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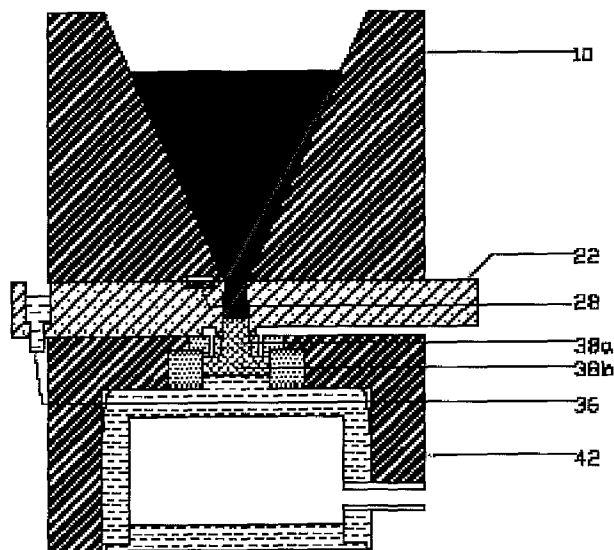


FIGURE 2(b)

(57) Abstract: This invention relates to a separating apparatus and a separation method for quantitative separation of molten collector material and a molten slag during a process of assaying mineral ore samples to determine the concentration of selected metals, particularly of gold and platinum group metals, in such samples. The separating apparatus comprises a separating vessel for receiving a fusion of collector material and slag; a collector mould disposed below the separating vessel for receiving the collector material; and a movable gate disposed intermediate the separating vessel and the collector mould for controlling the flow of molten material from the separating vessel into the collector mould. The separating apparatus defines a closed flow path between the separating vessel and the collector mould such that the collector material is not exposed to atmospheric air during casting.

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SEPARATION APPARATUS AND METHOD FOR ASSAYING

FIELD OF THE INVENTION

This invention relates to separation apparatus and a separation method for use in assaying mineral ore samples particularly, but not exclusively, to determine the concentration of gold and platinum group metals in such samples.

BACKGROUND TO THE INVENTION

It is common practice in gold and platinum group metals (PGM's) mining and exploration operations to assay ore samples to assess the amount of gold or PGM's (platinum, palladium, rhodium, osmium, iridium and ruthenium) present in the ore. So-called "fire assay" analysis has long been the only viable process for accurately analysing low grade ore samples containing PGM's and gold, because it is a robust and relatively cheap process compared to other analytical processes, and allows for the analysis of large representative samples.

(For purposes of this specification, any reference to PGM's should be interpreted to include a reference to gold.)

Fire assay analysis of PGM's involves first isolating the PGM's from a silicate and chromite sample matrix and collecting it into lead during fire

assay fusion. The fusion is usually carried out at a temperature in the range of 1100-1250°C, and in the presence of a flux that contains lead oxide (litharge); a suitable reductant, which is usually carbon-based; and a number of slag formers, such as anhydrous sodium tetraborate, sodium carbonate and silica powder. During fusion a carbothermic reduction process occurs which produces molten metallic lead and a molten oxide slag. As a result of their chemical affinity, the PGM's are selectively extracted into the molten metallic lead. The melt is cast into an iron mould and allowed to cool.

Upon cooling the molten metallic lead separate from the slag by virtue of a difference in density between the lead and slag, and the lead settles to the bottom of the mould. Once the metallic lead is cooled, it is separated from the slag for further processing. In traditional fire assay the slag is mechanically broken from the lead. The resultant lead sample, which generally includes small amounts of slag, is then treated further using cupellation, wet chemical digestion and ICP-OES (inductively coupled plasma optical emission spectrometry) analysis.

With modern progress in analytical science there has been a strong trend towards automation of analytical, including fire assay, processes, inter alia to reduce labour and costs, and to improve accuracy, precision, health and safety. In an automated fire assay process it is preferable to analyse the lead for PGM's directly using Spark-OES (optical emission spectrometry). This requires that the lead sample which is analysed is homogenous and

slag-free in order to achieve precise and accurate analysis. Traditional casting results in a slow-cooled product that may be inhomogeneous, so to ensure a homogenous lead sample the lead must be quenched by rapid cooling.

Moreover, complete separation of the lead sample from the slag and an accurate mass of the lead sample is paramount for performing a precise mass balance calculation to determine sample grade. The mass balance is essential, because the yield of lead during the fusion process is an unknown entity which varies with sample composition, flux composition, fusion temperature and draft conditions. Since these variations are beyond experimental control they need to be compensated for by an accurate mass balance of the process to yield the final result. Lead losses in the separation process will result in analytical bias. This necessitates the use of a reliable and robust lead/slag separator system that can isolate, rapidly cast and quench the lead from the molten state.

WO 00/26664 relates to an automated fire assay method and introduces a preheated separator comprising a removable melting pot that locates inside a ceramic housing, which in turn fits into an induction furnace. The melting pot includes two opposing pouring spouts and a lead receptacle, located in a sidewall of the melting pot proximate one of the spouts. After fusion, the slag and lead melt is introduced into the separator and the lead is allowed to settle at the bottom of the melting pot, with the slag on top of the lead. The molten slag and lead are separated by rotating the melting pot in a first

direction to decant the slag. As the slag is poured out of the pot, the molten lead is trapped in lead receptacle. The slag is cast into a mould where it is solidified and discarded. After the slag is decanted from the melting pot, the melting pot is rotated to a second, opposite direction to decant the molten lead into a water-cooled mould where it is rapidly quenched.

This separator suffers from a number of disadvantages. Firstly, the need for a ceramic housing increases the costs of this separator tremendously. Those who are engaged in the industry will appreciate that the tolerance on these types of items is fairly large and they are difficult to make reliably, particularly in a cost effective manner. High performance refractories are simply not a viable option as their cost is too high, particularly for use in disposable items.

Secondly, the lead receptacle volume must be tailored to match the volume of molten lead generated during the fusion process. If the lead receptacle volume is too small, lead losses would result because a portion of the lead would overflow the lead receptacle, together with the slag. If the lead receptacle volume is too large, it traps some of the slag with the molten lead, which carries over into the lead button. Moreover, high viscosity slag resists displacement from the lead, resulting in further lead losses during the decanting step, while highly fluid molten lead could overflow the lead receptacle together with the slag.

