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IMPORTANT EUROPEAN SCREW THREAD SYSTEMS AND DIMENSIONS OF BOLT AND SCREW HEADS AND NUTS

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IX. The Loewenherz screw thread system and screw heads

I. INTRODUCTION

This Circular is a collection of data appertaining to screw thread systems and standard dimensions for bolt and screw heads and nuts in use in various European countries. It covers, particularly, those standards which originated in Great Britain, France, Switzerland, and Germany, although they are used by other European nations as well.

So far as practicable the nomenclature in vogue in the United States and sanctioned by the National Screw Thread Commission has been used, in order that the information given may be understood and applied with as little difficulty as possible. An effort has been made to give a complete presentation of all essential data.

Since American standards for the dimensions of bolt and screw heads are still in the process of formulation, this collection of data may prove of use in arriving at such standards. These data should also prove useful to those who manufacture machinery for export.

II. BRITISH STANDARD WHITWORTH AND BRITISH STANDARD FINE SCREW THREADS

1. British standard Whitworth and British Standard Fine Screw threads.

The Whitworth series of screw threads was proposed in 1841 by Joseph Whitworth of Great Britain in a paper read before the Institution of Civil Engineers. The Whitworth thread angle, diameters, and pitches were chosen because they represented the average engineering practice at that time. Of thread angle, Mr. Whitworth said: "The mean of the angles in one inch screws was found to be about 55 deg. which was also nearly the mean in screws of different diameters, hence, it is adopted throughout the scale."

The British Engineering Standards Association adopted the British Standard Whitworth Screw Threads (B.S.W.) in 1905 and issued a report giving the essential dimensions of the series. The thread angle in an axial plane is 55 deg.; the threads are rounded equally at crest and root to a radius of 0.137329 times the pitch, and the resulting depth of thread becomes 0.640327

times the pitch. Thus, one-sixth of the depth of the basic triangle is removed from the crest of the thread, and one-sixth of the depth is filled in at the root. This form of thread is designated the "Whitworth" thread form, and is shown in Fig. 1.

The Whitworth form of thread is also used in the British Standard Fine Screw Threads (B.S.F.), British Standard Pipe Threads (B.S.P.), and British Standard Conduit Threads.

The British Standard Fine Screw Threads were introduced in 1908 by the British Engineering Standards Association, and are said to be well suited to the purposes for which they were designated. The pitches are obtained by the formula,

$$p = 0.1\ D^{2/3}$$

for sizes up to and including one inch, and

$$p = 0.1\ D^{5/8}$$

for sizes above one inch. In these formulas,

p = pitch
and D = major diameter

2. Dimensions, Allowances, and Tolerances.

The basic dimensions of British Standard Whitworth and British Standard Fine Screw Threads are given in Tables 1 and 4. In Tables 2, 3, 5, 6, 7, and 8 are given the dimensions and tolerances on bolts and nuts for both series.

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The maximum screw is made to the basic size. For example, the maximum major diameter of a 1/4 inch B.S.W. screw is 0.2500 inch, and the minimum major diameter is equal to the maximum major diameter minus the tolerance. The tolerance is given in Table 2 as 0.0018 inch, hence, the maximum major diameter is 0.2482 inch.

All allowances to provide for clearance are in the nut, the minimum diameter of the nut being above basic size. As shown in Table 3, the minimum diameter of the nut being above basic size. As shown in Table 3, the minimum major diameter of a 1/4 inch nut is 0.0005 inch above basic size, or 0.2505 inch. The maximum major diameter is 0.2523, being greater than the minimum major diameter by an amount equal to the tolerance, namely, 0.0018 inch.

3. British Standard Automobile Threads

In a report submitted by the Sub-Committee on Automobile Threads, which was adopted by the Sectional Committee on Screw Threads and Limit Gages, and approved by the British Engineering Standards Association in 1911, the sizes of the British Standard Fine Screw Threads from 1/4 in. to 1 in., inclusive, as given under bolt dimensions in Table 4, were taken as standard for threads used in automobile construction.

