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(54) **METHOD FOR THE ABRASIVE TREATMENT OF A CASTING.**

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Description

This invention relates to a method and apparatus for the abrasive treatment of a workpiece according to the preambles of claims 1 and 4.

In many manufacturing and assembly processes foreign material may be adhered to or deposited on the internal and external surfaces of the part being manufactured. The foreign material must be removed before the part is put into an assembly or into use.

A specific example of the general problem is in the casting industry wherein a variety of metal casting processes are used, with one such process involving the use of inexpensive styrofoam patterns which have been coated with a ceramic-type material. The patterns can be formed with intricate shapes having depressions, cavities, internal passages, crevices, chambers and the like. The pattern is positioned in a mould box and sand is formed therearound ready for casting. During the casting process, the styrofoam pattern melts away while the ceramic-type coating holds its shape long enough to form the metal casting. The ceramic type coating however also breaks up during the process and in doing so leaves particles of coating of foreign material or of sand adhered to the internal and external surfaces of the casting. Such particles or foreign material are, of course, undesirable in the finished product, and thus it is desirable to remove those particles. However, inasmuch as many castings will have internal passages, holes, crevices, chambers and the like which are hard to reach, the removal of those particles is difficult.

All mouldings systems suffer, in varying degrees, the same shortcomings, namely, leaving residual particles of foreign material of the pattern and the moulding sand on the external surfaces and in the internal surfaces of the castings. The residual particles need to be purged from the casting before the casting is processed further and/or put into use.

In GB—A—1067656, upon which the preamble of claims 1 and 4 are based, there is generally disclosed a method for the abrasive treatment of a part, comprising vibrating a mass of abrasive media substantially in a vertical direction, moving the workpiece to be abrasively treated within the vibrated media, and raising the workpiece when it has been abrasively treated substantially in a vertical direction out of the media.

More particularly, the part to be abrasively treated is a rotationally symmetrical workpiece which is moved within the vibrated media by being rotated about a fixed axis. As such, the method of GB—A—1067656 is not suitable for abrasively treating castings most of which are not symmetrical, since to rotate them in vibrated media will clean and wear the corners but leave the low areas on the casting untouched.

In accordance with the present invention as claimed, the aforesaid generally disclosed method is characterised in that the workpiece to be abrasively treated is a casting with internal and external surfaces, the casting is moved within the vibrated media by being vibrated substantially in a vertical direction with a frequency and amplitude to produce an acceleration of the casting greater than 1g, the media is vibrated with a frequency and amplitude to produce an acceleration thereof also greater than 1g by which the media will fluidize and flow across the internal and external surfaces of the vibrating casting to scrub particles therefrom, and the abrasively treated casting is raised, whilst still being vibrated, out of the media by which the media and freed particles are removed from the casting.

An advantage of the method of the invention over the method disclosed in GB—A—1067656 is that it is suitable for abrasively treating not only assymmetrical castings but also castings in general having internal and external surfaces formed by depressions, cavities, internal passages, crevices, chambers and the like, since the media in the fluidized state will flow into all such areas to clean the casting inside and out. Moreover, by vibrating the casting itself and continuing to vibrate it as it is raised and removed from the media ensures that the free particles scrubbed from the casting as well as any media adhering thereto will be discharged, leaving the casting clean.

An apparatus for carrying out the method generally disclosed in GB—A—1067696 generally comprises a container of abrasive media, means for vibrating the container to vibrate the media therein substantially in a vertical direction, means for moving the workpiece to be abrasively treated within the vibrated media, and means for raising the workpiece when it has been abrasively treated substantially in a vertical direction out of the media.

As said hereinbefore, in GB—A—1067696 the workpiece is moved within the vibrated media by being rotated about a fixed axis which, whilst suitable for rotationally symmetrical workpieces, is not for the majority of castings.

