Metric Screws, Fasteners & Screw Threads

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1.1 When talking of Screw Threads, it is interesting to know that the Screw is one of six simple machines, the other five being the Lever & Fulcrum, Wheel & Axle, Pulley, Inclined Plane and the Wedge. Over 2000 years ago Archimedes had used the Screw as a simple machine to elevate water. However the Screw became important in Commerce only after the Industrial Revolution.

1.2 A Screw Thread is essentially a spiral Inclined Plane and Wedge which has a mechanical advantage and could be used to increase the applied force. The most widely used function of a Screw Thread is its use as a Fastener. In fact, it is termed the Nail of the Metal Age. Screw Threads are commonly used as Connectors or Couplings, gas and liquid Seals and as Translators of motion and power. Although welding and adhesive binding is increasingly used for permanent fastening, threaded fasteners are unmatched in fastening parts that require future dis-assembling and in Couplings.

1.3 The parameters which go to define a Screw Thread can be varied very widely. As such, combination of these factors will give rise to numerous thread forms. In fact, at the time the need for standardization of Screw Threads was felt, there were nearly 200 thread forms' in use throughout the world. Fig. 1 depicts the ddevelopment of the I. S. O. metric Screw Thread and the predictions are that the whole world will adopt I.S.O. metric thread at least by 1984.

1.4 The origin of Screw Threads is obscure, but it could be logically assumed that it was discovered independently by a number of craftsmen. The earliest attempt to standardise Screw Threads has been recorded in the beginning of the Nineteenth Century by Mr. Holzappfel in London. He was able to control the diameters and pitches used by originating hand screw cutting too's from carefully preserved sets of master tools. However, independent reproducibility might have commenced with the development of the Lathe by Mr. Maudslay. In 1841, Sir Joseph Whitworth of the U.K. tabled a paper suggesting a comprehensive standard for Screw Threads based on the pitches and thread angles commonly used at that time. The present I.S.O. accepted flank angle of 60 was proposed by William Sellers in the U.S.A. in 1864.

1.5 The Whitworth thread was adopted as a British Standard in 1905. However, Sellers Thread had not been standardised nationally in the U.S.A. when World War I started. The need for interchangeability of parts in the mass production of war materials led to the formation of the National Screw Thread Commission which initiated the work on the American National Thread Series based on Sellers thread form. The first attempt to formulate International standards was made soon after World War II, attended by Canada, U.K. and the U.S.A. These conferences resulted in establishing standards for the Unified Screw Thread Series in 1948.

1.6 The International Standards Organisation (I.S.O.) established in 1946, took up the task of standardisation of the Screw Thread. This has been an uphill task, since the I.S.O. has had to strike a balance between two opposing movements, one that tends to proliferate the sizes and shapes of thread forms while the other is directed towards reduction in thread sizes and shapes to achieve standardisation. The I.S.O. Committee-TC 1, by 1958, had been able to develop the Metric Screw Thread System and the Unified Thread Series was accepted as an I.S.O. standard. However, the I.S.O. has still not completed the Metric Series for Screw Threads & Fasteners to cover all uses in industry and is still engaged in the process of this development.

2. Nomenclature and Definition—Refer 1—Fig. 2.

2.1 Parallel & Taper Threads

Crest and Root:—The crest is the prominent part of the thread whether external or internal, and the root is the bottom of the groove. The crests are therefore on the larger diameter of an external and the smaller diameter of an internal thread.

