

MECHANICAL DRAWING DIRECTLY COUPLED TO PRODUCTION

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0. Introduction

The drawing standards of JIS¹⁾ were revised on September 1, last year. The fundamental principle underlying the revision was, on one hand, to positively introduce three standards²⁾ concerning the drawing in ISO³⁾, but on the other hand as to those regulations which are not very convincing, or if, compared with correspondent regulations in ISO, those of JIS can be considered better applicable, to keep these JIS regulations as more practical and make appeal to introduce these into ISO.

Measures to enforce the principal projection and the uniqueness of the imaginary line

1. Enforcement of the principal projection

For the enforcement of the principal projection, there are such measures as rationalization of imaginary representation of imaginary sections, utilization of auxiliary projections, and the right position of special parts, but here I will consider the following two points.

1. Rationalization of imaginary sections
2. Rationalization of imaginary representation

1. 1 Rationalization of imaginary sections

There is on need to declare that representation of imaginary section is only an auxiliary method to enforce the principal projection. Therefore this plays an auxiliary role when the principal projection cannot fully represent the body concerned, and is utilized to make the principal projection easier to understand by adding partial description. Such being the case, the representation of the principal projection may sometimes be enfeebled, and become difficult to understand. But as the imaginary sections should, in principle, play an auxiliary role, and the standard procedures for drawing being firmly established, representation of imaginary sections is possible and its power exhibited. So, though it has an ability of various effectual representation, it should not be given the responsibility that should be accorded to the principal projection. If it is given such responsibility, it loses its proper meaning at that point. In its use, discretion must be used so that it be limited within its proper sphere, and can exhibit its force

to its utmost extent.

In the illustration given here, for example, the position of the imaginary section is described as being on the same side with that of the regular section, so the imaginary section is too much emphasized as to enfeeble the principal projection. This is to compel an unreasonable representation. The example given on the right shows a balanced and steady representation. To use the contour line for imaginary section will also obstruct natural understanding. That is an example in a foreign country.⁴⁾ JIS uses one dot or two dot chain lines.

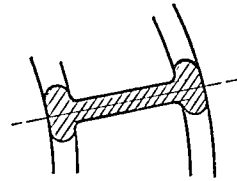


Fig 1

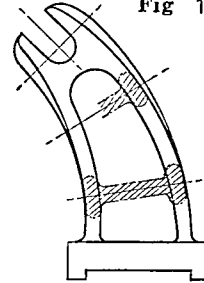


Fig 2

1. 1. A. Unevenness of the surface

The depth of unevenness of the surface is very clearly shown by using an imaginary section. It shows the concave more exactly than the section represented by the regular center line.

1. 1. B. Tube-cutting (key way, arm, tube-cutting)

The depth of the principal projection of a shaft is usually shown by a section, but this will be better done and more directly by means of an imaginary section, and it will make the drawing easier to understand. To give an example of a shaft, take the imaginary cutting line, in relation to the principal projection, at the point on the principal center line where sectioning is intended. This cutting center line is to be the standard line for the imaginary section, and it becomes the center of the section in a symmetrical section (or center of the drawing or

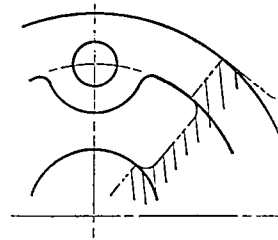


Fig 3

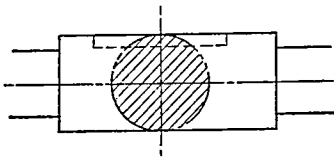


Fig 4

center of gravitation), and in an unsymmetrical section, it is the crossing line of the principal surface and the sectional surface. In such a case, representation of the cutting line is omitted.

