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# (54) Tumbling apparatus

Scheuertrommel

Tonneau de polissage

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## Description

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

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 better accomplished as shown in US-A-3793780 in respect of which the inventor, Albert Musschoot, is also the inventor of the present invention.

In the aforesaid US-A-3793780, there is generally described a vibratory apparatus comprising a container having a material supporting surface, mounting means for resiliently mounting the container for unconstrained vibratory movement relative to a mounting surface, and vibration generator means mounted on the container.

More particularly, the material supporting surface is concavely linear in cross-section and the vibration generator means during a shake-out operation to separate, say, sand from castings, will generate vibratory forces to tumble the castings on the concavely linear supporting surface.

The aforesaid US-A-3793780 generally discloses a method of operating a resiliently supported vibratory material handling container which comprises generating vibratory forces along a linear path and transmitting the forces to the container with the linear path displaced to one side of the centre of gravity of the container to cause the container to vibrate

EP 0 086 868 discloses a vibratory apparatus according to the preamble of claim 1 and a tumbling method according to the preamble of claim 11 in which the vibratory forces employed are exerted along a linear path intersecting the container. Furthermore, the vibratory generating means are not resiliently connected with the container.

In accordance with one aspect of the present invention as claimed a vibratory apparatus comprising a container having a material supporting surface, mounting means for resiliently mounting the container for unconstrained vibratory movement relative to a mounting surface, and vibration generator means mounted on the container is provided, wherein the material supporting surface is concavely curved in cross-section with respect to the interior of the container and is either generated about an axis when constituting a circular arc or is generated about the centres of circles osculating the concavely curved surface. The vibration generator means is mounted on the container offset from the axis or osculating circles centres and generates vibratory forces along a linear path offset from the axis or from the osculating circles centres, the vibration generator means and the container having a centre of gravity (OG) offset from the axis or from the osculating circles centres of the container, and the vibration generator means and the linear path of vibratory forces being on the same side of the centre of gravity. This vibratory apparatus is characterized in that the vibration generator means is mounted on a support plate, the vibration generator means and the support plate being resiliently mounted on a bracket mounted on the container, and in that the linear path of vibratory forces is outside the container, the vibratory forces vibrating each point of the material supporting surface along segments of circles which do not conform to the curvature of the curved material supporting surface at the related point, each circle segment having a centre of rotation which lies at a position spaced from the axis or from the osculating circles centres and from the centre of gravity and on the opposite side of the axis or the osculating circles centres of the container from the linear path of vibration forces.

In accordance with another aspect of the invention as claimed a method of operating a resiliently supported vibratory material handling container is provided which comprises using vibration generator means being mounted on the container, the vibration generator means being designed to generate vibratory forces along a linear path and to transmit the forces to the contai ner with the linear path displaced to one side of the centre of gravity of the container to cause the container to vibrate, wherein the container has a material supporting surface which is concavely curved in cross-section with respect to the interior of the container and is either generated about an axis when constituting a circular arc or is generated about the centres of circles osculating the concavely curved surface, the linear path along which the vibratory forces are generated being offset from the axis or from the osculating circle centres, the vibration generator means and the container having a centre of gravity offset from the axis or from the osculating circles centres of the container, and the vibration generator means and the linear path of vibratory forces being on the same side of the centre of gravity. This method is characterized by using a vibration generator means being mounted on a support plate, the vibration generator means and the support plate being resiliently mounted on a bracket mounted on the container, and by the linear path of vibratory forces being outside the container, the vibratory forces vibrating each point of the concavely curved material supporting surface along segments of circles which do not conform to the curvature of the concavely curved material supporting surface at the related point, each circle segment having a centre of rotation lying at a position spaced from the axis or from the osculating circles centres and from the centre of gravity and on the opposite side of the axis or the osculating circles centres of the container from the linear path of vibratory forces.

Both the aforesaid aspects of the present invention have the advantage of resulting in improved tumbling of

a batch of material (which may be castings with or without working media) in the container which may also be used to mix materials of different characteristics in a highly efficient manner. The material in the container is tumbled not only due to the coefficient of friction of the material with the supporting surface of the container, but also due to the angle of attack between the material and the supporting surface at any given point because the material in contact with or close to the supporting surface will follow the segmented circular bath of that point which is different from the curved profile of the supporting surface at that same point.

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 of castings, to vary the rate of tumbling, or to vary the conveying and tumbling action between the material and the supporting surface of the container.

Attention is also directed to US-A-3157004 of which the inventor is again Albert Musschoot. This patent concerns obtaining an improved finish on cast or moulded parts by adding a vibratory motion to the tumbling apparatus, the system being developed in the early 1960's. Specifically, the tumbling apparatus using a U-shaped tub mounted on trunnions. Vibratory force was applied directly to the U-shaped tub and passed through the centre 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.

In order that the present invention may be well understood there will now be described two embodiments thereof, given by way of example, reference being made to the accompanying drawings, in which:

Figure 1 is an end view of one preferred from of a vibratory tumbling machine with some parts shown in cross-section and some parts shown in phantom;
Figure 2 is an elevation view of the machine of Figure 1 as viewed from the right in Figure 1.
Figure 3 is a view like Figure 1 but with a difference in the line of application of the vibratory force;
Figure 4 is a view of one form of deck for mounting the vibration generator of Figure 1 showing alternative positions of the deck;
Figure 5 is a view similar to Figure 3 showing a modification of the preferred vibratory tumbling machine;
Figure 6 is a view like Figure 2 of the modified preferred vibratory tumbling machine;
Figure 7 is a copy of a chart of the paths of movement of material in the machine of Figure 1 in operation;
Figure 8 is a copy of a chart of the paths of movement of material in the machine of Figure 5 in operation; and
Figure 9 is a cross-sectional view of a cylindrical deflector with openings or ports therethrough.

In a preferred form of the invention shown in Figures 1-3, a tumbling apparatus for mixing, cleaning, and/or shake out of parts is designated by 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 2 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 shakeout is taking place.

A bracket 144 includes a pair of spaced apart mounting supports 146 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 centres of the two apertures 150 is parallel to the horizontal axis 139 of the container. A line 154 drawn through the centre (at the horizontal axis 139) of the container 112 and the centre (horizontal axis 152) of the apertures 150 of the bracket 144 forms an angle A to a vertical axis 156 of the machine. As shown, the angle A between the line 154 and the 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 apera-

tures 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 the 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.

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 a 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 our US-A-4495826 and US-A-3358815 may be substituted for the eccentric weights 176 on each end of the shaft 174. As illustrated in Figures 1-3, the linear vibratory forces are generated by a two mass system, the motor 172, the plate 169 and the weights 176 being one mass, and the container 112, the bracket 144 and the frame 118 being the second mass. The vibration generator 114 as shown in Figure 1 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.

