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Apparatus for processing particulates.

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GB-A- 2 130 784
GB-A- 2 151 960
US-A- 2 169 279
US-A- 2 531 706
US-A- 3 396 947

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EP 0 242 473 B1

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Description

The present invention relates generally to vibratory apparatus, and more particularly to an apparatus for processing particulates or the like.

Often, it is desirable to compact loose particulates to remove air voids therefrom. One example is in a metal casting process in which foundry sand is compacted about a pattern to create a mold. In some cases, the pattern may be of such complex shape that special techniques must be used to ensure that all air voids are removed from the particulate matter and all passages and cavities in the pattern are filled. One prior method of compacting particulates about a complex pattern is disclosed in applicant's prior U.S. Patent No. 4 454 906, assigned to the assignee of the instant application.

The above-noted patent discloses a vibratory method which utilizes an apparatus having vibration generators comprising horizontally mounted motors having eccentric weights thereon. The generators are operated to vibrate a bed which in turn supports a flask containing the pattern and foundry sand. Initially, the generators are operated to produce a vibratory acceleration on the mold flask and its contents in excess of the acceleration due to gravity. This acceleration causes the sand to fluidize and thus flow into and completely fill cavities in the pattern. After a short period of vibration at accelerations in excess of gravity, the stroke of the motors is reduced to reduce the acceleration to a magnitude less than the acceleration of gravity. This in turn compacts the foundry sand in place allowing it to retain its position when molten metal is subsequently introduced into the mold flask.

In accordance with the present invention, an apparatus for processing particulates including fluidizing and/or compacting same accomplishes such objectives in a simple and effective fashion.

The apparatus includes a vibratory bed, a base, a suspension coupled between the vibratory bed and the base whereby vibration of the vibratory bed is isolated from the base and a vessel carried by the vibratory bed for holding the particulates wherein vibrational motion of the vibratory bed in turn causes the vessel to vibrate and thereby fluidize and/or compact the particulates. The vibratory bed includes a motor having a vertically disposed shaft, at least one eccentric weight disposed on the shaft, a housing secured to and enclosing the motor and a bed plate disposed atop the housing wherein operation of the motor imparts vibrational motion to the bed plate. Advantageously, this motion is vibrogyratory in nature along an axis which, if upwardly projected, would describe the surface of an inverted cone.

In the preferred embodiment, the motor shaft includes first and second ends which extend outwardly from the motor and first and second eccentric weights adjustably mounted radially outwardly from the shaft so that the amplitude of the vibrations imparted to the vibratory bed can be varied. Unlike prior devices, it has been discovered that during operation of the instant invention at a constant motor speed, the vertical components of the vibrations at various contact points when the apparatus is operating with the acceleration in excess of gravity causes multiple impacts for each revolution of the shaft at frequencies which are multiples of a fundamental frequency. This multi-frequency vibration quickly and effectively fluidizes the particulates so that all of the cavities in the pattern are filled without damage to the pattern.

In one form of the invention there are at least three contact points between the vessel and the bed plate whereupon operating the apparatus with an acceleration in excess of gravity will create a number of multiples of the fundamental frequency equal to the number of contact points. Increasing the number of contact points increases the ratio of impact frequency to shaft revolutions per minute.

Also provided are means for maintaining substantial relative alignment of the vessel and the bed plate so that rotation of vessel relative to the bed plate is prevented.

Exemplary embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Fig. 1 is a plan view, partially in phantom, of the compaction apparatus of the present invention;

Fig. 2 is an elevational view of the apparatus shown in Fig. 1 with portions broken away to reveal the structure thereof and with dashed lines added to illustrate the vibration of the apparatus when in use;

Fig. 3 is an exploded perspective view of the apparatus shown in Figs. 1 and 2 with portions broken away to reveal the construction thereof;

Fig. 4 is an enlarged fragmentary elevational view of a portion of the apparatus shown in the preceding figures with dashed lines added to illustrate the vibration of the apparatus in use; and

Fig. 5 is a partial elevational view of a modified form of the invention with the vessel supported on at least three points and a pattern in the vessel.

Referring now to the figures, there is illustrated therein an apparatus 10 for processing particulates 12, such as fluidizing and compacting foundry sand or the like. It should be noted that the apparatus 10 may be used to fluidize and/or compact other particulates, if desired.