4. Interchangeability of United States National Coarse and British Standard Whitworth Threads by Diameter Modification.

Table 9 shows that the diameters and pitches of the U.S. National Coarse Thread Series and the British Standard Whitworth Threads, in most cases, correspond. Consequently the question of interchangeability between them has caused considerable discussion, both in this country and in England. A method of securing interchangeability is based on a slight modification of the diameters of either the National or the Whitworth threads, or both, without changing the angle or thread form of either. Table 10 shows the modification of diameters of either of the systems necessary to produce assembly. Since the Whitworth thread angle is 5 deg. less than that of the National thread, contact occurs near the crest of the Whitworth thread and near the root of the National thread. Table 10 includes only those threads whose pitches are common to both systems.

Fig. 2 shows the two possible combinations of the Whitworth and National threads. The conditions of stress developed in the thread would be the same in either system as would ordinarly

The maximum screw is made to the basic size. For example, the maximum major diameter of a 1/4 inch U.S.S. screw is 0.2500 inch, and the minimum major diameter is equal to the maximum major diameter minus the tolerance. The tolerance is given in Table 4 as 0.0036 inch, hence, the minimum major diameter is 0.2464 inch.

All allowances to provide for clearance are in the nut, the minimum diameter of the nut being above basic size. As shown in Table 3, the minimum diameter of the nut being above basic size. As shown in Table 4, the minimum major diameter of a 1/4 inch nut is 0.0008 inch above basic size, or 0.2508 inch. The maximum major diameter is 0.2547, being greater than the minimum major diameter by an amount equal to the tolerance, namely, 0.0039 inch.

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Fig. 2 shows the two possible combinations of the Whitworth and National threads. The conditions of fitting according to the thread would be the same in either system as would otherwise occur with a slight difference in angle between bolt and nut.

Institute of Civil Engineers, 1841, Vol. 1, page 157.
British Engineering Standards Association Reports Nos.
20 - 1913. Screw Threads
38 - 1913. Standard Systems for Limit Gages for Screw Threads.
54 - 1911. British Standard Threads, Nuts, and Bolt Heads for use in Automobile Construction.
84 - 1918. British Standard Fine Screw Threads and their Tolerances.

III. BRITISH ASSOCIATION SCREW THREADS

In 1878 the Horological Section of the Geneva Society of Arts recommended a system of screw threads designed by Prof. M. Thury. This system was based on the measurement of well proportioned watch and small instrument screws in actual use in European countries. This thread has an angle of 47.5 degrees; is rounded at the crest to a radius equal to one-sixth of the pitch; and is rounded at the root to a radius of one-fifth of the pitch. The sizes were designated by consecutive numbers (n) the pitch (p) corresponding to any size number being given by the formula $p = 0.9^n$, and the outside diameter (D) corresponding to any pitch being given by the formula $D = 6\ p^{6/5}$.

In 1884 the British Association for the Advancement of Science recommended the use of the Thury system, with modifications, for all screws less than 1/4 inch in diameter. The thread form was modified to give an equal rounding at crest and root of approximately $\frac{3}{11}$ p. See Fig. 2. The British Engineering Standards Association in their Report No. 20 on British Standard Screw Threads give dimensions of British Association screw threads, including recommended clearances between crests and roots of threads, which are given in tables 11 and 12.

References:

Systematique des Vis Horologeries by M. Thury.
Reports of the British Association for the Advancement of Science, 1884 and 1900.
British Engineering Standards Association Report No. 20-1913. Screw Threads.

IV. BRITISH STANDARD PIPE THREADS

1. The British Standard Pipe Thread for Iron and Steel Tubes (B.S.P.) (Ditto) was adopted in 1905 by the Sectional Committee on Screw Threads and Limit Gages of the British Engineering Standards Association. It was approved by the Association in March 1905.

The Whitworth form of thread was adopted. Two classes of pipe threads were recognized by the Association, and are now in use, namely,-

Class I - the taper thread
Class II- the parallel (straight) thread.

