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(54) **Titre : PROCEDE POUR L'AFFINAGE DE METAUX**
(54) **Title: PROCESS FOR REFINING METALS**

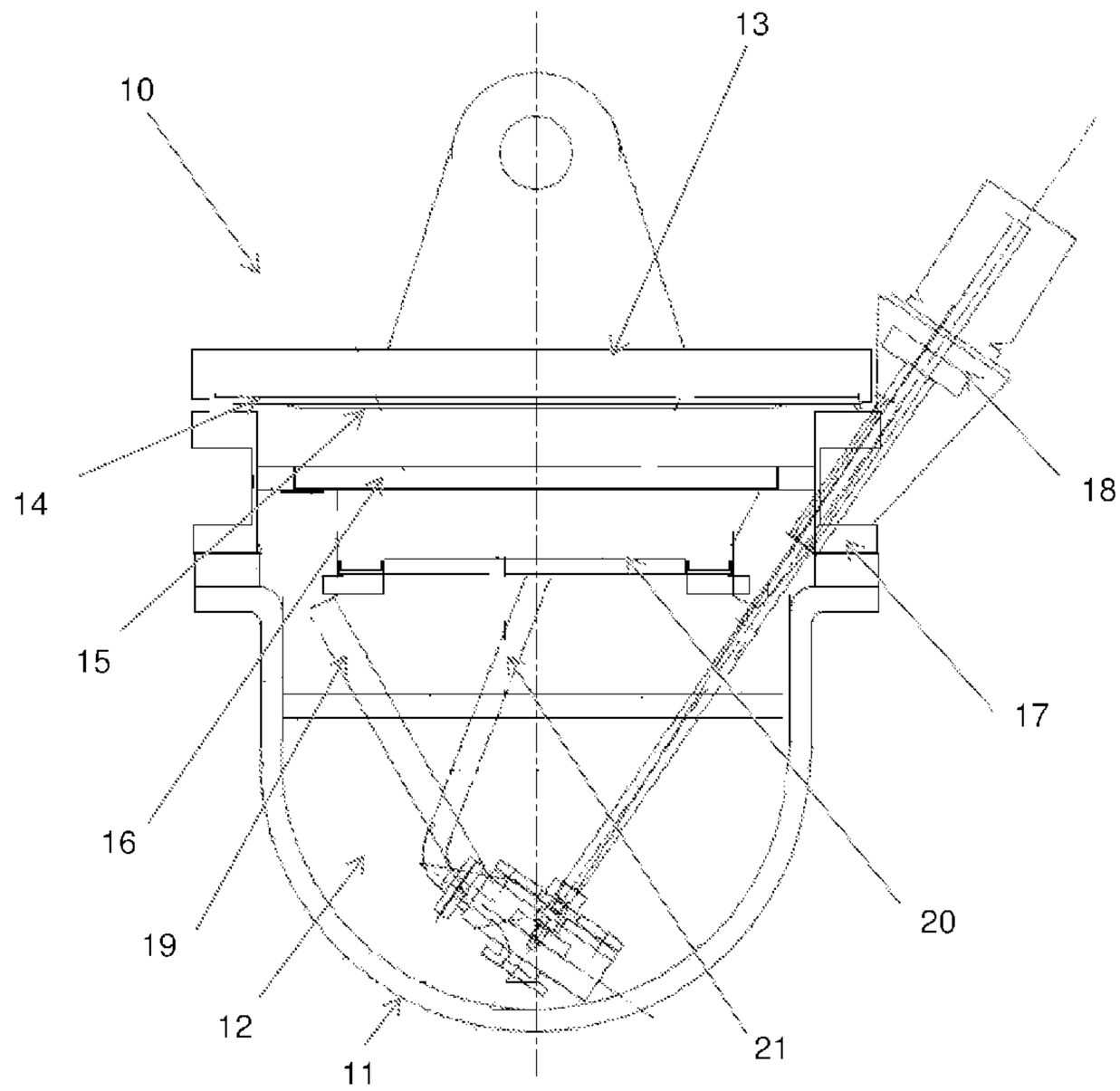



FIG 1

(57) **Abrégé/Abstract:**
A method for treating a silver-containing zinc alloy, the method comprising treating the alloy in a process vessel under conditions of elevated temperature and sub-atmospheric pressure so as to selectively vaporise the zinc, providing a filter through which the

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(57) **Abrégé(suite)/Abstract(continued):**
vaporised zinc passes prior to contacting a condensing surface on which the vaporised zinc condenses to solid zinc, and continuing to treat the alloy until a desired level of dezincing is achieved.

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*[Continued on next page]*

(54) Title: PROCESS FOR REFINING METALS

(57) Abstract: A method for treating a silver-containing zinc alloy, the method comprising treating the alloy in a process vessel under conditions of elevated temperature and sub-atmospheric pressure so as to selectively vaporise the zinc, providing a filter through which the vaporised zinc passes prior to contacting a condensing surface on which the vaporised zinc condenses to solid zinc, and continuing to treat the alloy until a desired level of dezincing is achieved.

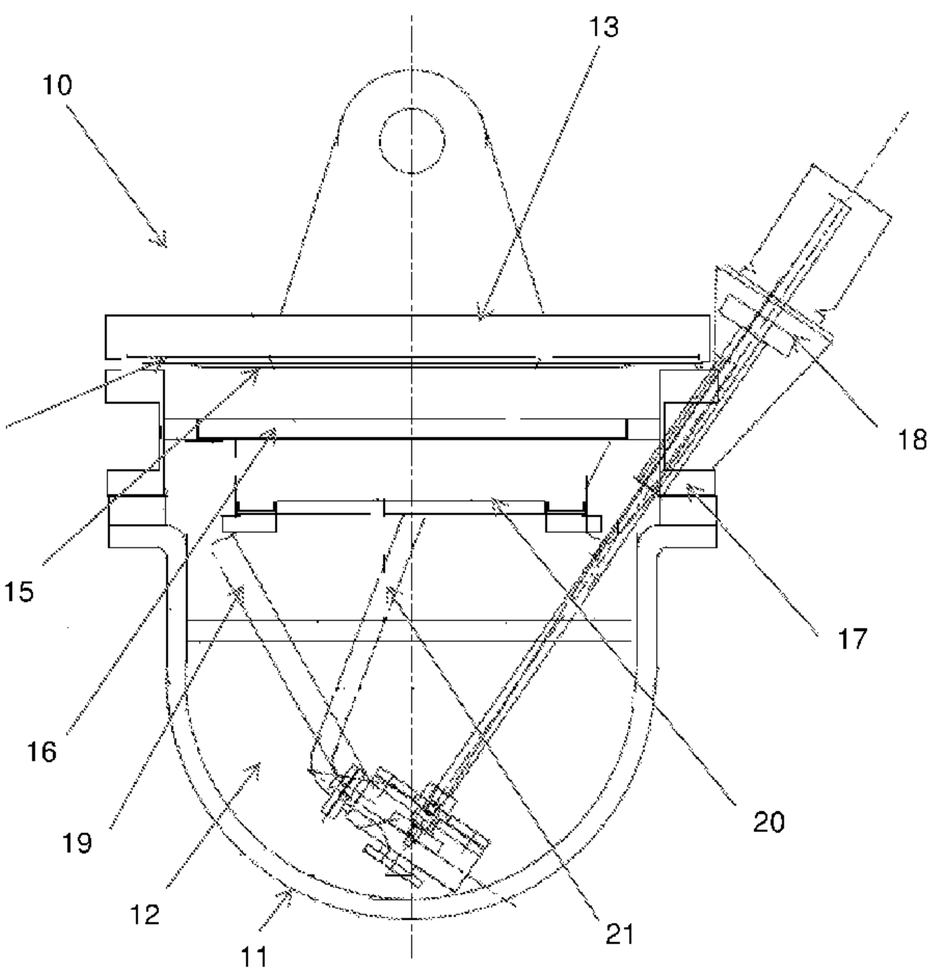



FIG 1

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# PROCESS FOR REFINING METALS

## TECHNICAL FIELD

[0001] The present invention relates to a process for refining metals. In particular, the present invention relates to a process for refining precious metals, such as silver.

