Oct. 2, 1934. C. L. CARMAN 1,975,501

TUBE MILL OR BALL MILL

Original Filed Nov. 19, 1928 2 Sheets-Sheet 1

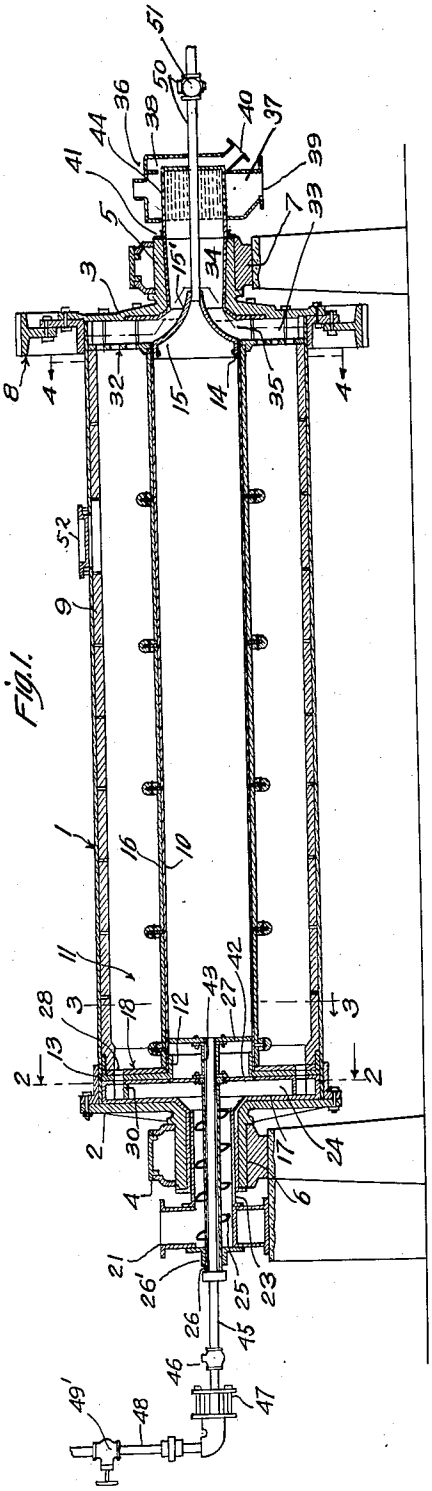


Fig. 1.

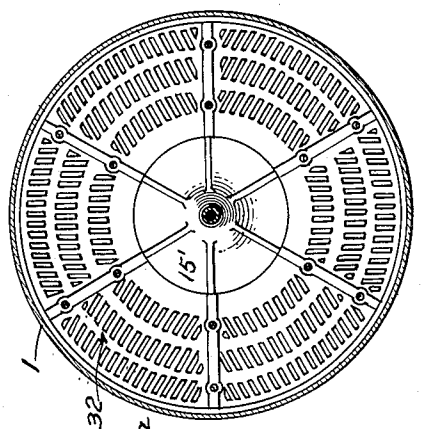


Fig. 4.

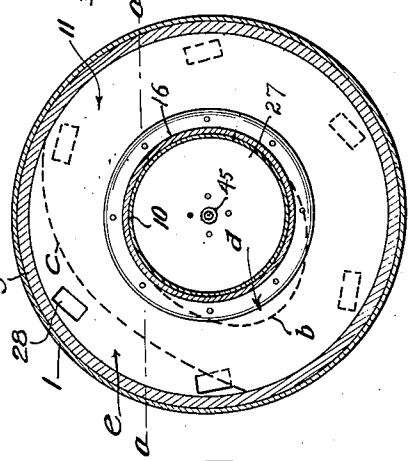


Fig. 3.

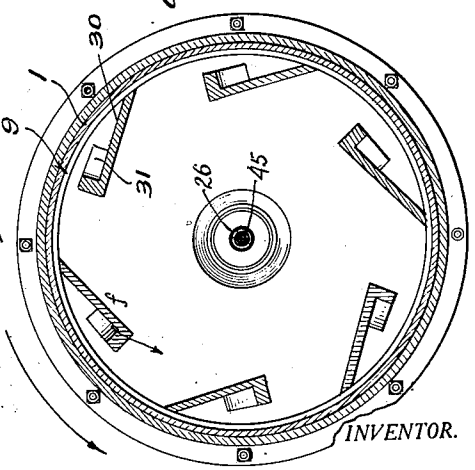


Fig. 2.