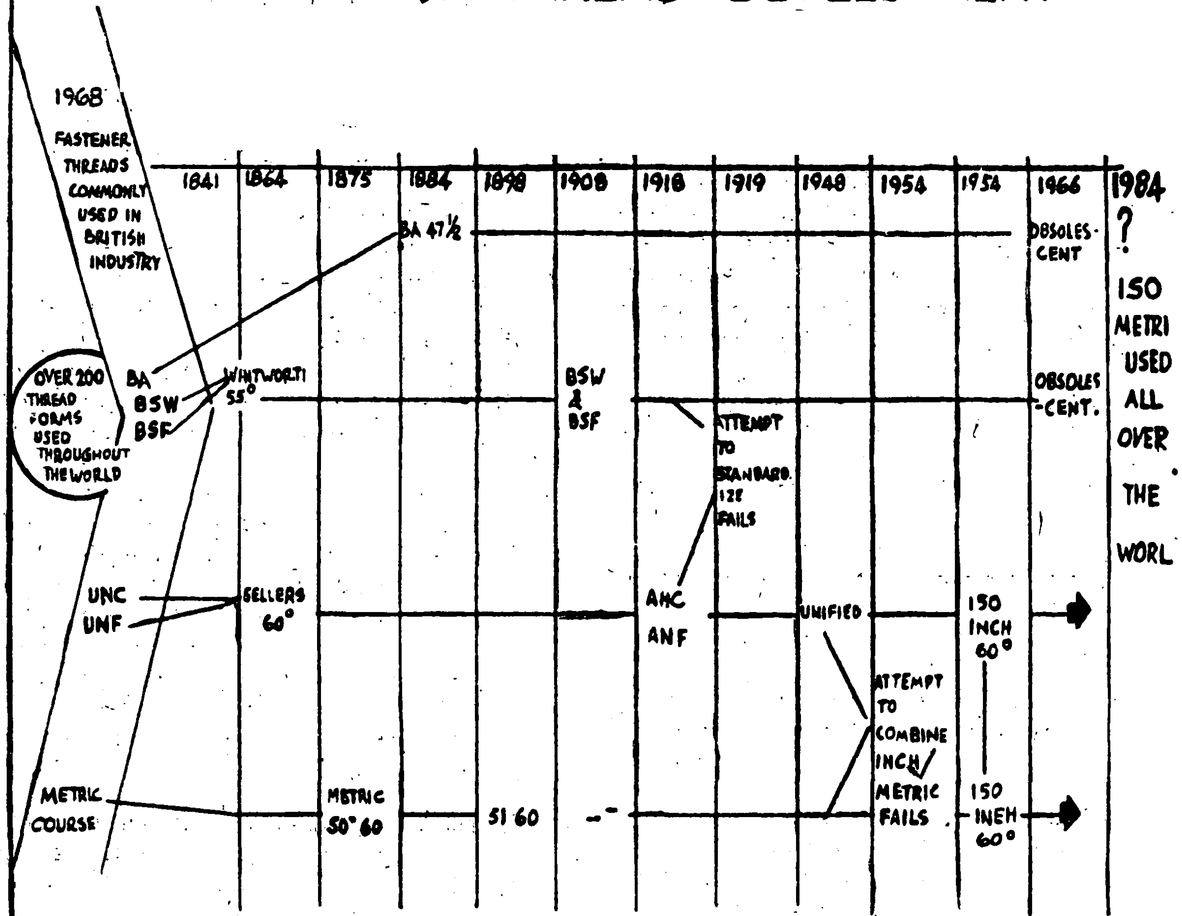
Fundamental Triangle:—The Fundamental Triangle is the triangle formed by the intersection of the extended flanks of thread.

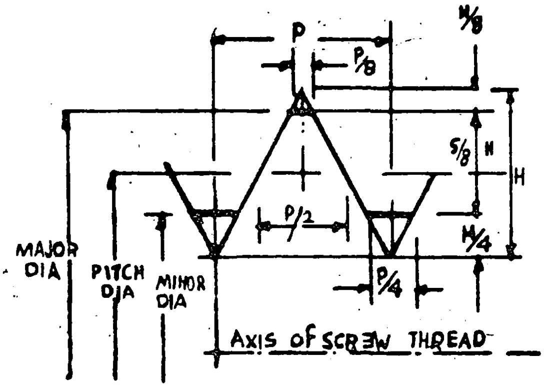
Pitch:—The pitch of a thread is the distance measured parallel to the axis between corresponding points on adjacent thread forms in the same axial plane.

Lead:—The lead is the axial distance advanced by the thread in one revolution. The lead and pitch of a single start thread is identical. In a multi-start thread, the lead is the same as the multiple of the pitch and number of starts.

