Sept. 29, 1953 N. L. HALL 2,653,769

ROTARY WEIGHT-IMPACT CRUSHING MILL

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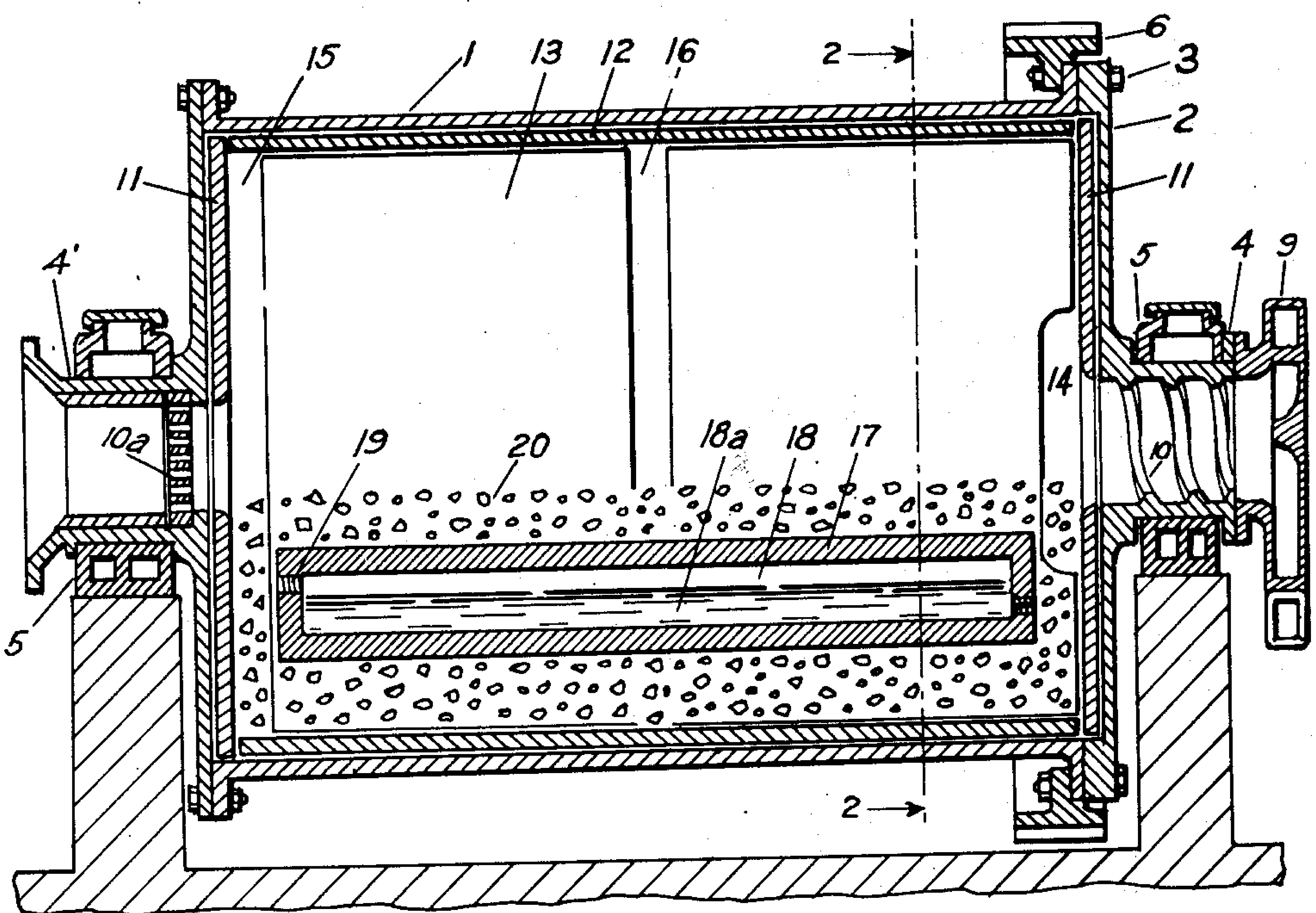

Fig. 1.