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TUBE MILL OR BALL MILL

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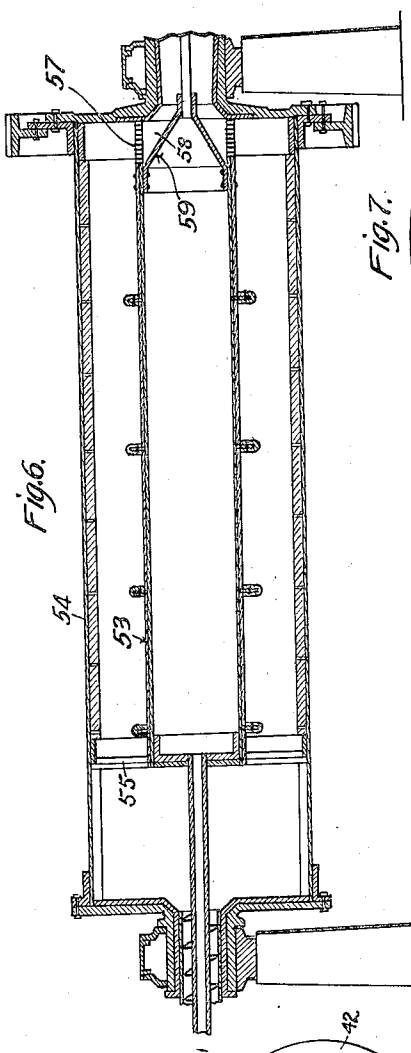


Fig. 6.

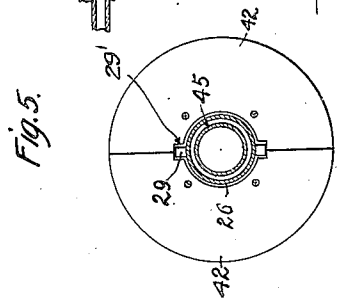


Fig. 5.

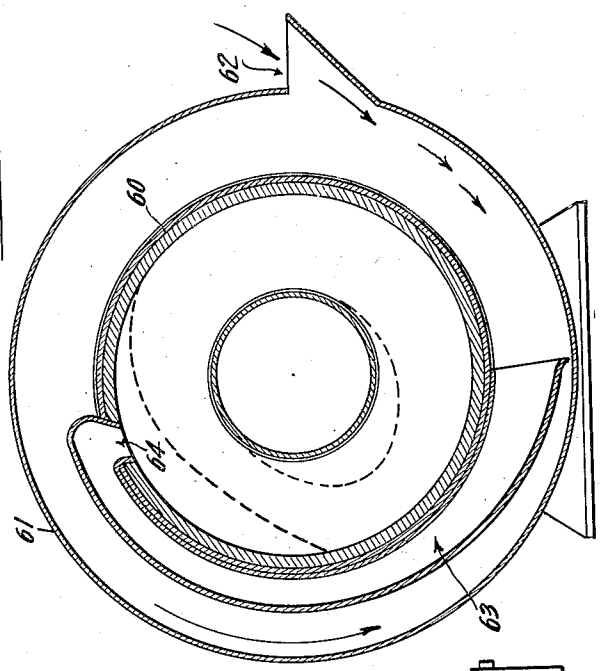


Fig. 7.

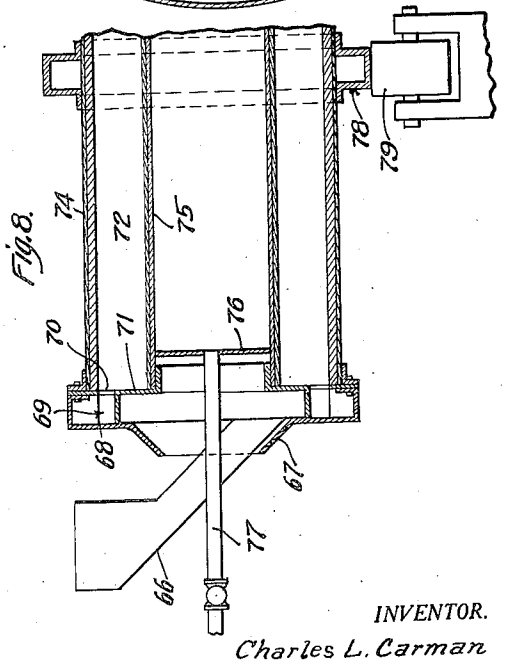


Fig. 8.