The aforesaid generally disclosed apparatus of GB—A—1067696, in accordance with the present invention, is characterised in that the apparatus is for the abrasive treatment of a workpiece in the form of a casting with internal surfaces and external surfaces, the means for moving the casting within the vibrated media is operable to vibrate the casting substantially in a vertical direction, the means for vibrating the container is operable to vibrate the media with a frequency and amplitude to produce an acceleration thereof greater than 1g by which the media will fludize and flow across the internal and external surfaces of the vibrated casting to scrub particles therefrom, and the means for raising the casting out of the media is operable to do so, whilst the casting vibrating means is vibrating the casting, by which to assist removal of the media and freed particles from the casting.

Thereby, use of the apparatus of the invention results in the hereinbefore stated advantages over GB—A—1067656.

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

Figure 1 is a partial cross-sectional view of a first embodiment of a vibratory scrubber;

Figure 2 is a view taken along line 2—2 of Figure 1;

Figure 3 is a partial enlarged cross-sectional view taken along line 3—3 of Figure 1;

Figure 4 is a cross-sectional view of a portion of the casting of Figure 3 after scrubbing by the scrubber; and

Figure 5 is a partial cross-sectional view similar to Figure 1 of an alternative embodiment of a vibratory scrubber.

Referring first to Figures 1 and 2, a vibratory scrubber 10 is shown specifically as scrubbing a casting. The scrubber 10 includes a container 12 for particulate scrubbing media 14, such as steel shot, mixture of liquid and solids or any other fluidizable material, and the container 12 is fixed to a platform 16. Due to the weight of the container 12 and media 14, it is necessary to have a suitably reinforced platform 16, as for example by connecting spaced plates 18, 20 with a bracing structure 22.

The platform 16 is mounted on four corners to springs 24 which are themselves mounted on a base 26 suitably secured to the floor 30.

A set of vibration generators 34 of any well known type is provided with the vibration generators shown being in the form of electric motors 36 having shafts 38 carrying eccentric weights 40. The generators are suspended from the bottom of the platform 16 in order to produce the vibrations. The vibration generators 34 may be of the type shown in U.S. Patent No. 3,358,815 where the effective force of the eccentric weights may be varied from zero to maximum and thus produce a variation in stroke as desired. Other types of vibration generators could be substituted for the eccentric vibration generators 34, such as hydraulic vibrators and the like.

The vibration generators 34 are energized to produce a vibratory motion for the container 12 and its contents substantially in a vertical direction and in excess of the acceleration due to gravity i.e. greater than 1g. The acceleration in g's can be calculated by the formula

$$\text{Acceleration} = \frac{S \times F^2}{70400}$$

where S is the amplitude of the stroke in inches and F is the frequency of the stroke in strokes per minute. For example, with a frequency of 3600 strokes per minute and a stroke amplitude of 0.007 inches, there is produced an acceleration of 1.29 g's on the container 12 and the media 14. This acceleration causes the media 14 to become fluidized, and thereby to flow freely.

Suspended by a chain 42 above the container 12 is a part or casting supporting structure 44 comprised of a frame 46, made of I-beams 48, having sufficient rigidity to support and vibrate in a substantially vertical direction a part or casting 50. A mounting beam 52 depends vertically downward from the frame 46 and is adaptable for mounting a desired number and type of part or casting 50. In the embodiment shown, two castings 50, 50 are fixed to the mounting beam 52 by bolting flanges 54 of the castings 50 onto the mounting beam 52. Of course, other means of fixing the parts or castings 50 shown, as well as other types of parts or castings, to the mounting beam 52 would be suitable and apparent to those skilled in the art. It is important that the openings 53 into the passageways 55 be kept open and unobstructed so that the media 14 can flow freely into and out of the passageways.

The frame 46 is directly connected to a second set of vibration generators 60, each of which in the illustrated form also comprises an electric motor 62 driving a shaft 64 having synchronized eccentric weights 66 on both ends. As with the vibration generators 34 of the container 12, it is desirable to drive the second set of vibration generators so that the frame and hence the part or castings 50 is vibrated substantially in a vertical direction and in a manner in which the

$$\text{Acceleration} = \frac{S \times F^2}{70400}$$

is greater than one, i.e. greater than 1g.

