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(54) **GEOTHERMAL DRILLING WEIGHT**

(57) A geothermal ground source drilling weight 300 comprising an article 50 that is made from metal fragments that are combined. The metal fragments may be compressed together to form the weight. The metal fragments may comprise swarf from known metal working processes. The drilling weight may comprise several articles. The article(s) may be enclosed in a tube 410 or encased in resin 510. The drilling weight may have an attachment point 20, 30 at one or both ends.

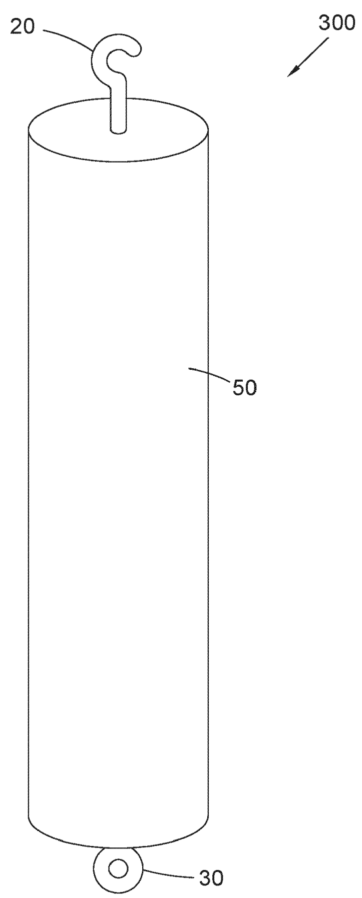

FIG. 4

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to the field of geothermal drilling weights, also known as loop weights.

BACKGROUND OF THE INVENTION

[0002] Geothermal drilling weights, also commonly referred to as (geothermal) loop weights, are single-use items which are used to facilitate the positioning of a geothermal loops in boreholes. The weights are needed because, typically, the geothermal loops are not heavy enough to fall to the bottom of the borehole under their own weight, particularly where water is encountered in the borehole.

[0003] Typically, drilling weights are made of metal, or sand-filled plastic.

[0004] Drilling weights made of metal are expensive.

[0005] Drilling weights made of a sand-filled plastic shell, whilst generally cheaper, are less dense than a metal equivalent. This means more are required for a given application, when compared to metal drilling weights. This increases the cubic volume of the weights for a required application, which causes greater transportation, storage, and manpower costs. Furthermore, plastic weights have higher buoyancy than metal weights, making them potentially less suitable where the weight needs to descend through water in a borehole.

SUMMARY OF THE INVENTION

[0006] The invention is defined by the claims.

[0007] According to examples in accordance with an aspect of the invention, there is provided a geothermal ground source drilling weight comprising an article which comprises metal fragments that are mechanically combined.

[0008] Mechanically combined means they are fixed in position relative to each other, in a manner resulting in a binding force that holds them together. For example, they may be compressed together. They may be compressed together in a machine which provides a pressure (compression force) of between 1,000 and 20,000 kg/cm^2, and this compressing process may be completed at a temperature of between -50 (minus 50) and 200 degrees centigrade.

[0009] Drilling weights comprising articles comprising metal fragments are significantly cheaper to manufacture than drilling weights comprising solid metal.

[0010] The metal fragments may be a waste metal from an industrial process, and of little alternative value, and thus may be obtained at minimal cost. The need for expensive, industrially produced metal is reduced.

[0011] Such an approach allows a high density, low buoyancy drilling weight to be made at low cost.

[0012] The metal fragments may comprise any form of known "swarf", including chips, turnings, filings, shavings, pieces, chunks, spirals, cuttings, coarse and fine metal dust, particles, and tendrils, in any combination. These may be the result of a machining, a subtractive metalworking, or a subtractive manufacturing processes. For example, the metal fragments may comprise the waste material from fine levelling of railway tracks wherein portions of metal track are shaved off to ensure the tracks are perfectly flat and level, or may comprise the waste product of many metalworking processes such as milling, drilling, grinding and turning.

[0013] Depending on the source material and process from which it was derived, the uncompressed (source) metal fragments may have a density of between 10 and 3,500 kg/m^3.

[0014] The largest individual pieces comprising the uncompressed metal fragments may have a width at a widest point of between 0.01mm and 100mm, and a length of between 0.01 and 1,000mm. The uncompressed metal fragments may be irregularly shaped, may be substantially regularly shaped, may be spiral shaped, may be substantially round, or may be any combination of one or more of these. The uncompressed metal fragments may be of similar shapes and sized, or of dissimilar shapes and sizes.

[0015] The metal fragments may comprise other particles including contaminants or other materials. The metal fragments may comprise steel, and optionally may or may not also include other metals. Steel is an ideal candidate as it has a higher density than other metals such as aluminium, and there are plentiful supplies of waste steel fragments. It is also less valuable than waste fragments from other metals such as copper.

[0016] Waste metal fragments are loosely packed, and thus not dense, resulting in a low weight per unit volume. Thus, waste metal fragments are expensive to transport and handle, so reprocessing them into articles saves expensive removal, and allows drilling weights to be made from an otherwise typically waste material. Co-locating drilling weight manufacture with premises that generate significant (waste) metal fragments may result in even further cost savings over the manufacture of drilling weights made from solid metal.

[0017] Further, waste metal fragments are often contaminated and not suitable for other purposes due to this contamination, so finding an industrial utility for such a product is highly beneficial.

[0018] The metal fragments that are mechanically combined may comprise dust.

[0019] Forming drilling weights which comprise metal fragments enables an otherwise waste material to be re-used, and saves on the use of new metal. Thus, drilling weights according to the invention are more environmentally friendly than existing drilling weights.

[0020] A drilling weight comprising combined waste metal fragments is dense and not buoyant, making it ideal for a geothermal ground source drilling weight which may need to descend through an underground water source.

[0021] In embodiments, the metal fragments are compressed together.

[0022] Forming the article by compressing metal fragments together provides a reliable method of providing mechanical fixation. Additionally, this compression allows the density of the article to be increased.

[0023] In embodiments, the article comprises a non-homogenous structure.

[0024] This non-homogenous structure is resultant from the manufacture process in which distinct metal fragments are compressed together to form a single article. The article may be non-homogenous in that that one or more material properties, such as tensile strength, compressive strength, surface roughness, or ability to withstand stress, vary at different positions within the material.

[0025] In embodiments, the article has a porosity of between 0.01% and 10%, or more preferably between 0.1% and 5%, or more preferably between 0.2% and 3%, or more preferably between 0.5% and 2%, or more preferably between 1% and 1.5%.

[0026] Porosity is a measure of the void spaces in a material, and is a fraction of the volume of voids over the total volume between 0 and 1 or 0% and 100%. $\phi = V_V/V_T$, where ϕ is porosity, Vv is void volume and V_T is total volume. Drilling weights made from solid metal are non-porous, i.e. have a porosity of 0%, essentially having no void spaces. Producing a drilling weight with a specific porosity may enable an optimal balance between production time and effort, and the resultant article density. For example, a very high porosity may reduce density to an unacceptable level, whereas a very low porosity may require compression pressures or combination techniques which may not be cost-effective to employ. Manufacturing techniques may be not cost effective because, for example, they require more powerful machines for limited technical benefit in the resultant product.

[0027] In embodiments, the article has a density of between 3,000 and 7,500 kg/m^3.

[0028] This density allows a useful and effective ground source drilling weight to be made, which may descend easily.

[0029] Increased density of the article may result in reduced transportation, manpower, storage and logistics costs, since less volume is required per unit weight.

[0030] In some embodiments the article may have a density of between 4,000 and 6,500 kg/m^3

[0031] In some embodiments the article may have a density of between 5,500 and 6,000kg/m^3.

[0032] In some embodiments, the article is encased in resin.

[0033] Encasing the article in a resin may be a cheap and convenient method to protect it from impacts, which may otherwise damage or disintegrate it, and may provide a smooth less hazardous surface, which may enable easier handling.

[0034] Encasing the article in a resin that is formed in a mould may allow the external shape of the weight to be different to the shape of the article. For example, a round article may be placed in a square mould which is then filled with resin, resulting in a square outer shape to the drilling weight. A typical article according to the invention may be made in a known industrial "pucking" machine, resulting in a round hockey puck shaped compressed article, whereas a square drilling weight may be useful, as it may be more convenient in some applications. Furthermore, a drilling weight that is square in cross section may be stored more conveniently and densely, since the resulting square profile drilling weights can be stably stacked and in such a manner that there are no air gaps between adjacent drilling weights. Space may be limited for the storage of drilling weights, so increasing the density of storage by reducing air gaps may reduce storage space requirements for a given total mass of drilling weights.

[0035] In some embodiments, the article is enclosed in a hollow tube.

[0036] Encasing the article in a hollow tube may be a cheap and convenient method to protect it from impacts, which may damage or disintegrate the article, and may provide a smooth less hazardous surface which may enable easier handling.

[0037] The hollow tube may be made of a metal such as steel, or made from plastic, GRP or any suitable material.

[0038] Hollow tube is readily available and relatively inexpensive.

[0039] Forming an article in a hollow tube is relatively inexpensive compared to an equivalent mass of drilling weight formed of solid metal.

[0040] Encasing the article in a hollow tube may be cheaper and easier than other methods of encasing it.

[0041] Where the hollow tube is formed of metal or a similarly dense material, the hollow tube both protects the article and increases the weight of the drilling weight.

[0042] Further, the article and the hollow tube may both have a round cross section.

[0043] Having the article and hollow tube both of round cross section may allow for minimal wasted space between the article and tube which may allow density of the drilling weight to be maximised.

