United States Patent

[11] 3,620,370

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[54] **ORE CONCENTRATOR**
5 Claims, 13 Drawing Figs.

[52] **U.S. Cl.** **209/144,** 209/148, 209/135, 209/250
[51] **Int. Cl.** **B04c 3/00**
[50] **Field of Search** ..... 209/144, 139 A, 148, 149; 55/393, 406

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ABSTRACT: Concentrators for metallic ores, particularly precious metal ores, using centrifuging cyclonic air action without water for primary separation of the heavy metal particles and ore from dust, dirt and lighter particulate. The relatively coarse ores and particulate are collected by gravity drop at the bottom of a centrifuge, while the fines and dust are withdrawn from adjacent the top thereof and fed through a further separating apparatus which blows out the dust and then passes the remaining particulate over dry riffle boards to collect the heavy particles. The cyclonic centrifuge is in the form of an upper, frustoconical, internally baffled or corrugated construction with a lower, inverted, frustoconical section likewise internally baffled or corrugated, the sections joining at their largest diameters. Pulverized ore particulate which is to be further concentrated is introduced through the upper frustoconical section. Air is drawn into the device from the top and bottom through a generally centrally located fan and then exited tangentially from the upper section, or, in another embodiment, the air is entered tangentially, with or without the fines therein, and exits the cyclonic separator from the top and bottom. A particulate collector ring may be mounted at the junction between the upper and lower centrifuge sections. The further separator comprises a velocity reducer and agitator and a dispensing box through which the fines pass with removal of the dust and with the dropping of the particulate onto the dry riffle boards.

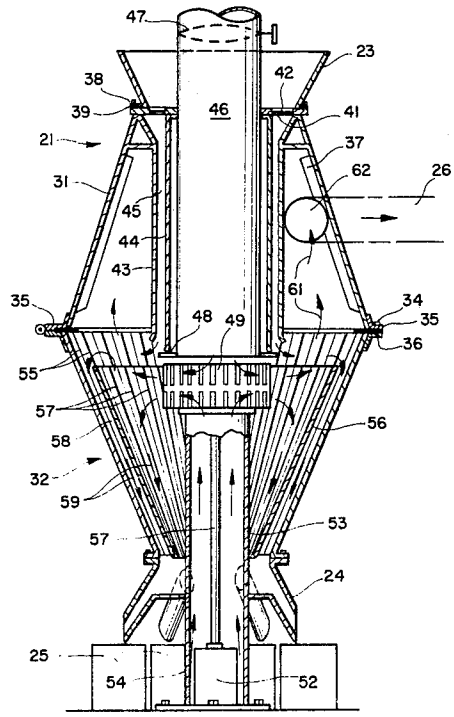
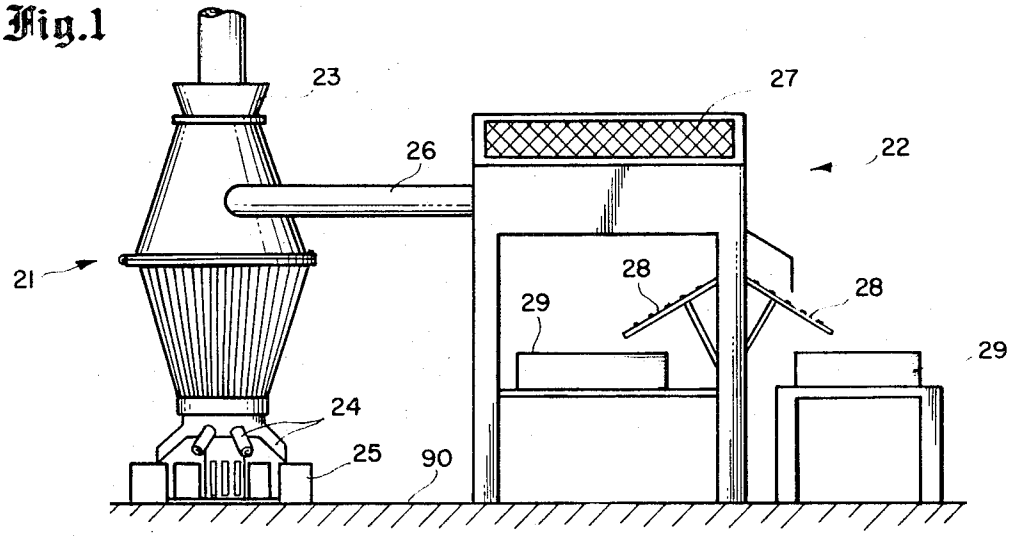


