March 4, 1958 R. HACKNEY ET AL 2,825,462

WET-ORE BELT STRATIFIER

Filed Feb. 20, 1956

2 Sheets-Sheet 1

Fig. 1

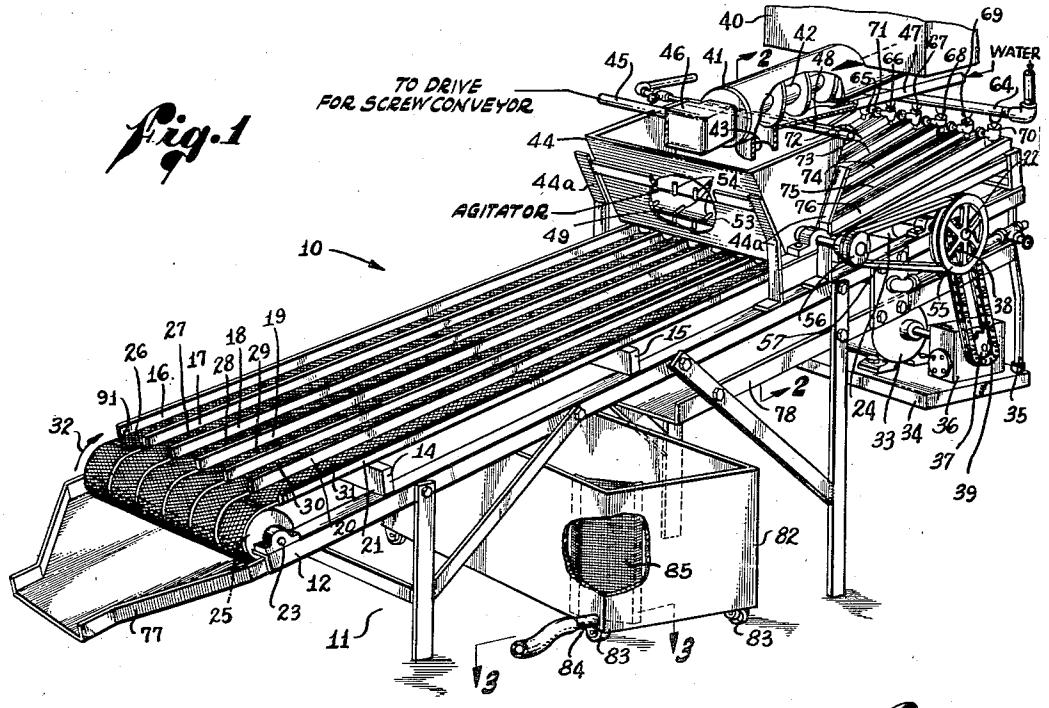


Fig. 2

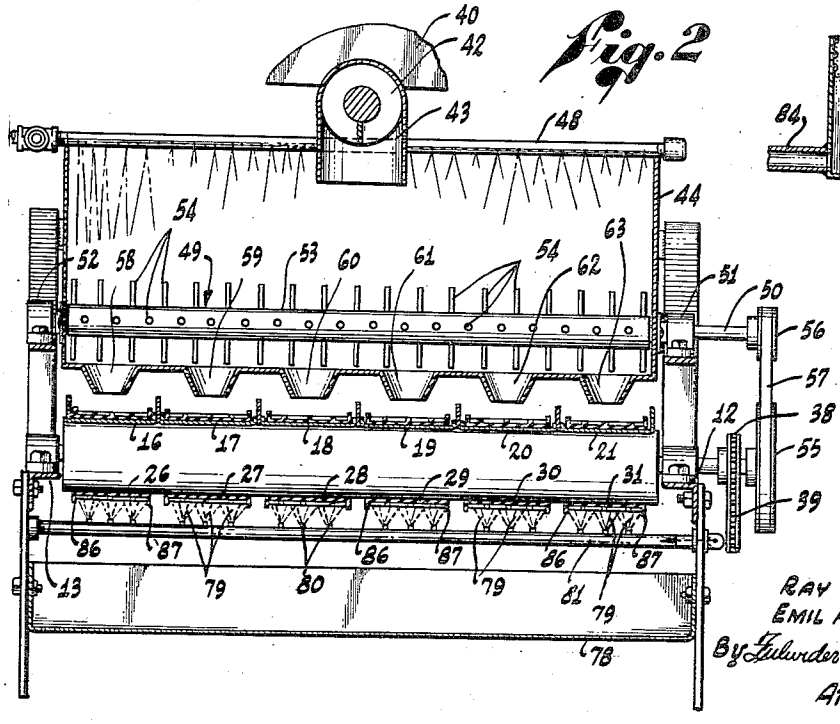
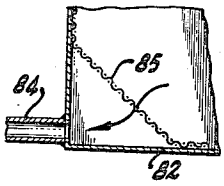