## BACKGROUND ART

[0002] In conventional metal refining processes, the production of precious metals, such as silver, from base metal ores is a complex process comprising a number of steps. For instance, in many pyrometallurgical lead refineries, the Parkes Process is used to extract silver and other precious metals from lead. Quantities of zinc are added to the lead metal bath containing silver, and the affinity of silver and other precious metals for dissolution in zinc versus dissolution in lead ensures their removal from the lead. The silver and zinc (with some entrained lead) forms a crust, known as "Parkes Crust", on the surface of the lead metal bath. The Parkes Crust material (containing approximately 4-5% silver) is removed and transferred to a silver refining process.

[0003] The Parkes Crust material is then melted by heating the material in a furnace to produce two immiscible alloys separated by the difference in the densities of the respective alloys. A zinc-rich liquid containing approximately 20% silver overlays a lead bullion, and the two liquids are tapped separately

[0004] Treatment of the zinc-rich alloy under vacuum (for example in a vacuum induction retort furnace) produces an alloy enriched in silver and precious metals. An alloy (comprising about 80% precious metals) which is suitable for cupellation can be produced.

[0005] There are numerous drawbacks to the conventional techniques for the treatment of Parkes Crust material in preparation for cupellation. Firstly, the unit processes (liquation and distillation in a vacuum furnace) are expensive to operate and complex to control, and the maintenance of their refractories is costly. Secondly, the lead emissions generated by these processes make them unattractive from a workplace health and safety point of view.

[0006] Thus, there would be an advantage if it were possible to produce a method for the refining of silver that was cost-effective, relatively simple, and reduced harmful emissions.

[0007] It will be clearly understood that, if a prior art publication is referred to herein, this reference does not constitute an admission that the publication forms part of the common general knowledge in the art in Australia or in any other country.

SUMMARY OF INVENTION

[0008] The present invention is directed to a process for refining metals, and particularly precious metals, which may at least partially overcome at least one of the abovementioned disadvantages or provide the consumer with a useful or commercial choice.

[0009] In one aspect, the invention resides broadly in a method for treating a silver-containing zinc alloy, the method comprising treating the alloy in a process vessel under conditions of elevated temperature and sub-atmospheric pressure so as to selectively vaporise zinc, providing a filter through which the vaporised zinc passes prior to contacting a condensing surface on which the vaporised zinc condenses to solid zinc, and continuing to treat the alloy until a desired level of dezincing is achieved.

[0010] In another aspect, the invention resides broadly in a method for treating a zinc alloy including one or more precious metals, the method comprising treating the alloy in a process vessel under conditions of elevated temperature and sub-atmospheric pressure so as to selectively vaporise zinc, providing a filter through which the vaporised zinc passes prior to contacting a condensing surface on which the vaporised zinc condenses to solid zinc, and continuing to treat the alloy until a desired level of dezincing is achieved.

[0011] It will be understood that the term “alloy” as used in this specification is intended to refer to a mixture of metals. Thus, this term is intended to encompass alloys (in which atoms of each constituent metal are randomly substituted for one another in the crystal structure) and intermetallics (in which different elements are ordered into different sites in the crystal structure, with distinct local environments and often a well-defined, fixed stoichiometry). In broad terms, all intermetallics can be considered to be alloys, but not all alloys can be considered to be intermetallics.

[0012] Any suitable silver-containing zinc alloy may be used in the method. In one embodiment of the invention the alloy is obtained from a process in which silver is separated from lead. Preferably, the alloy comprises a crust obtained from a refining process in which silver is separated from lead.

[0013] In another embodiment of the invention, the silver-containing zinc alloy may arise from the cementation of dissolved silver onto metallic zinc particles. In a specific example, the alloy may comprise a filtration product (filter cake) produced using the Merrill-Crowe process.

[0014] The alloy may be transferred to the process vessel using any suitable technique and

in any suitable form. Preferably, however, the alloy is transferred to the process vessel in an at least partially liquid state. However, it is envisaged that the alloy could be transferred to the process vessel as a solid which is then subsequently melted in the process vessel. Alternatively, the alloy could be transferred to the process vessel in a completely liquid (molten) state. During the operation of the method of the present invention, however, the alloy is in a substantially molten or liquid state.

[0015] The alloy may be removed from a lead processing vessel by scooping off the alloy that forms as a crust on the lead bath. In this embodiment, the alloy may be transferred in any suitable container from the lead processing vessel to the process vessel of the present invention. The container may be transferred by, for instance, crane, forklift, truck or similar vehicle.

[0016] The process vessel may be of any suitable form. It is envisaged, however, that the process vessel may comprise a furnace. Any suitable type of furnace may be used, although in some embodiments of the invention, the furnace may comprise a kettle. Preferably, the kettle is associated with a setting. Preferably, the process vessel is capable of being vacuum sealed.

[0017] The alloy may be treated at any suitable temperature. In a preferred embodiment of the invention, however, the alloy is treated at a temperature of between 500°C and 900°C. More preferably, the alloy is treated at a temperature of between 650° and 750°. Most preferably, the alloy is treated at a temperature of between about 700°C and 715°C.

[0018] In some embodiments of the invention, the process vessel may be lined with refractory material. However, given the relatively low temperatures used in the process vessel, the use of refractory material may not be required. Thus, in some embodiments of the invention, the process vessel may comprise an unlined steel vessel.

[0019] The elevated temperature in the process vessel may be achieved using any suitable technique. For instance, the process vessel may comprise an induction vessel or the like. Preferably, however, the process vessel is heated by one or more burners. The burners may be adapted to burn any suitable fuel to generate heat, such as, but not limited to, coal, gas (such as natural gas), oil or a combination thereof. It will be understood that the exact nature of the fuel burnt by the burners is not critical to the invention, provided that the fuel has sufficient calorific value to maintain the conditions in the process vessel at the desired temperature.

[0020] Similarly, the alloy may be treated at any suitable sub-atmospheric pressure. Preferably, the alloy is treated at a pressure of less than 0.1 atm. More preferably, the alloy is treated at a pressure of less than 0.01 atm. Still more preferably, the alloy is treated at a pressure

of less than 0.001 atm. Most preferably, the alloy is treated at a pressure of between about 0.0001 atm and 0.001 atm.

[0021] It will be understood that the exact type and configuration of the vacuum system used to achieve and maintain the sub-atmospheric pressures in the process vessel is not critical to the present invention, and no particular discussion on the vacuum system is required.

[0022] Any suitable condensing surface may be provided. Preferably, however, the process vessel is provided with a condensing dome including a condensing surface on which the zinc vapour condenses. It is envisaged that, in some embodiments on the invention, the condensing dome may be cooled to a temperature below the melting point of zinc such that zinc vapour that comes into contact with the condensing surface is cooled and solidifies on the condensing surface. In a preferred embodiment of the invention, the condensing surface is substantially flat.