Cumulative Pitch:—Cumulative Pitch is the distance between corresponding points measured over a given number of threads.

HISTORY OF THREAD DEVELOPMENT





UNIFIED THREAD I.S.O
BASIC PROFILE INCH & METRIC SERIES
THREAD HEIGHT = 5H/8

BASIC THREAD FORM, I.S.O (UNIFIED) THREAD

P SIGNIFIES PITCH AND H SIGNIFIES FUNDAMENTAL TRIANGLE HEIGHT

2.2 Parallel Threads

Major Diameter:—The major diameter is the diameter of an imaginary co-axial cylinder which touches the Crests of an external thread or the root of an internal thread.

Minor Diameter:—The minor diameter is the diameter of an imaginary co-axial cylinder touching the roots of an external thread or the crests of an internal thread.

Effective Diameter:—The effective diameter is defined as the diameter of the imaginary co-axial cylinder intersecting the thread in such a manner that the intercept on a generator of the cylinder between the points where it meets the opposite flanks of the thread groove is equal to half the pitch.

Virtual Effective Diameter:—Could be regarded as the simple effective diameter of the perfect thread with which the actual thread would just mate.

3. Methods of Manufacture of Screw Threads

3.1 Center Lathes

As stated earlier, the reproducibility of Screw Threads was achieved after the invention of the lathe machine. However, this method of manufacture is now largely superceded by faster methods of production.

3.2 Self-Opening Die Heads

In this method, unlike the solid die head, it is not required to reverse the spindle to remove the die head. The screw-cutting die heads could be spun out, thus disengaging the work. This kind of die heads are used with special thread cutting machines, which gives much higher production than the center lathe.

3.3 Thread Tapping

Thread tapping could be done either manually or by tapping machines. Although there has been considerable development in the methods of cutting external screw threads, there has been very little change to the actual cutting tool for producing threads in a small hole.

3.4 Thread Chasing

In thread chasing devices, the master screw of the lathe is used to control the pitch of threads, and taps or dies are used in releasing holders or self-opening dies. There are a range of automatic threading machines working on this principle.

3.5 Thread Rolling

Thread rolling machines give higher value of production compared with the other types of thread forming machines. In the thread rolling process, the thread is formed by the displacement of the metal. The metal is forced from the thread troughs to the adjacent crests. Thus, you see that this is the most economical way of production. The thread rolling process gives increased strength to the root of the thread.

3.6 Thread Milling

Thread milling is advantageous if thread cutting is to be done as a second operation e.g. initial work done in a specimen does not permit heavy cuts to be taken like that of a chaser in a die head or the heavy process of the thread roller. The light cuts of the milling cutter provide the answer.

3.7 Thread Grinding

In this process, the thread form is attained by reproducing the form of thread in the grinding wheel and the pitch is controlled by a lead screw. Thread grinding is used mainly to produce tools such as Taps, Cutters and Gauges when high accuracy is needed. The advantage of grinding is being able to do finishing after hardening.

3.8 In the above thread turning processes, the accuracy of the thread depends on the tools used. The thread form is completely dependant on the shape of the cutting tool. The pitch is directly related to the accuracy of the gear train and lead screw. In other kinds of thread forming, like tapping, chasing and rolling, one depends largely on the die manufacturer's reputation as nothing can be done to correct a thread form other than rejecting the dies.

