fine reduction of material to ultimate fineness. The pressure upon the material in the lower pan is increased or lessened by—(*a*) using the total weight of the upper rotary pan and all rollers; (*b*) using the weight of the upper rotary pan and the lower rollers; (*c*) using the weight of the lower rollers only.

In order that my invention may be clearly understood I will now describe the machine by reference to the accompanying drawings, in which Fig. 1 is a side view, half an outside view, and half a vertical section; Fig. 2 is an end view partly in section; Fig. 3 is a plan view, partly a section through upper roller, partly a view of underside of upper pan, partly a view of the bed-plate, and partly a view of the lower pan; Fig. 4 is a section of the lower roller, and of the lower pan and bed-plate; Fig. 5 is a plan partly over upper pan and rollers, and partly over lower pan and rollers. Figs. 6 and 7 are cross section, and side-view respectively, of the driving-boss of the lower rollers.

Within a suitable frame A is a central vertical shaft B, which has at the top a bevel wheel B^1 driven by suitable gearing, the bottom being supported in a footstep or bearing B^2. A lower pan C is fixed at the base of the machine, and is stationary, being provided with two annular grooves C^1, C^2, round which the rollers D D D D are carried by means of the axles M M. These are secured to the central shaft B by a driving-boss W by a hinge connection, which allows them to move a little vertically. The boss W encircles the shaft, and is secured thereto, and is provided with sockets, in which the ends of the axles are secured by horizontal pins.

Above the lower rollers is an upper pan E, which encircles the central shaft B, and is so fitted as to be free to slide up and down the shaft, but is provided with a feather or key, so that it is rotated with the shaft. This upper pan is supported upon two legs or brackets R R, which rest upon the axles M, M of the lower rollers. The rollers F F, of the upper pan are fitted upon axles S S, which do not have a radial motion, but are supported in bearings S^1, S^2, and S^3. The bearing S^1 encircles the central shaft B, and is free to move up and down, while the bearings S^2 and S^3 move up and down in slots in the frame A.

The method of operation of my machine is as follows: The ore or material to be reduced is fed through a spout or hopper into the upper pan E, where it is rapidly crushed between the faces of the rollers F F and the face of the pan. After being crushed, suitable scrapers, which are fixed upon the stationary bars G, come into operation and scrape the broken material through openings E^1 in the inner face of the pan, whence it falls upon the cone H, which deflects it, so that it falls between the lower rollers into the grooves C^1 C^2 in which they work, and is there ground to the requisite degree of fineness.

After being ground the material is pushed through openings C^3 in the inner sides of the grooves C^1 and C^2 by suitable scrapers fixed upon bars K secured to the driving-boss W of the lower rollers, and rotating with it. The material falls into a hopper or chute, and thence, by an elevator, it is carried to a centrifugal or other separator or sieves, where any portions not sufficiently ground are eliminated and returned to the pan for further reduction.

I prefer to work the machine as above described, but in dealing with certain kinds of material it may not be necessary to use all the weight upon the lower rollers. For some material the weight of the lower rollers alone may be sufficient, in which case I support the upper pan, with its rollers, upon a collar, or clamp N (see Fig. 1) secured to the central shaft B. This collar or clamp may be in two or more parts, bolted together and held in position by set-screws or cottars, as preferred. When not thus used, the collar or clamp is secured lower down the shaft. For other material it may be preferred to use the weight of the upper pan without that of its rollers. This is accomplished by supporting the axles of the upper rollers from the top of the frame by means of the brackets or straps P (see Fig. 1) at a sufficient height to still allow them to operate in the upper pan. When greater pressure is required upon the lower rollers, the nuts P^1 are slackened until all the weight, or any desired portion of it, is taken by the pan. Thus, by the use of my one machine, the hardest material may be reduced to fine powder, and work thereby accomplished which generally requires the use of two or more machines, and great economy is effected in the operation.

All the working parts are so designed as to be easily, quickly, and economically replaced, and the machines can be made of any size and weight required.

The whole of my grinding machine is enclosed within a dust-proof casing, whilst all the driving-gear is above the same, so that the driving-gear is entirely free from dust and grit, and the wear consequently thereon.

I do not confine myself to the precise number and shape of rollers, or of the pans and grooves therein, nor to the means of adjusting the weight and bearing of the upper parts, nor to any particular means of rotating the vertical shaft, nor to other details of construction which may be varied without departing from my invention, but—

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is,—

1. In crushing, grinding, or pulverising machinery, two circular pans provided with rollers, one pan and its rollers underneath the other pan and its rollers, the lower rollers carrying the weight of the upper pan and rollers, or of the upper pan, for the purpose set forth.

2. In crushing, grinding, or pulverising machinery, an upper rotary pan provided with legs resting upon the azles of a lower set of rotary rollers, as and for the purpose set forth.

3. In crushing, grinding, or pulverising machinery, an adjustable collar or clamp upon a vertical shaft for the purpose of supporting the weight of an upper pan, or of allowing the weight thereof to rest upon the lower axles as and when required, substantially as described.

4. In crushing, grinding, or pulverising machinery, brackets or straps whereby the axles of the upper rollers are raised and supported for the purpose of removing or reducing the pressure upon the lower axles as and when required, substantially as described.