The second set of vibration generators 60 are suspended from an upper plate 70 by a pair of springs 72. The upper plate 70 has a bracket 74 which is connected to the supporting chain 42. The upper plate 70 is isolated from the vibrations of the vibration generators 60 by the springs 72. Suitable means are provided to manipulate the chain 42 so as to lower the frame 46 and mounting beam 52 to locate the castings 50 in the media 14, and also to raise the frame 46 from the media ready for removal of the castings or parts 50.

Castings or parts 50 may be manufactured using styrofoam patterns which have been coated with a ceramic-type material. During the casting process, the styrofoam pattern is essentially melted away and the ceramic-type coating holds its shape long enough to form the casting 50 but then breaks up as well. This process leaves particles or foreign material 80 (see Figure 3) of the coating as well as other materials adhered to the external surfaces 82 and internal surface 84 of the casting 50. The scrubber 10 is used to remove these particles or foreign material 80 from all surfaces both external 82 and internal 84 of the casting 50.

To remove the particles or foreign material 80, the castings or parts 50 are fixed to the mounting beam 52 and then the vibration generator 34 for the container 12 and media and the generator 60 for the frame 46 and parts 50 are energized. The vibrating frame 46 is lowered to locate the parts

or castings 50 into the vibrating media 14 which is easily accomplished inasmuch as the media 14 in the container 12 is fluidized by the vibrations of the generators 34. The media 14 thus easily flows about the casting 50 and into crevices and passageways in the casting 50, and the vibration of the casting 50 itself ensures that the media 14 will flow freely into any such crevices and passageways in the casting 50 as well. The flow of the media 14 about the external surfaces 82 and through the passageways over the internal surfaces 84 in the castings 50 is abrasive on the surfaces of the castings 50 and thus the particles or foreign materials 80 are scrubbed clean from the parts or castings. The result in a clean and, with certain types of materials, shiny casting 50 as shown in Figure 4.

The vibration generators 60 on the supporting structure 44 may continue to be driven as the structure 44 is raised to remove the part or casting 50 from the container 12 so as to discharge the media and freed foreign material or particles 80 from the passageways 55 in the parts or castings.

An alternative embodiment of the vibratory scrubber 10' is shown in Figure 5. The same reference numerals are used for the members that are identical to Figure 1. This scrubber 10' uses a two mass sytem for vibrating the part or casting 50. With the scrubber of Figure 5, the set of vibration generators 60 used to apply a vibratory motion to the frame 52 and part 50 are not directly attached to the frame 46', but rather are attached to a second set of springs 88 extending between the first set of vibration generators 60 and a working weight 90 carried by the frame 46' and mounting beam 52. The second set of springs 88 are used to tune the vibrations of the frame 46 for enhacing the vibratory motion of the part or casting 50.

As another alternative, the casting may be vibrated at a frequency and amplitude to produce an acceleration thereof that varies from the acceleration produced on the media by the frequency and amplitude at which the media is vibrated, both such accelerations being greater than 1g.

Claims

1. A method for the abrasive treatment of a workpiece (50), comprising vibrating a mass of abrasive media (14) substantially in a vertical direction, moving the workpiece to be abrasively treated within the vibrated media, and raising the workpiece when it has been abrasively treated substantially in a vertical direction out of the media, characterised in that the workpiece to be abrasively treated is a casting (50) with internal surfaces (84) and external surfaces (82), the casting (50) is moved within the vibrated media by being vibrated substantially in a vertical direction with a frequency and amplitude to produce an acceleration of the casting (50) greater than 1g, the media is vibrated with a frequency and amplitude to produce an acceleration thereof also greater than 1g by which the media will fluidize and flow across the internal and external surfaces of the vibrated casting (50) to scrub particles (80) therefrom, and the abrasively treated casting (50) is raised, whilst still being vibrated, out of the media by which the media and freed particles are removed from the casting (50).