Fig.1



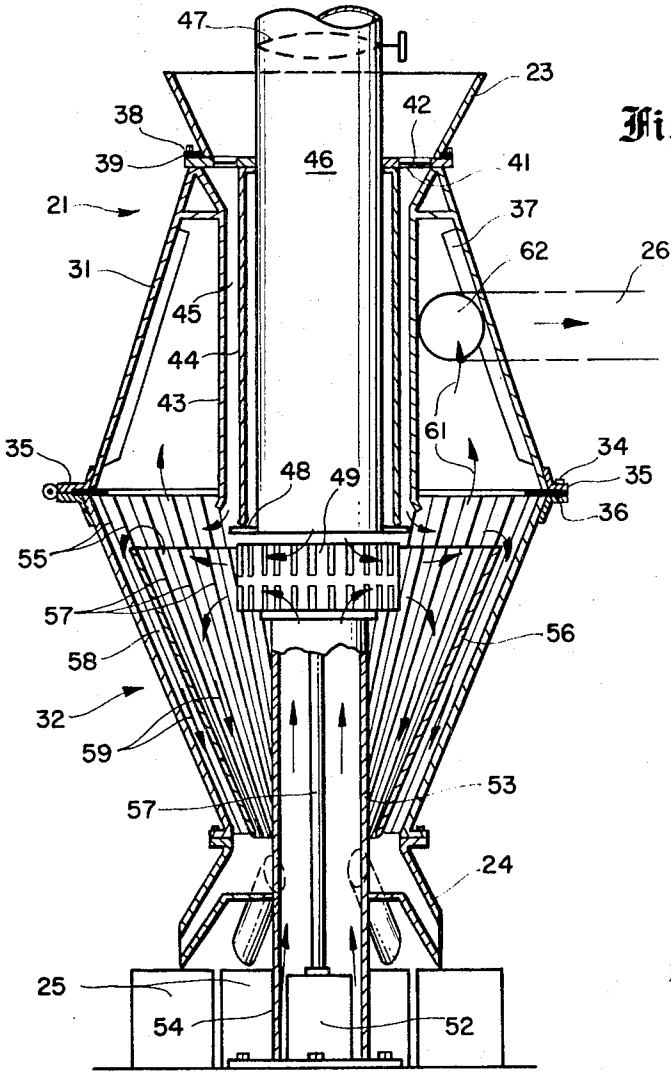


Fig.2

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Fig. 3

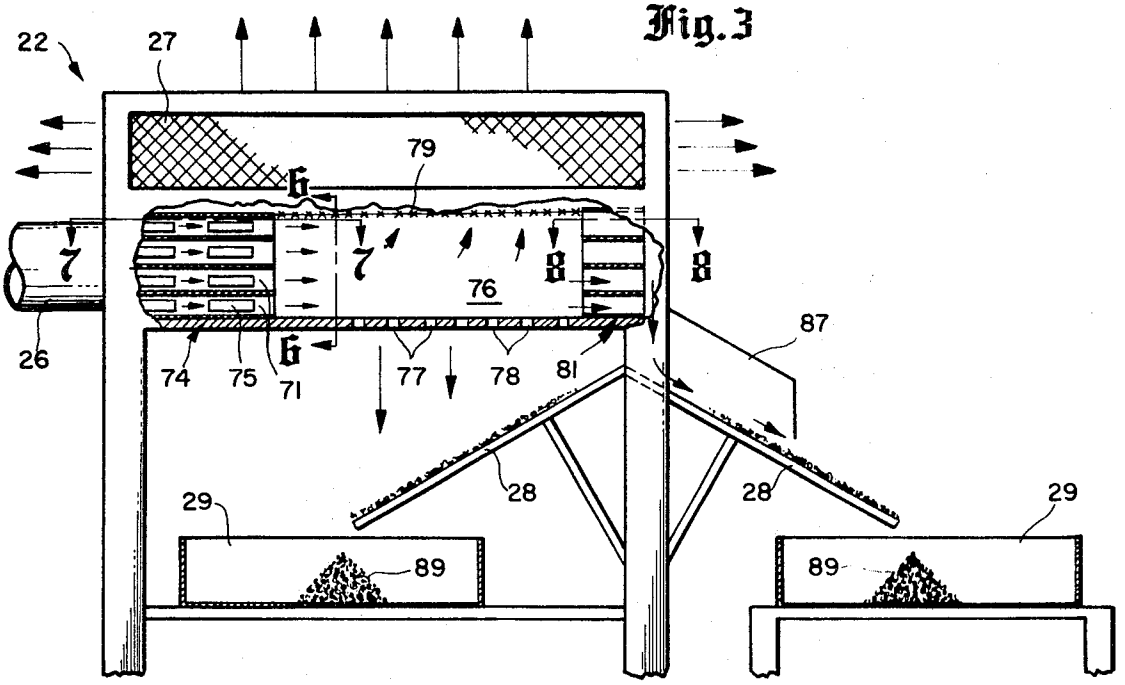


Fig. 5

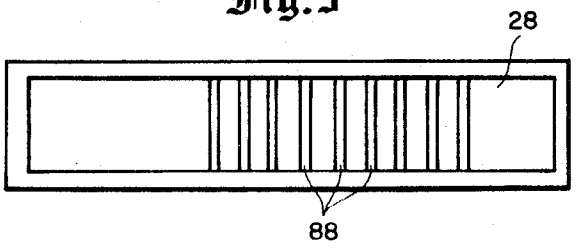


Fig. 4

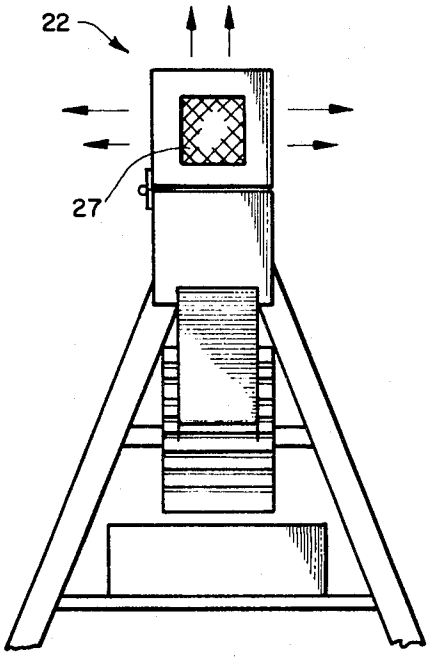
