − 0·0010	+ 0·0000 − 0·0015
Inspection.				
Full diameter	+ 0·0000 − 0·0006	+ 0·0000 − 0·0009	+ 0·0000 − 0·0014	+ 0·0000 − 0·0020
Effective diameter ..	+ 0·0000 − 0·0006	+ 0·0000 − 0·0009	+ 0·0000 − 0·0014	+ 0·0000 − 0·0020
Core diameter	+ 0·0000 − 0·0009	+ 0·0000 − 0·0014	+ 0·0000 − 0·0021	+ 0·0000 − 0·0030
Workshop.				
Full diameter	+ 0·0006 − 0·0000	+ 0·0009 − 0·0000	+ 0·0014 − 0·0000	+ 0·0020 − 0·0000
Effective diameter ..	+ 0·0006 − 0·0000	+ 0·0009 − 0·0000	+ 0·0014 − 0·0000	+ 0·0020 − 0·0000
Core diameter	+ 0·0006 − 0·0003	+ 0·0009 − 0·0005	+ 0·0014 − 0·0007	+ 0·0020 − 0·0010

* See Table VI, p. 58, for special tolerances on small B.A. gauges.

For tolerances on pitch and angle of thread, see pp. 11, 12.

For limits of size of B.S.W., B.S.F., B.S.P and B.A. inspection and workshop "go" gauges see Appendix VII, p. 70.

TABLE V.

LIMITS OF TOLERANCE FOR "GO" RING SCREW GAUGES.

Size of gauge :—	Up to and including 1·5 in.*	Above 1·5 and up to 3 in.	Above 3 and up to 6 in.	Over 6 in.
Reference.				
	In.	In.	In.	In.
Full diameter	+ *0·0005* – 0·0000	+ *0·0007* – 0·0000	+ *0·0010* – 0·0000	+ *0·0015* – 0·0000
Effective diameter ..	+ 0·0003 – 0·0000	+ 0·0005 – 0·0000	+ 0·0007 – 0·0000	+ 0·0010 – 0·0000
Core diameter	+ 0·0003 – 0·0000	+ 0·0005 – 0·0000	+ 0·0007 – 0·0000	+ 0·0010 – 0·0000
Inspection.				
Full diameter	+ 0·0009 – 0·0000	+ 0·0014 – 0·0000	+ 0·0021 – 0·0000	+ 0·0030 – 0·0000
Effective diameter ..	+ 0·0006 – 0·0000	+ 0·0009 – 0·0000	+ 0·0014 – 0·0000	+ 0·0020 – 0·0000
Core diameter	+ 0·0006 – 0·0000	+ 0·0009 – 0·0000	+ 0·0014 – 0·0000	+ 0·0020 – 0·0000
Workshop.				
Full diameter	+ 0·0003 – 0·0006	+ 0·0005 – 0·0009	+ 0·0007 – 0·0014	+ 0·0010 – 0·0020
Effective diameter ..	+ 0·0000 – 0·0006	+ 0·0000 – 0·0009	+ 0·0000 – 0·0014	+ 0·0000 – 0·0020
Core diameter	+ 0·0000 – 0·0006	+ 0·0000 – 0·0009	+ 0·0000 – 0·0014	+ 0·0000 – 0·0020

* See Table VI, p. 58, for special tolerances on small B.A. gauges.

For tolerances on pitch and angle of thread, see pp. 11, 12.

For limits of size of B.S.W., B.S.F., B.S.P. and B.A. inspection and workshop "go" gauges see Appendix VII, p. 70.

TABLE VI.

LIMITS OF TOLERANCE FOR SMALL B.A. "GO" SCREW GAUGES.

The tolerances on B.A. screws Nos. 0 to 7 inclusive are those given in the second column of Tables IV and V. For the smaller sizes, Nos. 8 to 15 inclusive, owing to the fineness of thread, the tolerances have to be restricted as follows :—

	Plugs.		Rings.	
	In.	mm.	In.	mm.
Reference.				
Full diameter	+ 0·0000 − 0·0002	+ 0·000 − 0·005	+ 0·0003 − 0·0000	+ 0·008 − 0·000
Effective diameter ..	+ 0·0000 − 0·0002	+ 0·000 − 0·005	+ 0·0002 − 0·0000	+ 0·005 − 0·000
Core diameter	+ 0·0000 − 0·0003	+ 0·000 − 0·008	+ 0·0002 − 0·0000	+ 0·005 − 0·000
Inspection.				
Full diameter	+ 0·0000 − 0·0004	+ 0·000 − 0·010	+ 0·0006 − 0·0000	+ 0·015 − 0·000
Effective diameter ..	+ 0·0000 − 0·0004	+ 0·000 − 0·010	+ 0·0004 − 0·0000	+ 0·010 − 0·000
Core diameter	+ 0·0000 − 0·0006	+ 0·000 − 0·015	+ 0·0004 − 0·0000	+ 0·010 − 0·000
Workshop.				
Full diameter	+ 0·0004 − 0·0000	+ 0·010 − 0·000	+ 0·0002 − 0·0004	+ 0·005 − 0·010
Effective diameter ..	+ 0·0004 − 0·0000	+ 0·010 −0 ·000	+ 0·0000 − 0·0004	+ 0·000 − 0·010
Core diameter	+ 0·0004 − 0·0002	+ 0·010 − 0·005	+ 0·0000 − 0·0004	+ 0·000 − 0·010

For tolerances on pitch and angle of thread, see pp. 11 and 12.

For limits of size of B.A. inspection and workshop "go" gauges see Tables XXXII to XXXV, Appendix VII, p. 80.

Table VII.

Limits of Tolerance for "Not Go" Effective Diameter Plug Screw Gauges.

Size of gauge :—	Up to and including 1·5 in. and B.A. screws Nos. 0 to 15.	Above 1·5 and up to 3 in.	Above 3 and up to 6 in.	Over 6 in.
Inspection.				
Effective diameter ..	In. + 0·0003 − 0·0000	In. + 0·0005 − 0·0000	In. + 0·0007 − 0·0000	In. + 0·0010 − 0·0000
Workshop.				
Effective diameter ..	+ 0·0000 − 0·0003	+ 0·0000 − 0·0005	+ 0·0000 − 0·0007	+ 0·0000 − 0·0010

For form of thread see Fig. 3, p. 7.

Table VIII.

Limits of Tolerance for "Not Go" Plug Gauges for Core Diameter of Nuts.

Size of gauge :—	Up to and including 1·5 in. and B.A. screws Nos. 0 to 15.	Above 1·5 and up to 3 in.	Above 3 and up to 6 in.	Over 6 in.
Inspection.				
Tolerance on gauge ..	In. + 0·0003 − 0·0000	In. + 0·0004 − 0·0000	In. + 0·0005 − 0·0000	In. + 0·0007 − 0·0000
Workshop.				
Tolerance on gauge ..	+ 0·0000 − 0·0003	+ 0·0000 − 0·0004	+ 0·0000 − 0·0005	+ 0·0000 − 0·0007

TABLE IX.

LIMITS OF TOLERANCE FOR "NOT GO" EFFECTIVE DIAMETER RING SCREW GAUGES.

Size of gauge :—	Up to and including 1·5 in. and B.A. screws Nos. 0 to 15.	Above 1·5 and up to 3 in.	Above 3 and up to 6 in.	Over 6 in.
Inspection.				
Effective diameter ..	In. +0·0000 −0·0003	In. +0·0000 −0·0005	In. +0·0000 −0·0007	In. +0·0000 −0·0010
Workshop.				
Effective diameter ..	+0·0003 −0·0000	+0·0005 −0·0000	+0·0007 −0·0000	+0·0010 −0·0000

For form of thread see Fig. 3, p. 7.

TABLE X.

LIMITS OF TOLERANCE FOR "NOT GO" RING OR GAP GAUGES FOR FULL DIAMETER OF SCREWS.

Size of gauge :—	Up to and including 1·5 in. and B.A. screws Nos. 0 to 15.	Above 1·5 and up to 3 in.	Above 3 and up to 6 in.	Over 6 in.
Inspection.				
Tolerance on gauge ..	In. + 0·0000 − 0·0003	In. + 0·0000 − 0·0004	In. + 0·0000 − 0·0005	In. + 0·0000 − 0·0007
Workshop.				
Tolerance on gauge ..	+ 0·0003 − 0·0000	+ 0·0004 − 0·0000	+ 0·0005 − 0·0000	+ 0·0007 − 0·0000

APPENDIX III.

TABLE XI.—VIRTUAL DIFFERENCE IN EFFECTIVE DIAMETER CORRESPONDING TO MEASURED ERRORS IN PITCH.

Error in Pitch.	Corresponding Virtual Difference in Effective Diameter.		
	Whitworth Threads.	B.A. Threads.	S.I., C.E.I. and U.S.S. Threads.
In.	In.	In.	In.
0·00005	0·00010	0·00011	0·00009
0·0001	0·00019	0·00023	0·00017
0·00015	0·00029	0·00034	0·00026
0·0002	0·00038	0·00045	0·00035
0·00025	0·00048	0·00057	0·00043
0·0003	0·00058	0·00068	0·00052
0·00035	0·00067	0·00079	0·00061
0·0004	0·00077	0·00091	0·00069
0·00045	0·00086	0·00102	0·00078
0·0005	0·00096	0·00114	0·00086
0·00055	0·00106	0·00125	0·00095
0·0006	0·00115	0·00136	0·00104
0·00065	0·00125	0·00147	0·00112
0·0007	0·00134	0·00159	0·00121
0·00075	0·00144	0·00170	0·00130
0·0008	0·00154	0·00181	0·00138
0·00085	0·00163	0·00193	0·00147
0·0009	0·00173	0·00205	0·00156
0·00095	0·00182	0·00216	0·00164
0·0010	0·00192	0·00227	0·00173

Note :—The "Difference" is to be taken as + for plug screws and — for ring screws.

Table XII.—Virtual Difference in Effective Diameter Corresponding to Measured Errors in Angle.

Whitworth Thread. Angle 55°.

