

June 24, 1947.

W. L. KEEFER

2,422,786

TUMBLING MILL AND METHOD OF TUMBLING

Filed Aug. 31, 1944

4 Sheets-Sheet 1

Fig. 1.

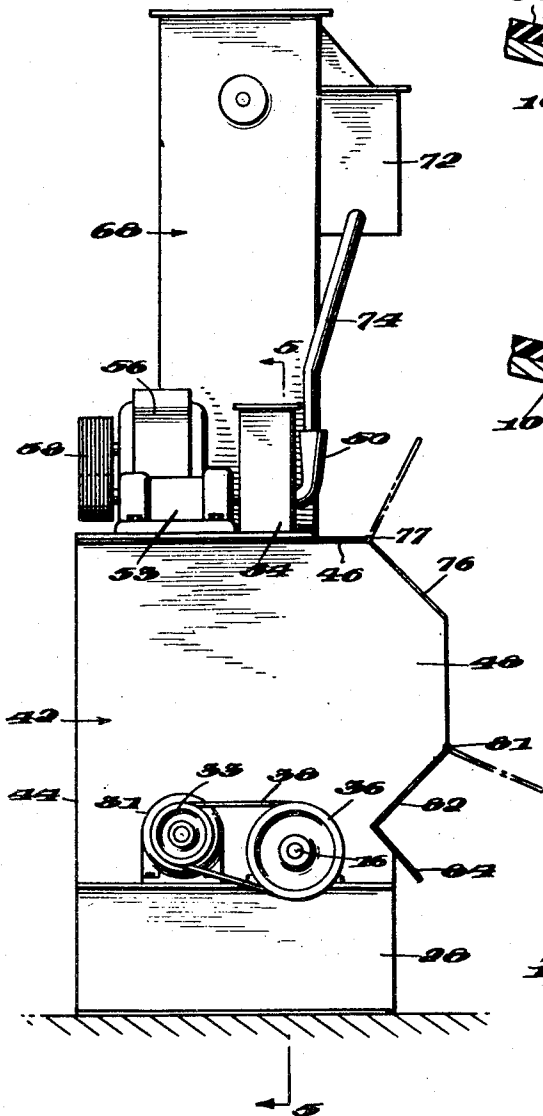


Fig. 6.

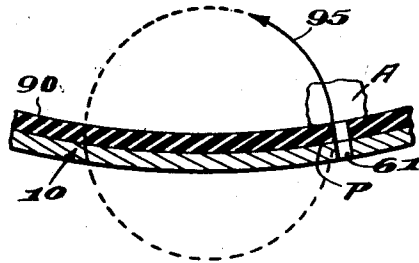


Fig. 7.

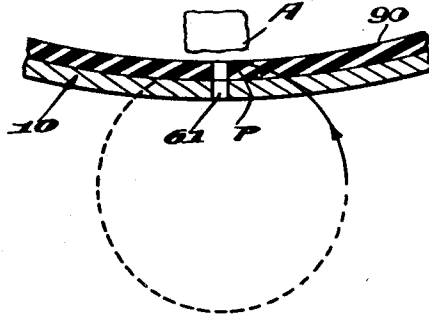
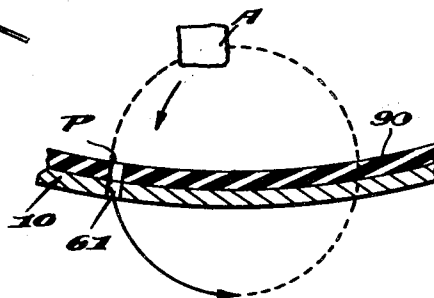


Fig. 8.



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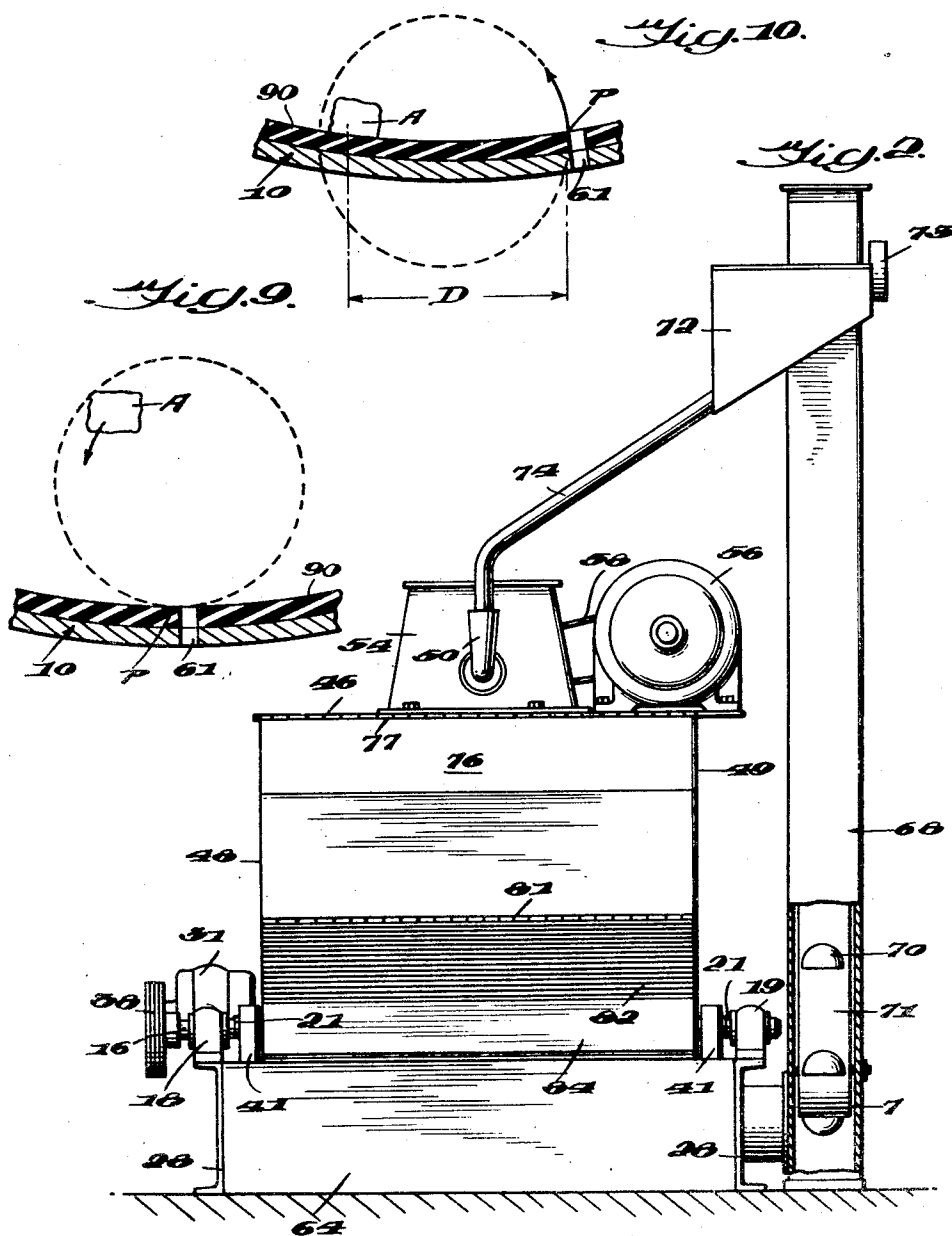
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4 Sheets-Sheet 2