4.1 Thread Inspection and Measurement

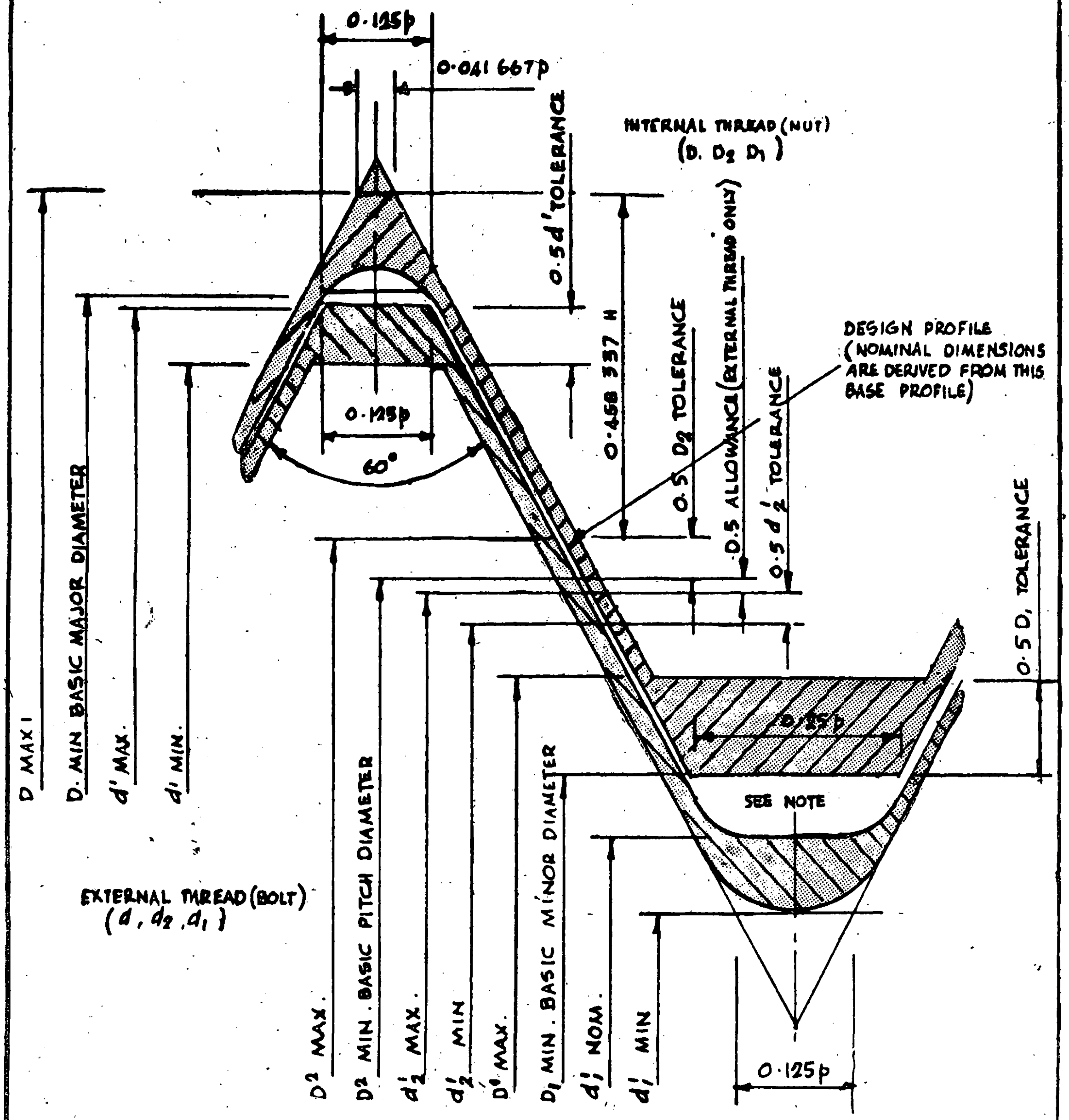
Accuracy and time are the two main factors which have to be considered in the use of gauges for inspection in industry. With the development of modern methods of producing accurate screw threads on a mass production basis, the equipment used for thread inspection has also developed to a higher grade of accuracy and efficiency. Another important factor which has to be thought of in the choice of inspection gauges, is the skill required to use the gauge. It is advisable if semi-skilled labour could handle these inspections. The most common type of gauges that fulfil these requirements are the 'go and no go' type of gauges which have to be designed to measure the parameters of the Screw Thread.

4.2 There are three parameters of the Screw Thread which must be checked for replaceability. They are the form of thread, the pitch and the effective diameter.

4.3 Fig. 3 shows the tolerances given for Screw Threads. These vary for different classes of fit. These tolerances are available in tabulated form in standard specification in Screw Threads.

