(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 186 357**
A2

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: **85308900.1**

(51) Int. Cl.[4]: **B 24 B 31/06**

(22) Date of filing: **06.12.85**

(30) Priority: **21.12.84 US 685121**
19.09.85 US 777821

(43) Date of publication of application:
02.07.86 Bulletin 86/27

(84) Designated Contracting States:
BE CH DE FR GB IT LI SE

(71) Applicant: **GENERAL KINEMATICS CORPORATION**
777 Lake Zurich Road
Barrington Illinois 60010(US)

(72) Inventor: **Musschoot, Albert**
Route 5 Dana Lane
Barrington Illinois 60010(US)

(74) Representative: **Allden, Thomas Stanley et al,**
A.A. THORNTON & CO. Northumberland House 303-306
High Holborn
London WC1V 7LE(GB)

(54) **Tumbling apparatus.**

(57) A vibratory material handling apparatus is provided for mixing of materials, cleaning, blending and/or shake-out of castings or the like. The machine comprises a horizontal container carried by a frame resiliently mounted on a foundation. A vibration generator is carried by the container and produces a line of force along an axis which passes exteriorly of the container or intersects with the container but offset from the center of gravity of the container. The vibration generator is adjustable on the container so that the direction of the line of vibratory force can be changed for changing the tumbling, mixing, cleaning, blending or shake-out characteristics of the machine. The relative movement between the inside of the container and the material in the container describes angles of attack with the container surface which movements are rotational about a center of rotation. A line from the center of rotation through the center of gravity of the container intersects the line of force from the vibration generator at a substantially right angle.

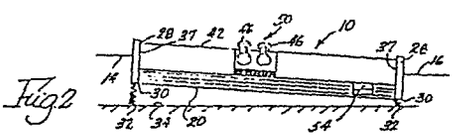


Fig.2

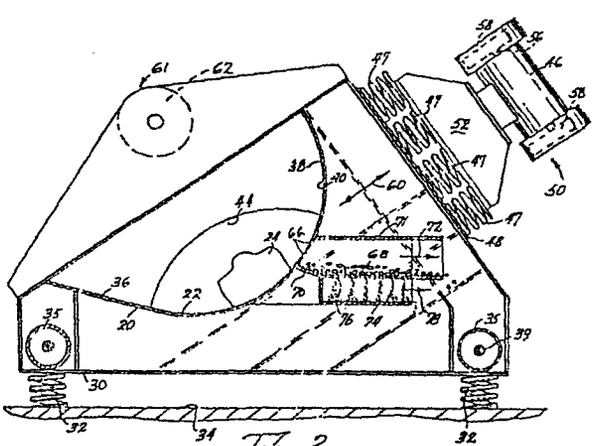


Fig.3

EP 0 186 357 A2

0186357

Tumbling Apparatus

Background of the Invention

Field of the Invention

This invention relates to tumbling apparatus and, in particular, to improved vibrating tumbling machines for mixing materials and for cleaning or shake-out of parts to be processed, such as castings, moldings or bulk material with or without a working media.

The Problem and the Prior Art

In many foundry operations, separation of sand and scale from castings is required. Typically, the castings are initially tumbled to dislodge foreign matter adhering to the castings. To assist this dislodging, shot may be caused to impinge upon the castings as they are tumbled. An exemplary structure through which dislodging of foreign matter according to the above can be accomplished is shown in U.S. Patent 3,793,780 to Musschoot.

In the Musschoot '780 patent, a tipped, U-shaped hopper is provided and has independently operable, vibratory imparting mechanisms associated with each leg of the hopper. Operation of the vibratory imparting mechanism is coordinated to move the casting towards a dead zone for tumbling and shot treating and

away from the dead zone upon completion of the tumbling and treating operations to discharge the castings.

The principal difficulty with this type of equipment is that the vibration is not imparted continuously during the separating operation. Rather, the vibration imparting mechanisms are stopped and started, requiring monitoring and coordination. Aside from the above, the intermittent operation of the vibration imparting mechanisms result in possible excessive wear thereon.

Another drawback with the equipment in the prior art is that intermixing of the castings with the shot, the separated sand and the scale occurs. In some prior art, it is intended that sand and shot remain in the hopper with the castings as the castings are agitated and transported for discharge. The discharged castings therefore can retain some of the shot, sand and scale. In the event that engine blocks or the like are cast, complete removal of sand, scale, shot and other foreign matter is absolutely essential. Thus, with the prior art structures, a subsequent cleaning operation would have to be performed in the cast parts.

It was found sometime ago that an improved finish could be obtained on cast or molded parts by adding a vibratory motion to the tumbling apparatus. In the early 1960's, I developed and patented under U.S. Patent No. 3,157,004, an improved burnishing apparatus using a U-shaped tub mounted on trunnions. Vibratory force was applied directly to the U-shaped tub and passed through the center of gravity of the tub. When the tub was tilted about the trunnions, the vibratory force was used to discharge the media and parts from the tub.

Although improved burnishing of the parts resulted from the above use of vibratory motion through the center of gravity of the tumbling apparatus, problems continued with the balance of the machine, with the wear on bearings, and with the time it took to obtain the finish.

The Invention

The present invention is specifically directed to overcoming the above-enumerated problems in a novel and simple manner.

According to the invention, a hopper is vibrated to advance castings continuously in a path between inlet and outlet ends. Simultaneously, shot, sand, scale and other foreign matter are discharged from the hopper separately from the castings. A preliminary shake-out of the castings takes place prior to the introduction of the castings into the hopper and a subsequent abrasive removal operation takes place separately upon the castings being discharged from the hopper. Shot can be propelled at the castings in the hopper to enhance dislodging of foreign matter therefrom. Castings leaving the system are effectively cleaned of all foreign matter, i.e. shot, sand and/or scale.

According to the latest versions of the invention, a vibrating tumbling apparatus comprises a container, which may be a cylindrical drum, and a frame which are resiliently mounted on a foundation. A bracket on the container supports a vibration generator capable of producing linear vibratory motion. The arrangement is such that the container is vibrated along small segments of an arcuate or circular path centered at a point offset from the center of the container. The tumbling apparatus

will have a batch of material (which may be castings with or without media) in the container. The apparatus may also be used to mix materials of different characteristics in a highly efficient manner. The material in the container is moved or conveyed and tumbled not only due to the coefficient of friction of the material with the surface of the container, but also due to the angle of attack between the material and the surface of the container at any given point because of the segmental circular path. A line from the center of rotation through the center of gravity of the machine intersects the linear line of force generated by the vibration generator at an angle of 90°. The angle of attack between the material and the container can be varied to vary the rate or character of mixing, to vary the rate of cleaning, to vary the amount of tumbling, to vary the conveying and tumbling action between the material and the surface of the container and the like.

Preferred forms of the invention are shown in the accompanying drawings.

Description of the Drawings

Figure 1 is a plan view showing schematically an overall system for separating foreign matter from castings with the present invention incorporated;

Figure 2 is a side elevation view of a continuous hopper section in the system of Fig. 1;

Figure 3 is an enlarged sectional view of the hopper taken along line 2-2 of Fig. 1;

Figure 4 is an end view of one preferred form of a vibratory tumbling machine with some parts shown in cross-section and some parts shown in phantom;

Figure 5 is an elevation view of the machine of Figure 4 as viewed from the right in Figure 4;

Figure 6 is a view like Fig. 4 but with a difference in the line of application of the vibratory force.

