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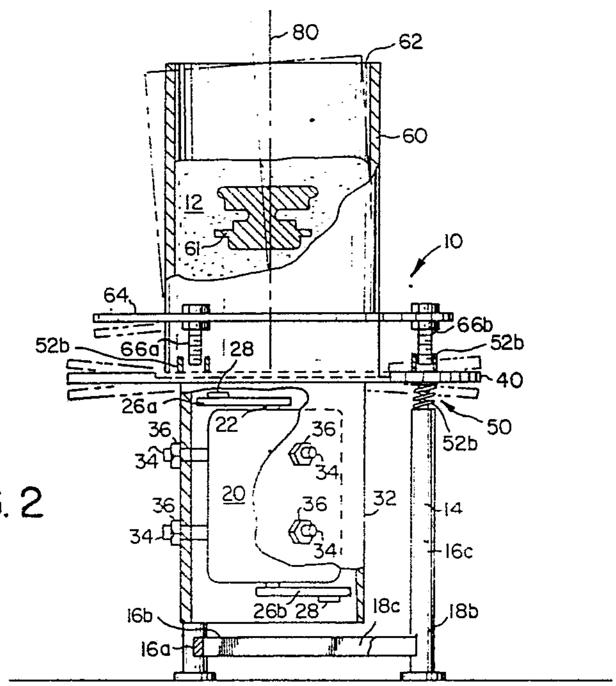
(54) Apparatus for processing particulates.

(57) An apparatus for processing particulates comprises a vibratory bed including a motor (20) with a vertically disposed shaft (22), at least one eccentric weight (26) disposed on the shaft, a housing (32) secured to and enclosing the motor. A bed plate (40) is secured atop the housing whereby operation of the motor (20) imparts vibrational gyratory motion to he housing and the bed plate. When vibrational gyratory motion of the bed plate has an acceleration in excess of gravity, the bed plate (40) will impact a vessel (60) on the bed plate at multiple frequencies for each revolution of the shaft. The impacts at the multiple frequencies will fluidize the particulates so that they can flow into cavities and crevices in a pattern or the like.

FIG. 2



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APPARATUS FOR PROCESSING PARTICULATES

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. 4,456,906, 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 disposed 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 46. 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 avibrogyratory 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 vibrogyrationally 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 (inches)	(mms)	Calculated Acceleration of Vessel 60 (g's)	Integer Multiples of Motor Speed
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

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

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 and separate therefrom, characterised in that the said vibratory bed comprises a support (32) carried by the bed plate (40), a substantially vertically disposed shaft (22) carried by the support, at least one eccentric weight (26) disposed on the shaft (22) whereby rotation of the shaft imparts vibrational gyratory motion to the bed plate, the vibrational gyratory motion of the bed plate impacting the vessel at multiple frequencies during each revolution of the shaft for fluidizing or compacting the particulates in the vessel.

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

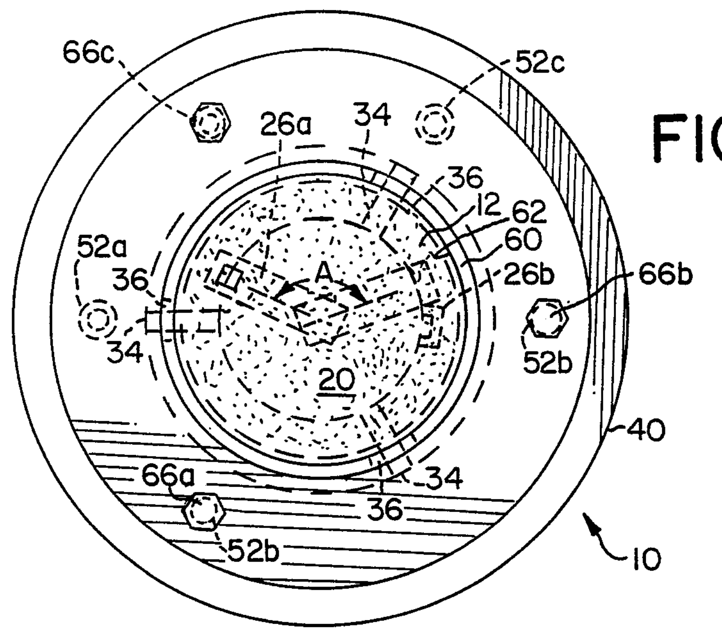
3. An apparatus as claimed in either claim 1 or claim 2, characterised in that it comprises a base (14) and a suspension (52) coupling the vibratory bed to the base.

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 bedplate.