Fig. 3



INVENTORS
RAY HACKNEY
EMIL A. CARLSON
By Fulwider Mattingly & Hunter
ATTORNEYS

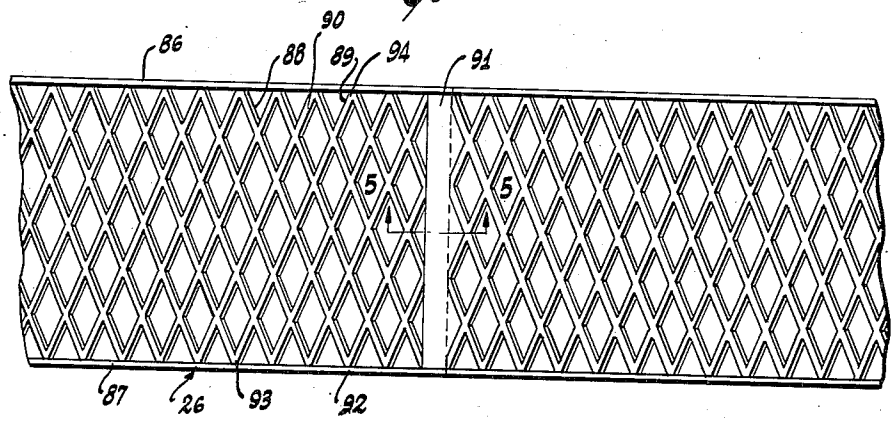
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2 Sheets-Sheet 2

Fig. 4



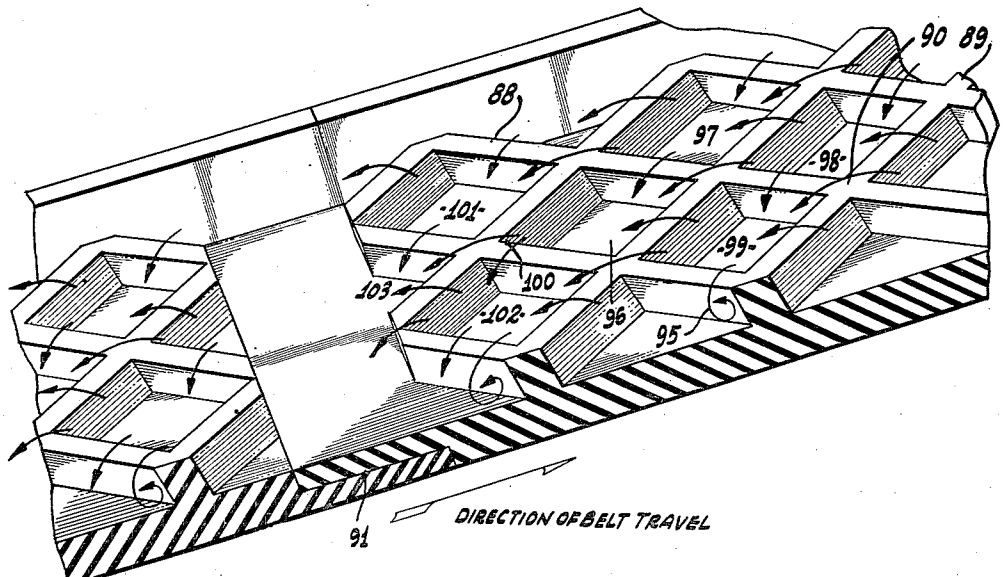


Fig. 5

INVENTORS
RAY HACKNEY
BY EMIL A. CARLSON
Fulwider Mattingly & Huntley
ATTORNEYS

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WET-ORE BELT STRATIFIER

Ray Hackney and Emil A. Carlson, Glendale, Calif.