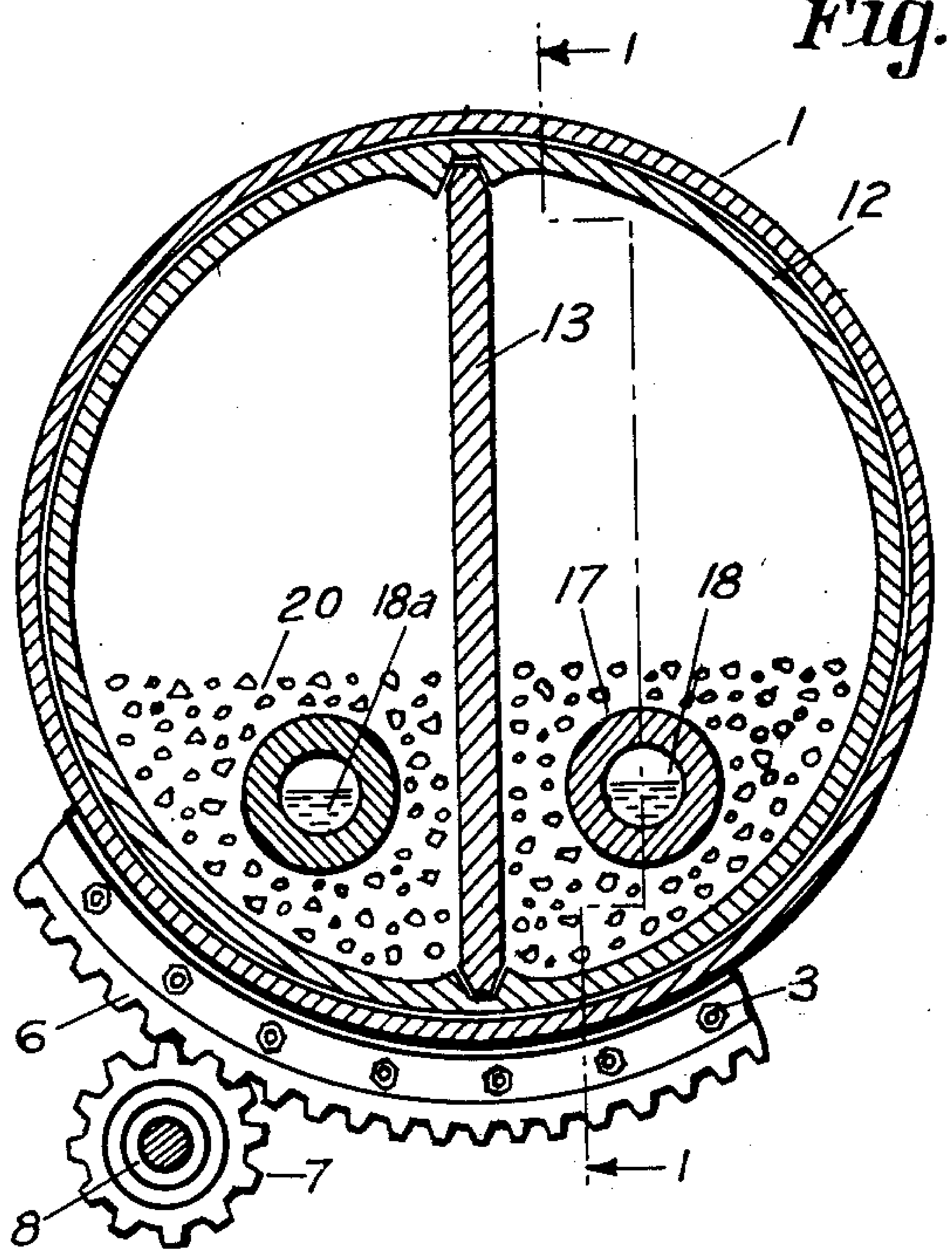

Fig. 2.

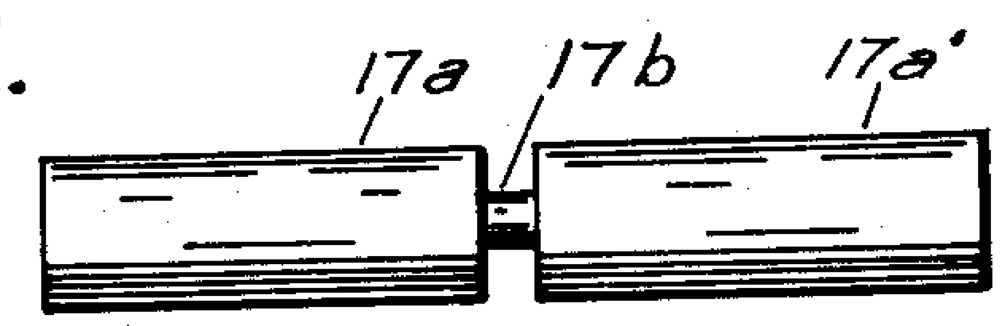

Fig. 3.

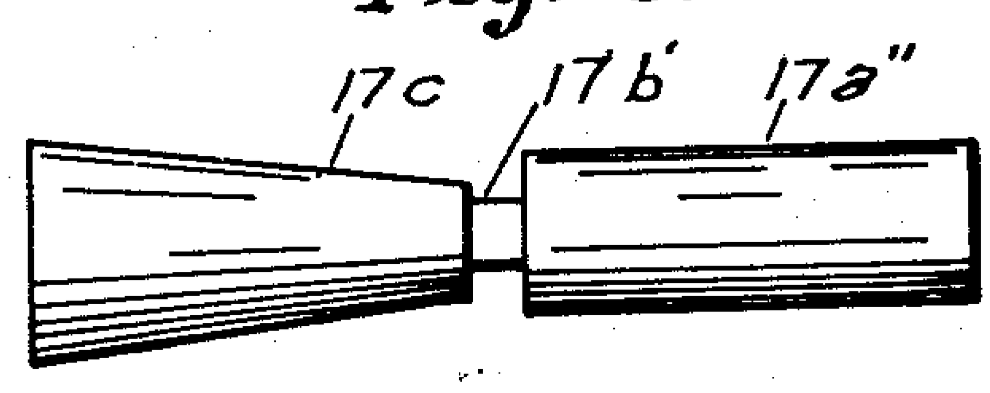

Fig. 4.

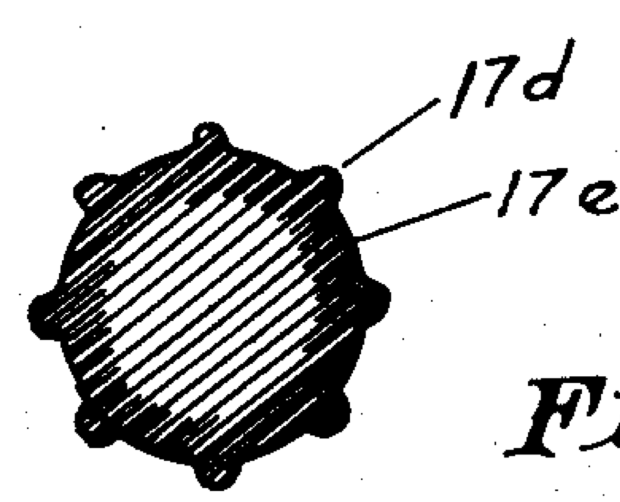

Fig. 5.