[0044] Having a drilling weight with a round cross section may result in less snagging from the drilling weight in use, and thus allow the drilling weight to pass through tight holes more easily.

[0045] Alternatively, the article or the hollow tube or both may have a square cross section or any other cross-sectional shape.

[0046] Further, the hollow tube may comprise an end portion at a first end, wherein the end portion is compressed to enclose the first end of the hollow tube.

[0047] Compressing an end of the tube to enclose it may be more cost effective or convenient than other methods of enclosing the tube, since additional materials and processes may not be needed to enclose the tube.

[0048] The compressed tube may, in the same or a subsequent processed by adapted to provide an attachment point, for example an eye or a hook, to be formed in the tube, or attached to the tube.

[0049] For example, the end of the tube may be stamped by a special machine to enclose the tube in a manner which also results in a circular hole in the newly stamped portion, which hole may be used as an attachment point, for a strap, for example.

[0050] As an alternative example, the end of the tube may be stamped (compressed) around a hook or eye, thus both enclosing the tube and resulting in an attachment point, which may be used to attach items to the tube, or to daisy-chain multiple tubes together.

[0051] Compressing an end of the tube may reduce cost and manufacturing time since additional processes such as welding may not be required.

[0052] Further, the hollow tube may comprise an end cap at a second end, wherein the end cap is configured to enclose the second end and thus retain the article in the hollow tube.

[0053] The end cap may be, for example, welded, friction fitted, or compressed on to the tube. Alternatively, the end cap may be threaded onto a corresponding thread on the tube. The end cap may be permanently affixed or may be removable.

[0054] One or both ends of the tube may be enclosed by an end cap.

[0055] The end cap and tube may comprise co-operating screw threads allowing the end cap to be screwed onto the tube.

[0056] The end cap may be integrally formed as part of the hollow tube, i.e. not attached during a subsequent process.

[0057] Capping the end of the tube may be a cheaper and more convenient method to retain the compressed article in the tube.

[0058] Capping the end of the tube may allow the tube to be easily opened and closed, permitting inspection, emptying the tube, adjusting the total weight by adding or removing one or more articles from the tube, or any other purpose for which it may be useful to easily open and close the tube.

[0059] The end cap may have a flat end. Where the end cap has a flat end, this may enable the drilling weight to be stored vertically or packed more densely when stored or transported.

[0060] The first end and second end may be opposite ends.

[0061] Further, the hollow tube may comprise metal, and the end cap at a second end may be welded to the hollow tube.

[0062] Welding the end cap to the tube may be a convenient and cost-effective method to enclose the tube.

[0063] Welding the end cap may prevent the end cap from easily being removed, which may be useful if it is desirable to not re-open the drilling weight after manufacture. For example, it may enable a total mass to be confidently asserted for (and perhaps stamped upon) a particular drilling weight.

[0064] Welding the end cap to the tube may result in a very secure fixing.

[0065] In some embodiments, the drilling weight comprises a frame comprising a spindle and a retaining end, the spindle comprising the retaining end at a first end, and wherein the article comprises a through-hole, wherein the through-hole is configured to allow the spindle to move through the through-hole, and wherein the retaining end is configured to prevent the retaining end from passing through the through-hole.

[0066] Thus, a convenient method of forming a drilling weight comprising the article may be provided.

[0067] Such a configuration may allow an article (or more than one article) to be conveniently positioned securely on the support structure, from where it may be retained without risk of falling off the other end (notionally the bottom).

[0068] This configuration may be cheaper and simpler to make than other methods of holding the article(s).

[0069] This configuration may make it easier to adjust the mass of the drilling weight, since one or more articles can be added or removed from the shaft without needing to invert the support structure.

[0070] The top or bottom ends, or both ends, of the support structure may have attachment points allowing the drilling weights to be daisy chained and/or attached to a lifting chain or device.

[0071] The spindle may be centrally located with respect to the retaining end and to the through-hole in the article, or may be located elsewhere. The through-hole in the article may be centrally located. There may be more than one through-hole in the article, of which one or none may be centrally located.

[0072] There may be more than one spindle, with corresponding through-holes being provided in the article(s).

[0073] One or both ends of the spindle may be compressed, to form a retaining end. For example, a first end may be compressed to widen the spindle so that it is larger than the through hole in the article, to form a retaining end, then one or more articles may be placed on the spindle, and the second end may optionally then also be compressed to form a second retaining end to then retain the one or more articles. As an alternative example, a one or more articles may be placed a straight spindle with no retaining end. Then one or both ends of the spindle may be compressed to form a retaining end or two retaining ends respectively.

[0074] In some embodiments, the drilling weight comprises an attachment point at a first end of the drilling weight configured to allow attachment to a second end of a second drilling weight.

[0075] The first end and second end may simply define opposing ends of the drilling weights. The first end may notionally be considered the ’top’ and the second end may notionally be considered the ’bottom’, considering the usual orientation of a drilling weight in use. Equally, the drilling weight may be inverted and the first end may notionally be considered the 'bottom' and the second end may notionally be considered the 'top'.

[0076] Providing a securing means at each end may allow two or more drilling weights to be daisy chained together, directly or indirectly. For example, the hook on one end of a first drilling weight may be hooked through the eye on the opposite end of a second drilling weight. For example, an eye on the bottom of a drilling weight could receive a hook attached to the top of another drilling weight, or the hook on the bottom of one weight could attach to the hook on the top of another weight. Alternatively, if each end of the drilling weight comprises eyes, two or more drilling weights may be daisy chained through the use of a shackle passing through the eye at one end (e.g. the top) of the first drilling weight as well as the eye at the opposite end (e.g. the bottom) of the second drilling weight.

[0077] Either or both of the first end or the second end may be an end which is compressed, or an end which has an end cap.

[0078] One or both ends of the drilling weight may comprise an attachment point. The attachment point at either end may be an eye, a hook, a through-hole or any other suitable means.

[0079] The drilling weight may have a hook at one or both ends.

[0080] The drilling weight may have an eye at one or both ends.

[0081] The drilling weight may have an eye on one end and a hook on the other end.

[0082] The attachment point, which may be an eye, a hook, or a through-hole, may be rotatable with respect to the central axis of the drilling weight. This may allow undesirable rotational movement to be accommodated without causing stress on the attachment points.

[0083] The attachment point, which may be an eye, a hook, or a through-hole, may be rotatable with respect to a non-central axis of the drilling weight.

[0084] The attachment point may be integrally formed as part of the article.

[0085] More than one attachment point may be provided at one or both ends of the drilling weight.

[0086] Where the attachment point comprises a through-hole, this enables a rope or cable to be passed through the article and secured to it, thus comprising an attachment point. The attachment point comprising a through-hole may be a through hole in the article, a through hole in the drilling weight, or both.

[0087] The attachment point may be hinged or otherwise articulated, so that it may be stored in a stowed position, flat, or substantially flat, against the end of the drilling weight when not in use, and from where it can be moved to an active position when in use or being attached to another drilling weight, or to lifting means such as a crane.

[0088] The drilling weight may comprise a recess in a surface into which the attachment point, which may be an eye or a hook, can be stored when in a stowed position, thus creating a flat profile when the attachment point is stowed.

[0089] In some embodiments, the drilling weight comprises a stack of two or more articles.

[0090] Forming the drilling weight from more than one article increases the weight of the drilling weight. Additionally, it enables a known "pucking" machine to be used to manufacture the articles, which may result in a simpler, cheaper and easier method of producing a drilling weight of a particular mass, compared to forming a drilling weight comprising a single article of the required mass.

[0091] Furthermore, it may allow the total drilling weight to be more easily adjusted, by adding or removing articles to increase or decrease the total mass of the drilling weight respectively.

[0092] The stack may comprise two or more articles stacked directly on top of each other.

[0093] The drilling weight may comprise plural parallel stacks of articles. For example, the drilling weight may comprise two parallel stacks of articles, three parallel stacks of articles, four parallel stacks of articles, or more than four parallel stacks of articles. Each of the articles in the two or more parallel stacks of articles may be in contact with articles in one or more of the other parallel stacks. That is, one or more of the stacks may be in direct contact with each other. The two or more stacks may be encased in resin. The articles in the two or more stacks may comprise a through hole allowing a spindle to be passed through each article in one stack. Each of the stacks may comprise a central spindle, and optionally one or both end of the central spindles may be connected together.

[0094] Further, at least two of the two or more articles may be glued together.

[0095] Two or more adjacent articles in a stack of two or more may be glued together.

[0096] Gluing may be a cheap and convenient method of forming a drilling weight comprising multiple articles.

[0097] Gluing the articles may negate the need for placing the articles in tube, encasing them or providing a support structure for them, so may result in a cheaper and more convenient method of manufacture.

[0098] Further, at least two of the two or more articles may be welded together.

[0099] One or more adjacent articles in a stack of two or more may be welded together.

[0100] Welding may be a cheap and convenient method of forming a drilling weight comprising multiple articles.

[0101] Welding the articles may negate the need for placing them in a tube, encasing them or providing a support structure for them, so may result in a cheaper and more convenient method of manufacture.

[0102] Alternatively, two or more of the articles may be mechanically attached by other fixing means. Two or more of the articles may be screwed or bolted together.

[0103] In some embodiments, the article comprises a maximum height and a maximum width, and wherein the maximum height as at least ten times the maximum width.

[0104] Where the article is circular (when viewed in a cross section perpendicular to a central axis), the maximum width is the diameter of the article.

