PRESS-WORKING OF METALS.

CHAPTER I.

INTRODUCTORY.

Beginnings of the Art.

Of the origin and history of the art of metal work as performed in dies, operated by presses, we know but little. The numberless wonderful and beautiful operations of to-day, most of which it must be acknowledged, however, tend rather to cheapening and unifying than to beautifying the articles produced, are merely the results of a long course of evolution, tending constantly to a survival of the fittest methods. Regarding the progress of the art as a whole, it cannot be said that any one age shines out upon the pages of history, or that any one inventor has made himself immortal. Processes identical in principle with many of our modern ones were undoubtedly practiced by that master metallurgist and machinist, Tubal-Cain, and by the long line of skilled artificers who have been his disciples and followers adown through all the ages which have gradually created civilization.

This civilization in its modern glory, and its far greater glory yet to come, may be regarded as almost wholly dependent upon the noble art of metal working in its various branches; for we cannot conceive of the existence of the constructions

and instruments of modern engineering and other sciences if we were limited to such primitive materials as wood and stone.

Fundamental Principles.

In choosing the specific subject of this book, differentiating the general theme of metal-working by selecting sheet- and bar-metals, and this again by limiting himself to the operations of a particular class of tools, the author realizes that he must not lose sight of certain fundamental principles which underlie the art as a whole; considering the important divisions of casting, forging and finishing, as well as press-working, but omitting reference to purely chemical and electrical processes.

It may be well in this connection to say that the four process-defining verbs employed near the end of the last sentence are used in a commercial and technical sense rather than in a scientific one, as they somewhat overlap each other in exact meaning. This is readily seen when we consider that casting, which generally means the running of molten material into a mold by the force of gravity merely, sometimes also means the forcing of the same thereinto by means of a pump, or its equivalent, as in type casting and the Whitworth pressure system of steel casting. From this it is but a step to the drop-forging of white-hot iron in the dies of the drop press or (in other materials) to the pressing to shape of semi-molten glass, or of cold soap and candy. The differences are chiefly those of the degree of plasticity in the substance treated. We thus find no very distinct line of demarcation between casting and forging, for much of the ordinary blacksmith's work is analogous to drop-forging, except that his tools are not as highly specialized, and do not so completely give their own form to the work. Again, we find that finishing (in the sense here used of paring and scraping or abrading the surface of the metal to more accurate shape,

as in machine shop processes) is partly included in a blacksmith's work, as in chiseling, filing, etc. Still again, we shall see that press-working may, and sometimes does, include all of the processes referred to—*e.g.*, forcing into molds, as in casting; cutting, shearing, punching, smashing, bending, stretching, compressing, etc., as in forging; and paring, etc., as in finishing.

In general, however, it may be said that press-work has much more in common with forging than with the other processes in question, and that it bears the same relation to the blacksmith's or the coppersmith's work that printing does to the scrivener's art, or chromo making to oil painting, or a knitting machine to one's grandmother. In any of these cases we have on the one hand a mechanico-reproductive process wherein the brain of the designer has been expended upon specialized tools which will produce predetermined articles, all exactly alike, for the benefit of the millions—in many cases, unfortunately, with but little embodiment of the æsthetic. On the other hand, we have much more expensive products, each made singly as the individual child of the artisan's brain, and each differing in some degree from its brethren. Should the artisan happen to be also an artist, as were the stone cutters of Greece and of mediæval Europe, the gold, bronze and iron workers of old Italy and Spain (but as are not, alas! the most of our metal workers of to-day), then his beauty-loving individualism in mechanical work serves as a leaven to leaven the lump of ugliness that tends to crush down all love of the beautiful in this intensely utilitarian age.

Referring again to certain general principles underlying the mechanical working of metals (at any rate, in all the processes mentioned except finishing), we have as one necessary condition a molecular structure which will enable the particles to flow among themselves when the proper force is

applied. In the case of *casting* this occurs at a temperature at which the particular metal in question happens to become a perfect liquid or nearly so. In *forging* the flow usually takes place at a bright red heat, although sometimes the metal is cooler than this, or even entirely cold—this latter term meaning here (and throughout this treatise) the ordinary temperature of the atmosphere. In *press-work* the metal is sometimes heated as in forging, but in the great majority of cases it is handled cold.