INVENTOR.
Newton L. Hall

ROTARY WEIGHT-IMPACT CRUSHING MILL

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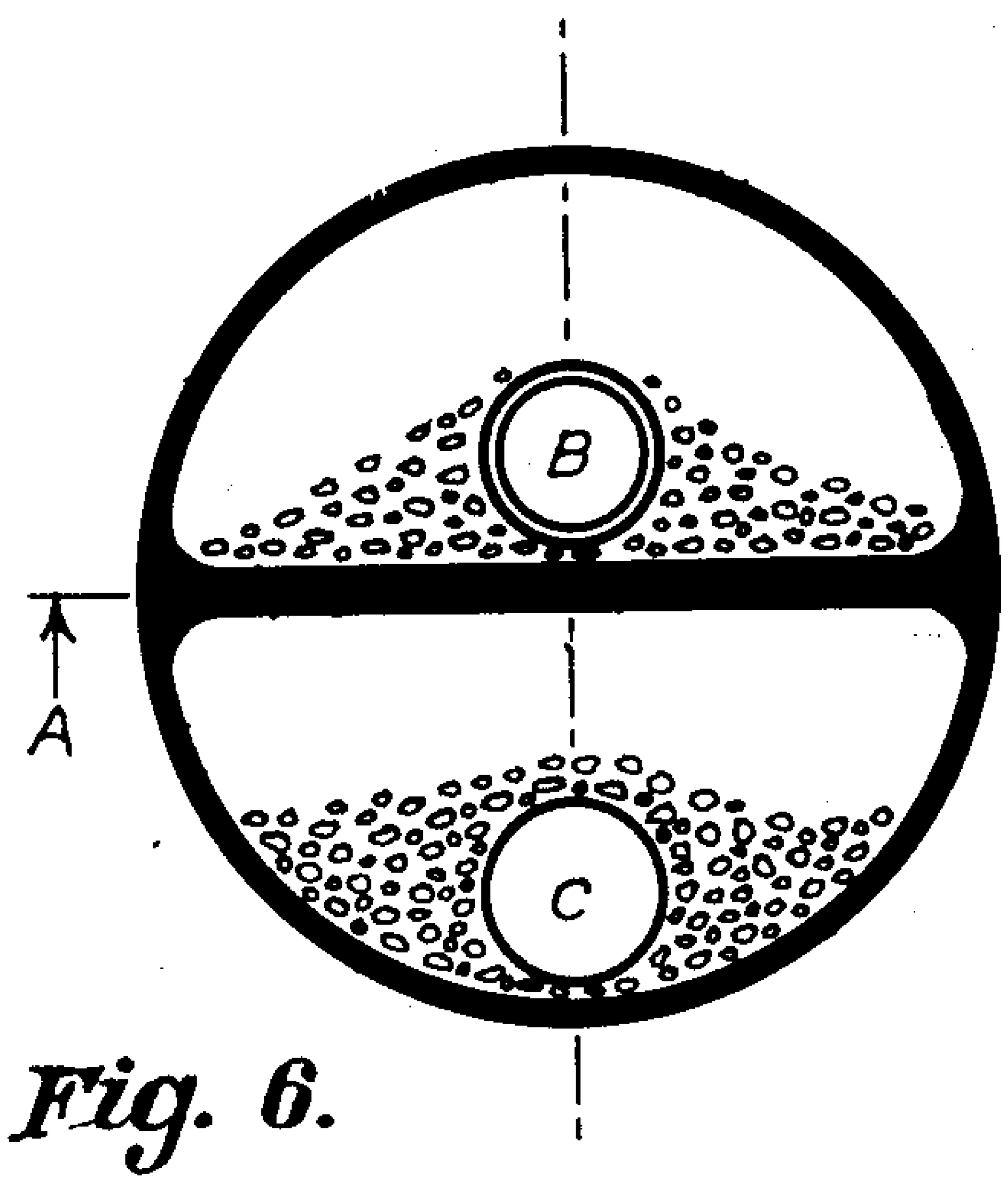

Fig. 6.

