CHAPTER XX.

The Helical Elbow.

The helical elbow is somewhat of a novelty in the sheet metal industry, and can hardly be recommended for general work. Other forms of ducts may usually be designed which will fulfil the requirements to better advantage. On the other hand, we may meet with an insistent demand for a fitting of this class. Therefore it seems desirable to discuss it in this work, although perhaps it makes the rule somewhat elastic when placed under the head of Triangulation.

Fig. 78 shows in a pictorial way a helical elbow exposed in the corner of a room and presumed to make connection between a pipe or duct passing through wall *A* and a similar pipe passing through wall *B*, which is at right angles to wall *A*. The pipe or duct in wall *B* is at a greater distance from the floor than that in wall *A*, therefore a considerable rise or pitch is demanded in the elbow while making a revolution of 90 degrees. In other words, the pipe or duct is required to revolve about the corner of the room as an axis and to have an equal rise for every unit of revolution. The heel and throat are but portions of a right circular cylinder, and the top and bottom or two cheeks, should be that surface known as the right helicoid.

It has been previously stated that the right helicoid is a warped surface and cannot be developed or forced into shape without a drawing or stretching of the material. On the other hand, we can secure passable results by introducing a series of breaks or bends, as will be hereinafter shown. Measurements are shown in Fig. 78, and the following diagrams have been worked to those measurements by using the scale in Fig. 79. It may be well to remind the reader that the distances in Fig 78

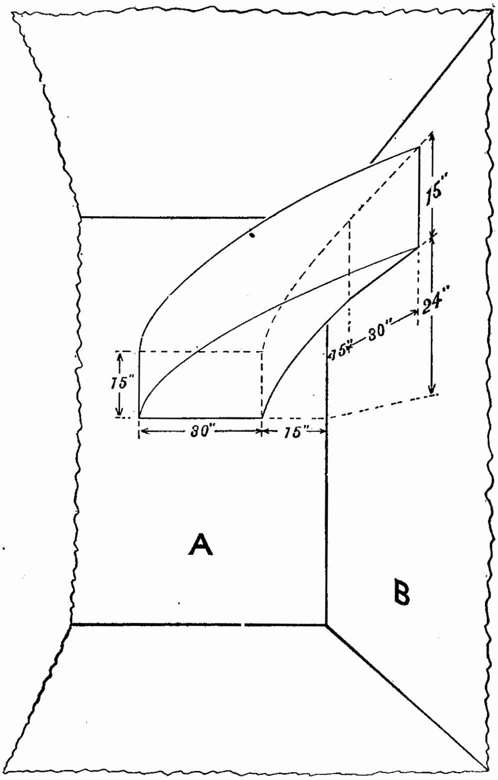

Fig. 78. Scenographic Representation of Helical Elbow in a Room Corner.

cannot be compared with the scale, since that drawing is purely scenographic.

From measurements shown in Fig. 78 it is but a simple operation to draw a plan. As for example, we draw a right line as *C D*, Fig. 79, and look upon this as a plan of wall *A*, Fig. 78. A line drawn from *D* perpendicular to *C D,* as *D E,* may likewise be looked upon as a plan of wall *B*. Then the point *D* is the plan of the vertex of an angle formed by the two walls of the room, or the axis of the elbow.

On examination of Fig. 78 we note that each end of the elbow is 15 inches distant from the corner of the room. Therefore we use that distance as radius and with point *D,* Fig. 79, as center, describe an arc of 90 degrees, as shown at *F G*. This arc is then looked upon as a plan of the throat. With the same point as center and with trummels set to a span of 45 inches as shown in Fig. 78, we describe the larger arc as also shown in Fig. 79. We have then before us the plan of the required elbow.

From the specification of the elbow, i.e., it must have a gradual rise throughout its 90 degrees of revolution, we conclude that the upper and lower edges of the throat and heel must describe in space that form known as the helix.* From the definition of the helix as given in the note below, we may also conclude that any right line drawn obliquely across the envelope of a right cylinder, will, when said envelope is developed into a cylinder, describe a helix in space. The angle at which this line should be drawn is dependent entirely upon the required rise or pitch of the helix, in the whole or part of a revolution.

Patterns for Throat and Heel.

Presuming the reader has acquired an understanding of the above, we may now proceed to secure patterns for the throat and heel by representing upon the plane of

* The Helix is designated as the path of a point, which, while revolving uniformly around an axis, also moves uniformly in a direction parallel thereto. This curve then lies upon the surface of a cylinder, cuts all its rectilinear elements at the same angle, and becomes a right line when the cylinder is developed into a plane.

