

## ON THE PROBLEM OF PRINCIPAL PROJECTION- SETTING ABOUT THE WORKING DRAWING OF MACHINE-SHOPS

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What is most important for the users of working drawings is that emphasis be focused exclusively on the proper projection that represents the whole view so that their need may be satisfied at a glance. The author calls this the **principal projection**, and give the following four laws to set this principal projection.

1. first law: law of adaptability
2. second law: law of principal center line
3. third law: law of right-side and law of upper-side
4. fourth law: law of true shape description

### 1. How to deal with the views and dimensions of the working drawing

**First law for the principal projection-setting** (Law of adaptability)

Projections and the dimensions of the working drawing must be coupled directly with operations.

Already explained in our Research Bulletin No. 1 (1965).

### 2. How to deal with the principal center line of working drawings

**Second law for principal projection-setting** (Law of principal center line)

The principal form that constitutes machine parts consists of a body of revolution and a body of planing and the principal center line will be drawn horizontally and emphasis is concentrated on the right side.

#### § 2.1 Working importance in bodies of revolution

The principal machine parts that comprise such elements as shafts, rings, wheels are all made up of a body of revolution. Machining processes which are directly concerned in producing these parts, such as turning, horizontal boring, circular milling and cylindrical grinding are representative operations that require working drawings, and "to couple the drawing directly with turning" means at the same time to couple it with operations in a body of revolution.

**a. The principal plane** The cross section which contains the principal center line in a simple body of revolution is everywhere the same and can be taken as its base. The author gives this the name of the **principal plane**.

**b. The normal working position of a work in turning** The normal working position in turning is determined as an absolute position as follows, from the three elements of "work, tool and measuring":

1. Taking the principal center line **horizontally**, make it coincide with the between centers of the lathe;

2. Apply the tool from the side of the tail-stock, i.e. from the **right-side** of the principal center line, and feed gradually to the left;
3. Measure the inside diameter from the **right-side**, and the outside diameter from the **upper-side**;

As a result from above, the following vitally important matters are determined in the drawing to be directly coupled with operations:

1. Take the principal center line **horizontally** in conformity with the normal turning position of a work;
2. Concentrate emphasis on the **right-side** of the principal center line.

In a body of revolution as machine part, there are commonly two sides, each on either of the longitudinal sides of the principal center line, which needs lot of machining and less machining. In drawing, depict on the right-side to make the drawing correspond to operations. In designing, concentrate operations on this side as far as possible and assign no operation of least possible unavoidable operation on the left-side.

## § 2.2 Main operational features in bodies of planing

Planing or shaping of a body of planing is performed only in cutting strokes. In planing and shaping, the relative movement of the tool and the work is different, but both are the same in this respect, that, on the drawing coupled directly with operations, it is necessary to make the center line of longitudinal direction taken on the surface of planing of a work at one with the direction of stroke.

The worker stands by the planer in his normal working condition with his hands stretched to the right and left in the direction of stroke and the cutting begins on the work on its right end, so the cutting goes on from right to left in relation to the tool and ends at the extreme left.

In planing, a grooved form with a depth is most common, though in case of surfacing only the surface is machined, and the indication to show the form of a groove is necessary.

Planing, however, is impossible unless the groove to be planed is fully open to the stroke on the planing surface. The tunnel hole operation is possible only with a special tool and is not a normal planing.

From above it is concluded that "the normal working position of a body of planing" is the state of a work put on the table with the planing surface upward in a condition convenient for the worker.

The same is true with surface milling and surface grinding. Therefore the projections to be coupled with planing are determined as follows:

1. Draw the principal center line horizontally to conform with the stroke;
  2. Conform the planing surface with the projecting surface;
  3. Establish the principal projection and concentrate emphasis on its **right-side** and **upper-side**.
3. Which side of the principal projection is the most important

**Third law for principal projection-setting** (Law of right- and upper-side of the principal projection) All of the important descriptions which

are shown on the working drawings, must be located on the right-side and the upper-side of the principal projection.

### § 3.1 Effects of motion studies in general on drawings

Of the results of motion studies in general, the following four can be counted as applicable to the drawing:

1. Emphasis in the operation performed in a posture with the upper half of the worker's body free like in the motion of drafting;
2. Emphasis in the operation of collating a view to the object with a sheet of paper such as a drawing in the left hand;
3. Emphasis in the operation when the sheet is placed horizontally;
4. Emphasis in the operation when it is hung.