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Patented Oct. 2, 1934 1,975,501

UNITED STATES PATENT OFFICE

1,975,501

TUBE MILL OR BALL MILL

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Application November 19, 1928, Serial No. 320,278
Renewed December 27, 1933

3 Claims. (Cl. 83—9)

This invention relates to improvements in tube mills and the main object of the invention is to provide for increasing the crushing efficiency and capacity of such mills. A further object of the invention is to reduce the power required for operation of tube mills.

An important feature of my invention consists in providing a tube mill with an inner member extending axially therein, in such manner as to control the motion of the balls so as to obtain maximum crushing effect with minimum application of power. Another feature of this invention is the provision of improved means for preventing overheating of the material being crushed.

The accompanying drawings illustrate embodiments of my invention, and referring thereto:

Fig. 1 is a horizontal section of a tube mill provided with my invention.

Fig. 2 is a section on line 2—2 in Fig. 1.

Fig. 3 is a section on line 3—3 in Fig. 1.

Fig. 4 is a section on line 4—4 in Fig. 1.

Fig. 5 is a section on line 5—5 in Fig. 1.

Fig. 6 is a longitudinal section of a modified form of the invention.

Fig. 7 is a transverse section of a tube mill showing another modification.

Fig. 8 is a partial longitudinal section of another modification.

Fig. 1 shows a tube mill body 1 consisting of an imperforate cylindrical member, having heads 2 and 3 provided with hollow trunnions 4 and 5, at its ends, said trunnions being mounted to rotate in bearings 6 and 7. Said mill body is provided with a gear 8 adapted to be engaged by the usual driving gear, not shown, to rotate the mill. The mill body 1 may be constructed as a steel jacket or cylinder having lining means 9 in the usual manner of tube mills, and is provided, according to my invention, with an inner imperforate tube 10 extending longitudinally and axially within the outer mill tube 1, and of sufficiently smaller diameter than the outer tube 1 to provide a space 11 between the inner and outer tube members, for receiving the crushing pebbles or balls, and the material to be crushed. The inner tube 10 is, however, sufficiently large in diameter relative to the internal diameter of the mill tube to ensure that the usual charge of grinding balls or media will fill the mill tube to a height above the bottom of the inner tube, and to cause all the balls and material to flow over the inner tube at each revolution of the mill. For this purpose it is necessary that the external diameter of the inner tube 10 shall be not less than one half the internal diameter of the mill tube 1.

Inner tube 10 is connected to the outer mill tube so as to rotate therewith, being rigidly mounted at one end on an annular flange 12 on a supporting disc or partition-plate 13 which is secured to the outer tube 1 or to head 2, said tube 10 being secured at its other end to an annular flange 14 on an inner head 15 fastened to head 3. Tube 10, head 2 and plate 13 are provided with lining members 16, 17, 18 and 19 adapted to resist wear and lining member 17 may extend into the bore of hollow trunnion 4 as shown.

Suitable feeding means are provided for supplying material through hollow trunnion 4 to the inside of the tube mill. For example, a feed box 21 adapted to receive material from any suitable means, is provided with a tube 23 extending into the bore of trunnion 4 and a screw conveyor 25 is mounted to rotate within this tube 23 to advance the material from feed box 21 to a feed chamber 24 between head 2 and plate 15, said conveyor being mounted on a hollow shaft or tube 26 mounted in bearing 26' and having lugs 29, see Fig. 5, engaging slots 29' in plates 42 fastened to a tube 43 which is secured to an inner head member 27 which closes one end of the inner tube 10 and is fastened thereto so that conveyor 23 rotates with the mill body. Means may be provided in or adjacent to chamber 24 for passing the material from chamber 24 to the crushing chamber 11, the partition plate 13 having one or more openings 28 through which the material passes. For reasons hereinafter set forth it is desirable to provide for introducing the material to chamber at the upper part thereof, and for this purpose lifters or elevating scoops 30 may be provided on plate 13 adjacent the openings 28 adapted to take up portions of the material as such scoops ascend from their lowermost position, and to eventually discharge such portions through openings 28 into the space or chamber 11, each scoop 30 being inclined inwardly and having a rear wall 31 inclined with respect to the axis of the mill so as to cause the material to slide forward through such opening, when the scoop has risen to position indicated at *f* in Fig. 2 and the openings 28 being adjacent the outer wall of chamber 11 so as to feed the material into the upper part of said chamber.