Figure 7 is a view of one form of deck for mounting the vibration generator of Figure 4 showing alternate positions of the deck;

Figure 8 is a view similar to Figure 6 showing a modified form of the invention;

Figure 9 is a view like Fig. 5 of the modified form of the invention;

Figure 10 is a copy of a chart of the paths of movement of material in the machine of Figure 4 in operation;

Figure 11 is a copy of a chart of the paths of movement of material in the machine of Figure 8 in operation; and

Figure 12 is a cross-sectional view of a cylindrical deflector with openings or ports therethrough.

Detailed Description of the Drawings

In Fig. 1, a depiction of an overall system appears for loading castings into a primary separation structure 10, in which foreign matter such as scale and/or sand is dislodged from the castings, and unloading of the castings upon treatment in the primary separation structure 10 for subsequent cleaning occurs. High frequency shake-out structure is indicated at 12 and is responsible for initial breakup of mold bound castings. The castings, after initial breakup of the molds occurs, are directed to an inlet 14 for the separation structure

10 and are operated upon in a manner that will be described in detail below. The castings discharge from the separation structure 10 at an outlet 16 and are directed to a casting roll-over, abrasive removal station 18 whereat final casting cleaning is carried out.

The details of the primary separation structure, wherein the present invention resides, are shown in Figs. 2 and 3. The primary separation structure has a hopper 20 with a bottom surface 22 for supporting the castings as they travel between the inlet and outlet ends. A typical casting 24 is shown in Fig. 3 and may be, for example, an engine block. The bottom surface 22 is supported in an inclined attitude as shown in Fig. 2 and slopes downwardly from the inlet end 14 towards the outlet end 16. The hopper 20 has attached, reinforced end walls 26, 28 with bottom surfaces 30 borne upon by isolation springs 32 interposed between the surfaces 30 and the system support surface 34. Spaced longitudinally directed tubes 35 are fit between the facing surfaces 37 of the end walls 26,28. Coaxial tie rods 39, internally of the tubes, draw the end walls 26,28 towards each other and agains the tube ends so that a unitary assembly results. The hopper 20 is fixed captively between the end walls 26,28.

The bottom surface 22 of the hopper has a substantially U-shaped configuration in cross-section, as seen clearly in Fig. 3, and is skewed with respect to the vertical so as to define a substantially horizontal leg 36 and a vertical leg 38 having an upstanding wall surface 40. The hopper 20 is sealed by a removable hood 42 between the end walls 26,28. The end walls 26,28 have curved cutouts 44 (one shown) defining passages for the castings at the inlet 14 and outlet 16.

Vibration imparting structure for the hopper 20 comprises motors 46 mounted resiliently, as by coil springs 47, to an inclined exciting wall 48 carried by the hopper 20 midway between the end walls 26,28. The disclosed arrangement is a two mass vibratory system. The exciting mass at 50 comprises the motors 46 and associated mounting base 52. The second mass comprises the hopper 20, end walls 26,28, hood 42 and discharge section 54 which diverts separated foreign matter. Each motor 46 has a shaft 56 offset from the vertical and substantially perpendicular to the line of movement of the castings between the hopper outlet and inlet. Each shaft 56 carries a pair of eccentric weights 58 at its ends. As the shafts 56 rotate, the hopper 20 is caused to move reciprocatively substantially along the line 60 so that conveyance of the castings 24 towards the right (Fig. 2) occurs.

The path of an exemplary casting 24 will now be described. As the motors 46 are activated, the casting follows the curvature of the bottom surface 22 and in effect begins climbing the upstanding wall 38. As the casting 24 moves vertically, gravitational forces on the casting due to the incline of the bottom surface 22 at the same time cause the casting 25 to vibrate towards the outlet 16. The casting 25 climbs until it ultimately tumbles over itself. As this operation continues, the casting 25 traces a substantially helical path. As the casting follows the described path, the foreign matter such as the scale and mold material tends to progressively dislodge.

The invention also contemplates that the separation of foreign matter be assisted by propelling shot towards the castings progressing through the

structure 10 at a shot treatment station 61. A conventional wheel 62 directs shot centrifugally through an opening 64 in the hood 42. The impinging shot jolts the castings to effect separation of foreign matter that might otherwise not occur through tumbling alone.

It is a further aspect of the invention to provide structure for diverting foreign matter, separated from the castings in the hopper, away from the hopper. To accomplish this end, openings 66 are provided in the wall of the hopper. A shelf 68 resides at the openings 66 and is fed by a ramp 70 inclined downwardly away from the hopper opening 66. The vibration of the hopper tends to shift the separated foreign matter towards the shelf. The ramp and shelf vibrate in conjunction with the hopper so that the foreign matter tends in the direction of arrow 72 by the combined effect of gravity and the vibratory conveying force imparted by motor 46.

The shelf 68 resides in a chamber 71 above a floor 74 at the bottom of the chamber and has openings 76 to permit passage of a first size material which drops to the floor 74 and moves in the direction of arrow 78 to a point of collection. Material unable to pass through the shelf discharges from the upper portion of the chamber separately from the smaller size particles. By separating the foreign matter as the castings move along the length of the separating structure, the foreign matter does not find its way back into chambers and/or crevices defined by the castings or reattach to the castings. Upon exiting the separation structure, the castings are rolled over and any remaining foreign matter separated at station 18.

In one preferred form of the invention shown in Figs. 4-6, a tumbling apparatus for mixing, cleaning,

and/or shake out of parts is designated by the numeral 110 and comprises a container 112 which in the illustrated form is a cylindrical drum and a vibration generator 114. The container 112 could be an open top member, an oval member or any desired shaped member as long as it has a horizontal axis. The container 112 is attached at each end to end plates 116 of a frame 118. In addition to the end plates 116, the frame has a bottom plate 120 connected to the end plates with corner reinforcing gussets 122 extending between the container, an end plate and the bottom plate for supporting the container 112. Gussets 124 extend between a flange 126 and the end plates in the vicinity of the corners of the machine to provide reinforced pads at the corners. The machine is resiliently supported on a foundation or base 128 by means of springs 130 attached to the pads on the flanges 126 and to the foundation. The springs 130 may be coil springs, as shown, or may be air springs or the like.

The container 112 has an inlet port 132 near the high point of the container at one end portion and is comprised of a flanged opening 134 having a funnel shaped hopper 136. The inlet port 132 could be through the high part of the end plate 116 just as well. An outlet port 138 is formed through the side wall of the container upward of the low point of the container and at the opposite end of the container from the inlet port. The outlet port 138 can be opened or closed, but when opened, has a platform 140 over which the discharged parts and/or media flows. A conveyor 142 communicates with the outlet port for conveying discharged parts and/or media away from the machine. The discharge or outlet port 138 could be through the low point of the cylinder of the container

for certain applications. It will be noted in Figure 5 that the horizontal axis 139 of the container angles a few degrees from the horizontal so that the outlet end of the container is lower than the inlet end. This accommodates flow of the material through the container as the tumbling, mixing, polishing and/or shake-out is taking place.

A bracket 144 includes a pair of spaced apart mounting supports 146 is affixed to the container on one side of the vertical axis of the container. The ends of the supports 146 spaced from the container have a substantially horizontal edge 148 with an aperture 150 through an end portion of each support in horizontal alignment with each other. A horizontal axis 152 connecting the centers of the two apertures 150 is parallel to the horizontal axis 139 of the container. As shown in Figure 1, a line 154 drawn through the center (at the horizontal axis 139) of the container 112 and the center (horizontal axis 152) of the apertures 150 of the bracket 144 forms an angle A to the vertical axis 156 of the machine. As shown, the angle A between line 154 and vertical axis 156 of the container is approximately 45°. The bracket 144 also has a mounting deck 158 between the supports 146 and, as shown, the deck is pivotally mounted to the supports 146 by pivot pins 160 passing through apertures 162 in depending flanges 164 on the deck and through the apertures 150 in the supports 146. The deck 158 is locked in position relative to supports 146 by means of a pair of bolts 166 passing through arcuate slots 168 in the supports 146. When the bolts 166 are tightened down, the deck 158 is locked in place on the supports on the container. For the purposes of Figure 1, the surface of the deck 158 lies in a plane perpendicular

to the vertical axis 156 and parallel to the horizontal axis 152 of the pivot pins 160.