The apparatus 10 includes a base 14 (shown in complete form in Fig. 3) which comprises a tripod including three legs 16a, 16b, 16c joined by cross-bars 18a, 18b, 18c. (Only the cross-bars 18b, 18c are visible in Fig. 3.)

A motor 20 includes a motor shaft 22 having first and second ends 24a, 24b which extend outwardly in a vertical direction from the motor 20. At least one and preferably two eccentric weights 26a, 26b are dis-

posed on the first and second ends 24a,24b of the shaft 22. The eccentric weights 26a,26b includes an arm 27a,27b releasably secured to the shaft 24. Weight blocks 28 are adjustably secured to the arms 27a,27b to increase or decrease the vibratory forces created by the rotation of the eccentric weights. Appropriate other well known means can be used to provide the eccentric weights on the shaft and to vary the relative positions of the weights with respect to the axis of the shaft and to each other. See my earlier U.S. Patents 3,358,815 and 4,168,774. The motor 20 could be a variable speed motor with appropriate well known means for varying the motor speed as desired.

A housing 32 is secured to and encloses the motor 20. A plurality of threaded studs 34 extend through the housing 32 and are maintained in position by means of nuts 36. The threaded studs contact the motor casing and restrain it against movement within the housing 32. Any well known apparatus for securing the motor 20 to the housing 32 is contemplated.

Disposed atop the housing 32 is a horizontally disposed bed plate 40 having a main portion 42 and an offset flange portion 44 which defines a stepped channel or recess 46. The bed plate 40 is joined to the housing 32 by any suitable means, such as by the weld 48 shown in Fig. 4.

The motor 20, the eccentric weights 26, the housing 32 and the bed plate 40 together comprise a vibratory bed wherein operation of the motor 20 imparts vibrational motion to the housing and to the horizontally disposed bed plate 40. A suspension 50, preferably in the form of coiled springs 52a,52b,52c is disposed between the bed plate 40 and the base 14. The springs 52a,52b,52c could be resilient blocks or the like. The suspension 50 isolates the vibration of the vibratory bed, and more particularly the bed plate 40, from the base 14.

A cushion 56 in the form of an elastomeric body may be disposed within the recess 46 of the bed plate 40. In the illustrated form, a vessel 60 sits atop the cushion 56. The vessel 60 has a hollow interior 62 for holding the particulate material 12 and, in the case of a foundry operation, a pattern 61. The vessel 60 may be a conventional mold flask that is circular or square in cross-section, although it may have a different cross-sectional shape.

The vessel 60 includes an outer flange 64 which, when the vessel 60 is seated on the cushion 56, is vertically spaced above and is substantially parallel to the bed plate 40. At least one and preferably three alignment pins 66a,66b,66c extend through apertures in the flange 64 and project into at least one and preferably three positioning cups 68a,68b,68c secured to an upper face 70 of main portion 42 of the bed plate 40. The pins 66 have a diameter less than the inner diameter of the cups 68 so that a limited amount of lateral movement of the vessel 60 relative to the bed plate is permitted. This relative movement is somewhat dampened by the elastomeric cushion 56. This limited lateral relative movement between the vessel 60 and the bed plate 40 is shown by the dashed lines of Fig. 4 and is sufficiently small to prevent substantial rotation of the vessel 60 about its center axis relative to the bed plate 40. The alignment pins 66 and the cups 68, therefore, comprise means for maintaining substantial relative alignment of the vessel and bed plate.

In operation, as the motor 20 rotates, the eccentric weights 26a,26b impart vibrational energy to the bed plate 40 through the housing 32. The bed plate 40 vibrates in a vibrogyratory fashion wherein the axis 80 (Fig. 2) of the bed plate through the center thereof and perpendicular to the surface 70 is inclined from the vertical and defines substantially a conical surface as it vibrates. This vibratory motion is transmitted through the elastomeric cushion 56 to produce a gyratory vibrational motion of the vessel 60, as shown by the dashed lines in Fig. 2. During such operation, the base 14 remains substantially stationary owing to the isolation provided by the suspension 50.

The operation is carried out in two phases, fluidization and compaction. In phase one, the sand is fluidized by virtue of operating the vibration generator to produce accelerations in excess of gravity. Acting like a fluid, the sand fills all passages and cavities of a pattern suspended in the vessel 60. It has been found that as the acceleration approaches 1G the sand is being fluidized and/or compacted.

