This invention relates to the separation of minerals having different specific gravities in a body of liquid medium of density intermediate between the heavier material sinks through the liquid and settles on a frictional conveying surface which continuously moves the sink from the separating zone and raises them out of the liquid by frictional contact between the sink and the conveying surface, when they are discharged, the lighter materials being separately collected at the surface and discharged. Examples of this method of process for separation are set forth in U.S. Patents Nos. 2,486,682 and 2,489,161.

This method of separation is advantageous in that the efficiency of the float and sink separation is enhanced by the influence of the frictional conveyance of the sinking material because only material which is actually denser than the liquid can be conveyed in this manner, and consequently there is no tendency of loss of lighter materials in the sinks product. For the most efficient conditions of frictional conveying, the liquid medium which is in contact with the surface should flow in the same direction as the surface and at similar speed. This is of advantage because it enables material of intermediate gravity which is only very slightly denser than the liquid to have better frictional contact with the surface and thereby be more readily conveyed by it. If there were no flow, or the flow were in a contrary direction to the movement of the surface, the material only slightly denser than the liquid would meet with some fluid resistance and thereby would not so readily grip the surface and be conveyed by it.

The object of this invention is to enhance the effect of frictional conveying by maintaining the flow of the liquid medium in the same direction as that of the movement of the surface throughout its full length and travel until the sinks are discharged from the liquid medium, thereby enabling material which is only very slightly denser than the liquid to maintain adherence with the surface and be conveyed by it throughout its length of travel. Another object is at the same time to provide improved means for regulating the amount, distribution and direction of flow of liquid medium in different zones of the body of the separating medium. Another object is to provide improved means for effecting the removal of the middlings. A still further object is to provide means whereby such middlings may be removed at will separately or with the floats.

In the particular apparatus described and shown in the above patent specifications the liquid was caused to flow in the direction of the belt until the floating materials were discharged at the surface. After this discharge the further flow with the belt was maintained by side weirs in the tank. These latter however did not maintain a continuous flow to the extreme end and across the width of the belt owing to their positions at the sides of the tank.

With the apparatus according to the invention the conveying surface of the belt is caused to discharge slightly below the liquid level at one extreme end of the body of liquid medium while a flow of liquid medium is induced immediately above the conveying surface in the same direction as and throughout the travel of the conveyed sinks, the said flow discharging with the sinks at the liquid level.

Since the discharge point of the conveying surface is slightly below the liquid level the liquid flows over the end of the conveying surface with the sinks, the flow thus being across the width and not at the sides, and flow is thus maintained to the extreme end of the body of liquid.

The apparatus according to a troughed invention has the belt passing over a delivery pulley located outside the tank at or slightly below the liquid level in said tank, the said belt discharge being adapted to discharge liquid medium with the sinks in the direction of travel of the belt, and at the feed end of the tank, liquid inlet means adapted to feed liquid medium above the belt to induce flow in the direction of travel of the sinks throughout the length of the carrying portion of the said belt.

The belt troughing is maintained between the discharge end of the tank and the delivery pulley so that the upturned edges of the belt retain the liquid within the width of the belt and prevent overflow at the sides before the delivery point is reached. This troughing may be caused by mitred rollers set to lead the belt in a gentle curve from the tank to the pulley. The belt may be troughed throughout its length by making the tank floor of transversely concave section and the troughing is then maintained from the end of the tank to the delivery pulley as above described.

The floats are preferably discharged over a weir into a transverse trough which projects downwardly into the body of liquid medium. This trough may be suitably shaped by a casing on its leading side to guide the floats up to the overflow weir which discharges into the trough. The said casing may also be shaped to form, with
the rising belt, a converging zone. A similar casing, or a continuation of said casing may also be formed on the trailing side of said trough, whereby the materials and liquid which pass under said trough emerge into an expanding zone.

The upper part of the casing on the trailing side of the trough leads into a weir on the trailing side of the trough which discharges into the trough in the reverse direction to the floats weir. Thus the Venturi effect is produced below the trough which intensifies the flow under the trough and thereby carries the semi-floating middlings from the separating zone and imparts an upward impetus to the middlings, means being provided for intercepting this upward flow of middlings and feeding the latter back into the middlings weir in the opposite direction to that of the liquid stream.

The invention will now be described by way of example with reference to the accompanying drawings which show apparatus for cleaning coal.

In the said drawings:

Fig. 1 is a plan.

Fig. 2 is a side elevation.

Fig. 3 is an end elevation of the delivery end of the apparatus.

Fig. 4 is a section on the line IV—IV of Fig. 2.