Class I. The thread at the pipe end is tapered 1/16 inch per inch of length, the threads being perpendicular to the surface of the cone and pitch being measured parallel to the axis of the thread. The thread in the coupling may be either straight or tapered; ordinarily, a straight coupling and tapered pipe end are used. Taper couplings are used to secure exceptionally good fits.

Dimensions of Class I tapered threads are given in Table 13. All threads for iron and steel pipe and tubing purporting to be of British Standard Dimensions shall have the dimensions given in this table.

Class II. Straight pipe threads have the same diameters as the diameters of tapered threads at the gaging notch. (See Column 3, Table 13).

2. British Standard Thread for Steel Conduit. Two classes of steel conduit are recognized as standard:-

Class A - plain,
Class B - threaded.

Class "A" is a light gage conduit. The coupling joining the lengths of tubing is a sleeve and neither the ends of the conduit, nor the coupling joining the lengths are threaded.

Class "B" is a heavy gage conduit. Both ends of the conduit are threaded with the Whitworth form of thread as defined for British Standard Pipe Threads.

The length of thread on the ends of conduits, which shall be the same for binds, tees, junction,boxes and other threaded accessories, is given in Table 14, and is deduced by the formula,

$L = 1/2\ D + 3/8$ inches,
in which L = length of thread,
and D = outside diameter.

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Dimensions of Class I tapered threads are given in Table 12. All threads for iron and steel pipe and tubing purporting to be of British Standard Dimensions shall have the dimensions given in this table.

Class II. Straight pipe threads have the same diameters as the diameters of tapered threads at the gaging notch. (See Column 7, Table 12).

2. British Standard Thread for Steel Conduit. Two classes of steel conduit are recognized as standard:-

Class A - plain.
Class B - threaded.

Class "A" is a light gage conduit. The coupling joining the lengths of tubing is a sleeve and neither the ends of the conduit, nor the coupling joining the lengths are threaded.

Class "B" is a heavy gage conduit. Both ends of the conduit are threaded with the Whitworth form of thread as defined for British Standard Pipe Threads.

The length of thread on the ends of conduits, which shall be the same for bends, tees, junction boxes and other threaded accessories, is given in Table 14, and is deduced by the formula,

$L = 1/2\ D + 3/8$ inches,

in which L = length of thread,
and D = outside diameter.

British Standard Dimensions of both Class "A" and Class "B" steel conduit are given in Table 14.

3. British Standard Dimensions for Copper Tubes and Their Screw Threads. The report of the Sub-Committee on Metal Tubes and Connections on Standard Specifications for copper tubes and their screw threads was adopted by the Sectional Committee on Screw Threads and Limit Gages, and was approved by the British Engineering Standards Association, in March 1913. For the heavier gage tubes the British Standard Pipe Threads, as given in Tables 13 and 16, were adopted, and for the lighter gage tubes the dimensions given in Table 15 were adopted, the Whitworth form of thread being used.

4. Gaging British Standard Pipe Threads. In order to insure correct gaging, it is necessary to define the position of the gage diameter on the pipe end and in the coupling. Fig. 4 is a drawing of one plug and ring gages which give satisfactory results. Instead of dimensions being given on the drawing, reference is made to column numbers of Table 13. By referring to the table, dimensions may be found for gaging any size of thread.

The distances between the surfaces A and B of the ring gages, for any given size, is the difference between values given in columns 10 and 11. The gage, having a plain conical surface, is slipped over the end of the pipe, and, when pressed on by hand, the pipe end must protrude beyond surface B. On the plug gage surfaces C and D correspond to surfaces A and B on the ring. The plug must enter beyond C, but surface D must remain outside.

References:

British Engineering Standards Association Reports
Nos. 21-1909. Pipe Threads for Iron or Steel Pipes and Tubes.
31-1910. Steel Conduits for Electrical Wiring
61-1913. Copper Tubes and Their Screw Threads.

British Standard Dimensions of [illegible] Class 'A' and Class 'B' [illegible] results are given in Table 15.