The vibration generator 114 comprises a support plate 169 resiliently mounted on the deck 158 of the bracket 144 by a plurality of springs 170. A motor 172 is mounted on the support plate 169 with the axis of the double ended drive shaft 174 lying substantially parallel to the longitudinal axis 139 of the container. Eccentric weights 176 are mounted on each end of the double ended shaft and are encased in covers 178. Variable force vibration generators such as the types shown in my U.S. Patent No. 4,495,826 and 3,358,815 may be substituted for the eccentric weights 176 on each end of the shaft 174. As illustrated in Figures 4-6, the linear vibratory forces are generated by a two mass system, the motor 172, plate 169 and weights 176 being one mass, and the container 112, bracket 144 and frame 118 being the second mass. The vibration generator 114 as shown in Figure 4 has an axis 180 which is vertical and intersects the axis 154 of the pivot pins 160 and is perpendicular to the support surface or foundation 128.

Operation of the vibration generator 114 will produce vibratory forces 182 (illustrated generally by the double ended arrow) along a linear path 180. As shown, the path 180 and the linear forces 182 pass exteriorly of the container 112. The path 180 may intersect the container, but it should not go through the center of gravity of the container.

When the apparatus shown in Figs. 4 and 5 is operating and the vibration generator is producing linear vibratory forces along the axis 182, the container 112 will move in an arcuate path, basically segments of a circle, having a center of rotation offset from the

center of the container and located at point R. The material within the container in contact with or close to the inside surface will be moved along an angle of attack with respect to the inside surface of the container. The angle of attack is arcuate, basically a segment of a circle centered at R.

The center of rotation R is either a point or a small closed figure such as a small circle or ellipse which for all practical purposes may be considered to be a point. The point R will lie along a line passing through the center of gravity CG of the container and intersecting the linear line of force 182 at an angle of 90°. That intersection is on one side of the center of gravity CG and the point R will be on the other side of the center of gravity.

The center of rotation R should be offset from the center of the cylindrical container. If the container is not cylindrical but has a concave material supporting surface, the center of rotation R should be offset from the centers of circles osculating said concave surface.*

To illustrate the concept, see Fig. 10, a sheet of paper was affixed to one end of the container 112 and the vibration generator 114 was energized and tuned to resonance, thereby producing a linear force 182 along the axis 180. A stylus carried by an immovably fixed support on the foundation or stationary surface 128 was engaged

---

* Webster's New Collegiate Dictionary 1975 defines an osculating circle as "a circle whose center lies on the concave side of a curve on the normal to a given point of the curve and whose radius is equal to the radius of curvature at that point".

with the paper at various points on the end plate in alignment with the surface of the container. A tracing of the movement of the container, indicated at 184, was subscribed on the paper by the stylus. The stylus was spotted against the paper and container, a multiplicity of times in the vicinity of the center of rotation until the point R was located; that is, the point about which the container rotated. By drawing radii 186 from point R to the tracings, it was found that the tracing segments of a circle are centered at R.

The movements 184 along the bottom (or low point) of the container are directed inward into the mass with an angle of attack to produce conveying action of the media and parts. The movements 184 acting on the working media 188 and/or parts 190 in the container provide a vigorous and effective counter-clockwise path of motion to the media and parts in the container. The parts and media are conveyed up the inner surface of the container adjacent the vibration generator before falling back into the container. The vigorous circulatory motion provides improved tumbling of the parts in the media to increase the speed and effectiveness of the mixing in the container and of the burnishing and polishing of the parts. Due to the slight tilt to the axis 139 of the container 112 to the horizontal, the parts, as they are tumbled, will migrate from the inlet end to the discharge end of the container. In the alternative, with the axis 139 of the container horizontal, the amount of material added at the inlet 136 will determine the amount of material discharged at the outlet port 138. The outlet port 138 can be open or closed (shown open in Figure 4). When outlet port 138 is open, the media and parts will exit the container on the ramp 140 at the upper portion

of the circulatory path. The ramp 140 can be foraminous to permit the media to fall down into a collection receptical prior to being returned to the container or, as shown, the parts and media are delivered onto the conveyor 142 and will be conveyed to the next processing station. The inner surface of the container may be coated or lined 183 with a material having a particular coefficient of friction to aid in the conveying action and to improve the tumbling of the parts. The lining acts as a wear surface and can be replaced when worn.

The character of movement of the container and handling of the material within the container may be altered or modified by moving the location of the center of rotation R. The position of R will change if the direction of the linear vibratory forces change. Similarly, the position of R will change if the center of gravity CG is changed such as, for example, by adding weights to the container. Incidentally, when the center of gravity of the container is referred to, it includes not only the container 112 but all parts attached to the container between the springs 130 and the springs 170.

The effects of changing the direction 82 of the vibratory forces is illustrated in Fig. 7. In this case the bolts 166 were loosened and the vibration generator 114 was tilted to incline the line of vibratory forces 182 some 5° from vertical and the line of vibratory forces angled toward the container. Inasmuch as the center of rotation R lies on a line normal to the line of force and passing through the center of gravity CG, R will assume a new position as shown in Fig. 7. With R in a new position, points on the inner surface of the container will move in a arcuate path or segments of a circle centered at the new location of R. This imparts a

vibratory conveying movement to the material adjacent or in contact with such point to move along such paths thereby providing a different character of movement of the mass of material inside the container. The effect that will be first noted with the relocation of R is the change in the slope of the material within the container.

A valuable and perhaps surprising characteristic in the operation of the apparatus shown when used as a vibrating tumbling apparatus where parts and a media are placed within the container is that the parts themselves will remain immersed in the media. This is of importance not only in enhancing the cleaning and burnishing effect of the operation but also prevents damage to the parts being treated which would occur if the parts surfaced and vibrated directly against the interior surfaces of the container and against each other.

Figs. 8 and 9 show the machine 110 with the axis of the vibration generator 114 tilted to a 95° angle as in Fig. 7. A baffle or deflector 92 is selectively located in the container with Fig. 11 showing the flow pattern and forces acting on the material when the deflector 192 is added to the system. All of the structural elements of Fig. 8 that are the same as the structural elements of Figure 4 will bear the same reference numerals. The line of vibrational force 182 is external of the container. The instantaneous center of rotation R will be located at point R so that the movements 184 acting on the material in the drum will subscribe the appropriate angle of attack with the surface of the container.

The baffle 192, which in Figs. 8 and 9 is cylindrical but which could be square, rectangular, tear drop shape or the like in cross section, extends from end

to end of the container 112 between the end walls 116 and can be adjusted to any desired position using appropriate means. The baffle or deflector 192 deflects a portion of the media over the outside of the deflector changing the pattern of flow of media and parts 190 in the container. The baffle can be set so that only media goes over the deflector so that the parts remain submerged in the media. The tumbling and mixing of the media was more pronounced and the media and parts climbed higher in the container before the media cascaded back down over the deflector. With the deflector 192 adjusted so that it was closer to the container walls, the parts were sometimes exposed on the surface of the media but once the parts 190 tumbled over the deflector, they re-immersed in the media thereby minimizing scratching and bumping between the parts.