2. A method as claimed in claim 1, wherein the casting (50) and the media (14) are vibrated with a frequency and amplitude to produce an acceleration thereof substantially equal to 1.3 g's.

3. A method as claimed in claim 1, wherein the casting (50) is vibrated with a frequency and amplitude to produce an acceleration thereof that varies from the acceleration produced on the media (14) by the frequency and amplitude at which the media is vibrated.

4. An apparatus for the abrasive treatment of a workpiece (50), comprising a container (12) of abrasive media (14), means (34) for vibrating the container to vibrate the media therein substantially in a vertical direction, means (60) for moving the workpiece to be abrasively treated within the vibrated media, and means (42) for raising the workpiece when it has been abrasively treated substantially in a vertical direction out of the media, characterised in that the apparatus is for the abrasive treatment of a workpiece in the form of a casting (50) with internal surfaces (84) and external surfaces (82), the means (60) for moving the casting within the vibrated media (14) is operable to vibrate the casting substantially in a vertical direction, the means (34) for vibrating the container (12) is operable to vibrate the media with a frequency and amplitude to produce an acceleration thereof greater than 1g by which the media will fluidize and flow across the internal and external surfaces of the vibrated casting to scrub particles (80) therefrom, and the means (42) for raising the casting out of the media is operable to do so, whilst the casting vibrating means (60) is vibrating the casting, by which to assist removal of the media and freed particles from the casting.

5. An apparatus as claimed in claim 4, wherein the means (60) for vibrating the casting (50) is operable to do so with a frequency and amplitude to produce an acceleration of the casting greater than 1g.

6. An apparatus as claimed in claim 5, wherein the means (60) for vibrating the casting (50) and the means (34) for vibrating the container (12) are respectively operable to vibrate the casting and vibrate the abrasive media (14) to produce an acceleration thereof substantially equal to 1.3 g's.

7. An apparatus as claimed in claim 5, wherein the means (60) for vibrating the casting (50) and the means (34) for vibrating the container (12) are respectively operable to vibrate the casting and vibrate the abrasive media (14) to produce an acceleration of one that varies from the acceleration of the other.

8. An apparatus as claimed in any one of claims 4 to 7, wherein the means (42) for raising the casting (50) comprises suspension means (42) for a frame (46, 46') and which is operable both to raise and lower the frame, and further comprising

means (52, 54) for mounting the casting to the frame.

9. An apparatus as claimed in claim 8, wherein the means (60) for vibrating the casting (50) is mounted on the frame (46).

10. An apparatus as claimed in claim 8, wherein spring means (88) are mounted between the frame (46') and the means (60) for vibrating the casting (50).

Patentansprüche

1. Verfahren zur abreibenden Behandlung eines Werkstückes (50), bei dem eine Masse eines Abreibmediums (14) im wesentlichen in einer vertikalen Richtung in Schwingung versetzt wird, das abreibend zu behandelnde Werkstück im in Schwingung versetzten Medium bewegt wird, und das Werkstück, nachdem es abreibend behandelt wurde, im wesentlichen in einer vertikalen Richtung aus dem Medium angehoben wird, dadurch gekennzeichnet, daß das abreibend zu behandelnde Werkstück ein Gußteil (50) mit inneren Flächen (84) und äußeren Flächen (82) ist, wobei das Gußteil (50) dadurch im in Schwingung versetzten Medium bewegt wird, daß es in einer im wesentlichen vertikalen Richtung mit einer solchen Frequenz und einer solchen Amplitude in Schwingung versetzt wird, daß eine Beschleunigung des Gußteiles (50) von mehr als 1 g hervorgerufen wird, wobei das Medium mit einer solchen Frequenz und einer solchen Amplitude in Schwingung versetzt wird, daß ebenfalls eine Beschleunigung von mehr als 1 g hervorgerufen wird, bei der das Medium fluidisiert und über die inneren und äußeren Flächen des in Schwingung versetzten Gußteils (50) strömt, um Partikel (80) von diesem abzuscheuern, und daß das abreibend behandelte Gußteil (50) unter fortdauerndem Schwingen aus dem Medium angehoben wird, wodurch das Medium und befreite Partikel vom Gußteil (50) entfernt werden.

