Oct. 21, 1947. G. A. BASTANCHURY 2,429,543

APPARATUS FOR AUTOMATICALLY ADJUSTING THE ANGULAR PLANE OF DRY CONCENTRATING TABLES

Filed Oct. 15, 1945 3 Sheets-Sheet 1

Fig. 1

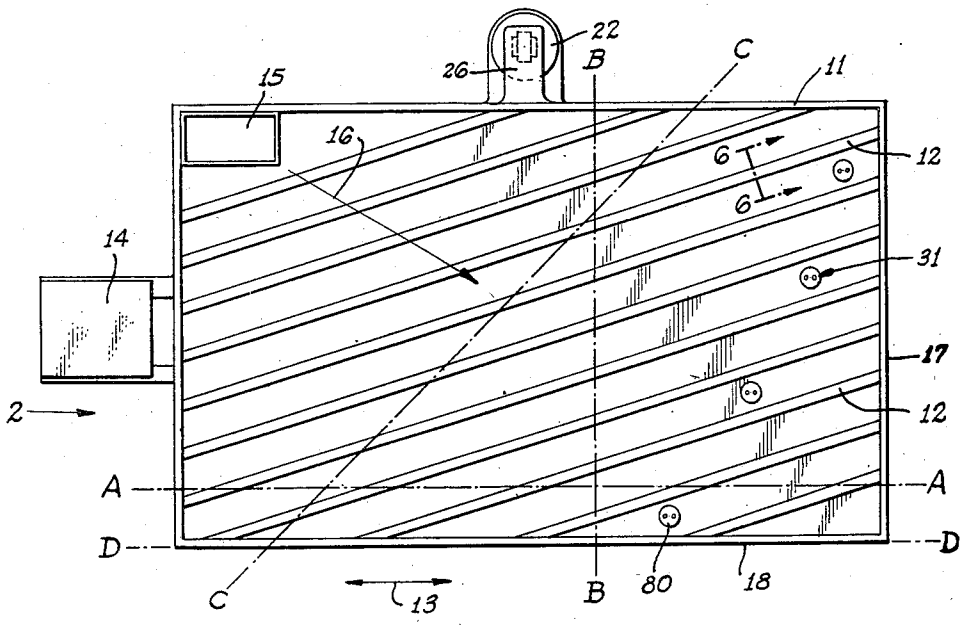
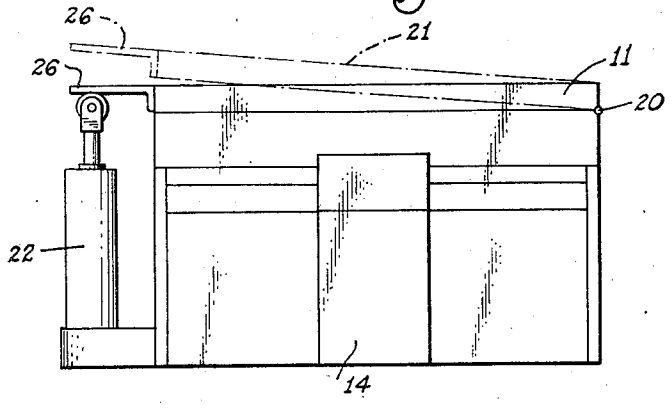


