ABSTRACT
The process comprises the sequential steps of classifying and selecting from gold-bearing siliceous material that fine material which passes a preselected screen, heating or roasting the selected material to a predetermined temperature, dry-air-float concentrating the material, and separating the material by wet-float slurry means. In practice, it has been found that the steps of heating and dry-air-float concentrating of the material may be performed concurrently.

Apparatus includes an inclined frame; a endless pervious belt assembly having a screen layer, a fabric layer and a multiplicity of riffle bars suitably fastened transversely at intervals to the fabric layer, the pervious belt being rectilinearly disposed at an angle coincident with the frame; a plurality of air-float cell assemblies transversely mounted in the frame and having one of the respective walls thereof contiguous with the belt; and a pulsating air supply assembly in communication with each of the respective air-float cell assemblies. In combination with the assemblies above described, the apparatus may be provided with a substantially enclosed housing formed by a multiplicity of abutting transversely mounted reflector assemblies disposed on the frame distally above the endless belt, and a tank assembly mounted on the frame. A heat assembly may be mounted in the housing between the reflector assemblies and the belt.
BANK MATERIAL

GRADING GRIZZLY

LARGE PARTICLES WASTE

SELECTED SMALL PARTICLES

VIBRATING SCREEN CLASSIFIER

WASTE

OVEN

AIR-FLOAT CONCENTRATOR

SLURRY CONCENTRATOR

FIG. 1
FIELD OF INVENTION

The present invention relates to the method and apparatus for processing gold-bearing ores, and, more particularly, to the method and apparatus for processing ores having extremely fine particulate gold not separable from the host materials by commonly known fired and chemical methods of extraction.

BRIEF DESCRIPTION OF THE PRIOR ART

It is well known that gold is usually hosted in siliceous materials. However, extremely fine particles of gold are extremely difficult to segregate from such materials, even though substantial quantities of gold may be hosted in sand and gravel materials. Fire and chemical assays frequently fail to reveal extremely small particles. Air-float concentrators, commonly known in the art, have, to some extent, been successfully used to segregate fine particles. Some similar flotation methods have been used successfully. It is known that particulate gold may be so fine that it may be floated and that it may not be recovered by air-float dry processes.

Accordingly, it is an important object of the present invention to provide a process by which extremely fine particulate gold may be segregated from its host materials.

Another object of the invention is to provide, in a concentrator, means by which commercial quantities of extremely fine particulate gold may be recovered.

These and other objects shall become apparent from the description following, it being understood that modifications may be made without affecting the teachings of the invention here set out.

SUMMARY OF THE INVENTION

Generally, the process of this invention comprises the sequential steps of classifying and selecting from gold-bearing siliceous material that fine material which passes a preselected screen, heating or roasting the selected material to a predetermined temperature, dry-air-float concentrating the material, and separating the material by wet-float slurry means. In practice, it has been found that the steps of heating and dry-air-float concentrating of the material may be performed concurrently.

Apparatus suitable to perform the steps of heating and dry-air-float concentrating here taught includes an inclined frame; a endless peripheral belt assembly having a screen layer, a fabric layer and a multiplicity of riffle bars suitably fastened transversely at intervals to the fabric layer, the previous belt being rectilinearly disposed at an angle coincident with the frame; a plurality of air-float cell assemblies transversely mounted in the frame and having one of the respective walls thereof contiguous with the belt; and a pulsating air supply assembly in communication with each of the respective air-float cell assemblies. In combination with the assemblies above described, the apparatus may be provided with a substantially enclosed housing formed by a multiplicity of abutting transversely mounted reflector assemblies disposed on the frame distally above the endless belt, and a tank assembly mounted on the frame. A heat assembly may be mounted in the housing between the reflector assemblies and the belt.

A more thorough and comprehensive understanding may be had from the detailed description of the preferred embodiment when read in connection with the drawings forming a part of this specification.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a flow chart setting out the steps of the method for processing gold as taught by this invention.

FIG. 2 is a left front perspective view of the concentrator apparatus of this invention.

FIG. 3 is a cross-sectional end elevational view of the apparatus taken substantially along the lines 3-3 of the FIG. 2 including the pulsating air supply assembly.

FIG. 4 is a fragmentary cross-sectional side elevational view, drawn to a larger scale, of the air-float cell assemblies and the traveling conveyer assemblies of this invention taken substantially along the lines 4-4 of the FIG. 2.