4.4 For general Engineering work, simple plug and ring gauges will suffice to check the accuracy of work. Normally, the Screw is checked for free running fit; when more accurate checking is required in a

ANNEXE 4
FIG I



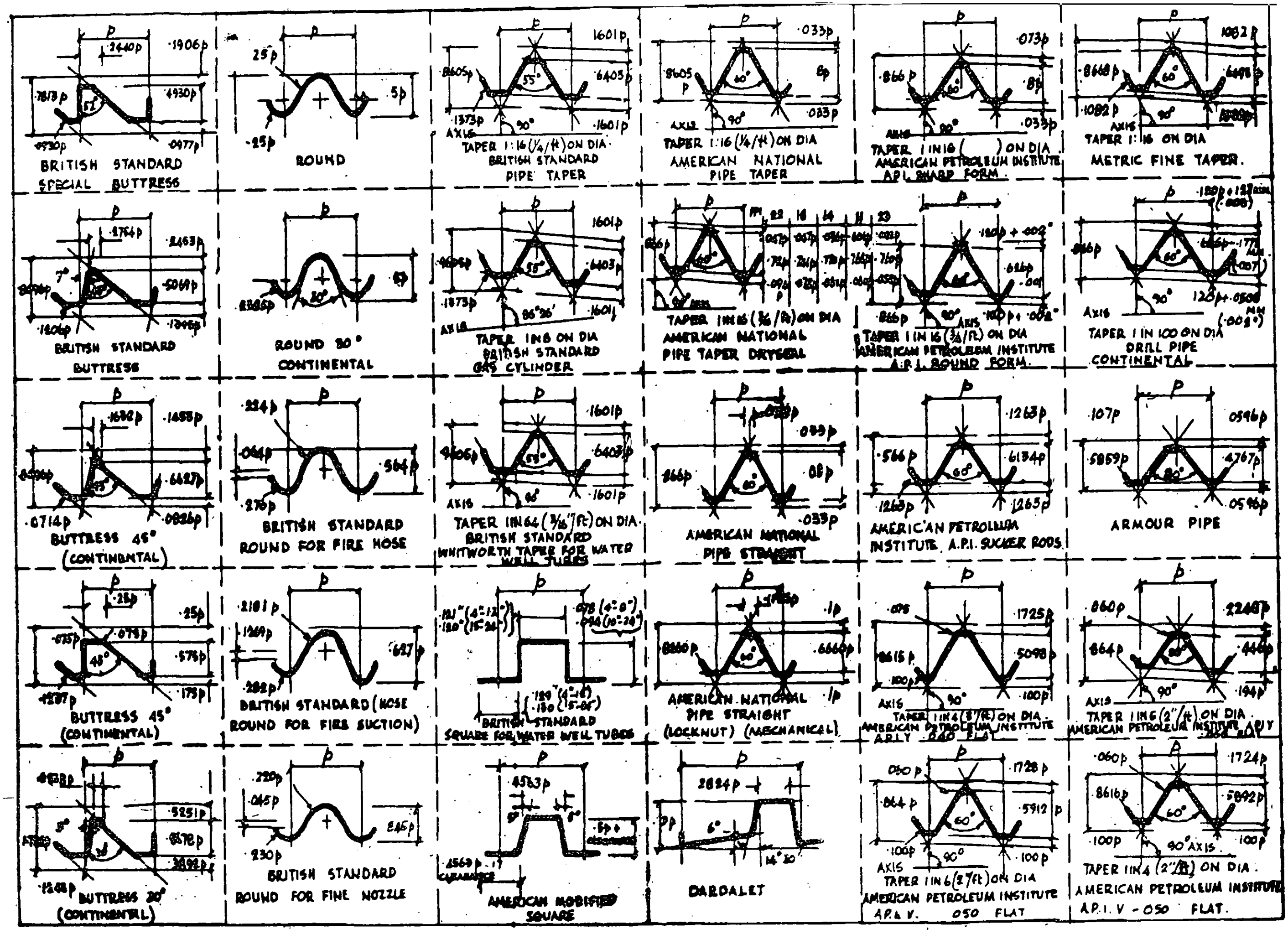
NOTES