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1 Claim. (Cl. 209—430)

This invention relates generally to wet-ore concentrators of the type in which a slurry of finely divided ore and water is flowed downwardly over an incline surface of an upwardly moving belt, and more particularly the invention relates to such a concentrator in which the consistency of the downflowing slurry is carefully controlled by providing separate channels and sources of auxiliary water for slurry from each part of the slurry hopper, and in which turbulence is promoted in the downflowing stream by means of closely spaced oblique baffles on the surface of said belt. Some of said baffles are inclined to the left and some to the right, the two kinds intersecting to present a succession of diamond shaped pockets in the path of the downflowing stream of water and ore.

In many types of mining, particularly in gold mining, the desired mineral is intimately associated with rock in the ore, and it is necessary to separate the two by grinding the ore to fine granules and then subjecting the powdered mixture to some means of separation. A common means of doing this, particularly successful in gold mining, is the wet-ore concentrator. The pulverized ore is mixed in a slurry and passed downwardly over an inclined bed, which may be immovable, but is preferably an endless belt continuously moving upwardly countercurrent to the flow of the mixture of water and granulated ore. It has been found desirable to supplement the water in the slurry with additional water deposited on the inclined surface at a point upstream from the point at which the slurry is fed onto the surface. The relatively light particles of rock are entrained in the downflowing water and carried to the downstream end of the inclined surface where they are discharged as waste tailings to a dump. The relatively heavy particles of valuable mineral tend to be precipitated out of the downflowing stream and to remain on the inclined surface, moving with it to the upstream end of the incline.

In the past, a substantial percentage of valuable mineral is carried down with the tailings and lost. With the improvement in wet-ore concentrators in recent years, it has become more and more profitable to rework tailings from old mines, or to work ores which were hitherto believed to be too poor to provide an economic recovery. One such improvement has been to cover the flexible belt with a flexible wire mat adapted to introduce turbulence in the downflowing slurry and thereby insure more effective and intimate washing. These wire mats have been subject to the objection however that their movement with the belt tended to subject the belt to such wearing and cutting that it was eventually destroyed, and also to the objection that the wire mats, even if coated, readily succumb to rust and corrosion.

Previously known ore belts have also been subject to the objection that they were relatively ineffectual in trapping fine grains of valuable metals but tended to snag twigs and leaves and other waste materials sometimes present in the slurry.

It has usually been the practice to discharge the granulated ore onto the inclined surface at a point a short distance downstream from the upper end, and to supply enough water at the upstream end to wash all the tailings to the lower end. However, the efficiency of separation of light and heavy particles has not been uniform at all points across the bed from one side to the other. If sufficient water was provided at the sides to achieve adequate washing in those locations, too many metal particles were carried away with the tailings from the center portion. On the other hand, if the downflowing stream was regulated to achieve most effective washing in the center, the lateral portions of the upwardly moving belt could not be used with maximum efficiency lest they begin to accumulate ore and carry it to the upper end of the incline without separation.

It is a major object of the present invention to provide a wet-ore concentrator in which the inclined ore bed is divided into a plurality of relatively narrow parallel channels each of which is supplied with a slurry of ore and water from a different part of the slurry hopper and above the upstream part of the inclined ore bed.

It is a further object of this invention to provide separate adjustable water taps for each of said channels so that the auxiliary water introduced at the upstream end of each channel may be exactly that required to complement the proportions of water and ore in the slurry supplied to that particular channel from the part of the slurry hopper with which it is in communication.

It is another object of this invention to provide a wet-ore concentrator in which the downflowing stream of finely divided ore entrained in water is passed over a continuous series of turbulence-inducing baffles which are molded integrally with the ore belt and are constructed of the same rubber-like material.

It is a still further object of this invention to provide ore belt baffles of a novel pattern, in which all the baffles are disposed obliquely to the direction of a belt travel, some baffles inclined to the left and some inclined to the right, and the right and left baffles intersecting each other to present a succession of diamond shaped pockets to the downflowing stream, whereby turbulence is introduced into the stream and particles of metal are accumulated in the upstream corners of said diamond shaped pockets.