The deflector 192 may be provided with openings, or ports 193, see Figure 12, through which hot air for heating the media or cold air for cooling the media can be piped. Burner jets could be provided in the deflector with the nozzles pointing into the media. When ignited, the jets would burn off carbonaceous particles on sand being processed and cleaned.

The line of force 182 along the axis 180 of the vibration generator passes exterior of the container or intersects the container, but does not pass through the center of gravity of the container.

Although I have described the improved tumbling apparatus as employing a two mass system, such as shown at 114 in Figure 4, the apparatus does operate effectively with any linear vibratory force system mounted directly on the container and producing a linear line of force. The vibration generator 114 is shown

upward and to the right of the container 112. It is to be understood that the vibration generator may be located at other positions as long as the line of force 182 is substantially offset from the center of gravity of the apparatus and so long as the center of rotation is not on the vertical centerline of the container 112. Thus, as all points on the material supporting surface of the container are moved in segments or paths of different circles having a common center at R, such segments or paths are not parallel.

Claims

1. A vibratory apparatus for separating foreign matter from castings comprising;

a hopper having an inlet for admitting the castings to the hopper, an outlet through which castings are discharged from the hopper and a bottom surface for supporting the castings;

means supporting the bottom surface of the hopper so that the hopper surface is inclined downwardly from the inlet toward the outlet end;

vibration imparting means operating on said hopper surface to agitate the castings to effect separation of foreign matter therefrom and move the castings between the hopper inlet and outlet; and

means for directing foreign matter separated from the castings in the hopper away from the hopper,

whereby said castings can be continuously directed between the hopper inlet and outlet and foreign matter can be continuously separated from the castings and directed away from the hopper.

2. The vibratory apparatus according to claim 1 wherein the vibration imparting means tumbles each casting as the casting is conveyed from the inlet toward the outlet.

3. The vibratory apparatus according to claim 1 wherein said vibration imparting means comprises a plurality of motors, each said motor having a shaft carrying at least one eccentric weight and means connecting each said motor resiliently to the hopper.

4. The vibratory apparatus according to claim 1 wherein said means for directing foreign matter away from the hopper comprises an opening in said hopper and a ramp at said opening inclined downwardly away from the hopper and said vibration imparting means has a force component directing foreign matter towards the ramp.

5. The vibratory apparatus according to claim 1 wherein said bottom surface is curved and has an integral, upstanding wall and said vibration imparting means is attached at an upper region of said upstanding wall.

6. The vibratory apparatus according to claim 1 wherein said bottom surface is curved and has an integral, upstanding wall and said vibration imparting means is attached at an upper region of said upstanding wall.

7. A vibratory apparatus for separating foreign matter from castings comprising:

a generally U-shaped hopper having a supporting surface for the castings, an upstanding wall at on side, an inlet for admitting castings from the hopper.

means supporting the hopper so that the supporting surface is inclined downward from the inlet towards the outlet end;

vibration imparting means operating on the hopper to cause said castings to move both towards said upstanding wall and the outlet end of the hopper; and

means for directing foreign matter separated from the castings in the hopper away from the hopper,

whereby said castings can be continuously directed between the hopper inlet and outlet and foreign matter can be continuously separated from the castings and directed away from the hopper.

8. The vibratory apparatus according to claim 7 wherein said supporting surface has a curved portion adjacent the upstanding wall and said castings move along the curved portion toward the upstanding wall as they travel towards the outlet and tumble over themselves, said castings thereby following a substantially helical path between the inlet and outlet ends so that foreign matter is effectively dislodged.

9. The vibratory apparatus according to claim 7 wherein said means for directing foreign matter away from the hopper comprises an opening in said hopper and an inclined ramp for directing foreign matter from said hopper to a shelf having openings allowing passage therethrough of foreign matter of a first size.

10. The vibratory apparatus according to claim 7 wherein a shot wheel is provided above said hopper upstream from said means for directing the foreign matter therefrom, said shot wheel propelling shot onto said castings as they are conveyed from the inlet to the outlet of the hopper.

11. The method of operating a vibratory material handling container which comprises vibrating the container in a segmental circular path about a center offset from the center of the container.

12. The method of operating a resiliently supported vibratory material handling container which comprises generating a vibratory force along a linear path, transmitting said force to the container with said linear path directed away from the center of the container and on one side of the center of gravity of the container to cause the container to vibrate in a segmental arcuate path about a center offset from said center of gravity and on the other side thereof.

13. The method of operating a vibratory material handling container having a concave material supporting surface which comprises vibrating the container in a segmental arcuate path about a center offset from the centers of circles osculating said concave surface.

14. The method of operating a vibratory container having a material supporting surface which comprises vibrating the container about a center of rotation offset from the center of the container to cause all points on said surface to move in segmental circular paths around said center of rotation with all segmental circular paths being non-parallel.

15. The method of operating a vibratory container having a material supporting surface which comprises vibrating the container about a center of rotation offset from the center of the container and offset from the center of gravity of the container to cause all points on said surface lying in a vertical plane passing through the centers of rotation and gravity to move in segmental circular paths around said center of rotation with all circular paths being non-parallel.

16. Vibratory apparatus comprising a generally horizontally arranged container, means mounting the container for vibratory movement, a vibration generator connected to the container and means for directing the vibratory force generated by the vibration generator along a line displaced from the central horizontal axis of the container and on one side of and displaced from the center of gravity of the container to cause points on the inner surface of the container to rotate along segments of circles, each circle having a common center located at a desired position displaced from said center of gravity on the other side thereof.

17. Vibratory apparatus comprising a container having a material supporting surface, means mounting the container for vibratory movement, a vibration generator for generating a vibratory force along a linear path displaced from the center of gravity of the container, said vibration generator being connected to the container, said vibratory force causing each point on the material supporting surface to vibrate along segments of circles having a common center at a desired position spaced from said center of gravity.

18. Vibratory apparatus comprising a container having a material supporting surface, means mounting the container for vibratory movement, a vibration generator secured to the container, said generator producing a vibratory force along a linear path extending on one side of the center of gravity of the container whereby each point on the material supporting surface will vibrate in paths lying on segments of circles having a common center at a point lying on a line normal to said linear path and

passing through said center of gravity, said point being located on the other side of said center of gravity.

19. Vibratory apparatus comprising a container having a material supporting surface, means mounting the container for vibratory movement, a vibration generator secured to the container, said generator producing a vibratory force along a linear path extending on one side and exteriorly of the container whereby each point on the material supporting surface will vibrate in paths lying on segments of circles having a common center at a point lying on a line normal to said linear path and passing through said center of gravity, said point being located on the other side of said center of gravity.

20. In a vibratory apparatus having a container and a frame resiliently mounted on a foundation with an axis of the container lying generally horizontal, a vibration generator mounted on the container for producing vibrational forces along a line passing on one side of the center of gravity of the container, said forces producing rotational forces acting on the container to cause the container to rotate segmentally about a center of rotation, said center of rotation being located on the other side of said center of gravity whereby the vibrational forces of the generator will produce rotational forces on the container which will convey the material up the adjacent surface of the container until it tumbles back into the container.

21. In the vibratory apparatus of claim 10 wherein said center of rotation lies on a line passing through said center of gravity of the apparatus and is

perpendicular to the vibratory force generated by the vibration generator.

22. In the vibratory apparatus of claim 10 wherein said vibration generator is adjustably mounted on said container whereby the direction of the vibrational forces of the vibration generator can be changed.