[0023] The condensing dome may be cooled using any suitable technique. Preferably, however, a suitable coolant is circulated throughout the condensing dome to ensure that the condensing surface is maintained at a temperature below the melting point of zinc. It is envisaged that the coolant will enter the condensing dome at a relatively low temperature and will exit the condensing dome at a relatively high temperature. Thus, it is envisaged that the coolant leaving the condensing dome is passed through a heat exchanger (such as a cooling tower or the like) so as to reduce the temperature of the coolant prior to being recirculated to the condensing dome.

[0024] It will be understood that the exact type and configuration of the heat exchange circuit through which the coolant flow is not critical to the invention. Similarly, the type and quantity of coolant used is not critical to the invention, and no further discussion of this is required.

[0025] It is envisaged that, if the layer of condensed zinc on the condensing surface becomes too thick, the condensing of further zinc may be prevented. Thus, it is envisaged that solidified zinc will be periodically removed from the condensing surface so as to maintain the efficacy of the dezincing process.

[0026] The solidified zinc may be removed using any suitable technique. For instance, the solidified zinc may be manually removed from the condensing surface (for instance, by scraping or chipping the zinc off the condensing surface), or the solidified zinc may be removed using automated techniques (such as mechanical or robotic scrapers).

[0027] If the solidified zinc is removed manually, it is envisaged that the condensing dome will be removed from the process vessel periodically to allow the zinc to be removed. The process vessel may be operating when this occurs, or operation of the process vessel may have ceased (for instance, if sufficient zinc has been removed from the alloy allowing the alloy to be pumped, tapped or otherwise removed from the process vessel).

[0028] Alternatively, if the removal of solidified zinc is achieved using automated techniques, the condensing dome may not need to be removed during the scraping process, and solidified zinc may be collected within the process vessel.

[0029] The solidified zinc removed from the condensing surface may be used or any suitable purpose. In one embodiment of the invention, however, the solidified zinc may be used in a process vessel where silver is separated from lead through the addition of zinc (i.e. a process vessel operating the Parkes process).

[0030] The filter may be of any suitable form. Preferably, however, the filter is located within the process vessel between the metal bath and the condensing surface. In this way, zinc vapour passes through the filter prior to contacting the condensing surface and solidifying thereon. Preferably, the filter is located above the metal bath and below the condensing surface.

[0031] The filter may be of any suitable size, shape or configuration, although in a preferred embodiment of the invention, the filter is of sufficient size so as to ensure that substantially all zinc vapour generated in the metal bath passes through the filter prior to contacting the condensing surface. Thus, it is envisaged that the size of the filter will be at least the same as the cross-sectional area of the process vessel.

[0032] The filter may be fabricated from any suitable material. For instance, the filter may be fabricated from a porous material or a material with one or more passages therethrough. In a preferred embodiment of the invention, the filter may be fabricated from a material having one or more tortuous passages therethough. In some embodiments of the invention, the filter may be fabricated from a metal, ceramic or the like, or a combination thereof. In a preferred embodiment of the invention, the filter may be fabricated at least partially from metal wool, such as, for example, steel wool. Preferably, the filter is fabricated from a material having a melting point above the operating (elevated) temperature of the process vessel.

[0033] The filter may comprise one or more layers of material. For instance, in some embodiments of the invention, the filter comprises a single layer of filter material. Alternatively, the filter may comprise a plurality of layers of filter material placed on top of each other. In this

embodiment, the layers of filter material may be the same as one another, or more differ from one another in terms of porosity, thickness, coarseness, aperture or pore size or the like, or a combination of these factors.

[0034] In a preferred embodiment of the invention, the filter may comprise a plurality of layers of metal wool placed on top of one another. In this embodiment, the lowermost layer of metal wool (i.e. the layer located closest to the metal bath) may be relatively coarse, meaning that the passages through the layer are relatively large. A layer of metal wool located above the lowermost layer may be less coarse than the lowermost layer. Any suitable number of layers of metal wool may be placed on top of one another in this manner such that the coarseness of the layers decreases from the lowermost layer to the uppermost layer (i.e. the layer closest to the condensing surface).

[0035] Preferably, the filter is maintained at substantially the same elevated temperature as the metal bath in the process vessel. By maintaining the filter at this elevated temperature, the solidification of zinc on the filter can be reduced or eliminated.

[0036] In some embodiments of the invention, the process vessel may be provided with one or more spacers. The one or more spacers may be located at any suitable location in the process vessel. For instance, a spacer may be provided between the metal bath and the filter in order to maintain a desired spacing between the metal bath and the filter. Alternatively, a spacer may be provided between the filter and the condensing surface in order to prevent the filter coming into contact with zinc solidifying on the condensing surface. In some embodiments of the invention, a first spacer may be provided between the metal bath and the filter, while a second spacer may be provided between the filter and the condensing surface.

[0037] The one or more spacers may be fabricated from any suitable material. In some embodiments of the invention, the one or more spacers may be fabricated from a metal, ceramic or the like, or a combination thereof.

[0038] Preferably, the one or more spacers are maintained at substantially the same elevated temperature as the metal bath in the process vessel. By maintaining the one or more spacers at this elevated temperature, the solidification of zinc on the one or more spacers can be reduced or eliminated.

[0039] In some embodiments of the invention, agitation of the metal bath in the process vessel may be desired or required. Any suitable agitation technique may be used. For instance, the metal bath may be agitated using one or more impellers, or may be agitated by bubbling a gas

(such as a suitable inert gas) through the metal bath. More preferably, however, agitation of the metal bath may be achieved using one or more molten metal pumps (such as a lead pump). The exact configuration of the one or more lead pumps is not critical to the invention, and no further discussion of this is required. Preferably, however, the one or more lead pumps are maintained at substantially the same elevated temperature as the metal bath in the process vessel. By maintaining the one or more lead pumps at this elevated temperature, the solidification of zinc on the one or more lead pumps can be reduced or eliminated.

[0040] It is envisaged that the use of the one or more lead pumps may cause the lead present in the metal bath to boil. Thus, in embodiments of the invention in which one or more molten lead pumps are present, it is envisaged that the process vessel may be provided with one or more protective members located between the lead pump and the filter. By positioning the one or more protective members in this location, splashing of lead onto the filter may be reduced or prevented.

[0041] It is also envisaged that the use of one or more lead pumps may assist in breaking up, or reducing the formation of, any dross material that may form on the surface of the metal bath in the process vessel.

[0042] The one or more protective members may be of any suitable size, shape or configuration. Preferably, however, the one or more protective members are of sufficient size to prevent molten lead splashing onto the filter, but are not so large as to prevent zinc vapour from reaching the filter. The one or more protective members may be fabricated from any suitable material, such as metal or ceramic. In a preferred embodiment of the invention, however, the one or more protective members are fabricated from metal, such as, but not limited to, steel. Preferably, the one or more protective members may comprise a shield positioned between an outlet of the metal pump and the filter.

[0043] It is envisaged that, once sufficient dezincing of the alloy has taken place, the metal remaining in the process vessel will be predominantly a silver-lead alloy (with the usual minor impurities, including a relatively small amount of residual zinc). It is envisaged that the silver-lead alloy will be tapped or otherwise removed from the process vessel once the silver content of the silver-lead alloy has risen to a predetermined level, or once the zinc content of the silver-lead alloy has decreased to a predetermined level. The silver content in the silver-lead alloy will rise during the dezincing process due to the removal of zinc from the alloy, while the zinc content will drop. While not wishing to be bound by any particular value, it is envisaged that a zinc content in the silver-lead alloy of less than about 10 wt% may be an acceptable level at which the

dezincing process may be considered to be complete.