Correspondg. Virtual Difference in Effective Diameter.	Errors in angle to nearest 0·1°.																								Correspondg. Virtual Difference in Effective Diameter.
In.																									In.
±0·0001	0·0	0·0	0·0	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·2	0·2	0·2	0·2	0·2	0·2	0·2	0·3	0·3	0·3	0·3	0·3	0·4	±0·0001
±0·0002	0·1	0·1	0·1	0·1	0·1	0·2	0·2	0·2	0·2	0·2	0·3	0·3	0·3	0·4	0·4	0·4	0·5	0·5	0·5	0·6	0·6	0·6	0·7	0·8	±0·0002
±0·0003	0·1	0·1	0·1	0·2	0·2	0·2	0·3	0·3	0·3	0·3	0·4	0·5	0·5	0·5	0·6	0·6	0·7	0·7	0·8	0·9	0·9	1·0	1·0	1·1	±0·0003
±0·0004	*0·2*	*0·2*	*0·2*	*0·2*	*0·3*	*0·3*	*0·3*	*0·4*	*0·4*	*0·5*	*0·5*	*0·6*	*0·7*	*0·7*	*0·8*	*0·8*	*0·9*	*1·0*	*1·1*	*1·1*	*1·2*	*1·3*	*1·4*	*1·5*	*±0·0004*
±0·0005	0·2	0·2	0·2	0·3	0·3	0·4	0·4	0·5	0·5	0·6	0·7	0·8	0·9	0·9	1·0	1·0	1·1	1·2	1·3	1·4	1·5	1·6	1·7	1·9	±0·0005
±0·0006	0·2	0·3	0·3	0·3	0·4	0·5	0·5	0·6	0·6	0·7	0·8	0·9	1·0	1·1	1·1	1·3	1·4	1·5	1·6	1·7	1·8	1·9	2·0	2·3	±0·0006
±0·0007	0·3	0·3	0·3	0·4	0·5	0·5	0·6	0·7	0·7	0·8	0·9	1·1	1·2	1·3	1·3	1·5	1·6	1·7	1·9	2·0	2·1	2·3	2·4	2·7	±0·0007
±0·0008	0·3	0·3	0·4	0·5	0·5	0·6	0·7	0·8	0·8	0·9	1·1	1·2	1·4	1·4	1·5	1·7	1·8	2·0	2·1	2·3	2·4	2·6	2·7	3·0	±0·0008
±0·0009	0·3	0·4	0·4	0·5	0·6	0·7	0·8	0·9	0·9	1·0	1·2	1·4	1·5	1·6	1·7	1·9	2·1	2·2	2·4	2·6	2·7	2·9	3·1	3·4	±0·0009
±0·0010	0·4	0·4	0·5	0·6	0·7	0·8	0·9	1·0	1·0	1·1	1·3	1·5	1·7	1·8	1·9	2·1	2·3	2·5	2·7	2·9	3·0	3·2	3·4	3·8	±0·0010
±0·0011	0·4	0·5	0·5	0·6	0·7	0·8	0·9	1·0	1·2	1·3	1·5	1·7	1·9	2·0	2·1	2·3	2·5	2·7	2·9	3·1	3·4	3·6	3·8	4·2	±0·0011
±0·0012	0·5	0·5	0·6	0·7	0·8	0·9	1·0	1·1	1·3	1·4	1·6	1·8	2·1	2·2	2·3	2·5	2·7	3·0	3·2	3·4	3·7	3·9	4·1	4·6	±0·0012
±0·0013	0·5	0·6	0·6	0·7	0·9	1·0	1·0	1·2	1·4	1·5	1·7	2·0	2·2	2·4	2·5	2·7	3·0	3·2	3·5	3·7	4·0	4·2	4·5	5·0	±0·0013
±0·0014	0·5	0·6	0·7	0·8	0·9	1·1	1·2	1·3	1·5	1·6	1·9	2·1	2·4	2·5	2·7	2·9	3·2	3·5	3·7	4·0	4·3	4·5	4·8	5·3	±0·0014
±0·0015	*0·6*	*0·6*	*0·7*	*0·9*	*1·0*	*1·1*	*1·3*	*1·4*	*1·6*	*1·7*	*2·0*	*2·3*	*2·6*	*2·7*	*2·9*	*3·1*	*3·4*	*3·7*	*4·0*	*4·3*	*4·6*	*4·9*	*5·1*	*5·7*	*±0·0015*
±0·0016	0·6	0·7	0·8	0·9	1·1	1·2	1·4	1·5	1·7	1·8	2·1	2·4	2·7	2·9	3·1	3·4	3·7	4·0	4·3	4·6	4·9	5·2	5·5	6·1	±0·0016
±0·0017	0·6	0·7	0·8	1·0	1·1	1·3	1·5	1·6	1·8	1·9	2·3	2·6	2·9	3·1	3·2	3·6	3·9	4·2	4·5	4·9	5·2	5·5	5·8	6·5	±0·0017
±0·0018	0·7	0·8	0·9	1·0	1·2	1·4	1·5	1·7	1·9	2·1	2·4	2·7	3·1	3·3	3·4	3·8	4·1	4·5	4·8	5·1	5·5	5·8	6·2	6·8	±0·0018
±0·0019	0·7	0·8	0·9	1·1	1·3	1·4	1·6	1·8	2·0	2·2	2·5	2·9	3·2	3·4	3·6	4·0	4·3	4·7	5·0	5·4	5·8	6·1	6·5	7·2	±0·0019
±0·0020	0·8	0·9	1·0	1·1	1·3	1·5	1·7	1·9	2·1	2·3	2·7	3·0	3·4	3·6	3·8	4·2	4·6	5·0	5·3	5·7	6·1	6·5	6·9	7·6	±0·0020
Threads per inch	4	4·5	5	6	7	8	9	10	11	12	14	16	18	19	20	22	24	26	28	30	32	34	36	40	Threads per inch

The angles of the opposite flanks of the threads should be measured each with respect to the axis of the screw or to the full diameter. The errors of the half angles should then be calculated and these errors added together *irrespective of sign*. The corresponding virtual difference in effective diameter can then be obtained from the table above. The + sign is to be applied in the case of plug screws and the − sign in the case of ring screws.

Example.—Screw 10 threads per inch. Half angles measure 27° and 27·9° Combined error in angle is 0·5° + 0·4°, *i.e.* 0·9°. The corresponding virtual difference in effective diameter is found from the table to be + 0·0009 in. for a plug screw and −0·0009 in. for a ring screw.

Table XIII.—Virtual Difference in Effective Diameter Corresponding to Measured Errors in Angle.

B.A. Threads. Angle 47½°.

Corresponding Virtual Difference in Effective Diameter.	Errors in angle to nearest 0·1°.																Corresponding Virtual Difference in Effective Diameter.
In.																	In.
± 0·0001	0·3	0·3	0·3	0·4	0·4	0·4	0·5	0·5	0·6	0·7	0·7	0·8	0·9	1·0	1·1	1·2	± 0·0001
± 0·0002	0·5	0·6	0·6	0·7	0·8	0·9	1·0	1·1	1·2	1·3	1·5	1·7	1·8	2·0	2·2	2·4	± 0·0002
± 0·0003	0·8	0·9	1·0	1·1	1·2	1·3	1·5	1·6	1·8	2·0	2·2	2·5	2·7	3·1	3·3	3·7	± 0·0003
± 0·0004	1·0	1·1	1·3	1·4	1·6	1·7	1·9	2·1	2·4	2·6	2·9	3·3	3·7	4·1	4·4	4·9	± 0·0004
± 0·0005	1·3	1·4	1·6	1·8	1·9	2·2	2·4	2·7	3·0	3·3	3·7	4·1	4·6	5·1	5·6	6·1	± 0·0005
± 0·0006	1·5	1·7	1·9	2·1	2·3	2·6	2·9	3·2	3·6	3·9	4·4	5·0	5·5	6·1	6·7	7·3	± 0·0006
± 0·0007	1·8	2·0	2·2	2·5	2·7	3·0	3·4	3·7	4·2	4·6	5·1	5·8	6·4	7·1	7·8	8·6	± 0·0007
± 0·0008	2·0	2·3	2·5	2·8	3·1	3·4	3·9	4·3	4·8	5·3	5·9	6·7	7·3	8·2	8·9	9·8	± 0·0008
± 0·0009	2·3	2·6	2·9	3·2	3·5	3·9	4·4	4·8	5·4	5·9	6·6	7·5	8·2	9·2	10·0	11·0	± 0·0009
± 0·0010	2·6	2·9	3·2	3·5	3·9	4·3	4·7	5·3	6·0	6·6	7·3	8·3	9·2	10·2	11·1	12·2	± 0·0010
B.A. No. . .	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	B.A. No.

The angles of the opposite flanks of the threads should be measured with respect to the axis of the screw or to the full diameter The errors of the half angles should then be calculated and these errors added together, *irrespective of sign* The corresponding virtual difference in effective diameter can then be obtained from the table above. The + sign is to be applied in the case of plug screws and the — sign in the case of ring screws.

Example.—Screw No 3 B A. Half angles measure 23·35° and 24·05° Combined error in angle is 0·4° + 0·3°, *i e* 0·7°. The corresponding virtual difference is found from the table to be + 0·0002 in. for a plug screw and — 0·0002 in for a ring screw.

Table XIV.—Virtual Difference in Effective Diameter Corresponding to Measured Errors in Angle.

System International Thread. Angle 60°.