1. PERMISSIBLE FORM FROM NEW TOOL
2. PERMISSIBLE FORM FROM WORN TOOL
3. FORM OF MANDATORY ROOT RADIUS

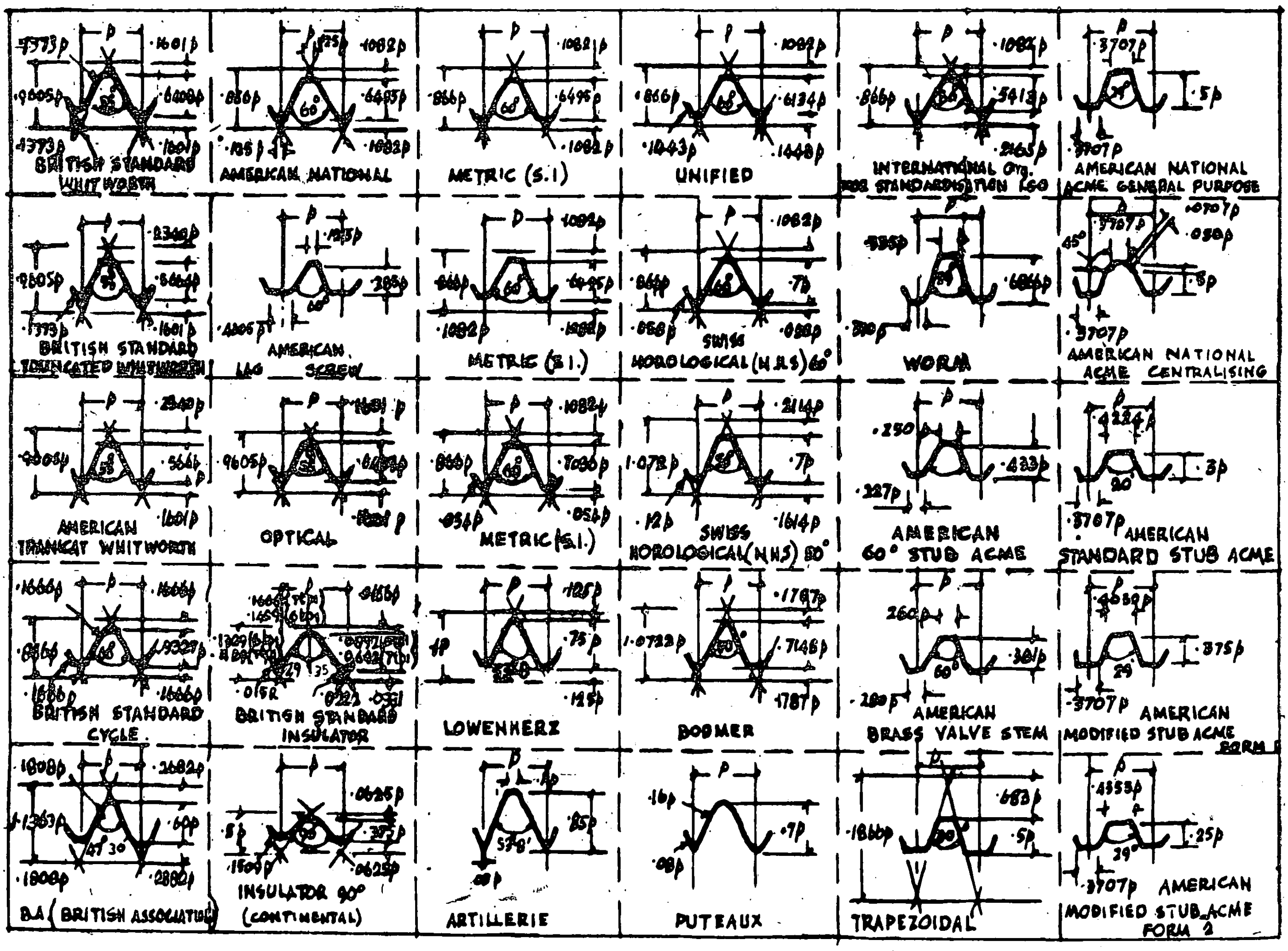
CHOICE OF FORM LEFT TO DESCRETION OF THE USER COUNTRY

DISPOSITION OF TOLERENCES ALLOWANCES AND CREST CLEARANCE FOR CLASSES 1A, 2A, 1B & 2B.