When the apparatus shown in Figures 1 and 2 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 centre of rotation offset from the centre of the container and located at a 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 centred at R.

The centre of rotation R is either a point or a small closed figure such as a small circle or ellipse which for all practice purposes may be considered to be a point. The point R will lie along a line passing through the centre 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 centre of gravity CG and the point R will be on the other side of the centre of gravity.

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

To illustrate the concept, see Figure 7, 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 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 the container, a multiplicity of times in the vicinity of the centre of rotation until the point R was located; that is, the point about which the container rotated. By drawing radii 186 from the point R to the tracings, it was found that the tracing segments of a circle are centred at R.

The movements 184 along the bottom (or low point) of the container are directed inward into the mass with an angle or 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 the 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 receptacle prior to being returned to the container or, as shown, the parts and media are delivered on to the conveyor 142 and will be conveyed to the next processing station. The inner surface 183 of the container may be coated or lined 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 centre of rotation R. The position of R will change if the direction of the linear vibratory forces change. Similarly, the

* Webster's New Collegiate Dictionary 1975 defines an osculating circle as "a circle whose centre 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 at that point".

position of R will change if the centre of gravity CG is changed such as, for example, by adding weights to the container. Incidentally, when the centre 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 182 of the vibratory forces is illustrated in Figure 4. 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 centre of rotation R lies on a line normal to the line of force and passing through the centre of gravity CG. R will assume a new position as shown in Figure 4. With R in a new position, points on the inner surface of the container will move in an arcuate path or segments or a circle centred 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 cut 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.

Figures 5 and 6 show a modified tumbler apparatus 110 with the axis of the vibration generator 114 tilted to a 95° angle as in Figure 4. A baffle or deflector 192 is selectively located in the container with Figure 8 showing the modified flow pattern and forces acting on the material when the deflector 192 is added to the system. All of the structural elements of Figure 5 that are the same as the structural elements of Figure 1 will bear the same reference numerals. The line of vibrational force 182 is external of the container. The instantaneous centre 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 Figures 5 and 6 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 defector with the parts remaining 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 9, 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, and does not pass through the centre or gravity of the container.

Although the improved tumbling apparatus has been described as employing a two mass system, such as shown at 114 in Figure 1, 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 or force 182 is substantially offset from the centre of gravity of the apparatus and so long as the centre of rotation is not on the vertical centreline 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 centre at R, such segments or paths are not parallel.

## Claims

1. A vibratory apparatus comprising a container (112) having a material supporting surface, mounting means (130) for resiliently mounting the container (112) for unconstrained virbratory movement relative to a mounting surface (128), and vibration generator means (114) mounted on the container (112), wherein the material supporting surface is concavely curved in cross-section with respect to the interior of the container (112) and is either generated about an axis (139) when constituting a circular arc or is generated about the centres of circles osculating the concavely curved surface, the vibration generator means (114) is mounted on the container (112) offset from the axis (139) or osculating circles centres and generating vibratory forces (182) along a linear path (180) offset from the axis (139) or from the osculating circles centres, the vibration generator means (114) and the container (112) having a centre of gravity (OG) offset from the axis (139) or from the osculating circles centres of the container (112), the vibration generator means

(114) and the linear path (180) of vibratory forces (182) being on the same side of the centre of gravity (CG) characterized in that the vibration generator means (114) is mounted on a support plate (169), the vibration generator means (114) and the support plate (169) being resiliently mounted on a bracket (144) mounted on the container (112), and in that the linear path (180) of vibrating forces (182) is outside the container (112), the vibratory forces (182) vibrating each point on the material supporting surface along segments of circles which do not conform to the curvature of the curved material supporting surface at the related point, each circle segment having a centre (R) of rotation which lies at a position spaced from the axis (139) or from the osculating circles centres and from the centre of gravity (CG) and on the opposite side of the axis (139) or the osculating circles centres of the container (112) from the linear path (180) of vibration forces (182).

2. A vibratory apparatus as claimed in claim 1, wherein the container (112) is rigidly mounted on a frame (118) and wherein the mounting means (130) for resiliently mounting the container (112) is comprised of isolation springs (130) between the frame (118) and the mounting surface (128).

3. A vibratory apparatus as claimed in claim 1 or claim 2, wherein the axis (139) lies substantially horizontal relative to the mounting surface (128) and wherein means are provided for changing the angle of tilt of the container (112) relative to the mounting surface (128).

4. A vibratory apparatus as claimed in any of claims 1 to 3, wherein the vibration generator means (114) comprises a support plate (169), vibratory force transmitting springs (170) connecting the support plate (169) to a bracket (144) on the container (112), a motor (172) mounted on the support plate (169), and eccentnc weights (176) driven by the motor (172) for producing the vibratory forces (182) along the linear path (180).

5. A vibratory apparatus as claimed in Claim 4, wherein the vibration generated means (114) is adjustable mounted on the bracket (144) whereby the direction of the linear path (180) of vibratory forces (182) of the vibration generator means (114) can be changed.

6. A vibratory apparatus as claimed in any of claims 1 to 4, wherein means (150, 160, 162, 166, 168) are provided for adjusting the vibration generator means (114) relative to the container (112) for changing the direction of the linear path (180) of the vibratory forces (182) which in turn changes the location of the centre of rotation (R) and changes the vibratory forces (182) vibrating each point on the material supporting surface.

7. A vibratory apparatus as claimed in any of claims 1 to 6, wherein the vibration generating means (114) includes a variable force vibration generator (114) for varying the vibratory forces (182) acting on the container (112).

8. A vibratory apparatus as claimed in any of claims 1 to 7, wherein deflector means (192) is disposed in the container (112) and is submerged in the media (188), the deflector means (192) changing the path of flow of media (188) and parts (190) being tumbled in the container (112).

9. A vibratory apparatus as claimed in claim 8, wherein the deflector means (192) lies parallel to the axis (139) of the container (112), and including means for passing air through the deflector means (192) and into the media (188) and parts (190) for modifying the condition of the media (188) and parts (190).

10. A vibratory apparatus as claimed in any of the preceding claims, wherein the centre (R) of rotation lies on a line perpendicular to the linear path (180) and passing through the centre of gravity (CG).