It is still another object of this invention to provide ore belts which are substantially impervious to corrosion by the ore and water mixture, and which are much more resistant to erosion by the slurried ore.

The foregoing objects, and other objects, are accomplished by means best understood from a description of a specific embodiment of the invention illustrated in the accompanying drawings, in which:

Figure 1 is a perspective view of a wet-ore concentrator constructed in accordance with this invention;

Figure 2 is a vertical sectional view taken transversely through the slurry hopper part of the concentrator as viewed upstream in the direction of the arrows 2—2 in Figure 1;

Figure 3 is a plan view of the fragment of a horizontal section through the concentrate recovery hopper as indicated by the arrows 3—3 in Figure 1;

Figure 4 is a plan view of an ore belt constructed according to the present invention and comprising a part of the apparatus illustrated in Figures 1 to 3; and

Figure 5 is a perspective view of an enlarged fragment of the belt of Figure 4 as it is seen from the vertical section taken in the direction of the arrows 5—5 in Figure 4.

In Figure 1 a wet-ore concentrator apparatus, indicated generally by the numeral 10 is supported in a framework 11 comprised of a bolted or welded metal structure. The upper part of framework 11 consists of a pair of angle irons 12 and 13 (the latter is visible in

Figure 2 but not in Figure 1) which are inclined to ground level and carry cross members 14 and 15.

Supported on cross members 14 and 15 are a plurality of parallel channels, 16, 17, 18, 19, 20, and 21.

A pair of pulley shafts 22 and 23, are transversely mounted in the wet-ore concentrator 10, between inclined frame members 12 and 13, at their upstream and downstream ends respectively, said shafts being provided with pulleys 24 and 25, respectively.

Six endless belts 26, 27, 28, 29, 30, and 31, made of rubber or other resilient rubber-like material, are mounted on pulleys 24 and 25 with their upper spans seated in channels 16, 17, 18, 19, 20, and 21 respectively, the lower span of the belts being carried under frame members 14 and 15. Pulleys 24 and 25 are driven in a clockwise direction, as viewed in Figure 1, with the upper belt surfaces moving up the incline as indicated by the arrow 32, by means of a motor 33, mounted on a motor platform 34 suspended by frame members 35 under the upper end of the inclined frame members 12 and 13. The motor 33 drives a speed reduction gear box 36, the output sprocket 37 of which rotates sprocket 38 on shaft 22 by means of a chain 39. Ore to be processed in the wet-ore separator 10 must be first reduced to a finely divided granulated form usually by crushing and grinding in a ball mill (not shown). The granulated ore may be conveniently fed from the ball mill or storage hopper 40 through a conduit 41, by means of a screw conveyor 42, through outlet 43, to a slurry hopper 44, supported on angle irons 12 and 13 by supports 44*a*. Screw conveyor 42 may be conveniently driven by means of a shaft 45 connected to power not shown, and to a gear box 46 mounted at the end of the screw conveyor. Preferably, movement of the finely divided ore through conduit 41 is facilitated by the introduction of water into the conduit by way of line 47.

Above the slurry hopper 44, a slurry water supply pipe 48, positioned transversely with respect to the wet-ore concentrator 10 discharges slurry water into the slurry hopper 44 at points distributed from one side of the concentrator to the other.

The slurry within slurry hopper 44 is stirred to a fairly uniform consistency by means of an agitator 49, which consists of a shaft 50, journaled at its right and left ends in pillow boxes 51 and 52 on the right and left sides, respectively, of the concentrator 10. The shaft 50 is provided with a sleeve 53 carrying radial stirring rods 54. Agitator 49 is driven by means of a driving pulley 55 mounted on the right end of the upstream ore belt shaft 22, a driven pulley 56 mounted on agitator shaft 50, and a belt 57 between pulleys 55 and 56.

The bottom of slurry hopper 44 is provided with a plurality of funnel-shaped outlet conduits 58 to 63, which are disposed in a line transverse to the moving belts 26 to 31. Although the slurry within slurry hopper 44 is stirred to fairly uniform consistency by the action of the agitator 49, it is inevitable in an apparatus of practical dimensions that there will be some variation in consistency and density of slurry from point to point along the length of slurry hopper 44. It is quite likely that the slurry descending through conduits 60 and 61 to center belts 28 and 29 will have a lower percentage of water and therefore greater density than the slurry descending through the side outlets 58 and 63 to side belts 26 and 31.