[0044] The silver-lead alloy produced in the process vessel may be treated using any suitable technique (such as, for instance, cupellation or electrorefining) in order to remove at least some of the lead (and optionally other impurities). For instance, it is envisaged that the silver-lead alloy may be treated under oxidising conditions so that lead (and optionally selected impurities) may be selectively oxidised and removed from the silver-lead alloy in order to further increase the silver content of the alloy. Any suitable process or process vessel may be used. For instance, in some embodiments of the invention, the silver-lead alloy may be treated using a BBOC™ process vessel.

[0045] In some embodiments of the invention, the silver-lead alloy may undergo an additional treatment step after the dezincing process and prior to a lead oxidation process in order to increase the silver content of the silver-lead alloy prior to the cupellation process. For instance, the silver-lead alloy may undergo a silver crystallisation process. By removing some of the lead in the silver-lead alloy prior to the lead oxidation process, the residence time of the silver-lead alloy in the lead oxidation process may be reduced.

[0046] It is envisaged that, in some embodiments of the invention, it may be necessary to add certain substances to the alloy prior to, or during, the treatment of the alloy using the method of the present invention. For instance, substances containing lead may be added to the alloy. Alternatively, two or more different alloys may be added to the process vessel for treatment. The two or more alloys may be added separately or may be blended together to produce a blended alloy having a desired content of precious metal and/or zinc.

[0047] In some embodiments, the method of the present invention may comprise one portion of a process. For instance, in some embodiments of the invention, the method may be used as a process step in a process.

[0048] In a specific embodiment of the invention, the method may be used as a process step in the Merrill-Crowe process. By way of background, The Merrill–Crowe process is a separation technique for removing precious metals (such as, but not limited to, gold) from a cyanide solution.

[0049] Typically, a solution is separated from the ore by such methods as filtration and counter current decantation. After the separation step(s) is conducted, diatomaceous earth is added to produce a clear solution. Gases are then removed by passing the clarified solution through a vacuum de-aeration column.

[0050] A precipitation step is then carried out in which zinc dust or powder is added to the clarified, de-aerated solution. Zinc has a higher affinity for the cyanide ion than gold, causing precious metal (such as silver and gold) to precipitate from the solution. Base metals, like copper, will also precipitate if present.

[0051] The gold precipitate (which includes some zinc powder) is then filtered out of the solution to produce a filter cake, and sulphuric acid is introduced to the filter cake to dissolve the zinc. The resulting solution is filtered, and the remaining solids are smelted to create a precious metal bullion.

[0052] It is envisaged that, by using the method of the present invention as a process step in the Merrill-Crowe process, the steps of dissolving zinc in the filter cake using sulphuric acid, filtering the remaining solution may be replaced by the method of the present invention.

[0053] Thus, in another aspect of the invention, the invention resides broadly in a method for treating a precipitate including zinc and one or more precious metals, the method comprising treating the precipitate in a process vessel under conditions of elevated temperature and sub-atmospheric pressure so as to selectively vaporise zinc, providing a filter through which the vaporised zinc passes prior to contacting a condensing surface on which the vaporised zinc condenses to solid zinc, and continuing to treat the precipitate until a desired level of dezincing is achieved.

[0054] Preferably, the precipitate is produced by cementation of precious metals onto zinc powder, commonly referred to as the Merrill-Crowe process.

[0055] In this embodiment of the invention, the zinc removed from the precipitate may be removed from the condensing surface and used for any suitable purpose. For instance, the zinc may be used as an alloying agent or the like.

[0056] Alternatively, at least a portion of the zinc may be recycled to a suitable process step within the Merrill-Crowe process. In this embodiment of the invention, at least a portion of the zinc may be recycled to the precipitation step in which zinc powder is added to a cyanide solution containing precious metals. In this way, the quantity of fresh zinc powder required to be added to the precipitation step may be reduced.

[0057] In an alternative embodiment of the invention, all of the zinc removed from the condensing surface is recycled to the precipitation step in the Merrill-Crowe process.

[0058] It is envisaged that, prior to its addition to the precipitation step, at least a portion of the zinc removed from the precipitate may be converted to a powder, for instance by grinding, pulverisation or any other suitable technique.

[0059] In another aspect, the invention resides broadly in an apparatus for treating a precious metal-containing zinc alloy, the apparatus comprising a container portion adapted to contain a quantity of the precious metal-containing zinc alloy, a heating portion adapted to maintain the temperature of the precious metal-containing zinc alloy in the container portion at a desired temperature to cause zinc vapour to be selectively emitted from the precious metal-containing zinc alloy, a vacuum portion adapted to maintain sub-atmospheric pressure within the container portion, a condensing portion including a condensing surface on which the zinc vapour condenses to form solid zinc, and a filter portion located between the container portion and the condensing portion, wherein the zinc vapour emitted from the container portion passes through the filter portion prior to contacting the condensing surface.

[0060] The present invention provides numerous advantages over prior art silver refining processes. The major advantage is that the process of producing a silver-lead alloy that is of a quality that can be used in a cupellation process is reduced to a single sealed vessel for liquation, separation and dezincing. This significantly reduces the complexity and cost of producing a silver-lead alloy of sufficient quality for cupellation. In addition, the time taken to produce the silver-lead alloy is reduced, meaning that a larger quantity of silver may be refined in a given period of time.

[0061] Further, due to the reduced number of phase changes within the material treated, better control of the process may be achieved. Also, a reduction in the material handling that is required not only reduces costs, but increases the safety of the process workers.

[0062] Finally, because no or negligible lead is removed from the alloy during the dezincing process, lead emissions are minimised, making the process more friendly for workplace health and safety.

[0063] Any of the features described herein can be combined in any combination with any one or more of the other features described herein within the scope of the invention.

[0064] The reference to any prior art in this specification is not, and should not be taken as an acknowledgement or any form of suggestion that the prior art forms part of the common general knowledge.

## BRIEF DESCRIPTION OF DRAWINGS

[0065] Preferred features, embodiments and variations of the invention may be discerned from the following Detailed Description which provides sufficient information for those skilled in the art to perform the invention. The Detailed Description is not to be regarded as limiting the scope of the preceding Summary of the Invention in any way. The Detailed Description will make reference to a number of drawings as follows:

[0066] Figure 1 illustrates a cross-sectional view of an apparatus for treating a silver-containing zinc alloy according to an embodiment of the present invention.

[0067] Figure 2 illustrates a cross-sectional view of an apparatus for treating a silver-containing zinc alloy according to an alternative embodiment of the present invention.

[0068] Figure 3 illustrates a prior art flowsheet of the Merrill Crowe process.

[0069] Figure 4 illustrates a modified flowsheet of the Merrill Crowe process incorporating a method for treating a precipitate including zinc and one or more precious metals according to an embodiment of the present invention.

## DESCRIPTION OF EMBODIMENTS

[0070] In Figure 1 there is illustrated a cross-sectional view of an apparatus 10 for treating a silver-containing zinc alloy according to an embodiment of the present invention. The apparatus 10 comprises a container portion in the form of a kettle 11, the kettle 11 adapted to contain a quantity of silver-containing zinc alloy 12 therein. The alloy 12 is heated by a burner (not shown) that is external to the kettle 11 and which maintains the temperature within the kettle 11 at a temperature to maintain the alloy 12 in a molten state while selectively vaporising zinc from within the alloy 12.

[0071] The apparatus 10 comprises a condensing dome 13 which is positioned above the alloy bath 12 and seals the kettle 11 so as to both prevent vapours from escaping from the kettle 11, and also to maintain the conditions of sub-atmospheric pressure within the kettle 11.

[0072] The condensing dome 13 includes a substantially flat condensing surface 14 on which zinc vapour rising from the alloy bath 12 condenses when brought into contact with the condensing surface 14. The condensing zinc vapours form a layer of solidified zinc 15 on the condensing surface 14, which is periodically removed by scraping the solidified zinc 15 off the condensing surface 14.