11. A method of operating a resiliently supported vibratory material handling container (112) which comprises using vibration generator means (114) being mounted on the container (112), the vibration generator means (144) being designed to generate vibratory forces (182) along a linear path (180) and to transmit the forces (182) to the container (112) with the linear path (180) displaced to the one side of the centre of gravity (CG) of the container (112) to cause the container (112) to vibrate, wherein the container (112) has a material supporting surface which is concavely curved in cross-section with respect to the interior of the container (112) and is either generated about an axis (139) when constituting a circular arc or is generated about the centres of circles osculating the concavely curved surface, the linear path (180) along which the vibratory forces (182) are generated being offset from the axis (139) of from the osculating circles centres, the vibration generator means (114) and the container (112) having a centre of gravity (OG) offset from the axis (139) or from the osculating circles centres of the container (112), the vibration generator means (114) and the linear path (180) of vibratory forces (182) being on the same side of the centre of gravity (CG) characterized by using a vibration generator means (114) being mounted on a support plate (169), the vibration generator means (114) and the support plate (169) being resiliently mounted on a bracket (144) mounted on

the container (112), and by the linear path (180) of vibratory forces (182) being outside the container (112), the vibratory forces (182) vibrating each point on the concavely curved material supporting surface along segments of circles which do not conform to the curvature of the concavely curved material supporting surface at the related point, each circle segment having a centre (R) of rotation lying at a position spaced from the axis (139) or from the osculating circles centres and from the centre of gravity (CG) and on the opposite side of the axis (139) or the osculating circles centres of the container (112) from the linear path (180) of vibratory forces (182).

**Patentansprüche**

1. Vibrationsvorrichtung mit einem Behälter (112), der eine Materialtragfläche aufweist, mit Haltemitteln (130) zur elastischen Aufnahme des Behälters (112) für eine uneingeschränkte Vibrationsbewegung in bezug auf eine Montagefläche (128), und mit einer auf dem Behälter (112) montierten Vibrationsgeneratoreinrichtung (114), wobei die Materialtragfläche in ihrem Querschnitt in bezug auf das Innere des Behälters (112) konkav gekrümmt ist und entweder um eine Achse (139) geformt ist, wenn sie als kreisförmiger Bogen ausgebildet ist, oder um die Mittelpunkte von Kreisen, die sich an die konkav gekrümmte Fläche anschmiegen, geformt ist, wobei die Vibrationsgeneratoreinrichtung (114) auf dem Behälter (112) von der Achse (139) oder den Mittelpunkten der Oskulationskreise beabstandet angebracht ist und Vibrationskräfte (182) entlang eines linearen Weges (180) erzeugt, der von der Achse (139) oder von den Mittelpunkten der Oskulationskreise beabstandet ist, wobei die Vibrationsgeneratoreinrichtung (114) und der Behälter (112) einen Schwerpunkt (CG) aufweisen, der von der Achse (139) oder von den Mittelpunkten der Oskulationskreise des Behälters (112) beabstandet ist, wobei die Vibrationsgeneratoreinrichtung (114) und der lineare Weg (180) der Vibrationskräfte (182) auf derselben Seite des Schwerpunktes (CG) liegen, dadurch gekennzeichnet, daß die Vibrationsgeneratoreinrichtung (114) auf einer Aufnahmeplatte (169) angebracht ist, wobei die Vibrationsgeneratoreinrichtung (114) und die Aufnahmeplatte (169) auf einem Träger (144) elastisch angebracht sind, der auf dem Behälter (112) angebracht ist, und daß sich der lineare Weg (180) der Vibrationskräfte (182) außerhalb des Behälters (112) befindet, wobei die Vibrationskräfte (182) jeden Punkt auf der Materialtragfläche entlang von Kreissegmenten, die nicht mit der Krümmung der gekrümmten Materialtragfläche an dem betreffenden Punkt übereinstimmen, in Vibration versetzen, wobei jedes Kreissegment ein Rotationszentrum (R) aufweist, das an einer Stelle liegt, die von der Achse (139) oder von den Mittelpunkten der Oskulationskreise und von dem Schwerpunkt (CG) beabstandet ist, und auf der gegenüberliegenden Seite der Achse (139) oder der Mittelpunkte der Oskulationskreise des Behälters (112) von dem linearen Weg (180) der Vibrationskräfte (182) liegt.

2. Vibrationsvorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß der Behälter (112) auf einem Rahmen (118) starr befestigt ist, und daß die Haltemittel (130) zur elastischen Aufnahme des Behälters (112) als Trennfedern (130) zwischen dem Rahmen (118) und der Montagefläche (128) ausgebildet sind.

3. Vibrationsvorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Achse (139) in bezug auf die Montagefläche (128) im wesentlichen horizontal angeordnet ist, und daß Mittel vorgesehen sind, um den Neigungswinkel des Behälters (112) in bezug auf die Montagefläche (128) zu verändern.

4. Vibrationsvorrichtung nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Vibrationsgeneratoreinrichtung (114) eine Aufnahmeplatte (169), Federn (170), die Vibrationskräfte übertragen und die Aufnahmeplatte (169) mit dem Träger (144) auf dem Behälter (112) verbinden, einen Motor (172), der auf der Aufnahmeplatte (169) angebracht ist, und exzentrische Gewichte (176) umfaßt, die von dem Motor (172) angetrieben werden, um die Vibrationskräfte (182) entlang des linearen Weges (180) zu erzeugen.

5. Vibrationsvorrichtung nach Anspruch 4, dadurch gekennzeichnet, daß die Vibrationsgeneratoreinrichtung (114) auf dem Träger 144 verstellbar angebracht ist, sodaß die Richtung des linearen Weges (180) der Vibrationskräfte (182) der Vibrationsgeneratoreinrichtung (114) geändert werden kann.

6. Vibrationsvorrichtung nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß Mittel (150, 160, 162, 166, 168) vorgesehen sind, um die Vibrationsgeneratoreinrichtung (114) in bezug auf den Behälter (112) zu verstellen, um die Richtung des linearen Weges (180) der Vibrationskräfte (182) zu ändern, was wiederum die Lage des Rotationszentrums (R) ändert und was die Vibrationskräfte (182) ändert, die jeden Punkt auf der Materialtragfläche in Vibration versetzen.

7. Vibrationsvorrichtung nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, daß die Vibrationsgeneratoreinrichtung (114) einen Vibrationsgenerator (114) mit variabler Kraft aufweist, um die Vibrationskräfte (182), die auf den Behälter (112)

einwirken, zu verändern.

8. Vibrationsvorrichtung nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß eine Ablenkeinrichtung (192) in dem Behälter (112) eingesetzt wird und in das Medium (188) eingetaucht wird, wobei die Ablenkeinrichtung (192) den Flußweg des Mediums (188) und von Teilen (190) verändert, die in dem Behälter (112) getaumelt werden.

9. Vibrationsvorrichtung nach Anspruch 8, dadurch gekennzeichnet, daß die Ablenkeinrichtung (192) parallel zu der Achse (139) des Behälters (112) liegt, und Mittel zur Durchführung von Luft durch die Ablenkeinrichtung (192) und in das Medium (188) und die Teile (190) aufweist, um den Zustand des Mediums (188) und der Teile (190) zu verändern.