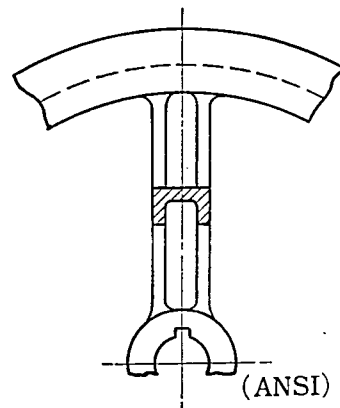


Fig 5

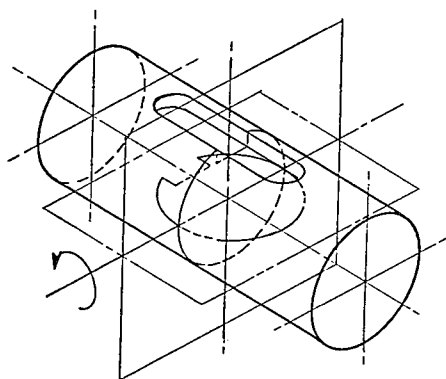


Fig 6

in which the principle of third angle system is not applied. In drawing and descriptive geometry, such an example as Fig. 8 is found. The place to be used to get the projected representation can be the second or the fourth quadrant. But this will not do in practical drawings. The drawing must always be seen from the right-hand side. The section in a long body is often represented as an in-between section as in Fig. 9 A, but it will be better understood if shown as an imaginary section as in Fig. 9 B.

To give an example of a hook attached to a crane, the treatment is the same with such a body whose principal center line is not a straight line, as is shown by the illustration. After determining each of the sectioning lines along the principal center line which is shown by a curve, if you revolve the sections by 90° and describe the shape, the changing aspect of the shape of sections is shown in succession, and it will facilitate understanding.

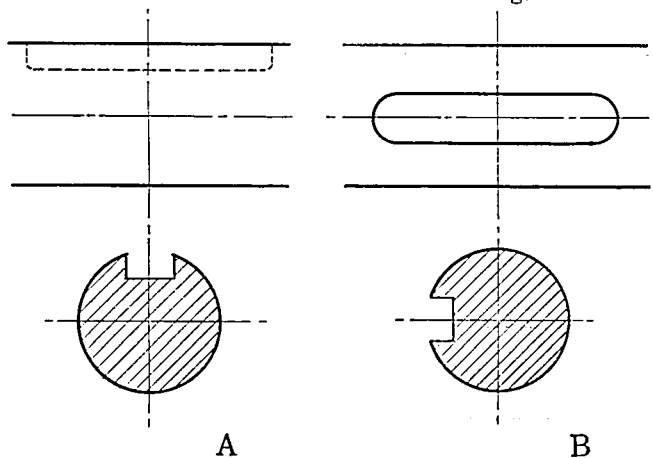
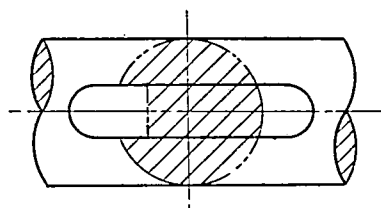
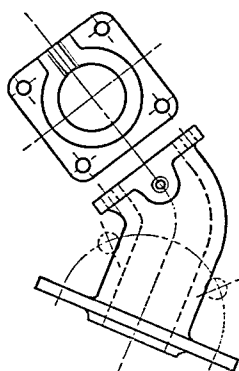


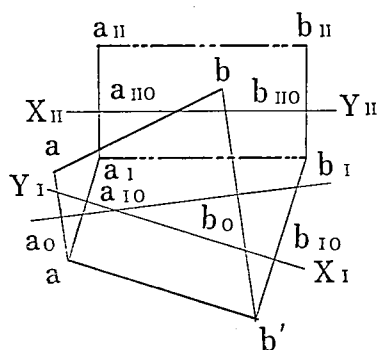
Fig 7



The direction of rotation is symmetrical in Fig. 7-A, so the rotation in either way presents no problem, but in Fig. 7-B the position of the key way is different. Therefore the direction of rotation of the section must be shown. But this must be limited to the cases



drawing (DIN)



descriptive geometry

Fig 8

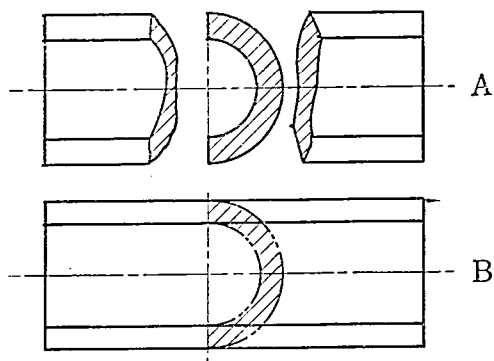


Fig 9

of sectional representation to an arm, the result is as follows.