[0073] The temperature of the condensing surface 14 is maintained at a temperature below that of the melting point of zinc (i.e. below 419.5°C) to ensure that zinc vapours coming into contact with the condensing surface 14 solidify. The condensing surface 14 is cooled by a recirculating coolant (not shown) that maintains the condensing surface 14 at the desired temperature.

[0074] A filter 16 in the form of a mesh screen is located above the alloy bath 12 and below the condensing surface 14. The filter 16 extends across the entire surface area of the alloy bath 12 such that zinc vapours emitted from the alloy bath 12 pass through the filter 16 prior to coming into contact with the condensing surface 14.

[0075] The apparatus 10 is further provided with a spacer ring 17 adapted to space the filter 16 away from both the alloy bath 12 and the condensing surface 14. The spacer ring 17 may be cooled using a suitable coolant if desired, although it is preferred that the temperature of the spacer ring 17 and the filter 16 is maintained at a temperature above the melting point of zinc so that zinc vapours do not condense on either the spacer ring 17 or the filter 16.

[0076] In the embodiment of the invention shown in Figure 1, the apparatus further comprises a molten metal pump 18 which is used to agitate the alloy bath 12. The pump 18 is attached to a wall of the kettle 11 via a frame 19.

[0077] A plate 20 is positioned between the outlet 21 of the pump 18 and the filter 16 so as to protect the filter 16 by ensuring that molten metal from the alloy bath 12 does not come into contact with the filter 16 during agitation of the alloy bath 12 by the pump 18.

[0078] In Figure 2 there is illustrated a cross-sectional view of an apparatus 10 for treating a silver-containing zinc alloy according to an embodiment of the present invention. As with Figure 1, the apparatus 10 of Figure 2 comprises a container portion in the form of a kettle 11, the kettle 11 adapted to contain a quantity of silver-containing zinc alloy 12 therein. The alloy 12 is heated by a burner (not shown) which maintains the temperature within the kettle 11 at a temperature to maintain the alloy 12 in a molten state while selectively vaporising zinc from within the alloy 12.

[0079] The apparatus 10 comprises a condensing dome 13 which is positioned above the alloy bath 12 and seals the kettle 11 so as to both prevent vapours from escaping from the kettle 11, and also to maintain the conditions of sub-atmospheric pressure within the kettle 11.

[0080] The condensing dome 13 includes a substantially flat condensing surface 14 on

which zinc vapour rising from the alloy bath 12 condenses when brought into contact with the condensing surface 14. The condensing zinc vapours form a layer of solidified zinc (not shown) on the condensing surface 14, which is periodically removed by scraping the solidified zinc (not shown) off the condensing surface 14.

[0081] The temperature of the condensing surface 14 is maintained at a temperature below that of the melting point of zinc (i.e. below 419.5°C) to ensure that zinc vapours coming into contact with the condensing surface 14 solidify. The condensing surface 14 is cooled by a recirculating coolant (not shown) that maintains the condensing surface 14 at the desired temperature.

[0082] A filter 16 in the form of a metal wool is located above the alloy bath 12 and below the condensing surface 14. In addition, a spacer ring 17 is placed between the condensing dome 13 and the edge of the kettle 11 so as to space the filter 16 away from the alloy bath 12.

[0083] In the embodiment of the invention shown in Figure 2, the apparatus further comprises a molten metal pump 18 driven by motor 22 which is used to agitate the alloy bath 12. The pump 18 (which is only partially illustrated) is positioned above the condensing dome 13 and passes through the condensing dome 13 and an aperture 23 in the filter 16 as it extends into the alloy bath 12.

[0084] In Figure 3 there is illustrated a conventional Merrill-Crowe process flowsheet. In this flowsheet, run-of-mine (ROM) ore 30 is comminuted 31 and classified 32 prior to a thickening step 33. The underflow 34 of the thickener is leached 35 and then, together with the thickener overflow 36, it is clarified 37 using diatomaceous earth 38.

[0085] The clarified solution is deaerated 39 and then zinc 40 is added to the solution so as to precipitate 41 gold, silver and other precious metals from the solution.

[0086] The precipitate 42 is filtered and sulphuric acid 43 is introduced so as to dissolve zinc in the precipitate 42 into solution. The zinc solution 44 is then removed and the remaining solids are smelted 45 to produce bullion.

[0087] In Figure 4 a modified Merrill-Crowe process flowsheet in accordance with an embodiment of the present invention is illustrated. The flowsheet is similar to the conventional flowsheet shown in Figure 3 with the exception that the precipitate 42 from the precipitation step 41 undergoes a dezincing process 46 in a kettle or furnace, such as that illustrated in Figures 1 or 2, and in accordance with the method described in connection with Figures 1 or 2.

[0088] The dezincing process 46 produces solid zinc 47 which may optionally be pulverised and recycled to the precipitation step 41 so as to reduce the quantity of fresh zinc 40 added to the precipitation step 41. This represents a reduction in the operational costs for the process.

[0089] Bullion 48 produced in the dezincing process 46 may be treated by, for instance, cupellation or electrorefining in order to remove at least some of the remaining impurities and increase the precious metal content of the bullion 48.

[0090] Making use of the dezincing step 46 in the Merrill-Crowe process provides a number of advantages. Firstly, as mentioned previously, operational costs may be reduced through a reduction in the fresh zinc 40 required to be added to the precipitation step 41.

[0091] In addition, once the precipitate 42 has been generated, the dezincing process 46 can be used to replace the several unit processes (acid wash, filtration and retort) shown in Figure 3. Thus, the use of the dezincing process 46 results in the more efficient production of the precious metal bullion 48 at reduced expense.

[0092] In the present specification and claims (if any), the word 'comprising' and its derivatives including 'comprises' and 'comprise' include each of the stated integers but does not exclude the inclusion of one or more further integers.

[0093] Reference throughout this specification to 'one embodiment' or 'an embodiment' means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearance of the phrases 'in one embodiment' or 'in an embodiment' in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more combinations.

[0094] In compliance with the statute, the invention has been described in language more or less specific to structural or methodical features. It is to be understood that the invention is not limited to specific features shown or described since the means herein described comprises preferred forms of putting the invention into effect. The invention is, therefore, claimed in any of its forms or modifications within the proper scope of the appended claims (if any) appropriately interpreted by those skilled in the art.

CLAIMS

1. A method for treating a silver-containing zinc alloy, the method comprising treating the alloy in a process vessel under conditions of elevated temperature and sub-atmospheric pressure so as to selectively vaporise the zinc, providing a filter through which the vaporised zinc passes prior to contacting a condensing surface on which the vaporised zinc condenses to solid zinc, and continuing to treat the alloy until a desired level of dezincing is achieved.

2. A method according to claim 1 wherein the alloy is in a substantially molten or liquid state during treatment.

3. A method according to claim 1 or claim 2 wherein the alloy is treated at a temperature of between 500°C and 900°C.

4. A method according to any one of the preceding claims wherein the process vessel is heated by one or more burners.

5. A method according to any one of the preceding claims wherein the alloy is treated at a pressure of less than 0.1 atm.

6. A method according to any one of the preceding claims wherein the process vessel is provided with a condensing dome including the condensing surface on which the zinc vaporized zinc condenses.

7. A method according to claim 6 wherein the condensing dome is cooled to a temperature below the melting point of zinc.

8. A method according to any one of the preceding claims wherein the solid zinc is periodically removed from the condensing surface so as to maintain the efficacy of the dezincing.