[0105] Providing a drilling weight comprising an elongate article may negate the need using multiple articles to create a particular mass of drilling weight. Accordingly it may result in a method of manufacture which is cheaper or more convenient, as steps such as welding, gluing, placing them in tube, encasing them, or providing a support structure for them, may not be necessary.

[0106] According to another aspect of the invention, there is provided a method of geothermal ground source drilling comprising the use of a geothermal ground source drilling weight according to the invention.

[0107] Such a method comprises the step of attaching the ground source drilling weight to a geothermal loop and using the weight to assist the loop to descend into a borehole.

[0108] Such a method permits more cost-effective geothermal ground source drilling which may be more environmentally friendly than prior methods.

[0109] According to another aspect of the invention, there is provided a method of manufacturing a ground source drilling weight comprising the steps of:

Mechanically combining metal fragments to form an article;
Creating a drilling weight comprising the article; and
Configuring the drilling weight to comprise an attachment point.

[0110] The method may comprise combining metal fragments into an article. This method may comprise the use of a binder to mechanically combine the metal fragments.

[0111] The method may comprise compressing metal fragments into an article. This method may optionally also include a binder to strengthen the mechanical combination. Any suitable commercially available binder may be used.

[0112] The method may comprise compressing metal swarf into an article.

[0113] According to one method of manufacture, the resultant drilling weight comprises a single article which comprises an attachment point. This method comprises compressing metal fragments to form a compressed article, and attaching an anchoring point to the compressed article itself. No separate step of creating a drilling weight comprising the compressed article is required, since step of attaching an attachment point creates the drilling weight from the compressed article.

[0114] The attachment point may be configured to allow attachment of a rope, chain, cable or another ground source drilling weight to the ground source drilling weight.

[0115] The steps of mechanically combining metal fragments to form an article, creating a drilling weight comprising the article, and configuring the drilling weight to comprise an attachment point, may comprise one, two, or three separate steps or processes.

[0116] For example, the three steps may be achieved simultaneously in one process, wherein metal is compressed to form a compressed article comprising an integral attachment point in the form of integral hook or through-hole, thus creating a drilling weight comprising the compressed article, which has an attachment point. A through hole in the compressed article or the drilling weight may comprise an attachment point.

[0117] The step of creating a drilling weight comprising the article may comprise one or more of the following processes: encasing the article(s) in resin; retaining the article(s) in a hollow tube; or gluing, welding or mechanically attaching a stack of two or more of the articles together. Mechanically attaching may comprise screwing, bolting or riveting.

[0118] The attachment point may be formed integrally with the article when it is formed. For example, the anchoring point may comprise a through-hole, hook or eye.

[0119] Configuring the drilling weight to comprise an attachment point may comprise forming an integral attachment point, or may comprise attaching an attachment point to the article, or may comprise attaching an attachment point to the drilling weight otherwise than to the article. The attachment point may comprise a hook or eye separate to the article. The attachment point may be glued, welded, screwed, riveted to the article or the ground source drilling weight, or attached by any other suitable means.

[0120] Further, the method of manufacturing a ground source drilling weight may comprise the step of compressing the metal fragments together.

[0121] Compressing the metal fragments together may provide an alternative method of manufacture and may result in a more cost-effective method of producing the ground source drilling weight. The method may result in a ground source drilling weight with greater density than weights made from sand-filled plastic.

[0122] In all embodiments, the article may be a hockey puck shape.

[0123] In all embodiments, the article may be a hockey puck shape comprising compressed metal fragments, held together with or without a binder.

[0124] These and other aspects of the invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0125] For a better understanding of the invention, and to show more clearly how it may be carried into effect, reference will now be made, by way of example only, to the accompanying drawings, in which:

Fig. 1 depicts a hockey puck shaped drilling weight according to a first embodiment.

Fig. 2 depicts alternative shapes for the drilling weight according to the first embodiment.

Fig. 3 depicts a drilling weight according to a second embodiment.

Fig. 4 depicts a drilling weight according to a third embodiment.

Fig. 5 depicts a drilling weight according to a fourth embodiment.

Fig. 6 depicts a drilling weight according to a fifth embodiment.

Fig. 7 depicts a drilling weight according to a sixth embodiment.

Fig. 8 depicts a drilling weight according to a seventh embodiment.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0126] The invention will be described with reference to the Figures.

[0127] It should be understood that the detailed description and specific examples, while indicating exemplary embodiments of the apparatus, systems and methods, are intended for purposes of illustration only and are not intended to limit the scope of the invention. These and other features, aspects, and advantages of the apparatus, systems and methods of the present invention will become better understood from the following description, appended claims, and accompanying drawings.

[0128] It should be understood that the Figures are merely schematic and are not drawn to scale. It should also be understood that the same reference numerals are used throughout the Figures to indicate the same or similar parts.

[0129] Variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality.

[0130] The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

[0131] Fig. 1 depicts a drilling weight 100, according to a first embodiment.

[0132] With reference to Fig. 1, the first embodiment comprises a drilling weight 100 which comprises an article 10 shaped like a hockey puck, i.e. in the shape of a truncated cylinder with a flat top and bottom which are parallel. The compressed article 10 is made from compressed metal fragments (i.e. metal fragments which are compressed together), which are a waste by-product of a metalworking process.

[0133] In the first embodiment, the article 10 is formed by compressing the metal fragments in a pucking machine.

[0134] The metal fragments may comprise other particles including contaminants or other materials. The metal fragments may comprise steel, and optionally may or may not also include other metals. Steel is an ideal candidate as it has a higher density than other metals such as aluminium, and there are plentiful supplies of waste steel fragments. It is also less valuable than waste fragments from other metals such as copper.

[0135] According to the invention, the article 10 comprising the main mass of the drilling weight 100 may be any shape or geometry. For ease of understanding the invention, in the first embodiment the article 10 is hockey puck shaped with parallel top 11 and bottom 12 surfaces which are both flat. The diameter of the compressed article 10 is 10cm to 50cm wide, and the height is 10cm to 50cm tall.

[0136] Attached to the article 10 is a hook 20 on a top surface 11 and an eye 30 on a bottom surface 12, allowing multiple drilling weights to be attached together in a daisy-chain, by passing the hook of one drilling weight through the eye of another drilling weight.

[0137] The hook 20 and eye 30 may be attached by welding, gluing, screwing, or any other suitable means for securely attaching them to the article 10 to providing a secure attachment point for the drilling weight. Alternatively, a screw thread may be cut into a hole in the article 10, for receipt of a corresponding thread on the hook or eye.

[0138] On the top surface 11, the article 10 may comprise a hook 20, eye 30, another attachment point or nothing. On the bottom surface 12, the article 10 may comprise a hook 20, eye 30, alternative attachment point or nothing. The attachment points may be formed integrally with the compressed article when the compressed article is formed.

[0139] The top surface 11 and bottom surface 12 of the article 10 may each or both be flat, concave or convex. The bottom surface 12 may be concave and the top surface 11 may be convex, to allow plural articles 10 to be stacked more easily (where attachment points are not provided or not fitted).

[0140] One or both of the top surface 11 and bottom surface 12 may have a feature to allow plural compressed articles to be stacked more easily. For example, the top surface 11 may comprise three protrusions (not shown) positioned and sized to correspond to three blind holes (not shown) in the bottom surface 12, such that two articles 10 may be securely fitted together without rotational movement. There may be one, two, three, or more of such features. The corresponding features may be sized such that they cause a friction fit when two articles 10 are compressed together, causing a secure attachment between the articles 10. There may be single central protrusion on the top surface 11 of one article 10, and a corresponding friction-fit central blind hole in the bottom surface 12 of the article 10, allowing two compressed articles 10 to be securely stacked and fitted together. In an alternative configuration, the feature which allows plural articles 10 to be stacked and securely may comprise one or more upstanding circular ridges on the top surface 11 of the compressed article 10 positioned between central axis of the article 10 and the circumference of the article 10, or at the circumference, and a corresponding one or more circular groove on the bottom surface 12. Where there are more than one ridge and groove, they may be concentric. Optionally, they may also be equally spaced. Further optionally, the circular ridge and groove may be square shaped, rectangular-shaped or hemispherically-shaped in cross section. Further optionally, instead of a circular shape when viewed from above, the corresponding ridge and groove may be triangular, square, rectangular, star, or kite shaped, or any other shape or pattern.

[0141] The article 10 may comprise one or more through-holes. The one or more through-holes may comprise a central through-hole.

[0142] A method of manufacturing the drilling weight comprises the steps of compressing metal fragments to form a compressed article, and then attaching a hook or eye as an attachment point. The attachment point may be welded, glued, screwed, bolted or attached by any other suitable means.

[0143] Another method of manufacturing the drilling weight comprises the steps of compressing metal fragments to form a compressed article comprising a through hole, and then passing a strap through the through hole and securing the strap to the compressed article to form a drilling weight. Instead of a strap, a chain or metal shackle may be passed through the through hole to form the drilling weight.

[0144] Another method of manufacturing the drilling weight comprises the steps compressing metal fragments onto an attachment point to form a compressed article comprising an integrated attachment point. For example, metal fragments may be compressed around a hook, to form a drilling weight comprising a hook as an attachment point.

[0145] According to the methods herein, the resultant article may have a density of between 3,000 and 7,500 kg/m^3 (kilograms per cubic metre). This is in contrast to a conventional drilling weight made of steel which may have a density of between 7,700 and 8,050 kg/m^3, or a sand-filled plastic drilling weight which may typically have a density of between 1,500 and 1,700kg/m^3. The resultant density is subject to various factors, including the compression force (where present), size of the fragments, presence of contaminants, binder volume and material (where present) and source material(s) for the metal fragments.