FIG. 5 is a fragmentary cross-sectional side elevational view of one of the air-float cells and the belt portions drawn to still a larger scale as viewed from the side opposite the FIG. 4.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and, more particularly, to the FIG. 1, the several steps of the method for processing gold-bearing ores here taught are set out in a flow diagram there shown. In practice, it has been found that a siliceous material, which may include such elements as silicon dioxide (SiO₂), tridomite, crytalmitite, or other unstable elements, is most likely to yield particulate gold (Au₂) when subjected to heat, since the unstable elements, such as tridomite and crytalmitite, tend to change physical state characteristics at relatively low temperatures, between 117⁰ centigrade and 275⁰ centigrade, thereby causing particulate gold to be separable from the mass. In pursuing the gold recovery process here taught, it has been found to advantage to separate and to classify bank-run materials by passing the bank-run materials through a commonly known grizzly, since a greater proportion of gold particles appears to result from treatment by the process of the present invention from the finer particulate mass than from particles of greater size, even when such particles are crushed or milled. Thus, it has been found economically more productive to select the lesser bulk of a mass having a lesser particle size. The selected smaller particles may be transported to a suitable processing site where the mass may be graded through a commonly known vibrating screen, preferably of two hundred mesh size screen. Although such grading may, in fact, take place at the mine location, material passing a two hundred mesh screen is light in weight and powder, and, therefore, difficult to transport. Hence, the first step of the process here taught is to classify a siliceous material and to select that fine material which passes a preselected screen size, such as two hundred mesh. Such material may thereafter be concentrated, as hereinafter disclosed.

The second step of the present process requires the heating of the selected siliceous material to approximately 200° centigrade. As earlier stated, certain substantially unstable elements in the mass tend to physically change and to apparently free particulate gold (Au₂) in the mass. It is important to note that gold does
not otherwise appear, or become available, in the mass of such material by other known means or processes than that taught by the present invention. Hence, the technological reasons or, in fact, the actual physical changes produced by the several steps are unknown. Suffice it to say that both the inventor and others taught to use and employ the sequential steps here taught have repeatedly been able to successfully recover gold from such materials.

An air-flow concentrator, commonly known in the art, such as that taught by U.S. Pat. No. 2,752,041 issued June 26, 1956 to R. E. Clint, has been found marginally satisfactory for laboratory concentrator production. However, air-flow concentrator means necessary to economically produce commercial quantities is hereinafter later more fully disclosed. Notwithstanding, the third step of the process of the present invention requires concentrating the selected particulate mass by blowing pulsating air currents through an inclined screen, a porous mat, or belt having ruffle bars, and through the selected particulate mass on the screen, mat, or belt. In this manner, particles tend to segregate with larger and smaller particles being in separate zoned masses.

The fourth and final step of the process of the present invention is to concentrate the gold product by the "wall-pannning" or "slurry concentrating" processes commonly known in the art in which the lighter sands tend to be floated away by the water and the heavier particles of gold tend to sink and to be concentrated at the bottom of the vessel. Slurry concentrating and sink-float separation methods and their modifications are well-known in the art; see: A. M. Gaudin Principles of Mineral Dressing, 1957; A. F. Taggart Hand Book of Mineral Dressing, 1943; and J. V. N. Door and F. L. Bosqui Cyanidation and Concentration of Gold and Silver Ores (2nd Ed., Chapt. IX).

In practice, it has been found that the steps of heating and of air floating may occur concurrently. However, air-flow concentrators, known in the prior art, are not adaptable for such combined concentrator processes, concentrated temperatures of 200° centigrade, or more, tend to destroy the screens and cloth mats forming a part of such concentrators. However, it has been found that circulating air at such temperatures, combined with continuous movement of the apparatus, tends to avoid such destruction, particularly when high-temperature materials, such as asbestos fabrics, are used in combination with continuously moving mat or belt elements.

The combination concentrator of the present invention is shown to advantage in the FIG. 2, and is generally identified by the numeral 10. The concentrator 10 of the present invention may be similar to a cyanar reduction furnace used and employed in the production of mercury, modified, however, to the needs and requirements of the process of this invention. The combination concentrator 10 may be conveniently divided into a feeder assembly 11; a plurality of air-flow cell assemblies 12, more clearly shown in the cross-sectional views of the FIGS. 3, 4 and 5; a pulsator-air supply assembly 13; a multiplicity of combination reflector assemblies 14; a heat assembly 15; a traveling float conveyor assembly 16; a concentrator tank assembly 17; including a slurry discharge means 18; and a material exitway 19. The combination concentrator 10 is downwardly inclined at an angle from the feeder assembly 11 towards the material exitway 19. The concentrator 10 is carried by a frame 20 comprising a substantially tablike structure supported by legs 21. The concentrator 10 may include a substantially enclosed housing, such as is formed by the reflector assemblies 14 and the concentrator tank assembly 17, mounted on the frame 20.