Fig. 2



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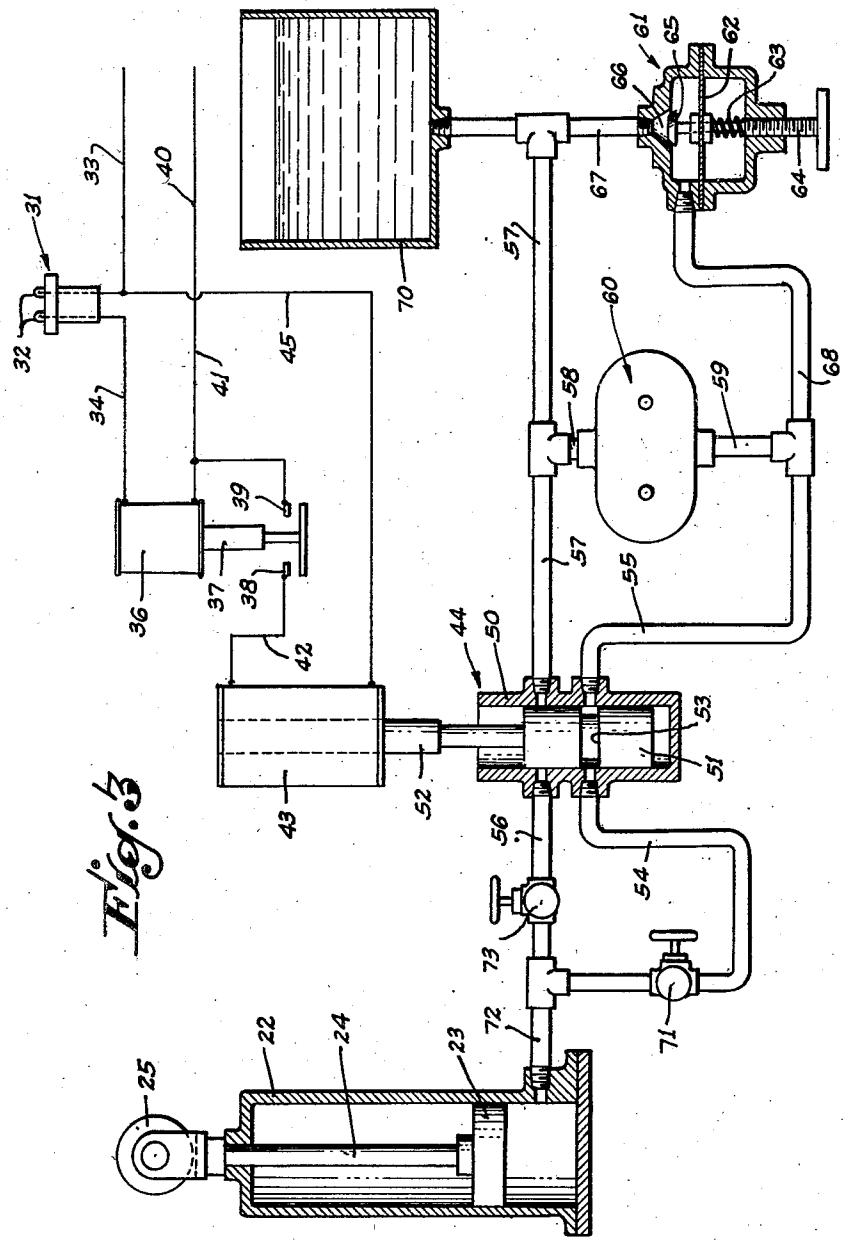