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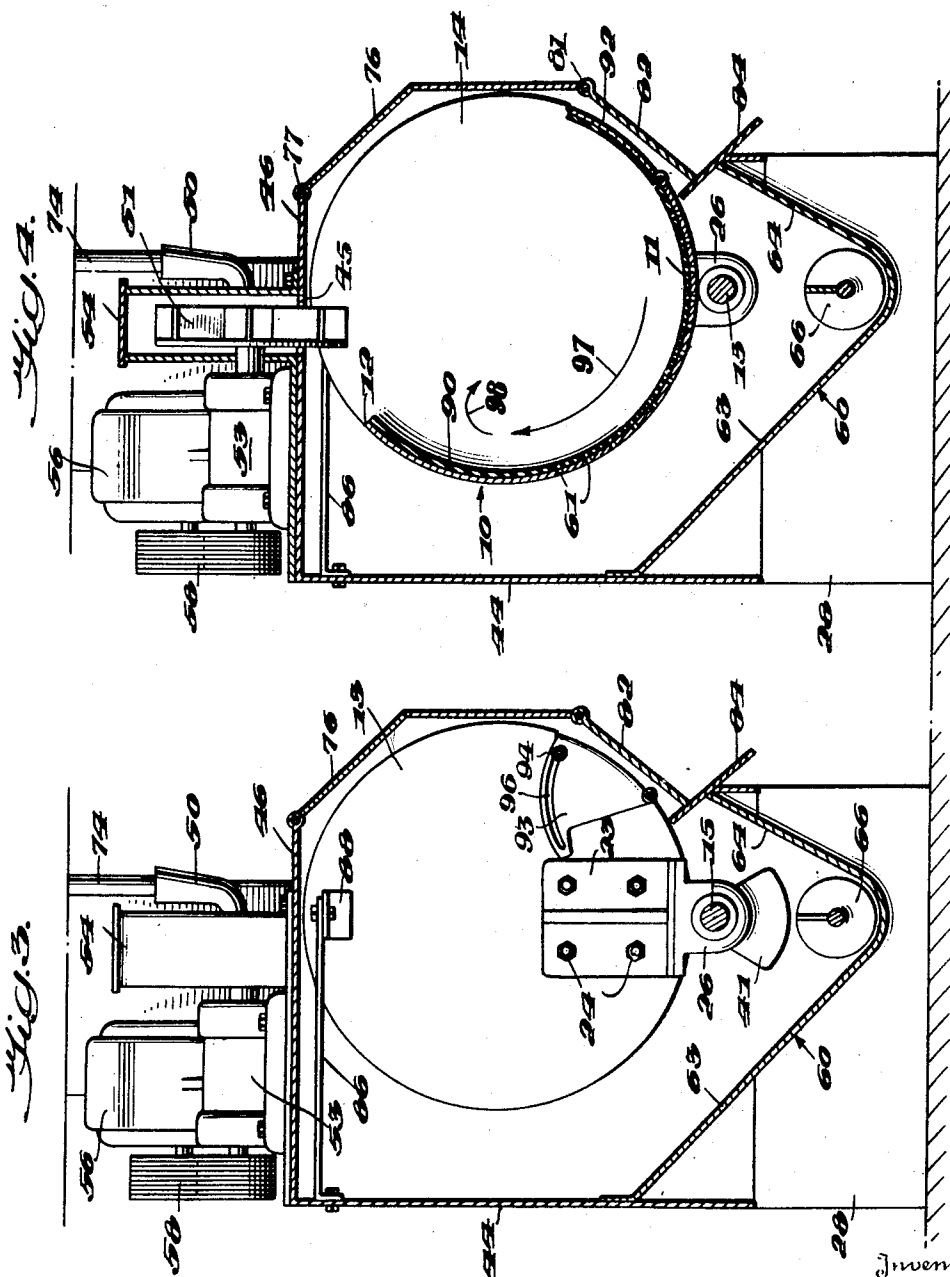
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TUMBLING MILL AND METHOD OF TUMBLING

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4 Sheets-Sheet 3



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TUMBLING MILL AND METHOD OF TUMBLING