10. Vibrationsvorrichtung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß das Rotationszentrum (R) auf einer zu dem linearen Weg (180) senkrechten Linie liegt, die durch den Schwerpunkt (CG) verläuft.

11. Verfahren zum Betreiben eines elastisch gelagerten Vibrationsbehälters (112) zur Materialbehandlung, das die Verwendung einer Vibrationsgeneratoreinrichtung (114) umfaßt, die auf dem Behälter (112) angebracht ist, wobei die Vibrationsgeneratoreinrichtung (114) derart ausgestaltet ist, daß sie Vibrationskräfte (182) entlang einem linearen Weg (180) erzeugt und die Kräfte (182) auf den Behälter (112) überträgt, wobei der lineare Weg (180) nach einer Seite des Schwerpunktes (CG) des Behälters (112) versetzt ist, um den Behälter (112) zu einer Vibration anzuregen, wobei der Behälter (112) eine Materialtragfläche aufweist, die in ihrem Querschnitt in bezug auf das Innere des Behälters (112) konkav gekrümmt ist und die entweder um eine Achse (139) geformt ist, wenn sie als kreisförmiger Bogen ausgebildet ist, oder um die Mittelpunkte von Kreisen geformt ist, die sich an die konkav gekrümmte Fläche anschmiegen, wobei der lineare Weg (180) entlang dem die Vibrationskräfte (182) erzeugt werden von der Achse (139) oder von den Mittelpunkten der Oskulationskreise beabstandet ist, wobei die Vibrationsgeneratoreinrichtung (114) und der Behälter (112) einen Schwerpunkt (CG) aufweisen, der von der Achse (139) oder von den Mittelpunkten der Oskulationskreise des Behälters (112) beabstandet ist, wobei die Vibrationsgeneratoreinrichtung (114) und der lineare Weg (180) der Vibrationskräfte (182) auf derselben Seite des Schwerpunktes (CG) liegen, gekennzeichnet durch die Verwendung einer Vibrationsgeneratoreinrichtung (114), die auf einer Aufnahmeplatte (169) angebracht ist, wobei die Vibrationsgeneratoreinrichtung (114) und die Aufnahmeplatte (169) auf einem Träger (144) elastisch angebracht sind, der auf dem Behälter (112) angebracht ist, und durch den linearen Weg (180) der Vibrationskräfte (182), der außerhalb des Behälters (112) liegt, wobei die Vibrationskräfte (182) jeden Punkt auf der konkav gekrümmten Materialtragfläche entlang von Kreissegmenten in Vibration versetzen, die mit der Krümmung der konkav gekrümmten Materialtragfläche an dem betreffenden Punkt nicht übereinstimmen, wobei jedes Kreissegment ein Rotationszentrum (R) aufweist, das an einer von der Achse (139) oder von den Mittelpunkten der Oskulationskreise und von dem Schwerpunkt (CG) beabstandeten Position liegt und auf der gegenüberliegenden Seite der Achse (139) oder der Mittelpunkte der Oskulationskreise des Behälters (112) von dem linearen Weg (180) der Vibrationskräfte (182) liegt.

**Revendications**

1. Appareil vibrant comprenant un conteneur (112) présentant une surface support de matériau, un moyen de montage (130) pour monter de manière élastique le conteneur (112) pour un mouvement vibratoire sans contrainte par rapport à une surface de montage (128), et un moyen générateur de vibration (114) monté sur le conteneur (112), la surface support de matériau étant incurvée de manière concave, en coupe transversale, par rapport a l'intérieur du conteneur (112) et étant, soit engendrée autour d'un axe (139) lorsqu'elle forme un arc de cercle, soit engendrée autour des centres de cercles osculateur de la surface incurvée de manière concave, le moyen générateur de vibrations (114) étant monté sur le conteneur (112), décalé par rapport à l'axe (139), ou par rapport au centre des cercles osculateurs, et produisant des forces vibratoires (182) le long d'un trajet rectiligne (180), décalé par rapport à l'axe (139), ou par rapport au centre des cercles osculateurs, le moyen générateur de vibrations (114) et le conteneur (112) ayant un centre de gravité (CG) décalé par rapport à l'axe (139), ou par rapport aux centres des cercles osculateurs, du conteneur (112), le moyen générateur de vibrations (114) et le trajet rectiligne (180) des forces vibratoires (182) étant du même côté du centre de gravité (CG), caractérisé en ce que le moyen générateur de vibrations (114) est monté sur une plaque support (169), le moyen générateur de vibrations (114) et la plaque support (169) étant montés de manière élastique sur une console (144) montée sur le conteneur (112), est en ce que le trajet rectiligne (180) des forces vibratoires (182) et au dehors du conteneur (112), les forces vibratoires (182) faisant vibrer chaque point sur la surface support de matériau le long de segment de cercles qui ne se conforment pas à la courbure de la surface incurvée support de matériau au point correspondant, et chaque segment de cercle

ayant un centre (R) de rotation qui se trouve dans une position écartée de l'axe (139) ou du centre des cercles osculateurs, et du centre de gravité (CG) et de l'autre côté de l'axe (139) ou du centre des cercles osculateurs du conteneur (112) par rapport au trajet rectiligne (180) des forces vibratoires (182).

2. Appareil vibrant tel que revendiqué dans la revendication 1, caractérisé en ce que le conteneur (112) est monté rigidement sur un bâti (118) et en ce que le moyen de montage (130) pour le montage élastique du conteneur (112) est constitué de ressorts d'isolation (130) entre le bâti (118) et la surface de montage (128).

3. Appareil vibrant tel que revendiqué dans la revendication 1 ou 2, caractérisé en ce que l'axe (139) est sensiblement horizontal par rapport à la surface de montage (128) et en ce que des moyens sont prévus pour modifier l'angle d'inclinaison du conteneur (112) par rapport à la surface de montage (128).

4. Appareil vibrant tel que renvendiqué dans l'une quelconque des revendications 1 à 3, caractérisé en ce que le moyen générateur de vibrations (114) comprend une plaque support (169), des ressorts (170) de transmission des forces vibratoires reliant la plaque support (169) à une console (144) sur le conteneur (112), un moteur (172) monté sur la plaque support (169), et des masses excentrées (176) entrainées par le moteur (172) pour produire les forces vibratoires (182) le long du trajet rectiligne (180).

5. Appareil vibrant tel que revendiqué dans la revendication 4, caractérisé en ce que le moyen générateur de vibrations (114) est monté de manière réglable sur la console (144), ce par quoi la direction du trajet rectiligne (180) des forces vibratoires (182) du moyen générateur de vibrations (114) peut être modifiée.