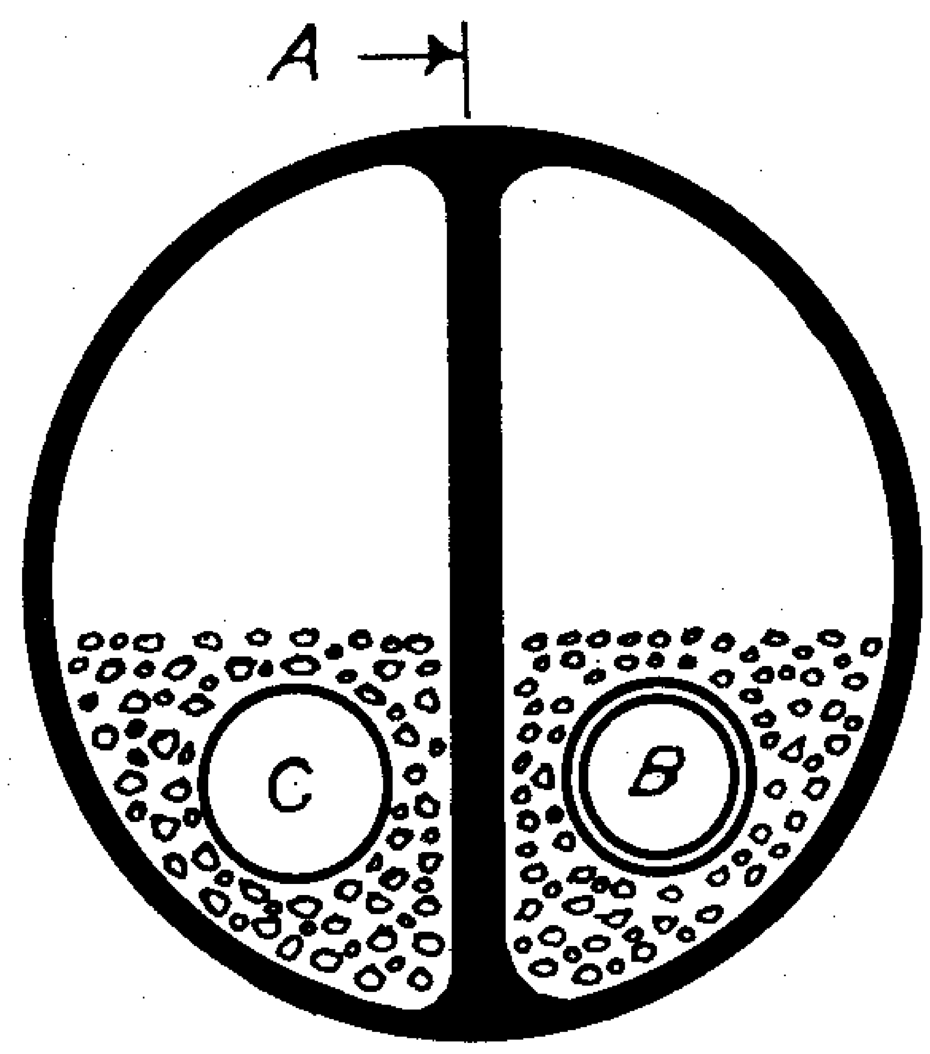

Fig. 7.

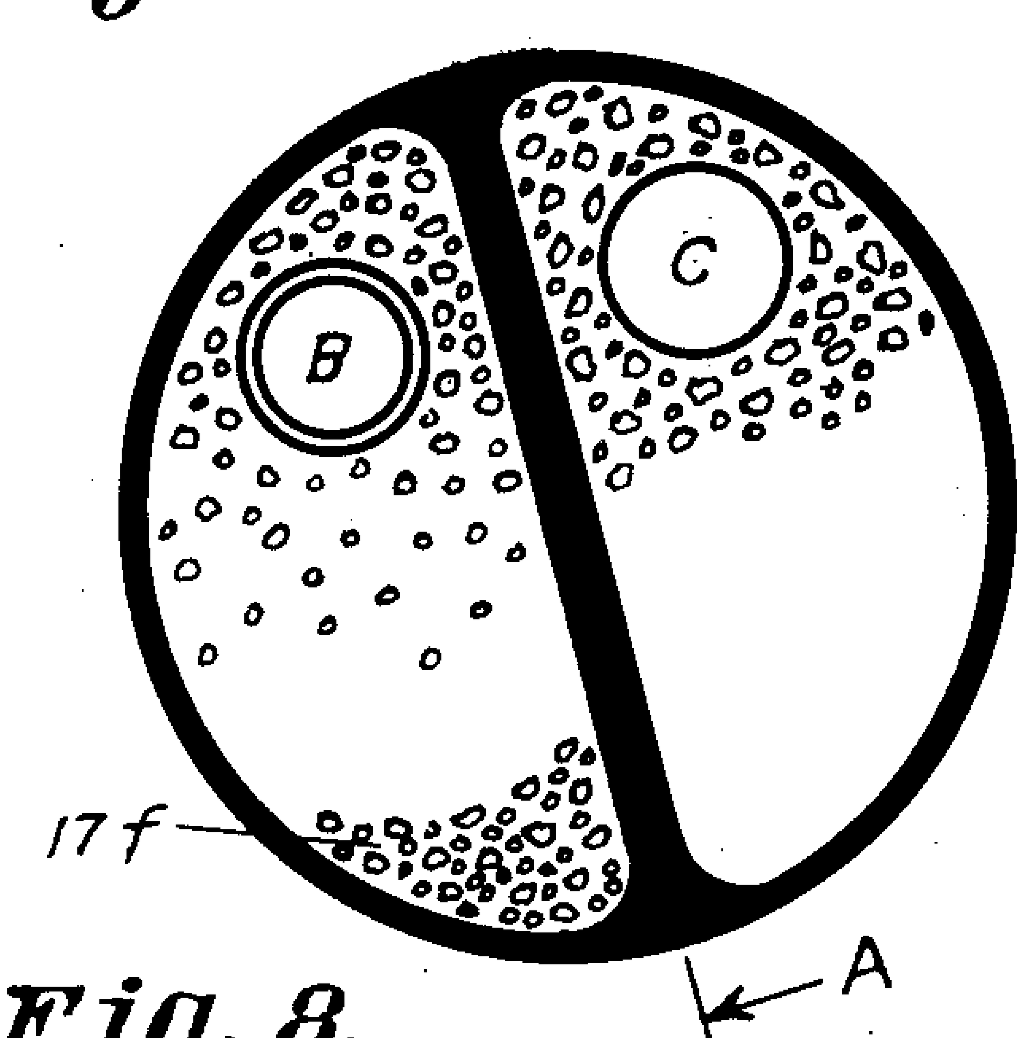

Fig. 8.