A third disadvantage is that the molten lead is exposed to air after the slag is removed. Molten lead is highly reactive and oxidises rapidly to produce volatile lead oxide fumes. Lead oxide acts as an extremely corrosive flux and reacts with the separator, resulting in increased deterioration of the ceramic housing. This causes the melting pot to widen, change volume and eventually leak, causing a steady deterioration in the separation process over time.

Further mechanical and cost disadvantages are associated with the requirements of heating the melting pot, and rotating the same to decant the slag and lead.

WO 02/04919 discloses a lead/slag separator including a conical ceramic vessel that terminates in an outlet duct, which is generally located at a lower termination of the vessel. The outlet duct is either so small that only the molten lead is capable of flowing through the duct opening, or the outlet duct is fitted with a separator insert which comprises a number of small holes wherein each hole is so small that only the lead can pass through the holes.

A molten charge is cast into the separator and the lead settles to the bottom of the vessel. The lead with its low viscosity and high fluidity drains rapidly through the outlet duct or through the holes in the separator insert, as the case may be, and is collected in a water-cooled mould located below the vessel. The slag, which has a higher viscosity, is unable to pass

through the holes and is drained off through a drain hole, with a small amount of slag remaining behind in the vessel.

Alternatively, the holes are dimensioned such that the slag also drains slowly through the holes after the lead has passed through, but due to its low velocity and the low interfacial tension between the vessel and the slag, the slag drains away from the holes along the base of the vessel and away from the mould. In this way an effective separation is achieved. The hole size of the outlet duct or insert is critical and must be approximately 0.8mm in diameter to effect efficient separation, without causing slag carry-over into the lead.

One major disadvantage of this separator is that the fine holes of the insert are easily blocked, corroded with time and widen, causing a decrease in separation efficiency. Moreover, in order to achieve the fine tolerances and chemical resistance required for the holes, the inserts are manufactured from high quality alumina ceramic which is bonded into the outlet duct. These inserts are extruded and made to fine tolerances before being cut to size and assembled in the separator by hand. This is a difficult and expensive step. Also, the separators are primarily hand-made, which further increases costs and reduces reproducibility.

The separator is a static device that is contained within a furnace. To get the separator into the separator furnace, which is operated at 1175°C, and then maintain the separator, is a mechanically complex and difficult

exercise. In addition, the furnaces used to heat the separators are expensive to run.

Further, as the lead drains from the holes it is exposed to air and undergoes rapid oxidation, depositing lead oxide onto the separator and ceramics of the furnace. The lead oxide deposits not only present a health hazard, but also corrode the furnace, thus increasing maintenance intervals and costs. Moreover, if the separator is incorrectly oriented, the lead may drain down the slag hole and bypass the mould.

Another problem with this separator is that the ceramic vessel has a limited life span and requires replacement after approximately 20 separations. These vessels are not only costly per se, but because they are contaminated with lead they also need to be properly disposed of, which further exacerbates costs.

SUMMARY OF THE INVENTION

According to the invention there is provided separating apparatus for quantitative separation of molten collector material and a molten slag during a process of assaying mineral ore samples to determine the concentration of selected metals in such samples, the separating apparatus comprising a separating vessel which defines an interior cavity for receiving a fusion of collector material and slag and which further defines an outlet duct disposed at the lower extremity of the separating vessel; a collector mould disposed co-axially below the outlet duct for receiving the collector

material; and a movable gate disposed intermediate the separating vessel and the collector mould for controlling the flow of molten material from the separating vessel into the collector mould, the gate being movable between a first, closed position in which it seals the outlet duct, and a second, open position in which it permits collector material to drain into the collector mould, the separating apparatus defining a closed flow path between the separating vessel and the collector mould such that the collector material is not exposed to atmospheric air during casting.

The separating vessel may include an open top for receiving the fusion of collector material and slag from a reaction vessel. The interior cavity of the separating vessel may terminate in a conical lower portion dimensioned for receiving a thin layer of slag, which first enters the separating vessel upon introducing the fusion of collector material and molten slag into the separating vessel and which solidifies into a thin-layered slag pocket at the lower extremity of the separating vessel, the slag pocket terminating in a slag plug that is trapped within the outlet duct, and secondly receiving the collector material, which displaces the molten slag in the lower extremity of the separating vessel and which is arrested within the slag pocket between the slag plug and the molten slag.

The outlet duct of the separating vessel may have a diameter of 4mm – 12mm, and preferably a diameter of 6mm – 10mm.

In one form of the invention the movable gate slidingly engages the separating vessel, although it will be appreciated that the gate may hingedly be disposed relative to the separating vessel.

The movable gate may include a recess which is co-axially disposed below the outlet duct when the gate is in the first, closed position. The recess may be dimensioned to accommodate a volume of molten material. In particular, the recess may be dimensioned to accommodate the slag plug. More particularly, the recess may be dimensioned to shear off the slag plug when the gate is moved between the first, closed position and the second, open position to expose the molten collector material.

The recess may have a depth of 0.3mm – 3.0mm, and preferably a depth of 0.5mm – 1.0mm.

The movable gate also may include a draining aperture which is laterally disposed from the recess. The draining aperture may co-axially be disposed below the outlet duct when the gate is in the second, open position such that it defines a downwardly depending draining tube extending from the outlet duct of the separating vessel and against which the collector mould sealingly engages, such that collector material drains through the draining tube into the collector mould.

The draining tube may be a tapered tube. In particular, the draining tube may taper outwardly from the separating vessel towards the collector mould.

The separating vessel is characterised therein that it permits controlled venting of trapped air in the collector mould during casting. For this reason, the movable gate may include at least one venting aperture which vents to atmosphere and which permits egress of air from the collector mould so as to allow for efficient draining of collector material into the mould. Preferably, the movable gate includes a number of venting apertures each with a diameter of 0.3mm – 1.0mm, and preferably a diameter of 0.5mm.

In one form of the invention the movable gate may include a venting insert defining the venting apertures. The venting insert may be manufactured of cast iron, copper and/or graphite.