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4 Sheets-Sheet 4

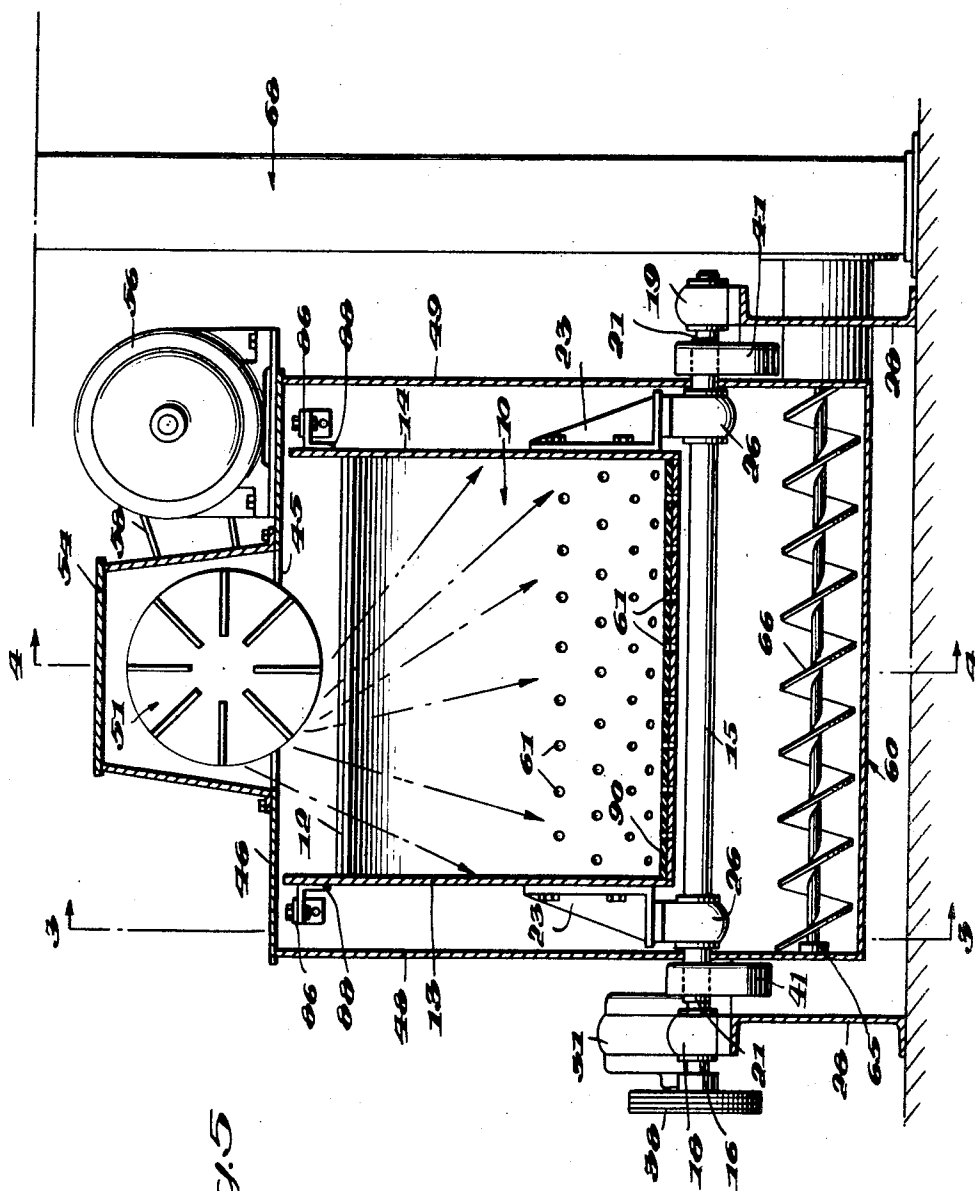


Fig. 5

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UNITED STATES PATENT OFFICE

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Application August 31, 1944, Serial No. 552,137

27 Claims. (Cl. 51-9)

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This invention relates to a method and an apparatus for the treatment of a group of articles such as small castings, or forgings, for cleaning, or otherwise improving the same, and more particularly to a method and apparatus wherein the articles move through an impingement zone where they are bombarded by granular particles, travelling at a high velocity, such as unbroken steel shot, broken steel shot, or a mixture of the two, or other granular medium, any one of which is intended to be comprehended by either of the terms "treating medium" and "abrasive" as hereinafter used.

The object of the invention is to effect a rapid, economical, and effective bombardment of the surface areas of the articles.

In respect to the apparatus, among the objects of my invention are to provide a simple, inexpensive and durable structure in which my method may be efficaciously practiced, in which the parts of the machine subjected to greatest wear may be readily replaced, in which the mechanism for propelling the treating medium may be most advantageously located in respect to the work, in which the articles will not only be caused to travel through an impingement, or bombardment, zone but during such travel will be caused to partake of a vibratory, or twisting and turning movement, so as to expose all surface areas thereof to treatment, and in which the articles may be readily charged to and discharged from the machine.

The method includes the step of placing a group of articles to be treated on a supporting member having a part inclining upwardly and forwardly and a substantially horizontally disposed portion which affords a pocket, or receptacle, for the group of articles undergoing treatment, the exposed or top surface of the group assuming an angle of substantially 45° to the vertical, or approximately the angle of repose thereof; imparting to the supporting member a rapid gyratory movement about a horizontal axis for carrying articles, supported on an area of the lower portion of the member, at or contiguous the bottom of said angle, to travel with the member until the area aforesaid reaches substantially the apogee of its orbital path, continuing the travel of the member independently of said articles, the latter travelling independently at a velocity and in a direction which is the resultant of their acquired momentum, and the force of gravity, the velocity of the supporting member relative to the independent movement of the articles being such that the support substantially

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completes its cycle before the articles reach a position of re-support by the member, whereby the articles are advanced along the member until they pass beyond the top of said exposed surface of the articles, whereupon they cascade along said surface and in their travel partake of a vibratory, shifting and turning movement.

The apparatus exhibiting the invention includes generally an arcuate shaped shell which curves upwardly from a horizontal portion and provides a pocket for receiving a group of articles to be bombarded or blasted including means for moving the shell upwardly and then retracting the shell to lateral position in such a timed relation to the falling of the articles that the articles engage the shell at a point displaced from the original position along the arcuate surface whereby the articles move in steps upwardly along the shell and tumble downwardly over other articles and through the blast stream.

The accompanying drawings disclose a preferred embodiment of my apparatus, which is likewise a preferred means for practicing my method.

25 In the drawings:

Fig. 1 is an end elevational view of a tumbling mill embodying the invention.

Fig. 2 is a front elevational view of the apparatus.

30 Fig. 3 is a sectional view taken on the line 3-3 of Fig. 5 showing the article supporting member in end elevation.

Fig. 4 is a transverse sectional view of the shell taken on the line 4-4 of Fig. 5.

35 Fig. 5 is an enlarged sectional view taken on the line 5-5 of Fig. 1.

Fig. 6 is an enlarged fragmentary sectional view of a lower portion of the article supporting member.

40 Fig. 7 is a similar view showing the manner in which an article is moved during a portion of an operating cycle.

Fig. 8 is a similar view illustrating the manner in which the shell retreats faster than the action of gravity acting on the article.

Fig. 9 shows the shell in its lowermost position in an operating cycle.

45 Fig. 10 illustrates the position of the shell in an exemplary operating cycle when the article re-engages the supporting member.