Corresponding Virtual Difference in Effective Diameter.	Errors in angle to nearest 0·1°.												Corresponding Virtual Difference in Effective Diameter.
In.													In.
± 0·0001	0·4	0·3	0·2	0·4	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·1	± 0·0001
± 0·0002	0·8	0·5	0·4	0·3	0·3	0·2	0·2	0·2	0·2	0·1	0·1	0·1	± 0·0002
± 0·0003	1·2	0·8	0·6	0·5	0·4	0·3	0·3	0·3	0·2	0·2	0·2	0·2	± 0·0003
± 0·0004	1·6	1·0	0·8	0·6	0·5	0·4	0·4	0·3	0·3	0·3	0·3	0·2	± 0·0004
± 0·0005	1·9	1·3	1·0	0·8	0·6	0·6	0·5	0·4	0·4	0·4	0·3	0·3	± 0·0005
± 0·0006	2·3	1·6	1·2	0·9	0·8	0·7	0·6	0·5	0·5	0·4	0·4	0·3	± 0·0006
± 0·0007	2·7	1·8	1·4	1·1	0·9	0·8	0·7	0·6	0·5	0·5	0·5	0·4	± 0·0007
± 0·0008	3·1	2·0	1·6	1·2	1·0	0·9	0·8	0·7	0·6	0·6	0·5	0·4	± 0·0008
± 0·0009	3·5	2·3	1·7	1·4	1·2	1·0	0·9	0·8	0·7	0·6	0·6	0·5	± 0·0009
± 0·0010	3·9	2·6	1·9	1·6	1·3	1·1	1·0	0·9	0·8	0·7	0·6	0·6	± 0·0010
± 0·0011	4·3	2·8	2·1	1·7	1·4	1·2	1·1	0·9	0·9	0·8	0·7	0·6	± 0·0011
± 0·0012	4·7	3·1	2·3	1·9	1·6	1·3	1·2	1·0	0·9	0·8	0·8	0·7	± 0·0012
± 0·0013	5·0	3·4	2·5	2·0	1·7	1·4	1·3	1·1	1·0	0·9	0·8	0·7	± 0·0013
± 0·0014	5·4	3·6	2·7	2·2	1·8	1·6	1·4	1·2	1·1	1·0	0·9	0·8	± 0·0014
± 0·0015	5·8	3·9	2·9	2·3	1·9	1·7	1·5	1·3	1·2	1·1	1·0	0·8	± 0·0015
± 0·0016	6·2	4·1	3·1	2·5	2·0	1·8	1·6	1·4	1·2	1·1	1·0	0·9	± 0·0016
± 0·0017	6·6	4·4	3·3	2·6	2·2	1·9	1·6	1·5	1·3	1·2	1·1	0·9	± 0·0017
± 0·0018	7·0	4·7	3·5	2·8	2·3	2·0	1·7	1·6	1·4	1·3	1·2	1·0	± 0·0018
± 0·0019	7·4	4·9	3·7	3·0	2·5	2·1	1·8	1·6	1·5	1·3	1·2	1·1	± 0·0019
± 0·0020	7·8	5·2	3·9	3·1	2·6	2·2	1·9	1·7	1·6	1·4	1·3	1·1	± 0·0020
mm. pitch ..	0·50	0·75	1·00	1·25	1·50	1·75	2·00	2·25	2·50	2·75	3·00	3·50	mm. pitch.

The angles of the opposite flanks of the threads should be measured with respect to the axis of the screw or to the full diameter. The errors of the half angles should then be calculated and these errors added together, *irrespective of sign*. The corresponding virtual difference in effective diameter can then be obtained from the table above. *The + sign is to be applied in the case of plug* screws and the — sign in the case of ring screws.

Example.—Screw 2·5 mm. pitch. Half angles measure 29·6° and 30·4°. Combined error in angle is 0·4° + 0·4°, *i.e.* 0·8°. *The corresponding virtual difference is found from the table to be + 0·001 in. for a plug screw and — 0·001 in. for a ring screw.*

APPENDIX IV.

Table XV.—Vee Pieces for Core Diameter Measurement.

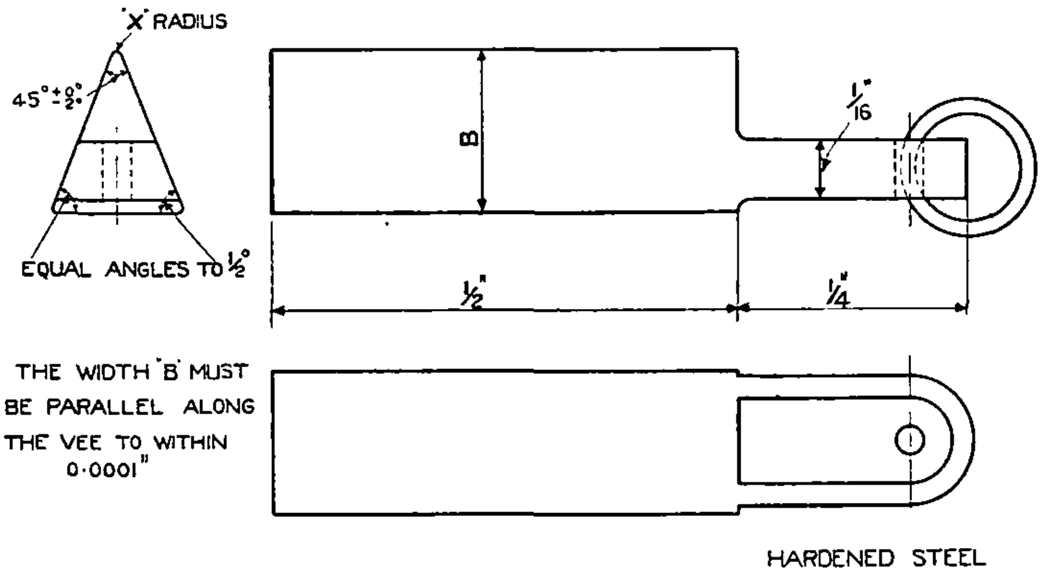


Fig. 33.

Designating Size.	Limits for Radius "X."	Dimension B (Tolerance ±0·005 in.)	Suitable for Screws :— Whitworth. Threads per inch.	Metric (S.I.) Pitch.	B.A.
	In.	In.		mm.	
A	0·0005 to 0·0010	0·125	48	1·0 and 1·25	Nos. 9 and 10
B	0·0015 to 0·0020	0·125	40 to 28	1·5 to 2·25	Nos. 3 to 8
C	0·0035 to 0·0040	0·175	26 to 14	2·5 to 4·0	Nos. 0 to 2
D	0·0080 to 0·0090	0·175	12 to 3	5·0 to 7·0	—

APPENDIX V.

" Best Size " Cylinders.

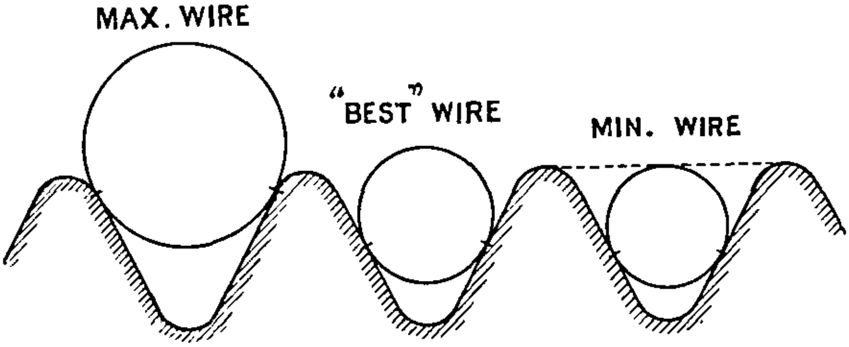


FIG. 34.

The " best size " cylinder is that which touches half way down the flanks of the thread, as shown in the centre of Fig. 34.

The same diagram shows the maximum and minimum sizes of cylinders. The former rests at the extreme upper ends of the straight portions of the flanks, while the minimum size is such that it comes just flush with the crests of the thread.

The diameters of the three sizes of cylinders can be calculated from the following formulae in which p represents the pitch of the thread :—

TABLE XVI.

Form of Thread.	Diameter of Cylinder.		
	Maximum.	" Best."	Minimum.
Whitworth	$0{\cdot}853 \times p$	$0{\cdot}564 \times p$	$0{\cdot}506 \times p$
British Association	$0{\cdot}730 \times p$	$0{\cdot}546 \times p$	$0{\cdot}498 \times p$
International System	$1{\cdot}010 \times p$	$0{\cdot}577 \times p$	$0{\cdot}505 \times p$

The following Tables XVII to XIX give the diameters of the " best size " cylinders for the more common Whitworth, B.A., and System International (Metric) pitches :—

Diameters of "Best Size" Cylinders

Table XVII.—Whitworth Threads. Angle 55°.

Pitch. Threads per inch.	"Best" Diameter.	Pitch. Threads per inch.	"Best" Diameter.
	In.		In.
3	0·1880	18	0·0313
3½	0·1611	19	0·0297
4	0·1410	20	0·0282
4½	0·1252	22	0·0256
5	0·1128	24	0·0235
6	0·0940	26	0·0217
7	0·0805	28	0·0201
8	0·0705	30	0·0188
9	0·0626	32	0·0176
10	0·0564	34	0·0166
11	0·0512	36	0·0157
12	0·0470	40	0·0141
14	0·0403	48	0·0117
16	0·0352		

Table XVIII.—British Association Threads. Angle 47½°.

B.A.	"Best" Diameter.	B.A.	"Best" Diameter.
No.	In.	No.	In.
0	0·0215	5	0·0127
1	0·0193	6	0·0114
2	0·0174	7	0·0103
3	0·0156	8	0·0092
4	0·0142		

Table XIX.—System International (Metric) Threads. Angle 60°.

Pitch.	"Best" Diameter.	Pitch.	"Best" Diameter.
mm.	In.	mm.	In.
4	0·0909	1·75	0·0397
3·5	0·0795	1·5	0·0341
3	0·0682	1·25	0·0284
2·75	0·0624	1	0·0227
2·5	0·0568	0·75	0·0170
2·25	0·0511	0·5	0·0114
2	0·0455		

APPENDIX VI.

TABLE XX.—B.A. SCREWS. EQUIVALENT PITCHES IN INCHES.

No of Threads	0 B.A.	1 B.A.	2 B.A.	3 B.A.	4 B.A.	5 B.A.	6 B.A.	7 B.A.	8 B.A.
	1·0 mm.	0·9 mm.	0·81 mm.	0·73 mm.	0·66 mm.	0·59 mm.	0·53 mm.	0·48 mm.	0·43 mm.
0	0	0	0	0	0	0	0	0	0
1	0·03937	0·03543	0·03189	0·02874	0·02598	0·02323	0·02087	0·01890	0·01693
2	0·07874	0·07087	0·06378	0·05748	0·05197	0·04646	0·04173	0·03780	0·03386
3	0·11811	0·10630	0·09567	0·08622	0·07795	0·06969	0·06260	0·05669	0·05079
4	0·15748	0·14173	0·12756	0·11496	0·10394	0·09291	0·08346	0·07559	0·06772
5	0·19685	0·17717	0·15945	0·14370	0·12992	0·11614	0·10433	0·09449	0·08465
6	0·23622	0·21260	0·19134	0·17244	0·15591	0·13937	0·12520	0·11339	0·10157
7	0·27559	0·24803	0·22323	0·20118	0·18189	0·16260	0·14606	0·13228	0·11850
8	0·31496	0·28346	0·25512	0·22992	0·20787	0·18583	0·16693	0·15118	0·13543
9	0·35433	0·31890	0·28701	0·25866	0·23386	0·20906	0·18780	0·17008	0·15236
10	0·39370	0·35433	0·31890	0·28740	0·25984	0·23228	0·20866	0·18898	0·16929
11	—	0·38976	0·35079	0·31614	0·28583	0·25551	0·22953	0·20787	0·18622
12	—	0·42520	0·38268	0·34488	0·31181	0·27874	0·25039	0·22677	0·20315
13	—	—	0·41457	0·37362	0·33780	0·30197	0·27126	0·24567	0·22008
14	—	—	—	0·40236	0·36378	0·32520	0·29213	0·26457	0·23701
15	—	—	—	—	0·38976	0·34843	0·31299	0·28346	0·25394
16	—	—	—	—	—	0·37165	0·33386	0·30236	0·27087
17	—	—	—	—	—	0·39488	0·35472	0·32126	0·28780
18	—	—	—	—	—	—	0·37559	0·34016	0·30472
19	—	—	—	—	—	—	—	0·35906	0·32165
20	—	—	—	—	—	—	—	—	0·33858

TABLE XXI.—SYSTEM INTERNATIONAL (METRIC SCREWS). EQUIVALENT PITCHES IN INCHES.