The movable gate may be manufactured of cast iron.

The movable gate may include locking means for locking the gate in the first and second positions respectively.

The collector mould may be a chilled mould, in particular a water-cooled copper mould. The collector mould may be adapted sealingly to engage the movable gate, the arrangement being such that collector material drains through the outlet duct of the separating vessel and the draining tube of the

movable gate directly into the collector mould without being disposed to atmospheric air, and in particular to oxygen.

The relative dimensions of the collector mould and draining tube of the movable gate may be such that, upon casting the collector material from the separating vessel into the collector mould, the collector material fills the collector mould and then extends upwardly into the draining tube, filling a lower portion of the draining tube, such that when the collector material solidifies, it is in the form a button of collector material, having a substantially disc-shaped body and a short elongate stem, extending from the body and which is defined by the draining tube, the stem being sealed at its end by a thin layer of slag that drains into the draining tube, following the collector material, during the casting step.

The collector mould may include at least one venting aperture for permitting egress of air from the collector mould so as to allow for efficient draining of collector material into the mould. Preferably, the collector mould includes a number of venting apertures that are coaxially arranged beneath the venting apertures in the movable gate when the gate is in the second, open position, so that air in the collector mould vents to atmosphere through the venting apertures in the collector mould and those in the movable gate during draining of collector material into the mould.

The apparatus may include lifting means for lifting the collector mould into engagement with the movable gate and lowering it to a position removed from the movable gate and the separating vessel.

The collector mould may be disposed within a cast iron base.

The separating apparatus also may include an additional copper sleeve disposed within the cast iron base for increasing cooling efficiency of the collector mould.

The separating vessel may be moveable between a first position in which it receives the fusion of collector material and slag, and a second position in which it discards the slag after the collector material has been drained from the separating vessel. In one form of the invention, the separating vessel may pivotally be movable between the first and second positions.

The separating vessel may be manufactured from graphitised cast iron.

According to another aspect of the invention there is provided a method for quantitatively separating molten collector material and a molten slag with the use of the apparatus set out above during a process of assaying mineral ore samples to determine the concentration of selected metals in such samples, the method comprising the steps of fusing, in a reaction vessel, a mixture of a comminuted mineral sample and flux material to form a fusion of molten collector material, which serves to extract the metal

present in the mineral sample, and a molten slag, wherein the collector material has a greater density and/or lower viscosity than the slag; moving the separating vessel to the first position for receiving the fusion of collector material and slag; moving the movable gate to the first, closed position such that the recess is co-axially disposed below the outlet duct of the separating vessel; introducing the fusion of collector material and slag into the separating vessel such that the molten slag first enters the separating vessel and solidifies into a thin-layered slag pocket in the conical lower portion of the separating vessel, terminating in a slag plug that is trapped within the outlet duct, followed by the collector material, which displaces the molten slag in the lower extremity of the separating vessel and which is arrested within the slag pocket between the slag plug and the molten slag; allowing the slag plug to solidify; moving the movable gate to the second, open position such that the recess shears off the slag plug to expose the molten collector material, and such that the downwardly depending draining tube is disposed co-axially below the outlet duct of the separating vessel; and draining the molten collector material into the collector mould to isolate the collector material from the slag.

The collector material may be lead.

The method may include lifting the collector mould into airtight engagement with the movable gate before moving the movable gate to the second, open position.

After the collector material has drained into the collector mould, the method may include the further steps of allowing the collector material to solidify to form a solid button of collector material, sealed at its upper extremity with a thin slag layer; lowering the collector mould away from the movable gate; removing the button of collector material; and removing the thin slag layer from the button.

The separating vessel may then be moved to the second position to discard the slag.

SPECIFIC EMBODIMENT OF THE INVENTION

Without limiting the scope thereof, the invention will now be described further with reference to the accompanying drawings in which –

- Figure 1 is an exploded diagrammatic view of the separating apparatus according to the invention;
- Figure 2a is an assembled diagrammatic view of the separating apparatus of Figure 1, wherein the movable gate is in the closed position and the collector material is arrested in the separating vessel;
- Figure 2b is an assembled diagrammatic view of the separating apparatus wherein the movable gate is in the open position so that collector material can drain into the collector mould;
- and

Figure 3 is a diagrammatic view of the separating apparatus wherein the separating vessel is pivoted to one side to discard the slag, and wherein the collector mould is lowered to a position removed from the movable gate, for recovering the solid button.

The invention provides separating apparatus particularly, although not exclusively, for use in a process of assaying mineral ore samples to determine the concentration of selected metals in such samples. More particularly, the apparatus is used in assay analysis of PGM's and gold. The separating apparatus is used for separating molten collector material, which is typically lead, and a molten slag, so as to extract a homogenous button of solid collector material, in which the metals to be analysed is extracted. The separating apparatus can quantitatively separate the collector material and slag, rapidly cast the collector material and quench the collector material from a molten state, without exposing the collector material to an oxidizing atmosphere and with virtually no contamination.

The separating apparatus includes a separating vessel 10 which defines an interior cavity 12 for receiving a fusion of collector material 14 and slag 16. The separating vessel 10 includes an open top for receiving the fusion of collector material 14 and slag 16 from a reaction vessel (not shown) and terminates in an outlet duct 18 disposed at the lower extremity of the separating vessel 10. The outlet duct 18 of the separating vessel 10 has a diameter of 4mm – 12mm, and preferably a diameter of 6mm – 10mm. The

interior cavity 12 of the separating vessel 10 terminates in a conical lower portion.

During first introduction of the fusion of collector material 14 and slag 16 into the separating vessel 10, a slag pocket 26 is generated. This is because the slag 16 is on top of the collector material 14 inside the reaction vessel and is poured out first. When the slag 16 comes into contact with the separating vessel 10, a thin layer of slag 16 solidifies in the interior cavity 12 of the separating vessel 10 to form a slag pocket 26, although the majority of slag 16 remains molten. A slag plug 28 forms in the outlet duct 18.