3. British Standard Dimensions for Copper Tubes and Light Gauge Tubes. The results of the [illegible] conducted [illegible] and [illegible] on Standard Dimensions for the copper tubes and light gauge tubes was [illegible] of the British Standards [illegible] for copper tubes and light gauge, and was [illegible] by the British Engineering Standards Association, [illegible]. For [illegible] the British Standard [illegible] Tubes, is given in Tables 13 and 14, each [illegible], and for the lighter gauge tubes the dimensions given in Table 16 [illegible] the [illegible] form of [illegible] being made.

4. [illegible] British Standard Pipe Threads. In order to insure correct jointing, it is necessary to define the position of the gauge diameter on the pipe and also in the coupling. Fig. 4 is a drawing of the pipe and ring gauge which give satisfactory results. Details of dimensions being given on the drawing, reference is made to column numbers of Table 17. By referring to the table, dimensions may be found for gauging any size of thread.

The drawings present the [illegible] of [illegible] gauge, for the pipe sizes, in the dimensions given in columns 10 and 11. The gauge, during a [illegible] position, is [illegible] over the end of the pipe, [illegible] on by hand, the pipe end must [illegible] between surfaces [illegible]. On the pipe [illegible] surfaces [illegible] on the ring gauge. [illegible]

References:

British Engineering Standards Association Reports
No. 21, 1938. Pipe Threads for Iron or Steel Pipes and Tubes.
No. 61-1947. [illegible]
No. 61-1947. [illegible]

V. BRITISH STANDARD BOLT HEADS, NUTS, AND SCREW HEADS.

1. British Standard Bolt Heads and Nuts.

Standard dimensions for hexagonal bright nuts and bright bolt heads; black nuts, black lock nuts, and black bolt heads; spanners; and castle nuts which were adopted by the Sectional Committee on Screw Threads and Limit Gages, and approved by the British Engineering Standards Association in 1906 are given in Tables 17, 18, and 19.

2. British Standard Automobile Bolt Heads and Nuts.

Standard dimensions for nuts and bolt heads used in automobile construction as given in Table 20 were submitted by the Sub-Committee on Automobile Threads, adopted by the Sectional Committee on Screw Threads and Limit Gages, and approved by the British Engineering Standards Association in 1911.

3. British Standard Heads for British Association Screws.

The proportions of heads for small screws, namely,- countersunk, instrument, round, cheese, filister, capstan, connection, and hexagon, for sizes 0 to 15 ("British Association" designating numbers) were established by the Sectional Committee on Machine Parts, their Gaging and Nomenclature, and approved on behalf of the British Engineering Standards Association in 1920. The sizes standardized range from 6 mm to 0.9 mm (0.236 in. to 0.035 in.) The smaller sizes not being in general use, except in special cases, were not standardized. See Tables 21-24, inclusive.

References:

British Engineering Standards Association Reports Nos.
28-1908. Nuts, Bolt Heads, and Spanners.
54-1911. Screw Threads, Nuts, and Bolt Heads for use in Automobile Construction.
57-1920. Heads for British Association Screws.

VI. INTERNATIONAL METRIC SCREW THREAD STANDARD.

The International Screw Thread Standard (S. I.) was adopted by a congress representing principal continental countries at Zurich in 1898. The system proposed was based on the French Metric Screw Thread System as adopted by the Societe d'Encouragement de l'Industrie Nationale in 1894. The principal difference between the two systems is in the pitch of three screws 8, 9 and 12 mm; the French system specifying 1, 1, and 1.5 mm pitch respectively while the International gives 1.25, 1.25, and 1.75 mm. The International form of thread has a 60° angle and the crest of thread is flattened 1/8th the height of the basic triangle while the root is filled in 1/16 the height, either flat or rounded, as shown in Fig. 14. This gives a definite clearance between the tops and bottoms of the threads of screw and nut. The actual form at the root is left to the choice of the manufacturer.