2. Verfahren nach Anspruch 1, bei dem das Gußteil (50) und das Medium (14) mit einer Frequenz und einer Amplitude in Schwingung versetzt werden, um eine Beschleunigung von im wesentlichen gleich 1,3 g hervorzurufen.

3. Verfahren nach Anspruch 1, bei dem das Gußteil (50) mit einer Frequenz und einer Amplitude in Schwingung versetzt wird, um eine Beschleunigung desselben zu erreichen, die sich von der Beschleunigung unterscheidet, die im Medium (14) durch die Frequenz und die Amplitude hervorgerufen wird, mit der das Medium in Schwingung versetzt wird.

4. Vorrichtung zur abreibenden Behandlung eines Werkstückes (50), mit einem ein Abreibmedium (14) enthaltenden Behälter (12), mit Mittel (34), um den Behälter in Schwingung zu versetzen, damit das darin aufgenommene Medium im wesentlichen in vertikaler Richtung in Schwingung versetzt wird, mit Mittel (60) zum Bewegen des abreibend zu behandelnden Werkstückes in dem in Schwingung versetzten Medium, und mit Mittel (42) zum Anheben des Werkstückes, nachdem es abreibend behandelt wurde, in einer im wesentlichen vertikalen Richtung aus dem Medium heraus, dadurch gekennzeichnet, daß die Vorrichtung für die abreibende Behandlung eines Werkstückes in Form eines Gußteiles (50) mit inneren Flächen (84) und äußeren Flächen (82) vorgesehen ist, daß die Mittel (60) zum Bewegen des Gußteiles in dem in Schwingung versetzten Medium (14) derart betreibbar sind, daß das Gußteil im wesentlichen in einer vertikalen Richtung in Schwingung versetzt wird, daß die Mittel (34), um die Behälter (12) in Schwingung versetzen, derart betreibbar sind, daß sie das Medium derart mit einer Frequenz und derart mit einer Amplitude in Schwingung versetzen, daß dieses mit mehr als 1 g beschleunigt wird, wodurch das Medium fluidisiert und über die inneren und äußeren Flächen des im Schwingung versetzten Gußteiles strömt, um Partikel (80) von diesem abzuscheuern, und daß die Mittel (42) zum Anheben des Gußteiles aus dem Medium dazu betreibbar sind, währenddessen die Gußteilschwingmittel (60) das Gußteil in Schwingung versetzen, um ein Entfernen des Mediums und der befreiten Partikel vom Gußteil zu unterstützen.

5. Vorrichtung nach Anspruch 4, bei der die Mittel (60), die das Gußteil (50) in Schwingung versetzen, derart mit einer Frequenz und derart mit einer Amplitude betreibbar sind, daß sie eine Beschleunigung des Gußteiles von mehr als 1 g hervorrufen.

6. Vorrichtung nach Anspruch 5, bei der die Mittel (60), die das Gußteil (50) in Schwingung versetzen, und die Mittel (34), die den Behälter (12) in Schwingung versetzen, jeweils derart betreibbar sind, daß sie das Gußteil und das arbreibende Medium (14) so in Schwingung versetzen, daß sie eine Beschleunigung derselben hervorrufen, die etwa gleich 1,3 g beträgt.

7. Vorrichtung nach Anspruch 5, daß die Mittel (60), die das Gußteil (50) in Schwingung zu versetzen, und die Mittel (34), die den Behälter (12) in Schwingung versetzen, jeweils derart betreibbar sind, daß sie das Gußstück und das abreibende Medium (14) derart in Schwingung versetzen, daß sich die Beschleunigung des einen von der Beschleunigung des andern unterscheidet.