The molten collector material 14 of the fusion is poured out and settles through the slag 16 in the conical lower portion of the interior cavity 12. It displaces the molten slag 16 and sits above the slag plug 28, arrested within the slag pocket 26. With the large difference in melting point between the collector material 14 (350°C - 400°C due to impurities such as Cu, Ni and S) and the slag 16 (~900°C), the collector material 14 remains molten and fluid for a substantial time before it solidifies.

The separating vessel 10 is manufactured from graphitised cast iron because of its low thermal expansion co-efficient and also because the slag 16 does not stick to graphitised cast iron.

The separating apparatus further includes a collector mould 20 disposed co-axially below the outlet duct 18 for receiving the collector material 14.

Disposed intermediate the separating vessel 10 and the collector mould 20 is a movable gate 22 for controlling the flow of molten material from the separating vessel 10 into the collector mould 20. The movable gate 22 is manufactured of cast iron and is movable between a first, closed position, as shown in Figure 2a, in which it seals the outlet duct 18, and a second, open position, as shown in Figure 2b, in which it permits collector material 14 to drain into the collector mould 20.

In the illustrated embodiment of the invention the movable gate 22 slidingly engages the separating vessel 10. The movable gate 22 includes a recess 24 which is co-axially disposed below the outlet duct 18 when the gate 22 is in the first, closed position. The recess 24 is dimensioned to accommodate a volume of molten material, and particularly to accommodate the slag plug 28. The recess 24 has a depth of 0.3mm – 3.0mm, and preferably a depth of 0.5mm – 1.0mm. When the gate 22 is moved between the first, closed position and the second, open position the recess 24 shears off the slag plug 28 to expose the molten collector material 14.

The movable gate 22 also includes a draining aperture 30 which is laterally disposed from the recess 24. The draining aperture 30 is co-axially disposed below the outlet duct 18 when the gate 22 is in the second, open position such that it defines a downwardly depending draining tube 30

extending from the outlet duct 18 of the separating vessel 10 and against which the collector mould 20 sealingly engages, such that collector material 14 drains through the draining tube 30 into the collector mould 20.

Small losses of collector material 14 can be trapped in the recess 24 when the movable gate 22 shears off the slag plug 28. Accordingly, the recess depth needs to be optimised for the slag system that is to be separated. This design has been improved by using a draining tube 30 that is tapered to facilitate removal of the solid button of collector material 14. In particular, the draining tube 30 is tapered outwardly from the separating vessel 10 towards the collector mould 20 to decrease thickness of the slag layer on top of the collector material 14. This result in less carry-over of solid slag particles into the collector mould and reduce lead losses in the recess 24.

A small recess 44 is also made in the separating vessel 10 to accommodate the slag plug 28 that is sheared off. If this slag plug 28 is not accommodated it can cause the movable gate 22 to jam and hence prevent separation.

The movable gate 22 also includes at least one venting aperture 32 which vents to atmosphere and which permits egress of air from the collector mould 20 so as to allow for efficient draining of collector material 14 into the mould 20. Preferably, the movable gate 22 includes a number of venting apertures each with a diameter of 0.3mm – 1.0mm, and preferably a diameter of 0.5mm.

In one form of the invention the movable gate 22 includes a venting insert 34 of cast iron and/or graphite, which defines the venting apertures.

The movable gate 22 also includes locking means 36 for locking the gate 22 in the first and second positions respectively.

The collector mould 20 is a chilled, water-cooled copper mould which sealingly engages the movable gate 22, the arrangement being such that, when the movable gate is in the second, open position, collector material 14 drains through the outlet duct 18 of the separating vessel 10 and the draining tube 30 of the movable gate 22 directly into the collector mould 20 without being disposed to atmospheric air, and in particular to oxygen.

The separating apparatus includes lifting means (not shown) for lifting the collector mould 20 into engagement with the movable gate 22 and lowering it to a position removed from the movable gate 22.

The relative dimensions of the collector mould 20 and draining tube 30 of the movable gate 22 are such that collector material 14 fills not only the collector mould 20, but also a portion of the draining tube 30 to form a button 38a,b of collector material 14 having a body 38b and a stem 38a, defined by the draining tube 30, and which is sealed by a thin layer of slag 16a that drains into the draining tube 30, following the collector material 14.

The collector mould 20 includes at least one venting aperture 40 for permitting egress of air from the collector mould 20 during draining of the collector material 14 into the mould 20. Preferably, the collector mould 20 includes a number of venting apertures 40 that are coaxially arranged beneath the venting apertures 32 in the movable gate 22 when the gate 22 is in the second, open position, so that air in the collector mould 20 vents to atmosphere through the venting apertures 40 in the collector mould 20 and those venting apertures 32 in the movable gate 22 during draining of collector material 14 into the mould 20.

A vented design to let air out of the collector mould is essential for reliable operation of the separating apparatus, otherwise air has to move upwards through the collector material 14 and slag 16 before the collector material 14 can drain into the collector mould 20. This can cause turbulence and result in small lead losses in the stem 38a of the lead button 38a,b. Alternatively, an air lock can form which prevents collector material 14 from filling the mould 20, resulting in no separation whatsoever. With a vented design this does not occur as it is easy for the air to escape unhindered - it is simply pushed out of the collector mould 20 as the collector material 14 fills the mould 20.

A potential problem with the vented design is that the molten collector material 14 can run up through the venting apertures 40, which can result in lead losses. This happens when the venting apertures 40 are too large. A diameter of 0.5mm seems to be optimal.

The collector mould 20 is disposed within a cast iron base 42. Cast iron is cooled efficiently and causes the lead to solidify before it can escape through the venting apertures 40. Cast iron also has good thermal expansion properties and is heat resistant.

In one form of the invention, the separating apparatus may include an additional copper sleeve 43 disposed within the cast iron base 42 for increasing cooling efficiency of the collector mould 20.

The separating vessel 10 is movable between a first position in which it receives the fusion of collector material 14 and slag 16 (Figures 2a and 2b), and a second position in which it discards the slag 16 after the collector material 14 has been drained from the separating vessel 10 (Figure 3).

