PRESSURE ATTAINABLE BY THE USE OF THE "DROP PRESS."

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[Read before the American Society of Mechanical Engineers, November, 1883.]

The writer has recently taken occasion to determine the magnitude of the pressures attainable and not infrequently utilized in the use of the "drop press," now so extensively employed in the process of "drop forging" and in the manufacture of small parts of sewing machines, firearms and light machinery.

The opportunity was afforded to make this determination in the course of an investigation of the efficiency of drop presses lately made by the Mechanical Laboratory of the Stevens Institute of Technology. It was found that the most efficient presses experimented with had an "efficiency," as the term is technically used, of 90 per cent.—*i.e.*, the work done by the drop was 90 per cent. of that which was due to the weight falling through the measured height. The table given below is based upon the assumption that this efficiency can be reached, and exhibits the mean pressure attained when the piece attacked is crushed to the amount of $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$ inch respectively. The maximum pressures must exceed those given. The mean pressures are calculated by determining the amount of energy of the falling drop at the instant before stopping—*i.e.*, of the quantity of work done upon it by gravity and stored in it, and dividing that measure in foot-pounds by the distance through which the crushing of the "work" takes place. These figures are seen to be simply enormous, and the power of this form of press is evidently limited only by the rigidity of its parts and their strength.

The figures given for the pressures reached when the compression is $\frac{1}{16}$ inch can be obtained only when the anvil is so set and of such material that the yielding there occurring cannot absorb more than the allowed 10 per cent. of the total work of the falling mass. The same remark applies to the table generally, but the loss may always be expected to fall within the assumed figure for the smaller weights and lesser heights fallen through. If the machine is well built and the anvil and foundation are of ample size and rigidity for good work, it is not improbable that the higher figures can be readily obtained; provided also that proper precautions are taken in the setting of the press.

The *intensity* of pressure attainable is evidently determined by the

area of the surface exposed to the action of the drop, and this in turn determines the distance through which crushing may occur. The figures given in the table are total pressures, and the mean intensity of pressure corresponding to these amounts is to be obtained by dividing the total pressure as shown in the table by the area of section of the crushed piece, or by the mean area opposed to the crushing action during the operation. The proper comparison is that of the energy of the falling weight with the "resilience," elastic or total, or both, of the mass on the anvil or in the dies.

PRESSURES OF THE DROP-PRESS.—(EFFICIENCY 90 PER CENT).