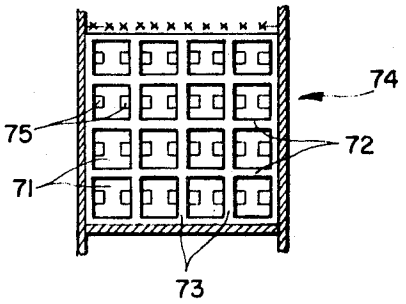


Fig. 6



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Fig.7

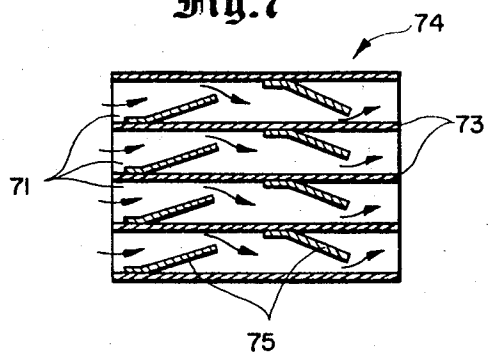


Fig.9

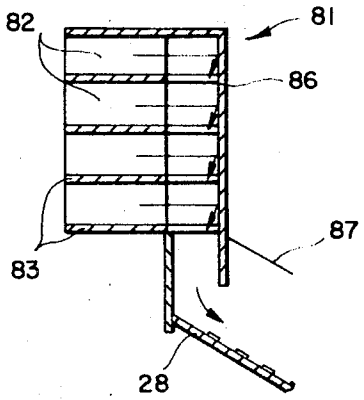


Fig.8

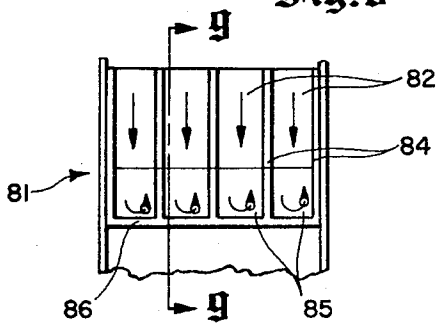
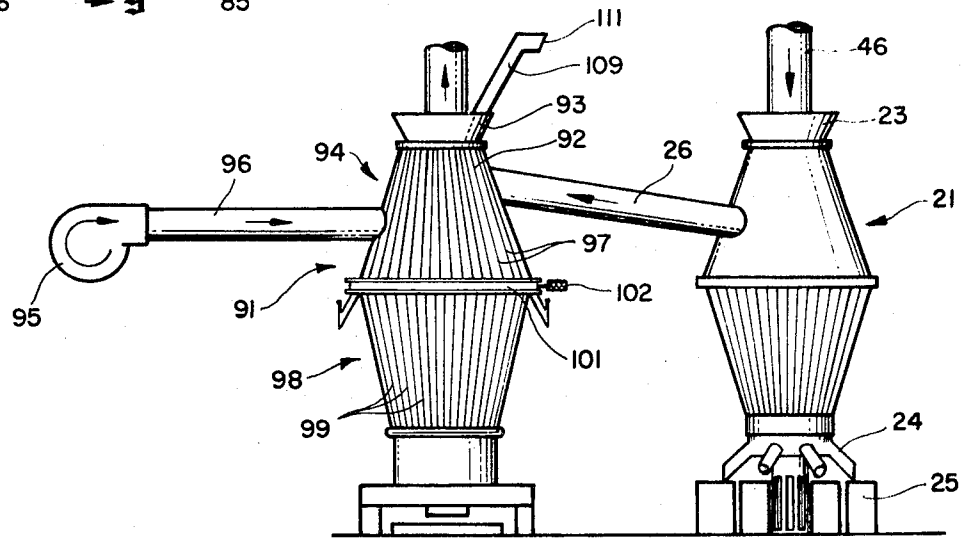