The separating apparatus of the invention is fairly robust and has been tested on button masses from 40g - 60g. The collector mould 20 has been optimised for a button mass of around 45g, but can tolerate smaller and larger buttons 38a,b in that the stem 38a can be up to 30mm long. If the button 38a,b needs to be larger or smaller, the collector mould 20 can simply be lowered or lifted, as the case may be, relative to the movable gate 22 and separating vessel 10. Alternatively, the venting insert 34 can be made with different thicknesses.

The separating apparatus was tested by using a known mass of lead 14 and slag 16. These were re-melted in a ceramic crucible in a furnace at a temperature of 1200°C. The molten fusion was cast into the separating vessel 10 after 20 minutes. The melt was allowed to settle for 5 seconds and then the movable gate 22 was hit with a hammer to facilitate the separation. The collector mould 20 was cooled with circulating water from a refrigerated water bath operated at a temperature of 10°C.

Once the slag 16 had solidified (i.e. after 4 minutes), the hinged separating vessel 10 was tipped and the slag 16 discarded. The collector mould 20 was lowered away from the movable gate 22 and the lead button 38a,b was pushed out of the mould 20. The sample was a 25mm diameter disc with a tapered cylindrical stem 38a. A small volume of slag 16a was adhered to the stem 38a, but this was removed by simply crimping the slag layer 16a with a pair of pliers. A complete separation of the slag 16 and lead button 38a,b was achieved.

The collector mould 20 and separating vessel 10 were cleaned with a blast of compressed air, reassembled and the following separation was done with the same apparatus.

The effectiveness of the separating apparatus is shown in Table 1 below:

<u>Trial</u>	<u>Lead</u> <u>/g</u>	<u>Lead</u> <u>button +</u> <u>adhering</u> <u>slag</u> <u>/g</u>	<u>Lead</u> <u>button</u> <u>/g</u>	<u>Adhering</u> <u>slag</u> <u>/g</u>	<u>Lead</u> <u>recovered</u> <u>from</u> <u>separator</u> <u>/g</u>	<u>%</u> <u>Lead</u> <u>recovered</u> <u>in button</u>	<u>%</u> <u>Lead</u> <u>recovered</u> <u>in total</u>
1	45.42	47.44	45.43	2.01		100.0	100.0

2	50.62	54.68	49.92	4.76	0.12	98.6	98.9
3	55.35	55.13	54.97	0.16	0.29	99.3	99.8
4	59.73	60.53	59.53	1.00	0.13	99.7	99.9

The results from these tests were encouraging and further tests on fusions with different sample types were also successfully achieved.

This new separating apparatus offers a number of advantages over the prior art. Firstly, it is a simple mechanical apparatus that is easy to automate, and it has a relatively small foot print. There is no molten slag 16 draining from the apparatus as the slag 16 is solidified and contained before it is discarded. The molten lead 14 is protected from oxidation by the slag 16 during the entire process. There are no consumable items that need to be discarded and disposed of. The running costs of this apparatus are anticipated to be lower than that of current systems, inter alia because a furnace is not required for heating the separating vessel 10. Since less lead oxide fumes are generated this is also a safer apparatus for operator maintenance.

It will be appreciated that other embodiments of the invention may be possible without departing from the spirit or scope of the invention as defined in the claims.

CLAIMS

1. Separating apparatus for quantitative separation of molten collector material and a molten slag during a process of assaying mineral ore samples to determine the concentration of selected metals in such samples, the separating apparatus comprising a separating vessel which defines an interior cavity for receiving a fusion of collector material and slag and which further defines an outlet duct disposed at the lower extremity of the separating vessel; a collector mould disposed below the outlet duct for receiving the collector material; and a movable gate disposed intermediate the separating vessel and the collector mould for controlling the flow of molten material from the separating vessel into the collector mould, the gate being movable between a first, closed position in which it seals the outlet duct, and a second, open position in which it permits collector material to drain into the collector mould, the separating apparatus defining a closed flow path between the separating vessel and the collector mould such that the collector material is not exposed to atmospheric air during casting.
2. The separating apparatus according to claim 1 wherein the apparatus permits controlled venting of trapped air in the collector mould during casting.
3. The separating apparatus according to claims 1 and 2 wherein the movable gate includes at least one venting aperture which vents to atmosphere and which permits egress of air from the collector mould

during casting to facilitate efficient draining of collector material into the collector mould.

4. A separating apparatus according to claim 3 wherein the movable gate includes a number of venting apertures each with a diameter of 0.3mm – 1.0mm, and preferably a diameter of 0.5mm.
5. A separating apparatus according to claim 3 wherein the movable gate includes a venting insert which defines the at least one venting aperture.
6. A separating apparatus according to claim 5 wherein the venting insert is manufactured of cast iron, copper and/or graphite.
7. A separating apparatus according to claim 1 wherein the separating vessel includes an open top for receiving the fusion of collector material and molten slag from a reaction vessel; and wherein the interior cavity terminates in a conical lower portion.
8. A separating apparatus according to claim 7 wherein the separating vessel is dimensioned such that in use the molten slag first enters the interior cavity when the fusion of collector material and molten slag is introduced into the separating vessel, forming a thin slag layer at the lower extremity of the separating vessel which solidifies into a thin-layered slag pocket in the conical lower portion of the separating vessel and which terminates in a slag plug that is trapped within the

outlet duct, the molten slag being followed by the molten collector material, which displaces the molten slag in the lower extremity of the separating vessel and is arrested within the slag pocket between the slag plug and the molten slag.

9. A separating apparatus according to claim 1 wherein the outlet duct of the separating vessel has a diameter of 4mm – 12mm, and preferably a diameter of 6mm – 10mm.
10. A separating apparatus according to claim 1 wherein the movable gate slidingly engages the separating vessel.
11. A separating apparatus according to claim 1 wherein the movable gate is hingedly disposed relative to the separating vessel.
12. A separating apparatus according to claims 10 or 11 wherein the movable gate includes a recess which is co-axially disposed below the outlet duct of the separating vessel when the movable gate is in the first, closed position; and wherein the recess is dimensioned to accommodate the slag plug.
13. A separating apparatus according to claim 12 wherein the recess is dimensioned to shear off the slag plug when the movable gate is moved between the first, closed position and the second, open position thereby to expose the molten collector material.

