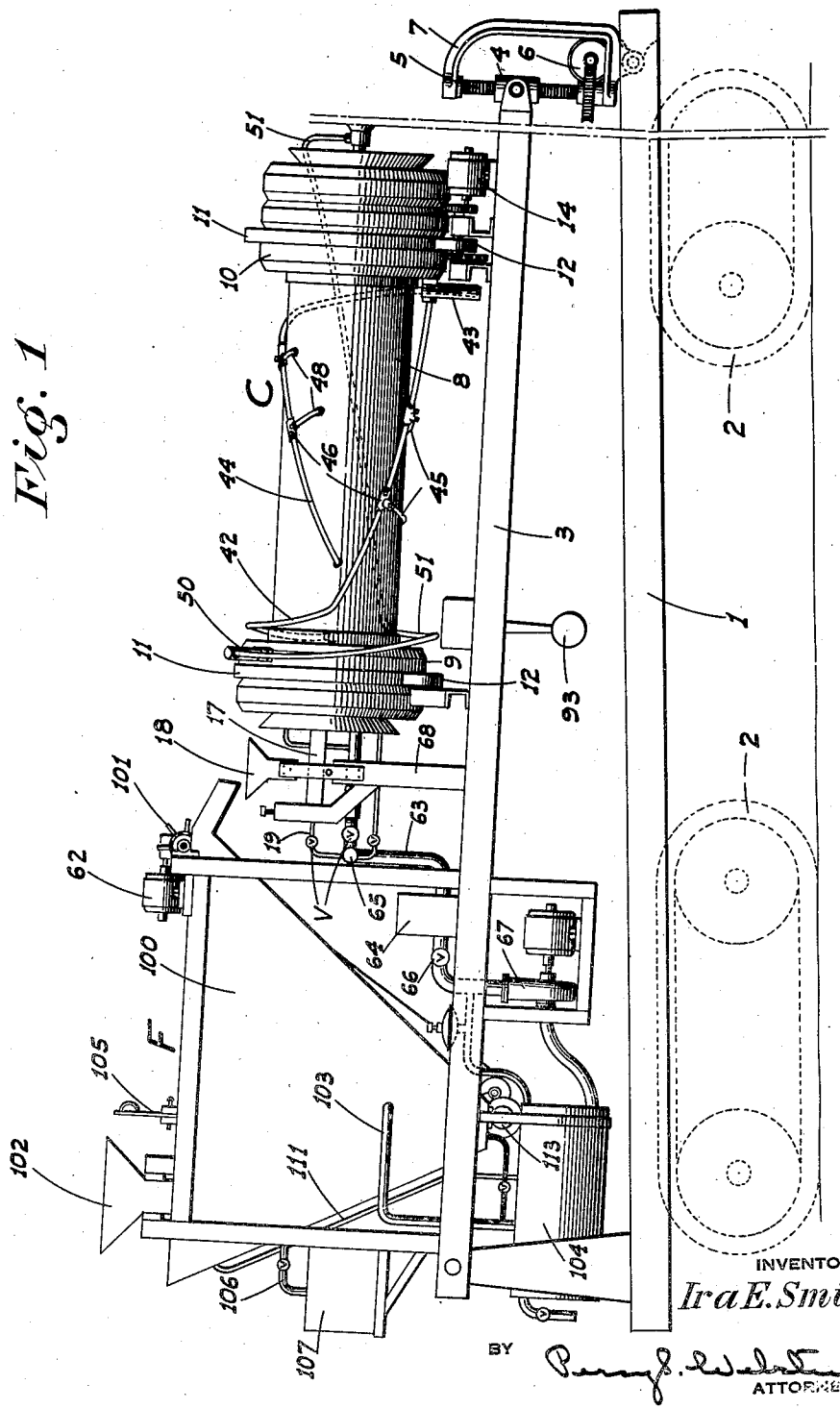
June 15, 1937. I. E. SMITH 2,083,674

SEPARATOR

Filed June 26, 1934 10 Sheets-Sheet 1

Fig. 1

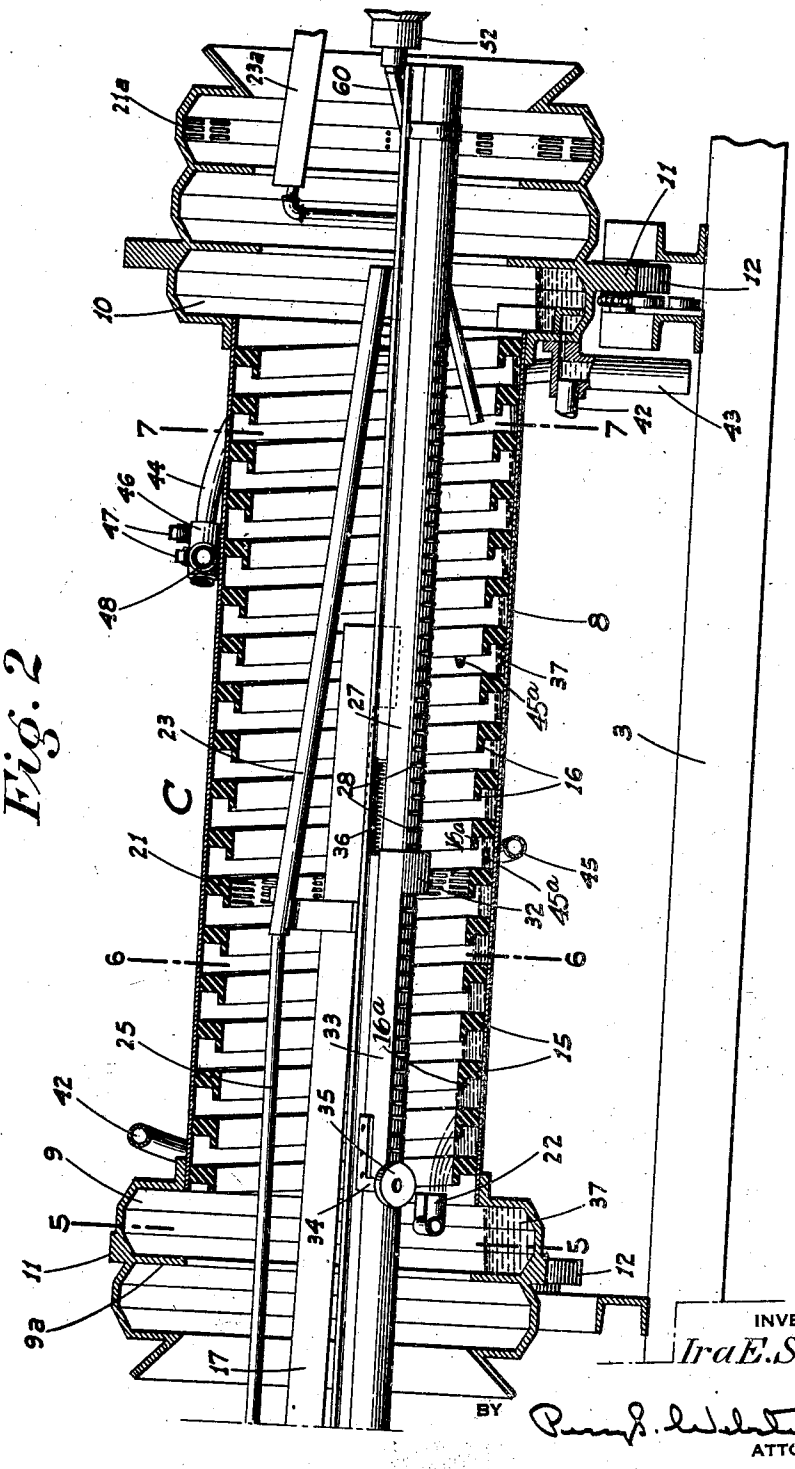