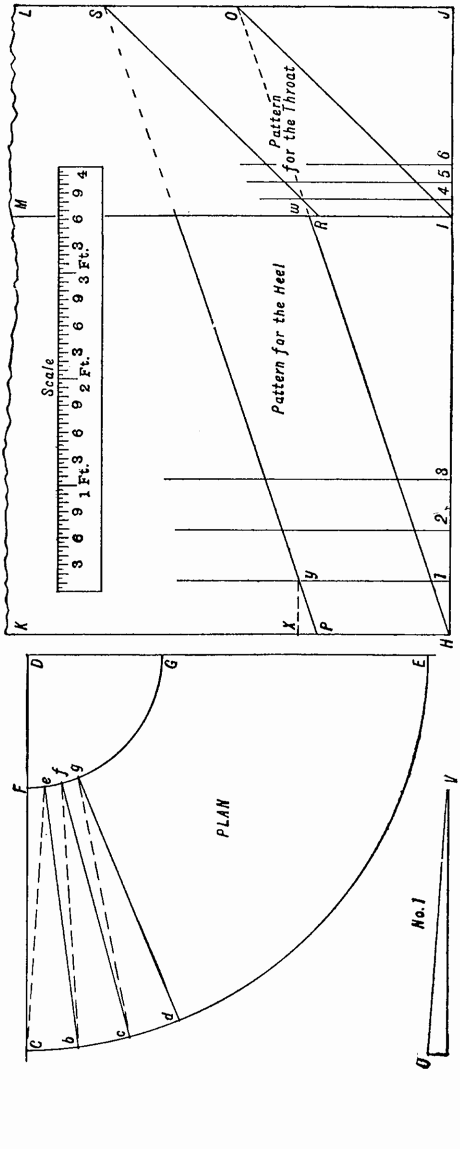

Fig. 79. Plan of Elbow and Pattern for Throat and Heel.

development the envelopment of the cylindrical forms, the plans of which are shown in Fig. 79. This is accomplished by drawing right lines equal in length to the lengths of those arcs, and through the extremities of said lines drawing additional lines perpendicular for the first, as shown at *H I* and *J,* Fig. 79. To confine Fig. 79 within reasonable bounds, one pattern has been made to overlap the other to some extent. This necessitates one being transferred when the pattern is cut.

As for example, the line *H J* is equal in length to arc *C E,* and a portion of the same line as *I J,* is the length of arc *F G.* We look upon the surface *H K L J* as the envelopment of a cylindrical form the plan of which is arc *F G.* We note from Fig. 78 that the rise of the elbow is to be 24 inches in its revolution of 90 degrees. Therefore we locate a point 24 inches from *J* upon line *J L* as at *O.* Lines drawn from points *H* and *I* to *O,* then represent the lower edges of the throat and heel upon the pattern. Since the pipe to be connected is shown to be 15 inches high, we locate points as *P R* and *S,* which are 15 inches above points *H I* and *O.* On drawing lines as *P S* and *R S,* the patterns for the throat and heel are completed, as shown.

We may here explain that when following this course to secure a connection as shown in Fig. 78, some distortion will exist together with some reduction in the capacity of the duct. This distortion may be modified, and the capacity increased, as will be hereinafter explained. For the present we shall presume that the elbow is to be made precisely as shown in Figs. 78 and 79.

Patterns for the Top and Bottom.

To secure the patterns for the top and bottom of the elbow, we may divide the arc *C E,* Fig. 79, into four equal parts, and sub-divide the first division from *C* into *3* or more equal parts as *b, c,* and *d.* By the use of our straight edge we draw lines as *b e, c f,* and *d g,* which are divergent lines from point *D,* and cut the arc *F G* in points *e f* and *g.* Points as *b c* and *d* upon arc *C E,* are now looked upon as the plans of elements upon the above spoken of cylindrical surface, of which *K H L J* is the covering. Therefore we may locate one or more points upon line *H J,* with distances between as found between *c b, b c,* or *c d* of the plan, as shown at *1, 2* and *3.* Lines are drawn perpendicular to said lines as shown, and intersecting those lines which represent the top and bottom of the pattern for the heel of the elbow.

In like manner we locate points along the line *I J* with distances between as found between points *F* and *e,* etc., on arc *F G* of the plan, as shown at *4, 5,* and *6.* From said points perpendicular lines are erected to intersect lines *R S* and *I O,* which are the top and bottom boundary lines of the pattern for the throat. The true distance between points, the plans of which are *C, b, c,* etc., is then found between points *P* and *y* of the pattern. Likewise we find the true distance between points, the plans of which are at *F, e, f,* etc., between points *R* and *w* of the pattern for the throat.