Referring more particularly to the drawings, 1 is a separating tank having an inclined bottom 2 which is concave in section, and over which is adapted to travel a rubber belt 3 the conveying surface of which is transversely trenched as a result of its travelling along the concave bottom 2. The trenched of the belt is maintained after it leaves the tank, by means of one or more sets of adjustable misted idler rollers 4, thereby enabling the liquid at the shallow end to be contained within the trenched of the belt and independently of the tank. With this arrangement the central portion of the belt is below liquid level while the upturned sides of the belt are above liquid level. The liquid is thus contained in the trenched belt until it reaches the delivery pulley 5, and is thereby prevented from overflowing the sides of the belt and discharges over the pulley 5 with the sinks. The return portion of the belt passes under the tank, over a pair of tandem driving pulleys 6, 1 back to a tail pulley 7 over which it passes to the tank over a set of misted idler rollers 9 which trenched it to the point at which it enters the tank on the level of the bottom 2 prior to its entering the tank on the level of the bottom through end seals 10 of the kind described in U. S. Patent No. 2,489,161.

The delivery pulley 5 is mounted on pulley blocks 11 which themselves are mounted for up and down adjustment on the side faces of pillars 12, so that the belt may be raised and lowered at the delivery end relatively to the level of the liquid medium, and thereby decrease or increase the amount of flow along the belt, and thus control the speed of flow with the belt. The mitre rollers 4 require to be adjusted to maintain the trenched of the belt in accordance with the position it is caused to take up by the pulley 5.

The above arrangement of the belt drive independently of the delivery pulley 5 enables the latter to be adjusted substantially without affecting the driving surface or the longitudinal tension of the belt.

The floats and middlings are discharged over weirs 13 into the trough 13 which is of substantially rectangular cross section having a central longitudinal (relatively to the trough) removable partition plate 14 which divides the trough into two compartments which are respectively con-}

nected to two separate discharge outlets. Embracing the said trough is a casing 14 having upwardly inclined and declined faces, 15 and 15′ respectively on the leading side of the trough, and similar upwardly inclined and declined faces, 15″ and 15‴ respectively, on the trailing side of the trough.

The effect of this casing is to lead the floats up the face 15″ to the weir 15‴ where a paddle 16, see page 4, throws the floats with their carrying liquid up the inclined face of the casing 15 into the trough 13.

The declined face 15‴ directs the liquid carrying the middlings through the Venturi-like passage formed between the faces 15‴ and 15‴ and the conveyor belt. This has the effect of increasing the velocity of flow of the liquid stream so that the middlings, after the floats have been discharged, are effectively carried from the separating zone under the casing 15 into what may be termed the middlings collecting zone where the middlings may finally settle on the belt or rise to the surface according to density. As the liquid and middlings emerge from under the face 15‴ the stream divides into a rising portion which carries the floating middlings upwards, and a forwards flowing portion which moves with the belt to discharge with the sinks. A second paddle 17 arranged on the trailing side of the trough 13 is used to intercept the rising middlings to deflect them in a backward direction up the inclined side 15‴ of the casing 15‴ over the edge of the trough 13 and into the lower side of the latter. The paddles 16, 17 are part of a set of paddles which are operated from a common shaft 18 having mounted thereon a belt pulley 19 by which it is driven from a motor 20 through a reduction gear 21, the other paddles of the set controlling the travel of the upper layers of liquid carrying the floats.

If the middlings are to be kept separate from the floats the partition plate 14 is placed in position as shown so that the two are prevented from mixing. If they are to be mixed the partition plate is removed.

Adjustable lips 15‴ are arranged at the weir edges to vary the depth of liquid medium over the weirs. By adjustment of these lips the relative heights of the floats and middlings weirs may be varied to allow more or less liquid medium to flow over either of them, so that the amount of flow under the trough 13 may be controlled. The adjustment of the lips 15‴ in connection with adjustment of the pulleys 5 thus provides control of the distribution of the flow in the different zones to suit the travel of the floats middlings and sinks.

When the liquid medium comprises a suspension of finely divided solids in water this adjustment of the lips 15‴ and the pulley 5 provide an improved control of the distribution of flow to counteract settlement of the suspension solids to maintain uniform density of the liquid medium. The distribution of the flow between the floats and middlings may be altered by means of the lips 15‴ and the pulley 5 maintains the overall flow in a substantially upwardly inclined direction which is the converse of the tendency of the suspension solids to settle in a downwardly inclined path. Settlement is thus counteracted, and the density maintained.

The sinks may be assisted up the portion of the belt 3 above liquid level by means of a rotary paddle 22 which is driven through bevel reduction gear 23 and a vertical shaft 24 from the belt driving gear. This paddle may be fitted with
5 flexible blades to prevent jamming between the blades and the sinks material. Liquid medium is introduced by means of a header 25 arranged at the deep or feed end of the tank, and having inlet openings 25a formed therein at different levels. 26 indicates the liquid level.

Additional liquid medium may be introduced at an intermediate point or points as shown, for example, at 27 in the tank sides whereby the flow along the belt may be increased.

In operation the material to be separated is introduced at the feed end of the tank at A where it separates into sinks, middlings and floats as in the above specifications. The liquid medium flows from the inlets 25a in the direction of the travel of the belt 3, the lower-most inlet ensuring a flow close above the belt. The upper and intermediate strata of liquid which carry the floats and middlings respectively also move in the same direction towards the trough 13.