50 This invention is directed to a tumbling mill embodying a principle of operation differing radically from that exhibited in the prior type tumbling mills. Apparatus exhibiting the present invention provides for shifting the articles

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to be blasted to an elevated position in a series of small increments or steps where the articles tumble downwardly over other articles forming a normal load in the tumbling mill without the use of a moving belt for shifting the articles to the elevated position. A tumbling mill exhibiting the present invention includes an article supporting member which is bodily vibrated in such a manner that the articles adjacent the surface of the supporting member creep upwardly to the elevated position where these articles exceed their angle of repose and tumble downwardly over other articles. The articles tumbling downwardly over the other articles are also subjected to the vibratory movement. Thus a tumbling mill embodying the present invention, and by reason of the vibratory movement, provides that the articles moving downwardly from the elevated position roll to a greater extent or turn over oftener than in prior type tumbling mills, and thus more efficiently expose the various surfaces of the articles to the impingement of the blast stream. The articles tumbling downwardly over the other articles eventually re-engage the surface of the supporting member and are moved in small increments upwardly along the supporting member to a position where they exceed their angle of repose and tumble downwardly over still other articles. The articles thus describe a generally elliptical circulatory path in the tumbling mill.

Referring to the drawings, there is shown at 10 an article supporting member which is so mounted as to extend upwardly from a horizontal portion 11, and thus provides a pocket for receiving a group or load of articles to be blasted. In the exemplary embodiment illustrated in the drawings, the article supporting member 10 comprises a segment of a cylinder which is so arranged that when the lower portion 11 thereof is in a substantially horizontal position the segment curves upwardly therefrom and may terminate at 12. The segment may thus be regarded as a shell forming the article supporting member. The end of the shell may be closed by means of disc shaped walls 13 and 14. The end walls may be provided with removable wear plates (not shown) so as to be readily replaced when worn. The end walls 13 and 14 are welded or otherwise secured to segmental portion of the supporting member.

The supporting member 10 is mounted for vibratory movement. In the embodiment illustrated a crank shaft 16 is rotatably mounted in bearings 18 and 19 and is offset at the points 21 as shown in Figs. 2 and 5 to provide a crank portion 15. The end walls 13 and 14 are provided with brackets 23 which are rigidly secured thereto in any appropriate manner, such as by means of bolts 24 or welding. The brackets 23 are provided with bearings 26 which embrace the crank portion 15 of the shaft 16. The entire load of the shell is supported by the crank shaft 16. The bearings 18 and 19 are accordingly mounted on channel members 28 which form a part of the base frame of the tumbling mill.

The crank shaft 16 may be driven in any appropriate manner such as by means of an electric motor 31 which may be mounted on one of the channel members 28. The motor 31 is of a reversible type so that it may be driven in either direction. A pulley 33 is mounted on the shaft of the motor 31 and a pulley 36 is mounted on the end of the crank shaft 16. A plurality of belts 38 are trained about the pulleys 33 and

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36 so as to provide means for driving the crank shaft 16 in either direction. In the embodiment shown the pulleys 33 and 36 are designed for accommodating V-belts. The motor 31 is also of the variable speed type so that the speed at which the shaft 16 is rotated may be varied. The crank portion 15 of the shaft 16 provides means for imparting vibratory movement to the article support member or the shell 10 by reason of the rigid connection of the brackets 23 with the end walls 13 and 14 and by reason of the bearings 26 which move with the crank portion 15 of the shaft 16. The shell 10 forms a pocket for receiving a load of articles to be blasted, and the weight of these articles and the weight of the shell are thus supported by the brackets 23 and the bearings 26 and the shaft 16. The vibratory movement of the supporting member 10 provides an unbalanced condition and counterweights are accordingly provided for rotation with the shaft. In the embodiment illustrated two counterweights 41 are secured to the shaft 16 to rotate therewith.

The tumbling mill includes a housing encasing the article supporting member and the housing may be formed of sheet material so as to prevent the escape of dust and abrasive when the articles are subjected to the abrasive blast. The housing is shown generally at 42 and includes a substantially flat rear wall 44 and a substantially flat top 46. The housing also includes substantially straight end walls 48 and 49. These walls may all be formed of sheet metal suitably reinforced to provide a relatively rigid housing. The top 46 is sufficiently reinforced to support an abrasive projecting device thereon as hereinafter described.

In the exemplary apparatus illustrated in the drawings the abrasive projecting device takes the form of an abrasive throwing wheel shown at 51. The abrasive throwing wheel is of a conventional type and is supported for rotation by means of a bearing assembly indicated at 53. The wheel proper is encased within a wheel housing 54. The top 46 of the tumbling mill housing 42 is provided with an opening 45 through which the wheel 51 projects the abrasive in a downward direction onto articles within the pocket provided by the article supporting member 10. The wheel 51 may be driven in any suitable manner such as by means of a motor 56 mounted on the top 46 of the tumbling mill housing 42. The motor 56 drives the wheel 51 by means of a belt arrangement shown at 58. The abrasive throwing wheel 51 is of the directional control type and is adapted to propel abrasive in a fan shaped stream downwardly onto the articles within the pocket of the shell 10 in a manner somewhat as indicated in Fig. 5.

The abrasive projected by the wheel 51 engages the articles at blasting velocities and the apparatus includes means for recovering the spent abrasive and returning it to a position for re-use by the abrasive projecting device. The peripheral portion of the supporting member 10 is provided with a plurality of apertures 61 which extend through the shell and a lining 90 therefor whereby the spent abrasive particles may sift through these apertures. A hopper 60 is provided for receiving the abrasive particles passing through aperture 61. The hopper is formed with inclined walls 63 and 64 which extend beyond the ends of the supporting member 10 as shown in Fig. 5. The abrasive recovery arrangement includes means for moving the abrasive to

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one end of the hopper 66, and such means may take the form of a helical worm 66 which is rotatably mounted in bearings, one of which is shown at 65. The worm 66 may be driven in any suitable manner. An elevator 68 of a conventional type including an endless band 71 and cups 70 thereon is provided for lifting the abrasive delivered by the worm 66 to a position for deposit in a storage hopper 72. The endless conveyor or belt 71 may be driven by a pulley 73 shown in Fig. 2. The abrasive moves downwardly from the storage hopper into the feed spout 50 of the abrasive throwing wheel through a suitable conduit represented at 74.