9. A method according to any one of the preceding claims wherein the filter is fabricated from a porous material or a material with one or more passages therethrough.

10. A method according to any one of the preceding claims wherein the filter is fabricated from a material having a melting point above the elevated temperature.

11. A method according to any one of the preceding claims wherein the filter is

maintained at the elevated temperature.

12. A method according to any one of the preceding claims wherein the alloy in the process vessel is agitated using one or more molten metal pumps.

13. A method according to any one of the preceding claims wherein the desired level of dezincing is achieved when the alloy has a zinc content of less than about 10 wt%.

14. A method for treating a zinc alloy including one or more precious metals, the method comprising treating the alloy in a process vessel under conditions of elevated temperature and sub-atmospheric pressure so as to selectively vaporise zinc, providing a filter through which the vaporised zinc passes prior to contacting a condensing surface on which the vaporised zinc condenses to solid zinc, and continuing to treat the alloy until a desired level of dezincing is achieved.

15. A method for treating a precipitate including zinc and one or more precious metals, the method comprising treating the precipitate in a process vessel under conditions of elevated temperature and sub-atmospheric pressure so as to selectively vaporise zinc, providing a filter through which the vaporised zinc passes prior to contacting a condensing surface on which the vaporised zinc condenses to solid zinc, and continuing to treat the precipitate until a desired level of dezincing is achieved.

16. A method according to claim 15 wherein the precipitate is produced in the Merrill-Crowe process.

17. A method according to claim 16 wherein at least a portion of the solid zinc is recycled to a precipitation step in the Merrill-Crowe process.

18. An apparatus for treating a precious metal-containing zinc alloy, the apparatus comprising a container portion adapted to contain a quantity of the precious metal-containing zinc alloy, a heating portion adapted to maintain the temperature of the precious metal-containing zinc alloy in the container portion at a desired temperature to cause zinc vapour to be selectively emitted from the precious metal-containing zinc alloy, a vacuum portion adapted to maintain sub-atmospheric pressure within the container portion, a condensing portion including a condensing surface on which the zinc vapour condenses to form solid zinc, and a filter portion located between the container portion and the condensing portion, wherein the zinc vapour emitted from the container portion passes through the filter portion prior to contacting the

condensing surface.

19. An apparatus according to claim 18 wherein the filter portion comprises one or more layers of metal wool.

20. An apparatus according to claim 18 and claim 19 wherein the alloy is in a substantially molten or liquid state during treatment.

21. An apparatus according to any one of claims 18 to 20 wherein the apparatus further comprises one or more spacers located between the container portion and the filter portion and/or between the filter portion and the condensing portion.

22. An apparatus according to any one of claims 18 to 21 wherein the apparatus further comprises one or more molten metal pumps.

23. An apparatus according to claim 22 wherein the apparatus further comprises one or more protective members located between the one or more molten metal pumps and the filter portion.