Fig. 3

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Fig. 4

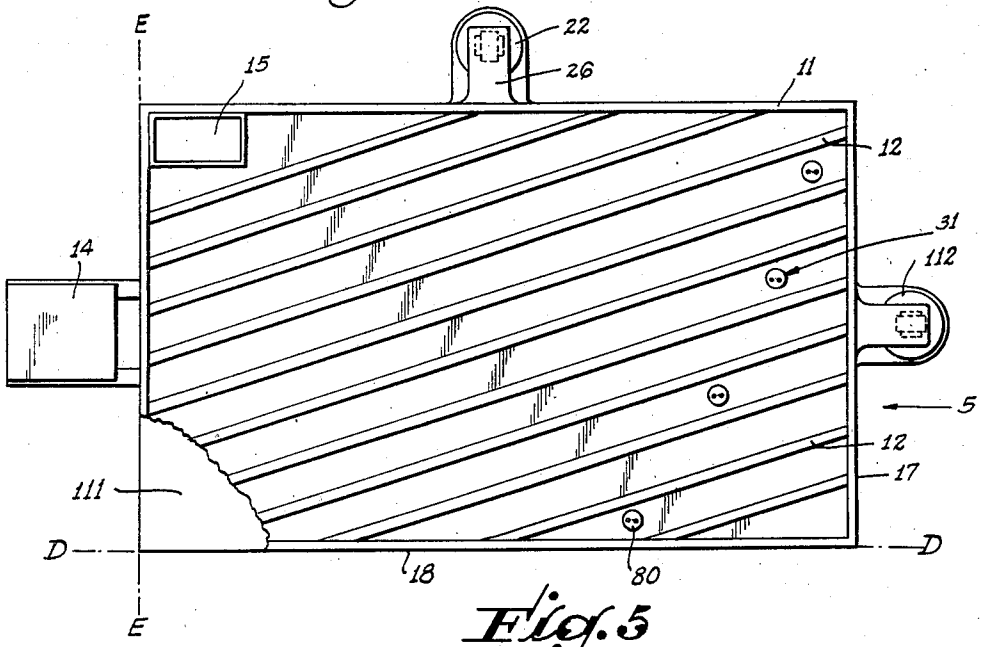


Fig. 5

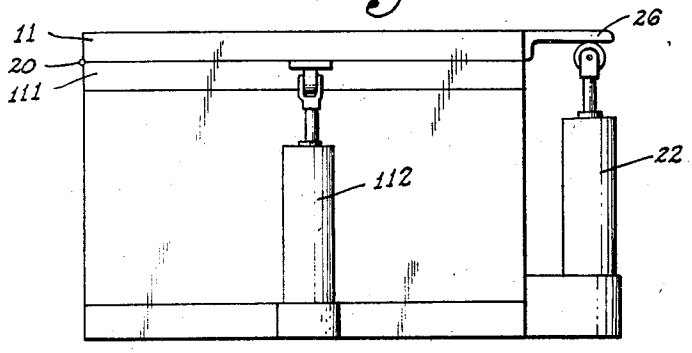
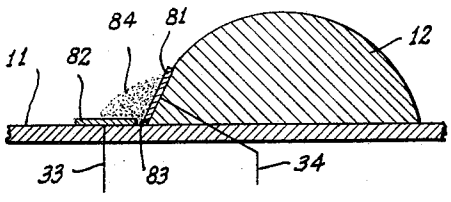


Fig. 6



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APPARATUS FOR AUTOMATICALLY ADJUSTING THE ANGULAR PLANE OF DRY CONCENTRATING TABLES

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2 Claims. (Cl. 209—489)

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My invention relates to dry concentrators, which are machines by which particles of material of high specific gravity, such, for example, as a metal, may be separated from a mass of coarsely or finely divided material consisting, for example, of particles of metal, and particles of material having a lower specific gravity, for example, quartz. Such materials are separated by treating them in the form of a slurry formed with water, which is termed "wet concentration," but my invention relates to dry concentration, in which the material is treated without water. In dry concentration the raw material is crushed or ground to a sufficient degree to largely free particles of the heavier material, that is, the material of high specific gravity, from the particles of light material, that is, material of low specific gravity, thus producing a mixture of light and heavy particles.

The object of the invention is primarily to produce a concentrate, that is, a mixture of light and heavy particles, from a raw mixture of such particles in which the proportion of heavy particles to the light ones is greater in the concentrate than in the raw mixture. Such concentrators produce two mixtures, one of which is termed a "concentrate" which contains a high proportion of heavy particles, and the other of which is usually known as "tailings" containing a relatively low proportion of such heavy particles, the tailings being usually considered a waste product. Dry concentrators may also be used to remove heavy material from lighter material, the lighter material being itself valuable if freed from the heavy material, the concentrate containing the heavy material being a waste or by-product. It should also be noted that there are deposits of raw material which are found in finely divided form and need no crushing or grinding before separation, the crushing or grinding step then not being necessary.

Dry concentrators such as I illustrate herein are old in the art and usually consist of an inclined flat table usually having diagonal riffles thereon, the table being oscillated in such a manner as to cause the raw material in finely divided form to travel across the table and thereby cause the heavier particles with or without some admixture of lighter particles to be delivered from one portion of the table, the waste material or tailings being rejected from another part of the table.