The front portion of the housing 42 is provided with a door 76 which may be opened to introduce a group of articles into the tumbling mill. The door 76 is hinged at 77 so that it can be swung to an open position whereby the articles may be introduced into the pocket provided by the supporting member 10. The door 76 is so designed that when it is closed it will provide a tight closure member preventing the escape of dust or ricocheting abrasive particles. The front wall of the housing 42 is also provided with an opening in the lower portion thereof for permitting the unloading of the articles from the tumbling mill as hereinafter described. This opening is adapted to be closed by a door 82 which is preferably hinged at its upper edge 81 to the front wall of the housing 42. The housing may also be provided with an inclined plate 84 for deflecting the articles outwardly from the housing when they are unloaded from the tumbling mill. The door 82 is likewise adapted to be closed so as to prevent the escape of dust and abrasive particles from within the housing.

The top portion of the article supporting member 10 is provided with means for yieldably steadying and preventing the tilting thereof, and such means may take the form of flexible arms 86. These arms permit vertical movement of the upper portion of the article supporting member. The flexible arms 86 extend forwardly from the rear wall and are secured to the discs 13 and 14 by means of brackets shown at 88. The ends of the flexible arms or springs 86 may be bolted to the brackets 88 and the housing wall 44 or welded thereto.

The inner surface of the shell 10 is lined with a suitable sound deadening material such as layer of rubber 90. This yieldable layer in addition to providing means for deadening the sound of the articles engaging and re-engaging the shell also provides means for increasing the coefficient of friction between the articles and the inner surface of the supporting member. The sound deadening layer 90 may be adhesively joined to the surface of the article supporting member or otherwise secured in operative relation thereon. The apertures 61 for the escape of the abrasive also extend through the layer 90 as shown in Figs. 4 and 5.

The circumferential extent of the shell at the lower end thereof may be increased by means of an arcuate shaped plate 92 so as to prevent the inadvertent escape of articles from the shell during the tumbling and blasting operation. The plate 92 is curved so as to provide a continuation of the arcuate shape of the shell 10. The inner surface of this plate 92 is also covered with a layer of yieldable sound deadening material. The plate 92 is hinged for the purpose of swinging downwardly for the discharge of the articles from the shell after the blasting operation is com-

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plete. A mounting for the plate 92 may include a pair of end brackets 93 carried by the plate 92 and arranged along the outer surfaces of the discs 13 and 14. These brackets 93 are provided with arcuate shaped slots 96 through which bolts 94 carried by the discs 13 and 14 extend so as to provide one type of means for maintaining the arcuate shaped plate 92 in a position shown in Figs. 3 and 4 to provide an extension of the circumferential portion of the shell. The plate 92 may be swung to a downwardly inclined position by loosening the bolts 94 whereby the plate 92 will swing outwardly and downwardly with the ends of the slots 96 limiting the swinging movement of the plate.

The tumbling mill may be loaded by opening the door 76 whereby a group or load of articles may be introduced into the pocket provided by the article supporting member 10. The door 76 is then moved to the closed position and the apparatus is in condition for initiation of the blasting operation. The motor 31 is then supplied with current so as to drive the crank shaft 16 in a counter-clockwise direction as viewed in Fig. 1. The rotation of the crank shaft 16 imparts a gyratory movement to the article supporting member 10 and particularly the lower portion 11 thereof by reason of the crank portion 15.

In an exemplary embodiment of the invention the crank portion 15 is displaced from the axis of the shaft 16 by approximately one-eighth of an inch and this shaft is rotated at about seven hundred and ten revolutions per minute. The motor 31 is of a variable speed type as hereinabove indicated so that the speed at which the crank shaft 16 is driven may be adjusted. After the crank shaft 16 attains the desired speed the articles adjacent the surface of the yieldable layer 90, are moved upwardly towards the upper end 12 in the direction of the arrow 97 shown in Fig. 4. A detailed analysis of what appears to be the fundamental principle of operation embodied in the tumbling mill after the crank shaft 16 has attained the proper speed is illustrated in Figs. 6 to 10. The circles shown in these parts of the drawings indicate the path, or orbit, described by the lower and more horizontal portion 11 of the shell 10, and while this gyratory movement measures one-quarter inch in diameter in an exemplary embodiment, the circular path shown in Figs. 6 to 10 has been materially enlarged for the purpose of more clearly depicting the principle of advancing the articles along the supporting member 10.

When the speed of the gyratory movement is correctly established for a given crank arm length and of approximately seven hundred and ten revolutions per minute for a crank arm length of approximately one-eighth inch, the articles will engage the supporting member from a previous cycle of operation when the shell is in that portion of the gyratory path shown in Fig. 6. Thus an article A which has then engaged the lined surface of the member 10 is moved upwardly in the direction of the arrow 95. It will be noted that the article A is then engaging the yieldable layer 90 of the shell at the point P. This upward movement is angular and directed towards the upper end 12 of the shell. As the article is moved upwardly it attains a momentum which tends to keep the article A moving in the direction of the arrow 95. In Fig. 7 the article supporting member 10 has arrived at its uppermost position in the gyratory movement and the article A by reason of its inertia tends to move above the sur-

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face of the supporting member. The upward movement of the article A continues until its inertia is spent and the article then ceases to move upwardly and is momentarily stationary above the surface of the article supporting member.

An important feature of the invention pertains to the retraction of the supporting member 10 and moving this shell so that the point P thereon arrives at a position in back or laterally of the article A before the suspended article will as a result of the action of gravity re-engage the article supporting member. The article A after starting to fall moves approximately in the direction indicated by the arrow shown in Fig. 8, but it will be observed that the article supporting member 10 has by that time retracted through the position shown in Fig. 8. It will be noted from a consideration of Fig. 9 that the article A has not moved downwardly to its original level as shown in Fig. 6 when the shell is in the lowermost part of the gyratory path. The speed of the gyratory movement should be such that the article supporting member 10 arrives substantially in the position shown in Fig. 10 before the article has dropped sufficiently to reengage the surface of the supporting member. The point P on the shell has therefore returned to its original or approximately the three o'clock position and the article A engages the member 10 at a point displaced from the point P and in a direction towards the upwardly curved part of the supporting member. The article A has therefore advanced a distance D as will be apparent from a consideration of Fig. 10. The gyratory movement is repeated at a rapid rate and the article A will, according to theoretical considerations, advance in a step or increment D upwardly along the article supporting member in the direction of the arrow 97 in Fig. 4 during each gyration.