When the stream reaches the leading portion of the trough casing 15 the floats are at the surface while the middlings are mostly in the lower portion where they are caused to move at an increased speed under the casing 15 as above described. The floats are assisted along the surface by the paddles and are fed with some liquid medium by the paddle 16 into the floats portion of the trough 13, while the uprising middlings with some liquid medium are swept backwards by the paddle 11 into the middlings portion of the trough 13. When it is not required to keep the middlings separate from the floats, the partition 14 is removed and the products mixed in the trough 13.

The sinks are conveyed upwards by the belt 3 out of the liquid medium over the rollers 4 to discharge, so that the uniflow action of the process is maintained throughout the travel of the liquid medium. By adjusting the height of the discharge pulley 5 the depth, and therefore the amount of liquid medium discharging with the sinks may be varied, so that the speed of liquid flow above the belt 3 may be controlled to suit the speed of travel of the sinks.

At the extreme delivery point of the pulley, rubber skirts may be fitted to prevent the liquid flowing over the sides of the pulley.

I claim:

1. Apparatus for separating solid granular materials in a liquid separating medium of density intermediate those of the solids being separated, comprising a tank adapted to contain a stream of the liquid medium, a uniformly inclined and transversely troughed floor in said tank, a conveyor belt adapted to traverse the floor of said tank, said belt being adapted to conform to the troughed form of said floor and to receive the settled sinks and convey said sinks by frictional contact with the surface of said belt to the surface of the liquid medium, a transversely troughed extension of said floor beyond said tank, a delivery pulley located at a distance beyond the discharge end of the tank with its upper surface slightly below the liquid level whereby it leaves the tank and is thereby adapted to contain the overflowing liquid medium after it leaves the tank and to lead it with the sinks over said delivery pulley, and at the feed end of the tank liquid inlet means adapted to feed liquid medium above the belt to induce flow in the direction of travel of the sinks throughout the length of the carrying portion of said belt, and means independent of the conveyor belt for removing the floats from the surface of the liquid medium intermediate the ends of the tank.

2. Apparatus for separating solid granular materials in a liquid separating medium of density intermediate those of the solids being separated, comprising a tank adapted to contain a stream of the liquid medium, a uniformly inclined and transversely troughed floor in said tank, a conveyor belt adapted to traverse the floor of said tank, said belt being adapted to conform to the troughed form of said floor and to receive the settled sinks and convey said sinks by frictional contact with the surface of said belt to the surface of the liquid medium, a transversely troughed extension of said belt beyond said tank, a delivery pulley located at a distance beyond the discharge end of the tank with its upper surface slightly below the liquid level whereby the belt is transversely troughed where it leaves the tank and is thereby adapted to contain the overflowing liquid medium after it leaves the tank and to lead it with the sinks over said delivery pulley, and at the feed end of the tank liquid inlet means adapted to feed liquid medium above the belt to induce flow in the direction of travel of the sinks throughout the length of the carrying portion of said belt, and means independent of the conveyor belt for removing the floats from the surface of the liquid medium intermediate the ends of the tank.
troughing roller means being located with their central portions slightly below the liquid level and adapted to lift the edges of the extended portion of said belt in the vicinity of the liquid level whereby the belt is transversely troughed where it leaves the tank and is thereby adapted to contain the overflowing liquid medium after it leaves the tank and to lead it with the sinks over said delivery pulley, pillar means for carrying said pulley, pulley carrying blocks, said pillar means having faces on which said blocks are adjustably mounted, tandem driving pulleys for driving said belt independently of said delivery pulley, said driving pulleys being located so that the portion of the belt between the belt receiving pulley of said tandem driving pulleys and the delivery pulley is substantially normal to said pillar faces to enable said delivery pulley to be raised or lowered without affecting the driving surface and the longitudinal tension of said belt, and at the feed end of the tank liquid inlet means adapted to feed liquid medium above the belt to induce flow in the direction of travel of the sinks throughout the length of the carrying portion of said belt, and means independent of the conveyor belt for removing the floats from the surface of the liquid medium intermediate the ends of the tank.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,209,618</td>
<td>Vogel</td>
<td>July 30, 1940</td>
</tr>
<tr>
<td>2,319,457</td>
<td>Hirst</td>
<td>May 18, 1943</td>
</tr>
<tr>
<td>2,320,519</td>
<td>Hirst</td>
<td>June 1, 1943</td>
</tr>
<tr>
<td>2,458,035</td>
<td>Tromp</td>
<td>Jan. 4, 1949</td>
</tr>
<tr>
<td>2,465,065</td>
<td>Walker</td>
<td>Apr. 19, 1949</td>
</tr>
<tr>
<td>2,480,682</td>
<td>Ridley</td>
<td>Nov. 1, 1949</td>
</tr>
<tr>
<td>2,489,161</td>
<td>Scholes</td>
<td>Nov. 22, 1949</td>
</tr>
</tbody>
</table>