The amplitude of the vibrations is then reduced, by reducing rotational speed of the eccentric weights or by reducing the effective mass of the eccentric weights by using the system shown in U.S. Patent No. 3,358,815 or in U.S. Patent No. 4,168,774. Reducing the amplitude of vibrations so that the acceleration is less than gravity compacts the sand.

The vibrational gyratory motion of the bed plate causes the bed plate to impact the vessel at multiple frequencies. That is, the vertical components of the vibrations at various contact points, when the vibrational forces are in excess of the acceleration of gravity, produces multiple impacts between the bed plate and the vessel for each revolution of the shaft.

During the fluidization process, the motor develops sufficient vibrational forces in the bed plate 40 to create accelerations in excess of gravity. Portions of a bottom lip 90 (Figs. 3 and 4) of the vessel 60 thereby vibrogyratorially move out of contact and into contact with the cushion 56 (if used) or a top surface 92 of the flange portion 44 (if the cushion 56 is not used). This action produces multiple impacts of the vessel 60 against the bed plate 40 so that the vessel 60 vibrates at various frequencies, even when the motor speed is constant. These frequencies have been found to consist of a fundamental frequency and integer multiples thereof wherein the fundamental frequency is the same as the rotational speed of the motor 20. This multi-frequency vibration readily fluidizes the particulates and minimizes the incidence of damage to a pattern in the vessel.

As an example, with the shaft rotating at 2140 RPM, the vibrational gyratory motion of the bed plate

will impact the vessel with multiple impacts and at various frequencies with each revolution of the shaft. The various frequencies will be integer multiples of a fundamental frequency which is the same as the rotational speed of the motor. The number of impacts will be equal to or greater than the speed of the motor.

Applicant has conducted several tests of an apparatus constructed according to the foregoing details, each at a different motor speed, and has achieved the following results.

Table 1 – Motor Speed 2140 RPM

Measured Vibrational Frequencies (strokes per minute)	Amplitude of Vibration Measured at a Particular Point on the Flange 64		Calculated Accelera- tion of Vessel 60 (g's)	Integer Multiples of Motor Speed
	(inches)	(mms)		
2140	0.022	(.5588)	1.43	
4280	0.003	(.0762)	0.78	2
8560	0.0013	(.03302)	1.35	4
12800	0.0005	(.0127)	1.16	6

Table 2 – Motor Speed 3000 RPM

Measured Vibrational Frequencies (strokes per minute)	Amplitude of Vibration Measured at a Particular Point on the Flange 64		Calculated Accelera- tion of Vessel 60 (g's)	Integer Multiples of Motor Speed
	(inches)	(mms)		
3000	0.015	(.381)	1.92	
6000	0.001	(.0254)	0.512	2
12000	0.0007	(.01778)	1.43	4
18000	0.00025	(.00635)	1.15	6

Table 3 – Motor Speed 2500 RPM

Measured Vibrational Frequencies (strokes per minute)	Amplitude of Vibration Measured at a Particular Point on the Flange 64		Calculated Accelera- tion of Vessel 60 (g's)	Integer Multiples of Motor Speed
	(inches)	(mms)		
2500	0.0023	(.05842)	0.204	
5000	0.0019	(.04826)	0.675	2
12600	0.00026	(.0066)	0.586	5
17600	0.0002	(.00508)	0.88	7
22400	0.00017	(.004318)	1.21	9

Fig. 5 shows a modified form of the invention wherein all of the parts that are the same as in Fig. 3 are identified with the same numerals. The vessel 60 containing, for instance, sand 12 and a pattern 61 has three equally spaced apart protrusions, contact pads or contact points 63 extending downwardly from the lower edge 90 (only 2 of the protrusions or pads 63 are visible in Fig. 5). The pads 63 contact either the ring 56, when a ring is used, or the flange surface 44 when no ring is used. The three contact pads or points 63 locate the impact surfaces between the bed plate 40 and the vessel so that the impact frequencies caused by the multiple impacts between the bed plate and the vessel are limited to three. An increase in the number of contact points or pads will increase the number of impact frequencies by the same number.