14. A separating apparatus according to claim 12 wherein the recess has a depth of 0.3mm – 3.0mm, and preferably a depth of 0.5mm – 1.0mm.
15. A separating apparatus according to claim 12 wherein the movable gate includes a draining aperture which is laterally disposed from the recess and which is co-axially disposed below the outlet duct when the gate is in the second, open position such that the draining aperture defines a downwardly depending draining tube extending from the outlet duct of the separating vessel and against which the collector mould sealingly engages, such that collector material drains through the draining tube into the collector mould.
16. A separating apparatus according to claim 15 wherein the draining tube is a tapered tube, in particular tapering outwardly from the separating vessel towards the collector mould.
17. A separating apparatus according to claim 1 wherein the movable gate is manufactured of cast iron.
18. A separating apparatus according to claim 1 wherein the movable gate includes locking means for locking the movable gate in the first, closed and second, open positions respectively.

19. A separating apparatus according to claim 1 wherein the collector mould is a chilled mould, in particular a water-cooled copper mould.
20. A separating apparatus according to claim 15 wherein the collector mould sealingly engages the movable gate in such a way that collector material drains through the outlet duct of the separating vessel and the draining tube of the movable gate directly into the collector mould without being exposed to atmospheric air, and in particular to oxygen.
21. A separating apparatus according to claim 20 wherein the collector mould and the draining tube of the movable gate are dimensioned such that, upon casting the collector material from the separating vessel into the collector mould, the collector material fills the collector mould and then extends upwardly into the draining tube, filling a lower portion of the draining tube, such that when the collector material solidifies, it is in the form a button of collector material.
22. A separating apparatus according to claim 21 wherein the button of collector material has a substantially disc-shaped body and a short elongate stem, extending from the body and which is defined by the draining tube, the stem being sealed at its end by a thin layer of slag that drains into the draining tube, following the collector material, during the casting step.

23. A separating apparatus according to claims 1 and 2 wherein the collector mould includes at least one venting aperture for permitting egress of air from the collector mould so as to allow for efficient draining of collector material into the mould.
24. A separating apparatus according to claims 3 and 23 wherein the at least one venting aperture of the collector mould is arranged coaxially with and beneath the at least one venting aperture of the movable gate when the movable gate is in the second, open position, so that air in the collector mould vents to atmosphere through the at least one venting aperture in the collector mould and the at least one venting aperture in the movable gate during draining of collector material into the mould.
25. A separating apparatus according to claims 4 and 24 wherein the collector mould includes a number of venting apertures that are coaxially arranged with and beneath the venting apertures in the movable gate when the movable gate is in the second, open position.
26. A separating apparatus according to claim 1 wherein the collector mould is disposed within a cast iron base.
27. A separating apparatus according to claim 25 including an additional copper sleeve disposed within the cast iron base for increasing cooling efficiency of the collector mould.

28. A separating apparatus according to claim 1 including lifting means for lifting the collector mould into engagement with the movable gate and lowering it to a position removed from the movable gate and the separating vessel.
29. A separating apparatus according to claim 1 wherein the separating vessel is moveable between a first position in which it receives the fusion of collector material and slag, and a second position in which it discards the slag after the collector material has been drained from the separating vessel.
30. A separating apparatus according to claim 28 wherein the separating vessel is pivotally movable between the first and second positions.
31. A separating apparatus according to claim 1 wherein the separating vessel is manufactured from graphitised cast iron.
32. A method for quantitatively separating molten collector material and a molten slag during a process of assaying mineral ore samples to determine the concentration of selected metals in such samples, the method comprising the steps of providing the apparatus as claimed in anyone of claims 1, 8, 12 or 28; fusing, in a reaction vessel, a mixture of a comminuted mineral sample and flux material to form a fusion of molten collector material, which serves to extract the metal present in the mineral sample, and a molten slag, wherein the

collector material has a greater density and/or lower viscosity than the slag; moving the separating vessel to the first position for receiving the fusion of collector material and slag; moving the movable gate to the first, closed position such that the recess is co-axially disposed below the outlet duct of the separating vessel; introducing the fusion of collector material and slag into the separating vessel such that the molten slag first enters the separating vessel and solidifies into a thin-layered slag pocket in the conical lower portion of the separating vessel, terminating in a slag plug that is trapped within the outlet duct, followed by the collector material, which displaces the molten slag in the lower extremity of the separating vessel and which is arrested within the slag pocket between the slag plug and the molten slag; allowing the slag plug to solidify; moving the movable gate to the second, open position such that the recess shears off the slag plug to expose the molten collector material, and draining the molten collector material into the collector mould to isolate the collector material from the slag.

33. The method according to claims 15 and 31 wherein the downwardly depending draining tube is disposed co-axially below the outlet duct of the separating vessel when the movable gate is moved to the second open position.
34. A method according to claim 31 wherein the collector material is lead.

35. A method according to claim 31 including the step of lifting the collector mould into airtight engagement with the movable gate before moving the movable gate to the second, open position.
36. A method according to claim 31 including the further step of allowing the collector material, after draining into the collector mould, to solidify to form a solid button of collector material, sealed at its upper extremity with a thin slag layer; lowering the collector mould and the button of collector material away from the movable gate; removing the button of collector material from the collector mould; and removing the thin slag layer from the button.
37. A method according to claim 35 including the further step of moving the separating vessel to the second position to discard the slag.
38. The method according to claim 31 wherein the mineral ore samples are assayed in discrete individual batches of different composition to determine the concentration of selected metals in such samples.
39. A separating apparatus according to claim 1 substantially as herein described and exemplified with reference to the accompanying figures.
40. A method according to claim 31 substantially as herein described and exemplified with reference to the accompanying figures.