23. In a vibratory apparatus having a frame, resilient means mounting the frame on a foundation, a container having an inlet port at one end and an outlet port at the other end, the container being mounted on the frame with the axis of the container tilted from the inlet end toward the outlet end at an angle of a few degrees from the horizontal, a vibration generator mounted on the container with the vibrational forces extending along an axis of the vibration generator, offset from the center of the container on one side of the center of gravity thereof, to produce a center of rotation on the other side of the center of gravity to produce rotational forces acting perpendicular to radii drawn from the center of rotation to a point on the inside surface of the container whereby media and parts being tumbled in the container will be moved up the inside surface of the container setting up a path of tumbling movement.

0186357

Fig.1

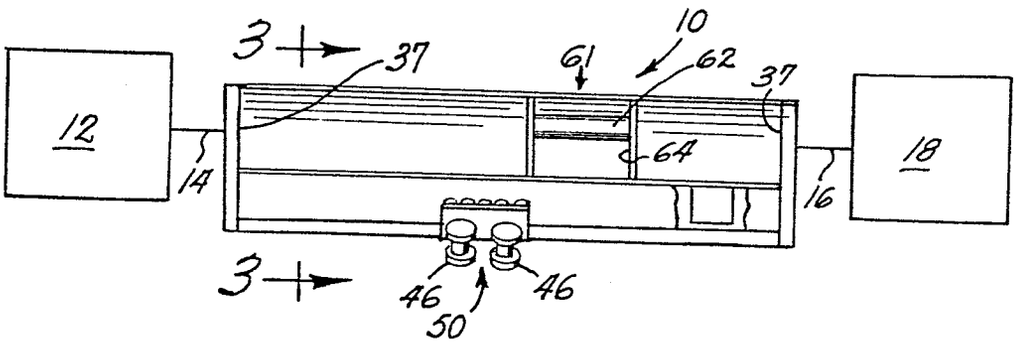
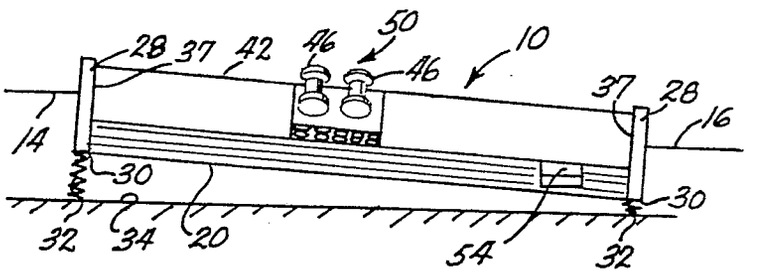


Fig.2



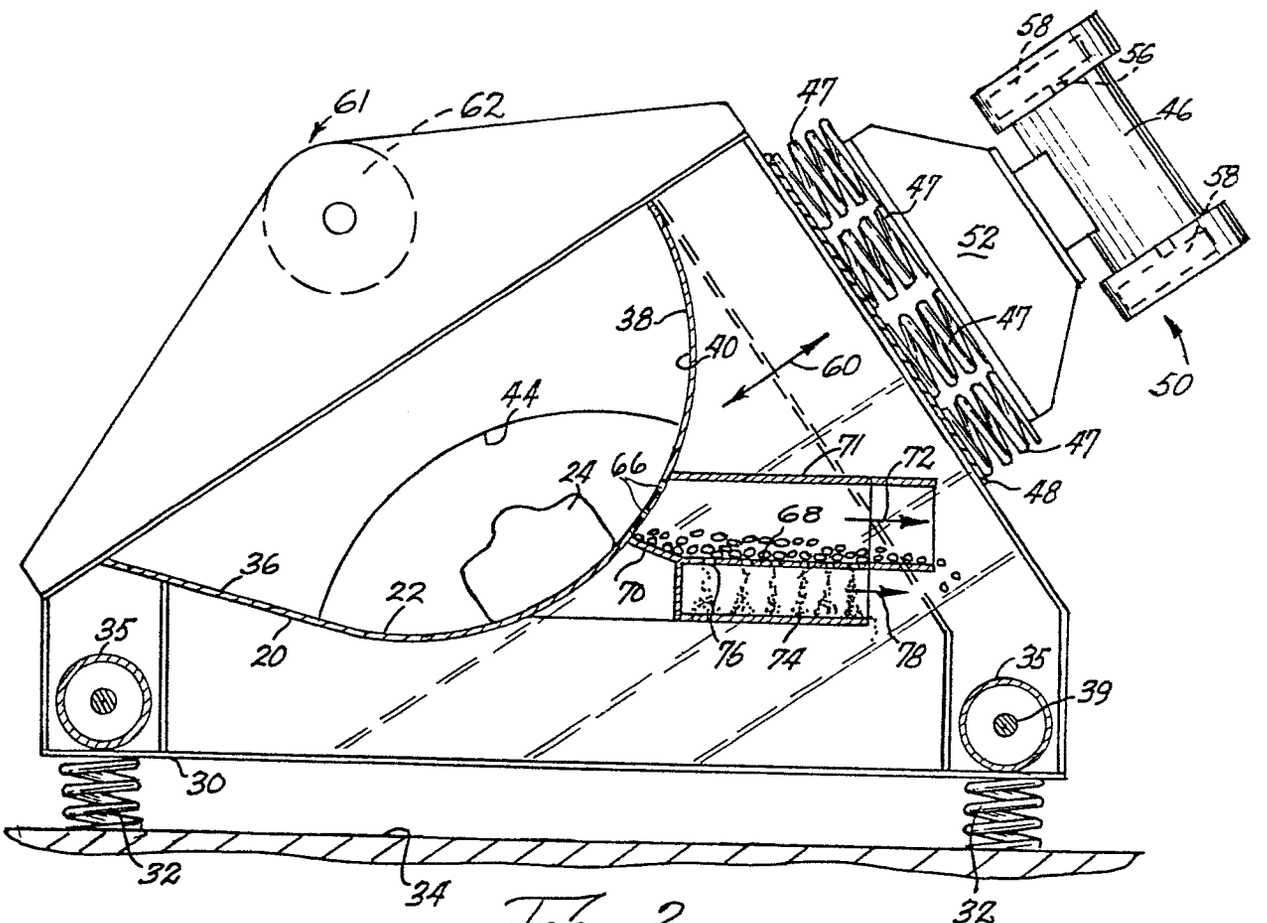
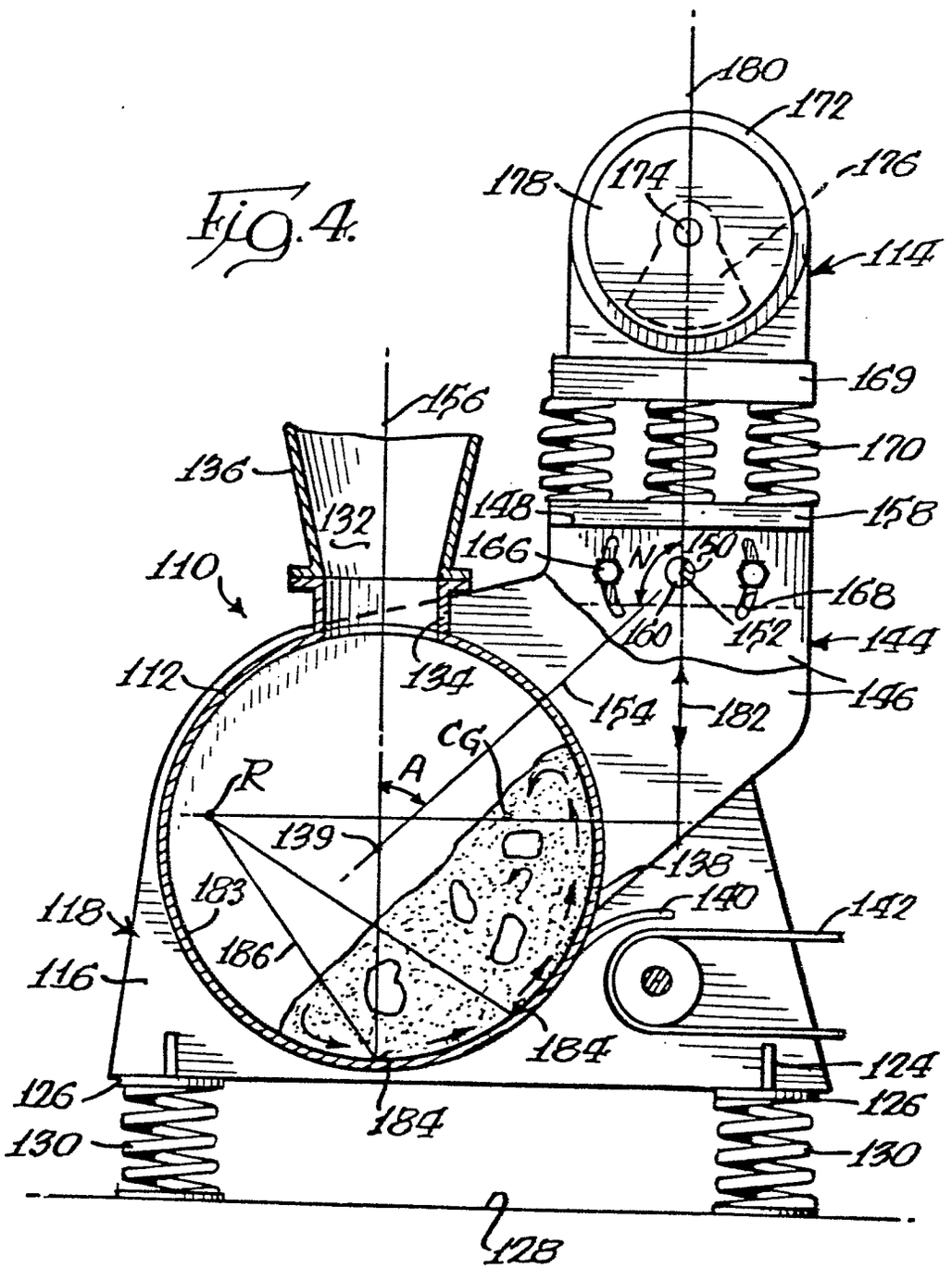