June 15, 1937 I. E. SMITH 2,083,674

SEPARATOR

Filed June 26, 1934 10 Sheets-Sheet 2

Fig. 2



June 15, 1937. I. E. SMITH 2,083,674

SEPARATOR

Filed June 26, 1934 10 Sheets-Sheet 3

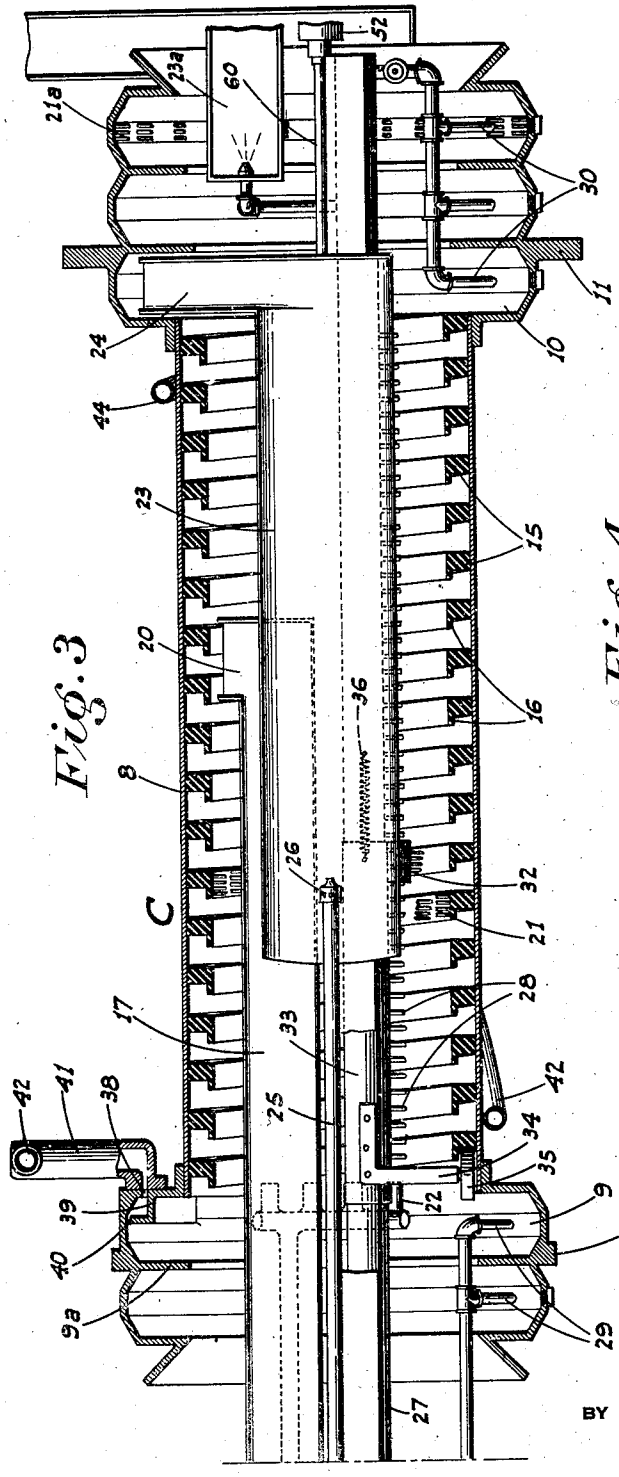