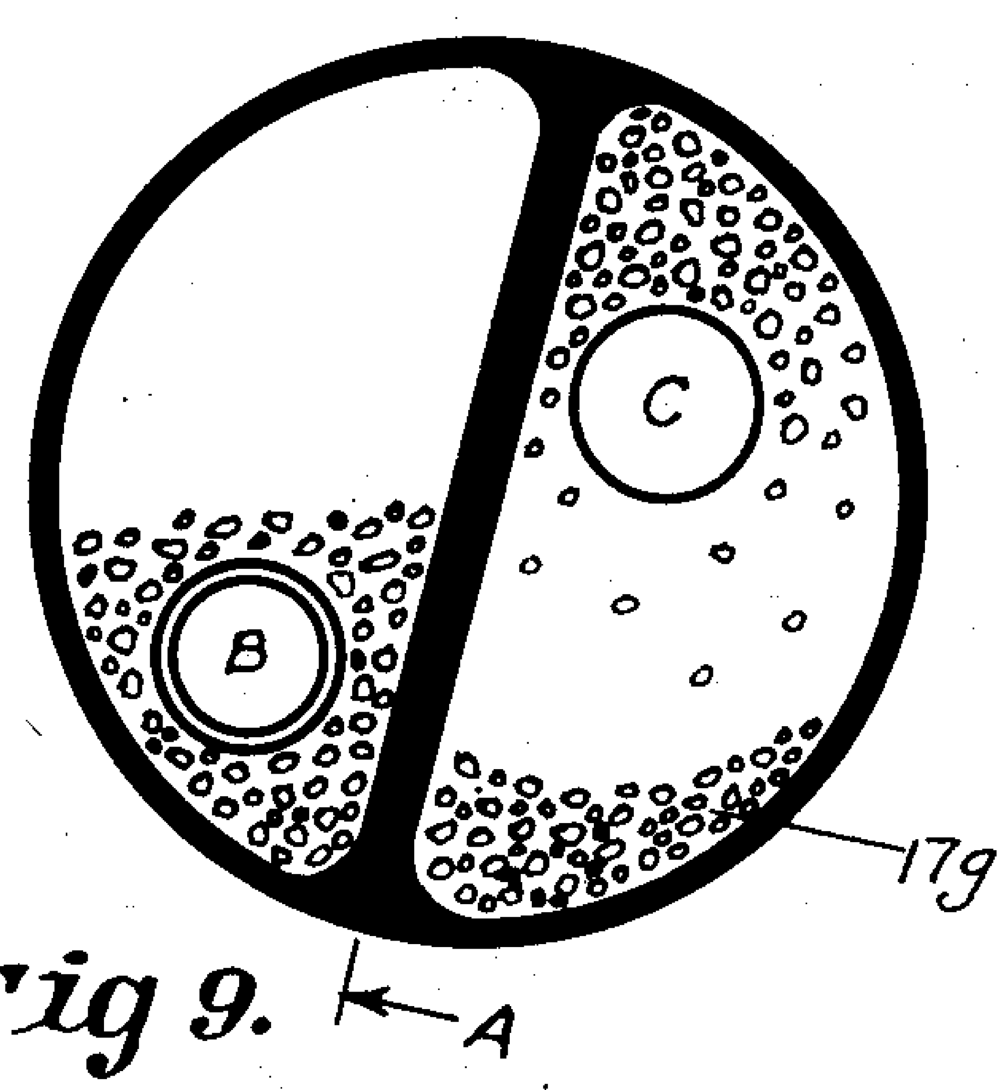

Fig 9.

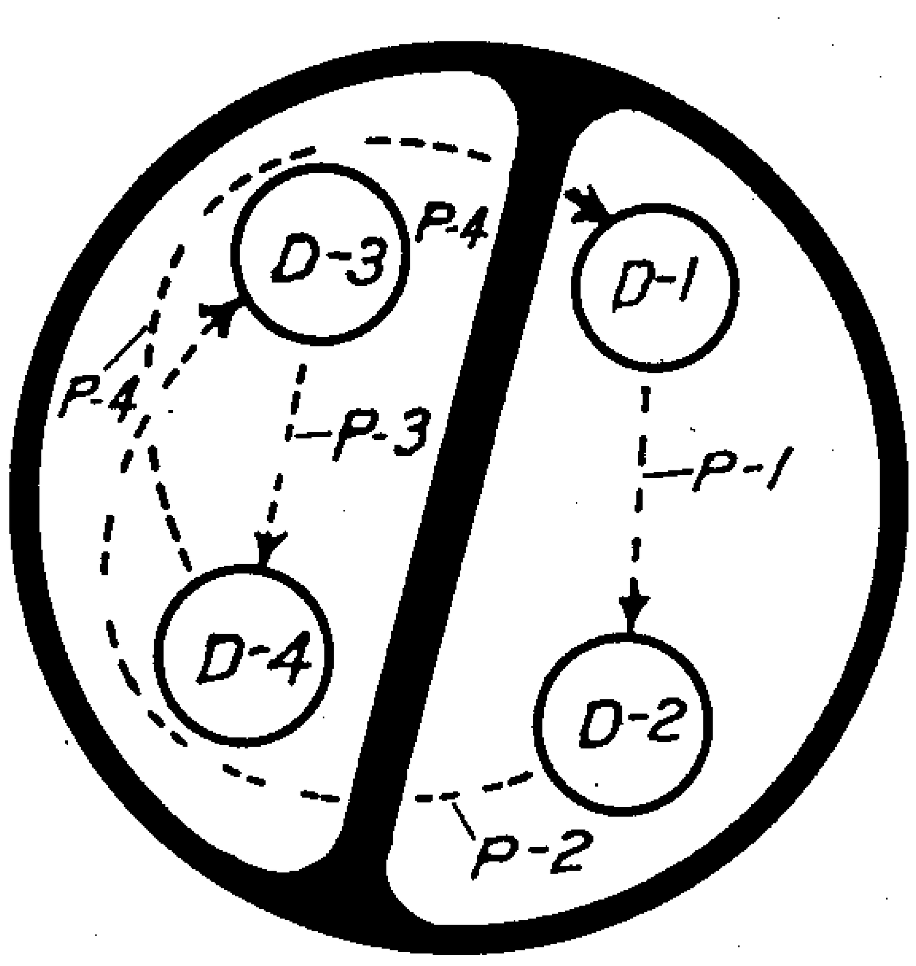

Fig. 10.