Fig. 3

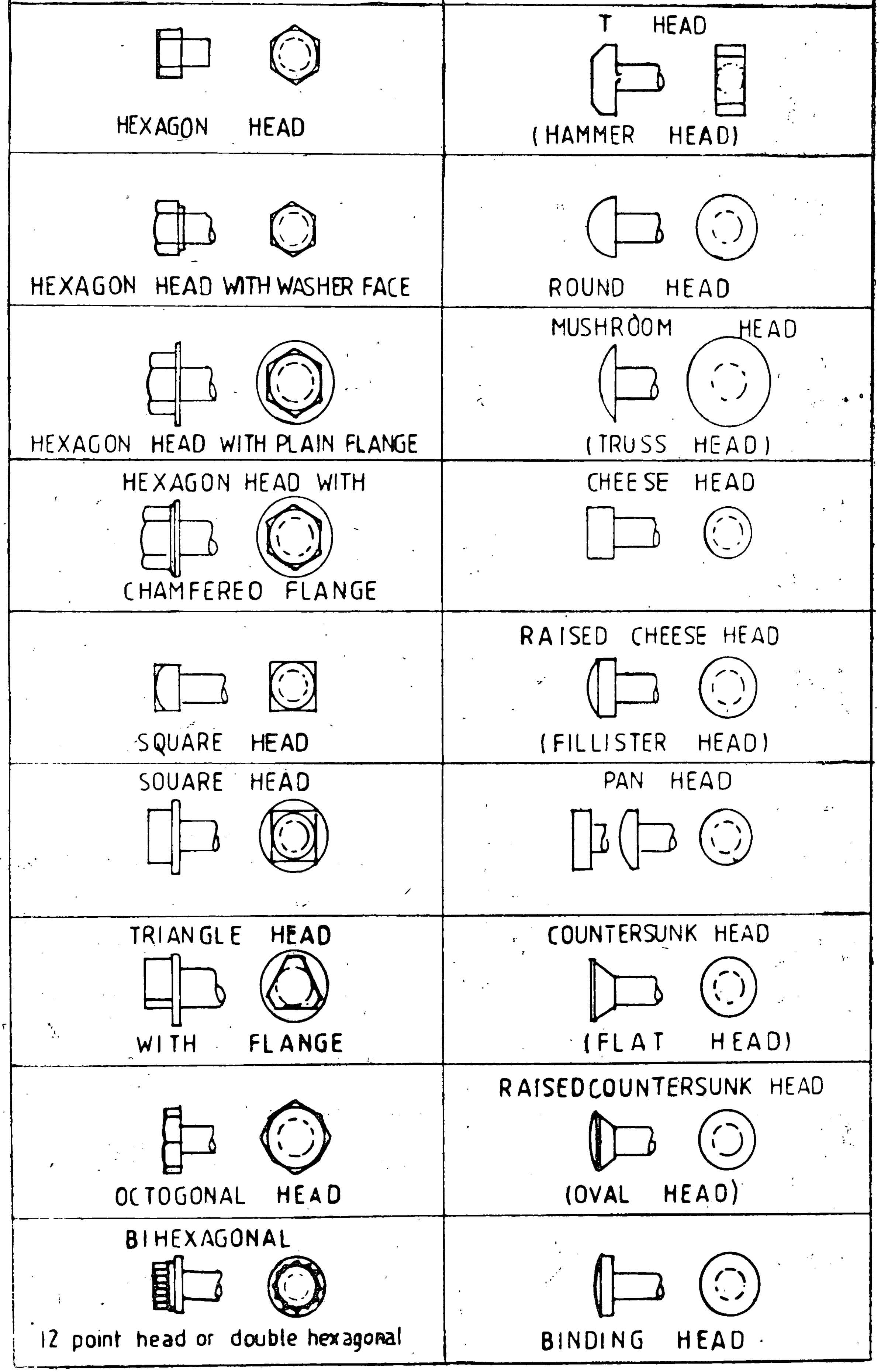


SCREW THREAD FORMS IN COMMON USE THROUGHOUT THE WORLD



SCREW- THREAD FORMS IN COMMON USE THROUGHOUT

ANNEXE 2
FIG 2



mass production line, 'go & no go' guages are used. The 'go' ring guage is a full-form guage to the exact basic profile of the Screw. The 'no go' guage is slightly less on the effective diameter according to the tolerance and truncated on the core diameter to avoid interference with the root of the thread. For internal thread, one more additional plug guage is also used to check the high limit of the core diameter.

4.5 For very accurate work, and if a measurement is required of any thread parameter, then special measuring instruments have to be employed, which will record a fundamental measurement instead of having to depend on master guages.

4.6 The simple effective diameter is measured by a floating carriage diameter measuring instrument. Universal pitch measuring machines are used to compare thread form and angles.

4.7 For internal thread measurement, a wax casting is formed on the internal thread and this is subjected to the above measuring processes. Dental wax is commonly used for this purpose.

4.8 B.S. 919:1960 gives the limits of tolerances for screw guages. The I.S.O. recommendation on guaging has been issued in 1970.

5. Limits and Fits

There are three grades of fits for Screw Threads. Namely:—

Close Fit:—used for Precision Screw with very small play.

Medium Fit:—used for general purpose screws for machines, tools, structures etc.

Free Fit:—used for construction and installation work which does not require much accuracy but required fast fixing.

In each class of fit, the nominal diameter-major, minor or effective—is the upper limit for the bolt and lower limit for the nut.

6.1 Errors in Threads

Five important elements in threads that should be controlled strictly are:—major, minor and effective diameters and pitch & angle of thread form. The other features being general form, radii at crest and root and, mutual concentricity of the various diameters.

Pitch:—Errors in pitch may be of four kinds—Progressive, Periodic, Drunkenness and Irregular.

Progressive error:—is a gradual, but not necessarily uniform divergence of the pitch form the true and normal form.