The feeder assembly 11 is mounted at one of the terminal ends of the concentrator 10, and includes a hopper 22, its discharging end issuing onto the traveling float conveyor assembly 16 mounted in the frame 20, as hereinafter later described. In practice, it has been found to advantage to provide a commonly known vibrator means mounted on the hopper 22, such as generally shown at 23, since the selected material mass tends to be dense, and, thereby, otherwise bridge the discharge opening in the hopper 22, unless it is mechanically caused to move therethrough, such as by the vibrator means 23.

Referring now to the FIGS. 4 and 5, the air-flow cell assemblies 12 are shown to advantage. The cell assemblies 12 are mounted transversely in side by side abutting relationship in the frame 20. Each of the cell assemblies 12 comprises a box-like pan 24 having an upstanding side walls 25, a bottom wall 26, and a perforated top wall 27. The top wall 27 includes a perforated plate 28, a selected fine-mesh screen 29, and a table board 30 having a plurality of venturi-like air passageways 31. The passageways 31 are provided with areas of larger diameters at each of the respective opposite terminal ends thereof, while the central portions of the passageways 31 are a smaller diameter. Each of the cell assemblies 12 are in communication with the pulsator-air supply assembly 13, being interconnected to the assembly 13 by a respective conduit 32 suitably fastened to an entranceway 33 provided in one of the upstanding side walls 25 of the pan 24.

Referring again to the FIG. 3, the pulsator-air supply assembly 13 is shown to advantage. The assembly 13 includes a centrifugal, high-pressure pump or blower 34 driven from a suitable source of power. The pump 34 blows air under pressure into an enclosed plenum 35. Mounted in the plenum 35 is a rotating damper wheel 36 having a multiplicity of damper faces 37 operable to prevent air from entering the respective conduits 32 when one of the faces 37 is aligned with the exitway in the plenum 35 to which a conduit 32 is connected. The damper wheel 36 is journaled for rotation in the plenum 35, and is rotatably driven from a source and drive assembly, such as is shown at 38. Hence, air under pressure is intermittently blown through respective conduits 32 in a pulsating manner to the respective assemblies 12.

The traveling float conveyor assembly 16 comprises an endless belt 39 driven about head and tail pulleys 40 and 41, shown to advantage in the FIG. 4. The belt 39 includes a laminated selected screen 42 and a porous fabric 43. The assembly 16 is rectilinearly disposed in the frame 20, and is coextensive in length therewith. The belt is, however, transversely narrower than the assembly 17. The belt 39 may be driven from a commonly known suitable driving assembly connected to a suitable motive source. A multiplicity of riffle bars 44 are transversely fastened at intervals on the fabric portion 43. The traveling float conveyor assembly 16 is carried in the housing on the table board 30 of the top wall 27 of the float cell assemblies 12. Hence, intermit-
tent pulsating air under pressure is caused to be blown through the belt 39 and the selected material carried thereby.

The uppermost wall of the substantially enclosed housing of the concentrator 10 is formed by a multiplicity of combination reflector assemblies 14 transversely disposed with respect to the frame in a side by side abutting relationship. The reflector assemblies 14 each comprises a convex cooling chamber-reflector assembly. The assemblies 14 include a jacket-like cover 45 enclosing a plurality of cold water pipes 46 and a convex insulated wall 47. Cold water under pressure from a suitable source is supplied through a conduit 48 to pipe 46, and is discharged through a conduit 48' on the opposite side of pipes 46. Hence, cold water is circulated through the reflector assembly 14 to cool the assembly 14. In this manner, the atmosphere in the concentrator assembly may be controlled within strict limits. In practice, it has been found that control of the atmosphere, including humidity and the like, tends to improve the results of gold recovered. It has been found to advantage to provide a polished reflection surface on the lowermost portion of the walls 47 to tend to reflect heat downwardly toward the conveyor assembly 16, as hereinafter described.

A heating assembly 15 is provided between the assemblies 14 and the conveyor assembly 16. The heating assembly 15 comprises a multiplicity of encapsulated fuel burners 49 having suitable fuel under pressure supplied through a header 50 and combustion air supplied through a conduit 51 to respective combustion manifolds 52, an exhaust flue 53 connected to the respective burners 49, and stack 54 through which the products of combustion may be exhausted.

The concentrator 10 includes substantially enclosed tank assembly 17 mounted on the frame 20. The lower portion of the tank assembly 17 is provided with a plurality of water-misting heads 55 disposed in the tank below the conveyor belt 39, as shown to advantage in the FIG. 3. It may be observed that the bottom wall 56 is transversely inclined upwardly from the upstanding side wall 57. Condensate slurry discharge means 18 is provided in the side wall 57 adjacent the lowermost intersection of the bottom wall 56 and the side wall 57. It has been found to advantage to provide a multiplicity of rectilinearly spaced V-shaped sections in the bottom wall 56, shown to advantage in the FIG. 2, so that slurry may be conducted more readily to the means 18 in each of two directions, i.e. both rectilinearly and transversely. It is to be understood that some of the selected material from the belt 39 will fall into the tank 17 and may be recovered by this means.

