WORKING SHEET METAL.

The operations of flattening, raising, spinning and bending sheet metal depend for their success upon the malleability of the metal so treated. There are few vessels the figure of which are so complicated and intricate that they cannot be worked into shape. A high degree of skill is required in this class of work, and the best work must necessarily be done by hand.

Flattening. The flattening of thin sheet metals is effected as in principle the other operations are performed, by causing certain parts of the metal to glide or spread over other parts immediately adjacent, so that parts which are tense by comparison with parts adjacent become loosened and extended to approximate to the condition of the parts adjacent, until all parts are in equal condition of tension. This is done by hammering the parts in tension, by means of what are termed solid blows, so spreading or extending the metal laterally, and allowing the bulged or loose parts room to expand or spread out. It would not do to hammer the loose or bulged portions, because that would increase the bulge by spreading or enlarging the area or curvature of the bulged portion. The metal there is bulged because it is prevented from expanding by reason of the tight parts adjacent, and the only way in which the bulge can be removed is by just giving it room to spread out, and this can only be effected by removing the excess of tension from the parts adjacent, so allowing them

to spread out away from the bulge, leaving the latter free to expand into a true plane. A very minute amount of bulging is sufficient to cause buckle in a plate, the term buckle being commonly used to signify the condition of local tension and bulging, but however minute the degree of difference, nothing save the removal of the local tensions by hammering or by rolling will produce a true and level plate. The condition of buckle, even when slight, is easily recognized. When of considerable extent, it is recognized by the straightedge, or by casting the eye across the surface. Even when slight in extent, it can be recognized by the bending of the plate backwards and forwards, when if buckled there is a lack of elasticity evident to the practised hand and ear. There is the feeling that the continuity of the plate is broken, and a whip-like sound as of crackling or flapping.

The term solid, or opposed blows, signifies that the blows are delivered upon the plate between two hard, unyielding, and strictly opposed surfaces, as the face of the hammer and the face of the anvil. These blows invariably compress, and thin, and extend, or spread, and also harden the metal. The term is used in opposition to hollow blows, in which the metal is struck upon a yielding body, or with no body beneath it, the effect in this case being the reverse of the previous, the metal being bent, thrown up, or thickened. In much raised work the blows are of a dual character, partly solid, partly hollow, as when it is desired to produce curvatures without altering the thickness of the metal.

Raising. The formation of curved, dished, or hollow vessels by the process of raising depends for results upon the malleability of the metal. If a metal

or alloy were rigid in the same sense of degree that a piece of cast-iron or tempered steel is rigid, then the formation of a curved surface by hammering would be impracticable. Cast iron and tempered steel are not malleable, from the practical point of view. In other words, the particles of which they are composed are so hard, rigid, and crystalline that they possess no faculty of relative movement over one another, no property of gliding, or viscosity. Therefore they do not yield under the hammer, but fracture only. The property of malleability possessed eminently by copper, and in a lesser degree by some other metals and alloys, is one to which there appears to be no limit in practice, to the alterations in form which are practicable by the simple process of hammering, provided due annealing is resorted to, sufficient in amount to counteract the brittleness induced by hammering, and restore the original ductility. In hammering, the metal is thinned and thickened alternately, now spread out, now thrown up again at the will of the workman, and almost as if by instinct. The first operation in raising a dish or a flaring rim, is the creation of a series of puckers or wrinkles. This is the result of trying to bring a larger circle into the circumference of a smaller one, the metal possesses a sufficient rigidity to resist, and becomes waved in consequence round the edges. But these wrinkles are obliterated by the subsequent process of raising, in which the projecting flutes are set down in detail, and made to glide into the adjoining depressions, with the result that a general curve, more or less regular, is formed.

In doing such work, the blows delivered partake of the solid or dead blow, and the hollow or elastic char-

acter, the result being that the metal is not permanently thinned or thickened in different localities, but its thickness is averaged about equal all over alike. It is difficult to describe the process clearly, as it is a matter of intelligent dexterity, which the workman is better able to perform than to describe. The principles, however, are those just laid down.

The details of raising hollow work are very numerous. In the case of a vessel with flared sides, it is usual to mark a circle to indicate where the dishing is to commence. The metal is first beaten roughly down, into a hollow most suitable to the form required, which wrinkles or flutes the edges, after which the razing down commences. In many cases the wrinkling is done over the edge of a suitable stake, the metal being bent with hammer or mallet. In all but the shallowest work, the bending is done in courses, or narrow circles, or curves, the metal being annealed after the formation of each course. Frequently in repetitive work several similar pieces are hollowed at once. The pieces are secured together by the outer sheets being prolonged to form clips for the temporary embracement of the inner sheets. The accuracy of the work is facilitated by turning the sheets round upon one another from time to time, in order to correct inequalities.