		Weights of Drop								
Fall of drop in feet and inches.	Compression in inches.	Pounds. 50.	Pounds. 100.	Pounds. 200.	Pounds. 400.	Pounds. 600.	Pounds. 800.	Pounds. 1,000.	Pounds. 1,500.	Pounds. 2,000.
0'3"	1-16"	2,160	4,320	8,640	17,281	25,921	34,562	43,202	64,803	86,405
	1/8"	1,080	2,160	4,320	8,640	12,960	17,281	21,601	32,401	43,202
	1/4"	540	1,080	2,160	4,320	6,480	8,640	10,800	16,200	21,601
0'6"	1-16"	4,320	8,640	17,281	34,562	51,843	69,124	86,505	129,607	172,811
	1/8"	2,160	4,320	8,640	17,281	25,921	34,562	43,202	64,803	86,405
	1/4"	1,080	2,160	4,320	8,640	12,960	17,281	21,601	32,402	43,202
0'9"	1-16"	6,480	12,960	25,921	51,843	77,764	103,686	129,608	174,412	259,216
	1/8"	3,240	6,480	12,960	25,921	38,882	51,843	64,804	87,206	129,608
	1/4"	1,620	3,240	6,480	12,960	19,441	25,921	32,402	43,603	64,804
1'0"	1-16"	8,640	17,281	34,562	69,124	103,687	138,249	172,811	259,216	345,622
	1/8"	4,320	8,640	17,281	34,562	51,843	69,124	86,405	129,608	172,811
	1/4"	2,160	4,320	8,640	17,281	25,922	34,562	43,202	64,804	86,405
1'6"	1-16"	12,960	25,921	51,843	103,686	155,529	207,373	259,216	388,824	518,432
	1/8"	6,480	12,960	25,921	51,843	77,764	103,686	129,608	194,412	259,216
	1/4"	3,240	6,480	12,960	25,921	38,882	51,843	64,804	97,206	129,608
2'0"	1-16"	17,281	34,562	69,124	138,249	207,373	276,498	345,622	518,433	691,244
	1/8"	8,640	17,281	34,562	69,124	103,686	138,249	172,811	259,216	345,622
	1/4"	4,320	8,640	17,281	34,562	51,843	69,124	86,405	129,608	172,811
2'6"	1-16"	21,601	43,202	86,405	172,811	259,216	345,622	433,028	648,042	864,056
	1/8"	10,800	21,601	43,202	86,405	129,608	172,811	216,014	324,021	432,028
	1/4"	5,400	10,800	21,601	43,202	64,804	86,405	108,007	162,010	216,014
3'0"	1-16"	.....	51,843	103,686	207,373	311,059	414,747	518,433	777,649	1,036,866
	1/8"	.....	25,921	51,843	103,686	155,529	207,373	259,216	388,824	518,433
	1/4"	.....	12,960	25,921	51,843	77,764	103,686	129,608	194,412	259,216
3'6"	1-16"	.....	.....	120,967	241,935	362,902	483,871	604,838	916,257	1,209,677
	1/8"	.....	.....	60,483	120,967	181,951	241,935	302,419	458,128	604,838
	1/4"	.....	.....	30,241	60,483	90,975	120,967	151,209	229,064	302,419
4'0"	1-16"	.....	.....	.....	276,498	414,747	552,996	691,244	1,036,866	1,382,488
	1/8"	.....	.....	.....	138,249	207,373	276,498	345,622	518,433	691,244
	1/4"	.....	.....	.....	69,124	103,686	138,249	172,811	259,216	345,622
5'0"	1-16"	.....	.....	.....	.....	518,434	691,245	864,056	1,296,084	1,728,112
	1/8"	.....	.....	.....	.....	259,217	345,622	432,028	648,042	864,056
	1/4"	.....	.....	.....	.....	129,609	172,811	216,014	324,021	432,028

The limit to the resistance of any mass on the anvil is found at the

pressure at which the metal will "flow" continuously. This pressure varies not only with the kind of metal, but also with every variation in the chemical composition, the physical structure or the form and method of support of the piece. For general use the value of this "modulus" may be taken at about the value of the shearing resistance of the material. For soft wrought iron, for example, it may be taken at about 50,000 pounds per square inch (3,515 kg. per sq. cm.) for moderately hard iron at a figure 20 per cent. higher, and for pure copper at about one-half the latter figure. There is, however, a great difference in the behavior of the two metals under pressure. The former has a distinct elastic limit in its original state which becomes "exalted," as was shown by the writer some ten years ago, when the piece is distorted, and becomes approximately equal to the maximum force, producing change of form, remaining permanently altered. The metal thus transformed does not yield subsequently to any less pressure. It will not flow under any pressure less than that which is required to produce distortion immediately upon its application. Copper, however, has no true and measurable elastic limit in its original condition as found in the market, and it does flow under the continued action of forces far less than those required to produce rapid and continuous distortion by steady pressure. A load which produces no visible effect when first applied will after a time be found to have caused a very decided, and often a very extensive, alteration of the form of the mass. This is also a now well-known property of some kinds of brass and of many other metals belonging to what the writer has called the tin class, to distinguish them from the metals of the iron and steel class, which do not exhibit this treacherous behavior. This difference is of some importance, not only as indicating the best method of working them, but also as showing that the first of these two classes is a safer class to deal with where the metal is to be used in the carrying of heavy and unintermitted stress than is the second class.