6. Appareil vibrant tel que revendiqué dans l'une quelconque des revendications 1 à 4, caractérisé en ce que des moyens (150, 160, 162, 166, 168) sont prévus pour régler le moyen générateur de vibrations (114) par rapport au conteneur (112) pour modifier la direction du trajet rectiligne (180) des forces vibratoires (182) ce qui, à son tour, modifie l'emplacement du centre de rotation (R) et modifie les forces vibratoires (182) faisant vibrer chaque point sur la surface support de matériau.

7. Appareil vibrant tel que revendiqué dans l'une quelconque des revendications 1 à 6, caractérisé en ce que le moyen générateur de vibration (114) comprend un générateur de vibration à force variable (114) pour faire varier les forces vibratoires (182) sur le conteneur (112).

8. Appareil vibrant tel que revendiqué dans l'une quelconque des revendications 1 à 7, caractérisé en ce que un moyen déflecteur (192) est disposé dans le conteneur (112) et est immergé dans le matériau (188), le moyen déflecteur (192) modifiant le trajet d'ecoulement du matériau (188) et des éléments (190) qui sont roulés dans le conteneur (112).

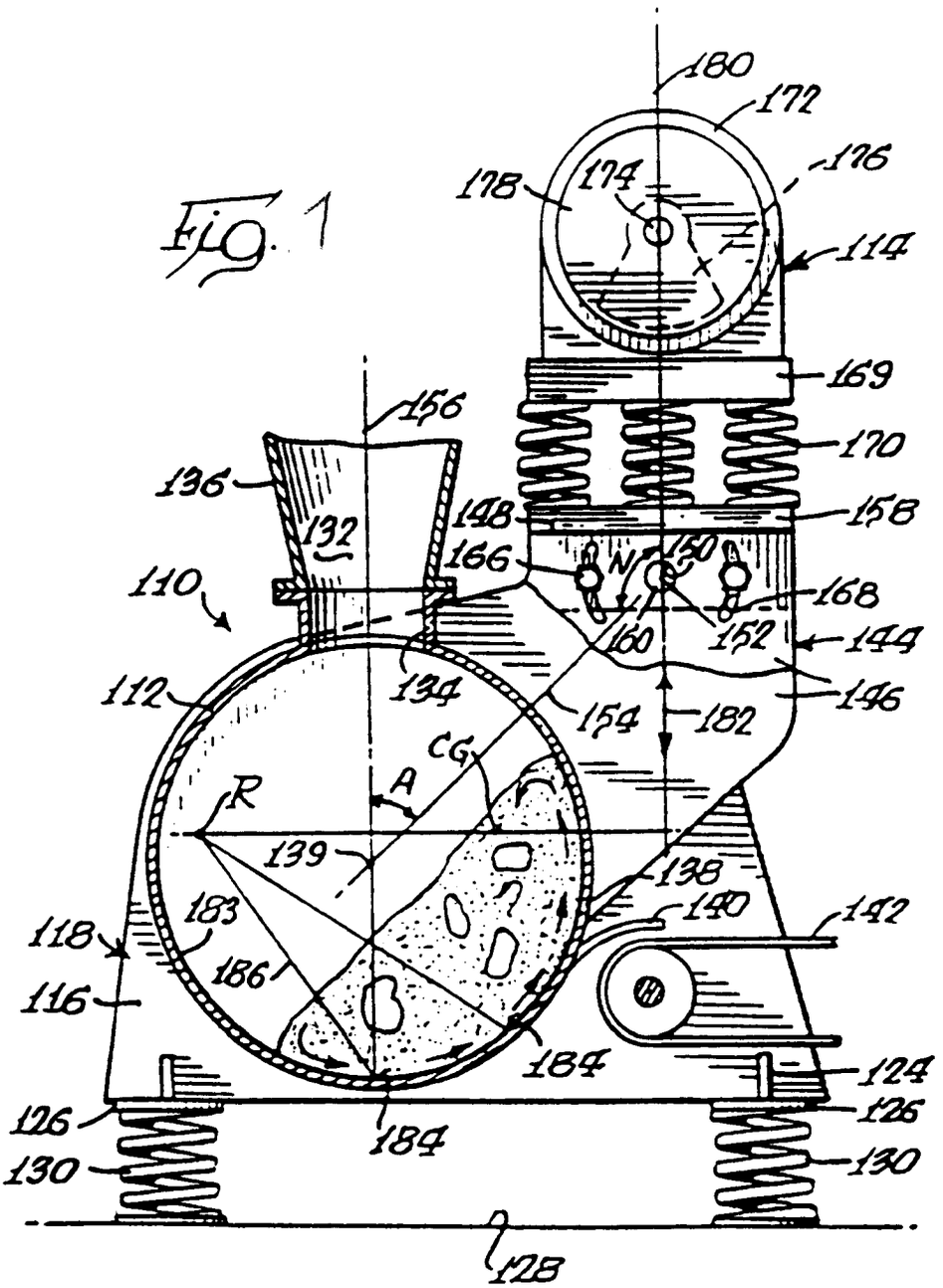
9. Appreil vibrant tel que revendiqué dans la revendication 8, caractérisé en ce que le moyen déflecteur (192) est parallèle a l'axe (139) du conteneur (112), et comprend un moyen pour faire passer de l'air à travers le moyen déflecteur (192) et dans le matériau (188) et les éléments (190) pour modifier l'état du matériau (188) et des éléments (190).

10. Appareil vibrant tel que revendiqué dans l'une quelconque des revendications précédentes, caractérisé en ce que le centre (R) de rotation se trouve sur une ligne perpendiculaire au trajet rectiligne (180) et passant par le centre de gravité (CG).