Fig.13



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Fig.10

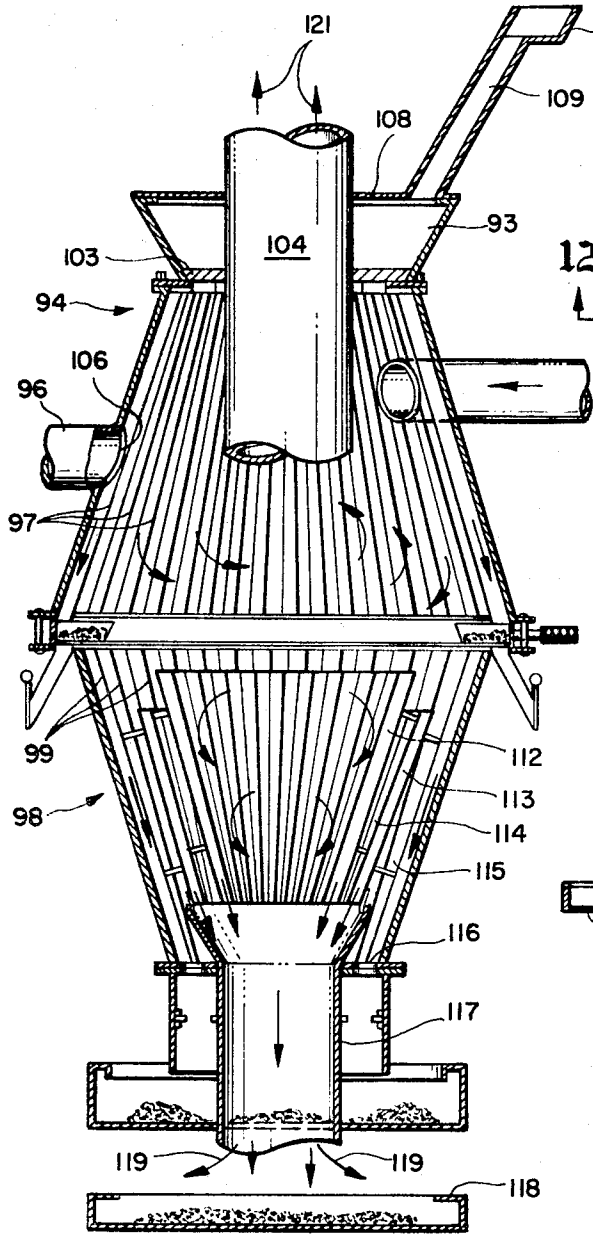


Fig.11

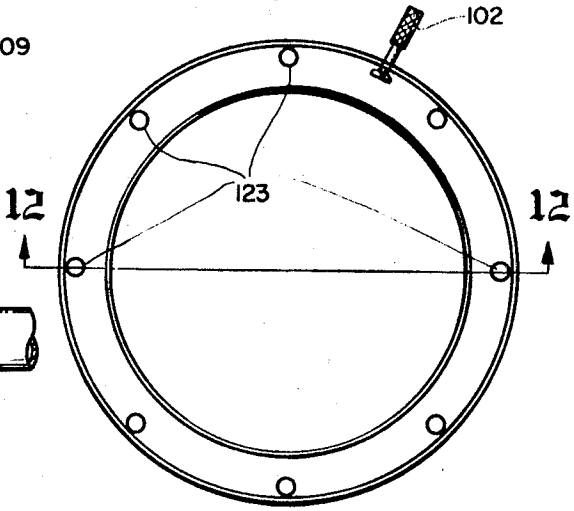
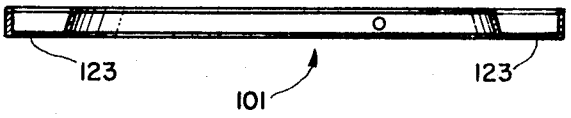


Fig.12



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ORE CONCENTRATOR

BACKGROUND OF THE INVENTION

This invention is in the field of ore concentrators for separating metallic particles and ore from dust, dirt and other waste materials, and for increasing the percentage of valuable ores in a particulate.

The dry concentration of metallic ores by cyclonic centrifuge with air in the absence of water is known in the art, but for various reasons has not been efficient or economical in operation and separation of the valuable ore from the waste material. The centrifuges used have been constructed without regard for the most efficient separation and collection of the materials. Also, the prior art has lacked the combination with the cyclonic centrifuge separator of a further separator for separating the dust from the metallic fines, particularly those which are withdrawn upwardly from the centrifuge while the heavier and larger particles are gravity dropped therethrough. The efficiency of the concentration operation over that of known apparatus is increased by the construction of the centrifuge and may be further increased by sending the fines through a pair of centrifuges of different construction. Attempts to separate particulates of different specific gravities, including ores, are represented in the following patents:

U.S. Pat. No.	Patentee
609,540	Gray
883,278	Belt
1,579,660	Reilly
2,099,505	Weaver
2,883,407	Mead et al.
3,289,318	Roos

SUMMARY OF THE INVENTION

The ore concentrators of the present invention are constructed to operate, preferably, on previously pulverized ore having a particle size of approximately one-sixteenth inch, mixed with dust and fine metal and ore particles. The invention is particularly adapted for use in processing waste heaps of ore, although it is also usable as a primary separator of raw mined ore.