The operating sequence graphically depicted in Figs. 6 to 10 and as hereinabove described represents an ideal operating characteristic in that the article A is advanced a distance D along the surface of the supporting member 10 during each gyration thereof. It will be appreciated that such an operating characteristic requires that the time necessary for completing three-quarters of a gyration or movement of the point P from the twelve o'clock position to about the three o'clock position must equal the time required for the article A to move upwardly beyond the position shown in Fig. 7 by inertia and possibly centrifugal force acting thereon and other factors and then come to a stop and fall from its maximum elevated position onto the surface of the supporting member. The tumbling mill will function to advance the articles in small increments along the surface of the supporting member even though the ideal operating conditions described in connection with Figs. 6 to 10 are not present. The article A will be advanced as long as the speed at which the supporting member is gyrated is such as to cause the point P to arrive between the seven and twelve o'clock positions in moving through a counter-clockwise gyration from the twelve o'clock position before said article reaches a position of re-support by the supporting member. In other words, as long as the point P on the surface of the supporting member is retracted to a position in back of the falling article, the article will advance in small increments along the surface of the supporting member 10.

The operating conditions shown diagrammatically in Figs. 6 to 10 represent the theoretical

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principle of operation. In order that this theory of operation may be made clear, the movement of a single article A has been described in connection with one gyration of the article supporting member. In practice a plurality of articles or a group of castings are arranged in the pocket of the article supporting member 10. The apparatus in actual operation has been found to advance a plurality of articles, and particularly those adjacent the surface of the supporting member, in small increments in the direction of the arrow 97 shown in Fig. 4 when a group of articles are arranged within the pocket of the article supporting member. The weight of the articles over the articles adjacent the layer 90 appear to retain these latter articles in their new displaced positions upon re-engagement with the surface of the supporting member 10. Thus when a load of articles are arranged within the pocket of the shell, the articles immediately adjacent the layer 90 advance in small increments upwardly circumferentially along the article supporting member and in the direction of the arrow 97 in Fig. 4. The group of articles resting on other articles may possibly modify the theoretical operating conditions graphically illustrated in Figs. 6 to 10. The movement of the article supporting member in the gyratory path causes all of the articles to vibrate, possibly alters the theoretical movement of any one article as hereinabove described. The advancement of the articles in actual operation of the apparatus also continues when the speed of the crank shaft 16 is varied between 650 and 800 revolutions per minute for a crank arm length of one-eighth of an inch.

The under layer or layers of articles adjacent the surface of the member 10 move in small increments in the direction of the arrow 97, and as these articles reach the more vertical portion of the article supporting member 10, these articles no longer engage surfaces materially displaced laterally from the original positions on the surface of the shell. These articles nevertheless move upwardly to a point approximating the nine o'clock position in Fig. 4. The articles adjacent the surface of the shell at points roughly between the eight and nine o'clock positions in Fig. 4 appear to be pushed upwardly by articles advancing along the more horizontal portion 11 of the shell.

As the articles arrive at approximately the nine o'clock position in the shell, they tumble over substantially in the direction of the arrow 98. These articles then move downwardly over the other articles in the pocket, since these elevated articles or castings exceed the normal angle of repose for the average article or casting. The vibratory movement imparted to all the castings further pronounces the rolling of these articles as they move downwardly over the surface of the other articles and as they tend to nestle in the pockets which are created by the vibration of all of the articles.

The abrasive projecting device as represented by the abrasive throwing wheel 51 is so arranged as to direct the abrasive stream onto the articles as they tumble downwardly in the shell. The abrasive throwing wheel 51 is accordingly started by supplying energy to the driving motor 56 when the vibrating mechanism is set in operation. The abrasive projected by the wheel 51 engages the articles at a blasting velocity for the purpose of blast cleaning the surfaces thereof or for otherwise blast treating the articles. The articles

tumbling downwardly in a repeated number of tumbling operations cause the various surfaces thereof to be exposed to the blast stream.

The spent abrasive projected into the tumbling mill sifts through the articles and this operation is facilitated by the vibrating movement imparted to the group of articles. The spent abrasive particles thus move through the apertures 61 and fall into the hopper 60. The spiral conveyor 66 may be driven in any suitable manner to move the abrasive into the elevating mechanism 68. The elevator may be set in operation by driving the pulley 73 so as to move the belt 71 upwardly whereby the cups 70 will lift the abrasive to a position for dropping into the storage hopper 72. The abrasive passes from the storage hopper 72 through the conduit 74 into the feed spout 50 and is thus re-supplied to the abrasive projecting device.

The apparatus exhibiting the invention provides for the convenient discharge of the articles from the shell 10 after the blasting operation is complete. The abrasive projecting device may be rendered ineffective by interrupting the supply of abrasive to the feed spout 50 after which the door 82 may be opened for the discharge of the article. The arcuate shaped plate 92 is then dropped by loosening the retaining means 94. The arcuate shaped plate 92 will then swing downwardly to a position limited by the ends of the curved slots 96 in the brackets 93. The direction of rotation of the motor 31 is then reversed so as to reverse the gyratory movement imparted to the supporting member 10. The articles will thereby be advanced in small increments over the lower end of the shell and will slide downwardly over the arcuate shaped plate 92 into a tote box or other conveyance. Thereafter the hinge plate 92 is returned to its operative position as shown in Fig. 4 and the bolts 94 tightened to retain the plate 92 in a position to provide a continuation of the shell 10. The door 82 may then be closed and the apparatus is in condition for receiving a further load of articles to be blasted.

While the invention has been described with reference to specific structural details and with regard to one type of vibratory movement being imparted to the article supporting member, it will be appreciated that other mechanisms may be employed for vibrating the shell so as to move the articles upwardly in a series of small increments to a position where they will tumble downwardly through the blast stream. The length of the crank arm or the distance at which the eccentric portion of the crank shaft is displaced from the axis thereof may be varied and the speed of gyratory movement accordingly altered to retract the supporting surface to a downward and laterally displaced position before the articles re-engage the surface of the supporting member without altering the principle of operation. Such modifications may be made without departing from the spirit and scope of the invention as set forth in the appended claims.

I claim:

1. A tumbling mill comprising, an article supporting member having a substantially horizontal portion and a substantially vertical portion and an intermediate inclined portion for receiving a group of articles, means for moving said article supporting member upwardly and then to a downward and lateral position before the articles raised by the supporting member fall back onto said member to thereby advance the articles up-

wardly along the supporting member to a position where said articles tumble downwardly over other articles, and means located above the articles supported by said member for projecting abrasive against said articles.