**a. The motion emphasis in case the upper half of the body is free as in drafting** Generally speaking, in the operation in which work is done with the upper half of the body free, as in drafting, without moving the feet and in which continual operation is done only by using the hand, the eyes and hands alone are the objects of motion study.

In an operation in which only the hands are moved along the operating plane, e.g. of a desk, the locus of free sight points in a natural working posture is on the horizontal line which lies at 45° in front of the position of the eyes as the base. The portion further upward is easy to see but the portion this side of the line is difficult to see. Therefore emphasis is laid on the further side of the center line, i.e. on the **upper-side**, in the technical term of drawing, so far as the eyes are brought into consideration.

In common operation, the range for the right hand working comprises all the upper-side and the right-side, and the whole working space forms an rectangle like a drawing board. The part to be emphasized is on the right-hand and the upper-side of the diagonal, drawn from the left top corner down to the right bottom corner.

As the eyes are always governed by the right hand, the working space of the right hand coincides with the locus of the sight points. Therefore, in such a working space, emphasis is laid, as regards both the hand and eyes, on the **upper-side** and the **right-side**.

**b. The space where emphasis concentrates when collation is done by moving the drawing** When a worker collates the drawing to the work in its normal working position by moving the drawing, he uses the left hand that is free.

In this case the focus of observation comes on the right hand upper-side of the diagonal drawn from the left top corner down to the right bottom opposite on the drawing. That is, emphasis must be laid on the **upper-side** through the **right-side**.

**c. The focus of observation in case the drawing is at standstill** When the drawing is hung up, the natural focus of observation comes on the upper half from the center. The upper edge of the drawing is always at the fixed position, so the larger the sheet becomes, the lower it comes down, and the **upper-side** is more easy to look at with the result that the lower side tends all the more to escape from observation.

When operation is performed from the drawing put horizontally, the

normal working position of the work is in front of the worker, and in all cases, such drawings are placed leftward from the center, so the focus comes again, on the spread-out drawing, on the upper-right-side of the diagonal drawn from the left top to the right bottom, as has already explained.

### § 3.2 The motion of the right hand

As regards the rotating motion of the right hand of the operator with the shoulder as its center, it is universally known that the clock-wise rotating motion is more advantageous than the anticlock-wise motion in consideration of the number of revolution, continuous duration and the intensity of force.

The motion of the right hand in drawing also conforms to this principle, especially the motion of the right hand with a pencil in it, is limited to the motion along the quarter arc from the **left bottom** to the **right top** in the second quadrant of a full rotation. Therefore in drawing lines, these three,

Horizontal line.....from left to right

Vertical line .....from bottom to top

Inclined line .....from left bottom upward to right top

gained by analyzing the arc, become the absolute directions determined from motion study. Other lines are seldom used and, moreover, can be avoided to some extent.

An inclined line which has no needs of direction, going up to the right is most logical. Therefore, it is right to take the driver-grooves of screws, the diagonal dimension lines, the hatchings and the leaders always at 45° right upward.

### § 3.3 Lines of drawing-out and lines of drawing-in

A line is drawn through the given point, is named, according to the position of that point;

from the given point, a line of **drawing-out**  
to the given point, a line of **drawing-in**.

It is proved from experiments that lines of drawing-out are more advantageous than lines of drawing-in in respect both of time and technique. They are more beautiful and exact in addition to these. The directions of various lines that compose a drawing are difficult to determine according to the view, but excepting special cases, it is not so difficult to use more lines of drawing-out and fewer of drawing-in.