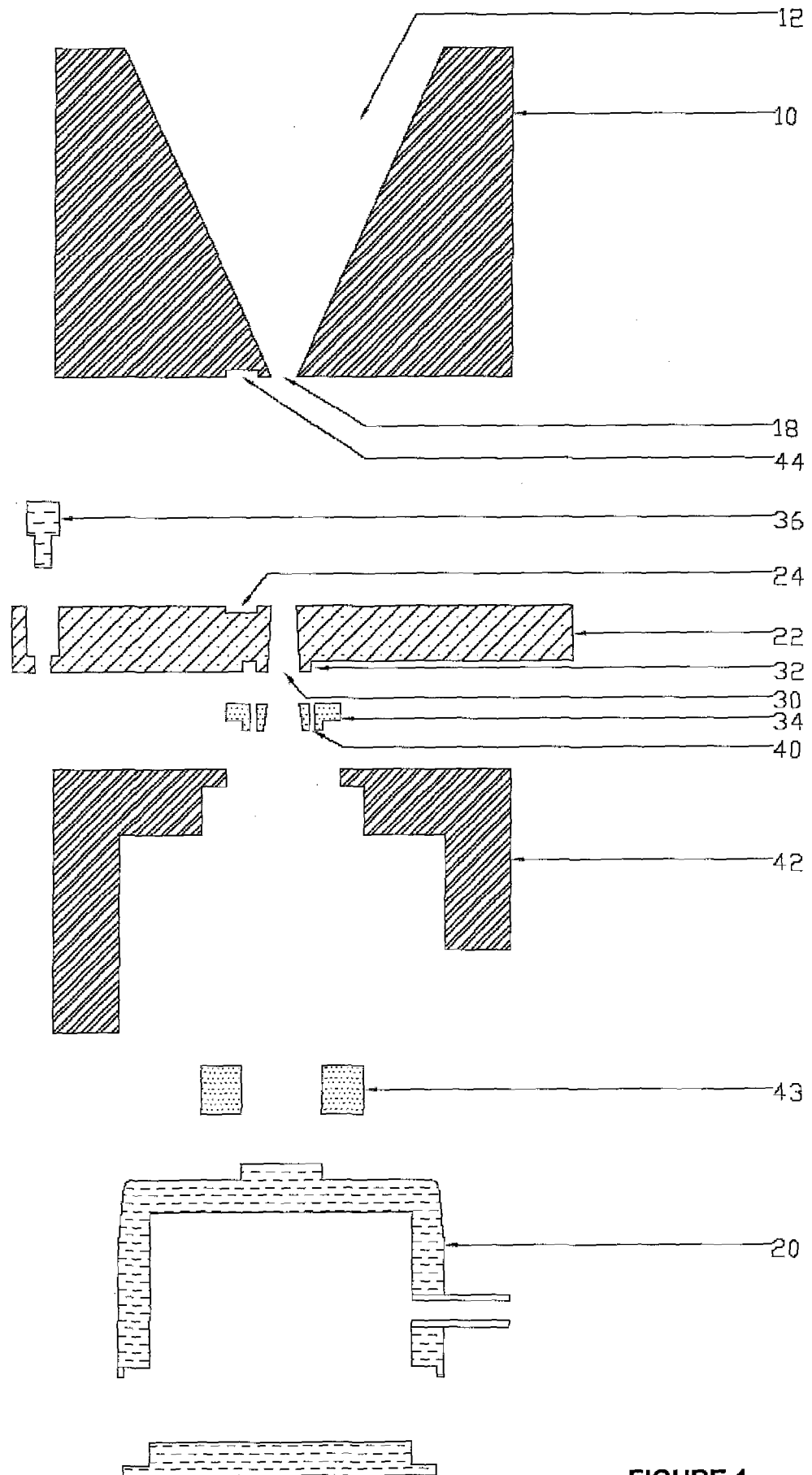


FIGURE 1

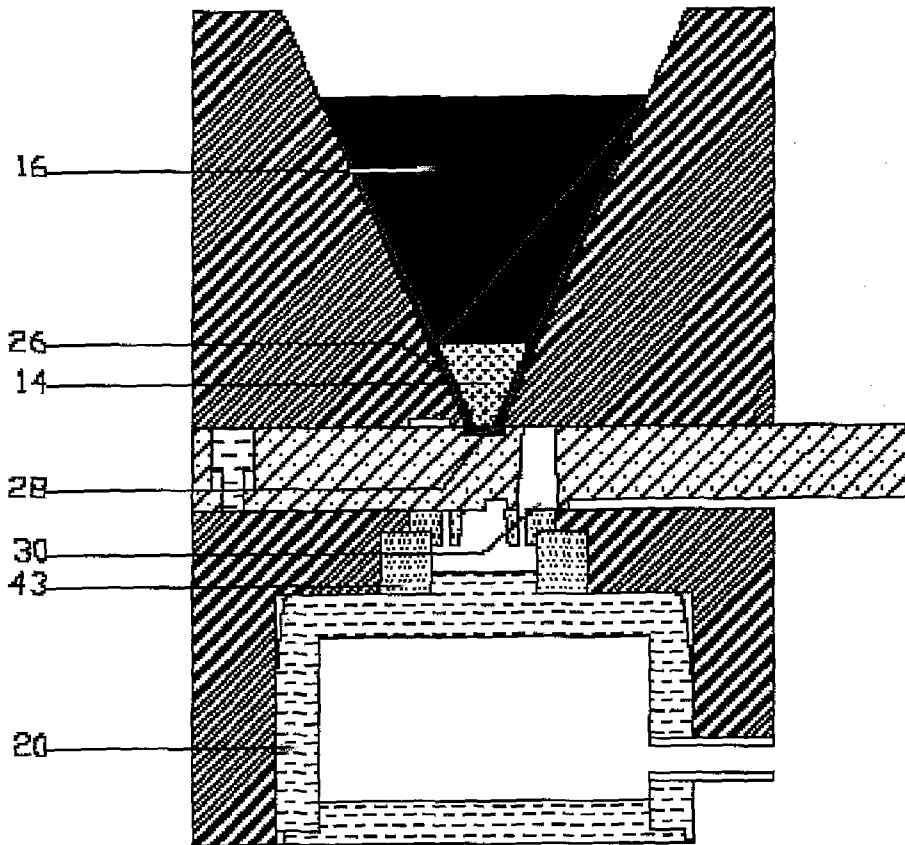


FIGURE 2(a)