8. Vorrichtung nach einem der Ansprüche 4 bis 7, bei der die Mittel (42) zum Anheben des Gußteiles (50) Aufhängemittel (42) für einen Rahmen (46, 46') aufweisen, und die derart betreibbar sind, daß sie den Rahmen anheben und absenken können, und daß ferner Mittel (52, 54) vorgesehen sind, um das Gußteil am Rahmen zu befestigen.

9. Vorrichtung nach Anspruch 8, bei der die Mittel (60), die das Gußteil (50) in Schwingung versetzen, auf dem Rahmen (46) angebracht sind.

10. Vorrichtung nach Anspruch 8, bei der Federmittel (88) zwischen dem Rahmen (46') und den Mitteln (60), die das Gußteil (50) in Schwingung versetzen, angebracht sind.

Revendications

1. Procédé pour le traitement abrasif d'une pièce (50), comportant le fait de faire vibrer une masse de médium abrasif (14) sensiblement dans la direction verticale, de déplacer, à l'intérieur du médium vibré, la pièce que doit subir un traitement abrasif, et de relever la pièce, sensiblement en direction verticale, pour la sortir hors du médium, lorsqu'elle a subi le traitement abrasif, caractérisé en ce que la pièce qui doit subir un traitement abrasif est une pièce moulée (50) présentant des surfaces intérieures (84) et des surfaces extérieures (82); en ce que l'on déplace la pièce de fonderie (50) à l'intérieur du médium vibré tout en la faisant vibrer sensiblement dans une direction verticale avec une fréquence et une amplitude calculées pour donner une accélération de la pièce moulée 50 supérieure à 1 g; en ce que l'on fait vibrer le médium avec une fréquence et une amplitude calculées pour lui donner également une accélération supérieure à 1 g, ce par quoi le médium se fluidise et coule le long des surfaces intérieures et extérieures de la pièce moulée vibrée (50), pour en décocher les particules (80); et en ce que l'on relève la pièce moulée (50), qui a subi un traitement abrasif, tout en continuant à la vibrer, pour la sortir hors du médium, de sorte que le médium et les particules libérées se détachent de la pièce moulée (50).

2. Procédé selon la revendication 1, dans lequel on fait vibrer la pièce moulée (50) et le médium (14) avec une fréquence et une amplitude calculées pour leur donner une accélération sensiblement égale à 1.3 g.

3. Procédé selon la revendication 1, dans lequel on fait vibrer la pièce moulée (50) avec une fréquence et une amplitude calculées pour lui donner une accélération différente de l'accélération donnée au médium (14) par la fréquence et l'amplitude avec lesquelles on fait fibrer le médium.

4. Appareil pour le traitement abrasif d'une pièce (50), comportant un conteneur (12) de médium abrasif (14), des moyens (34) pour faire vibrer le conteneur, pour faire vibrer sensiblement en direction verticale le médium qui s'y trouve, des moyens (60) pour déplacer à l'intérieur du médium vibré la pièce qui doit subir un traitement abrasif, et des moyens (42) pour relever la pièce sensiblement en direction verticale, pour la sortir hors du médium, lorsqu'elle a subi un traitement abrasif, caractérisé en ce que l'appareil est conçu pour le traitement abrasif d'une pièce en forme de pièce moulée (50) présentant des surfaces intérieures (84) et des surfaces extérieures (82); en ce que les moyens (60) prévus pour déplacer la pièce moulée à l'intérieur du médium vibré (14) peuvent fonctionner pour faire vibrer la pièce moulée sensiblement en direction verticale; en ce que les moyens (34) pour faire vibrer le conteneur (12) peuvent fonctionner pour faire vibrer le médium avec une fréquence et une amplitude calculées pour lui donner une accélération supérieure à 1 g, ce par quoi le médium va se fluidiser et couler le long des surfaces intérieures et extérieures de la pièce moulée vibrée pour en décocher des particules (80); et en ce que les moyens (42) prévus pour relever la pièce moulée hors du médium peuvent fonctionner pour y procéder tandis que les moyens (60) prévus pour faire vibrer la pièce moulée la font vibrer, de façon à faciliter le détachage du médium et des particules libérées d'avec la pièce moulée.