All divergent lines from point *D* shown in the plan are perpendicular to the corner of the room, or horizontal. Therefore broken lines as *C e, b f,* etc., of the plan, are in reality at an angle to the horizontal, dependent upon the rise of the elbow between those points, i.e., that vertical distance as shown between *P* and *X* of the pattern. To secure true lengths of broken lines shown in plan, we construct a triangle as shown at No. 1, Fig. 79, with base equal in length to line *C e* of the plan, and the perpendicular of which is *P X* of the pattern. Then *U V* is the true length of not only *C c* of the plan, but of all similar lines shown or assumed.

Having before us the lengths of all lines which we presume to be upon the pattern, and as the pattern is but a series of triangles joined together, the dimensions of which are equal, we can, if thought more convenient, cut one section from sheet metal, the plan of which is *C F e b*, Fig. 79, and shown at *C F e b* of the pattern, Fig. 80. This section may be duplicated upon the plane of development to complete the whole pattern, or we may use our trummels in the usual manner. However, since in this instance the pattern is composed of twelve equal sections, all similar measurements will be equal, as is shown at the pattern, Fig. 80. Care must be used in this to secure accurate lengths for the throat and heel, which should be equal to those lengths shown at *P S* and *R S*, Fig. 79. As is indicated at Fig. 80, the inside of the top cheek is shown.

The full and broken lines which bound the several triangles of which this piece is composed, are also a key to the direction the metal should be bent. That is, the metal is to be bent up on the broken lines, and down on the full lines. The angle of these bends is dependent upon the rise of the elbow and the radius of the throat, i.e., the radius of its plan. As for example, we look upon the surface *C F e b*, Fig. 79, as a plane which may be revolved about the line *C F* as an axis. Presuming this to have been revolved in a manner to elevate point *e* *1* inch above point *F*, then point *b* would be considerably more than *1* inch above point *C*. However, since in reality the elbow is no higher at point *b* than it is at point *e*, a bend is necessary upon line *C e*.

We could as consistently assume a bend on a line drawn from *F* to *b*, since it would make no material difference except to demand the bend in the opposite direction. Thus it is but a simple matter to establish in theory the angle at which the metal should be bent upon those lines. However, since this bending process serves our purpose in another way, the exact angle in every instance

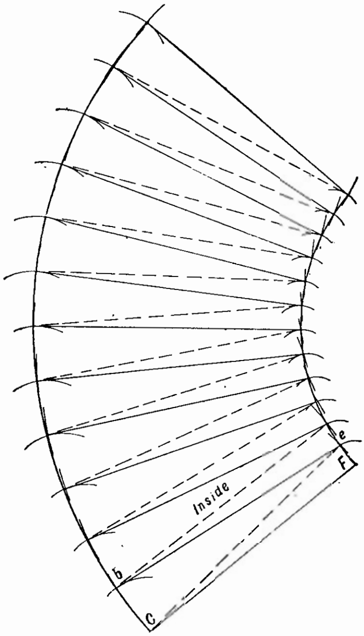

Fig. 80. Pattern for Top and Bottom of Elbow.

has little or no effect upon the required results. There is a super-abundance of material in the center of the cheek, and by making these bends, and drawing out the edges so as to make the cheek appear somewhat as shown at Fig. 81, the required twist is developed. Too little twist denotes that there has not been a sufficient quantity of material consumed in the center, and too much twist denotes that too much material has been consumed. Therefore we must make the bends shallower or deeper as the case demands.

Loss of Capacity When Used as a Duct.

Some loss of capacity will be found in an elbow of this class, as well as some distortion, where said elbow makes connection with ducts of a given area of cross-section. As for example, in this instance it has been presumed that the elbow is to connect ducts with cross-sections of 15 x 30 inches. We find upon referring to Fig. 79 that

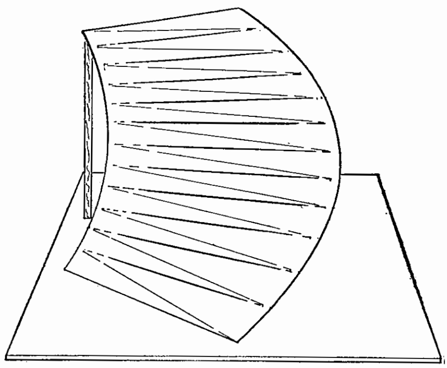

Fig. 81. Pictorial Representation of Top or Bottom, Showing Breaks or Bends.

the width of the heel is approximately 14 inches and of the throat approximately 10½ inches. This, as will be noted, makes an average of 12¼ inches, or in a primitive way, we find that the elbow will average 12¼ x 30 inches.