No. of Threads	0·50 mm.	0·75 mm.	1·00 mm.	1·25 mm.	1·50 mm.	1·75 mm.	2·00 mm.	2·50 mm.	3·00 mm.	3·5 mm.	4·00 mm.
0	0	0	0	0	0	0	0	0	0	0	0
1	0·01969	0·02953	0·03937	0·04921	0·05906	0·06890	0·07874	0·09843	0·11811	0·13780	0·15748
2	0·03937	0·05906	0·07874	0·09843	0·11811	0·13780	0·15748	0·19685	0·23622	0·27559	0·31496
3	0·05906	0·08858	0·11811	0·14764	0·17717	0·20669	0·23622	0·29528	0·35433	0·41339	0·47244
4	0·07874	0·11811	0·15748	0·19685	0·23622	0·27559	0·31496	0·39370	0·47244	0·55118	0·62992
5	0·09843	0·14764	0·19685	0·24606	0·29528	0·34449	0·39370	0·49213	0·59055	0·68898	0·78740
6	0·11811	0·17717	0·23622	0·29528	0·35433	0·41339	0·47244	0·59055	0·70866	0·82677	0·94488
7	0·13780	0·20669	0·27559	0·34449	0·41339	0·48228	0·55118	0·68898	0·82677	0·96457	—
8	0·15748	0·23622	0·31496	0·39370	0·47244	0·55118	0·62992	0·78740	0·94488	1·10236	—
9	0·17717	0·26575	0·35433	0·44291	0·53150	0·62008	0·70866	0·88583	1·06299	—	—
10	0·19685	0·29528	0·39370	0·49213	0·59055	0·68898	0·78740	0·98425	—	—	—
11	0·21654	0·32480	0·43307	0·54134	0·64961	0·75788	0·86614	1·08268	—	—	—
12	0·23622	0·35433	0·47244	0·59055	0·70866	0·82677	0·94488	—	—	—	—
13	0·25591	0·38386	0·51181	0·63976	0·76772	0·89567	1·02362	—	—	—	—
14	0·27559	0·41339	0·55118	0·68898	0·82677	0·96457	—	—	—	—	—
15	0·29528	0·44291	0·59055	0·73819	0·88583	1·03347	—	—	—	—	—
16	0·31496	0·47244	0·62992	0·78740	0·94488	—	—	—	—	—	—
17	0·33465	0·50197	0·66929	0·83662	1·00394	—	—	—	—	—	—
18	0·35433	0·53150	0·70866	0·88583	—	—	—	—	—	—	—
19	0·37402	0·56102	0·74803	0·93504	—	—	—	—	—	—	—
20	0·39370	0·59055	0·78740	—	—	—	—	—	—	—	—

APPENDIX VII.

Limits of Size for Screw Gauges of Standard Types.

TABLE XXII.—LIMITS FOR B.S.W. SCREW GAUGES.

Full Form " Go " Plugs.

INSPECTION.

Nominal Size.	Threads per inch.	Full Diameter.	Effective Diameter.	Core Diameter.
In.		In.	In.	In.
1/4	20	0·2500–0·2494	0·2180–0·2174	0·1860–0·1851
5/16	18	0·3125–0·3119	0·2769–0·2763	0·2414–0·2405
3/8	16	0·3750–0·3744	0·3350–0·3344	0·2950–0·2941
7/16	14	0·4375–0·4369	0·3918–0·3912	0·3460–0·3451
1/2	12	0·5000–0·4994	0·4466–0·4460	0·3933–0·3924
9/16	12	0·5625–0·5619	0·5091–0·5085	0·4558–0·4549
5/8	11	0·6250–0·6244	0·5668–0·5662	0·5086–0·5077
11/16	11	0·6875–0·6869	0·6293–0·6287	0·5711–0·5702
3/4	10	0·7500–0·7494	0·6860–0·6854	0·6219–0·6210
13/16	10	0·8125–0·8119	0·7485–0·7479	0·6844–0·6835
7/8	9	0·8750–0·8744	0·8039–0·8033	0·7327–0·7318
15/16	9	0·9375–0·9369	0·8664–0·8658	0·7952–0·7943
1	8	1·0000–0·9994	0·9200–0·9194	0·8399–0·8390
1 1/8	7	1·1250–1·1244	1·0335–1·0329	0·9420–0·9411
1 1/4	7	1·2500–1·2494	1·1585–1·1579	1·0670–1·0661
1 3/8	6	1·3750–1·3744	1·2683–1·2677	1·1616–1·1607
1 1/2	6	1·5000–1·4994	1·3933–1·3927	1·2866–1·2857
1 5/8	5	1·6250–1·6241	1·4969–1·4960	1·3689–1·3675
1 3/4	5	1·7500–1·7491	1·6219–1·6210	1·4939–1·4925
1 7/8	4·5	1·8750–1·8741	1·7327–1·7318	1·5904–1·5890
2	4·5	2·0000–1·9991	1·8577–1·8568	1·7154–1·7140
2 1/8	4·5	2·1250–2·1241	1·9827–1·9818	1·8404–1·8390
2 1/4	4	2·2500–2·2491	2·0899–2·0890	1·9298–1·9284
2 3/8	4	2·3750–2·3741	2·2149–2·2140	2·0548–2·0534
2 1/2	4	2·5000–2·4991	2·3399–2·3390	2·1798–2·1784
2 5/8	4	2·6250–2·6241	2·4649–2·4640	2·3048–2·3034
2 3/4	3·5	2·7500–2·7491	2·5670–2·5661	2·3841–2·3827
2 7/8	3·5	2·8750–2·8741	2·6920–2·6911	2·5091–2·5077
3	3·5	3·0000–2·9991	2·8170–2·8161	2·6341–2·6327

For tolerances on pitch and angle of thread see pages 11 and 12.

Table XXIII.—Limits for B.S.W. Screw Gauges.

Full Form "Go" Rings.

Inspection.

Nominal Size.	Threads per inch.	Full Diameter.	Effective Diameter.	Core Diameter.
In.		In.	In.	In.
1/4	20	0·2500–0·2509	0·2180–0·2186	0·1860–0·1866
5/16	18	0·3125–0·3134	0·2769–0·2775	0·2414–0·2420
3/8	16	0·3750–0·3759	0·3350–0·3356	0·2950–0·2956
7/16	14	0·4375–0·4384	0·3918–0·3924	0·3460–0·3466
1/2	12	0·5000–0·5009	0·4466–0·4472	0·3933–0·3939
9/16	12	0·5625–0·5634	0·5091–0·5097	0·4558–0·4564
5/8	11	0·6250–0·6259	0·5668–0·5674	0·5086–0·5092
11/16	11	0·6875–0·6884	0·6293–0·6299	0·5711–0·5717
3/4	10	0·7500–0·7509	0·6860–0·6866	0·6219–0·6225
13/16	10	0·8125–0·8134	0·7485–0·7491	0·6844–0·6850
7/8	9	0·8750–0·8759	0·8039–0·8045	0·7327–0·7333
15/16	9	0·9375–0·9384	0·8664–0·8670	0·7952–0·7958
1	8	1·0000–1·0009	0·9200–0·9206	0·8399–0·8405
1 1/8	7	1·1250–1·1259	1·0335–1·0341	0·9420–0·9426
1 1/4	7	1·2500–1·2509	1·1585–1·1591	1·0670–1·0676
1 3/8	6	1·3750–1·3759	1·2683–1·2689	1·1616–1·1622
1 1/2	6	1·5000–1·5009	1·3933–1·3939	1·2866–1·2872
1 5/8	5	1·6250–1·6264	1·4969–1·4978	1·3689–1·3698
1 3/4	5	1·7500–1·7514	1·6219–1·6228	1·4939–1·4948
1 7/8	4·5	1·8750–1·8764	1·7327–1·7336	1·5904–1·5913
2	4·5	2·0000–2·0014	1·8577–1·8586	1·7154–1·7163
2 1/8	4·5	2·1250–2·1264	1·9827–1·9836	1·8404–1·8413
2 1/4	4	2·2500–2·2514	2·0899–2·0908	1·9298–1·9307
2 3/8	4	2·3750–2·3764	2·2149–2·2158	2·0548–2·0557
2 1/2	4	2·5000–2·5014	2·3399–2·3408	2·1798–2·1807
2 5/8	4	2·6250–2·6264	2·4649–2·4658	2·3048–2·3057
2 3/4	3·5	2·7500–2·7514	2·5670–2·5679	2·3841–2·3850
2 7/8	3·5	2·8750–2·8764	2·6920–2·6929	2·5091–2·5100
3	3·5	3·0000–3·0014	2·8170–2·8179	2·6341–2·6350

For tolerances on pitch and angle of thread see pages 11 and 12.

Table XXIV.—Limits for B.S.W. Screw Gauges.

Full Form " Go " Plugs.

Workshop.