2. A tumbling mill comprising, an article supporting member having an arcuate surface extending upwardly from a substantially horizontal portion for receiving a group of articles to be surface treated, means for moving said article supporting member in a gyratory path so that the articles are moved upwardly and thereafter moves at such speed that the points at which the articles originally engaged the supporting member are positioned laterally of the suspended articles before the falling articles again engage the article supporting member whereby the articles move upward in increments along the arcuate surface to a position beyond the angle of repose of other articles supported by said member and tumble downwardly thereover, and means projecting abrasive at blasting velocities onto the articles.

3. A tumbling mill comprising, an arcuate shaped shell arranged to form a pocket for receiving a group of articles to be surface treated, a shaft, means for rotating said shaft, a crank arm driven by the shaft, means providing a connection between the crank arm and shell for moving the shell in a circulatory path at a speed to move the articles in small increments upwardly along the arcuate shell to a point where they tumble downwardly over other articles of the group.

4. A tumbling mill comprising, an arcuate shaped shell arranged to provide a pocket for receiving a group of articles, a shaft, an eccentric carried by said shaft, means providing a connection between the eccentric and the shell, and means for driving the shaft in one direction to move the articles upwardly along the arcuate shaped shell to a position for tumbling downwardly therein, and for driving the shaft in another direction to discharge said articles from the shell.

5. A tumbling mill comprising, a cylindrical segment having end walls positioned to provide a pocket for receiving articles to be blasted, a shaft, an eccentric carried by the shaft, brackets secured to said end walls, bearings embracing the eccentric and attached to said brackets, driving means for rotating said shaft in one direction to move the cylindrical segment in a gyratory path whereby the articles move in a series of steps upwardly along the cylindrical segment to a position where the articles tumble downwardly over other articles, an abrasive throwing wheel for directing abrasive particles at a blasting velocity onto the articles in said cylindrical segment, and said driving means being reversible to move the cylindrical segment in an opposite gyratory path so as to discharge the articles from the segment.

6. In a tumbling mill, a shell comprising segment of a cylinder and end walls therefor providing a pocket for receiving articles to be tumbled, a displaceable plate providing a circumferential continuation of said cylindrical segment, means for moving said shell in a gyratory path and at such a speed that the articles move in steps upwardly along the cylindrical surface to a position where they tumble downwardly over other articles, said displaceable plate being movable to a downward inclined position, and said means for moving the shell being operable to reverse the gyratory movement of the shell to dis-

charge the articles from the circumferential end of the segment adjacent said displaceable plate.

7. A tumbling mill comprising, an upwardly inclined article supporting member for receiving a group of articles to be blasted, means moving said member upwardly and downwardly and laterally in such timed relation with the falling of the articles that the articles move in steps upwardly along the surface of said supporting member and tumble downwardly over other articles, means projecting abrasive at a blasting velocity onto the articles as they tumble downwardly, said article supporting member having apertures therein for the escape of spent abrasive, and means receiving the abrasive escaping through said apertures.

8. A tumbling mill comprising, a cylindrical segment having end walls positioned to provide a pocket for receiving articles to be blasted, a shaft, an eccentric carried by the shaft, brackets carried by said end walls, bearings embracing the eccentric and attached to said brackets, means for rotating said shaft in one direction to move the cylindrical segment in a gyratory path whereby the articles move in a series of steps along the cylindrical segment to a position where the articles tumble downwardly over other articles a counterweight rotatable with the shaft, and an abrasive throwing wheel for directing abrasive particles at a blasting velocity onto the articles as they tumble downwardly in said cylindrical segment.

9. A tumbling mill comprising, an article supporting member having a substantially horizontal portion and an arcuate portion extending upwardly therefrom constituting a sole support for articles to be treated, eccentric means on which the substantially horizontal portion of said article supporting member is mounted, means for rotating said eccentric means to cause the horizontal portion of said article supporting member to move in an orbital path and at such speed in relation to free falling of the articles so as to advance the articles supported thereon upwardly along the arcuate portion of the supporting member to a position where the articles tumble downwardly and means for projecting abrasive into engagement with the articles.

10. In a tumbling mill, a unitary shell including a substantially horizontal portion and an arcuate portion extending upwardly from the horizontal portion and constituting the sole support for a group of articles, eccentric means coupled to the substantially horizontal portion of the shell, means rotating said eccentric means to move the horizontal portion of the shell in an orbital path and in timed relationship to free falling of the articles to thereby advance the articles along the horizontal portion for guided movement upwardly along the arcuate portion of the shell to a position where the articles tumble downwardly.

11. A tumbling mill comprising, a shell including a substantially horizontal portion and an arcuate portion extending upwardly therefrom arranged to provide a pocket for receiving a group of articles, means for moving the substantially horizontal portion of the shell upwardly to elevate the articles and to a downward position and laterally of the falling articles as the articles fall onto the shell whereby some of the articles move in steps along the surface of the more horizontal portion of the shell and are guided upwardly along the arcuate portion

thereof and tumble downwardly over other articles.

12. A tumbling mill for treating castings comprising, a supporting member having its supporting wall formed substantially as a segment of a cylinder providing a pocket for receiving a group of castings, means for moving the supporting member upwardly to elevate the castings and thereafter retracting said member downwardly at a velocity greater than the free falling rate of the castings and to a position rearwardly of the falling castings to provide an advanced re-engagement of the castings with said supporting wall whereby some of the castings are advanced step by step to a position where they tumble downwardly over other castings.

13. A tumbling mill comprising, an article supporting member formed substantially as a segment of a cylinder providing a pocket for receiving a group of articles, means for moving the article supporting member upwardly to elevate the articles and thereafter retracting the supporting member downwardly at a velocity greater than the falling rate of the articles and to position points on the surface of the article supporting member, where the articles originally engaged the supporting member, rearwardly of the falling articles before the free falling articles again engage the supporting member whereby some of the articles are moved along the supporting member and are guided upwardly to a position where the articles tumble downwardly over other articles.

14. A tumbling mill comprising, an article supporting member including a substantially horizontal portion and an arcuate portion extending upwardly therefrom arranged to provide a pocket for receiving a group of articles, means for moving the horizontal portion upwardly to elevate the articles and thereafter retracting the horizontal portion at a velocity greater than the falling rate of the articles and to a position where the points at which the articles originally engaged the supporting member are positioned downwardly and rearwardly of the falling articles before the articles fall into re-engagement with the supporting member whereby some of the articles are moved in steps along the more horizontal portion of the article supporting member and are guided upwardly along the arcuate portion and tumble downwardly over other articles, and means projecting abrasive into impingement with said articles.