The cyclonic centrifuge portion of the apparatus comprises upper and lower frustoconical sections inclining in opposite directions from a central large diameter, that is, the lower section being inverted, and with the interior surfaces of the sections provided with baffles or accordion-pleated corrugations for stopping or slowing rotation of the particulate impinging thereagainst, the larger sized particles dropping by gravity through the inverted lower section, and the dust and metal and ore fines being exhausted tangentially from the upper section of the centrifuge. The lower section of the centrifuge preferably has one or more smaller, inverted, concentric cones therein which may likewise be baffled or corrugated to slow rotation of the particulate material. These lower cones are spaced from the main outer wall to provide an inverted frustoconical passage therebetween through which the larger particulate may pass by gravity drop to collection means at the bottom of the centrifuge. In one embodiment, a blower or centrifugal fan is mounted generally centrally in the centrifuge and the ore to be concentrated is dropped into the cyclonic vortex created thereat without impinging on the blower or fan. This ore particulate is then rotated in the vortex with the larger particulate engaging the inverted frustoconical surfaces to slow up rotation, shake dust and fines therefrom, and then drop by gravity into collection areas at the bottom of the centrifuge. In this device a central ring is provided to prevent the larger particles rising into the upper portion of the centrifuge and the dust and fines rise with the air, impinge on corrugations or baffles on the walls of the upper section, and then exit generally tangentially thereof.

The dust and fines leaving the upper portion of the centrifuge are further concentrated either in a stationary separator and riffle board arrangement, or may be passed through a second centrifuge from which the dust only is exhausted.

In the stationary separator, there are provided a plurality of substantially horizontal, nested tubes which extend parallel with an interruption intermediate the end portions, from which the waste dust is removed. The passages through entrance portion of the tube separator are provided with fingers which both agitate and slow up the movement of the dust and fines which then pass into the interrupting free chamber. The waste dust is removed from this chamber, some of the particulate dropping downwardly upon a riffle board, other portions of the particulate passing through the exit passage portions of the tubes to impact on an end surface and drop vertically onto another riffle board therebeneath. The lightweight material passes downwardly over the riffle boards into riffle boxes as waste material, and the heavy metal particles and ores collect in the transverse pockets of the riffle boards to be removed therefrom in known manner.

In cyclonic centrifuge separation for the dust and fines exiting the primary concentrator, another double-cone construction is used with the internal surfaces baffled or corrugated to stop or slow rotation of particulate impinging thereon. The combined dust and fines are here introduced tangentially into the upper portion of the centrifuge and booster air may likewise be introduced tangentially at this point. The dust and fines rotate in the centrifuge with the particulate material finally dropping by gravity through the lower inverted conical sections, which may, as before, be of multiple cone construction with conical chambers therebetween, into receptacles at the bottom. Several conical chambers may be provided dropping particulate therethrough into different locations. In this second centrifuge for the dust and fines, the air enters, as stated, tangentially of the upper portion and exhausts with the waste dust centrally from the top or bottom, or both, of the centrifuge.

In the centrifuging concentrators, it is found that there tends to be a concentration of heavy metal particulate adjacent the middle, high-pressure part of the centrifuge and a ring chamber or receptacle may be placed at this location to collect these heavy metal particles separately from those which are gravity dropped through the lower portion of the centrifuge.

The above-described second centrifuge separator for the dust and fines may also be used as the primary separator with ore fed into the upper portion by the centrifuge, and air only blown tangentially into the upper portion with primary concentration taking place in the centrifuge. This construction avoids an internal blower or fan in the cyclonic centrifuge.

The separators of this invention operate with greater efficiency than those of the prior art in removing a greater proportion of waste material, while saving a greater proportion of the desired valuable metallic ore and particles. The centrifuge construction of both the internal blower and external pressure air feed is improved over prior art construction and operates with greater efficiency, and the combination of the centrifuges, as well as the combination of a primary centrifuge with the stationary separator, further increases the efficiency of the concentration and the percentage of the desirable and valuable ore and particulate which is retained by the device while waste material is removed therefrom.