Nominal Size.	Threads per inch.	Full Diameter.	Effective Diameter.	Core Diameter.
In.		In.	In.	In.
1/4	20	0·2500–0·2506	0·2180–0·2186	0·1857–0·1866
5/16	18	0·3125–0·3131	0·2769–0·2775	0·2411–0·2420
3/8	16	0·3750–0·3756	0·3350–0·3356	0·2947–0·2956
7/16	14	0·4375–0·4381	0·3918–0·3924	0·3457–0·3466
1/2	12	0·5000–0·5006	0·4466–0·4472	0·3930–0·3939
9/16	12	0·5625–0·5631	0·5091–0·5097	0·4555–0·4564
5/8	11	0·6250–0·6256	0·5668–0·5674	0·5083–0·5092
11/16	11	0·6875–0·6881	0·6293–0·6299	0·5708–0·5717
3/4	10	0·7500–0·7506	0·6860–0·6866	0·6216–0·6225
13/16	10	0·8125–0·8131	0·7485–0·7491	0·6841–0·6850
7/8	9	0·8750–0·8756	0·8039–0·8045	0·7324–0·7333
15/16	9	0·9375–0·9381	0·8664–0·8670	0·7949–0·7958
1	8	1·0000–1·0006	0·9200–0·9206	0·8396–0·8405
1 1/8	7	1·1250–1·1256	1·0335–1·0341	0·9417–0·9426
1 1/4	7	1·2500–1·2506	1·1585–1·1591	1·0667–1·0676
1 3/8	6	1·3750–1·3756	1·2683–1·2689	1·1613–1·1622
1 1/2	6	1·5000–1·5006	1·3933–1·3939	1·2863–1·2872
1 5/8	5	1·6250–1·6259	1·4969–1·4978	1·3684–1·3698
1 3/4	5	1·7500–1·7509	1·6219–1·6228	1·4934–1·4948
1 7/8	4·5	1·8750–1·8759	1·7327–1·7336	1·5899–1·5913
2	4·5	2·0000–2·0009	1·8577–1·8586	1·7149–1·7163
2 1/8	4·5	2·1250–2·1259	1·9827–1·9836	1·8399–1·8413
2 1/4	4	2·2500–2·2509	2·0899–2·0908	1·9293–1·9307
2 3/8	4	2·3750–2·3759	2·2149–2·2158	2·0543–2·0557
2 1/2	4	2·5000–2·5009	2·3399–2·3408	2·1793–2·1807
2 5/8	4	2·6250–2·6259	2·4649–2·4658	2·3043–2·3057
2 3/4	3·5	2·7500–2·7509	2·5670–2·5679	2·3836–2·3850
2 7/8	3·5	2·8750–2·8759	2·6920–2·6929	2·5086–2·5100
3	3·5	3·0000–3·0009	2·8170–2·8179	2·6336–2·6350

For tolerances on pitch and angle of thread see pages 11 and 12.

Table XXV.—Limits for B.S.W. Screw Gauges.

Full Form "Go" Rings.

Workshop.

Nominal Size.	Threads per inch.	Full Diameter.	Effective Diameter.	Core Diameter.
In.		In.	In.	In.
1/4	20	0·2503–0·2494	0·2180–0·2174	0·1860–0·1854
5/16	18	0·3128–0·3119	0·2769–0·2763	0·2414–0·2408
3/8	16	0·3753–0·3744	0·3350–0·3344	0·2950–0·2944
7/16	14	0·4378–0·4369	0·3918–0·3912	0·3460–0·3454
1/2	12	0·5003–0·4994	0·4466–0·4460	0·3933–0·3927
9/16	12	0·5628–0·5619	0·5091–0·5085	0·4558–0·4552
5/8	11	0·6253–0·6244	0·5668–0·5662	0·5086–0·5080
11/16	11	0·6878–0·6869	0·6293–0·6287	0·5711–0·5705
3/4	10	0·7503–0·7494	0·6860–0·6854	0·6219–0·6213
13/16	10	0·8128–0·8119	0·7485–0·7479	0·6844–0·6838
7/8	9	0·8753–0·8744	0·8039–0·8033	0·7327–0·7321
15/16	9	0·9378–0·9369	0·8664–0·8658	0·7952–0·7946
1	8	1·0003–0·9994	0·9200–0·9194	0·8399–0·8393
1 1/8	7	1·1253–1·1244	1·0335–1·0329	0·9420–0·9414
1 1/4	7	1·2503–1·2494	1·1585–1·1579	1·0670–1·0664
1 3/8	6	1·3753–1·3744	1·2683–1·2677	1·1616–1·1610
1 1/2	6	1·5003–1·4994	1·3933–1·3927	1·2866–1·2860
1 5/8	5	1·6255–1·6241	1·4969–1·4960	1·3689–1·3680
1 3/4	5	1·7505–1·7491	1·6219–1·6210	1·4939–1·4930
1 7/8	4·5	1·8755–1·8741	1·7327–1·7318	1·5904–1·5895
2	4·5	2·0005–1·9991	1·8577–1·8568	1·7154–1·7145
2 1/8	4·5	2·1255–2·1241	1·9827–1·9818	1·8404–1·8395
2 1/4	4	2·2505–2·2491	2·0899–2·0890	1·9298–1·9289
2 3/8	4	2·3755–2·3741	2·2149–2·2140	2·0548–2·0539
2 1/2	4	2·5005–2·4991	2·3399–2·3390	2·1798–2·1789
2 5/8	4	2·6255–2·6241	2·4649–2·4640	2·3048–2·3039
2 3/4	3·5	2·7505–2·7491	2·5670–2·5661	2·3841–2·3832
2 7/8	3·5	2·8755–2·8741	2·6920–2·6911	2·5091–2·5082
3	3·5	3·0005–2·9991	2·8170–2·8161	2·6341–2·6332

For tolerances on pitch and angle of thread see pages 11 and 12.

TABLE XXVI.—LIMITS FOR B.S.F. SCREW GAUGES.

Full Form " Go " Plugs.

INSPECTION.

Nominal Size.	Threads per inch.	Full Diameter.	Effective Diameter.	Core Diameter.
In.		In.	In.	In.
7/32	28	0·2188–0·2182	0·1960–0·1954	0·1731–0·1722
1/4	26	0·2500–0·2494	0·2254–0·2248	0·2007–0·1998
9/32	26	0·2813–0·2807	0·2566–0·2560	0·2320–0·2311
5/16	22	0·3125–0·3119	0·2834–0·2828	0·2543–0·2534
3/8	20	0·3750–0·3744	0·3430–0·3424	0·3110–0·3101
7/16	18	0·4375–0·4369	0·4019–0·4013	0·3664–0·3655
1/2	16	0·5000–0·4994	0·4600–0·4594	0·4200–0·4191
9/16	16	0·5625–0·5619	0·5225–0·5219	0·4825–0·4816
5/8	14	0·6250–0·6244	0·5793–0·5787	0·5335–0·5326
11/16	14	0·6875–0·6869	0·6418–0·6412	0·5960–0·5951
3/4	12	0·7500–0·7494	0·6966–0·6960	0·6433–0·6424
13/16	12	0·8125–0·8119	0·7591–0·7585	0·7058–0·7049
7/8	11	0·8750–0·8744	0·8168–0·8162	0·7586–0·7577
1	10	1·0000–0·9994	0·9360–0·9354	0·8719–0·8710
1 1/8	9	1·1250–1·1244	1·0539–1·0533	0·9827–0·9818
1 1/4	9	1·2500–1·2494	1·1789–1·1783	1·1077–1·1068
1 3/8	8	1·3750–1·3744	1·2950–1·2944	1·2149–1·2140
1 1/2	8	1·5000–1·4994	1·4200–1·4194	1·3399–1·3390
1 5/8	8	1·6250–1·6241	1·5450–1·5441	1·4649–1·4635
1 3/4	7	1·7500–1·7491	1·6585–1·6576	1·5670–1·5656
2	7	2·0000–1·9991	1·9085–1·9076	1·8170–1·8156
2 1/4	6	2·2500–2·2491	2·1433–2·1424	2·0366–2·0352
2 1/2	6	2·5000–2·4991	2·3933–2·3924	2·2866–2·2852
2 3/4	6	2·7500–2·7491	2·6433–2·6424	2·5366–2·5352
3	5	3·0000–2·9991	2·8719–2·8710	2·7439–2·7425

For tolerances on pitch and angle of thread see pages 11 and 12.

Table XXVII.—Limits for B.S.F. Screw Gauges.

Full Form "Go" Rings.

Inspection.

Nominal Size.	Threads per inch.	Full Diameter.	Effective Diameter.	Core Diameter.
In.		In.	In.	In.
7/32	28	0·2188–0·2197	0·1960–0·1966	0·1731–0·1737
1/4	26	0·2500–0·2509	0·2254–0·2260	0·2007–0·2013
9/32	26	0·2813–0·2822	0·2566–0·2572	0·2320–0·2326
5/16	22	0·3125–0·3134	0·2834–0·2840	0·2543–0·2549
3/8	20	0·3750–0·3759	0·3430–0·3436	0·3110–0·3116
7/16	18	0·4375–0·4384	0·4019–0·4025	0·3664–0·3670
1/2	16	0·5000–0·5009	0·4600–0·4606	0·4200–0·4206
9/16	16	0·5625–0·5634	0·5225–0·5231	0·4825–0·4831
5/8	14	0·6250–0·6259	0·5793–0·5799	0·5335–0·5341
11/16	14	0·6875–0·6884	0·6418–0·6424	0·5960–0·5966
3/4	12	0·7500–0·7509	0·6966–0·6972	0·6433–0·6439
13/16	12	0·8125–0·8134	0·7591–0·7597	0·7058–0·7064
7/8	11	0·8750–0·8759	0·8168–0·8174	0·7586–0·7592
1	10	1·0000–1·0009	0·9360–0·9366	0·8719–0·8725
1 1/8	9	1·1250–1·1259	1·0539–1·0545	0·9827–0·9833
1 1/4	9	1·2500–1·2509	1·1789–1·1795	1·1077–1·1083
1 3/8	8	1·3750–1·3759	1·2950–1·2956	1·2149–1·2155
1 1/2	8	1·5000–1·5009	1·4200–1·4206	1·3399–1·3405
1 5/8	8	1·6250–1·6264	1·5450–1·5459	1·4649–1·4658
1 3/4	7	1·7500–1·7514	1·6585–1·6594	1·5670–1·5679
2	7	2·0000–2·0014	1·9085–1·9094	1·8170–1·8179
2 1/4	6	2·2500–2·2514	2·1433–2·1442	2·0366–2·0375
2 1/2	6	2·5000–2·5014	2·3933–2·3942	2·2866–2·2875
2 3/4	6	2·7500–2·7514	2·6433–2·6442	2·5366–2·5375
3	5	3·0000–3·0014	2·8719–2·8728	2·7439–2·7448

For tolerances on pitch and angle of thread see pages 11 and 12.

Table XXVIII.—Limits for B.S.F. Screw Gauges.

Full Form "Go" Plugs.

Workshop.