In order to adjust washing conditions on each belt in order to achieve most effective separation of metal from ore for a given volume of ore handled per hour, slurry from each part of slurry hopper 44 is confined to its own sluice channel and to the belt on which it is initially deposited, and the amount of auxiliary wash water, introduced onto the belts at a point upstream from the slurry conduits 58 to 63 by means to be described hereinafter, is separately adjusted in flow rate for each of the belts 26 to 31.

Upstream from slurry conduits 58 to 63, auxiliary water is flowed to each of the belts 26 to 31 by means of an auxiliary water pipe line 64 which is provided with separately adjustable taps 65 to 70, one for each of the belts 26 to 31. Auxiliary water from taps 65 to 70 flows to the upstream ends of belts 26 to 31 via troughs 71 to 76.

As slurry from conduits 58 to 63 is deposited on the belts 26 to 31, it tends to be carried up the incline by the belt movement, but the constant flow of auxiliary wash water from troughs 71 to 76 provides a stream which carries the powdered rock particles down the inclined belts counter-current to the direction of belt movement, to the downstream end of the ore concentrator 10.

At the downstream end a collecting trough 77 carries away the suspension of tailings and water to a tailing dump.

The valuable particles of metal, however, which are much heavier than the rock particles are precipitated from the downflowing suspension on to the surface of the belt, and entrapped thereon by means of a baffle arrangement to be described in connection with Figures 4 and 5, and carried over the upstream pulley 24. As the belt is inverted in its movement along the lower return span, the accumulated metal particles are dumped into a concentrate trough 78.

The concentrate is washed from the baffles by means of concentrate wash sprays 79 discharged from openings 80 disposed along a concentrate wash pipe 81 which is supported transversely to ore concentrator 10 under the downwardly moving inverted belt surfaces.

The recovered concentrate is washed downwardly in concentrate recovery chute 78 to a concentrate bin 82, which may conveniently be mounted on casters 83 to facilitate replacement of a filled bin with an empty one. Water escapes from the bin 82, as the concentrate settles therein, by way of an outlet 84, which, as seen from the broken away portion of the corner of bin 82 in Figure 1, and also the plan view of Figure 3, is shielded by means of a filtering screen 85, behind which a bed of settled concentrate gradually fills up bin 82.

The construction of the belts 26 to 31 is shown in detail in Figures 4 and 5. The belt is made of molded rubber, or other rubber-like material, which is sufficiently flexible to pass around the pulleys, and has the tough resilient qualities of rubber, which assist in resisting erosion or other deterioration as a result of constant exposure to a water suspension of finely divided rock and metal. Preferably, the belt is made in sections a few feet in length which may be vulcanized together to make an endless belt of any desired length, or may be used to replace a damaged section of a used belt. The belt is in the form of a channel with vertical side walls 86 and 87, between which diagonal baffles such as baffle 88 and baffle 89 are formed, extending across the belt from side wall 86 to side wall 87 and intersecting one another at 90. Successive belt sections are vulcanized together by means of overlapping tongues at their ends as indicated at 91 and seen most clearly in the sectional portion of the perspective view of Figure 5.

The intersecting baffles, such as 88 and 89, may be classified according to their direction of inclination as right flow baffles 88, which incline obliquely across the belt 26 with the right end downstream from the left end 92 a distance which, in the particular embodiment shown, is about three times the space between successive baffles. Right flow baffles tend to divert downflowing liquid-solid suspension to the right. The left flow baffles, such as baffle 89, are positioned obliquely across the downflowing stream with the left end 93 a corresponding distance downstream from the right end 94. Left flow baffles tend to impart a leftward component to the liquid-solids mixture flowing down over the belt.