5. Appareil selon la revendication 4, dans lequel les moyens (60) prévus pour faire vibrer la pièce moulée (50) peuvent fonctionner pour y procéder avec une fréquence et une amplitude calculées pour donner à la pièce moulée une accélération supérieure à 1 g.

6. Appareil selon la revendication 5, dans lequel les moyens (60) prévus pour faire vibrer la pièce moulée (50) et les moyens (34) pour faire vibrer le conteneur (12) peuvent respectivement fonctionner pour faire vibrer la piéce moulée et faire vibrer le médium abrasif (14) pour leur donner une accélération sensiblement égale à 1.3 g.

7. Appareil selon la revendication 5, dans lequel les moyens (60) prévus pour faire vibrer la pièce moulée (50) et les moyens (34) prévus pour faire vibrer le conteneur (12) peuvent respectivement fonctionner pour faire vibrer la pièce moulée et pour faire vibrer le médium abrasif (14) pour donner à l'un une accélération différente de l'accélération donnée à l'autre.

8. Appareil selon l'une quelconque des revendications 4 à 7, dans lequel les moyens (42) prévus pour relever la pièce moulée (50) comportent des moyens de suspension (42) pour un cadre (46, 46') qui peuvent fonctionner à la fois pour relever et abaisser le cadre, et comportent en outre des moyens (52, 54) pour monter la pièce moulée sur le cadre.

9. Appareil selon la revendication 8, dans lequel les moyens (60) prévus pour faire vibrer la pièce moulée (50) sont montés sur le cadre (46).

10. Appareil selon la revendication 8, dans lequel des moyens élastiques (88) sont montés entre le cadre (46') et les moyens (60) prévus pour faire vibrer la pièce moulée (50).