Another important distinction between these two classes is, as indicated by the results of investigations made by the writer, that the "iron class," which includes all the irons and all of the steels, offers more resistance as the rupturing action is slower, while the "tin class," which includes nearly all the other metals and very nearly all of the alloys that the writer has ever tested, yields the more readily the more slowly the distortion goes on. The second class is thus subject to that

singular kind of change of form under heavy, continuous stress which is illustrated in the movement of all viscous solids—ice, for example, as seen in its flow in the glacier. This, it seems probable, may often occur under pressures far within those which are required to cause change of form in the testing machine in the ordinary methods of test. Iron has been found by Vicat, and later by the writer, to exhibit some such a phenomenon, but only when the pressures are considerably above one-half those usually found for the moduli of rupture, and this action is only seen in serious degree when the iron has been annealed and thus softened. Common merchant iron, so far as the writer is aware, does not show any tendency to such slow and imperceptible yielding under moderate loads.

The bearing of these facts upon the value of the drop press as a means of working iron and other metals into shape is obvious. Change of form can begin only when the elastic limit of the material is passed, and flow can progress steadily and uninterruptedly only when the pressure applied is in excess of the resistance of the metal in question to flow. The soft metals which belong to the "tin class" are best attacked by processes which cause a comparatively slow motion of their particles in changing form; iron and steel, on the contrary, being less resistant at high than at low velocities of flow, are best wrought by methods which produce rapid distortion. Professor Kick, of Prague, has shown very plainly that this difference in the amount of work demanded by the soft metals under the two kinds of treatment may amount to a very important quantity. He finds that the distortion of bodies by the action of the hydraulic press and by the action of a hammer dealing a succession of blows to produce the same change of form consume power in the ratio, in some cases, of one to ten. It is thus evident that the hammer or the drop is to be used for those special cases in which the pressures desired can not be reached by ordinary methods, and that it is best adapted to the working of iron and steel. The hydraulic press and automatic machinery are to be preferred where they can be conveniently and cheaply used. For much of the work that is now done in our smaller kinds of manufacturing, the drop has been shown by experience to be the only machine which will give the required enormous pressures and do the work rapidly and cheaply.

The maximum area of surface exposed to pressure which will be allowable for any given amount of compression can be determined

approximately by dividing the total mean pressure due to the action of the drop with the given fall, and the proposed compression by the maximum resistance of the material. The maximum area which will permit any action upon the surface is to be ascertained by dividing the same maximum pressure due the fall of the drop by the elastic limit of the metal in compression.

The total work absorbed, or the resilience of the mass, up to the elastic limit is to be measured by multiplying the elastic resistance by one-half the percentage of compression which marks the elastic limit; the result measures the resilience in inch-pounds when the unit of measure is the inch, and in centimeter-kilograms when the units are metric. The total work done in any permanent change of shape is proportional to the volume affected and to the maximum resistance of the material to such deformation.

What figures shall be adopted for the resistance to be calculated upon in the production of flow in metals subjected to the action of the drop press is a question which the writer is unable to answer definitely. It would seem probable that the effect of the blow may be, in the case of cold metal, somewhat similar to that of cold-rolling, and, this being the case, the initial resistance to flow must be taken as at least 70,000 pounds per square inch (4,921 kg. per sq. cm.) and the resilience during flow at as high as 70,000 inch-pounds per cubic inch (4,921 kg. m., per cubic centimeter) for good common wrought iron. It may be safe to take the figure for hot iron, as usually wrought at less than one-half this amount. For copper the writer would, in the absence of exact data, take the work of deformation to be two-thirds that of iron for pieces of small section, and would expect a great increase of resistance with either metal when the surface acted upon by the drop becomes large in proportion to its thickness. Probably no very reliable figures can yet be given. Whatever the resistance may be, the drop will be very certain to overcome it, and the variation in its amount will simply determine how many blows must be struck to obtain a given amount of change of form.

Phosphorescent Paper.—The *Papier Zeitung* gives the following recipe for preparing a waterproof paper, which will shine in the dark: 10 parts water, 40 parts paper stock, 10 parts phosphorescent powder, 1 part gelatine, and 1 part bichromate of potash.—*Dingler's Journal*, November, 1882. C.