As to the body to be planed, refer to BOOO1⁵⁹-Fig.10 of JIS, which so describes the working surface, taking the longitudinal direction horizontally, that it becomes the principal projection. In case of a simple drawing, an imaginary section is easier to understand.

When it is impossible to indicate the depth by an imaginary section, give an auxiliary projection on the right; when this is also insufficient, give a second projection. If you apply the regulations

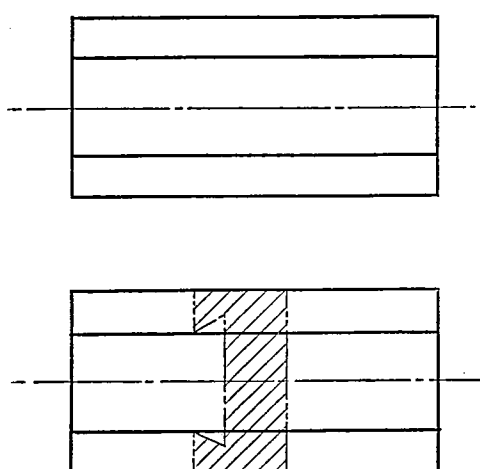


Fig 10

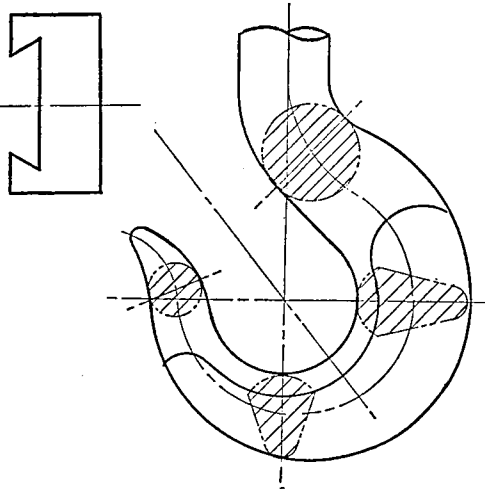
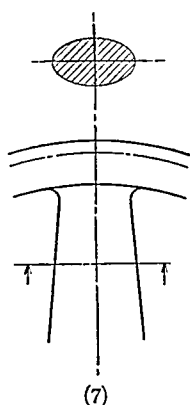
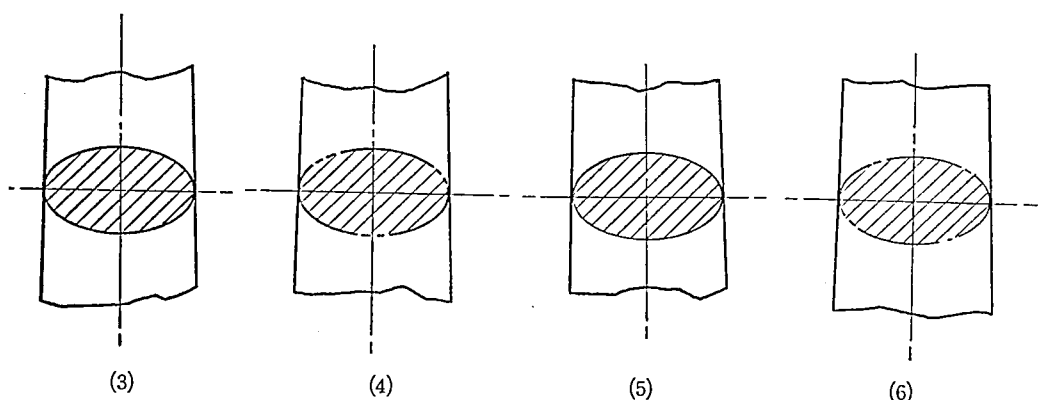
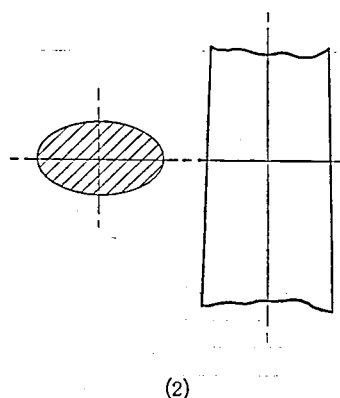
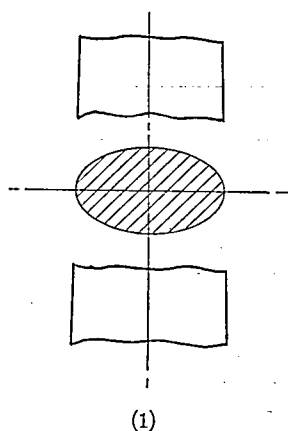