[0146] Since the article may be formed by compressing metal fragments together, a cross sectional view of the resultant article may reveal a textured surface, which is a result of the shapes of the constituent fragments, and the fact that the resultant article comprises many different fragments compressed together, rather than having been formed from a single piece of metal.

[0147] A method of manufacturing the drilling weight comprises compressing metal fragments at a pressure of between 3,000 and 10,000 kg/cm^2. This process may be completed at a temperature between -10 (minus 50) and 40 degrees centigrade.

[0148] The resultant compressed article may comprise between 100 and 10,000 distinct source metal fragments which are compressed together to form the article.

[0149] The resultant article according to one or more methods contained herein may be distinguishable from a drilling weight formed from one homogenous piece of metal in several ways, for example the compressed article may:

- Comprise a non-homogenous structure, resultant from the manufacture process in which distinct metal fragments are compressed together to form a single article. The article may be non-homogenous in that that one or more material properties, such as tensile strength, compressive strength, surface roughness, or ability to withstand stress, vary at different positions within the material;
- Comprise a non-uniform structure. The resultant compressed article may have visible boundaries between the compressed metal fragments, when viewed in cross section. A cross sectional view of the article comprising compressed metal fragments may reveal between 2 and 500,000 metal fragments per 100 cm^2;
- Exhibit an increased variation of the stress profile across the material. A drilling weight formed from one homogenous piece of metal will have a relatively uniform stress profile across the main body of the article, whereas the structure of an article comprising compressed metal fragments will have a highly variable stress profile across the main body, indicative of having been produced by mechanical combination e.g. compression of metal fragments. Methods of stress measurement include the known sectioning method, hole-drilling method, strain gauge method, X-ray diffraction, magnetic-elastic method, and neutron diffraction methods;
- Exhibit an increased porosity compared to a drilling weight made of solid metal, wherein porosity is a measure of the void spaces in a material, and is a fraction of the volume of voids over the total volume between 0 and 1 or 0% and 100%. $\phi = V_V/V_T$, where ϕ is porosity, Vv is void volume and V_T is total volume. An article comprising compressed metal fragments may have a porosity of between 0.01% and 10%, or more preferably between 0.1% and 5%, or more preferably between 0.2% and 3% or more preferably between 0.5% and 2%, or more preferably between 1% and 1.5%; or
- Exhibit an increased surface roughness in a sectional view. Roughness may be measured by tracing the probe of a contact-type roughness meter across the surface of the sectional surface of the compressed article

[0150] According to any of the methods disclosed herein, a binder may also be present as the fragments are compressed together.

[0151] The compressed article created from a known pucking machine may a resultant shape is similar to a hockey puck, i.e. a truncated cylinder having a diameter in a radial direction that is larger than its height in an axial direction. Thus, it may be shorter in a longitudinal direction running along its axis than it is wider in a transverse radial direction. Such a compressed article may have a circular cross section in a first direction, and substantially rectangular cross section in a second direction which is perpendicular to the first direction. The article may have a ratio between its diameter and its height of between 1.5 and 10, or more particularly between 2 and 5 or more particularly between 2.5 and 4 or more particularly between 3 and 3.5.

[0152] The article may be of any shape. The article may be of any regular or irregular shape in cross section, for example it may be round, triangular, square, rectangular, pentagonal or hexagonal, of any other repeating or non-repeating pattern, or may be entirely or partially irregular in cross section.

[0153] The cross-sectional shape of the compressed article may be consistent at every height, or may be different at different heights. The cross-sectional size may be consistent at every height or may vary linearly or non-linearly with height.

[0154] The article may be of irregular shape in either or both a width and height direction.

[0155] The article of any cross-sectional shape may have a flat top or bottom or both.

[0156] The article may have a blind hole in it.

[0157] The article may have a through hole in it.

[0158] Where the article has a blind or through hole in it, this hole may be formed when it is compressed, or may be formed through a later process such as drilling or milling.

[0159] An attachment point may be provided at one or both ends of the article. The attachment point may comprise a hook or eye threaded into a corresponding thread formed in the article. The securing or anchoring point may comprise a hook or eye glued or welded to the article.

[0160] In this embodiment, any permutation of optional and further optional features or step may be combined in any manner.

[0161] Fig. 2 depicts alternative shapes for the drilling weight 100 according to a first embodiment.

[0162] In the first embodiment, the drilling weight 100 comprises an article 10 in the form of a hockey puck shape. The compressed article 10 is formed from compressed metal fragment may be any regular or irregular shape or geometry. For example, the compressed article 10 may be a cylinder 41, cube 42, cuboid 43, pyramid 44, triangular prism 45, hexagonal prism 46, sphere 47, hemisphere 48 or cone 49, as shown in Fig. 2.

[0163] Fig. 3 depicts a drilling weight 200 according to a second embodiment, which is a variation on the first embodiment, showing a drilling weight 200 comprising a plurality of the hockey puck shaped compressed articles 10, which are stacked and secured together by a suitable adhesive or resin.

[0164] They may be attached to each-other by gluing, welding, mechanically fastening or by any other suitable means. Alternatively, they may be securely attached by being compressed together and held together according to corresponding friction-fit features, as discussed earlier in relation to the first embodiment.

[0165] A method of manufacturing the drilling weight 200 comprises the steps of taking a first article 10 and positioning it as the start of a stack, applying adhesive or resin to the top surface 11, stacking another article 10 on top of the stack, and repeating the steps of applying an adhesive/resin to the top surface of the article 10 at the top of the stack and stacking another article on top of the stack to become the new top of the stack, until the stack is of the desired height. A next step comprises leaving the adhesive/resin to cure. A next step comprises attaching an attachment point to the top and or bottom of the stack, which may optionally be performed whilst the adhesive/resin bonding the stack cures.

[0166] A method of manufacturing the drilling weight 200 comprises the steps stacking a plurality of articles 10 and spacers in the form of a stack, positioning a spacer between each of the articles 10 wherein the spacer is configured create a void (air gap) between the articles, filling the void between the articles 10 with an adhesive or resin and allowing the adhesive or resin to cure, then attaching an attachment point to the top and or bottom of the stack. The spacer may comprise, for example, three matchstick shape pieces of metal or wood which are positioned on the top surface of each article 10 in the stack other than the top one, and extend in a radial direction, equally spaced around the surface of each article 10.

[0167] All variations applicable to the first embodiment also apply to the second embodiment.

[0168] In this embodiment, any permutation of optional and further optional features or steps may be combined in any manner.

[0169] Fig. 4 depicts an elongate version of the drilling weight 300, according to a third embodiment, which is a variation on the first embodiment shown in figure 1.

[0170] The article 50 is similar to that shown in Fig.1 except that the article now is taller and thus fully cylindrical in shape.

[0171] The article 50 may have height which is at least 10 times its diameter.

[0172] A method of manufacturing the drilling weight 300 comprises forming an elongate article 50 in a pucking machine configured to form an elongate cylinder of compressed metal fragments, and then attaching attachment points 20, 30 to the top and / or bottom surfaces of the elongate compressed article 50.

[0173] The method may optionally comprise a step of re-shaping the elongate article 50 after it has been formed in the pucking machine.

[0174] One or both ends of the compressed article 50 may be flat, tapered, chamfered, hemispherical or otherwise shaped. The shape of the article 50 may be achieved when it is formed, or through a later process such as cutting, or shaping whilst spinning on a lathe.

[0175] All variations applicable to the first and second embodiment also apply to the third embodiment. For example, a plurality of articles 50 according to the third embodiment may be stacked and secured together using any method as discussed in relation to the second embodiment 200.

[0176] In this embodiment, any permutation of optional and further optional features or steps may be combined in any manner.

[0177] Fig. 5 depicts a drilling weight 400 according to a fourth embodiment, which is a variation on the second embodiment as shown in Fig. 3, showing a drilling weight 400 comprising a plurality of stacked hockey puck shaped compressed articles 10, now enclosed in a metal tube 410.

[0178] The metal tube 410 comprises and end cap 420 at a first (notionally bottom) end, which is welded on to permanently enclose one end of the tube 410.

[0179] The metal tube 410 comprises a second end cap 430 at a second (notionally top) end which encloses the second end of the tube after the articles 10 have been positioned in the tube 410. The second end cap 430 comprises and internal screw thread 440 which cooperates with an external screw thread 450 at the end of the second end of the tube. Alternatively, the end cap may comprise an external screw thread and the tube may comprise a cooperating internal screw thread.

[0180] Since the articles 10 are enclosed in a tube 410, they do not need to be secured to each-other. Optionally, however, one or more of the compressed articles 10 are secured together within the tube.

[0181] The metal tube may be made of steel, or any other suitable metal.

[0182] Optionally, the tube 410 and end cap 420 may be made of plastic and solvent welded or glued together.

[0183] Optionally, instead of comprising a welded-on end cap 420 at the first (bottom) end, the tube may comprise a first end cap comprising an internal screw thread 440 which cooperates with an external screw thread 450 (as shown at the second (top) end), at the end of the first end of the tube.

[0184] Alternatively, where the tube comprises one or more threaded end cap, one or both of the one or more threaded end cap(s) may comprise an external screw thread and the tube may comprise a cooperating internal screw thread.

[0185] The tube 410 may comprise an end cap 420 at both ends, which may be welded, glued, or compressed onto the tube.

[0186] The one or more end cap may be removable or permanently affixed.

[0187] One end cap 420 may be integrally formed as part of the tube, the tube thus comprising a hollow cylinder which is closed at one end.