The dimensions of the International Screw Thread System are given in Table 25. The sizes from 6 mm to 80 mm, inclusive, were standardized at the Congress of Zurich, and those above 80 mm were added by the Societe de Encouragement pour l'Industrie Nationale of France. No tables of allowances and tolerances for this thread series are available. A chart showing a comparison of the pitches and diameters of the International with the U. S. National Coarse and Fine Thread Series is given in Fig. 15.

References:

Bulletin Soc. d'Encouragement l'Industrie Nationale, Mar. 1899 and Sept.-Oct. 1919.

Protokoll International Commission, 1898 (Druck von F. Lehbauer)

VII. SCREW THREAD STANDARDS IN USE IN FRANCE

The International form of thread (Fig. 13) is the standard form for screw threads used in France. The diameters and pitches of the International System are most widely used for those sizes which fall within the range of this series. The Societe d'Encouragement pour l'Industrie Nationale has supplemented the International series by introducing sizes between 12 mm and 40 mm so that the series advances by 1 mm steps throughout this range. The interpolated diameters have, in each case, the same pitch as the next larger diameter in the Congress of Zurich series. See Table 26.

A small machine screw series (Serie de la Petite Mecanique) below the International series, from 2.5 to 5.5 mm inclusive, Tables 26 and 27, were addedbby the Societe d'Encouragement in 1906, and the small watchmakers' screws (Systeme Horolgere), Table 27, were standardized by the same body in 1909.

The various commercial interests recognize selected sizes, given in Table 26, of the International and Societe d'Encouragement series, with the following exceptions and additions:

1. The Establissements Schneider et Cie add a size having a diameter of 106 mm and a pitch of 8.5 mm.

2. In the series of the Chambre Syndicale des Constructeurs d'Automobiles, the sizes 0.3 mm and 0.5 mm have the pitches 0.5 mm and 0.75 mm respectively, and are, therefore, not interchangeable with the corresponding sizes of the "Serie de la Petite Mecanique". The same is true of the 5 mm size in the series of the Chambre Syndicale des Industries Aeronautiques.

There are also variations in practice as to the form of thread at crest and root. The Societe d'Encouragement does not specify a clearance at the major and minor diameters of screw and nut, and the Syndicale des Constructeurs d'Automobiles do not round the profile at the root. Neither of these modifications, however, prevent interchangeability with S. I. threads.

No tables of allowances and tolerances are available except those for the Aircraft Threads given in Tables 28 and 29. These tolerances were suggested by the British Engineering Standards Association at the request of the Naval and Military Air Service.

References:

Bulletin Soc. d'Encouragement l'Industrie Nationale, Sept.-Oct. 1919.

VIII. STANDARD DIMENSIONS OF BOLT HEADS, NUTS, AND SCREW HEADS IN USE IN FRANCE

The commercial practice in France as to dimensions of bolt heads, nuts, and screw heads, varies among the various industrial organizations. The standard practice of each organization is given separately for each element in Tables, 30, 31, 32 . This information was taken from two numbers of the Bulletin of the Societe d'Encouragement pour l'Industrie Nationale, September - October 1919 and April 1921. The wrench openings specified by the Congress of Zurich, all dimensions specified by L'Union des Syndicats d'Electricite, the depth of slot of circular heads, and the angle of countersunk heads were copied directly from tables published in the Bulletin. The remainder of the dimensions given in the tables herein were computed from the formulas published in the Bulletin.

1. Width Across Flats or Diameters of Bolt Heads, Nuts, and Screw Heads (Table 30)

Congress of Zurich. The Congress of Zurich did not fix the sizes of heads as such but specified a wrench opening for every diameter of the International Standard Series, determined by the formula 1.4 D + 4 mm, in which D is the diameter of body in millimeters. These wrench openings thus determine the widths across flats of both hexagon and square heads and nuts.

Societe d'Encouragement pour l'Industrie Nationale. For hexagon heads and nuts of the small machine screw series, a diameter across corners of 2 D is recommended, that is, 1.732 D is the width across flats. For circular heads a diameter of 2 D is recommended.