The other necessary condition, besides a capability of approximately non-elastic flow in the material worked, is the employment of certain tools that will first cause this flow and that will then limit it, so as to produce the predetermined shapes required. In ordinary casting these tools consist of the molds to inclose and limit the shape, together with a proper pouring tube (wherein the sprue or gate is formed) to give "head" or pressure to the metal. In forging, they consist of the surfaces and corners of hammers and anvils, together with horns, swages, fullers and other more specialized tools. In that modification of a forge-shop called a rolling mill, the tools in question, of course, consist of the surfaces of the rolls, whether they be cylindrical to produce sheet metal, or grooved in various ways to produce bars. In press-working the forcing tools are the press rams, while the limiting and shaping operations are performed by the dies.

PROBABLE ORIGIN.

Before proceeding to a practical analysis of the press-working art as we find it existent to-day, it will be well to recur once more to the historical aspect of the subject, that we may trace its probable beginnings back in the primitive ages of the world's history. The first man who chanced to dig up a little nugget of native gold or copper, or some other man who found a piece of malleable metal in the ashes of

his fire as a result of the accidental smelting of certain ore happening therein, may very probably have pounded it out thinner between two stones, and thus have become the first sheet-metal manufacturer. If he then cut it in two by lapping it over the sharp edge of a stone and sliding another one down past it, he had invented the first shearing press. If he pushed the end of a sharp-edged cylindrical stone through it into a hole in a stone underneath he was doing the first punching. If the upper tool was rounded off so as not to cut through, being perhaps a hard-wood stick, he was making a little cup by the process of forming or stamping. In the frontispiece a hint at such performances is attempted, but it is only fair to state that no photographs of the figures or landscape were available.

Thus simple, however, in principle, are most of the operations that we still perform in sheet-metal work. We have improved them only in detail, gradually evolving better and better tools, to the end of obtaining more and more accuracy, uniformity and rapidity of production. The transition from a punch or upper die, held in and guided by the hand, to a simple machine wherein the same was guided by being attached to a moving ram, was but a natural one and something that required no great inventive ability. The great economic and epoch-making advance which followed later was the specialization of a part of this work into certain

ROTARY OPERATIONS.

It is evident that the action of a pair of rolls, such as are used in ordinary rolling mills, for reducing the thickness and increasing the length, and sometimes the width, of a piece of metal, as well as in some cases bending it to a different form, as, *e.g.*, in the case of corrugating, is somewhat analogous to the action of dies approaching each other in a press —in the processes of mashing, forming, embossing, coining,

etc. The shearing action of a press also has its analogue in the rotary cutters mounted upon parallel shafts which are often used for slitting and trimming sheet-metals. All this rolling work is of course but a specialized specimen of the general operations of forging, of which press-work is another specimen.

PRESS DEFINITIONS.

A general definition of the word "press," as used for the purposes with which we are concerned in this treatise, might be written as follows: A machine in which a bed or anvil is approached by a ram or hammer, having a reciprocating motion in a line approximately at right angles to said bed, and the said ram being suitably guided in the framework of the machine so that it may always move in the same path. It will thus be seen that the two important members in any ordinary press are the bed and the ram, and that they are only a more highly specialized form of the blacksmith's anvil and hammer or of the still more primitive large stone and small stone used by the predecessors of Tubal-Cain.

Such a generic form is shown in the pictures, Figs. 1 and 2, wherein *F* is the frame, *b* the part thereof serving as a bed and *R* the ram, the views being side and top respectively. The ram is arranged with a handle at the top for the most primitive method of operation possible.

PRESS QUALIFICATIONS.