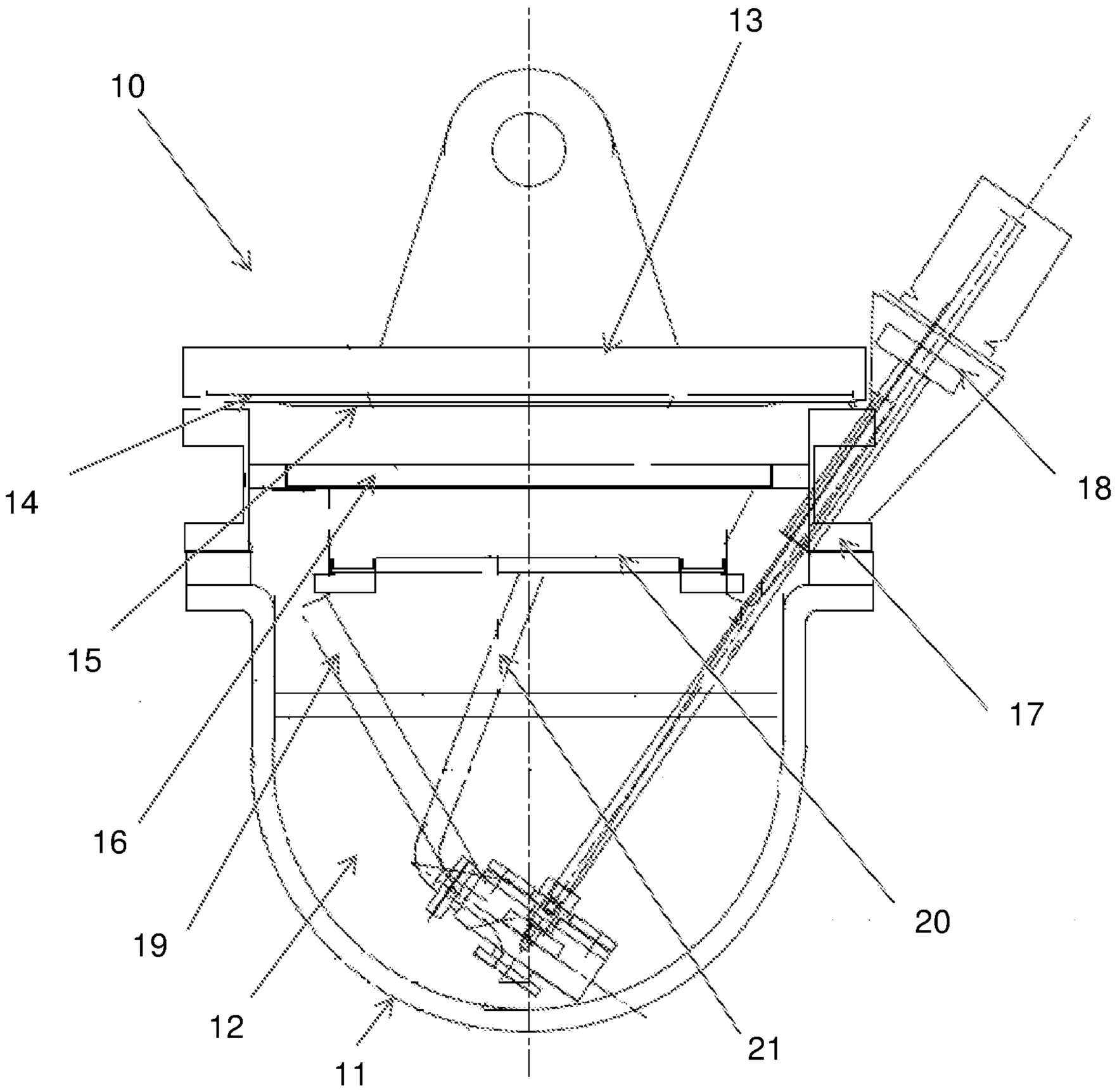



FIG 1

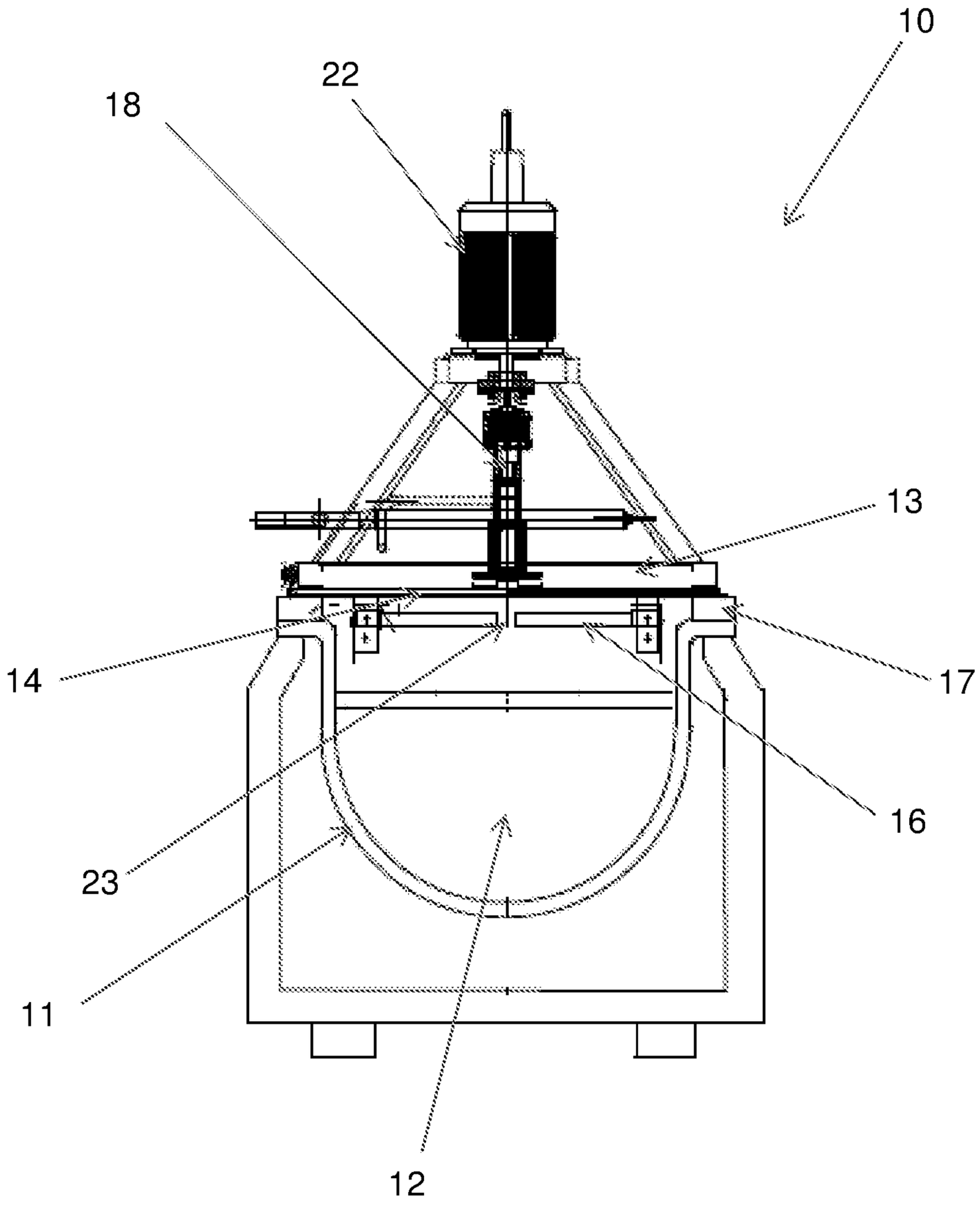



FIG 2

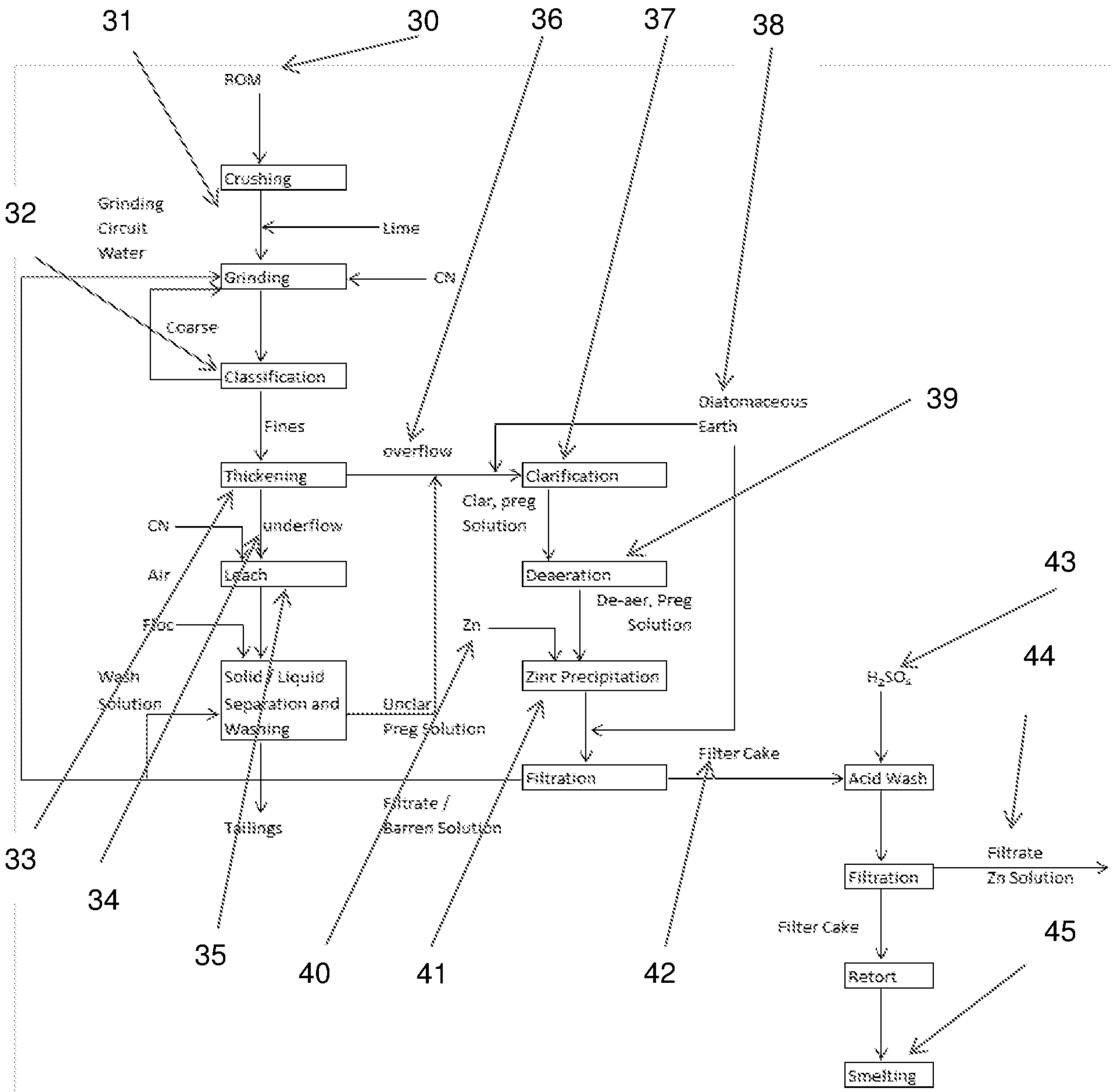



FIG 3 – Prior Art

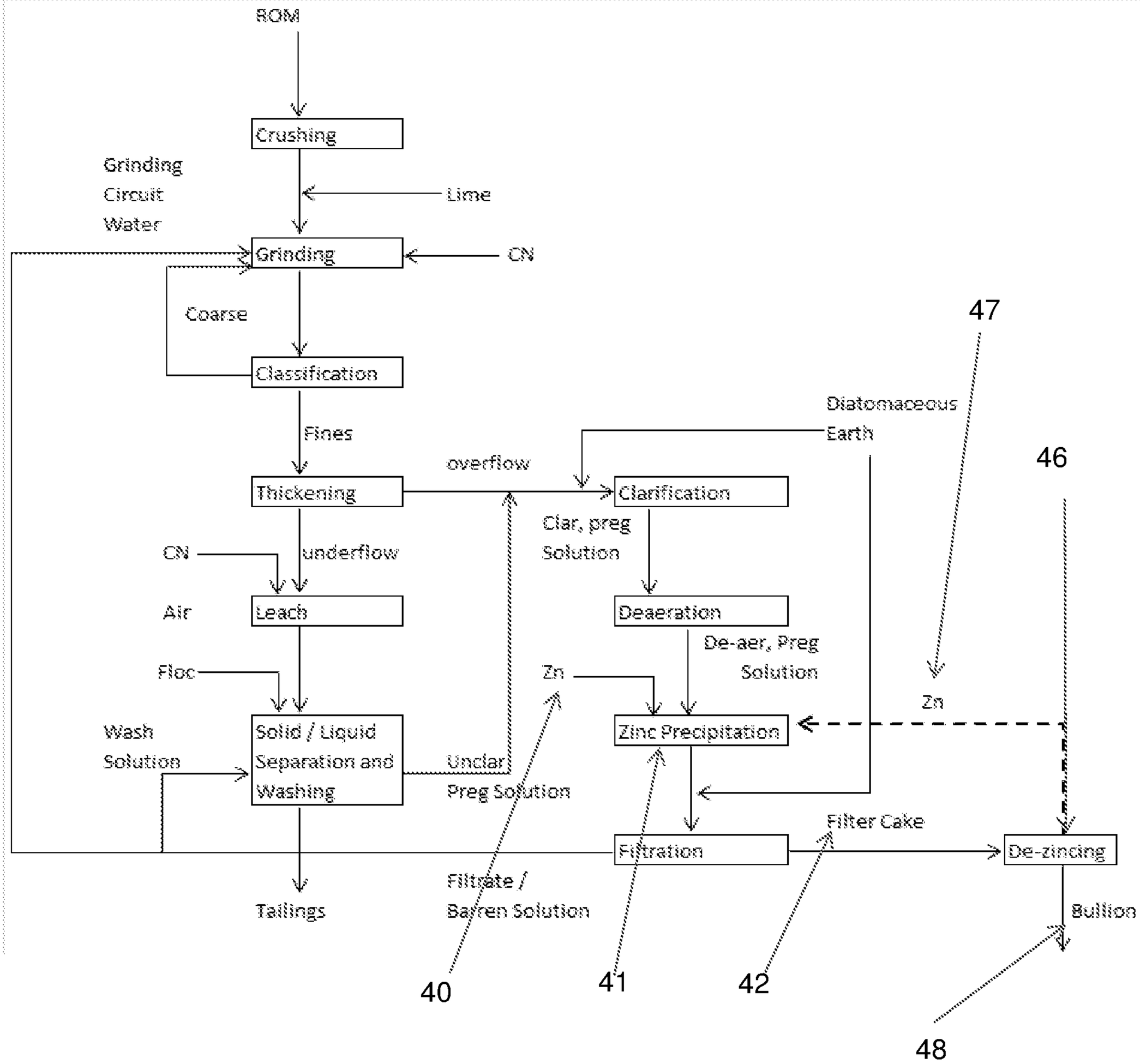

ROM
Crushing
Grinding Circuit Water
Lime
Grinding
CN
Coarse
Classification
Fines
Thickening
overflow
Clarification
Diatomaceous Earth