The ratio of impact frequency to shaft rotation in RPM between the bed plate and the vessel, in the range of contact points between at least 3 and up to approximately 10, is a function of the number of support points between the vessel and the bed plate. Increase the number of contact points increases the ratio of impact frequency to shaft rotation speed in RPM.

Claims

1. Apparatus for processing particulates comprising a vibratory bed including a horizontally disposed bed plate (40) and a vessel (60) for the particulates carried by the bed plate (40) and separate there-

from, characterised in that the said vibratory bed comprises a housing (32) mounted to the bed plate (40), and containing a substantially vertically disposed rotatable shaft (22) having at least one eccentric weight (26) disposed thereon, whereby rotation of the shaft (22) imparts vibrational gyratory motion to the bed plate (40), the vibrational gyratory motion of the bed plate (40) impacting the vessel (60) at multiple frequencies during each revolution of the shaft (22) for fluidising or compacting the particulates in the vessel (60).

2. An apparatus as claimed in claim 1, characterised in that the shaft (22) is driven by a motor (20) mounted to the housing (32).

3. An apparatus as claimed in either claim 1 or claim 2, characterised in that it comprises a base (14) and a suspension (52) coupling the vibratory bed to the base.

4. An apparatus as claimed in any one of the preceding claims, characterised in that it comprises means (66, 68) for retaining the vessel in substantial vertical alignment with the bed plate.

5. An apparatus as claimed in any one of the preceding claims, characterised in that it further comprises a cushion means (56) between the vessel and the bed plate.

6. An apparatus for processing particulates characterised in that it comprises a vibratory bed having a planar bed plate (40), a housing (32) mounted to the bed plate (40), a motor (20) mounted to the housing and having a vertically disposed shaft (22), an eccentric weight (26) disposed on the shaft wherein operation of the motor imparts vibrational gyratory motion to the bed plate (40); a base (14); a suspension (52) coupled between the bed plate and the base for isolating the vibration of the bed plate; a vessel (60) disposed atop the bed plate and separate therefrom for holding the particulates and impacted by the vibrational gyratory motion of the bed plate when in excess of the acceleration of gravity with multiple frequencies with each revolution of the shaft so as to fluidise or compact the particulates in the vessel.

7. An apparatus as claimed in any one of claims 2 to 6, characterised in that the motor is driven at a selected speed and the multiple frequencies are integer multiples of a fundamental frequency which is the same as the selected speed of the motor.

Patentansprüche

1. Vorrichtung zur Verarbeitung von Partikelstoffen mit einem Vibrierbett, das eine horizontal angeordnete Bettplatte (40) und ein Gefäß (60) für den Partikelstoff, das durch die Bettplatte (40) getragen und davon getrennt ist, enthält, dadurch gekennzeichnet, daß das Vibrierbett ein Gehäuse (32) umfaßt, das an der Bettplatte (40) montiert ist und eine im wesentlichen vertikal angeordnete drehbare Welle (22), die wenigstens ein darauf angeordnetes exzentrisches Gewicht (26) aufweist, enthält, wobei die Rotation der Welle (22) der Bettplatte (40) eine Vibrationsdrehbewegung verleiht, und die Vibrationsdrehbewegung der Bettplatte (40) während jeder Drehung der Welle (22) bei einer Vielfalt von Frequenzen das Gefäß (60) beaufschlagt, um den Partikelstoff in dem Gefäß (60) zu fluidisieren oder kompakt zu machen.

2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Welle (22) durch einen Motor (20), der an dem Gehäuse (32) montiert ist, angetrieben ist.

3. Vorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß sie ein Basiselement (14) und eine das Vibrierbett mit dem Basiselement verbindende Aufhängung (52) aufweist.

4. Vorrichtung nach wenigstens einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß sie eine Einrichtung (66, 68) zum Halten des Gefäßes in einer im wesentlichen vertikalen Ausrichtung zu der Bettplatte umfaßt.

5. Vorrichtung nach wenigstens einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß sie weiterhin eine Polstereinrichtung (56) zwischen dem Gefäß und der Bettplatte umfaßt.