15. A tumbling mill comprising, an article supporting member having a substantially horizontal portion and an arcuate portion extending upwardly therefrom for supporting articles to be treated, eccentric means for moving said article supporting member, means for rotating said eccentric means to move the horizontal portion of said article supporting member in an orbital path and thereby advance the articles upwardly along the arcuate portion to a position where articles tumble downwardly, and a lining on the article supporting member increasing the co-efficient of friction between the articles and supporting member.

16. In a tumbling mill, a casing, a shell located therein comprising end walls and a peripheral wall forming a cylinder segment concentric to a horizontal axis, one edge of the segment terminating above a horizontal plane intersecting said axis and at one side of a vertical plane also intersecting the axis, and the other edge of the segment terminating on the other side of said

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vertical plane and below said horizontal axis, the arcuate portion of the segment below the axis serving as an initial support for the articles introduced into the machine for treatment, means supported by the casing for projecting an abrasive medium at abrading velocity through the opening between said edges of the segment against the articles supported by the latter, and means for bodily gyrating the shell at a sufficiently high velocity for carrying, during each cycle of the gyratory movement, articles supported upon an area of the arcuate portion aforesaid below said axis to the apogee of the path travelled by said area and for returning the same to substantially its starting position during the period the articles supported thereon, at the commencement of its movement, travel after passing out of contact with said area until they reach a point or re-support by the segment, substantially as described.

17. In a tumbling mill, a casing, a shell located therein comprising end walls and a peripheral wall forming a cylinder segment concentric to a horizontal axis, one edge of the segment terminating above a horizontal plane intersecting said axis and at one side of a vertical plane also intersecting the axis, and the other edge of the segment terminating on the other side of said vertical plane and below said horizontal axis, the arcuate portion of the segment below the axis serving as an initial support for the articles introduced into the machine for treatment, means supported by the casing for projecting an abrasive medium at abrading velocity through the opening between said edges of the segment against the articles supported by the latter, and means including the offset portion of a rapidly rotating crank shaft connected to the shell below and substantially in the aforesaid vertical plane intersecting the axis of the shell for bodily gyrating the shell at a sufficiently high velocity for carrying during each cycle of the gyratory movement articles supported upon an area of the arcuate portion aforesaid below said axis to the apogee of the path travelled by said area and for returning the same to substantially its starting position during the period the articles supported thereon at the commencement of its movement travel after passing out of contact with said area until they reach a point of re-support by the segment, substantially as described.

18. A method of tumbling articles, comprising, supporting articles upon a concave supporting surface, and moving said supporting surface through a gyratory path having a radius of about one-eighth of an inch and at a frequency of the order of 650 to 800 cycles per minute.

19. In the art of tumbling articles, the steps comprising, positioning an article upon a given area of the upper surface of a supporting member, imparting a gyratory movement to the member to cause the area to travel in an orbital path so that when it reaches the apogee of the latter the article will continue its movement independently of the support, and thereafter completing the cycle of the movement of said area at a speed relative to the independent movement of the unsupported article such that at or prior to the completion of the cycle the article will have reached a position of resupport in advance of said area.

20. In the art of tumbling articles, the steps comprising, positioning an article upon a given area of the upper surface of a supporting member, imparting movement to the member for

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causing the area to travel in an orbital path in a vertical plane and at a uniform velocity with the article travelling therewith until the area reaches approximately the apogee of its path, the travel of the area being so related to that of the article that in the continued movement of each after the apogee is passed the article will reach a position of resupport by the supporting member in advance of said area.

21. A method for the surface treatment of a group of small metallic articles comprising, positioning the articles on the arcuate surface of a supporting member whereby during treatment they will group themselves with an exposed surface approximating the chord of an arc forming approximately a 45° angle to a vertical plane intersecting the lower end of the chord and approximating the angle of repose of the group of articles during treatment, imparting a gyratory movement to the member to move the supporting surface thereof in an orbit in a vertical path, some of said articles being supported upon an area of the surface of said member, at or adjacent the lower end of said group of articles, being carried with said area until it reaches approximately its apogee and thereafter continuing their travels independently of the support and at such relative speed thereto that the latter will substantially complete its cycle prior to the said articles reaching a position of resupport.

22. A tumbling mill, comprising, a pocket including an arcuate portion arranged to form a support for a plurality of articles to be treated, means connected with said pocket for imparting a gyratory movement thereto, and flexible means connected with said pocket for yieldably steadying said pocket during such movement.

23. A tumbling mill, comprising, a pocket having an arcuate portion arranged to form a support for a plurality of articles to be treated, and having an end wall at each end of said arcuate portion, means connected with the lower portion of said end walls for bodily gyrating said pocket, and a flexible arm connected with the upper portion of each of said end walls for yieldably steadying said pocket.

24. A tumbling mill, comprising, a pocket including an arcuate portion arranged to form a support for a plurality of articles to be treated, a shaft having a crank connected with the lower portion of said pocket for bodily gyrating said pocket, a counterweight on said shaft, and flexible means connected with the upper portion of said pocket for yieldably steadying said pocket.

25. In the art of treating a group of articles by subjecting them to a blasting stream, the method of tumbling the articles across the path of the stream comprising the step of assembling the articles upon an arcuate surface of a supporting member and imparting to the member a rapid gyratory movement in a vertical orbit for carrying the articles to be treated supported on areas of said surface to at least the apogee of the orbital movement aforesaid, said areas then moving out of supporting relation to said articles and returning to their initial positions prior to the articles reaching a position of resupport, substantially as described.

26. In a method of blasting a group of articles, the steps of assembling the group upon an arcuate surface of a supporting member with the exposed surface of the group substantially coinciding with the chord of the arcuate surface and approximating the angle of repose of the articles, effecting by imparting a gyratory movement to the

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supporting member the advancement of the articles along said arcuate surface to cause the articles to reach a position beyond the angle of repose and tumble down said chordal surface, and playing a blasting stream upon the tumbling articles.

27. In a method of blasting a group of articles, the steps of assembling the group upon an arcuate surface of a supporting member with the exposed surface of the group substantially coinciding with the chord of the arcuate surface and approximating the angle of repose of the articles, effecting by imparting a gyratory movement to the supporting member the advancement of the articles along said arcuate surface to cause the articles to reach a position beyond the angle of repose and tumble down said chordal surface, said gyratory movement effecting movements of the falling articles additional to those resulting from

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a normal tumbling action, and playing a blasting stream upon the tumbling articles.

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