The raising is done in courses or circles, and the term "raising a course" is applied to each successive operation of this kind. The effect is the same as when metal is spun in the lathe, only that the hammer takes the place of the burnisher. In each case the metal is stretched, and thinned, or thrown up, and thickened, becoming accommodated to the new form imposed upon it by burnisher or hammer.

Obviously, therefore, in raised metal work, a rearrangement of the particles of metal must take place, the relative disposition of its molecules must be changed, notwithstanding that the total area remains the same, or nearly the same, and the thicknesses should also be practically the same all over. In all work of this character, therefore, the piece of metal required to produce a given form should be cut approximately the same area as that of the finished work, so that there shall be no excess and consequent waste or shortness of material, or inequality of thickness. In raising work in successive courses thus, the wrinkles or flutes which are outside in one course are made inside in the next course, in order that the hammer shall work equally on the inside and outside of the vessel. After a vessel has been raised, the marks left by the hammers are obliterated, either with a smooth-faced hammer or with a wooden mallet.

Spinning. In the art of metal spinning, the thin sheet of malleable metal or alloy, cut to the form of a flat disc at first, is bent into concentric curves by means of gentle and continuous pressure applied with a blunt but perfectly smooth burnisher held against the disc during its revolution in the lathe. The burnisher thins and spreads and thickens according as it is moved from center to circumference of the spinning sheet, or the reverse way, both movements being made to alternate, at will, according as the metal requires spreading, or thickening. The pressure is necessarily heavy. There are only three or four types of burnishers used, one, a plain round rod with a rounding end, another having its end shaped of a more or less globular form, another curved something like a machinist's curved burnisher,

another flattened and rounded at the end. These are made of hardened steel and perfectly polished in order not to scratch the work. The lathe used for this work is of special construction. Wooden chucks or forms are turned of suitable shapes for the jobs in hand, and mounted on the face-plate of the headstock, and the thin sheet metal is gradually forced to take the outlines of the forms by continuous pressure exerted by the burnisher. Much of the work is done by a double-action of burnishers, and sticks or rubbers acting on opposite sides of the sheet, so bending it to double curvatures, and lessening the tendency of the work to chatter or wobble. The lathe-rest is fitted with pins, which afford fulcrums for the different positions of the burnisher and rubber, and the work is held by pressure on the center between the chuck and a holding-block, cupped holder, or other suitable means thrust against it by the tailstock. As the work is advanced the burnisher is moved along, taking its leverage from successive pins as suitable fulcrums, from which to operate the sweep of the burnisher forward and backward.

Stamping. In the work of spinning, the metal is stretched and bent as in bending rolls, the bending and stretching taking place, however, in concentric circles instead of in a cylindrical form. Very intricate shapes can be produced in this way, including the turning over and wiring of edges. It is, however, practicable only with very thin sheets. When comparatively thick sheets have to be operated on, then quick curvatures can only be imparted by hammering or by stamping. Spinning is frequently resorted to in order to finish work already stamped roughly to shape in dies. Thus

the common hand-bowls used for washing are made by first stamping in a press, which brings them nearly into shape, but leaves a lot of pucker marks from the stamps. The bowls are then put in the spinning lathe, and the puckers all removed with steel burnishers. The concentric rings seen on these bowls when new are the marks left by the burnishing tool.

Spun work of awkward outlines, in which there are considerable differences in diameter, is usually made in two or more pieces, spun separately and soldered together. The easiest material to spin is white metal. The edges of round tins are squeezed over by means of rollers or discs. Among work so treated are tea cannisters, gunpowder cans, biscuit tins, gasoline cans, and tins and cans of any shape, rectangular, hexagonal, or oval. Square irregular tins have tops and bottoms crimped on by a squeezing machine with four jaws, which run up at the same time and fasten the tops or bottoms instantly at one blow.

There is a large class of machines employed for the formation of beads on traveling trunks and similar articles, and for folding or bending work, these operations being performed sometimes on separate machines, sometimes on a machine which combines both functions. By the setting down of the top rollers the required curvature lengthwise is imparted to the beading in course of formation. In some machines splitting cutters are added for dividing such beads down the center. Of kindred types are the cramp folding machines, and the guttering machines, used also for bending sheet metals into numerous forms. By means of dies and formers, pipes, ridge caps, and spouts, in diverse forms are readily bent. These machines are made to

be operated both by hand wheel and gear, or by belt pulleys and gear. Other machines are made for bending tubes or pipes, their capacity ranging from about two and a half to ten inches bore, by from six feet to ten feet in length. The rolls are geared together and supported at several points to lessen the tendency to springing.

Small circular tins are formed and beaded on revolving rollers turned against a suitably grooved mandrel. Those other than circular are formed by pressure against blocks or forms of the shapes required.