Fig 11



- | | |
|-----|--|
| (1) | In-between section (revolved section) |
| (2) | Drawn-out section (removed section, auxiliary section) |
| (3) | Revolved section (A) The visible line is used. |
| (4) | " " (B) Two dot chain line is used. |
| (5) | " " (C) Thin line is used. |
| (6) | " " (D) One dot chain line is used. |
| (7) | " " |

2. Uniqueness of imaginary representation

Imaginary representation is a graphic description of imaginary conditions, and the line used in this case is called an imaginary line. JIS before revision authorized three kinds of lines, that is, one-dot chain line, two-dot chain line, and thin solid line. In revising the standards, JIS abolished, to simplify the kinds of lines, the use of thin solid line, the line indicating the adjacent part in ISO, for the imaginary line.

The following is the table of lines now in use in main countries in the world.

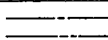
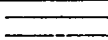
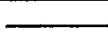
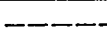
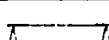
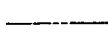
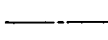

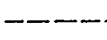
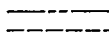
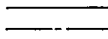
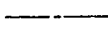
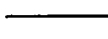

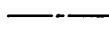
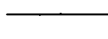
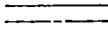

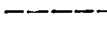
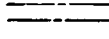
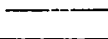
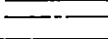
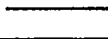
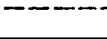
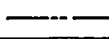
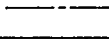
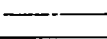
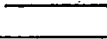
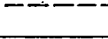
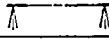
	[phantom fictitious outline]		(contour line)		
	imaginary line	center line	visible outline	hidden outline	cutting plane line
JIS					
ANSI ⁶⁾					
BSI ⁷⁾					
DIN ⁸⁾					
CSA ⁹⁾					
ISO					

table 1

As may be easily understtd, the visible line, the center line and the hidden line have traditionally been in stable use in the standards of various countries. But as to the use of other kinds of lines, at the present time, regulations differ. But when the object of using a certain kind of line is quite clear and can be distinguished from others, uniqueness of the line should be asserted.

It was in the provisional JES 428¹⁰⁾ that the two dot chain line was firstprescribed formally in this country. After that, in JIS Z8302, next in BOOO1 it was taken up in succession and was in use for a long time, and as it was very convenient, the scope of its application was extended.

However, in the recent revision of BOOO1, though it has been retained because it is still partly used, the tendency seems to favour the practice of ISO which uses one dot chain line.

The drawing practice, and broadly speaking, the whole industrial practice in this country was introduced from Europe and America, and formerly German and English methods were adopted and had been intermixed through a long period of time. After the War, with multi-phasic contact with the U. S. A. in addition to the development of the means of communication and transportaion, international influence became deeper and more extensive.