Establissements Schneider et Cie. The widths across flats of hexagon and square heads, and hexagon nuts are the same as the wrench openings specified by the Congress of Zurich, that is, 1.4 D + 4 mm. The diameters of circular heads are the same as the widths across flats of the corresponding hexagon heads.

Chambre Syndicale des Constructeurs d'Automobiles. The widths across flats of square and hexagon heads are determined by the width of a hexagon inscribed in a circle whose diameter is 2 D (that is, 1.732 D), in which D is the diameter of body of the next smaller size in the series. More than half of the sizes thus determined do not fit the wrench sizes specified by the Congress of Zurich.

The diameters of circular heads are not listed in Table 30, since they are permitted to vary from 1.8 D to 2 D for cylindrical and countersunk heads. Round heads are somewhat smaller.

The widths across flats of hexagon nuts is 1.732 D, D being the diameter of the body of the bolt. The nuts are, thus, larger than the corresponding bolt heads/

Union des Syndicats d'Electricite. For sizes from 2.5 to 7 mm the widths across flats for square and hexagon heads and nuts are equal to the diameter of the body four steps larger in the series. For sizes from 8 to 12 mm. the widths across flats are 1.4 D" + 4 mm., d" being the diameter of body of two steps smaller in the series. Thus the same widths across flats, or wrench openings are used as those specified by the Congress of Zurich, but are associated with different sizes of bolts or screws.

For circular heads, whether rounded, cylindrical or countersunk, the diameters are equal to the diameter d' of the bolt four steps larger in the series. The diameters of circular heads agree, therefore, with those of the body diameters of bolts and screws, thus reducing the necessary number of sizes of bar stock.

2. Height of Bolt and Screw Heads and Thickness of Nuts (Tables 31 and 32)

Congress of Zurich. The Congress of Zurich recommended a height of 0.7 D for squareaand hexagon bolt and screw heads, and a thickness equal to D for nuts, D being the major diameter of the thread.

Societe d'Encouragement pour l'Industrie Nationale. The height of heads, whether hexagonal or circular, and also the thickness of nuts, is equal to the diameter of thread, D.

Establissements Schneider et Cie. The height of hexagonal or cylindrical heads is approximately 0.7 D. Two different thicknesses of nuts are provided, - thick nuts whose thickness is equal to D, and lock nuts of a thickness equal to 0.7 D.

Chambre Indicale des Constructeurs d'Automobiles. The heights of heads approved by this association vary considerably. For hexagonal or square heads, the height is about 2/3 D. The thicknesses of nuts are equal to D, and of lock-nuts, 2/3 D.

L'Union des Syndicats d'Electricite. The heights of heads for corresponding sizes are the same for hexagonal, cylindrical, and rounded forms, and are equal to 0.7 D. The height of the conical portion of a countersunk head is determined by the cone-angle, 84°, and the diameter of the head. It is equal to 1.555 times the difference between the diameters of the head and body.

The dimensions of circular heads are not listed in Table 20, since they are permitted to vary from 1.8 D to 2 D for cylindrical and countersunk heads. Round heads are somewhat smaller.

The width across flats of hexagon nuts is 1.732 D, D being the diameter of the body of the bolt. The nuts are, thus, larger than the corresponding bolt heads.

Union des Syndicats d'Electricite. Nut sizes from 1.4 to 7 mm, the widths across flats for square and hexagon heads and nuts are equal to the diameter of the body four sizes larger in the series. For sizes from 8 to 18 mm. the widths across flats are 1.4 D" + 4 mm., D" being the diameter of body of two sizes smaller in the series. Thus the same widths across flats, or wrench openings are used as those specified by the Congress of Zurich, but are associated with different sizes of bolts or screws.

For circular heads, whether rounded, cylindrical or countersunk, the diameters are equal to the diameter D' of the bolt four sizes larger in the series. The diameters of circular heads are, therefore, also those of the body diameters of bolts and screws, thus reducing the necessary number of sizes of bar stock.