Fig. 3

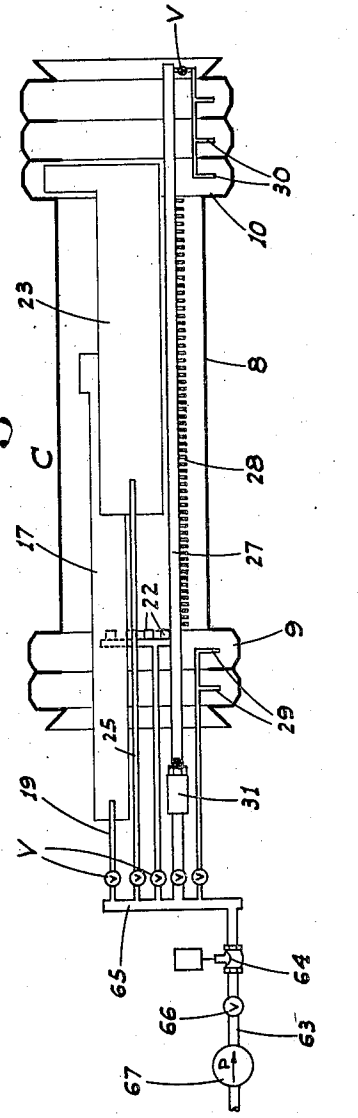


Fig. 4

INVENTOR

Ira E. Smith

BY

ATTORNEY

June 15, 1937. I. E. SMITH 2,083,674

SEPARATOR

Filed June 26, 1934 10 Sheets-Sheet 4