In Japan, there is, as is self-evident, no traditional and limited frame of scope as is the case in foreign countries. Various regulations exist side by side without strict unity among them, causing sometimes much inconvenience. But relatively speaking, it has its advantageous aspect that this this enables the choice and utilization of the merits of various regulations.

Just as the method used in this country for describing the projection has had a historical process that it was first introduced from Europe and then American

method has gradually taken its place, the imaginary representation is rather of late origin but has widely been used.

At present, U. S. A., Canada and Japan prescribe the use of two dot chain line in their regulations, but the way it is used is not the same among these countries.

2. 1. Thickness of lines

There is an inevitable limitation for prescribing the thickness of lines according to the use so as to facilitate reading of the drawing. In some country, the thickness of lines is strictly prescribed, but in most countries, it is relatively prescribed as thick, medium thick and thin. DIN prescribes the ratio of thickness as $1:\sqrt{2}:2$. This will be the utmost that can be expected in distinguishing the thickness of one line from that of another. This means that there are three kinds of lines and three kinds of thickness to be used for description, but, in fact, it seems not the practice to distinguish the thickness of lines very closely according to their uses.

The thick line is used for the contour line and partly for the sectioning line, the medium thick line only for the hidden line and for one other case, and for all other parts the thin line is used. DIN allows to use the thick line to show the hidden line. This means that there are only two kinds of thickness of lines for drawing. JIS maintains that this fact makes the difference of thickness very clear and contributes to labor-saving. If the kinds of thickness are limited to two, they are forced to perform various service, and it is doubtful whether this contributes to labor-saving.

2. 2. Problems of two dot chain line (alternate long and two short dashes line)

What is disadvantageous with the two dot chain line seems to be that it takes more time to draw, difficult to draw into a narrow space and is not easy to tell from the hidden line.

To begin with, I will show a table to explain the relation between the kinds of lines used in drawing and the time used in drawing them, and compare the both.

This table shows the results of measuring, with a stopwatch, the time required to draw each of the various kinds of lines by about 100 sophomores. It gives a value which has been preestimated, but it does not seem there is any remarkable difference in the time required between one dot and two dot line.

The following is a table which shows the comparative relation of MTM¹¹⁾ value, length of line and the time measured.

This table also shows that the two dot chain line takes much time, but it is less than the MTM preestimated value.

The above is a consideration from the standpoint of drawing, but from the standpoint of the worker (the worker who performs machining), what is important is the legibility of the drawing. In practice, the latter standpoint should have the preference.

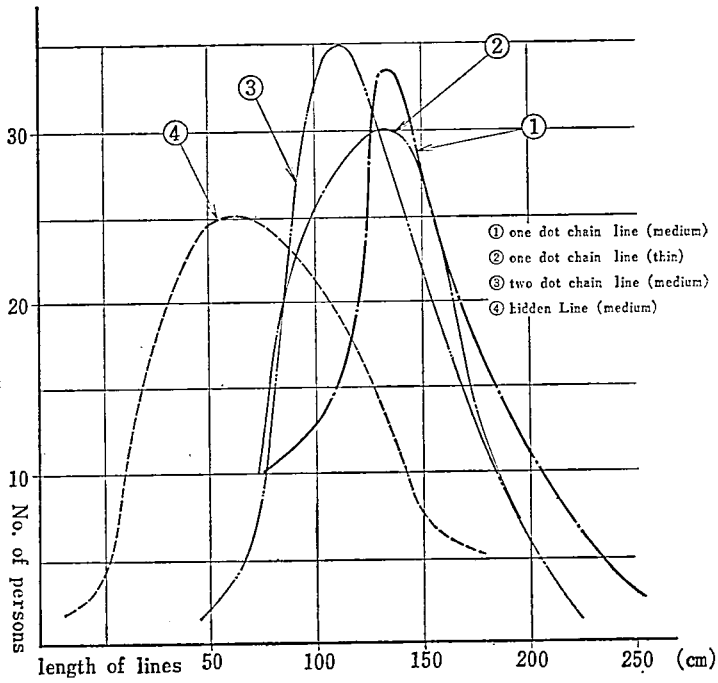
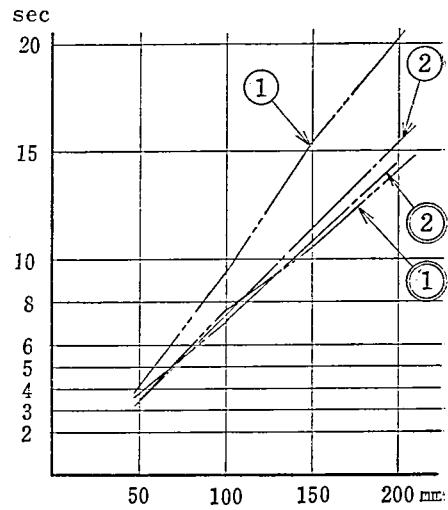
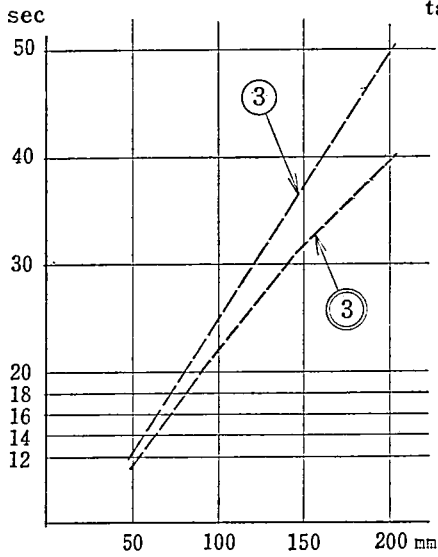