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 support (32) on the bed plate, a motor (20) carried by the support 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 fluidize 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.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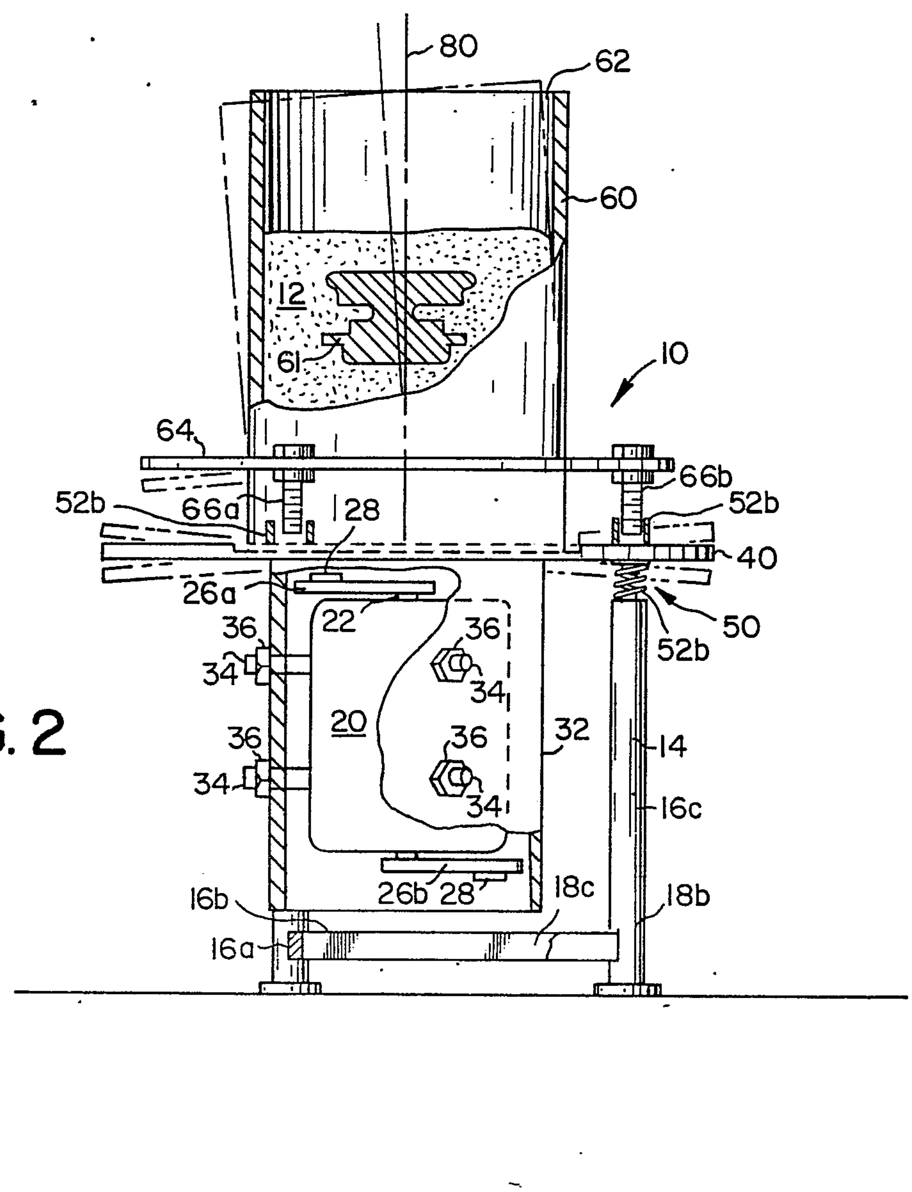
52c
26a
34
36
12
62
60
26b
66b
52a
36
A
34
20
52b
40
66a
34
36
52b
10

FIG. 1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60
12
61
10
64
66b
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66a
52b
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22
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52b
36
34
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32
14
36
34
34
16c
16b
26b
28
18c
18b
16a