11. Procédé de mise en oeuvre d'un conteneur vibrant (112) de manipulation de matériau supporté de manière élastique qui comprend l'utilisation d'un moyen générateur de vibrations (114) étant monté sur le conteneur (112), le moyen générateur de vibrations (114) étant construit pour produire des forces vibratoires (182) suivant un trajet rectiligne (180) et pour transmettre les forces (182) au conteneur (112), le trajet rectiligne (180) étant décalé d'un côté du centre de gravité (CG) du conteneur (112) pour faire en sorte que le conteneur (112) vibre, le conteneur (112) ayant une surface support de matériau qui est incurvée de manière concave, en coupe transversale, par rapport à l'intérieur du conteneur (112), et étant, soit engendrée autour d'un axe (139) lorsqu'elle forme un arc de cercle, soit engendrée autour des centres de cercles osculateurs de la surface incurvée de manière concave, le trajet rectiligne (180), suivant lequel les forces vibratoires (182) sont produites, étant décalé par rapport à l'axe (139), ou par rapport au centre des cercles osculateurs, le moyen générateur de vibrations (114) et le conteneur (112) ayant un centre de gravité (CG) décalé par rapport à l'axe (139), ou par rapport aux centres des cercles osculateurs du conteneur (112), le moyen générateur de vibrations (114) et le trajet rectiligne (180) des forces vibratoires (182) étant du même côté du centre de gravité (CG), caractérisé en ce qu'on utilise un moyen générateur de vibrations (114) monté sur une plaque support (169), le moyen générateur de vibrations (114) et la plaque support (169) étant montés de manière élastique sur une console (144) montée sur le conteneur (112), et en ce que le trajet rectiligne (180) des forces vibratoires (182) étant en

dehors du conteneur (112), les forces vibratoires (182) faisant vibrer chaque point sur la surface support de matériau incurvée de manière concave le long de segments de cercles qui ne se conforment pas à la courbure de la surface incurvée support de matériau de manière concave au point correspondant, et chaque segment de cercle ayant un centre (R) de rotation qui se trouve dans une position écartée de l'axe (139) ou des centre des cerlces osculateurs, et du centre de gravité (CG) et de l'autre côté de l'axe (139), ou du centre des cercles osculateur du conteneur (112) du trajet rectiligne (180) des forces vibratoires (182).

Fig. 1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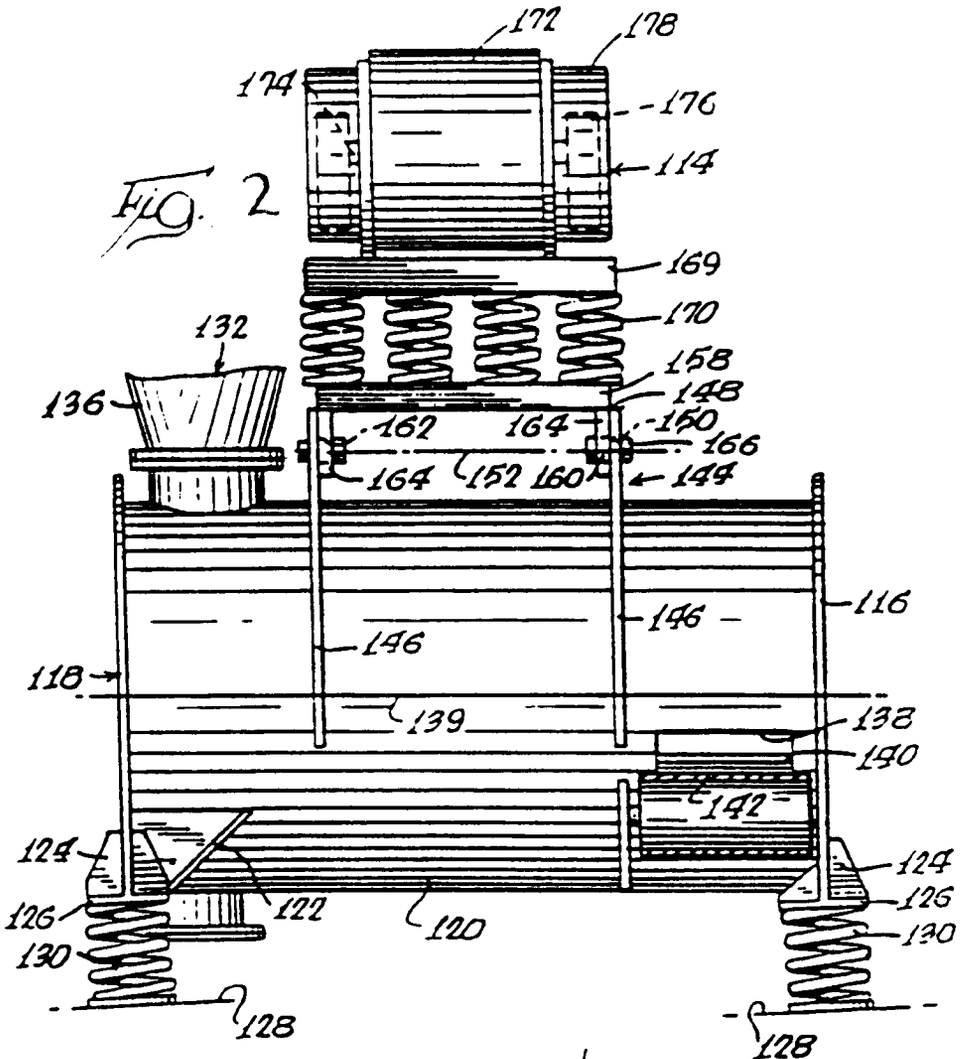
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Fig. 2

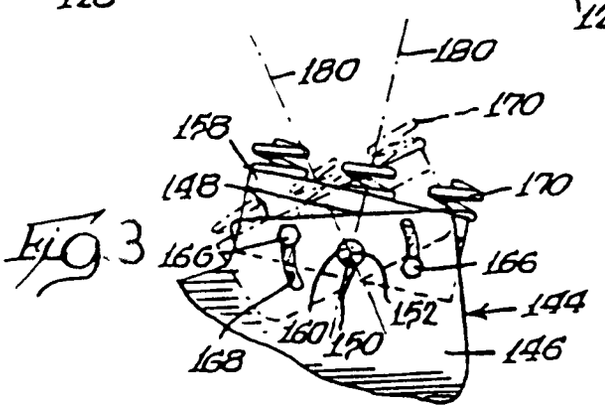
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Fig. 3