table 2



Hidden lines

① } measured
 ② } mean
 ③ } values

Centre lines
Imaginary lines

① } estimate
 ② } MTM value
 ③ }

table 3 Centre lines Imaginary lines

If what is desired of a good drawing is accuracy and legibility, even if it takes a slightly more time to use the two dot chain line, it ought to be used.

In dealing with a narrow portion, we should avoid too complicated a description and show it on an enlarged scale as a detail drawing. The kinds of lines do not seem to matter.

2. 3. Uniqueness of lines

Uniqueness of lines does not mean a very difficult thing. It means the specificity of each of the lines now in use. That is to say, the contour line must be a distinct, thick and continuous line; it is the same with the center line and the hidden line. For example, DIN allows the hidden line to be as thick as the contour line, but this makes the drawing unstable and difficult to read, and the speciality of the hidden line will be lost. This means that the standpoints both of the draftsman and the worker (reader of the drawing) should be taken into consideration and the choice of lines should be made within a certain limit, in accordance to the demand of human engineering.

2. 4. Practical application of imaginary line

1) In the case in which it is required to show the portion this side of the standard section of a body which is shown in sectional representation. In this case, the projection of the section is described as being in the condition that the body is cut at the section and the portion this side of the section is

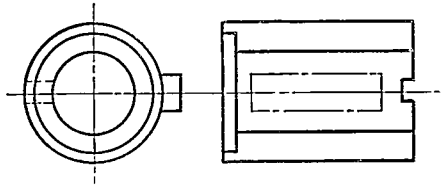


Fig 13

(JIS B0001 Fig 3)

taken away, so that the portion taken away cannot be shown on the sectional view. But it is sometimes useful to show even only a part of what has been taken away. In describing this part, the imaginary line must be used, on other lines being inadequate.

2) Description of other than the main object of description By describing what is not the main object of description, the object of description is more effectively obtained on some occasion.

(1) When the article described is a part of the main body to which it is to be fixed.

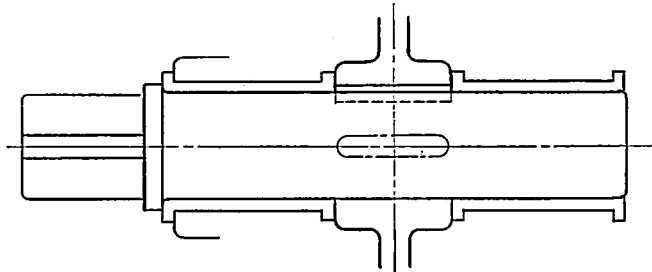


Fig 14

(H, Yamanaka Fig 2. 54)¹²⁾

(2) A part to be fixed to the part described (an appanage) A body is always described on the drawing independently, but when it is useful to show the mate in assembling, this part should be described. In most cases of joining bearings and gears, and of insertion, it will be useful to show the adjoining parts.