The degree of concentration, that is, the proportion of waste material carried over in the concentrate, is an economic consideration. If a high

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concentration is sought, that is, a concentrate is desired that contains very little waste matter, it is usually found that valuable material is lost in the tailings, and if the concentrator is so operated that almost no values are lost in the tailings, considerable tailings must go over in the concentrate. A balance must be struck between loss of values in the tailings and excess tailings in the concentrate. Dry concentrators are sometimes operated to make three "cuts," delivering a concentrate whose values are sufficiently high for the concentrate to be processed economically, for example, by smelting, discarding tailings whose value is so low that they are discarded as waste, and recovering middlings whose values are not sufficiently high to warrant smelting or other final processing. The middlings are often returned to the material being fed to the table for reprocessing on the table, forming what is known as the "circulating load." The operator of such a concentrator must decide just where he must adjust his operations to make the most money.

This adjustment in a dry concentrator is generally made by adjusting the tilt of the table, that is, the solid angle the table makes with the horizontal plane, and it is usually determined by trial and error, that is, if an operator finds too much valuable material is being lost in the tailings or too much waste material is going into the concentrate, he adjusts the angle of the table to correct the situation. This is not particularly difficult if the raw material is uniform as to size of particles and proportion of valuable material therein. Operating on raw material of variable characteristics, constant readjustments of table angle are necessary and must of necessity be rough and imperfect if they depend wholly on the operator.

The principal object of my invention is to provide apparatus for controlling the operation of a dry concentrator, so that it will deliver a concentrate of reasonably constant characteristics even when the characteristics of the raw material being treated vary very widely.

A further object of the invention is to provide such a control which is determined by the characteristics of the concentrate, or the tailings, and is not dependent on the skill or judgment of the operator.

A further object of the invention is to provide means in a dry concentrator for automatically changing the table angle to compensate for changes in the characteristics of the raw material being treated so that a concentrate of reasonably constant characteristics may be pro-

duced, and undue losses of valuable constituents to the tailings will be avoided.

Further objects and advantages will be made evident hereinafter.

Referring to the drawings, which are for illustrative purposes only,

Fig. 1 is a plan view of a dry concentrator equipped with my invention;

Fig. 2 is an end view, the table in Fig. 1 being viewed in the direction of the arrow 2 in Fig. 1;

Fig. 3 is a diagram showing electrical and hydraulic controls;

Fig. 4 is a plan view of an alternate form of concentrator;

Fig. 5 is an end view of the concentrator shown in Fig. 4 viewed in the direction of the arrow 5 in Fig. 4; and

Fig. 6 is a section of a portion of the table 11 taken on the line 6—6 of Fig. 1.

The dry concentrator shown in Fig. 1 is of the conventional type consisting of a flat table 11 having diagonal ribs or riffles 12 projecting upwardly from the surface thereof. The table may be imperforate, or it may be made of screen or fabric, having air forced upwardly therethrough by means not shown. The table is oscillated in the direction of the arrow 13 by a mechanism carried in a case 14. This mechanism is so devised that it makes a quick motion in one direction and a slow motion in the other, so that the material is delivered into a distributor 15 and flows across the table in the direction roughly that of the arrow 16. The arrow 16, of course, represents only the composite motion of the particles, some of them emerging as concentrate over the end 17 of the table and some of them emerging as tailings over the side 18 of the table. The material delivered to the distributor 15 may be finely or coarsely divided, the degree of division being governed by the material being treated, this division having been effected either by grinding or by the material being in a finely divided natural state. This material ordinarily is a mixture of metal particles, hereinafter called "the values," and non-metallic particles, hereinafter referred to as "the gangue."

The operation of such concentrators is well understood, the material travelling thereacross being usually lifted by jets of air periodically directed upwardly therethrough, the heavy material settling to the bottom and being caught by the riffles and travelling generally in the direction of these riffles 12. The particles of the metal tend, however, to spill over the riffles and proceed downwardly over the table toward the side 18, the degree of travel of the metal particles being governed by the inclination of the table, the strength of the puffs of air, and, of course, the size of the particles. The table 11 which I use is pivoted on a pivot 20, as shown in Fig. 2, so that it may be raised from the position shown in full lines in that figure to the position shown at 21 in dotted lines.