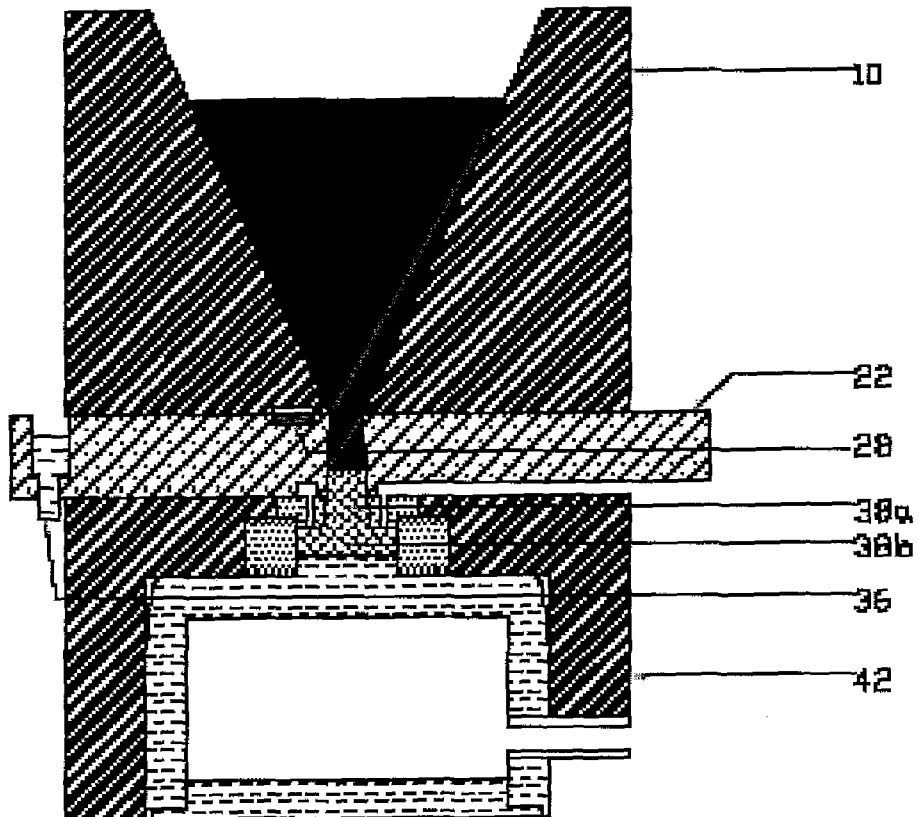


FIGURE 2(b)

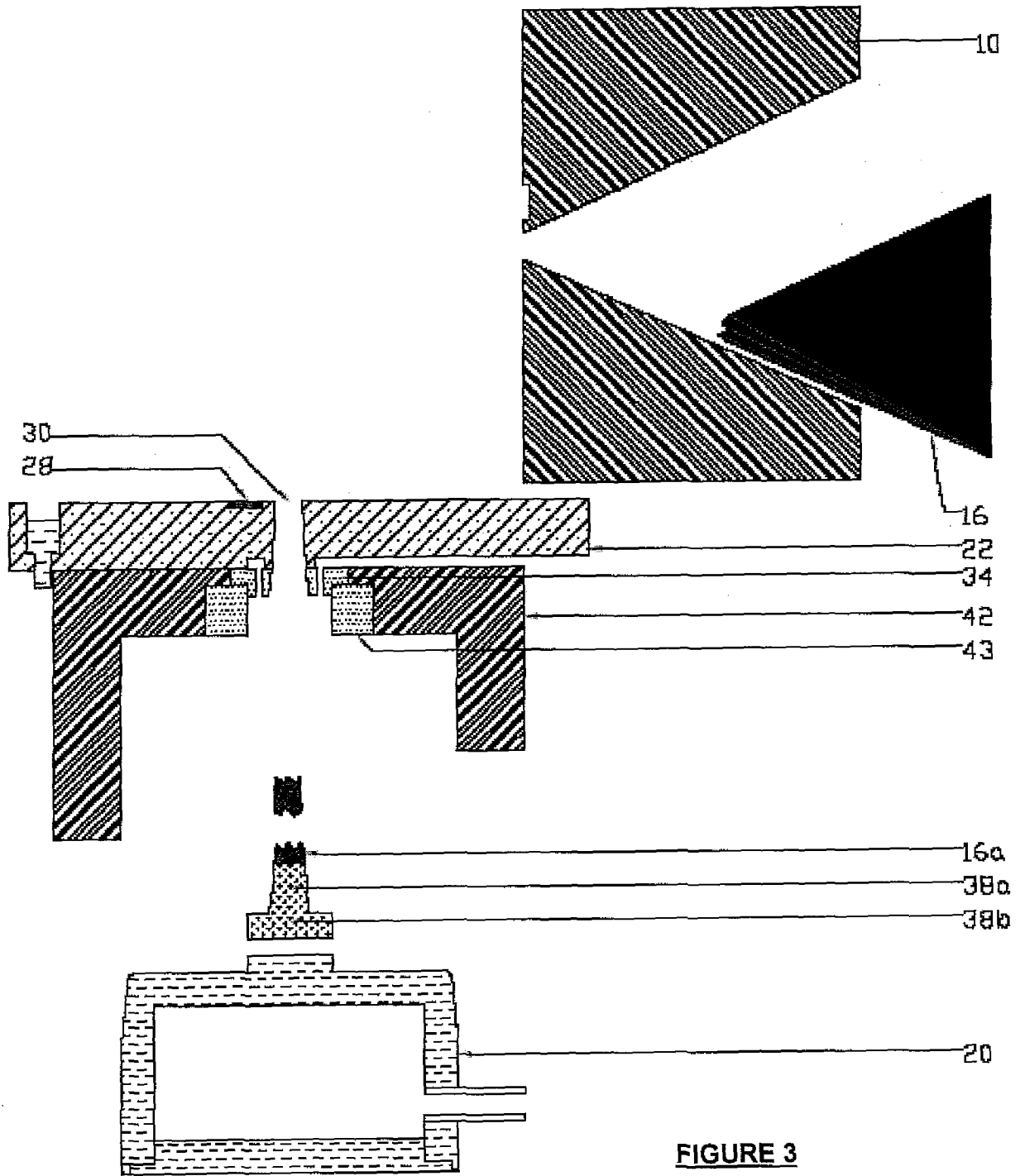


FIGURE 3