In some cases, the adjoining parts are described in thin, solid lines, but as dimensions are entered on a working drawing, it will make the drawing complicated and liable to be misread. So it is better to avoid it

3) Supplementing the shape which is necessary for working

(1) The shape described on the drawing represents, as a rule, that of the body after working. But is sometimes necessary to show the shape before working.

(2) Case in which the shape after the first working is given, but the shape after a secondary working is also required.

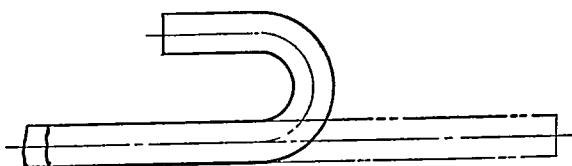


Fig 15
(T. SEIKE Fig 351dV)

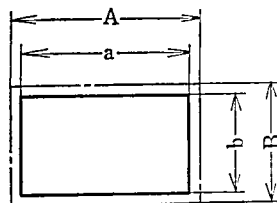


Fig 16
(T. FUKUNAGA Fig 5. 6)

(3) Case in which special working is required on a part of the body shown on the drawing.

This case abounds in such working as plate work, pipe work, etc. The finishing allowance that should be indicated, the core print of wood pattern preferably to be specifically described, and the rib to be attached to steelcastings to prevent strain, all these belong to this category. This also applies to some high-frequency hardening, cementation hardening, plating or when a part of finishing is different from the rest, and so on.

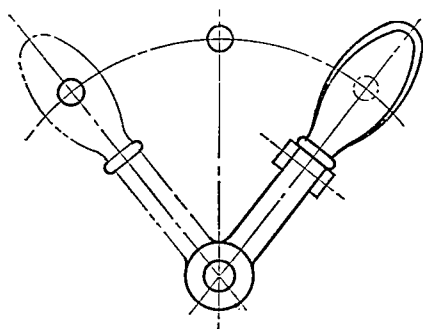


Fig 17
(T. SEIKE Fig 351, dv)

4) Method to express motion on the drawing

This is already in general use as may be witnessed, for example, in the case of indicating the extent of movement of a lever in the assembly drawing so as to show its motion. The actual shape should be described with the contour line, but in other descriptions including the description of the limit position of a movement, the imaginary line should be used.

JIS and ISO prescribe one dot chain line

for this use, but as this is te with the center line, it is sometimes difficult to make difference between the two.

5) In case of partial imaginative projection

This appears in DIN, VSM¹³⁾ and other standards of several countries. JIS B0001 Fig. 99 can be elucidated as follows.