Fig.3

0186357

Fig. 4.



0186357

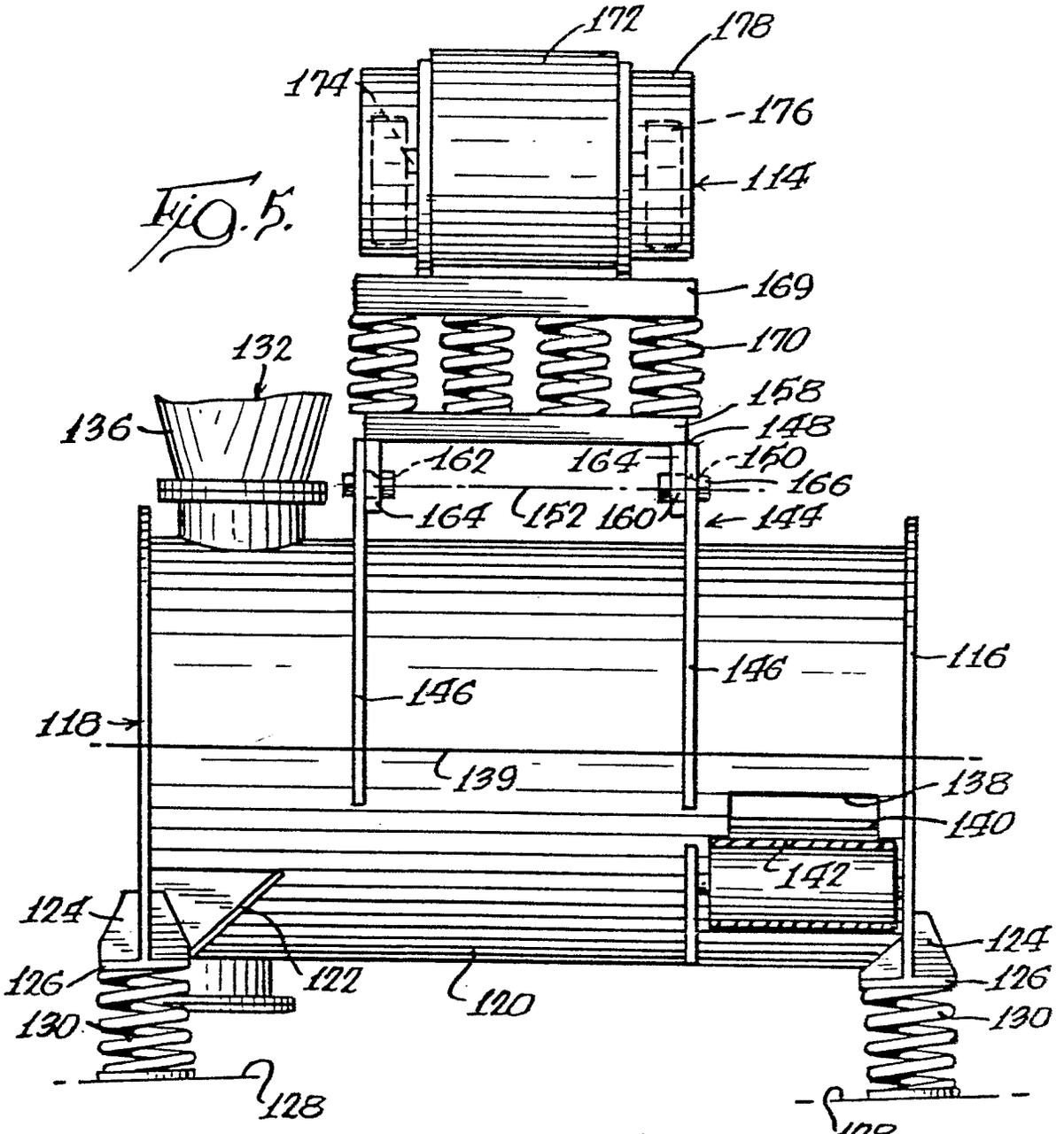


Fig. 5.