[0188] A method of manufacturing the drilling weight 400 comprises the steps of welding a first end cap 420 onto a metal tube 410 at a first end, positioning a plurality of articles 10 in the metal tube 410, screwing a second end cap 430 to a second end of the metal tube. Each of the first end cap 420 and second end cap 430 comprise an integrated attachment means. For example, the first end cap 420 comprises an eye 30 which is screwed on to the first end cap 420, and the second end cap comprises a hook 20 which is screwed to the second end cap. Alternatively, the attachment means may be attached to one or more end cap via a later step.

[0189] In this embodiment, any permutation of optional and further optional features or steps may be combined in any manner.

[0190] Fig. 6 depicts a drilling weight according to a fifth embodiment 500, which is a variation on the second embodiment as shown in Fig. 3, showing a drilling weight comprising a plurality of stacked hockey puck shaped compressed articles 10 encased in resin 510.

[0191] The articles are securely fixed in position by the resin binder 510. An alternative binder to resin may be used.

[0192] Optionally, the drilling weight 500 may further comprise an inner tube (not shown), positioned between the articles 10 and the resin 510. The inner tube may be formed of plastic, metal or any other suitable material. The inner tube may make manufacture easier as the weights may be more easily positioned in the manufacture process since they are held in position by the inner tube.

[0193] Further optionally, the drilling weight 500 may further comprise an outer tube, positioned outside the resin. The outer tube may be formed of plastic, metal or any other suitable material. The outer tube may strengthen the tube and reduce the amount of resin required, and may protect the resin.

[0194] Further optionally, the drilling weight 500 may further comprise an integral tube, positioned within the resin. The integral tube may be formed of plastic, metal or any other suitable material and may strengthen the tube and reduce the amount of resin required.

[0195] Any combination of inner tube, outer tube and integral tube may be provided.

[0196] A method of manufacturing the drilling weight 500 comprises forming a stack of compressed articles 10 within a mould, the mould having an internal diameter larger than the external diameter of the articles 10, filling the mould with resin, allowing the resin to cure, and removing the stack from the mould. Optionally, a further step comprises adding attachment points to the top and/or bottom of the drilling weight 500. Further optionally, an integral tube may be positioned within the mould before resin is added such that the integral tube becomes encased in the resin at the end of the process (i.e. such that the integral tube comprises resin on both the inside and outside).

[0197] A method of manufacturing the drilling weight 500 comprises forming a stack of compressed articles 10 within a metal tube, the metal having an internal diameter larger than the external diameter of the articles 10, filling the mould with resin, and allowing the resin to cure. Optionally, a further step comprises adding attachment points to the top and/or bottom of the metal tube. Further optionally, an integral tube may be positioned within the mould before resin is added such that the integral tube becomes encased in the resin at the end of the process (i.e. such that the integral tube comprises resin on both the inside and outside).

[0198] A method of manufacturing the drilling weight 500 comprises forming a stack of compressed articles 10 within a snug-fit metal tube with an enclosed bottom end, positioning the tube in a mould, the mould having an internal diameter larger than the external diameter of the metal tube, filling the mould with resin, allowing the resin to cure, and removing the metal tube encased in resin from the mould. Optionally, a further step comprises adding attachment points to the top and/or bottom of the metal tube. Further optionally, the mould may be a further metal tube, which may form an external metal tube once the resin cures.

[0199] In this embodiment, any permutation of optional and further optional features or steps may be combined in any manner.

[0200] Fig. 7 depicts a drilling weight according to a sixth embodiment, which is a variation on the second embodiment as shown in Fig. 3, showing a drilling weight 600 comprising a plurality of stacked hockey puck shaped compressed articles 60, now each having a central, axial through-hole 14. The stacked articles 60 are supported on a frame 80 which comprises a retaining end 82 and at one end of a spindle 84. At the other end of the spindle 84, the spindle 84 comprises a screw thread 86, which allows an attachment point in the form of a hook 22 which has a cooperating internal screw thread 24 allowing it to be attached to the frame 80. The through-hole 14 is larger in diameter than the spindle 84, such that, before hook 22 is attached, each of the articles 60 can slid along the spindle 84 to a position where they can be retained in their respective position on the spindle 84 by the support base 82. In a later step, the hook 22 is screwed onto the spindle 84.

[0201] Alternatively, the attachment point may take the form of a hook or eye, permanently attached to the spindle 84, which is less wide than the diameter of the axial through-hole 14 in the articles 60. Accordingly, the articles can be positioned on the spindle without a need to add an attachment point after the articles have been positioned. Alternatively, the spindle 84 may comprise a gentle series of bends thus forming a hook portion, the bend diameter of which is sized relative to the articles 60 with their central through holes 14, to allow the articles 60 to be freely moved along the hook portion. Accordingly, in this configuration the articles 60 can be positioned on the spindle without a need to add an attachment point in a later step.

[0202] The retaining end may also comprise an attachment point, which may be the same or different to the attachment point at the other end of the spindle.

[0203] A method of manufacturing the drilling weight 600 comprises taking a frame 80 comprising a spindle 84 with a retaining end 82 at a first (bottom) end, the spindle comprising a second (top) end, sliding a plurality of compressed articles 60 over a top end of the spindle 84 to form a stack of articles retained in on the frame by the retaining end 82. An additional, optional, step comprises attaching an attachment point onto the top of the spindle. Optionally, this comprises the step of screwing a hook or eye having an internal thread onto a corresponding external thread at the top of the spindle. Alternatively, the hook or eye comprises an external thread and the top of the spindle comprises an external thread.

[0204] In this embodiment, any permutation of optional and further optional features or steps may be combined in any manner.

[0205] Fig. 8 depicts a drilling weight according to a seventh embodiment, which is a variation on the sixth embodiment shown in Fig. 7, wherein each of the stacked hockey puck shaped compressed articles 70 comprises a through-slot 16 that extends from the central, axial through hole 14, to the circumference of the compressed article. The through slot 16 is narrower than the diameter of the central, axial hole 14, and also narrower than the diameter of the spindle 90 over the majority of its length. The spindle is of substantially uniform diameter along its length but comprises a narrower neck portion 96 positioned close to the top end of the spindle 90 below the integrally-formed attachment point. The width of the neck portion 96, the width of the through-slot 16, the diameter of the through-hole 14, and the diameter of the spindle elsewhere than at the neck, are configured to allow the compressed articles to be positioned on the spindle 90 only at the narrower neck portion. Accordingly, the through-slot 16 is narrower than the diameter of the spindle elsewhere than at the neck (so that the compressed article 70 cannot laterally slip off once the spindle 90), but wider than the diameter of the spindle at the narrower neck portion 96 (so that it can be placed on the spindle at this position). The through hole 14 is larger than both the diameter of the neck portion 96 and the diameter of the spindle elsewhere than at the neck. Thus, the through slot 16 of the articles 70 allows them to be transversely slid onto the spindle 90 at the narrower neck portion 96, after which they can be slid down the spindle 90 to form a stack retained by the retaining end. Since the diameter of the spindle 90 away from the narrower neck portion 96 is wider than the through slot 16, the articles are securely held on the frame, and may only be removed by elevating them to the position of the narrower neck portion 96, and moving them in a transverse direction such that the narrower neck portion 96 passes through the through slot 16.

[0206] The retaining end may also comprise an attachment point, which may be the same or different to the attachment point at the other end of the spindle.

[0207] In this embodiment, any permutation of optional and further optional features or steps may be combined in any manner.

[0208] The features of the embodiments may be combined in any manner except where they are incompatible.

[0209] Any reference to "article" in the embodiments, either as a product or as a result of a process, may refer to an article comprising metal fragments that are compressed together. Such metal fragments may comprise metal swarf. Such an article may optionally comprise a binder.

[0210] If the term "adapted to" is used in the claims or description, it is noted the term "adapted to" is intended to be equivalent to the term "configured to". If the term "arrangement" is used in the claims or description, it is noted the term "arrangement" is intended to be equivalent to the term "system", and vice versa.

[0211] Any reference signs in the claims should not be construed as limiting the scope.

Claims

1. A geothermal ground source drilling weight comprising an article which comprises metal fragments that are mechanically combined.

2. A geothermal ground source drilling weight according to claim 1 wherein the article comprises a non-homogenous structure.

3. A geothermal ground source drilling weight according to claim 1 or claim 2 wherein the article has a porosity of between 0.01% and 10%.

4. A geothermal ground source drilling weight according to any of claims 1 to 3 wherein the article has a density of between 3,000 and 7,500 kg/m^3.

5. A geothermal ground source drilling weight according to any of claims 1 to 4 wherein the article is encased in resin.

6. A geothermal ground source drilling weight according to any of claims 1 to 5 wherein the article is enclosed in a hollow tube.

7. A geothermal ground source drilling weight according to claim 6 wherein the hollow tube comprises an end portion at a first end, and wherein the end portion is compressed to enclose the first end of the hollow tube.

8. A geothermal ground source drilling weight according to any claims 6 or claim 7 wherein the hollow tube comprises an end cap at a second end, and wherein the end cap is configured to enclose the second end and thus retain the article in the hollow tube.

9. A geothermal ground source drilling weight according to claim 8 wherein the hollow tube comprises metal and the end cap at a second end is welded to the hollow tube.

10. A geothermal ground source drilling weight according to any of claims 1 to 9 comprising a frame comprising a spindle and a retaining end, the spindle comprising the retaining end at a first end, and wherein the article comprises a through-hole, wherein the through-hole is configured to allow the spindle to move through the through-hole, and wherein the retaining end is configured to prevent the retaining end from passing through the through-hole.