Fig. 4

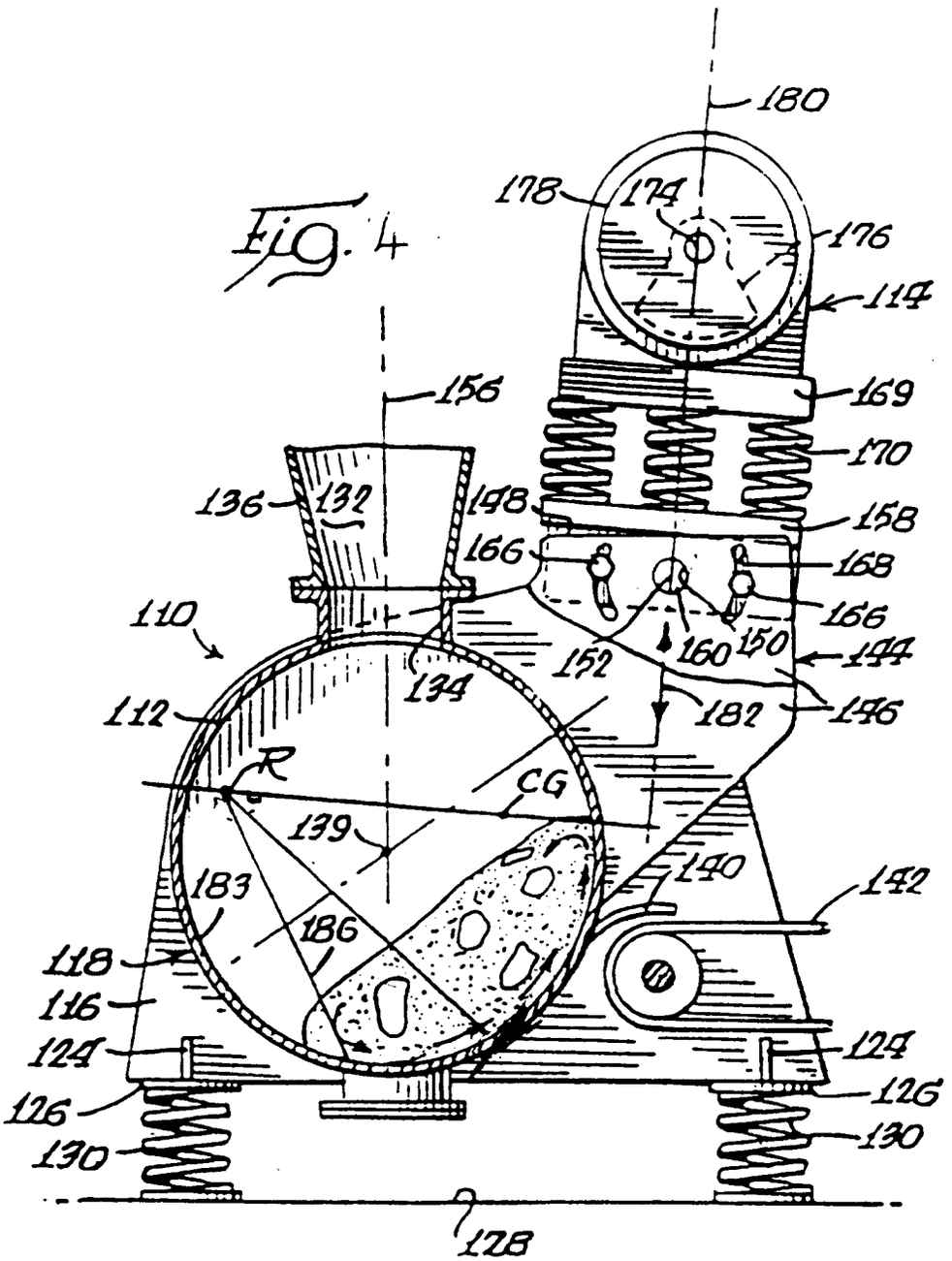
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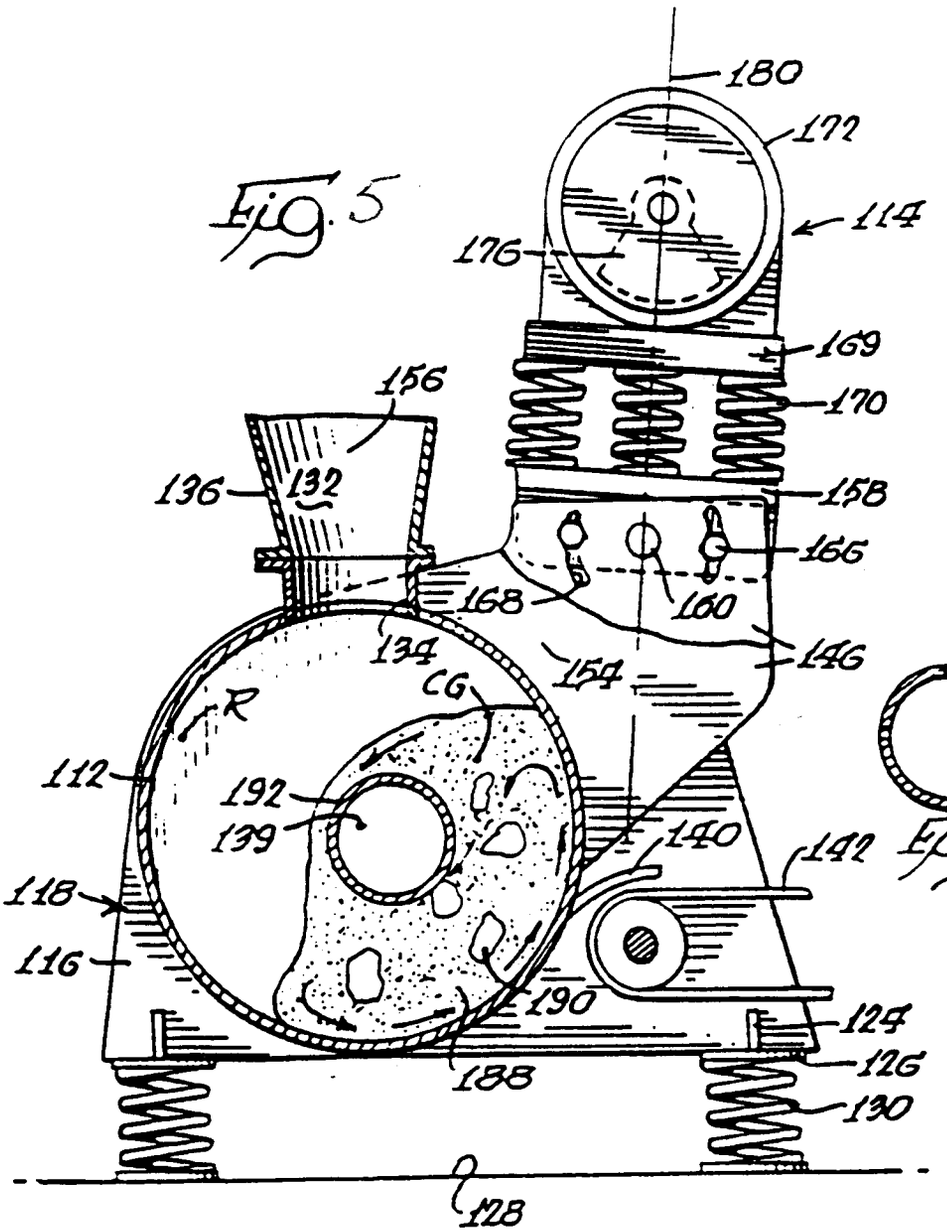
Fig. 5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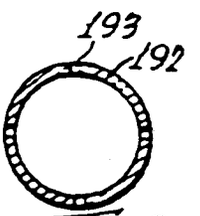
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Fig. 9.