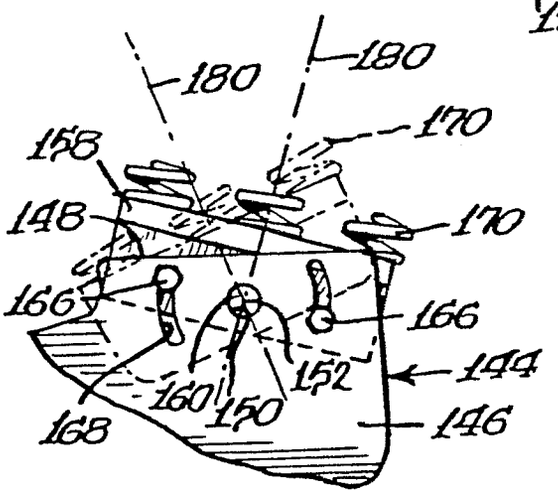
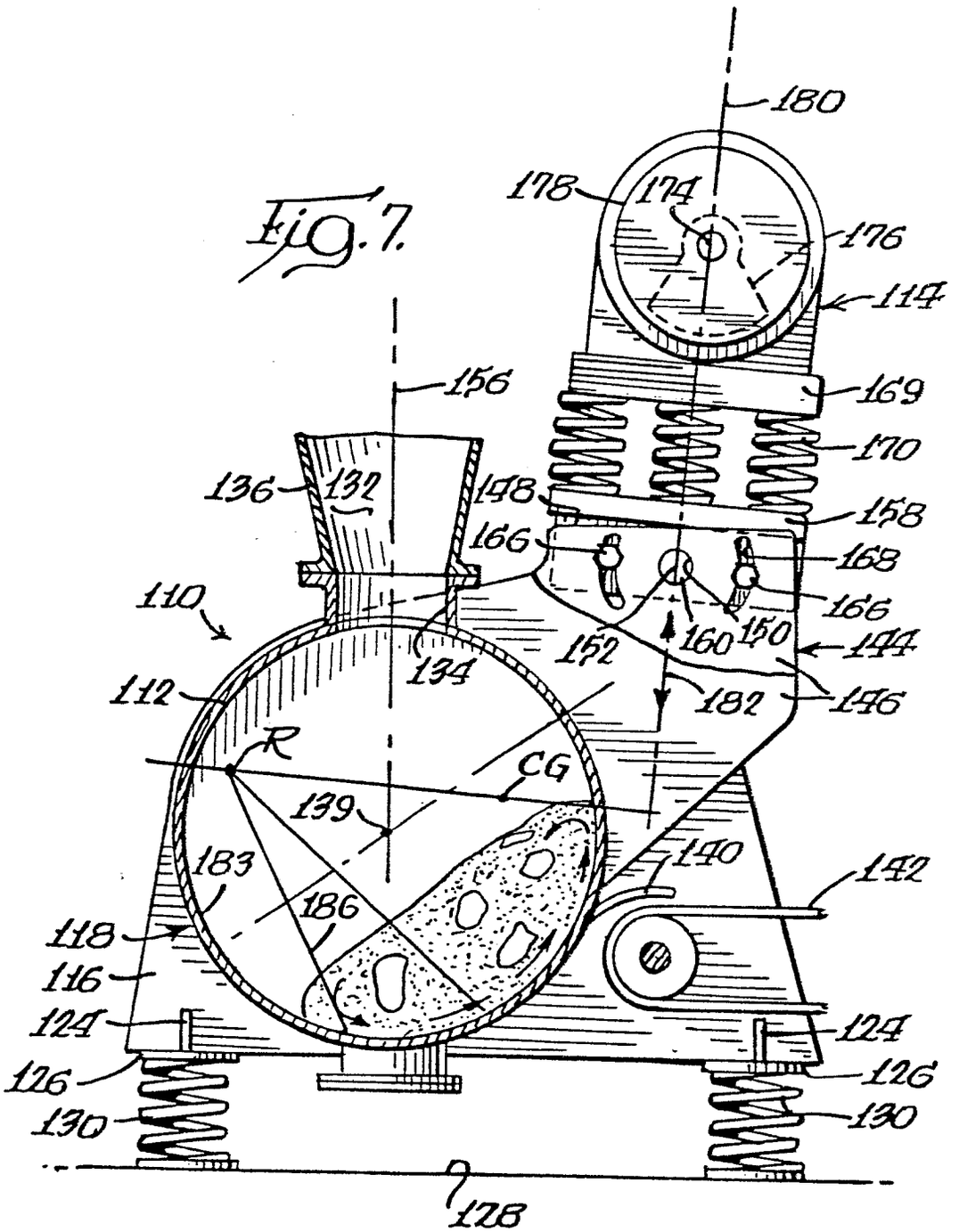


Fig. 6.

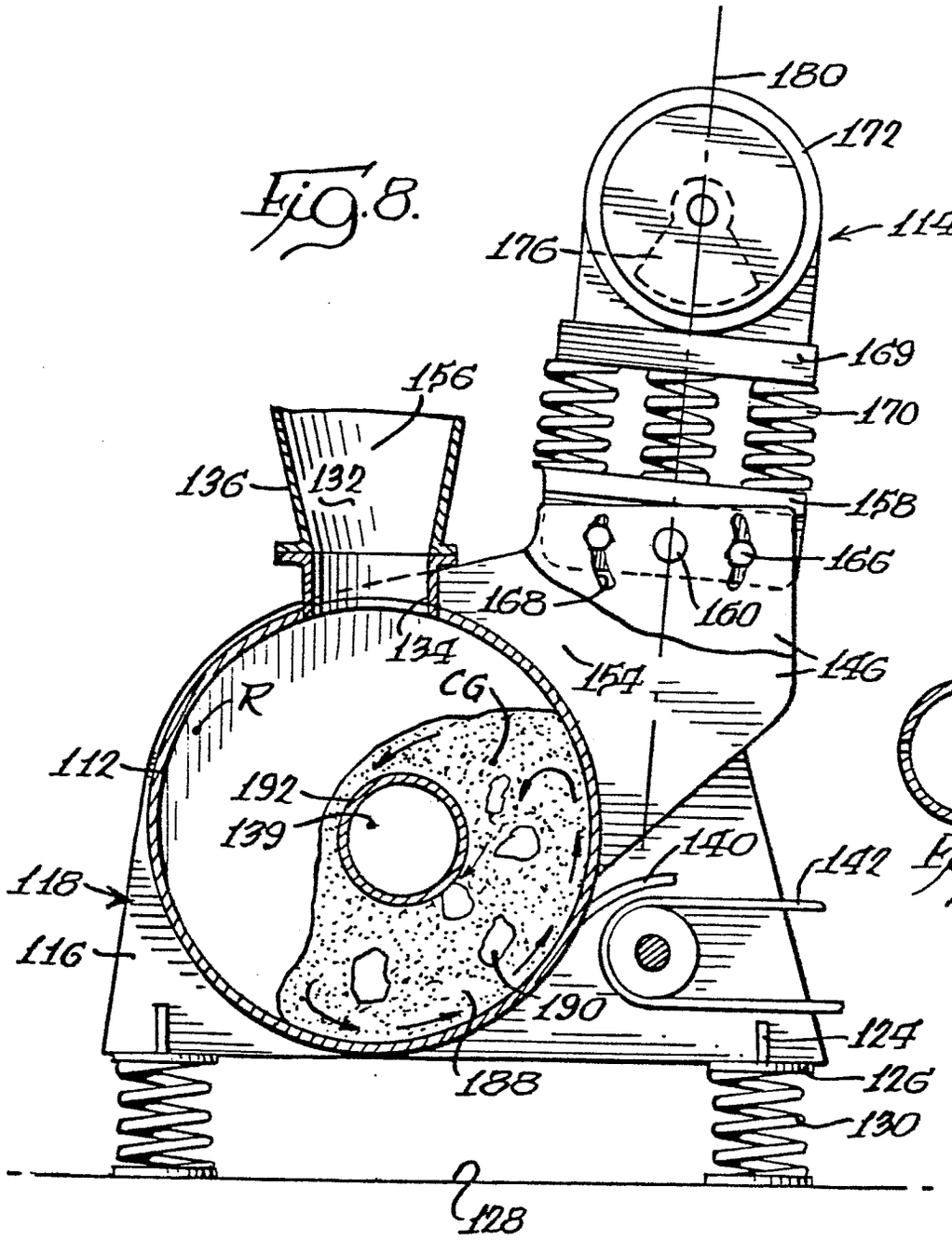
0186357

Fig.7.



0186357

Fig.8.