47
46
CN
underflow
Clar, preg Solution
Air
Leach
Deaeration
De-aer, Preg Solution
Floc
Zn
Wash Solution
Solid / Liquid Separation and Washing
Unclar Preg Solution
Zinc Precipitation
Zn
Filtration
Filter Cake
De-zincing
Tailings
Filtrate / Barren Solution
Bullion
40
41
42
48

FIG 4

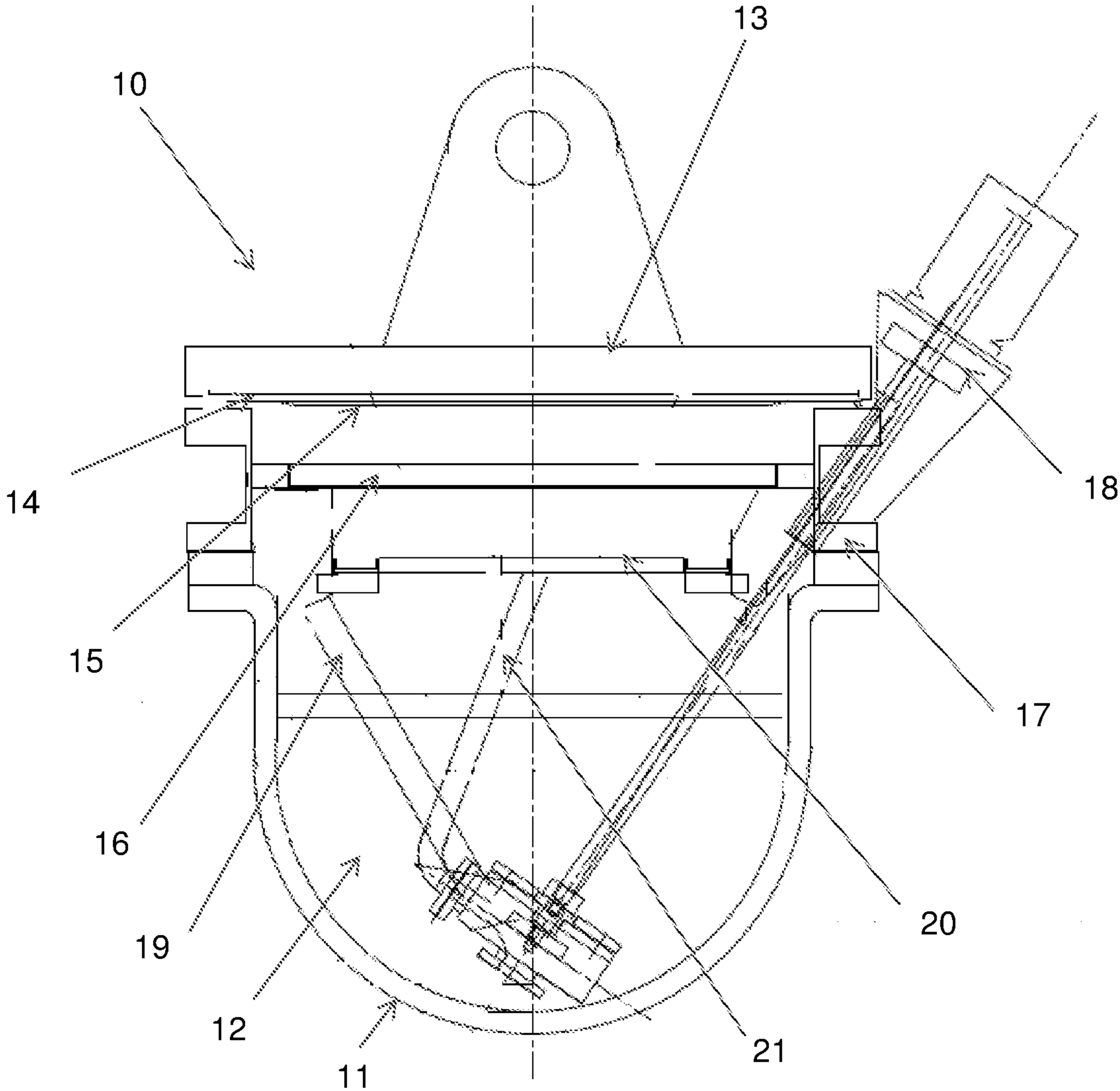



FIG 1