Other objects and features of the invention will be apparent to those skilled in the art from the following specification and the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view of a combined centrifuge and horizontal tube ore concentrator according to the invention;

FIG. 2 is a vertical sectional view through the cyclonic centrifuge portion of FIG. 1;

FIG. 3 is a side elevational view with parts broken away of the stationary tube separator for the dust and fines and including the riffle board arrangement;

FIG. 4 is an end elevational view of the separator of FIG. 3;

FIG. 5 is a top plan view of a riffle board;

FIG. 6 is a vertical sectional view on the line 6—6 of FIG. 3;

FIG. 7 is a horizontal sectional view on the line 7—7 of FIG. 3;

FIG. 8 is a horizontal sectional view on the line 8—8 of FIG. 3;

FIG. 9 is a vertical sectional view on the line 9—9 of FIG. 8;

FIG. 10 is a vertical sectional view through the modified form of cyclonic centrifuge which is used primarily to separate the dust from the fines;

FIG. 11 is a plan view of a collector ring receptacle from the centrifuge of FIG. 10;

FIG. 12 is a sectional view through the collector ring of FIG. 11, taken on line 12—12 thereof; and

FIG. 13 is an elevational view of a combined concentrator using the centrifuges of FIGS. 2 and 10.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows the combination of a double-cone cyclonic centrifuge 21 and a fines separator 22. The centrifuge 21 has an ore hopper 23 for the introduction of pulverized raw ore which may be of a particle diameter, for example, of one-sixteenth inch. The coarser particulate exits the centrifuge from the bottom through the pipes 24 into bins 25. Fines of small metal particles, ore and dust are taken tangentially from the upper part of the centrifuge 21 through the pipe 26 into the separator 22 from which the waste dust is blown through the grill 27, the fine particulate is dropped onto riffle boards 28 which catch the heavy metal particles, and ore and drop waste particulate into disposal bins 29.

A vertical sectional view through the cyclonic centrifuge 21 is shown in FIG. 2 with a frustoconical upper section 31 and an inverted frustoconical section 32 hingedly connected together at 33 and lock bolted at 34 to permit tilting rotation of the top section into an open position relative to the bottom section. The sections 31 and 32 are clamped together at their largest diameters against a sealing ring 35 which has an annular extension 36 into the interior of the centrifuge to provide a baffle or abutment under- surface against which some of the coarser particulate is driven in the cyclonic centrifuge.

The inner surface of the upper conical section 31 is provided with baffle plates, or is accordion pleated, or is corrugated, at 37 against which particulate is driven to slow its rotary motion and permit gravity drop through the centrifuge. The hopper 23 may be mounted on the upper edge of the top section 31 by bolts 38 against a sealing gasket 39. Holes 41 are provided in the bottom of the hopper through which the raw ore enters the centrifuge and have screens 42 therein which prevent the entrance of large pieces into the centrifuge and also tend to restrict the exit of air thereat.

Centrally of the upper section 31 are a pair of spaced, concentric, cylindrical pipes 43 and 44 defining therebetween a cylindrical passage 45 through which ore from the hopper 23 is directed into the middle part of the centrifuge. An air intake pipe 46 provided with a damper 47 is sealed within the internal cylindrical pipe 44 and introduces air adjacent the middle of the centrifuge. The bottom of the air inlet pipe 46 is provided with a flange 48 which extends partially beneath the cylindrical ore passage 45 to prevent the incoming ore from impinging on or directly hitting a blower fan 49 disposed in the centrifuge beneath the air pipe 46 and adjacent the upper part of the lower inverted frustoconical section 32.

The blower fan 49 is of the centrifugal type and provides a rotating cyclonic air flow within the centrifuge. It is drivingly mounted rotatable on a shaft 51 which is, in turn, drivingly connected to a motor, engine, pulley or other driving means 52. The shaft 51 is surrounded by a bottom air intake pipe 53 having bottom openings 54 through which air is inducted to the fan 49. Air thus enters the centrifuge both downwardly through the pipe 46 and upwardly through the pipe 53, to the fan 49 where it is given a circular cyclonic movement.

Into this rotating stream of air is introduced the raw ore which passes from the hopper 23 through the cylindrical passage 45 over the annular baffle plate 48 and then into the cyclonic zone. The particulate material entering the airstream is rotated thereby and moved outwardly by centrifugal force in conventional manner until it engages the interfering baffled or corrugated surfaces of the centrifuge which shake off the dust and slow down the coarser particles so that they drop by gravity to the bottom of the centrifuge and through pipes 24 into the bins 25.

The lower, inverted frustoconical section 32 is provided with accordion-pleated corrugations 55 and has mounted adjacent thereto a smaller diameter, inverted frustoconical member 56 whose surface may likewise be corrugated at 57 and which provides between its outer surface and the inner surface of the lower section 32 an inverted frustoconical passage 58 through which a part of the coarser particulate may drop to the exit pipes 24.

The coarser and heavier particles within the centrifuge are engaged with the baffles or corrugations 37, 55 and 57, have their rotation slowed, and drop, by gravity, as indicated by the arrows 59, to the lower exit from the centrifuge. The fine metallic particles, ore and dust rise with the air in the centrifuge, as indicated by the arrows 61, and the combined air and fines are taken tangentially from the upper section 31 through an opening 62 therein into the pipe 26. It will be noted that some of the particulate, particularly of intermediate size, will engage the undersurface of the ring 36, as indicated by the arrows 63, will be prevented from rising into the upper section 31 and forced into engagement with the corrugations 55 which will slow it up sufficiently so that it will gravity drop through the passage 58 to the bottom exit.