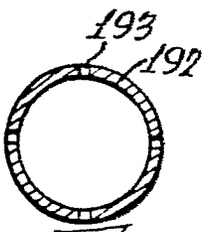
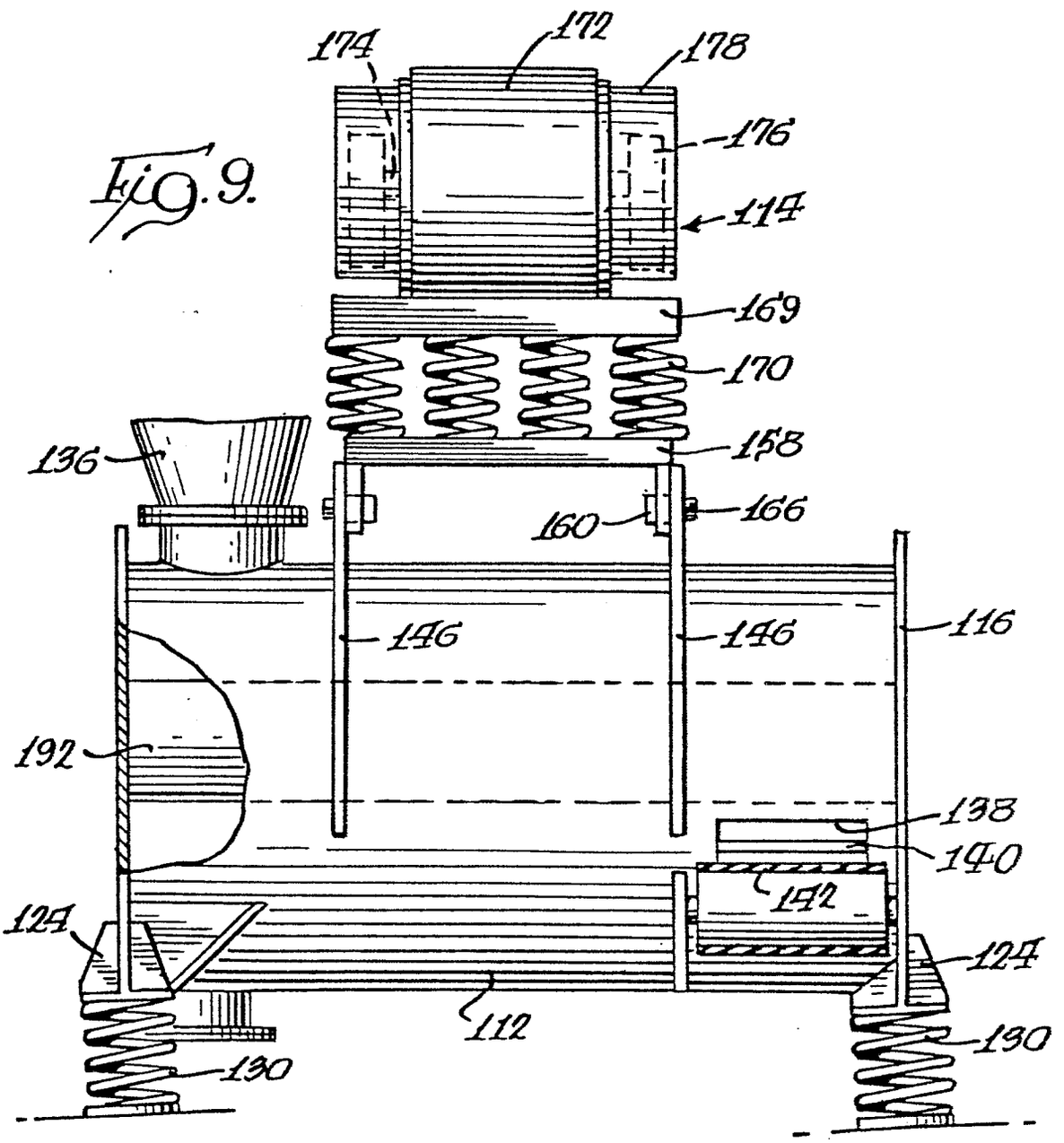


Fig.12.

0186357

Fig.9.



0186357

FIG.10.

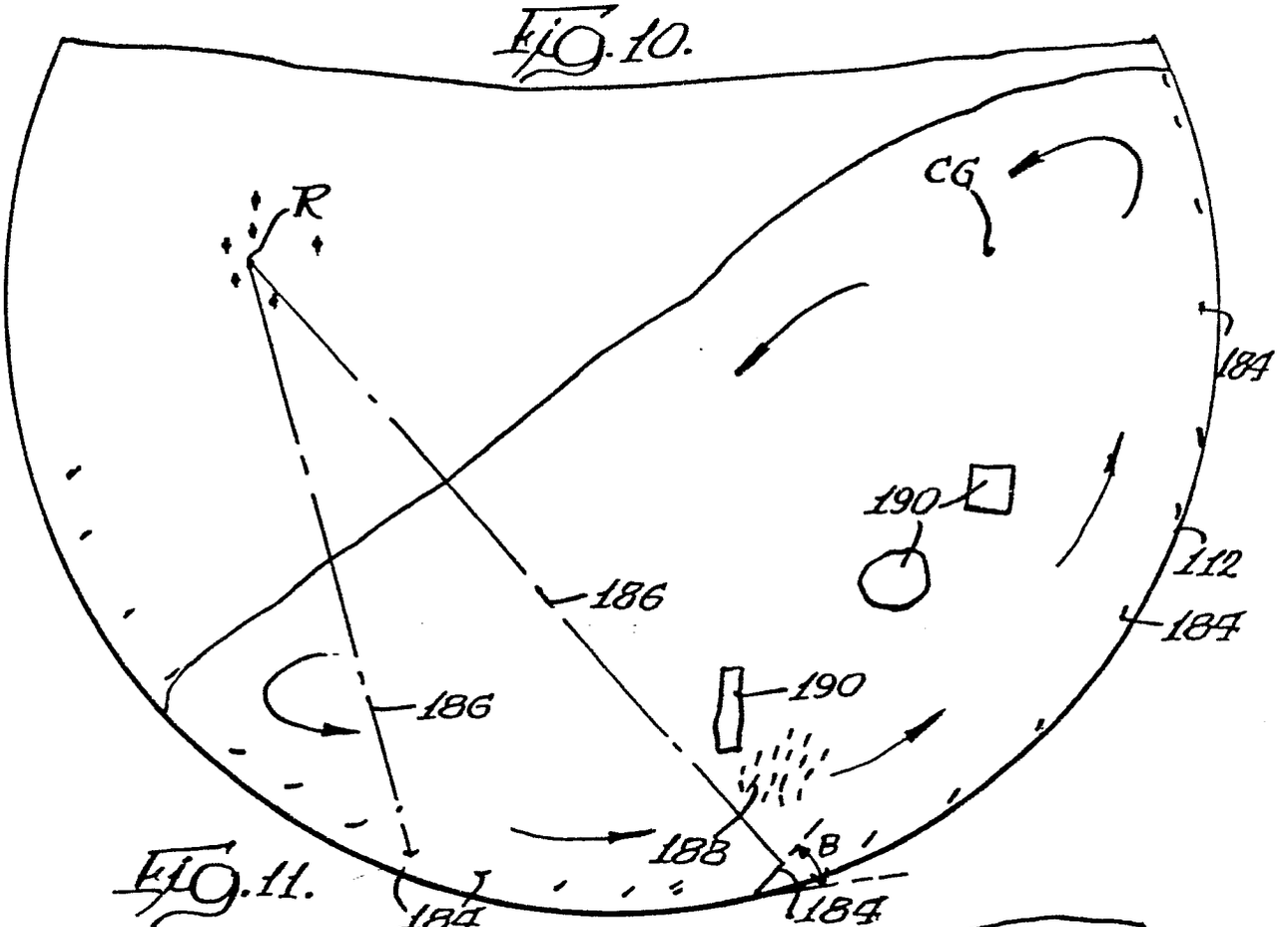


FIG.11.