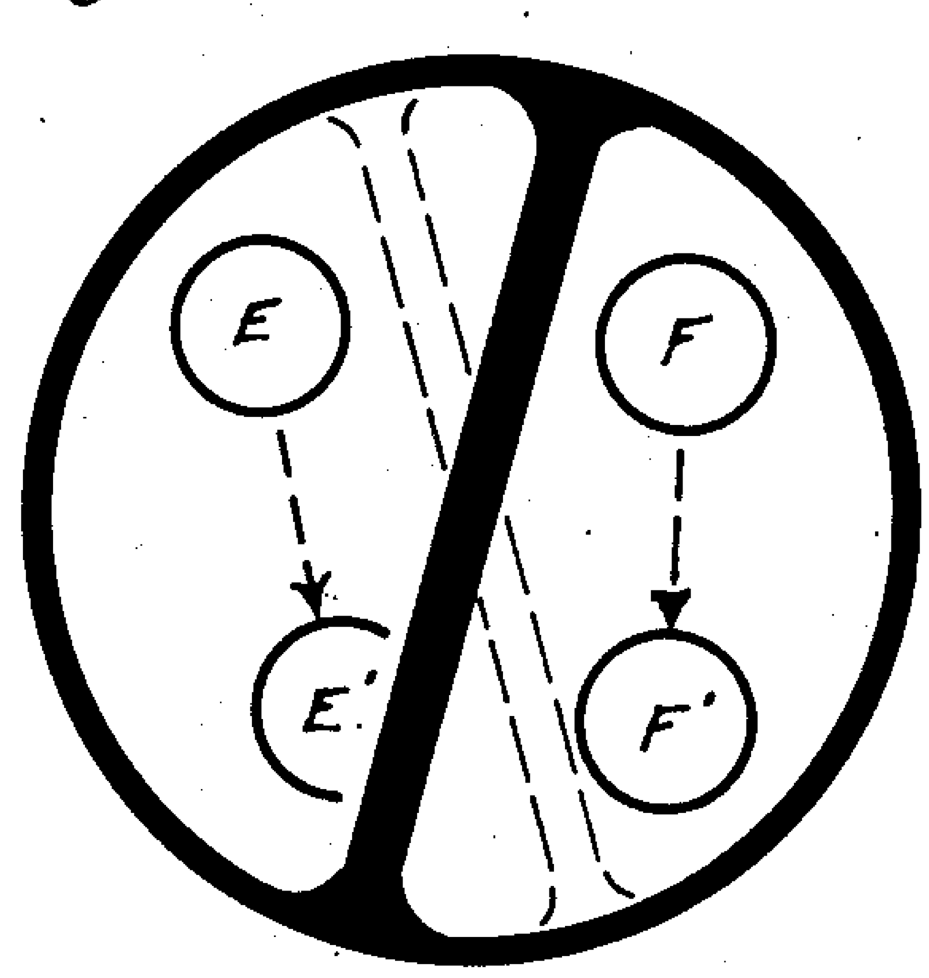

Fig. 11.

INVENTOR.

Newton L. Hall

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ROTARY WEIGHT-IMPACT CRUSHING MILL

Newton L. Hall, Long Beach, Calif.

Application August 22, 1950, Serial No. 180,752

3 Claims. (Cl. 241—137)

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This invention relates to rotary crushing or pulverizing mills used for the crushing or fine grinding of ores, cement, or other granular material.

Under the trade name of "rotary impact crushing mill" it is used for the crushing, grinding or comminuting of rocks, the dressing of ores, or the fine grinding of materials to a dry powder, or a wet pulp, and wherein a load of primarily crushed rock or material is freely tumbled in a revolving cylinder of longitudinal compartment design to develop its secondary crushing or finer grinding with a crushing medium of concentrated load-weights, one for each compartment, freely tumbling within the mill and its load to assist in the comminuting operation.

In this class of mills the load is subject to a tumbling action or falling in a drum or other rotating receptacle as distinguished from machines in which the material is broken up by the crushing action of stamps, rolls, jaws, or similar crushing elements.

One of the objects of the invention is, to provide a rotary mill with concentrated load-weights to develop an internal crushing action within the load, and, between the load-weight and the mill shell and compartment wall.

Another object of the invention is, to concentrate the crushing medium into a compact body of considerable weight and to eliminate the use of crushing media of comparatively small size units of light weight thereby concentrating and enlarging the effective crushing action and reducing the extent of wearing surface exposed to crushing action and wear on both the crushing media, the mill shell lining, and on the compartment wall.

Another object of the invention is, to provide a rotary mill with longitudinal load-weights which effectively advance the transient material passing through the mill by virtue of the load-weight shape and falling action.

Other objects of the invention will become apparent as the invention is disclosed.

This invention consists in the details of construction, and the arrangement and combination of the several parts of my improved rotary impact crushing mill whereby certain important advantages are obtained as will be hereinafter more fully set forth.

In the following descriptions reference is made to the accompanying drawings wherein:

Figure 1 is a longitudinal vertical section of a rotary mill, taken on line 1—1 of Figure 2 and embodying one form of my invention;

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Figure 2 is a cross section of a rotary mill taken on line 2—2 of Figure 1 and showing the driving gears in partial cut;

Figure 3 is a side elevation of a load-weight of a twin cylinder of a dumb bell type;

Figure 4 is a side elevation of a load-weight showing a modification for one of variable sections;

Figure 5 is a cross section of a fluted load-weight;

Figure 6 is a diagrammatic cross section of the cylinder of a compartment mill with the compartment wall in a horizontal position as it would be in starting, and with the load and load-weight shown in each compartment;

Figure 7 is a diagrammatic cross section of the cylinder of a compartment mill, similar to Figure 6, with the compartment wall in a vertical position and with the load and load-weights in a lowered position, the mill advance being noted in each view from the position of the arrows A;

Figure 8 is a diagrammatic cross section of the cylinder of a compartment mill, similar to Figure 7, with the compartment wall shown in an advanced position and with the load and load-weights having been carried towards the zenith of the mill interior and prior to the falling of the loads from their positions;

Figure 9 is a diagrammatic cross section of the cylinder of a compartment mill, similar to Figure 8, with the compartment wall in a further advanced position and with the rearward load and load-weight having fallen to a lower position prior to the falling of the forward load and load-weight and which follows in sequence, the mill advance being noted from the position of the arrow A;

Figure 10 is a diagrammatic cross section of the cylinder of a compartment mill, with the same load-weight shown in various positions, without the load, and showing the orbit of a single load-weight in passing through one revolution of the mill;

Figure 11 is a diagrammatic cross section of the cylinder of a compartment mill, showing the compartment wall in dotted lines for position when the rearward load takes its first fall, followed by an advanced position of the wall in full lines, whereupon the forward load takes its fall secondly, the sections of the view being shown without the load.