In practice, the table 11 may be inclined about either of two axes A—A or B—B or axes parallel thereto. In practice, the material usually moves slightly uphill along the axis A—A as it moves toward the end 17 of the table, and downhill along the axis B—B as it moves toward the side 18 of the table, having a composite motion usually downhill diagonally toward the lower right-hand corner of the table. A simultaneous adjustment may be made along the axes A—A and B—B if the table is pivoted on a single axis C—C. In the drawings I show a table pivoted about an axis D—D which is parallel to the axis A—A previously referred to. The table may be initially so set that the axis D—D is horizontal or inclined slightly to the horizontal. In practice, I prefer to so set the table that material moving along the axis A—A toward the end 17 climbs slightly uphill.

I provide for the changing of the solid angle between the surface of the table and the horizontal plane by the mechanism shown diagrammatically in Fig. 3. This mechanism consists of a cylinder casting 22 having a cylindrical bore therein in which a piston 23 can move vertically, this piston having a piston rod 24 which carries a roller 25 at its upper end. The roller 25 engages a projection 26 on the table 11, and as the roller moves upwardly, being forced up by the piston 23, the table is moved from the position shown in full lines in Fig. 2 to the position 21 shown in dotted lines in this figure. The piston 23 is moved hydraulically by water, or preferably by a light oil. To control the action of the piston 23 and the inclination of the table 11, I provide a series of rosettes 31 which in their preferred form are simply cylinders of porcelain or similar insulating material having two projecting points 32 which extend upwardly from the insulating material, the top of which lies approximately in the same level as the surface of the table 11. These two points 32 are connected respectively to wires 33 and 34, as shown in Fig. 3. One of these wires 33 is connected to a source of electrical supply, and the other wire 34 extends down to a relay 36 having a core 37 which is pulled upwardly whenever the relay is actuated, closing a connection between contacts 38 and 39. The other terminal of the relay 36 is connected through a wire 40 to the source of electrical supply. The source of electrical supply is also connected through a wire 41 with the contact 39. The contact 39 is connected through a wire 42 with a coil 43 of a valve 44. The other terminal of the coil 43 is connected through a wire 45 with the wire 33. The electrically connected apparatus above described works as follows:

When the core 37 of the relay 36 is down in the position shown in the drawings, the coil 43 is not energized, and the valve 44 is in its lower position as shown in the drawings. When the core 37 of the relay 36 is pulled upwardly, the coil 43 is energized, and the valve is moved into an upper position, as will later be explained. The actuation of this electrical system depends upon the collection between the points 32 of a sufficient number of particles of metallic or other conducting matter to form a connection between these points and allow the relay 36 to operate the valve 44. Whenever this metallic or conducting material collects in sufficient amounts to so form a bridge between the points 32, the valve 44 is pulled upwardly, and whenever this bridge is broken by the intrusion of non-conducting material, the valve 44 is dropped to its lower position as shown in Fig. 3.

The valve 44 includes a casting 50 having a cylindrical bore in which a piston 51 slides, this piston being connected to the core 52 which is actuated by the coil 43. The piston 51 has a central groove 53 therein. In its lower position the groove provides an open communication between pipes 54 and 55. In the upper position of the piston 51 the groove 53 provides an open communication between pipes 56 and 57. Oil is delivered under pressure from a pipe 58 to a pipe 59 by a pump 60, this pump being constantly