Nominal Size.	Threads per inch.	Full Diameter.	Effective Diameter.	Core Diameter.
In.		In.	In.	In.
7/32	28	0·2188–0·2194	0·1960–0·1966	0·1728–0·1737
1/4	26	0·2500–0·2506	0·2254–0·2260	0·2004–0·2013
9/32	26	0·2813–0·2819	0·2566–0·2572	0·2317–0·2326
5/16	22	0·3125–0·3131	0·2834–0·2840	0·2540–0·2549
3/8	20	0·3750–0·3756	0·3430–0·3436	0·3107–0·3116
7/16	18	0·4375–0·4381	0·4019–0·4025	0·3661–0·3670
1/2	16	0·5000–0·5006	0·4600–0·4606	0·4197–0·4206
9/16	16	0·5625–0·5631	0·5225–0·5231	0·4822–0·4831
5/8	14	0·6250–0·6256	0·5793–0·5799	0·5332–0·5341
11/16	14	0·6875–0·6881	0·6418–0·6424	0·5957–0·5966
3/4	12	0·7500–0·7506	0·6966–0·6972	0·6430–0·6439
13/16	12	0·8125–0·8131	0·7591–0·7597	0·7055–0·7064
7/8	11	0·8750–0·8756	0·8168–0·8174	0·7583–0·7592
1	10	1·0000–1·0006	0·9360–0·9366	0·8716–0·8725
1 1/8	9	1·1250–1·1256	1·0539–1·0545	0·9824–0·9833
1 1/4	9	1·2500–1·2506	1·1789–1·1795	1·1074–1·1083
1 3/8	8	1·3750–1·3756	1·2950–1·2956	1·2146–1·2155
1 1/2	8	1·5000–1·5006	1·4200–1·4206	1·3396–1·3405
1 5/8	8	1·6250–1·6259	1·5450–1·5459	1·4644–1·4658
1 3/4	7	1·7500–1·7509	1·6585–1·6594	1·5665–1·5679
2	7	2·0000–2·0009	1·9085–1·9094	1·8165–1·8179
2 1/4	6	2·2500–2·2509	2·1433–2·1442	2·0361–2·0375
2 1/2	6	2·5000–2·5009	2·3933–2·3942	2·2861–2·2875
2 3/4	6	2·7500–2·7509	2·6433–2·6442	2·5361–2·5375
3	5	3·0000–3·0009	2·8719–2·8728	2·7434–2·7448

For tolerances on pitch and angle of thread see pages 11 and 12.

Table XXIX.—Limits for B.S.F. Screw Gauges.

Full Form " Go " Rings.

Workshop.

Nominal Size.	Threads per inch.	Full Diameter.	Effective Diameter.	Core Diameter.
In.		In.	In.	In.
7/32	28	0·2191–0·2182	0·1960–0·1954	0·1731–0·1725
1/4	26	0·2503–0·2494	0·2254–0·2248	0·2007–0·2001
9/32	26	0·2816–0·2807	0·2566–0·2560	0·2320–0·2314
5/16	22	0·3128–0·3119	0·2834–0·2828	0·2543–0·2537
3/8	20	0·3753–0·3744	0·3430–0·3424	0·3110–0·3104
7/16	18	0·4378–0·4369	0·4019–0·4013	0·3664–0·3658
1/2	16	0·5003–0·4994	0·4600–0·4594	0·4200–0·4194
9/16	16	0·5628–0·5619	0·5225–0·5219	0·4825–0·4819
5/8	14	0·6253–0·6244	0·5793–0·5787	0·5335–0·5329
11/16	14	0·6878–0·6869	0·6418–0·6412	0·5960–0·5954
3/4	12	0·7503–0·7494	0·6966–0·6960	0·6433–0·6427
13/16	12	0·8128–0·8119	0·7591–0·7585	0·7058–0·7052
7/8	11	0·8753–0·8744	0·8168–0·8162	0·7586–0·7580
1	10	1·0003–0·9994	0·9360–0·9354	0·8719–0·8713
1 1/8	9	1·1253–1·1244	1·0539–1·0533	0·9827–0·9821
1 1/4	9	1·2503–1·2494	1·1789–1·1783	1·1077–1·1071
1 3/8	8	1·3753–1·3744	1·2950–1·2944	1·2149–1·2143
1 1/2	8	1·5003–1·4994	1·4200–1·4194	1·3399–1·3393
1 5/8	8	1·6255–1·6241	1·5450–1·5441	1·4649–1·4640
1 3/4	7	1·7505–1·7491	1·6585–1·6576	1·5670–1·5661
2	7	2·0005–1·9991	1·9085–1·9076	1·8170–1·8161
2 1/4	6	2·2505–2·2491	2·1433–2·1424	2·0366–2·0357
2 1/2	6	2·5005–2·4991	2·3933–2·3924	2·2866–2·2857
2 3/4	6	2·7505–2·7491	2·6433–2·6424	2·5366–2·5357
3	5	3·0005–2·9991	2·8719–2·8710	2·7439–2·7430

For tolerances on pitch and angle of thread see pages 11 and 12.

Table XXX.—Limits for B.S.P. Screw Gauges.

(Engineers' Threads.)

Full Form " Go " Plugs.

Inspection.

Nominal Pipe Bore.	Threads per inch.	Full Diameter.	Effective Diameter.	Core Diameter.
In.		In.	In.	In.
1/8	28	0·3830–0·3824	0·3602–0·3596	0·3373–0·3364
1/4	19	0·5180–0·5174	0·4843–0·4837	0·4506–0·4497
3/8	19	0·6560–0·6554	0·6223–0·6217	0·5886–0·5877
1/2	14	0·8250–0·8244	0·7793–0·7787	0·7335–0·7326
5/8	14	0·9020–0·9014	0·8563–0·8557	0·8105–0·8096
3/4	14	1·0410–1·0404	0·9953–0·9947	0·9495–0·9486
7/8	14	1·1890–1·1884	1·1433–1·1427	1·0975–1·0966
1	11	1·3090–1·3084	1·2508–1·2502	1·1926–1·1917
1 1/8	11	1·4920–1·4914	1·4338–1·4332	1·3756–1·3747
1 1/4	11	1·6500–1·6491	1·5918–1·5909	1·5336–1·5322
1 3/8	11	1·7450–1·7441	1·6868–1·6859	1·6286–1·6272
1 1/2	11	1·8820–1·8811	1·8238–1·8229	1·7656–1·7642
1 3/4	11	2·1160–2·1151	2·0578–2·0569	1·9996–1·9982
2	11	2·3470–2·3461	2·2888–2·2879	2·2306–2·2292

Workshop.

Nominal Pipe Bore.	Threads per inch.	Full Diameter.	Effective Diameter.	Core Diameter.
In.		In.	In.	In.
1/8	28	0·3830–0·3836	0·3602–0·3608	0·3370–0·3379
1/4	19	0·5180–0·5186	0·4843–0·4849	0·4503–0·4512
3/8	19	0·6560–0·6566	0·6223–0·6229	0·5883–0·5892
1/2	14	0·8250–0·8256	0·7793–0·7799	0·7332–0·7341
5/8	14	0·9020–0·9026	0·8563–0·8569	0·8102–0·8111
3/4	14	1·0410–1·0416	0·9953–0·9959	0·9492–0·9501
7/8	14	1·1890–1·1896	1·1433–1·1439	1·0972–1·0981
1	11	1·3090–1·3096	1·2508–1·2514	1·1923–1·1932
1 1/8	11	1·4920–1·4926	1·4338–1·4344	1·3753–1·3762
1 1/4	11	1·6500–1·6509	1·5918–1·5927	1·5331–1·5345
1 3/8	11	1·7450–1·7459	1·6868–1·6877	1·6281–1·6295
1 1/2	11	1·8820–1·8829	1·8238–1·8247	1·7651–1·7665
1 3/4	11	2·1160–2·1169	2·0578–2·0587	1·9991–2·0005
2	11	2·3470–2·3479	2·2888–2·2897	2·2301–2·2315

For tolerances on pitch and angle of thread see pages 11 and 12.

TABLE XXXI.—LIMITS FOR B.S.P. SCREW GAUGES.

(ENGINEERS' THREADS.)

Full Form " Go " Rings.

INSPECTION.

Nominal Pipe Bore.	Threads per inch.	Full Diameter.	Effective Diameter.	Core Diameter.
In.		In.	In.	In.
1/8	28	0·3830–0·3839	0·3602–0·3608	0·3373–0·3379
1/4	19	0·5180–0·5189	0·4843–0·4849	0·4506–0·4512
3/8	19	0·6560–0·6569	0·6223–0·6229	0·5886–0·5892
1/2	14	0·8250–0·8259	0·7793–0·7799	0·7335–0·7341
5/8	14	0·9020–0·9029	0·8563–0·8569	0·8105–0·8111
3/4	14	1·0410–1·0419	0·9953–0·9959	0·9495–0·9501
7/8	14	1·1890–1·1899	1·1433–1·1439	1·0975–1·0981
1	11	1·3090–1·3099	1·2508–1·2514	1·1926–1·1932
1 1/8	11	1·4920–1·4929	1·4338–1·4344	1·3756–1·3762
1 1/4	11	1·6500–1·6514	1·5918–1·5927	1·5336–1·5345
1 3/8	11	1·7450–1·7464	1·6868–1·6877	1·6286–1·6295
1 1/2	11	1·8820–1·8834	1·8238–1·8247	1·7656–1·7665
1 3/4	11	2·1160–2·1174	2·0578–2·0587	1·9996–2·0005
2	11	2·3470–2·3484	2·2888–2·2897	2·2306–2·2315

WORKSHOP.

Nominal Pipe Bore.	Threads per inch.	Full Diameter.	Effective Diameter.	Core Diameter.
In.		In.	In.	In.
1/8	28	0·3833–0·3824	0·3602–0·3596	0·3373–0·3367
1/4	19	0·5183–0·5174	0·4843–0·4837	0·4506–0·4500
3/8	19	0·6563–0·6554	0·6223–0·6217	0·5886–0·5880
1/2	14	0·8253–0·8244	0·7793–0·7787	0·7335–0·7329
5/8	14	0·9023–0·9014	0·8563–0·8557	0·8105–0·8099
3/4	14	1·0413–1·0404	0·9953–0·9947	0·9495–0·9489
7/8	14	1·1893–1·1884	1·1433–1·1427	1·0975–1·0969
1	11	1·3093–1·3084	1·2508–1·2502	1·1926–1·1920
1 1/8	11	1·4923–1·4914	1·4338–1·4332	1·3756–1·3750
1 1/4	11	1·6505–1·6491	1·5918–1·5909	1·5336–1·5327
1 3/8	11	1·7455–1·7441	1·6868–1·6859	1·6286–1·6277
1 1/2	11	1·8825–1·8811	1·8238–1·8229	1·7656–1·7647
1 3/4	11	2·1165–2·1151	2·0578–2·0569	1·9996–1·9987
2	11	2·3475–2·3461	2·2888–2·2879	2·2306–2·2297

For tolerances on pitch and angle of thread see pages 11 and 12.