3. Height of Bolt and Screw Heads and Thickness of Nuts (Tables 21 and 22)

Congress of Zurich. The Congress of Zurich recommended a height of 0.7 D for square-and hexagon bolt and screw heads, and a thickness equal to D for nuts, D being the major diameter of the thread.

Société d'Encouragement pour l'Industrie Nationale. The height of heads, whether hexagonal or circular, and also the thickness of nuts, is equal to the diameter of thread, D.

Etablissements Schneider et Cie. The height of hexagonal or cylindrical heads is approximately 0.7 D. Two different thicknesses of nuts are provided, - thick nuts whose thickness is equal to D, and lock nuts of a thickness equal to 0.7 D.

Chambre Syndicale des Constructeurs d'Automobiles. The heights of heads approved by this association vary considerably. For hexagonal or square heads, the height is about 0.7 D. The thicknesses of nuts are equal to D, and of lock-nuts, 0.5 D.

Union des Syndicats d'Electricite. The heights of heads for corresponding sizes are the same for hexagonal, cylindrical and rounded forms, and are equal to 0.7 D. The height of the conical portion of a countersunk head is determined by the cone-angle, 90°, and the diameter of the head. It is equal to 1.249 times the difference between the diameters of the head and body.

A cylindrical portion surmounts the cone, its height being equal to one-half the pitch of the thread. The total height of the flat countersunk head is equal to the sum of the heights of these two portions. If the head is convex, the height of the rounded portion is added to this height.

Two thicknesses of nuts are provided, both of which apply to either square or hexagonal nuts. For thick nuts, the thickness is equal to the diameter of body, D, two steps smaller in the series. The thickness of thin nuts is equal to 2/3 that of the thick nuts.

3. Dimensions of Slots in Screw Heads (Table 33)

Neither the Congress of Zurich nor the Societe d'Encouragement have specified the dimensions of slots in circular screw heads.

Establissements Schneider et Cie. The width of slot is specified for screws from 6 mm to 18 mm in diameter. The depth of slot varies for different types of head between the limits indicated in Table 33.

Chambre Syndicale des Constructeurs d'Automobiles. The width of slot is specified for screws from 3 mm to 30 mm in diameter. The depth of slot varies for different types of head between the limits indicated in Table 33.

Union des Syndicats d'Electricite. The width of slot is the same for corresponding sizes of all forms of heads. The depth of slot is the same for cylindrical and rounded heads, and is equal to 1/3 the height of the head. For countersunk heads the depth of slot is equal to one-half the total height of head.

4. Length Below Head and Length of Threaded Portion of Bolts and Screws. (Tables 34 and 35)

Establissements Schneider et Cie. There are twenty-nine lengths of bolts, studs, and screws listed in Column 1 of Table 34, which are obtained by adding to the minimum length of 10 mm the successive increments listed in Column 3, which are also used in determining threaded lengths.

The length of threading is such that if the screw, stud, or bolt were cut down to the next shorter length in the series, the threaded part would still remain long enough to take a nut. The formula applied is

$$F = D + 3/2\ R,$$

in which F = length of threaded part,
D = diameter of thread,
and R = difference in length between the bolt and the next shorter one in the series.

A cylindrical portion surmounts the cone, its height being equal to one-half the pitch of the thread. The total height of the flat countersunk head is equal to the sum of the heights of these two portions. If the head is curved, the height of the rounded portion is added to this height.

Two thicknesses of nuts are specified, each of which may be either square or hexagonal nuts. For thick nuts, the thickness is equal to the diameter of body, D, two steps smaller in the series. The thickness of thin nuts is equal to 2/3 that of the thick nuts.

3. Dimensions of Slots in Screw Heads (Table 43)

Neither the Congress of Munich nor the Societe d'Encouragement have specified the dimensions of slots in circular screw heads.

Schweizerische Normalien of Ges. The width of slot is specified for screws from 2 mm to 25 mm in diameter. The depth of slot varies for different types of head between the limits indicated in Table 43.

Association Francaise des Constructeurs d'Automobiles. The width of slot is specified for screws from 3 mm to 30 mm in diameter. The depth of slot varies for different types of head between the limits indicated in Table 43.