Fig. 5

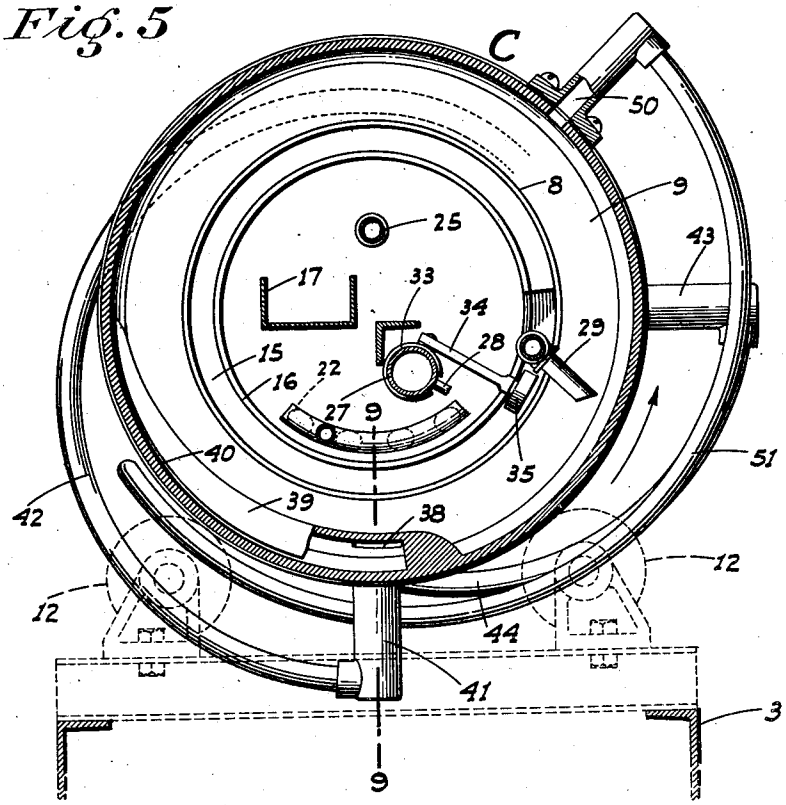


Fig. 10

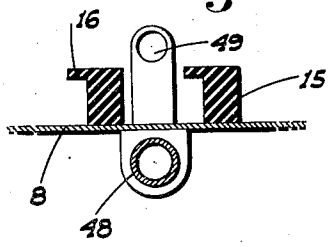


Fig. 9

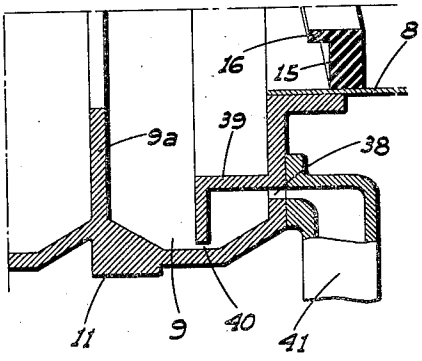
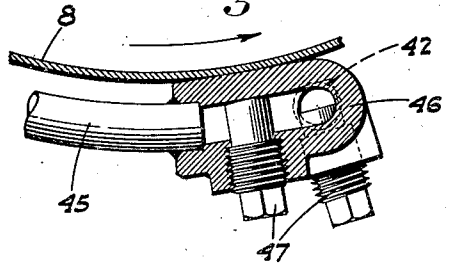