driven by an electric motor or other means (not shown). The pump may be of any size which will deliver considerable pressure, but it need not have a large capacity, as the movement of the table is very slow. I prefer to use a gear pump or some other similar device. To prevent the pump from building up excessive pressure, a pressure regulating valve 61 is provided, this valve being of conventional design and having a diaphragm 62 forced upwardly by a spring 63, the tension of this spring being controlled by a threaded member 64. The spring 63 normally holds the diaphragm in its upper position so that a valve member 65 closes an opening 66 in a pipe 67. Oil under pressure from the pipe 59 flows through a pipe 68 into the space above the diaphragm 62. Whenever the pressure in this space exceeds the predetermined amount, which is established by the spring 63, the diaphragm 62 is forced down, and oil is allowed to escape into the pipe 67, which is connected to the pipe 57, the pipe 58 also being connected to the pipe 57. The pipe 57 is also connected into the bottom of an oil reservoir 70. The pipe 54 is connected through a regulating valve 71 with a pipe 72 connected into the bottom of the cylinder casting 22. The pipe 56 is similarly connected through a regulating valve 73 to the pipe 72.

The method of operation of the apparatus is as follows: With the table 11 in its lower position, as shown in Fig. 2, the mechanism in the case 14 is started, and the table is set to oscillate, material being fed into the distributor 15. Due to the fast and slow motion of the table, this material is projected across the table toward the end 17 of the table. The material stratifies, and the heavy material is caught by the riffles 12, the lighter material passing over the riffles. If the table has no inclination with the horizontal, the movement of all of the material is from left to right, as shown in Fig. 1, the heavy material being forced slightly upwardly by the riffles. The operator will ordinarily allow the table to operate in this manner for a few minutes to get it covered and to get the material partially stratified. During this time no electrical energy is supplied to the apparatus shown in Fig. 3, so that the pump 60 is not in operation, nor is the other electrical apparatus energized. As soon as the table is covered and some stratification has occurred, electrical energy is supplied to the wires 33 and 40 and to the motor operating the pump 60. Unless sufficient metallic particles have accumulated in and around the points 32 of the rosettes 31, the parts are in the position shown in Fig. 3, the piston 51 of the valve 44 being in its lower position. The pump 60 is supplying oil under pressure to the pipe 59, this oil flowing through the pipe 55 and the groove 53 to the pipe 54, and from this pipe to the pipe 72 and into the bottom of the cylinder casting. This oil under pressure tends to raise the piston 23, which in turn raises the table 11 from the position shown in full lines in Fig. 2 toward the position shown in dotted lines in that figure. This inclination of the table tends to throw material on the surface of the table toward the side 18, the lighter particles moving much more predominantly in this direction than the heavier particles.

In starting the apparatus, the rosette indicated by 80 in Fig. 1 is usually selected as a control rosette, and as long as the table 11 is moving horizontally without inclination, little or no metallic values arrive at this rosette, these values

being deflected by the riffles 12 and constantly moving toward the end 17 of the table. Thus, with the table horizontal, substantially no metallic values will arrive at the rosette 80, and, in fact, very little of the gangue will spill over the side 18 of the table. Oil from the pump 60 will therefore continue to force the piston 23 upwardly, the rate at which it is forced being regulated by the regulating valve 71. This valve may be so set that the increase in the slant of the table is very slow, it taking several minutes for the piston 23 to complete its stroke. As soon as the table starts to slant, material will start to spill over the side 18 of the table, most of this material being lighter particles or gangue. The ideal situation, of course, would be to have all the gangue spill over the side 18 of the table and all the metallic particles spill over the end 17 of the table. This ideal condition is never reached. As soon as the metallic particles start to cross the riffles toward the side 18 in sufficient amount to reach the rosette 80, the rosette 80 is short-circuited or a connection is made between the points 32 of that rosette. This causes the relay 36 to be energized, which energizes the coil 43 of the valve 44, and the piston 51 is pulled into its upper position, with the groove 53 connecting the pipes 56 and 57. This closes off all connection between the pipes 54 and 55, and the oil under pressure delivered by the pipe 59 passes through the pipe 68 into the valve 61. Pressure promptly builds up in this pressure valve so that oil is released through the pipe 67 to the pipe 57. Thereafter the oil simply circulates through the relief valve. The pipe 56 being in open communication with the pipe 57, there is, therefore, an open communication between the space inside the cylinder casting 22 below the piston 23 and the oil reservoir, and the weight of the table acting on the roller 25 forces the piston 23 down and forces oil back through the pipes 72, 56, and 57 into the oil reservoir 70. The rate at which this oil is forced back is regulated by the regulating valve 73. As the piston 23 moves down, the table moves from the slanted position shown at 21 in Fig. 2 toward a strictly horizontal position, and the degree of side throw of the table is cut down so that less and less material tends to move toward the side 18 of the table. When this movement has progressed to a sufficient degree, there are not sufficient metallic particles in the material passing off the side of the table to maintain the circuit between the points 32 of the rosette 80, and the circuit is broken, the relay 36 dropping to the position shown in Fig. 3, opening the circuit to the coil 43 of the valve 44 and dropping the piston 51 of the valve 44 to the position shown in the drawings. This causes oil under pressure to be applied to the piston 23, and the piston 23 starts to rise and increase the slant of the table. In practice, the table 11 is more or less in constant movement, moving slowly up or down and hunting a position at which the process operates properly, spilling a large portion of the metallic particles over the end 17 and a much smaller proportion over the side 18. Whenever sufficient particles are present in the rosette 80, the table starts to assume a horizontal position, and more metallic particles are thrown toward the end of the table, thus breaking the circuit between the points 32. The table will at this time have moved to a position below that which gives the best results, and as soon as the circuit is broken, the