TABLE XXXII.—LIMITS FOR B.A. SCREW GAUGES.

Full Form " Go " Plugs.

INSPECTION.

No.	Full Diameter.		Effective Diameter.		Core Diameter.	
	mm.	In.	mm.	In.	mm.	In.
0	6·000–5·985	0·2362–0·2356	5·400–5·385	0·2126–0·2120	4·800–4·777	0·1890–0·1881
1	5·300–5·285	0·2087–0·2081	4·760–4·745	0·1874–0·1868	4·220–4·197	0·1661–0·1652
2	4·700–4·685	0·1850–0·1844	4·215–4·200	0·1659–0·1653	3·730–3·707	0·1468–0·1459
3	4·100–4·085	0·1614–0·1608	3·660–3·645	0·1441–0·1435	3·220–3·197	0·1268–0·1259
4	3·600–3·585	0·1417–0·1411	3·205–3·190	0·1262–0·1256	2·810–2·787	0·1106–0·1097
5	3·200–3·185	0·1260–0·1254	2·845–2·830	0·1120–0·1114	2·490–2·467	0·0980–0·0971
6	2·800–2·785	0·1102–0·1096	2·480–2·465	0·0976–0·0970	2·160–2·137	0·0850–0·0841
7	2·500–2·485	0·0984–0·0978	2·210–2·195	0·0870–0·0864	1·920–1·897	0·0756–0·0747
8	2·200–2·190	0·0866–0·0862	1·940–1·930	0·0764–0·0760	1·680–1·665	0·0661–0·0655
9	1·900–1·890	0·0748–0·0744	1·665–1·655	0·0656–0·0652	1·430–1·415	0·0563–0·0557
10	1·700–1·690	0·0669–0·0665	1·490–1·480	0·0587–0·0583	1·280–1·265	0·0504–0·0498
11	1·500–1·490	0·0591–0·0587	1·315–1·305	0·0518–0·0514	1·130–1·115	0·0445–0·0439
12	1·300–1·290	0·0512–0·0508	1·130–1·120	0·0445–0·0441	0·960–0·945	0·0378–0·0372
13	1·200–1·190	0·0472–0·0468	1·050–1·040	0·0413–0·0409	0·900–0·885	0·0354–0·0348
14	1·000–0·990	0·0394–0·0390	0·860–0·850	0·0339–0·0335	0·720–0·705	0·0283–0·0277
15	0·900–0·890	0·0354–0·0350	0·775–0·765	0·0305–0·0301	0·650–0·635	0·0256–0·0250

For tolerances on pitch and angle of thread see pages 11 and 12.

(12/1280)

TABLE XXXIII.—LIMITS FOR B.A. SCREW GAUGES.

Full Form " Go " Rings.

INSPECTION.

No.	Full Diameter.		Effective Diameter.		Core Diameter.	
	mm.	In.	mm.	In.	mm.	In.
0	6·000–6·023	0·2362–0·2371	5·400–5·415	0·2126–0·2132	4·800–4·815	0·1890–0·1896
1	5·300–5·323	0·2087–0·2096	4·760–4·775	0·1874–0·1880	4·220–4·235	0·1661–0·1667
2	4·700–4·723	0·1850–0·1859	4·215–4·230	0·1659–0·1665	3·730–3·745	0·1468–0·1474
3	4·100–4·123	0·1614–0·1623	3·660–3·675	0·1441–0·1447	3·220–3·235	0·1268–0·1274
4	3·600–3·623	0·1417–0·1426	3·205–3·220	0·1262–0·1268	2·810–2·825	0·1106–0·1112
5	3·200–3·223	0·1260–0·1269	2·845–2·860	0·1120–0·1126	2·490–2·505	0·0980–0·0986
6	2·800–2·823	0·1102–0·1111	2·480–2·495	0·0976–0·0982	2·160–2·175	0·0850–0·0856
7	2·500–2·523	0·0984–0·0993	2·210–2·225	0·0870–0·0876	1·920–1·935	0·0756–0·0762
8	2·200–2·215	0·0866–0·0872	1·940–1·950	0·0764–0·0768	1·680–1·690	0·0661–0·0665
9	1·900–1·915	0·0748–0·0754	1·665–1·675	0·0656–0·0660	1·430–1·440	0·0563–0·0567
10	1·700–1·715	0·0669–0·0675	1·490–1·500	0·0587–0·0591	1·280–1·290	0·0504–0·0508
11	1·500–1·515	0·0591–0·0597	1·315–1·325	0·0518–0·0522	1·130–1·140	0·0445–0·0449
12	1·300–1·315	0·0512–0·0518	1·130–1·140	0·0445–0·0449	0·960–0·970	0·0378–0·0382
13	1·200–1·215	0·0472–0·0478	1·050–1·060	0·0413–0·0417	0·900–0·910	0·0354–0·0358
14	1·000–1·015	0·0394–0·0400	0·860–0·870	0·0339–0·0343	0·720–0·730	0·0283–0·0287
15	0·900–0·915	0·0354–0·0360	0·775–0·785	0·0305–0·0309	0·650–0·660	0·0256–0·0260

For tolerances on pitch and angle of thread see pages 11 and 12.

F

TABLE XXXIV.—LIMITS FOR B.A. SCREW GAUGES.

Full Form " Go " Plugs.

WORKSHOP.

No.	Full Diameter.		Effective Diameter.		Core Diameter.	
	mm.	In.	mm.	In.	mm.	In.
0	6·000–6·015	0·2362–0·2368	5·400–5·415	0·2126–0·2132	4·792–4·815	0·1887–0·1896
1	5·300–5·315	0·2087–0·2093	4·760–4·775	0·1874–0·1880	4·212–4·235	0·1658–0·1667
2	4·700–4·715	0·1850–0·1856	4·215–4·230	0·1659–0·1665	3·722–3·745	0·1465–0·1474
3	4·100–4·115	0·1614–0·1620	3·660–3·675	0·1441–0·1447	3·212–3·235	0·1265–0·1274
4	3·600–3·615	0·1417–0·1423	3·205–3·220	0·1262–0·1268	2·802–2·825	0·1103–0·1112
5	3·200–3·215	0·1260–0·1266	2·845–2·860	0·1120–0·1126	2·482–2·505	0·0977–0·0986
6	2·800–2·815	0·1102–0·1108	2·480–2·495	0·0976–0·0982	2·152–2·175	0·0847–0·0856
7	2·500–2·515	0·0984–0·0990	2·210–2·225	0·0870–0·0876	1·912–1·935	0·0753–0·0762
8	2·200–2·210	0·0866–0·0870	1·940–1·950	0·0764–0·0768	1·675–1·690	0·0659–0·0665
9	1·900–1·910	0·0748–0·0752	1·665–1·675	0·0656–0·0660	1·425–1·440	0·0561–0·0567
10	1·700–1·710	0·0669–0·0673	1·490–1·500	0·0587–0·0591	1·275–1·290	0·0502–0·0508
11	1·500–1·510	0·0591–0·0595	1·315–1·325	0·0518–0·0522	1·125–1·140	0·0443–0·0449
12	1·300–1·310	0·0512–0·0516	1·130–1·140	0·0445–0·0449	0·955–0·970	0·0376–0·0382
13	1·200–1·210	0·0472–0·0476	1·050–1·060	0·0413–0·0417	0·895–0·910	0·0352–0·0358
14	1·000–1·010	0·0394–0·0398	0·860–0·870	0·0339–0·0343	0·715–0·730	0·0281–0·0287
15	0·900–0·910	0·0354–0·0358	0·775–0·785	0·0305–0·0309	0·645–0·660	0·0254–0·0260

For tolerances on pitch and angle of thread see pages 11 and 12.

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Table XXXV.—Limits for B.A. Screw Gauges.

Full Form " Go " Rings.

Workshop.

No.	Full Diameter.		Effective Diameter.		Core Diameter.	
	mm.	In.	mm.	In.	mm.	In.
0	6·008–5·985	0·2365–0·2356	5·400–5·385	0·2126–0·2120	4·800–4·785	0·1890–0·1884
1	5·308–5·285	0·2090–0·2081	4·760–4·745	0·1874–0·1868	4·220–4·205	0·1661–0·1655
2	4·708–4·685	0·1853–0·1844	4·215–4·200	0·1659–0·1653	3·730–3·715	0·1468–0·1462
3	4·108–4·085	0·1617–0·1608	3·660–3·645	0·1441–0·1435	3·220–3·205	0·1268–0·1262
4	3·608–3·585	0·1420–0·1411	3·205–3·190	0·1262–0·1256	2·810–2·795	0·1106–0·1100
5	3·208–3·185	0·1263–0·1254	2·845–2·830	0·1120–0·1114	2·490–2·475	0·0980–0·0974
6	2·808–2·785	0·1105–0·1096	2·480–2·465	0·0976–0·0970	2·160–2·145	0·0850–0·0844
7	2·508–2·485	0·0987–0·0978	2·210–2·195	0·0870–0·0864	1·920–1·905	0·0756–0·0750
8	2·205–2·190	0·0868–0·0862	1·940–1·930	0·0764–0·0760	1·680–1·670	0·0661–0·0657
9	1·905–1·890	0·0750–0·0744	1·665–1·655	0·0656–0·0652	1·430–1·420	0·0563–0·0559
10	1·705–1·690	0·0671–0·0665	1·490–1·480	0·0587–0·0583	1·280–1·270	0·0504–0·0500
11	1·505–1·490	0·0593–0·0587	1·315–1·305	0·0518–0·0514	1·130–1·120	0·0445–0·0441
12	1·305–1·290	0·0514–0·0508	1·130–1·120	0·0445–0·0441	0·960–0·950	0·0378–0·0374
13	1·205–1·190	0·0474–0·0468	1·050–1·040	0·0413–0·0409	0·900–0·890	0·0354–0·0350
14	1·005–0·990	0·0396–0·0390	0·860–0·850	0·0339–0·0335	0·720–0·710	0·0283–0·0279
15	0·905–0·890	0·0356–0·0350	0·775–0·765	0·0305–0·0301	0·650–0·640	0·0256–0·0252

For tolerances on pitch and angle of thread see pages 11 and 12.