As seen in the plan view of Figure 4, the intersecting right and left flow baffles present a diamond pattern of pockets several pockets wide and endlessly succeeding

one another along the length of the belt, except at **91**, where two sections are connected. The suspension of ore particles entrained in water is passed down over the upwardly moving belt **26** in a shallow stream confined between the side walls **86** and **87** and not much deeper than the height of the baffles **88** and **89**. The baffles promote turbulence in the stream, causing the suspended particles to be repeatedly shaken and sorted according to density as they are momentarily picked up or deposited in the circulatory currents which eddy about the baffle surfaces, as indicated by the current flow arrows **95**. The baffles promote uniformity of consistency of slurry at every point across the width of the belt **26**, since there is constant right and left mixing as the liquid-solid suspension moves down through the series of successive diamond-shaped pockets **96**. Thus, pocket **96** receives some liquid from three upstream pockets **97**, **98**, and **99**, mixes them, and discharges at its downstream corner **100** into three downstream pockets **101**, **102**, and **103** (the latter being partly broken by the overlap attachment section **91**). The current tends to carry along most of the particles in the downstream corner **100** of the pocket **96**. The upstream sides of the baffles are swept fairly clean of any deposit. However, the heavier particles of valuable metal tend to accumulate at the downstream sides of the baffles and particularly in the upstream corner and the right and left corners of the pockets, such as pocket **96**. The downstream sides of the baffles slightly overhang the bottoms of the pockets, a feature which encourages the accumulation of metal particles. However, it will be seen that the oblique arrangement of the baffles **88** and **89** insures that even the deposited concentrate will be constantly subjected to some washing, whereas in ordinary transverse baffles, a deposit is likely to remain even if of lower density than desirable concentrate. In the present invention, however, a concentrate which has not arrived at the maximum density, which indicates the desired degree of separation, will be washed away by the relatively heavy current of water at the upstream end of the ore concentrator **10**. It is only that deposit which is suitably dense which will be able to resist the transverse currents eddying about the downstream wall surfaces of the baffles **88** and **89**.

It will be understood that the degree of inclination, dimensions, and the rate at which water is passed down the incline of the ore concentrator **10** will be determined by such factors as the material being treated, the fineness of the particle size, and the efficiency of separation which is desired to achieve. In general, however, ores must be granulated to a size not larger than ⅛ mesh. Most ores are suitably passed over an incline of between 10% and 20% grade. The volume of water and slurry admitted should be sufficient to maintain a flow not much deeper than the baffles themselves, which must be of sufficient depth to shield accumulated metal particles from being washed away too readily, i. e. about one eighth inch to one inch in depth for the preferred range of ore pulverization and wet-ore concentrator construction.

It will be appreciated that the specific embodiment shown might be varied in details without departing from the principles of our invention, and that our invention is not restricted to the form described but rather by the scope of the appended claim.

We claim:

A wet-ore concentrator of the type in which a stream of finely divided ore slurried with water is flowed down over an inclined surface, which includes: a plurality of inclined sluice channels; a slurry hopper disposed transversely across said sluice channels at a point intermediate their upstream and downstream ends; means for introducing finely divided ore and water into said slurry hopper; agitation means in the lower portion of said slurry hopper for intimately mixing said finely divided ore and said water; walls in the bottom of said slurry hopper defining a slurry distributor having a plurality of openings for distributing slurry from each part of said hopper to one of said sluice channels; a flexible endless belt of rubber-like material mounted in each of said sluice channels and adapted to be moved upstream in said sluice channel and to return under said sluice channel from the upstream end thereof to the downstream end; side walls on each lateral edge of each of said belts, said walls formed integrally with said belt material and adapted to confine a downflowing stream therein; a series of right flow baffles molded integrally in the surface of said belt and disposed obliquely across the path of said downflowing stream with their right ends downstream from their left ends so as to impart a right transverse component to the flow of said stream; a series of left flow baffles molded integrally in the surface of said belt and disposed obliquely across the path of said downflowing stream, with their left ends downstream from their right ends so as to impart a left transverse component to flow of said stream, said left flow baffles intersecting said right flow baffles to form diamond-shaped pockets on the surface of said belt; and adjustable water supply means at the upstream end of each of said channels for introducing additional water as required by the slurry supplied to said belt therein from the particular part of said slurry hopper with which it is in communication; and means under said inclined chanels for collecting heavy particles from said belts.

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