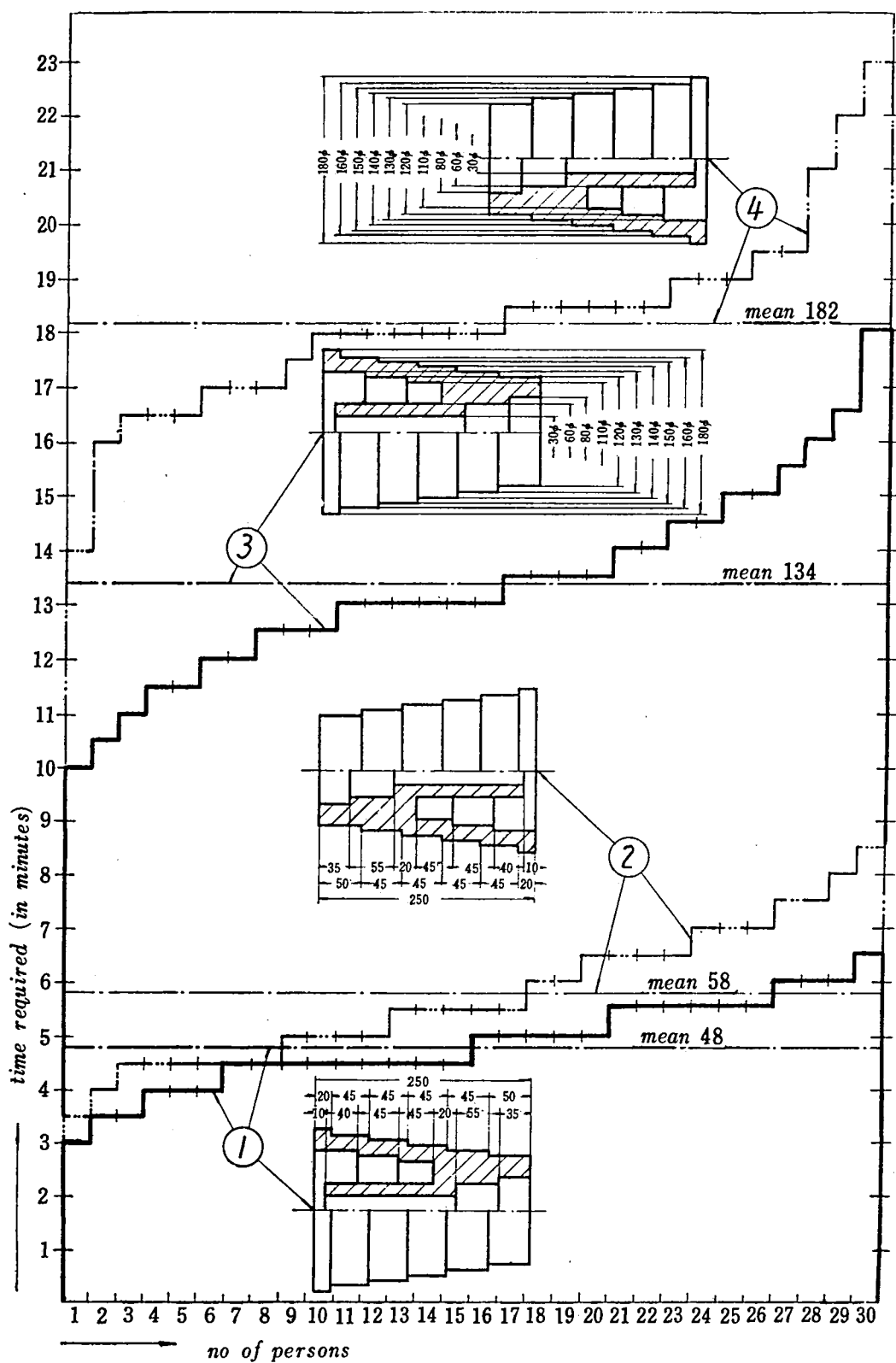
Especially it is possible to make extension lines in every drawing only by **lines of drawing-out**. Therefore it can be set down as absolute from the results of motion study for making a drawing. And to place dimension on the **upper-side** and on the **right-side** of the principal projection with lines of **drawing-out** tallies with the results of operation study from the side of the users of drawings.

According to the case of dimensions of a stepped wheel are placed,

Case 1: on the upper-side      Case 2: on the lower-side

Case 3: on the right-side      Case 4: on the left-side

of the principal projection in the following Figure and give the following data,



a. To place dimension lines on the right-side is more advantageous than to place them on the left-side. The time required in Case 3 and Case 4 is proportionate only to the velocity of the lines of drawing-out and the lines of drawing-in as extension lines, and the average of 13.4 minutes in Case 3 where the dimensions are collected on the right-side as the lines of drawing-out, shows a remarkable advantage over that of 18.2 minutes in Case 4 where the dimensions are collected on the left-side as the lines of drawing-in, giving the ratio of 1.36.