Similar reference characters refer to similar parts in all of the views.

In the description herein used the term "compartment mill" specifically applies to a mill with its interior divided into two semi-cylindrical and longitudinal compartments, formed by virtue of a diametral wall extending from side to side of the mill interior, and substantially the full length of the mill, such a wall revolving with the mill shell and effecting the characteristic compartment mill action. Compartments of other cross section, developing a similar action, could be used without departing from the spirit of the invention.

As used herein, the term "load" refers to the material being ground. The term "load-weight" refers to the concentrated crushing medium or cylinder as used in the current descriptions.

The term "mill load" refers to the combined load within the mill including both the material being ground and the grinding media.

Referring to the drawings:

Figure 1 is a longitudinal vertical section of a mill embodying one form of my invention wherein the cylindrical mill shell **1** has heads **2** which are attached thereto by the bolts **3**, and having integral therewith hollow trunnion bearings **4** which rotate in the supporting bearings **5**, the cylinder as a unit being revolved by the drive gear **6** which in turn is actuated by the pinion **7** and which is motivated by the drive shaft **8** from any suitable motive power; see Figure 2.

The hollow trunnion **4** at the feed end of the cylindrical mill is fed by means of the scoop **9** which discharges its load into the hollow trunnion where it is advanced by the internal thread **10** which revolves with the mill trunnion **4**. At the discharge end of the mill, the discharge trunion **4'** with its screen grate **10***a* grades the circulating load in its advance and discharge from the mill.

The mill shell has protecting liners on its interior, for the heads **11**, and for the cylindrical shell **12**. Extending diametrally across the mill from wall to wall, a compartment wall **13** extends substantially from head to head of the mill dividing the mill interior into two semi-cylindrical compartments.

At the feed end of the mill the compartment wall is recessed at **14** to provide for a better distribution of the entering and advancing feed. At the discharge end of the mill the wall is discontinued to provide space **15** for a combination of the loads from each compartment prior to their passing through the grate **10***a* and the discharge trunnion **4'**. The diametral compartment wall is opened by the space **16** which effects a clear and open slot provision extending from wall to wall of the mill shell and provides for a free and unobstructed passage of a portion of the load to equalize the loads on each side of the compartment wall during action.

As shown in Figures 1 and 2, a circulating load **20** carries within it an elongated cylindrical load-weight **17**, substantially the length of the mill interior, one for each compartment and which move freely within the respective load as the mill is revolving under action. For the purpose of varying the weight of this load-weight, it is formed hollow and the weight can be varied by loading within its interior **18**, liquid as **18***a*, through the plugged vent **19**.

The load-weight as shown in Figure 3 is formed of two similar cylinders **17***a* and **17***a'*, rigidly connected at the neck **17***b* to act as one body, and provides for a contracted opening at the neck to co-act on the load through the open space of the wall **16**.

The load-weight as shown in Figure 4 is formed of varying cross section, one as a true cylinder **17***a''*, and the other as a truncated cone **17***c*, being rigidly connected at the neck **17***b'*. The conical shape of the load-weight in falling has a resultant thrust upon the load parts and the cone can be used to advance such parts in one direction, or retard them to the opposite direction as the load parts are migrating through the mill.

As shown in Figure 5, the cross section of a weight cylinder has ribbed projections **17***d*, and the exterior portions near the surface of the load-weight can be hardened as at **17***e* to improve its wearing qualities. The load-weight can be of any suitable cross section to engage and confine the load to produce an effective crushing action.

As shown in Figure 10, the orbit of one load-weight during one revolution of the mill: The position of the wall in starting being the same as for Figure 9 with the load-weight D–**1** falling through the orbit or path P–**1** to the position D–**2**, then ascending through the path P–**2** to the position D–**3** (the position of the wall as shown being disregarded) then falling through the path P–**3** to the position D–**4**, then ascending through the path P–**4** to the position D–**1**, the place of beginning.

As shown in Figure 11, with one load-weight in each compartment, and with the position of the compartment wall as shown in dotted lines; the load-weight E takes a first fall to the position E', and with the advance of the wall to the position as shown in full lines, the load-weight F follows with a fall to the position F'. Each load and load-weight in falling—following the advancing wall in its rotation—falls first in a short fall rearward of the compartment wall, followed by a fall of the load and load-weight forward of the wall into a longer fall. Each half load with its load-weight receives two falls for each revolution of the mill, one as it follows the wall in a short fall, and then as it is carried to the zenith of the mill interior, in a longer fall on the side in advance of the compartment wall.

Referring to a mill of a full cylindrical cross section and without a diametral wall as a "plain mill": A concentrated load-weight within a freely tumbling load of a plain mill will vary its positions within the load, for its position is uncontrolled and the center of gravity of such an erratic load is constantly changing position and may be anywhere within the mill-load. The motive power applied to a plain mill with a homogeneous load is constantly being influenced by irregularities of the mill-load in its positions and the revolving mill-load with its crest in cascade does not place a uniform resistance upon the motivating power. Placing a concentrated load-weight within such a load exaggerates the conditions, for the load-weight can take any position within or on the load and do so without control, and the position of the center of gravity of the revolving load and load-weight is variable and constantly without control.