A screen member 32 is provided at the outlet end of the crushing chamber 11, said screen member being formed for example, as a perforate disc extending between, and secured to, the tubes 1 and 10, and allowing the escape of crushed material to the delivery chamber 33 between screen plate 32 and head 3 of the mill. Suitable pas-

sages 35 are formed in inner head 15 for permitting material to pass from chamber 33 to outlet passage 34 in trunnion 5. Inner head 15 closes one end of inner tube 10 and is preferably formed with a conical or tapering boss 15' for directing the screened material into passage 34.

A delivery box 36 may be provided having two chambers 37 and 38 provided with respective outlets 39 and 40 and a drum 41 mounted on trunnion 5 and is provided with a screen portion 44 through which finely divided material may pass to chamber 37 and thence to outlet 39, the coarse particles, such as ball or pebble fragments, passing through the open end of drum 41 to chamber 38 and outlet 40.

In case the mill is to be used for dry grinding or crushing, I prefer to provide for cooling the material being crushed in the mill, by passing a cooling fluid, for example, water, through the inner tube 10. For this purpose a pipe 45 is connected to one end of said inner tube and communicates through check valve 46, and stuffing box 47, with a water supply pipe 48 having a regulating valve 49'; and a pipe 50 is connected to the other end of inner tube 10 and is provided with a valve 51 to control the discharge of cooling fluid.

Balls or pebbles are introduced into the mill, for example, through a manhole indicated at 52 in Figure 1, in sufficient amount for effective crushing and/or grinding, filling the chamber 11 to a certain height, which is above the lowest part of the inner tube 10, and below the highest part of said tube. When the mill is rotated by its driving means, at any suitable speed, the balls are carried forward in the direction of rotation shown by the arrow in Fig. 2 and are depressed at the descending side and lifted at the rising side of the mill tube and discharged over the top of the tube 10, falling in trajectories which cause them to eventually strike the outer wall or lining of the tube mill and/or the mass of balls and rock or other material therein, on the descending side of the mill.

Material such as cement mix, cement clinker, ore, or rock or other material to be crushed and/or ground, is introduced in a suitable state of relatively coarse division, through the feed means above described, into the chamber 11, and the body of crushing elements or balls, and material to be crushed may be assumed to fill the mill chamber 11 to a height which would be represented by the line *a*—*a*, if the mill were at rest. The effect of rotation of the mill is to cause the balls and work material to be substantially confined to a zone between an inner surface indicated by dotted line *b* and an outer surface indicated by dotted line *c*, leaving two zones or "pockets" *d* and *e* which are substantially free from balls or work material.

The form of the ball mass in the inner tube mill more nearly fills the annular grinding chamber than does that in a plain mill, leaving, however, two zones at the feed end of the grinding chamber which are not covered by the ball mass, as shown at *d* and at *e* of the drawings. The scoop means above described is adapted to receive the material to be crushed and to feed it into the space or zone *e*, at the upper part of the crushing chamber between the outer and inner mill tubes and at one end of said chamber, this space being sufficiently open to permit unobstructed feeding thereat. Feeding in this manner also has the advantage that the material then enters upon the outside of the ball mass and receives its initial crushing between the balls and the mill shell. It is hardly possible to feed at *d* and not clog the mill. Therefore, feeding at *e* makes practically possible the benefits to be had from the inner tube.

The cooling feature of the inner tube when filled with water is one which applies to dry grinding in large mills, and particularly to grinding Portland cement clinker whose friability begins to decrease at temperatures above 250° F., reducing the output of the mill and affecting the quality of the cement produced particularly the gypsum content. Temperatures of 350° F. are often reached in these large mills. This heat generation is due to the impact and attrition of the ball mass on the material and on itself and the mill shell.

The radiating surface of the shell of a mill increases directly as the diameter, while the ball mass increases as the square of the diameter, so a point is reached where radiation through the shell is not sufficient to keep the contents reasonably cool. The length of a mill is also an important factor of internal heat generation.