11. A geothermal ground source drilling weight according to any of claims 1 to 10 comprising an attachment point at a first end of the drilling weight configured to allow attachment to a second end of a second geothermal ground source drilling weight.

12. A geothermal ground source drilling weight according to any of claims 1 to 11 wherein the article comprises a maximum height and a maximum width, and wherein the maximum height as at least ten times the maximum width.

13. A method of geothermal ground source drilling comprising the use of a geothermal ground source drilling weight according to any previous claim.

14. A method of manufacturing a geothermal ground source drilling weight comprising the steps of:

    a. Combining metal fragments to form an article;
    b. Creating a drilling weight comprising the article; and
    c. Configuring the drilling weight to comprise an attachment point.

15. A method of manufacturing a geothermal ground source drilling weight according to claim 14, wherein the step of combining metal fragments to form an article comprises compressing the metal fragments together.

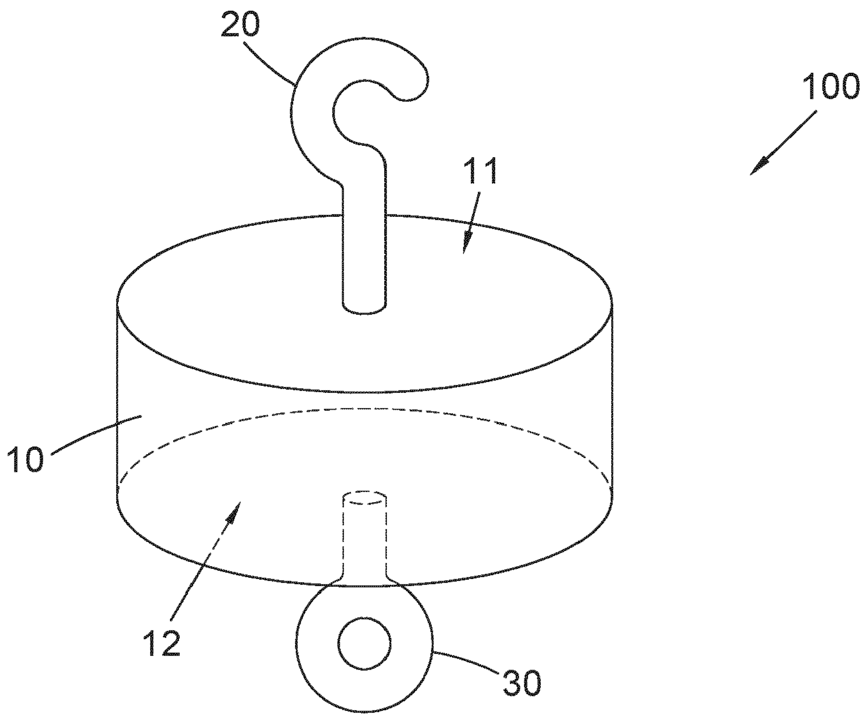

FIG. 1

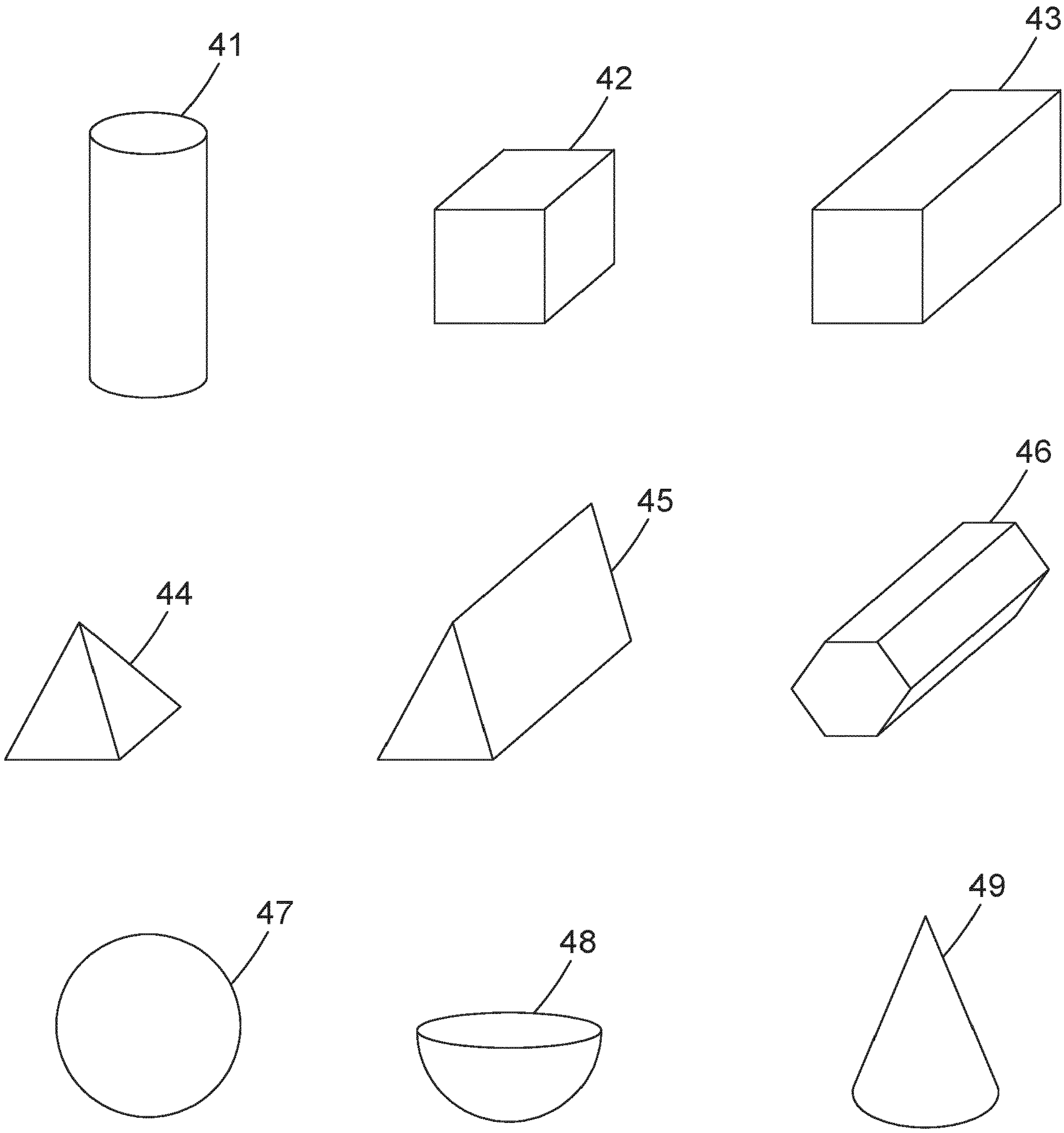

FIG. 2

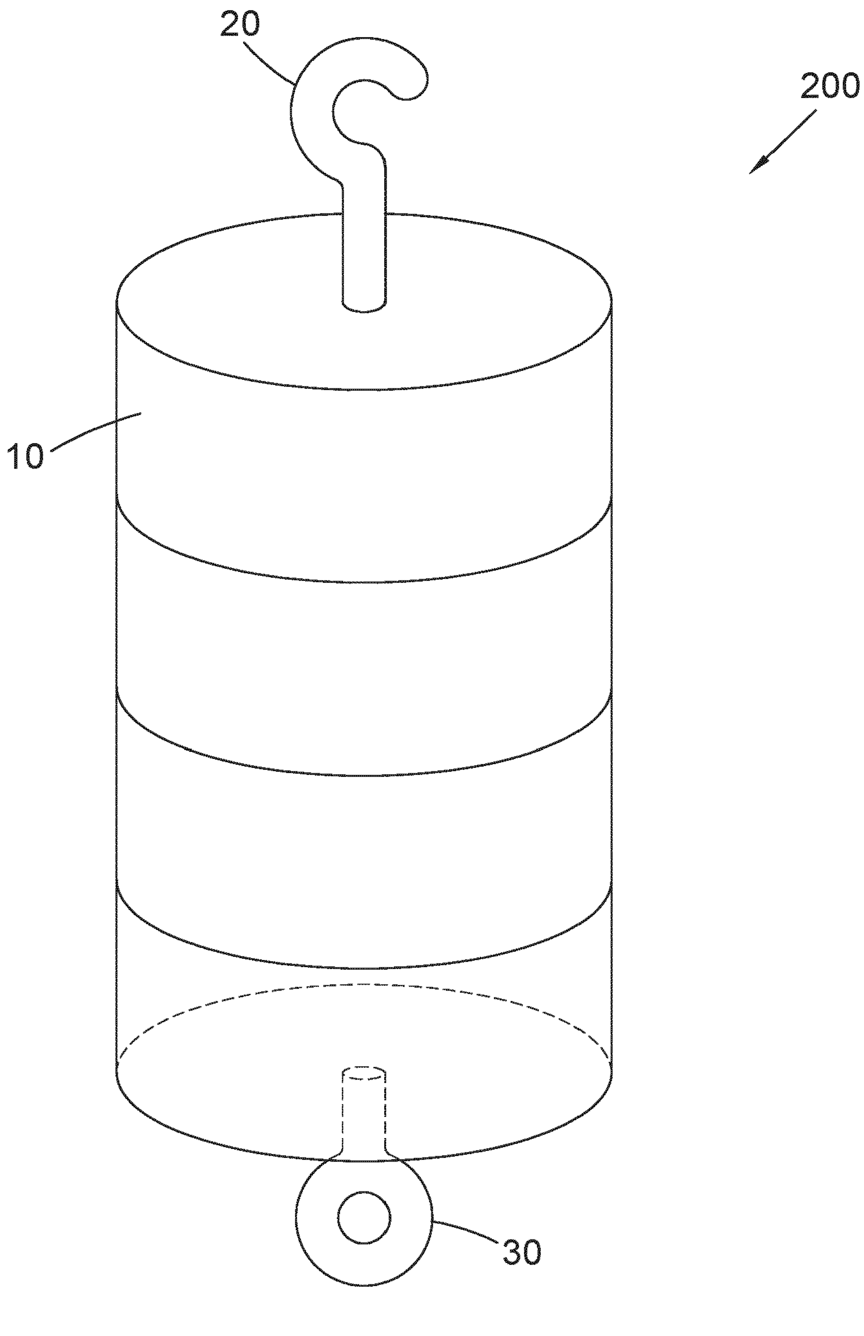

FIG. 3

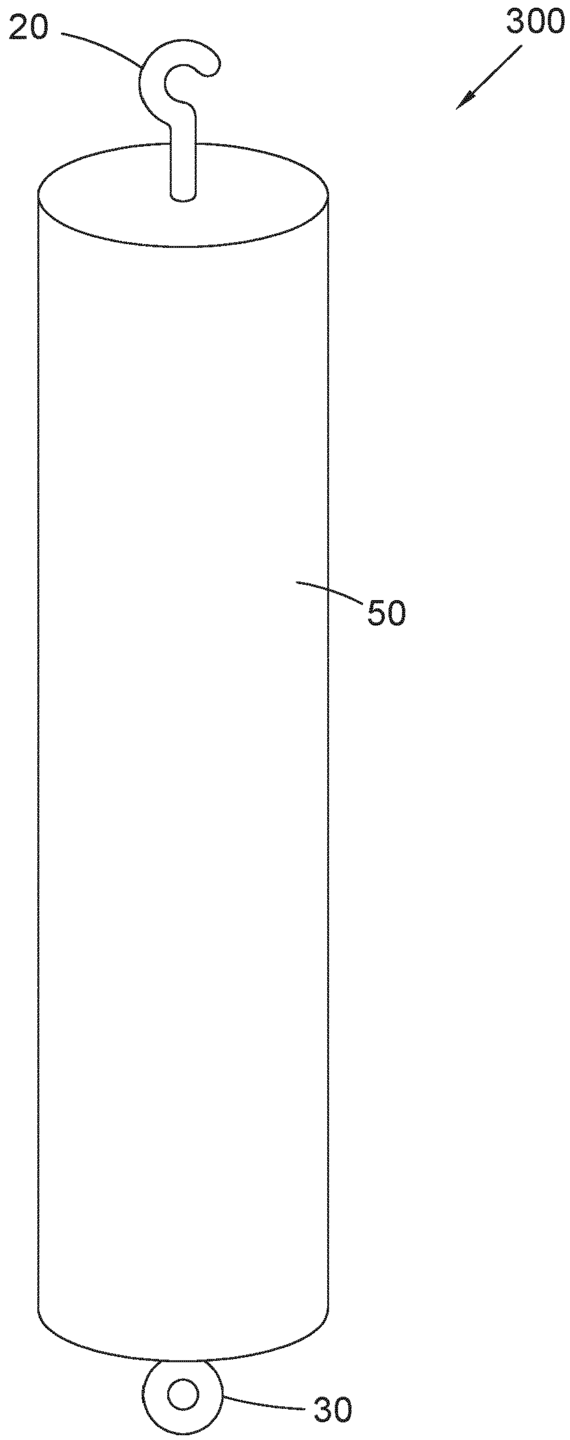

FIG. 4

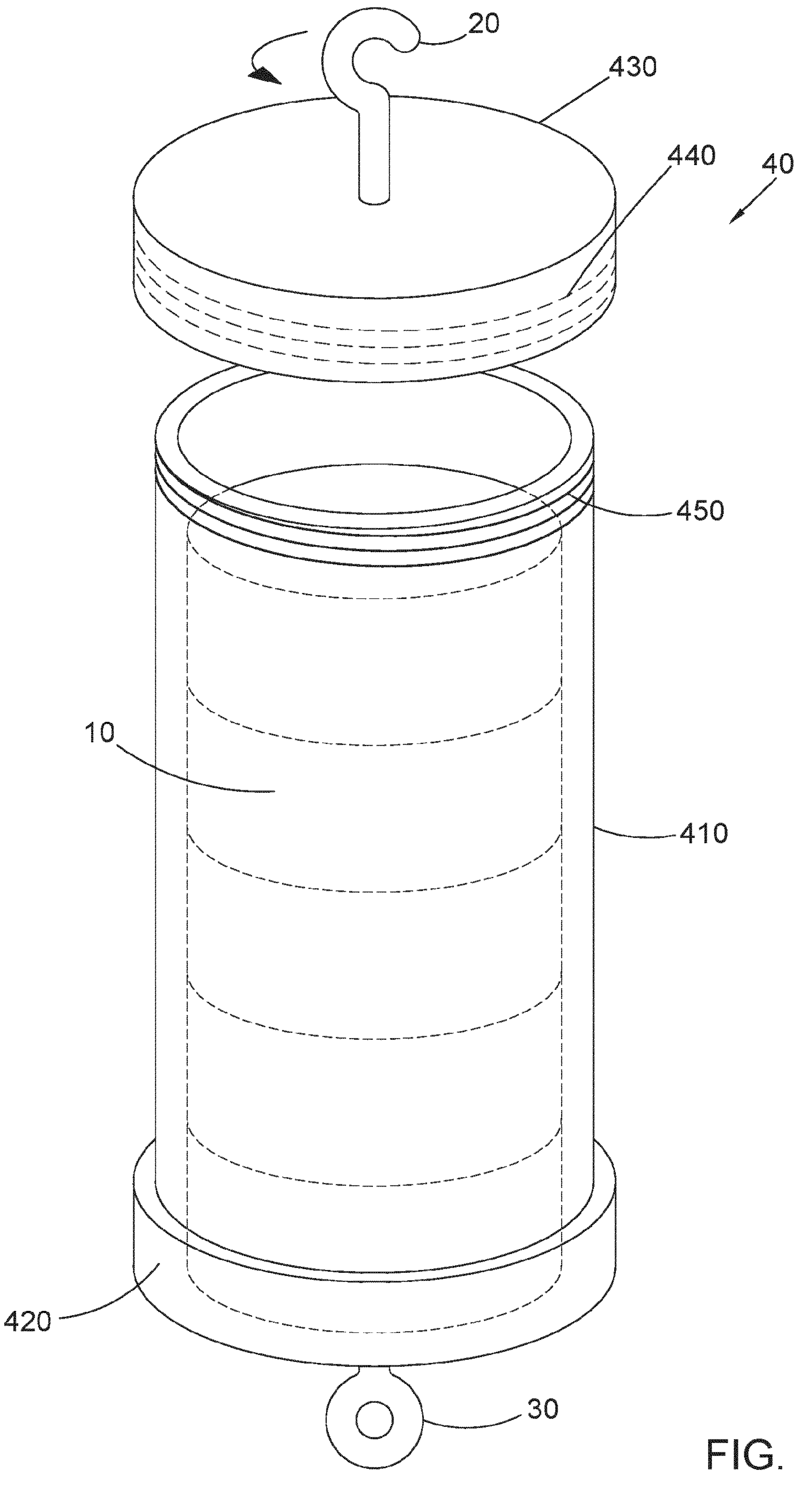

FIG. 5

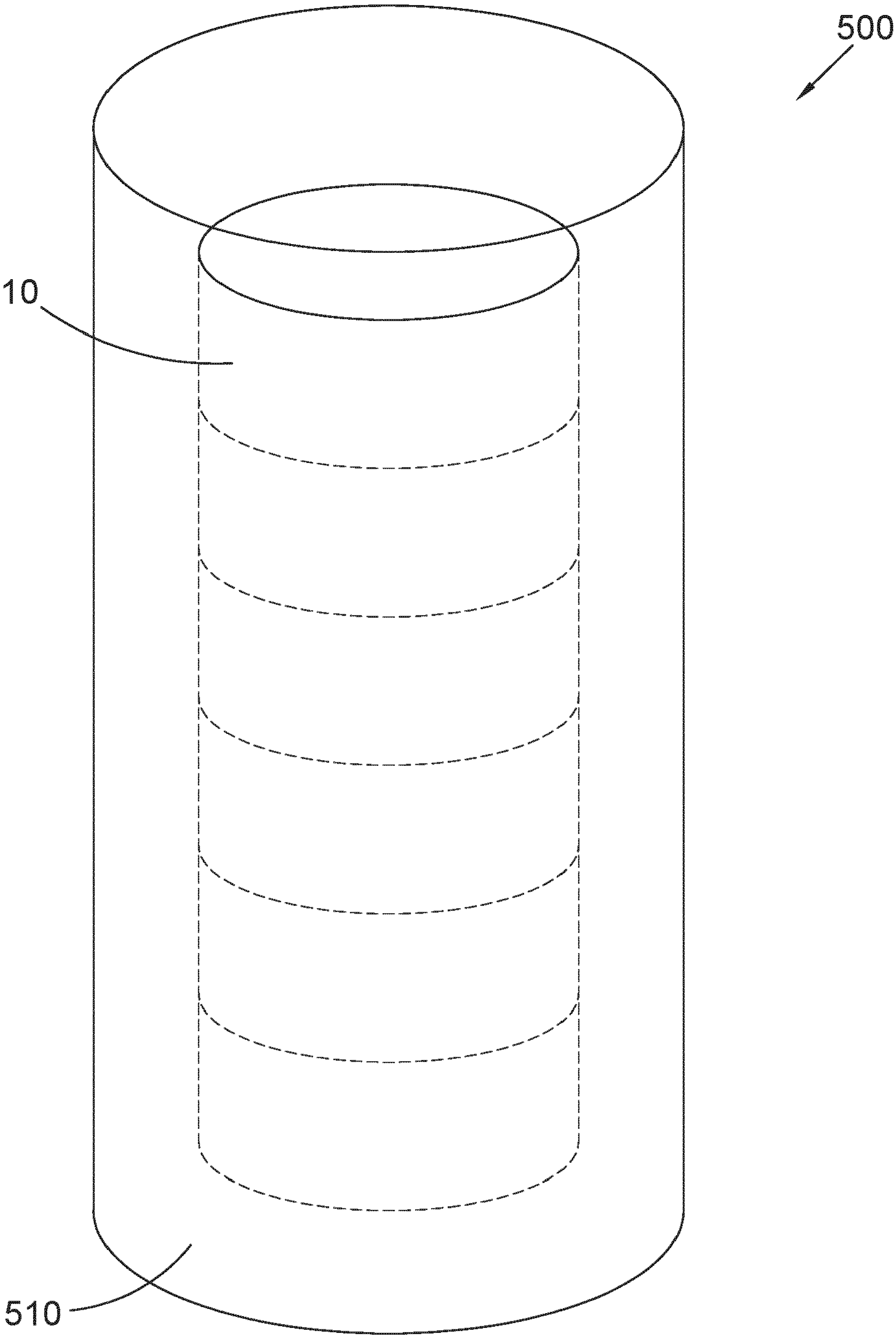