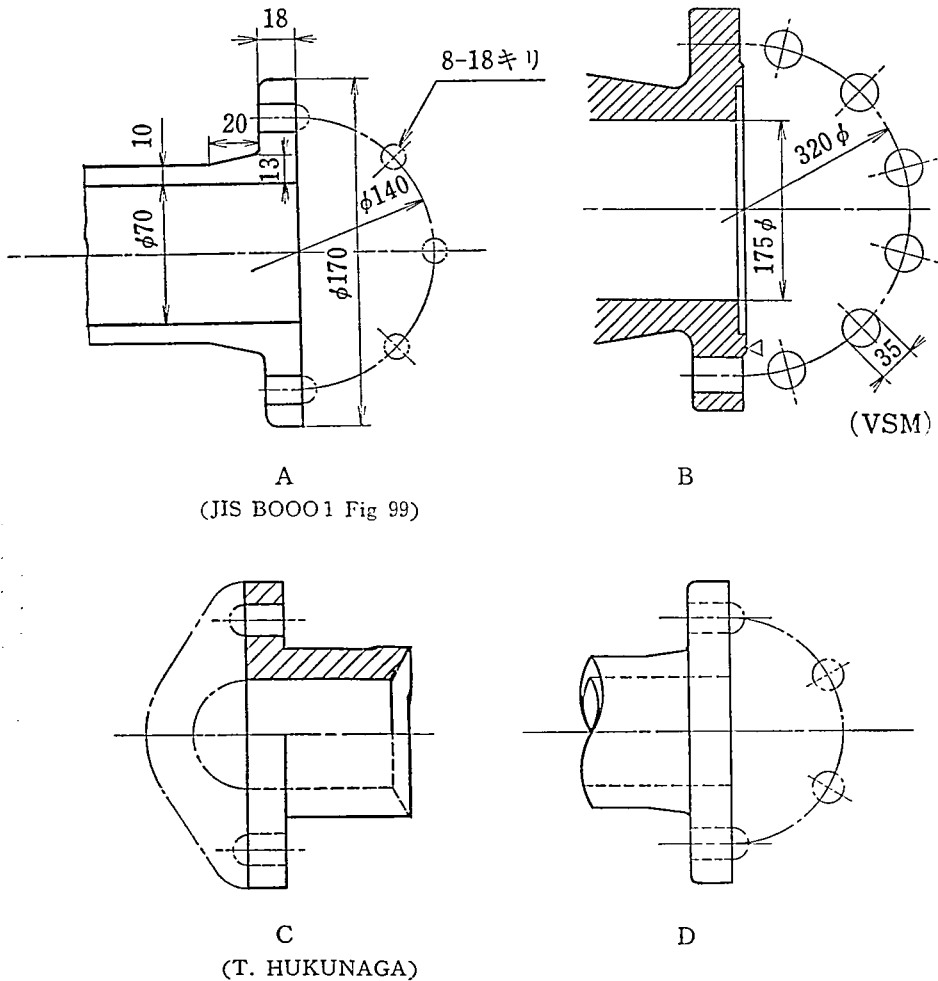


Fig 18

6) Case in which a new article can be obtained by making a slight modification on the body described in the drawing.

This method is used to get a new article which will have B part that will replace A part in the article already described in the drawing. It is waste of time and money to draw up a new drawing and even make another wood pattern every time a small modification is necessary. In such a case, not only additional explanations should be added on the main body, but also the part number

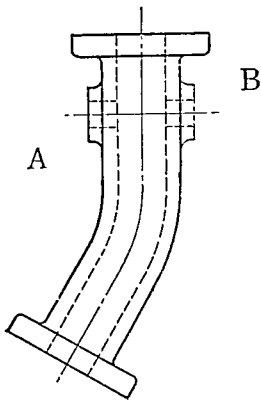


Fig 19

to indicate this should be entered in the drawing notes, thus to show distinctly that this is quite a different article.

3. Postscript

As an assertion of taking a close-up of the principal projection, I have been considering a rationalization of imaginary section and imaginary representation. I confess that this is like a repetition of what has already been expounded many times. But it is always important to come back to the principle and think again. I want to continue making searching inquiries into this field. The fundamental attitude for inquiry should be--

1. To fully appreciate the current regulations of each country.
2. To take into consideration the theoretical aspect of graphic science and geometry and the technological aspect of working and human-engineering.
3. To keep in mind that the legibility of a drawing to the worker is more important than the facility and convenience enjoyed by the draftsman.

- 1) Japanese Industrial Standard.
- 2) ISO R128, R129, R408.
- 3) International organization for Standardization.
- 4) Engineering Graphics Frederick E. Giesecke
- 5) JIS Drawing Office Practice for Mechanical Engineering.
- 6) American National Standards Institute.
- 7) British Standards Institution.
- 8) Deutscher Normenausschuss.
- 9) Canadian Standards Association.
- 10) General Rules for Engineering Drawing Office Practice
- 11) Methods-Time Measurement.
- 12) H. Yamanaka.
- 13) Verein Schweizerischer Maschinenindustrieller.