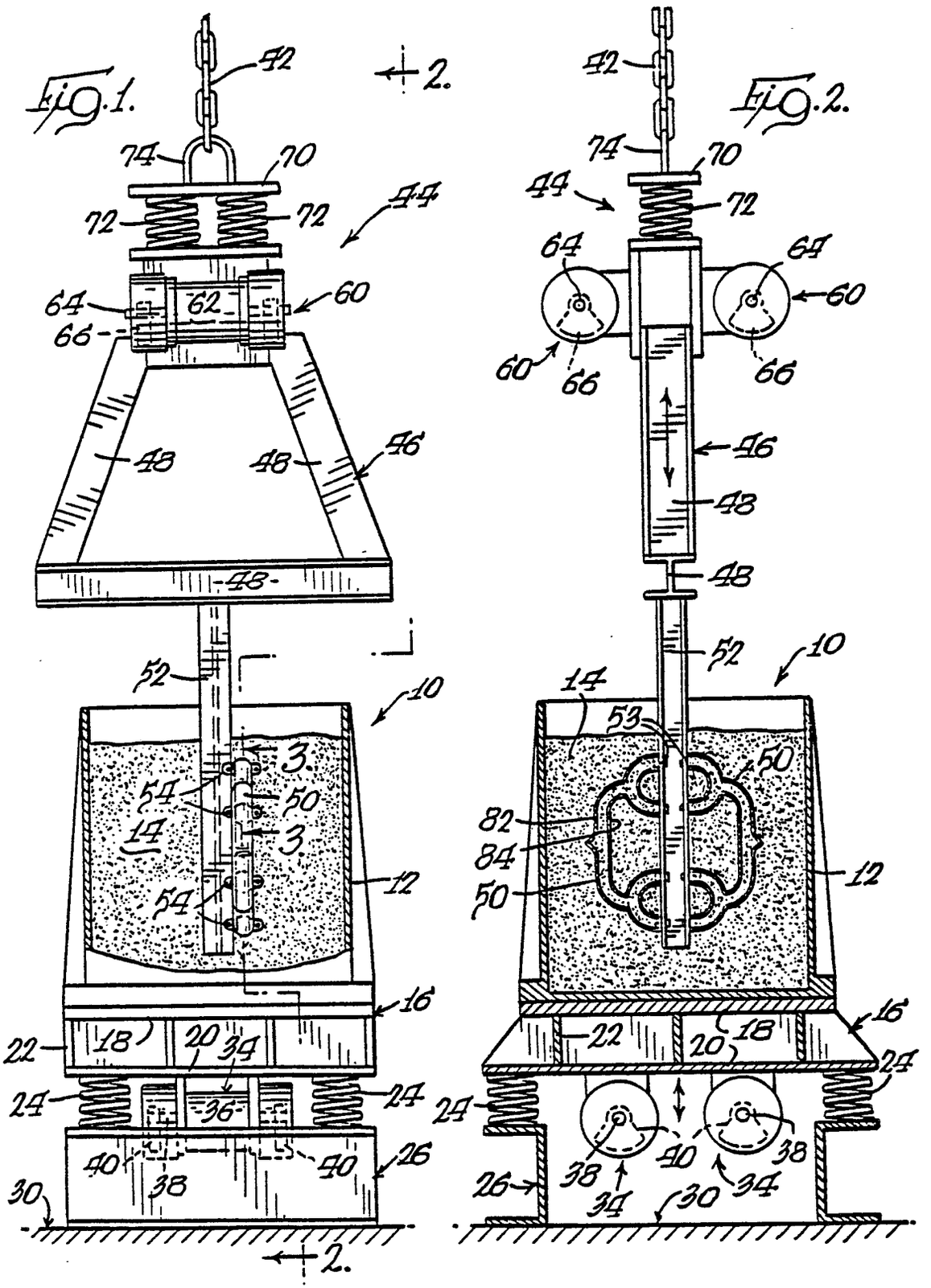
Fig.1.
Fig.2.
42
74
70
72
44
64
62
60
66
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46
52
10
14
53
50
82
84
12
16
22
18
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34
24
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38
26
30
3
2

Fig.3.

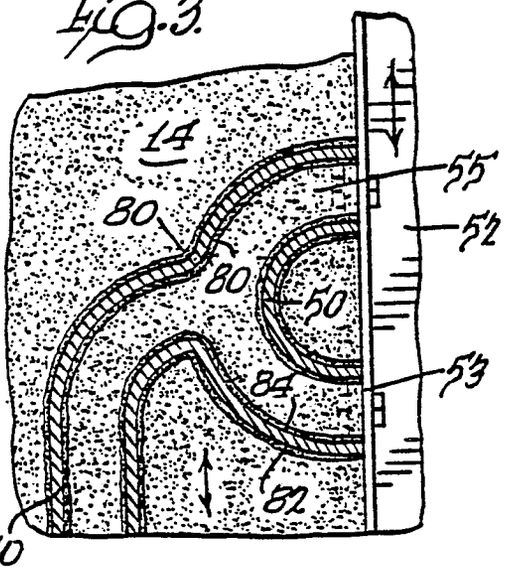

Fig.4.

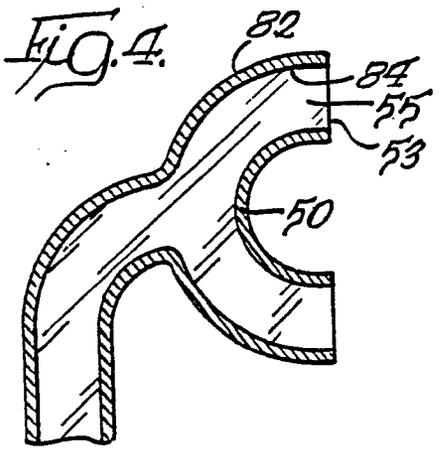

Fig.5.