The use of a compartment mill with its diametral wall and divided load and load-weights changes the fundamental conditions of action; Although the load-weight is freely tumbling the compartment wall controls its position and it does not have an unrestricted freedom of action, and if the load and load-weights are correctly proportioned for size and weight, the load-weight will retain its position submerged within the load and in action the load-weight will seldom strike the mill shell or diametral wall and a cushion of a part of the load will be in advance and positioned between the load-weight and the shell, or wall.

The compartment mill necessitates that the mill load take two falls for each revolution of the mill and in so doing, parts of the load will fall ahead of the load-weight and be in position to receive and cushion the load-weight in its fall, and the fallen load will receive the concentrated crushing action between the load-weight and the mill shell, or, compartment wall. As shown in Figure 8, that portion of the load which has fallen, as 17f, will be in position to receive the load-weight B in falling, receiving a crushing action between the load-weight and the mill shell, and to the fallen position of the load-weight B as shown in Figure 9. The wall and mill being advanced to the position as shown in Figure 9, a portion of the load 17g, having fallen in advance to receive the load-weight C, develops a similar crushing action on the load between the load-weight and the mill shell.

As characteristic of the compartment mill, the compartment wall provides the lifting provision for the load and no internal shell projections for lifters for engaging the load are required, thereby allowing the full transverse dimension of the mill section to be available for effective mill load action.

Mills which use small balls or slugs intermixed as a grinding media within the load, act without a control of the mill load parts and the balls can strike in any direction and wear on other balls, or, on the mill lining, and do so indiscriminately without developing any effective crushing action on the material to be ground, accordingly, and unless material to be crushed is positioned between the steel parts, such work is wearing on the steel parts without a grinding effect on the material.

The compartment mill can have its mill load adjusted to suit the density of the material to be ground and when properly adjusted for size and weight, the load-weight can be maintained submerged within the material load so that the full action of the load-weight can be exerted in crushing the material in which it is submerged. When under rotation, any irregularity of the centers of gravity of the load parts is balanced and absorbed within the weight of the mill structure. The mill load of one compartment is balanced over the mill supports by the mill load of the corresponding compartment.

The load-weight is preferably cylindrical, of a hardened or tough steel surface capable of resistance to wear and presents a concentrated weight to develop an enlarged and effective crushing force on the load, and by virtue of its position control as offered by the compartment mill feature, the weight can be submerged within the load by further virtue of its variable weight to produce a concentrated crushing action internal to the load and do so without bringing the crushing medium into contact with the mill shell or its parts and avoid non-essential contacts with their destructive wear.

The mill load can be a combination of materials to be ground, intermixed with grinding balls if desirable to form a secondary grinding media, combined with the load-weights for forming the primary grinding media.

As the load of each compartment falls it changes position with the contained air within the compartment and in addition to the crushing actions as described, the intermixing air can float and carry in suspension the extreme fines and

fibres of the load by an air swept system for removal from the mill.

The load-weight can be of various shapes and sizes to develop the desired result when falling upon or within the mill-load, or load. The weight can be formed with various cross sections so that in falling upon the load it can advance or retard the parts of the load as desired by virtue of the resultant thrust as induced by the shape of the load-weight.

The effective crushing action of the falling concentrated load-weight upon the load can develop an enlarged crushing or impact action, and by reason of the load-weight being submerged within the load and not striking the mill shell or wall, an enlarged impact is produced in crushing the material than would be the case wherein a mass of small balls were used as a crushing media, accordingly, the range of size for the mill feed can be decidedly changed or enlarged, the result being accomplished with an economy of steel wear upon the mill parts.

In the conventional plain mill using small balls as a grinding media within a mill load and grinding a wet pulp, clean washed balls are not as effective in grinding as when using a pulp of lower moisture content thereby developing a muddy coating to the ball whereby the pulp sticks to the ball and is held in position to receive the contacting impact of adjoining and cascading balls, and thus a load pulp can be of too high a moisture content for effective grinding.

In the compartment mill using a load-weight within the mill load, the crushing or grinding action of the load-weight upon the load is independent of the moisture condition of the load pulp and an effective crushing action is developed by the load-weight in falling upon the load, regardless of the moisture content of the load.

I claim:

1. In combination: a horizontal rotary mill comprising; a cylindrical casing having openings at both ends for receiving and discharging material; and a wall within the casing lying substantially in a diametral plane and extending across the full diametral width of the casing and longitudinally for a major portion of the length of the casing to divide the interior thereof into two compartments; said wall being provided with an opening intermediate its ends extending across the full diametral width of the casing to provide for free passage of material by gravity through said opening from each compartment to the other, and a single elongated cylindrical major load-weight extending approximately the full length of and in each of said compartments, said load-weights having intermediate sections of reduced diameters spaced in conformity with said intermediate openings of said wall to provide a co-action within and between the said materials passing through said openings during rotation of the mill.

2. A horizontal rotary mill comprising: a cylindrical casing mounted for rotation about its longitudinal axis; a wall within the casing lying substantially in a diametral plane and extending across the full diametral width of the casing and longitudinally for the major portion of the length of the casing to divide the interior thereof into two substantially semi-cylindrical compartments; and a single major load-weight disposed in each of said compartments and free to move therein upon rotation of the casing, each of said load-weights extending longitudinally for a greater portion of the length of the casing.

3. A horizontal rotary mill comprising: a cylindrical casing mounted for rotation about its longitudinal axis; a wall within the casing lying substantially in a diametral plane and extending across the full diametral width of the casing and longitudinally for a major portion of the length of the casing to divide the interior thereof into two substantially semi-cylindrical compartments; said wall being provided with an opening intermediate its ends and extending across the full diametral width of the casing to provide for free passage of material in divided condition by gravity through said opening from each compartment to the other upon rotation of the casing; and a single major load-weight disposed in each of said compartments and free to move therein upon rotation of the casing, each of said load-weights extending longitudinally for a greater portion of the length of the casing and extending across said opening and projecting beyond the position of said opening toward each end of the casing so as to be retained in its respective compartment.

NEWTON L. HALL.

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