Fig. 6

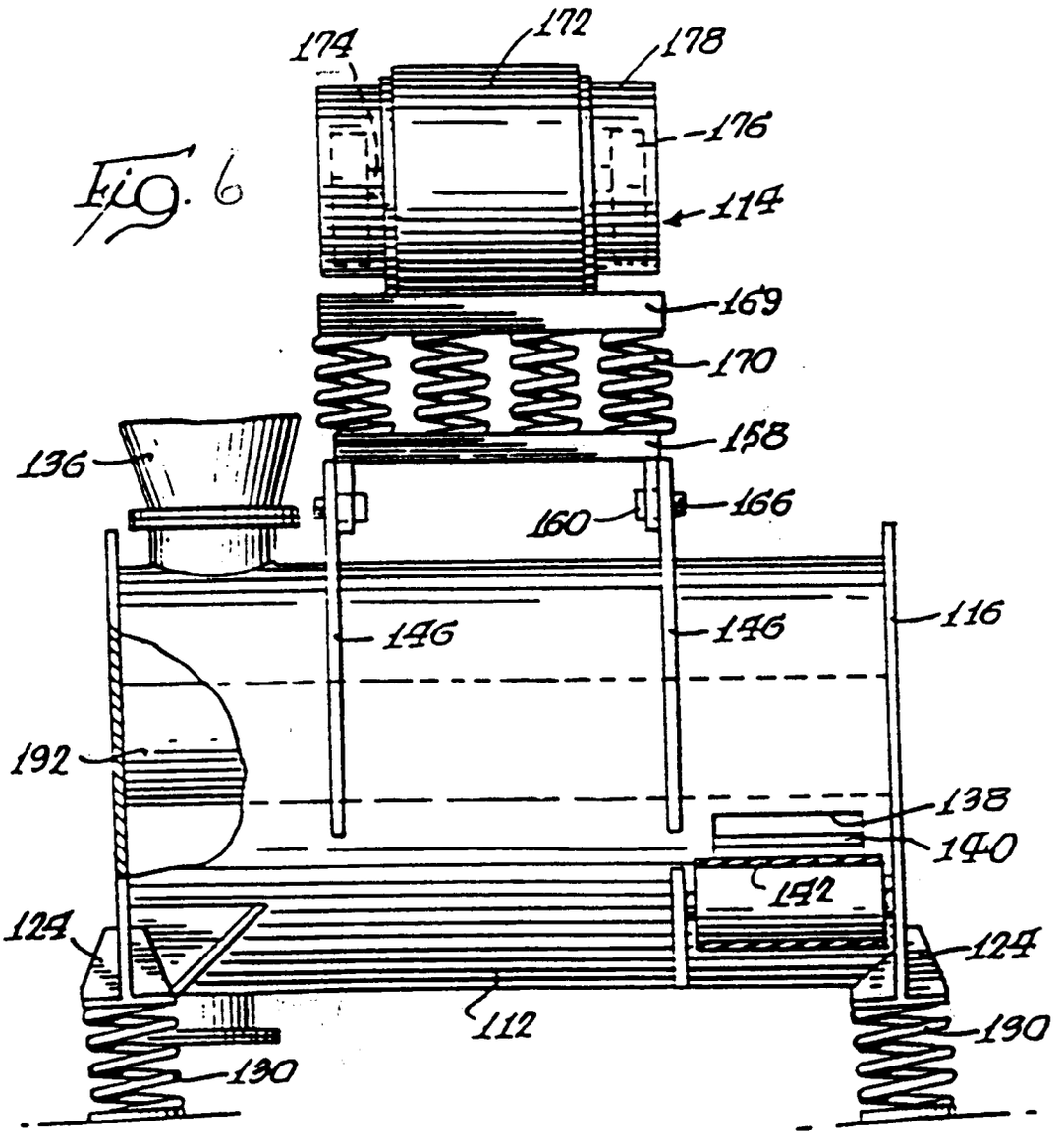
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FIG. 7

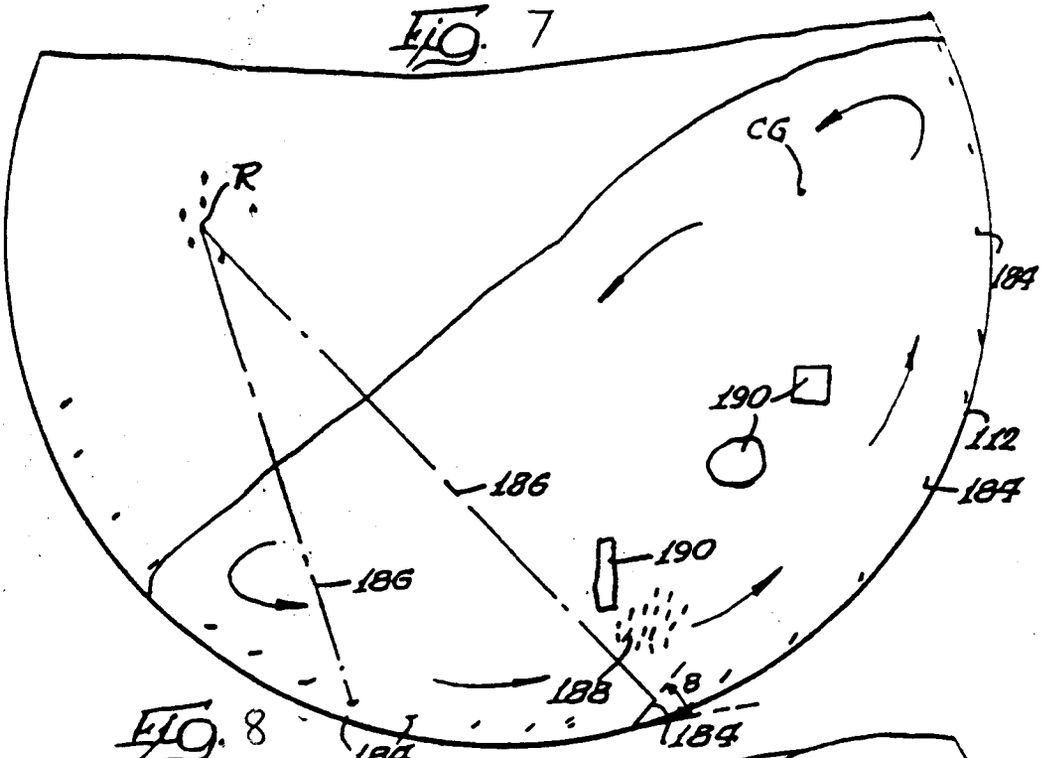


FIG. 8