Union des Syndicats d'Electricite. The width of slot is the same for corresponding sizes of all types of heads. The depth of slot is the same for cylindrical and rounded heads, and is equal to 1/3 the height of the head. For countersunk heads the depth of slot is equal to one-half the total height of head.

4. Length Under Head and Length of Threaded Portion of Bolts and Screws. (Tables 44 and 45)

Schweizerische Normalien of Ges. There are twenty-nine lengths of bolts, studs, and screws listed in Column 1 of Table 44, which are obtained by adding to the minimum length of 10 mm the successive increments listed in Column 2, which are also used in determining threaded lengths.

The length of threading is such that if the screw, stud, or bolt were cut down to the next shortest length in the series, the threaded part would still remain long enough to take a nut. The formula applied is

$$l = \Delta + 3/2\, D,$$

in which l = length of threaded part,
D = diameter of thread,
and Δ = difference in length between the bolt and the next shorter one in the series.

When the threaded part must also carry a locknut, the threaded length is increased by the thickness of the locknut and becomes,

$$F' = F + 0.7\ D = 1.7\ D + 3/2\ R.$$

Chambre Syndicale des Constructeurs d'Automobiles. The total lengths below heads are graduated as follows:

by 5 mm	steps	between	10 mm	and	100 mm,
" 10 "	"	"	100 "	"	200 "
" 50 "	"	"	200 "	"	300 "

Thus there are 30 different lengths from 10 mm to 300 mm.

Threads to take nut and locknut have a length equal to 2 d, and for nut and washer equal to 1.5 d, d being the diameter of the next smaller (in diameter) bolt in the series. For sizes up to and including 12 mm this length is increased by 2 mm. This is not sufficient, in all cases, to permit a bolt cut down to the next shorter length to take a nut.

Union des Syndicats d'Electricite. The minimum lengths below head for each diameter of screw are given in Table 35. The series of lengths above these minima corresponds to the series obtained by adding successively and cumulatively to the base 4 mm the natural series of numbers 1, 2, 3, 4, 5, etc. giving the lengths given in Column 7, Table 34. These values serve only as a suggestion and are those recognized by Establissements Schneider et Cie, and Chemius de fer Francais.

5. Angles of Countersunk Heads.

The Congress of Zurich made no recommendation in regard to the cone angle of countersunk heads. The angles specified by other organizations are as follows:

Societe d'Encouragement,	84 degrees,
Schneider et Cie,	84 "
Constructeurs d'Automobiles,	90 "
Syndicates d'Electricite,	84 "

IX. THE LOEWENHERZ SCREW THREAD SYSTEM AND STANDARD INSTRUMENT AND MACHINE SCREWS

The Lowenherz Screw Thread System and Screw Heads. The Verein Deutscher Ingenieure in 1888 adopted a system of metric screw threads for sizes from 6 mm to 40 mm diameter inclusive. The thread form selected, shown in Fig. 15, has an angle of 53° 8' and is flattened at top and bottom 1/8th the height of the basic triangle. The angle 53° 8' gives a triangle whose height is equal to its base, therefore, the depth of thread is 3/4 of the pitch.

In December 1893 a commission representing German instrument makers, technical socities, and government departments, adopted a system of threads ranging in diameter from 1 mm to 10 mm and especially intended for use in small machines and instruments. The same form of thread is employed as in the earlier system and the overlapping sizes 6 mm to 10 mm are identical. The system was called the Loewenherz System after Dr. Leopold Loewenherz, at one time Director of the Physicalisch-Technische Reichsanstalt. The dimensions of the Lowenherz Screw Thread System are given in Table 36.

At the same time standard proportions for instrument and machine screws for sizes from 1.0 to 10.0 mm were adopted by the commission, which are given in Table 37.

References:

Zeitschrift Verein Deutcher Ingeneure, 1888,
Zeitschrift fur Instrumentkunde, February 1893, pages 41-58; June 1893, pages 246-249; and August 1894, pages 285-291.