THE HARDINGE CONICAL MILL FOR FINE GRINDING.

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Crushing is not confined to the efforts of the metallurgist alone, but it has an equally wide range, or even wider range, as it finds its way into commercial industries, so numerous and varied that though we may have given years to the subject, in the same manner as have all metallurgical investigators, our learning is but slight.

Crushing or dividing may possibly be subject to two or three general mechanical principles. Dynamic action due to impact, when the energy forces rend along the lines of

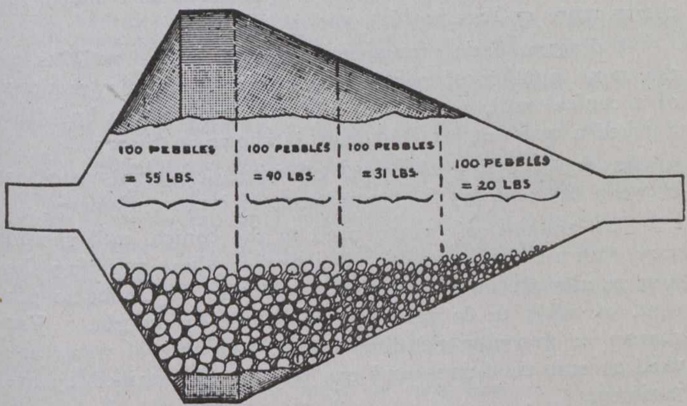

Fig. 1.

least cohesive resistance, or by pressure strains rending through slower separation of the crystals, deforming the mass; or by abrasion and separation from the surface inward. The first can be defined as a blow from a hammer, the second by compression in the jaws of a crusher, but the third is more difficult to define, because of its limited employment owing to its waste of energy, but might be likened to the wearing away of the faces of millstones. Nature in the manufacture of soil from the rocks has employed all three, but evidences would tend to show that in finest division she has been prodigal of her energy, for such fine division has been mainly produced through abrasion, except in the case of the chemical separation in the formation of the many clays. It is with this fine division that we, as metallurgists, are at present interested and how best economically it may be produced. For years the "California" stamp has been the most widely used device for the crushing of ores, and held its position in the first rank because fine grinding, as understood at present, was not a necessity, but with the advance from mechanical separation of the gold and silver content of ores, to that of chemical separation, the necessity for finer and finer grinding in order to liberate the mineral has progressed much faster than the mechanical means to do this fine grinding, so that to-day the stamp is slowly giving way to other applications of crushing energy. We very well remember when in 1895 and 1896 we were shown the first adaptation of the pebble or tube mill, and when told what it would do in the way of fine grinding, there was no hesitancy on our part in declaring that the claims were absurd, but shortly after the small mill was started, we were converted, and became the strongest of advocates of the pebble mill for still further reducing what at that time was considered fine grinding, mainly by stamps and rolls.

In this tube mill was a principal of step reduction not obtained by any mechanical device before that time. The stamp had reached its possible limit because it, with every blow, receded farther and farther from efficiency, owing to increasing disparity of size and weight, between reducer and particle. It has taken a long time to bring us to a recognition of the fact that to economize our energy, the units of force must correspond to the units of matter being acted upon. The well known rule of physics particularly applies here, i.e.: "Crushing strength of a body is in proportion to the area of its section."

We have many times been asked to explain the action within the conical mill, and the cause for its sizing action. Many articles have been written on the theory of the pebble and ball mill, which in turn have produced suggestions and practices resulting in changes of length, diameter, feed, discharge, speed of rotation, charge of pebbles, size of pebbles, etc.

Improvements have been left to the discretion of the machinery designer, who, as a rule, has but little knowledge of the specific technical requirements of the metallurgist, or of where the economic limit begins or ends. We could cite many instances where a lesser expenditure of energy would have improved metallurgical results, and it should be the aim of the metallurgist to fit his machinery to his ore, and not endeavor to adapt his ore to any specific machine. Realizing these conditions, we thought we saw in the conical form of mill a device which could be made more or less adjustable to many classes of ores—from granulation for concentration to sliming for cyanidation, for in the zone of largest diameter, we have all the features necessary for the greatest application of energy, e.g., the largest pebbles or balls, the greatest superincumbent weights, the greatest height of fall and impact due to greatest peripheral speed, and in this zone is found the largest particles of material to be reduced, thus admitting of a much coarser feed than would otherwise be possible if the crushing forces were not segregated. After a first division or reduction, these par-

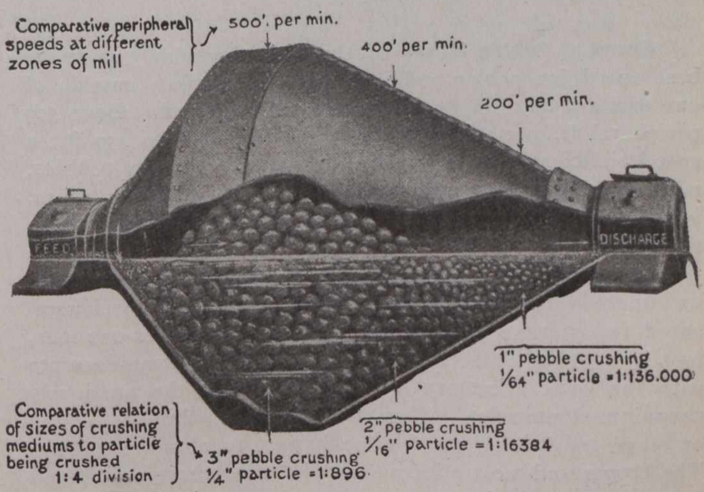

Fig. 2.

ticles, through the action of the displacement, dependent upon their relative mass, travel up the cone, through constantly decreasing zones of size and weight of crushing bodies as well as decreasing energy due to reduction of peripheral rotation speed proportionate to the division of the particles in passing through successive zones, as illustrated in Fig. 1.

In addition to the automatic adjustments of work to mechanical energy, the device is subject to a still further regulation by changing the axis from the horizontal to

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