table starts back, again passing through this point of most desired operation. If at a given instant materials very low in metal values are being delivered to the distributor 15, a proper concentrate cannot be obtained if the table is very close to a horizontal position.

The points 32 may be thin metal discs projecting only the thickness of the discs above the surface of the table so that they will offer very little resistance to the movement of material over them, or they may be in the form shown in Fig. 6. This shows the riffle 12 carried on the surface of the table 11. One plate 81 is affixed to the riffle 12, and a plate 82 is affixed to the surface of the table. The wire 34 is connected to the plate 81, and the wire 33 is connected to the plate 82, the plates being insulated from each other and there being a gap 83 therebetween, this gap being preferably somewhat smaller than the major thickness, width, or length of the average conducting particle of the material being treated. This may be impractical with very finely divided material, but electrical conduction between the plates 81 and 82 due to the accumulation of the mass 84 of conducting particles which tends to pile up in the corner occupied by the gap 83 produces such conduction.

While I have shown a table adjustable only about the axis D—D, it is, of course, possible to cause it to shift about an axis C—C which may be located to suit the nature of the material being treated.

Another method of controlling the table is shown in Figs. 4 and 5. In this concentrator the table 11 is not only adjustable about the axis D—D by the apparatus previously described, but it is adjustable about an axis E—E. This I accomplish by placing an intermediate member 111 directly below the table and pivoting it about the axis E—E, it being raised or lowered by apparatus 112, which is a duplicate of that previously described as used in moving the table proper and which is shown in Fig. 3. By a proper manipulation of the valves 71 and 73 which regulate the operation of the table and the similar valves which regulate the operation of the intermediate member 111, almost any desired composite movement may be attained.

I claim as my invention:

1. A concentrator comprising: a supporting structure; a table having a plane surface carried by said structure in such a manner that the solid angle between said surface and the horizontal plane can be varied; means for feeding material containing electrically conducting particles to said table, which is so formed and operated in accordance with well known principles that said particles tend to aggregate; power means for so varying said angle; and electrical means responsive to the electrical conductivity of said particles for so controlling said power means that said table is maintained at the angle at which the most economical concentration of said particles is obtained from said material, said angle being varied automatically as the character of said material varies.

2. A concentrator comprising: a supporting structure; a table having a plane surface carried by said structure in such a manner that the solid angle between said surface and the horizontal plane can be varied; means for feeding material containing electrically conducting particles to said table, which is so formed and operated in accordance with well known principles that said particles tend to aggregate; power means for so varying said angle; electrical contacts placed in the path of said particles as they move across said table, said contacts being so placed that an electrical current passes through said particles between said contacts whenever said particles are in position to establish said conduction; and means by which said current causes said power means to shift said table toward the angle at which the most economical concentration of said particles is obtained from said material, said shifting being accomplished automatically as the character of said material varies.

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