In operation, heat within the temperature range of 200° centigrade to 275° centigrade is directed from the heating assembly 15 by the respective reflector plates of the assemblies 14 toward the conveyor assembly 16 and onto selected material thereon. The mist discharged by the misting heads 55 tends to cause the particles falling from the terminal sides of the belt 39 and the return traveling portion of the belt 39 into the tank assembly to become saturated and to form a recoverable slurry, to be collected in the bottom wall of the tank assembly, and to be carried off through slurry discharge means 18. It has been found that the condensate material in the housing tends to carry with it a substantial quantity of particulate gold material, and it is to advantage to provide a collector conduit 58 in communication with the slurry discharge means 18.

In operation, selected siliceous material is introduced into the hopper 22 of the feed assembly 11. The material may be urged to fall through the hopper 22 in response to movement of the vibrator 23 and onto the endless belt 39 of the traveling conveyor assembly 16. The belt 39 is rectilinearly mounted in the inclined frame 20. The head and tail pulleys 40 and 41, journaled for rotation in opposite ends of the frame 20, carry the belt 39 at an angle coincident with the frame 20. Hence, material from the hopper 22 tends to be carried downwardly at an angle by the belt 39 toward the material exitway 19.

Air under pressure generated by the high-pressure, centrifugal pump 34 is blown into the plenum 35, through exitways in the plenum 35 in communication with conduits interconnecting each of the pans 24 of the several air-flow cells 12 with the plenum 35. Air is exhausted out of the respective pans 24 through the respective perforated plates 28, the screens 29, and the venturi-like passageways 31 of the table board 30, and through the laminated belt 39 having a screen layer 42, a fabric layer 43 and a multiplicity of riffle bars 44 suitably fastened transversely of the belt 39 at spaced intervals. Selected material carried by the belt 39 tends to become segregated into layers of heavier and lighter particles of materials. The damper wheel 36 journaled for rotation in the plenum 35 adjacent the exitways and conduits 32 connected thereto may be rotated so that the damper faces 37 carried thereby may intermittently interrupt the flow of air to the cells 12 when a face 37 is aligned with an exitway and conduit so that a pulsating flow of air currents is transmitted to the cells 12, the belt 39 and to the materials carried thereon. Such pulsating air currents tend to cause eddies distally from the riffle bars 44, permitting lighter particles to be thrown only nominally above the fabric layer 43 while heavier particles tend to collect adjacent the riffle bars 44. It is to be understood that the apparatus here described may be used and employed as a continuously moving air-flow concentrator without the addition of the heat assembly 15, the reflector assemblies 14, and the tank assembly 17, earlier described, which have been found to be advantageously combined with the air-flow assembly when practicing the process taught by this invention.

Having thus described in detail a preferred apparatus which embodies the concepts and principles of the invention and which accomplishes the various objects, purposes and aims thereof, it is to be appreciated and will be apparent to those skilled in the art that many physical changes could be made in the apparatus without altering the inventive concepts and principles embodied therein. Hence, it is intended that the scope of the invention be limited only to the extent indicated in the appended claims.

I claim:

1. An apparatus for recovering gold, comprising; a dry-air-flow concentrator the combination of an inclined frame, an endless pervious belt assembly rectilinearly mounted at an angle in said frame, means driving said belt assembly, said belt assembly comprising a head pulley and a tail pulley journaled for rotation distally from the opposite terminal ends of said frame and a laminated endless belt, said belt having a screen layer, a pervious fabric layer and a multiplicity of riffle bars
suitably fastened to said fabric layer transversely thereof at spaced intervals, a plurality of air-float cell assemblies mounted transversely in side by side abutting relationship in said frame contiguous with said screen fabric layer of said laminated belt, each of said air-float cells comprising a bottom wall, a plurality of substantially upstanding side walls and a pervious top wall, each of said air-float cell assemblies being communicatively connected to a source of air under pressure; and a substantially enclosed housing formed by a multiplicity of combination reflector assemblies and heating assembly transversely mounted on said frame in side by side abutting relationship, and a tank assembly, said reflector assemblies and said heating assembly being disposed on said frame above said belt assembly, and said tank assembly being carried by said frame, said belt assembly and said air-float cell assemblies being disposed in said tank assembly.

2. The apparatus of claim 1 including a plurality of misting heads disposed in said tank below said belt.