FIG. 2

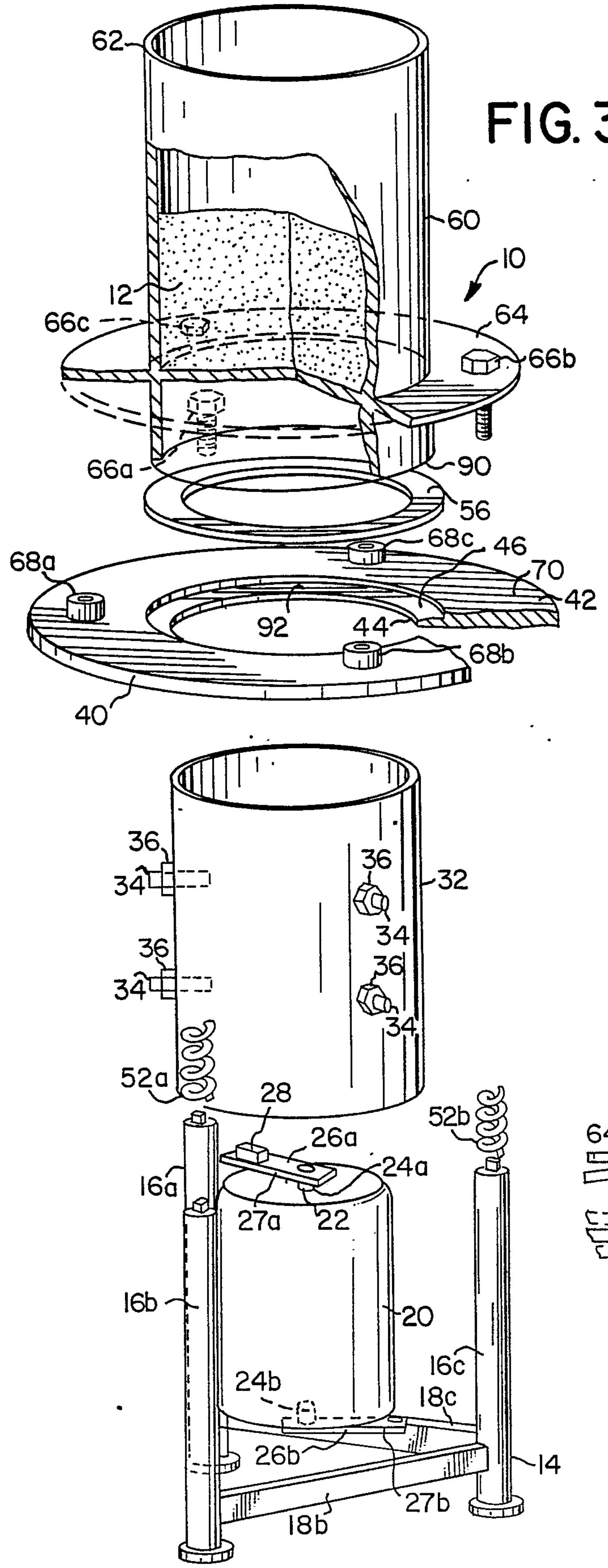

FIG. 3

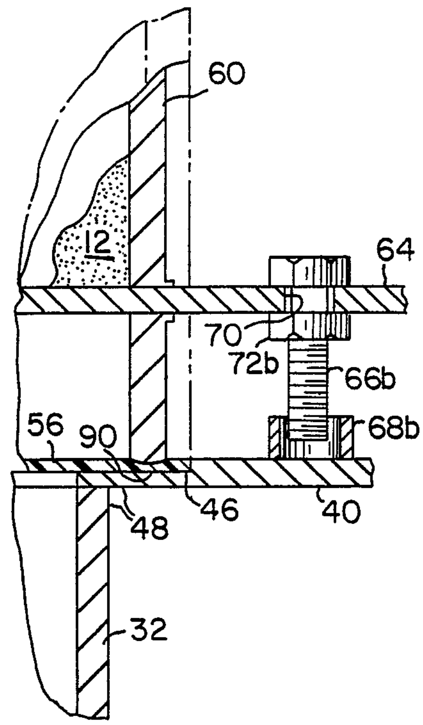

FIG. 4

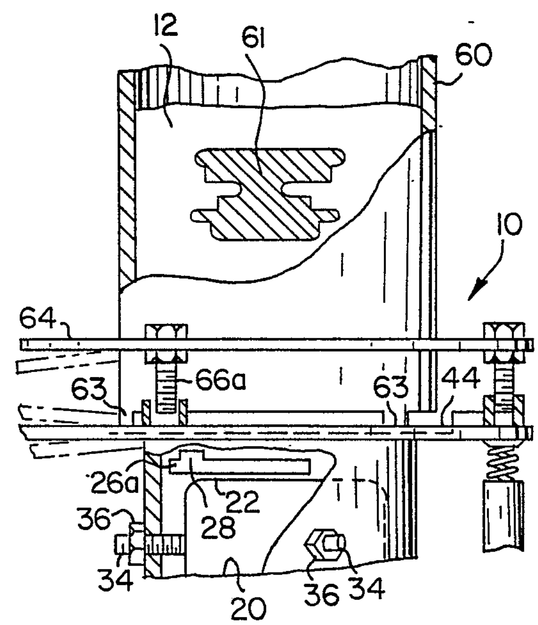

FIG. 5