The position of the inner tube is particularly good for the absorption of the heat, said tube being at the axis of the mill, and the heat withdrawal due to said tube being added to that due to radiation from the outer mill tube. The inner tube has the following characteristics:

First.—Reduces the power necessary to operate the mill about 33%. This is due to a more nearly annular disposition of the ball load with resulting decreased distance between its center of gravity and the axis of rotation of the mill, as compared with that of a plain mill. To this must be added the impact of practically the entire ball load at each revolution, delivered at a point on the descending side of the mill nearly tangential to a horizontal line drawn through the center of the mill. To illustrate: In a mill in which the ball load weighs 60 tons there will be the impact of that weight falling a few feet every revolution upon the previously fallen balls, tending to rotate the mill.

Second.—Increases grinding capacity. This is due to the fact that while in a plain mill the balls lying against the shell have a greater fall than do those in the inner tube mill, the average fall of all the balls is greater in the latter and all the balls are brought into maximum action each revolution which is not the case in the plain mill, in which about 45% of the ball mass is in action each revolution.

As shown in Fig. 6, the inner tube shown at 53 may be supported on the outer tube 54 by inner head 59 and arms or spider 55 so as to form a feed chamber communicating directly with the crushing chamber between the inner and outer tubes so as to enable the balls and material to pass directly to such chamber. This figure also illustrates an arrangement of the discharge screen as a continuation of the inner tube, the screen 57 being mounted on radial arms 58 extending from inner tube head 59, and forming a cylindrical extension of the inner tube. The construction and operation may be otherwise the same as above described.

Instead of the feed means shown in Figs. 1 and 2, any ordinary lifting scoop means may be used, as shown in Fig. 7, the feed end of the outer mill tube 60 being surrounded by a fixed feed box 61, supplied with material through an inlet 62 and the tube 60 having a scoop 63 adapted to lift the material and to discharge it through a passage

64 in the outer wall of tube 60 into the upper part of the space between the inner and outer tubes.

Another form of feed means is shown in Fig. 8, the feed chute 66 delivering material to an open ended chamber 67 formed on the head 68 at one end of the tube mill, suitable means, such as scoops 69 similar to the scoops shown in Figs. 1 and 2, being provided to lift the material from chamber 67 and discharge it through openings 70 in a partition means 71, to the crushing chamber 72 between the outer tube 74 and inner tube 75. The corresponding end of the inner tube 75 may be closed by a head 76, and a pipe 77 may be connected to the inner tube, as above described, to supply cooling liquid thereto. Instead of mounting the mill on trunnions, it may be provided with bearing rings, (such as indicated at 78 in Fig. 8) running in rolls, indicated at 79, in the usual manner of such devices.

While I have described my invention particularly as applied to tube mills, it will be understood that it is applicable generally to any ball mill or pebble mill or any mill of the same general type.

I claim:

1. A tube mill comprising an outer cylindrical tube, provided with end heads, bearings for said outer tube, an inner cylindrical tube connected to the outer tube so as to rotate therewith extending axially within the outer tube so as to form a crushing chamber adapted to receive crushing elements, between the inner and outer tubes, a partition means extending within the outer tube adjacent the head at one end of the mill and forming a feed chamber between said partition means and said end head, said partition means being secured to the inner and outer tubes and being provided with passage means adjacent the outer tube, scoop means within said feed chamber for lifting material to said passage means, means for feeding material to said feed chamber, and means at the other end of the mill for supporting the inner tube and for discharging crushed material at said other end of the mill.

2. A crushing mill comprising an outer imperforate cylindrical tubular member, an inner imperforate cylindrical tubular member extending axially in the outer tubular member and spaced therefrom to form a crushing chamber between the outer and inner tubular members, said inner tubular member being connected to said outer tubular member so as to rotate therewith and means for feeding material to be crushed to one end of said crushing chamber at the upper part of said chamber, means for discharging crushed material from the other end of said crushing chamber, and means for passing a cooling medium through said inner tubular member.

3. A crushing mill comprising an outer imperforate cylindrical mill tube, an inner imperforate cylindrical tube connected to the outer tube to rotate therewith and extending axially within the outer tube so as to form a crushing chamber between said inner and outer tubes adapted to receive crushing balls or the like and material to be crushed, and elevating scoop means adapted to receive material to be crushed and mounted to rotate with the outer and inner tubes and having discharge opening means adjacent the outer wall of the crushing chamber so as to feed material into the upper part of the crushing chamber.

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