Fig. 82 is included for the purpose of conveying to the reader·through the medium of the eye, an understanding of this Upon examination, it will be noted that this diagram shows in a pictorial way, portions of the heel and throat of the elbow connected to the duct. The heel and throat are in reality strips of material cut at the ends at a suitable angle to secure the required rise in a given length. As for example, the heel and throat must rise to the same level while passing around cylindrical forms of varying diameter. Therefore that which passes around the cylindrical form of the least diameter must have the most rise per unit of measurement upon the base of the cylinder. Thus in every instance the throat must have a greater relative rise than the heel. Since vertical lines upon each are of equal lengths, the material which forms these portions must be of varying widths, dependent upon the radius of those parts.

The Right Helicoid.*

Fig. 84 has been constructed to conform to the definition of a right helicoid, which was given in the eighteenth

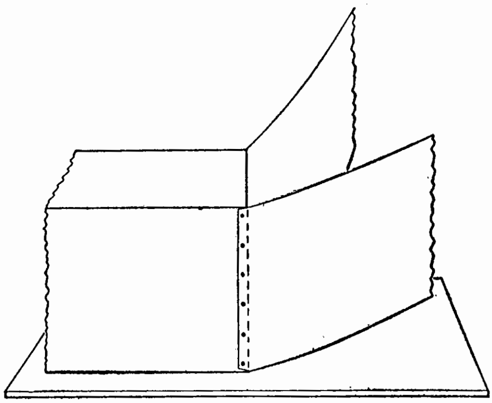

Fig. 82. Portions of Throat and Heel Connected to Duct.

chapter, also in the note below. The vertical line E is presumed to be the vertical axis. The thirteen horizontal lines are presumed to be one line which has been revolved

* The right helicoid is a surface which may be conceived as being generated by a right line revolving about an axis, and perpendicular to it; also moving uniformly parallel to said axis. A surface so generated is usually presumed to lie between two concentric cylinders.

about the vertical line E, and shown in different positions which are 7½ degrees distant from each other while making a quarter revolution.

Presuming the total rise to be 24 inches, the rise for

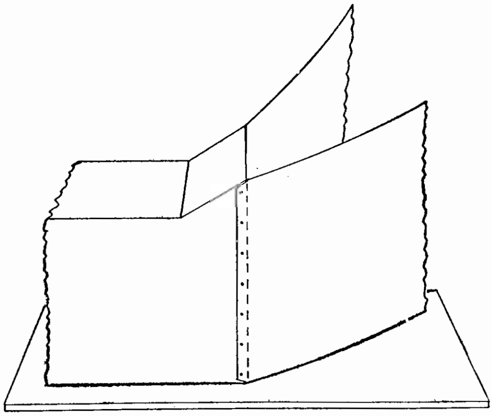

Fig. 83. Duct Enlarged at Intersection of Duct and Elbow.

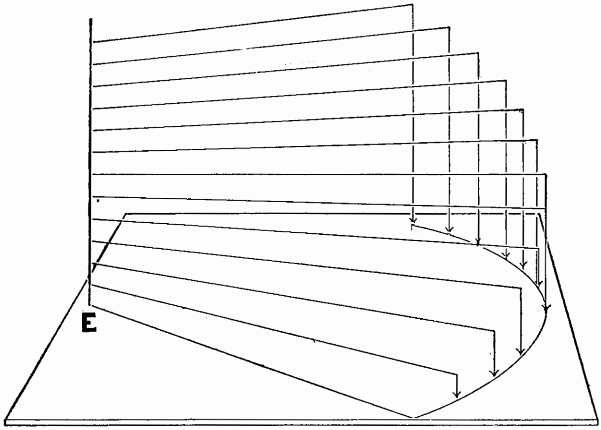

Fig. 84. Generation of Surface Known as Right-Helicoid.

each position would then be 2 inches. Arrow heads point out the plan of the path which the right hand extremity of this line would describe in space while being revolved. From this we conclude that with a given rise for the elbow, as the throat and heel approach the axial line the pitch increases, and conversely, as these parts recede from the axial line the pitch decreases, i.e., the relative pitch to the base of cylinders of which they may be conceived as being a part. When the radius is Zero, the throat becomes a vertical line. As the throat of the elbow recedes from the axial line, loss of capacity and distortion decrease.

Fig. 83 offers some suggestions in a pictorial way on how the capacity of the elbow may be maintained and distortion modified by increasing the hight of the duct at the intersection of duct and elbow. This will become necessary at each end of the elbow, that is, that modification shown in Fig. 83 would be also applied to the bottom of the duct in wall *B*.