The general essentials in such a machine are a massive and rigid bed with a flat and true surface upon which to fasten one of the dies; a rigid framework extending toward and surrounding the ram that it may slide, or sometimes swing, therein with a considerable degree of accuracy; means for taking up lost motion caused by original looseness of fitting or by subsequent wear; and a somewhat massive and rigid

ram, carrying proper means for fastening and securely holding the other die. The surface of the ram nearest the bed is usually flat and parallel thereto, although for some shearing work and occasionally for rough punching a ram is allowed to swing in the arc of a circle, usually being itself in such case a part of one arm of its operating lever. In the vast majority of cases, however, a ram is of cylindrical or prismatic form, sliding accurately in true bearings in the frame of the press. These bearings should, if the machine is of correct

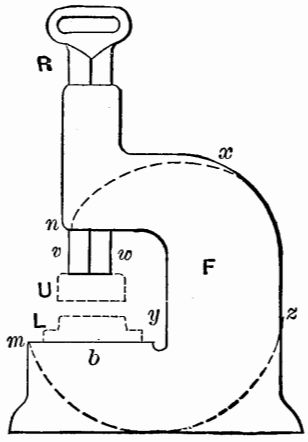

FIG. 1.

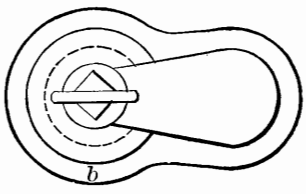

FIG. 2.

design, be of great length in proportion to the thickness of the ram, the object of thus maintaining the ram rigidly in its predetermined path of motion being to always bring the dies together with the same relation to each other, that they may not be injured and that the work may be uniformly shaped thereby.

The causes which tend to destroy this accuracy of motion are: 1. The springing of the ram itself, when made too slim and when projecting too far out of its bearings. 2. False motions (sidewise) in its bearings, either by their not embracing it tight enough or by their being so short as to magnify by means of the leverage the slight looseness which

is necessary in any working bearings. 3. The springing of the frame out of its normal shape at points between its bed and the ram bearings. It may therefore be said, in general, that it is almost impossible to make these parts of a press too clumsy, and that the more metal they contain, within reason and consistently with the space available, the better they are, especially as they want not only the strength to keep them in position, but all the inertia possible to prevent vibration when acted upon by the powerful and often rapidly applied forces necessary to move the ram.

NOMENCLATURE.

Hereafter in this treatise certain parts shown in the illustrations will be uniformly referred to by the following letters: *F* for press-frame; *b* for the bed thereof, which is usually but not always a part of the same casting; *R* for ram; *P* for plunger; *a* for axis of ram; *L* for lower-die; *U* for upper-die; *U'* for drawing-punch or inner-upper-die; *M* for matrix; *K* for knock-out; *S* for stripper; *G* for gauge; *p* for pressure between ram and bed in the line of ram's axis; *t* for throat, and *M* for metal or other material to be worked in the dies. The meaning of such of the above names as are not self-explanatory will be made clear further on, except perhaps the somewhat indefinite word "throat." This (with its derived adjective "throated") will refer to the gap or space containing the dies in that type of press where the main body of the frame extends back of the vertical axis or center-line of the ram, rather than at each side of it as in most "columnar" frames. "Throat" is sometimes used to express the distance, in inches or some other unit, from axis *a* back to frame, as shown in Figs. 11 and 13. This, however, does not conflict with its meaning the whole gap when no dimensions are affixed.

The other essential parts pertaining to presses and dies

are so numerous that no definite system can be maintained in referring to them. The nomenclature herein used will follow conventional practice as far as is feasible, but in names with a number of synonyms the word which seems the most in accordance with common sense will be selected. A case in point is the ram of a press, which, called by this name, seems to be expressed in a short, crisp manner which almost explains itself (because of its ramming functions) even to a layman. Other names frequently used for this member are slide, slide-bar, bar, mandrel, gate, head, platen, drop, hammer, plunger, etc. The last-named word will be herein used for the inside ram of double-action presses, the outside one being called simply a ram.

In dealing with locations, relative positions and directions the simple and definite words, top, bottom, right-side, left-side, front, back; and up, down, right, left, forward, backward, will be respectively used—it being understood that they are governed by the operator's anatomy as he faces the working side of the machine, which is its *front*. Thus "forward" is toward him, "right" to his right, etc.