Periodic error:—this error repeats itself in regular intervals.

Drunkenness error:—is an error similar to periodic error, but repeating once per turn of thread.

Irregular errors:—have no special causes.

6.2 Errors in pitch reference to effective diameter

The male thread is virtually over-size to the extent of the simple effective diameter equivalent of the pitch error. The female thread is considered to be under-sized by the same equivalent of pitch error.

6.3 Errors in Flank angles with reference to effective diameter

Errors in Flank Angles of a Screw Thread have similar effect to the errors in pitch and result in a male thread of otherwise satisfactory, dimensions being virtually over-size on the simple effective diameter, while the female thread suffers a virtual reduction in effective diameter.

7.1 Sri Lanka being a developing Country, we have to follow the trends set by the developed Countries. With many developing Countries changing to the metric system, it is predicted that around 1984, most developed Countries will adopt the I.S.O. metric thread form recommendation. At present Sri Lanka could opt to use I.S.O. recommended Screw Thread and Fasteners for new machinery components and for general Engineering work. At the same time, we will have to carry adequate stocks of other forms of Screw Threads to serve our maintenance requirements. This involves heavy inventory costs and extra expenditure on thread manufacturing equipment.

7.2 The present problem in Sri Lanka is that we have to produce almost all the varieties of Screw Threads recorded in industry to serve our maintenance requirements. In fact, B.A. & B.S.W. threads which are considered obsolete in developed Countries, are needed in appreciable quantities in Sri Lanka. It will take a considerable length of time for Sri Lanka to reap benefits from the reduction of thread sizes due to the change over to I.S.O. metric. However, when this goal is achieved, we would have done away with 90% of the thread forms we are now manufacturing.

References:

1. U.S. Metric Study Interim Report.
2. Machinery's Screw Thread Book.
3. J. S. Murphy—Screw Thread Production.

Acknowledgements

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