With the apparatus and operation above explained, the centrifuge 21 gives a first separation between the coarser and heavier particulate and the metal, ore, fines and dust, the former dropping into the bins 25 while the fines and dust exit with the air through the pipe 26. The concentration of valuable ore in the waste material is generally greater in the lines exiting through the pipe 26 than in the coarse particulate of the bins 25.

The separator for the fines is more particularly illustrated in FIGS. 3 through 9. It disposes at the exit end of pipe 26 a plurality of horizontal rectangular tubes 71 nested together and formed between horizontal parallel walls 72 and vertical parallel walls 73, as shown more particularly in FIG. 6, and forming an entrance multitubular section 74. Within the tubes 71 and mounted, for example, on the vertical walls 73, as by welding, are fingers 75 which interfere with the air flow through the tubes 71, agitate the fines and dust in the air, and decelerate their movement. The tubes 71 exit into a chamber 76 within the separator 22 in which the dust is separated from the metallic and ore fines by leaving the chamber 76 through an upper screen 79 and the outer grill 27. Metal and ore fines which are sufficiently slowed may drop by gravity through holes 77 in the bottom wall 78 defining the chamber 76.

At the right-hand side of the chamber 76, as viewed in FIG. 3, is another tube section 81, shown more particularly in FIG. 9, where horizontal rectangular tubes 82 formed between horizontal walls 83 and vertical walls 84, in an arrangement similar to that of section 74, exit into vertical tubular passages 85 defined by an end wall 86 against which ore and metal fine particles impact to drop by gravity through passage 85 onto one of the riffle boards 28, the particulate passing through the openings 77 dropping onto the other riffle board. An end hood 87 prevents bouncing of the particulate off the outer riffle board 28.

A riffle board 28 is shown in plan in FIG. 5 as having the usual crosspiece obstructors 88 over which the fine particulate passes, with the waste material at 89 dropping into the bins 29 while the valuable heavy fines and ores are collected in the pockets provided on the forward sides of the obstructors 88, in known manner. The waste material may pass over the riffle boards 28 by gravity slide or the boards may be vibrated to encourage the downward flow of the waste material. The highest concentration of valuable metal particles and ore will, of course, occur in the riffle board pockets. This will be very fine

material, but its percentage concentration in a given volume of waste material will be much higher than in the bins **25** where the coarser particulate collects and which is composed mainly of sand and small pebbles, although any small nuggets entering the centrifuge will also find their way into bins **25**.

The apparatus above described and shown in FIG. **1** may be mounted at a semipermanent location or may be portably mounted on the bed of a truck or trailer to be moved to various mine sites for the processing of waste heaps of ore. In the latter case, the surface **90** of FIG. **1** becomes the bed of the truck or other vehicle.

FIG. **13** illustrates the combination of a primary cyclonic centrifuge separator, as at **21**, previously described, with a second and different form of cyclonic centrifuge separator **91** having an upper tangential entrance at **92** for the combined dust and fines passing through the pipe **26** forming the exit from the centrifuge **21**. The centrifuge **91** may be provided with an auxiliary hopper at **93** for the entrance of raw ore whereby it may be used as a primary concentrator. The hopper exit is ordinarily closed in the combination of FIG. **13**. The air and fines **26** are introduced tangentially into the frustoconical upper section **94** and booster air may likewise be entered into the upper section **94** from a blower fan **95** and a pipe **96**. The upper section **94** has accordion-pleated corrugations at **97** and is mounted on an inverted frustoconical lower section **98** which has like accordion-pleated corrugations **99**. An annular collector bin **101** is disposed between the sections **94** and **98** and is rotatable through a small angle by a manual handle **102** so that the annular collector bin also serves as a valve.

The secondary of modified cyclonic centrifuge **91** is shown in vertical section in FIG. **10** and the annular collector ring **101** is shown in FIGS. **11** and **21**. When used as a secondary concentrator for the fines, the centrifuge **91** has the bottom of its hopper **93** closed by a removable sealing ring **103** to prevent the exit of air therethrough. The upper section **94** is now of simple frustoconical shape having, internally, only the exit air pipe **104**, the entrance **105** for the fines from pipe **26** and the entrance **106** from pipe **96** for the booster air, where used. The hopper **93** in this modification may be used where the centrifuge **91** is used as a prime separator, in which case the sealing ring **103** is removed and raw ore introduced into the centrifuge through the openings **107**. The hopper **93** differs from the hopper **23** previously described by having a lid **108** communicated through a passageway **109** with a small entrance hopper **111**.