(1)	time required (min)	3	3.5	4	4.5	6	5.5	6	6.5										mean 4.8
	no. of persons	1	2	3	9	5	6	3	1										total 30
(2)	time required (min)	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5					mean 5.8
	no. of persons	1	1	6	4	5	2	4	3	2	1	0	0	1					total 30
(3)	time required (min)	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15	15.5	16	16.5	17	17.5	18	mean 13.4
	no. of persons	1	1	1	2	2	3	6	4	2	2	2	1	1	1	0	0	1	total 30
(4)	time required (min)	14	16	16.5	17	17.5	18	18.5	19	19.5	20	20.5	21	21.5	22	22.5	23		mean 18.2
	no. of persons	1	1	3	3	1	7	6	3	2	0	0	1	0	1	0	1		total 30

b. To place dimension lines on the upper-side is more advantageous than to place them on the lower-side. If the extension lines are put on the upper- or lower-side, the dimension lines are placed horizontally. As the horizontal lines are drawn from left to right with a T-square, in placing dimension lines on the upper-side of a projection, the draftsman, hindered by the opacity of the wooden T-square, is obliged to do his work sliding the T-square slightly out of place and examining the space between the lines every time it is required for correct spacing. As he can place dimension lines on the lower-side gazing at the space and the projection, it is needless to say that the former is less advantageous than the latter. If one takes only this point into consideration, to put dimensions on the lower side of a projection seems more advantageous than otherwise. And too many people see only the disadvantage resulting from an opaque T-square and fail too see the matter in its entirety, and are convinced that dimensions should be placed on the lower-side.

In spite of this disadvantage, to put the extension lines, double the number of the dimension lines, as lines of drawing-out on the upper-side is far more advantageous, and the ratio of the average time of 4.8 minutes in Case 1 where the dimensions are collected on the upper-side against that in Case 2 where they are collected on the lower-side is given as 1.21.

### § 3.4 Emphasis on the drawing board

a. The important portion on the drawing board. Drawings are also affected by the drawing board. For the draftsman at his normal working position,

the right side upper half above the diagonal line drawn from the left top corner to the right bottom opposite on the drawing board, is the most convenient working space.

Therefore it is most desirable for the sake of efficiency to arrange the drawing instruments on the right-side upper corner.

**b. The position of the paper** In making a small drawing on a large drawing board, put the horizontal center line of the drawing paper on that of the drawing board, setting the sheet to the left as far possible, with the left edge of the sheet always at the left of the board.

**c. The upper-side of the drawing board** The upper-side of the drawing board has the following advantages for work:

1. The **upper-side** is advantageous because all the results of general motion studies hold good also here;
2. In drawing, the body of draftsman is apt to turn to the right drawn by his right hand, so the **upper** half of the board becomes the main working space for his right hand;
3. This tendency is all the more intensified in making vertical lines because the body turns to the left a great deal more.

**d. The lower half of the drawing board** In contrast with the upper-side, the lower-side of the drawing board is disadvantageous from the following reasons:

1. In doing work on the lower-side, the right hand must be turned extremely to the left;
2. As the T-square is always on the lower-side of the board, work is often obstructed by the T-square.

### § 3.5 The law of the right-side and upper-side

As a conclusion to the remarks stated thus far, it is inferred that the main importance in a drawing concentrates on the **right-side** and the **upper-side** of the **principal projection** as in table. From this fact the author gives the law of the **right-side** and the **upper-side**, and insists that, in all cases of representation, the main points must be concentrated on the right-side and the upper-side of the **principal projection** obtained with the principal center line as its base line.

Kind of operations	Side of emphasis	
	right	upper
Turning .....	right	upper
Planing .....	right	upper
Operation done with the upper half of the body .....		upper
Collating of the drawing by moving.....	right	upper
Collating of the drawing hanging-up .....		upper
Collating of the drawing put horizontally .....	right	upper
Motion of the right hand .....	right	upper
Lines of drawing-out .....	right	upper

According to these principles it is correct in drawing to concentrate all the principal features of representation on the right-side upper half of the diagonal drawn from the left top corner to the right hand bottom opposite.

#### 4. The law of true shape description

**Fourth law for principal projection-setting** (Law of true shape description) The principal projection of the working drawing must be described according to the law of true shape description.

A description which has no technical value and does not give and benefit to operations, can not be called a correct one in a working drawing, though it may be formally good as a geometrical description. What is most frequent in this category is a foreshortened description, as in a case where an inclined circle is represented as an ellipse. In a machine drawing, especially in the principal projection of working drawings such a representation should be avoided and only the **true shape** should be described. The author calls this the law of **true shape description** and maintains this as one of the principles for determining a view in a working drawing in addition to the above mentioned three laws of the **principal center line**, the **right-side** and the **upper-side**.

This principle is applied not only to the lines and planes in a view, but also to the representation of distances between centers.