B 2

Limits for Screw Gauges for Thread of Sparking Plug and Hole.

Two different sets of tolerances have been laid down by the B.E.S.A. for sparking plug threads, one for aircraft and the other for automobile engines. These are given in B.E.S.A. Specifications No. 2E9 (1930) and No. 45 (1928) respectively.

The following tables give the limits for gauges to suit the two classes of work. For the general design of the gauges, reference should be made to the above-mentioned Reports.

Table XXXVI.—*Full Form " Go " Screw Gauges (Aircraft).*

Type of Gauge.	Nominal Size.	Pitch.	Full Diameter.	Effective Diameter.	Core Diameter.
	mm.	mm.	mm.	mm.	mm.
Inspection Plug	18·025	1·5	18·025–18·010	17·051–17·036	Less than 15·914
Workshop Plug	18·025	1·5	18·025–18·040	17·051–17·066	Less than 15·914
Inspection Ring	17·975	1·5	Greater than 18·137	17·001–17·016	16·026–16·041
Workshop Ring	17·975	1·5	Greater than 18·137	17·001–16·986	16·026–16·011

Thread form to be in accordance with the System International (see Fig. 31).

For tolerances on pitch and angle of thread see pages 11 and 12.

Table XXXVII.—*" Not Go " Effective Diameter Screw Gauges (Aircraft).*

Type of Gauge.	Nominal Size. Effective Diameter.	Pitch.	Full Diameter.	Effective Diameter.	Core Diameter.
	mm.	mm.	mm.	mm.	mm.
Inspection Plug	17·176	1·5	17·776–17·806	17·176–17·191	Less than 16·068
Workshop Plug	17·176	1·5	17·776–17·746	17·176–17·161	Less than 16·068
Inspection Ring	16·876	1·5	Greater than 18·013	16·876–16·861	16·276–16·246
Workshop Ring	16·876	1·5	Greater than 18·013	16·876–16·891	16·276–16·306

Plain Plug Gauges for Core Diameter of Sparking Plug Hole (Aircraft).

		Diameter.
" Go " Plug.. .. .. Nominal size, 16·076 mm.	Inspection.	16·076–16·069 mm.
	Workshop.	16·076–16·083 mm.
" Not go " Plug .. .. Nominal size, 16·201 mm.	Inspection.	16·201–16·208 mm.
	Workshop.	16·201–16·194 mm.

Plain Ring Gauges for Full Diameter of Sparking Plug (Aircraft).

		Diameter.
" Go " Ring .. .. Nominal size, 17·975 mm.	Inspection.	17·975–17·982 mm.
	Workshop.	17·975–17·968 mm.
" Not go " Ring .. .. Nominal size, 17·850 mm.	Inspection.	17·850–17·843 mm.
	Workshop.	17·850–17·857 mm.

TABLE XXXVIII.—*Full Form " Go " Screw Gauges (Automobile).*

Type of Gauge.	Nominal Size.	Pitch.	Full Diameter.	Effective Diameter.	Core Diameter.
	mm.	mm.	mm.	mm.	mm.
Inspection Plug	18·000	1·5	18·000–17·985	17·026–17·011	Less than 15·889
Workshop Plug	18·000	1·5	18·000–18·015	17·026–17·041	Less than 15·889
Inspection Ring	18·112	1·5	Greater than 18·112	16·976–16·991	16·001–16·016
Workshop Ring	18·112	1·5	Greater than 18·112	16·976–16·961	16·001–15·986

Thread form to be in accordance with the System International (see Fig. 31). For tolerances on pitch and angle of thread see pages 11 and 12.

TABLE XXXIX.—*" Not Go " Effective Diameter Screw Gauges (Automobile).*

Type of Gauge.	Nominal Size. Effective Diameter.	Pitch.	Full Diameter.	Effective Diameter.	Core Diameter.
	mm.	mm.	mm.	mm.	mm.
Inspection Plug	17·201	1·5	17·801–17·831	17·201–17·216	Less than 16·043
Workshop Plug	17·201	1·5	17·801–17·771	17·201–17·186	Less than 16·043
Inspection Ring	16·776	1·5	Greater than 17·957	16·776–16·761	16·176–16·146
Workshop Ring	16·776	1·5	Greater than 17·957	16·776–16·791	16·176–16·206

Plain Plug Gauges for Core Diameter of Sparking Plug Hole (Automobile).

		Diameter.
" Go " Plug .. .. Nominal size, 16·051 mm.	Inspection.	16·051–16·044 mm.
	Workshop.	16·051–16·058 mm.
" Not go " Plug .. .. Nominal size, 16·226 mm.	Inspection.	16·226–16·233 mm.
	Workshop.	16·226–16·219 mm.

Plain Ring Gauges for Full Diameter of Sparking Plug (Automobile).

		Diameter.
" Go " Ring .. .. Nominal size, 17·950 mm.	Inspection.	17·950–17·957 mm.
	Workshop.	17·950–17·943 mm.
" Not go " Ring .. .. Nominal size, 17·750 mm.	Inspection.	17·750–17·743 mm.
	Workshop.	17·750–17·757 mm.

TABLE XL.—LIMITS FOR B.S. STEEL CONDUIT SCREW GAUGES.

Full Form " Go " Plugs.

INSPECTION.

Nominal Diameter.	Threads per inch.	Full Diameter.	Effective Diameter.	Core Diameter.
In.		In.	In.	In.
½	18	0·5000–0·4994	0·4644–0·4638	0·4289–0·4280
⅝	18	0·6250–0·6244	0·5894–0·5888	0·5539–0·5530
¾	16	0·7500–0·7494	0·7100–0·7094	0·6700–0·6691
1	16	1·0000–0·9994	0·9600–0·9594	0·9200–0·9191
1¼	16	1·2500–1·2494	1·2100–1·2094	1·1700–1·1691
1½	14	1·5000–1·4994	1·4543–1·4537	1·4085–1·4076
2	14	2·0000–1·9991	1·9543–1·9534	1·9085–1·9071
2½	14	2·5000–2·4991	2·4543–2·4534	2·4085–2·4071

TABLE XLI.—*Full Form " Go " Rings.*

INSPECTION.

Nominal Diameter.	Threads per inch.	Full Diameter.	Effective Diameter.	Core Diameter.
In.		In.	In.	In.
½	18	0·5000–0·5009	0·4644–0·4650	0·4289–0·4295
⅝	18	0·6250–0·6259	0·5894–0·5900	0·5539–0·5545
¾	16	0·7500–0·7509	0·7100–0·7106	0·6700–0·6706
1	16	1·0000–1·0009	0·9600–0·9606	0·9200–0·9206
1¼	16	1·2500–1·2509	1·2100–1·2106	1·1700–1·1706
1½	14	1·5000–1·5009	1·4543–1·4549	1·4085–1·4091
2	14	2·0000–2·0014	1·9543–1·9552	1·9085–1·9094
2½	14	2·5000–2·5014	2·4543–2·4552	2·4085–2·4094

TABLE XLII.—*Full Form " Go " Plugs.*

WORKSHOP.

Nominal Diameter.	Threads per inch.	Full Diameter.	Effective Diameter.	Core Diameter.
In.		In.	In.	In.
½	18	0·5000–0·5006	0·4644–0·4650	0·4286–0·4295
⅝	18	0·6250–0·6256	0·5894–0·5900	0·5536–0·5545
¾	16	0·7500–0·7506	0·7100–0·7106	0·6697–0·6706
1	16	1·0000–1·0006	0·9600–0·9606	0·9197–0·9206
1¼	16	1·2500–1·2506	1·2100–1·2106	1·1697–1·1706
1½	14	1·5000–1·5006	1·4543–1·4549	1·4082–1·4091
2	14	2·0000–2·0009	1·9543–1·9552	1·9080–1·9094
2½	14	2·5000–2·5009	2·4543–2·4552	2·4080–2·4094

TABLE XLIII.—*Full Form " Go " Rings.*

WORKSHOP.

Nominal Diameter.	Threads per inch.	Full Diameter.	Effective Diameter.	Core Diameter.
In.		In.	In.	In.
½	18	0·5003–0·4994	0·4644–0·4638	0·4389–0·4283
⅝	18	0·6253–0·6244	0·5894–0·5888	0·5539–0·5533
¾	16	0·7503–0·7494	0·7100–0·7094	0·6700–0·6694
1	16	1·0003–0·9994	0·9600–0·9594	0·9200–0·9194
1¼	16	1·2503–1·2494	1·2100–1·2094	1·1700–1·1694
1½	14	1·5003–1·4994	1·4543–1·4537	1·4085–1·4079
2	14	2·0005–1·9991	1·9543–1·9534	1·9085–1·9076
2½	14	2·5005–2·4991	2·4543–2·4534	2·4085–2·4076

For tolerances on pitch and angle of conduit gauges see pages 11 and 12.

LIMITS FOR GAUGES FOR ROYAL MICROSCOPICAL SOCIETY'S STANDARD OBJECTIVE THREAD.

TABLE XLIV.—*" Go " Full Form Screw Ring for Objective.*

FORM OF THREAD, WHITWORTH 36 T.P.I.

—	Full Diameter.	Effective Diameter.	Core Diameter.
	In.	In.	In.
Inspection Ring	0·7982–0·7991	0·7804–0·7810	0·7626–0·7632
Workshop Ring	0·7985–0·7976	0·7804–0·7798	0·7626–0·7620

TABLE XLV.—" *Go* " *Full Form Screw Plug for Nose-piece.*

FORM OF THREAD, WHITWORTH 36 T.P.I.

—	Full Diameter.	Effective Diameter.	Core Diameter.
	In.	In.	In.
Inspection Plug	0·8000–0·7994	0·7822–0·7816	0·7644–0·7635
Workshop Plug	0·8000–0·8006	0·7822–0·7828	0·7641–0·7650

Length of thread on screw gauges to be at least $\frac{3}{16}$ in.

For tolerances on pitch and angle of thread see pages 11 and 12.

" NOT GO " PLAIN CYLINDRICAL RING FOR OBJECTIVE.

	Diameter. In.
Inspection Ring ..	0·7951–0·7949
Workshop Ring ..	0·7951–0·7953

" NOT GO " PLAIN CYLINDRICAL PLUG FOR NOSE-PIECE.

	Diameter. In.
Inspection Plug ..	0·7675–0·7677
Workshop Plug ..	0·7675–0·7673

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