The lower, inverted frustoconical section **98** has concentric, smaller diameter, corrugated, frustoconical members **112** and **113** therein providing therebetween an inverted, frustoconical passage **114**, and, between the member **113** and the inner wall of the lower section **98**, an inverted frustoconical passage **115**. Particulate material which is heavier and of larger size passes down the wall of the section **98** after being slowed by the corrugations **99** and through holes **116** into a bin **120**. Lighter particulate and air pass through the passage **114** and the interior of the member **112** to a lower exit pipe **117**, the particulate falling into a bin **118** while the air exits to atmosphere, as indicated by the arrows **119**. Air and waste dust issue upwardly through the pipe **104**, as indicated by the arrows **121**. The relative quantities of air flowing upwardly and downwardly out of the centrifuge **91** can be controlled to some extent by the members **112** and **113**, particularly if they are mounted in the lower section **98** with their axis rotated **180** degrees so that they are no longer concentric with the section **98**, but are now upright like the section **94**. Their positions direct and control the movement of the air and the proportions in which the exiting air divides air between the upper pipe **104** and the lower **117**. In all cases the particulate is slowed by engagement with the corrugated interiors of the upper section **94**, the lower section **98** and the members **112** and **113** and then gravity drops either through the holes **116** or the pipe **117** into the bins **120** and **118**, respectively.

It has been found that there is a tendency for highly concentrated metal particles and ore to be deposited adjacent the largest diameter portion of the centrifuges **21** and **91**, that is, at the interior junction of the upper and lower sections. To collect this high value concentrate, there may be provided, in both centrifuges, an annular collection bin **101**. While not shown in the drawing, the mounting of the upper section **94** may be hinged, as described, for the centrifuge **21**, so that it may be tilted away from the lower section **98** and also the annular bin **101** may be removable from the centrifuge **91**, with or without substitution of a ring like that at **35** therefor. Below the annular bin **101** are mounted stationary exit pipes **121** which may be closed by manual or spring-biased closing plates **122**. The annular collection bin **101** is rotatable through a small angle by a manual handle **102** to place exit holes **123** into and out of registry with the pipes **121**. The collection bin **101** therefore acts as a valve, since when the holes **123** are not indexed with the pipes **121**, they close off exit from the bin and permit accumulation of particulate within the bin, with the air blowing the lighter particulate over the top of the material in the bin so that the heavier and valuable metal particles and ore accumulate in the bottom of the bin **101** and may be periodically removed therefrom by rotating the bin to index the exit holes **123** with the pipes **121**, whereby highly concentrated particulate may be removed from the middle annular bin.

It will be understood that the centrifuge **91** may be used as a primary separator, in which case the ring **103** is removed and raw ore entered through hoppers **111** and **93** into the cyclonic air flowing within the upper section **94** of the centrifuge. In this case, air may enter the centrifuge through either or both of the pipes **26** and **96**. In such operation, the centrifuge **91** may be used either alone or as a primary separator in combination, for example, with a separator as at **22** in FIG. **1**, where it would replace the centrifuge **21**.

It will be further understood that the central collector ring **101** may be incorporated into the centrifuge **21** of FIG. **2** in place of the ring **35**, and the hopper **93** may be substituted for the hopper **23**, and that other modifications and changes may be made with regard to the foregoing detailed description without departing from the spirit of the invention.

I claim:

1. An ore concentrator for particulate material containing metallic ores comprising:

an upper upright frustoconical section;

a lower inverted frustoconical section joined to said upper section at their largest diameters, the axis of said frustoconical sections being vertical,

the interior surfaces of both of said sections having longitudinally extending baffle elements on the surface thereof;

means for introducing a cyclonic air sweep into said concentrator comprising an air inducing and rotating fan disposed generally centrally of said sections to rotate on a vertical axis therein, means for driving said fan, and air inlet means through both the bottom and top sections to said fan;

means for introducing particulate into said concentrator to be rotated therein by said air sweep, said particulate being slowed by engagement with the baffle elements on the interior surfaces of said sections, whereby at least portions of said particulate will gravity drop to the bottom of said lower section;

means for exiting air from said concentrator; and

means for collecting particulate at the bottom of said concentrator.

2. The concentrator defined in claim **1**, including:

an entrance for raw ore at the top of said concentrator; and

means for directing said ore into the airstream out of contact with said fan.

3. The concentrator defined in claim **2**, in which said directing means comprises:

a cylindrical passage leading from the top of the concentrator to the fan; and

baffle means at the bottom of said tubular passage for preventing the entering raw ore from impinging on the fan.

4. The concentrator defined in claim 1, including:

a tangential outlet in the upper portion of said upper section for the exit of air and fines from the concentrator.

5. The concentrator defined in claim 1 including:

an inverted frustoconical member in said lower section concentric with said lower section and spaced therefrom to provide a passage for the particulate material between said inner frustoconical member and the inner wall of said lower section;

second inverted frustoconical member inside said first member, said second member also having corrugated walls and defining between said first and said second members another passage for leading particulate to the bottom of the concentrator;

means for exiting air and waste dust from the top of said concentrator; and

means for collecting the separated particulate material from the bottom of said concentrator through said passages as well as from the interior surface of said second member.

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