6. Vorrichtung zur Verarbeitung von Partikelstoffen, dadurch gekennzeichnet, daß sie ein Vibrierbett mit einer ebenen Bettplatte (40), einem Gehäuse (32), das an der Bettplatte (40) montiert ist, einem Motor (20), der an dem Gehäuse montiert ist und eine vertikal angeordnete Welle (22) aufweist, einem exzentrischen Gewicht (26), das auf der Welle angeordnet ist, wobei die Arbeit des Motors der Bettplatte (40) eine Vibrationsdrehbewegung verleiht; mit einem Basiselement (14); einer Aufhängung (52), die zwischen der Bettplatte und dem Basiselement zur Isolation der Vibration der Bettplatte vorgesehen ist; einem Gefäß (60) zur Aufnahme des Partikelstoffes, das auf der Oberseite der Bettplatte und davon getrennt angeordnet ist und durch die Vibrationsdrehbewegung der Bettplatte bei Überschreitung der Gravitationsbeschleunigung mit einer Vielfalt von Frequenzen mit jeder Drehung der Welle so beaufschlagt wird, daß der Partikelstoff in dem Gefäß fluidisiert oder kompakt gemacht wird.

7. Vorrichtung nach wenigstens einem der Ansprüche 2 bis 6, dadurch gekennzeichnet, daß der Motor bei einer ausgewählten Geschwindigkeit angetrieben ist und die Vielfalt von Frequenzen durch ganzzahlige Vielfache einer Grundfrequenz, die der ausgewählten Motorgeschwindigkeit entspricht, gegeben ist.

Revendications

1. Dispositif pour traiter des matériaux granulaires, comportant une assise vibratoire comprenant une plaque d'assise (40) disposée horizontalement et un récipient (60) pour les matériaux granulaires porté

par la plaque d'assise (40) et séparé d'elle, caractérisé en ce que ladite assise vibratoire comporte une enveloppe (32) montée sur la plaque d'assise (40) et contenant un arbre tournant (22) disposé sensiblement verticalement sur lequel est disposé au moins un poids excentrique (26), ce par quoi la rotation de l'arbre (22) communique un mouvement vibratoire giratoire à la plaque d'assise (40), le mouvement vibratoire giratoire de la plaque d'assise (40) provoquant des heurts contre le récipient (6) à des multiples fréquences au cours de chaque tour de l'arbre (22) pour fluidiser ou compacter les matériaux granulaires qui se trouvent dans le récipient (60).

2. Dispositif selon la revendication 1, caractérisé en ce que l'arbre (22) est entraîné par un moteur (20) monté dans l'enveloppe (32).

3. Dispositif selon l'une quelconque des revendications 1 ou 2, caractérisé en ce qu'il comporte une base (14) et une suspension (52) couplant l'assise vibratoire à la base.

4. Dispositif selon l'une quelconque des revendications précédentes, caractérisé en ce qu'il comporte des moyens (66, 68) pour retenir le récipient en alignement sensiblement vertical avec la plaque d'assise.

5. Dispositif selon l'une quelconque des revendications précédentes, caractérisé en ce qu'il comporte en outre un moyen formant coussin (56) entre le récipient et la plaque d'assise.

6. Dispositif pour traiter des matériaux granulaires, caractérisé en ce qu'il comporte une assise vibratoire comprenant une plaque d'assise plane (40), une enveloppe (32) montée sur la plaque d'assise (40), un moteur (20) monté sur l'enveloppe et comprenant un arbre disposé verticalement (22), un poids excentrique (26) disposés sur l'arbre, le fonctionnement du moteur communiquant un mouvement vibratoire giratoire à la plaque d'assise (40); une base (14); une suspension (52) couplée entre la plaque d'assise et la base pour isoler la vibration de la plaque d'assise; un récipient (60) qui est disposé en tête de la plaque d'assise et séparé de celle-ci pour contenir les matériaux granulaires et que heurte le mouvement vibratoire giratoire de la plaque d'assise lorsqu'il est supérieur à l'accélération de la pesanteur avec des fréquences multiples à chaque tour de l'arbre de façon à fluidiser ou à compacter les matériaux granulaires qui se trouvent dans le récipient.

7. Dispositif selon l'une quelconque des revendications 2 à 6, caractérisé en ce que le moteur est entraîné à une vitesse choisie et en ce que les fréquences multiples sont des entiers multiples de la fréquence fondamentale qui est la même que la vitesse choisie pour le moteur.