FIG. 6

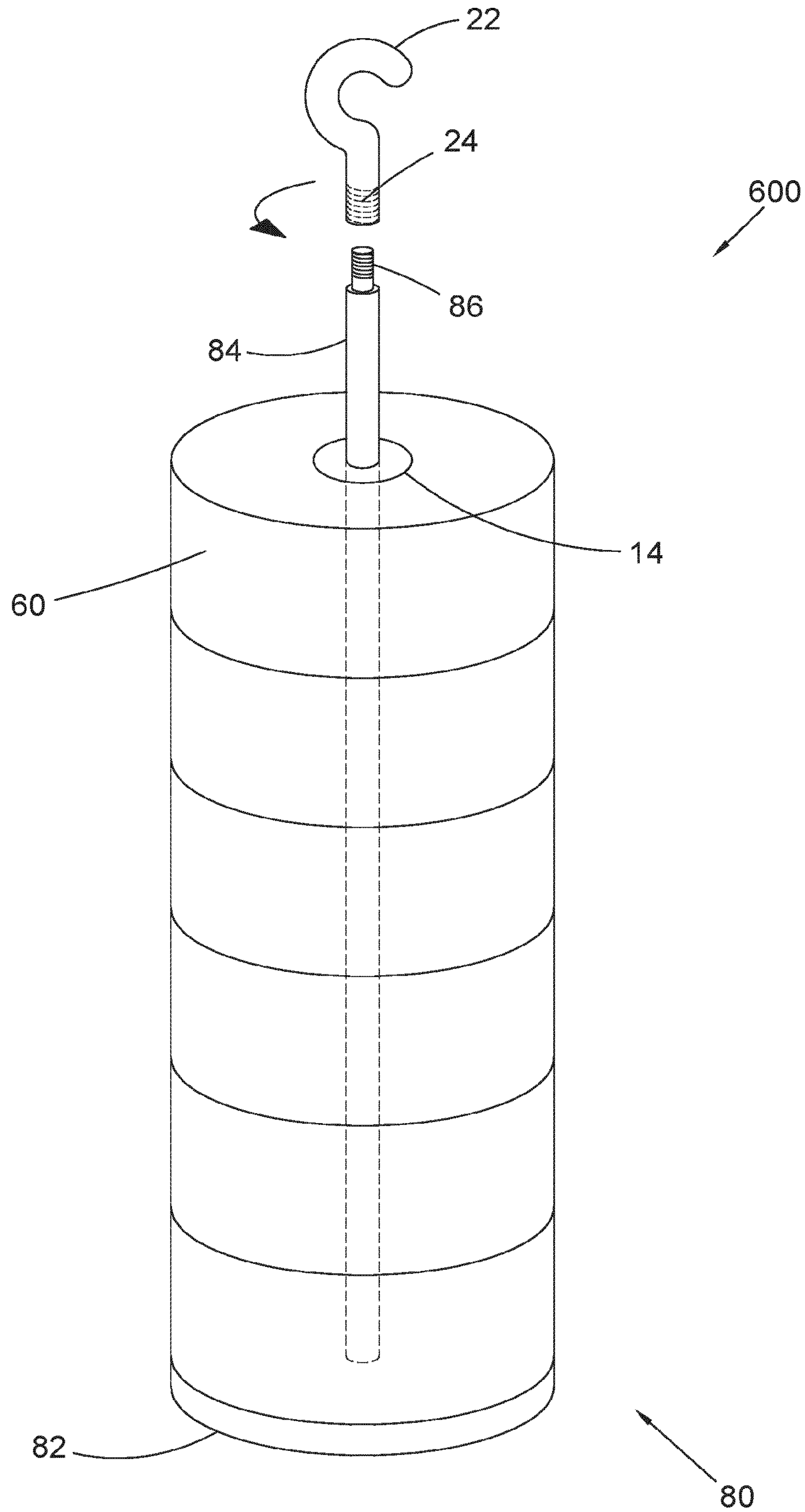

FIG. 7

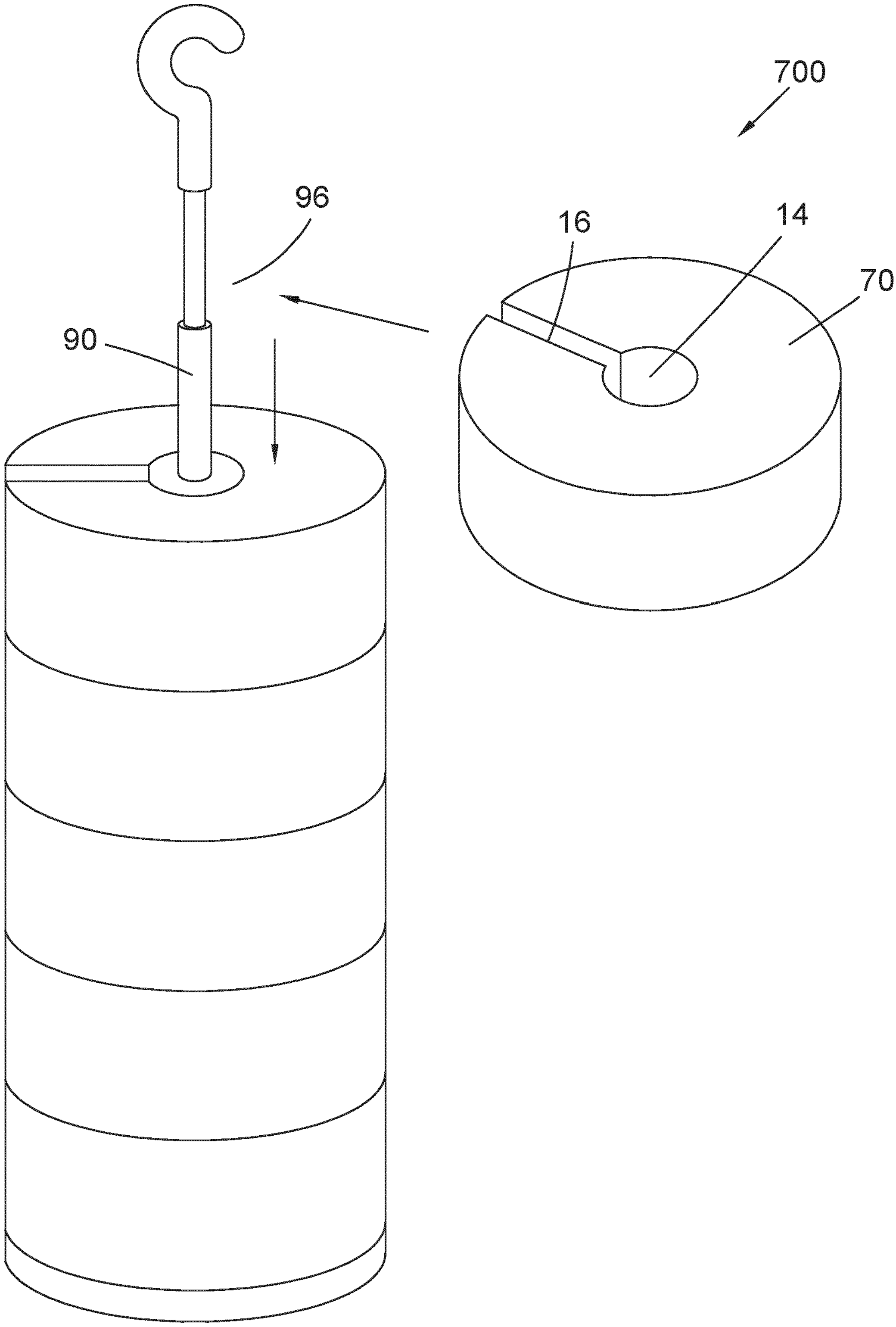

FIG. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 22 19 4212

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	20 February 2023	Oliveira, Casimiro

CATEGORY OF CITED DOCUMENTS

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The present search report has been drawn up for all claims

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& : member of the same patent family, corresponding document

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TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

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