Fig. 11



INVENTOR

Ira E. Smith

BY

ATTORNEY

June 15, 1937. I. E. SMITH 2,083,674

SEPARATOR

Filed June 26, 1934 10 Sheets-Sheet 5

Fig. 6

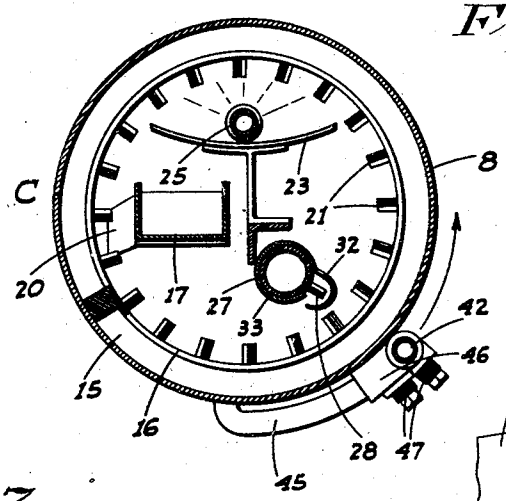


Fig. 8

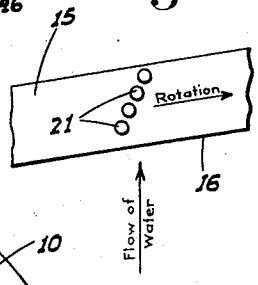
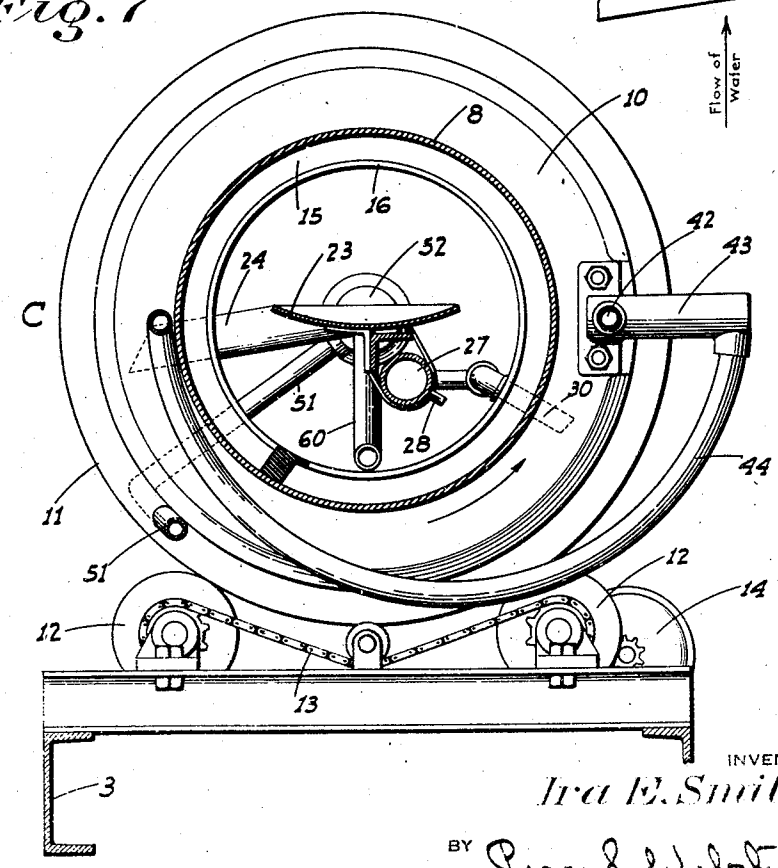


Fig. 7



INVENTOR

Ira E. Smith

BY Percy S. Webster

ATTORNEY

June 15, 1937. I. E. SMITH 2,083,674

SEPARATOR

Filed June 26, 1934 10 Sheets-Sheet 6

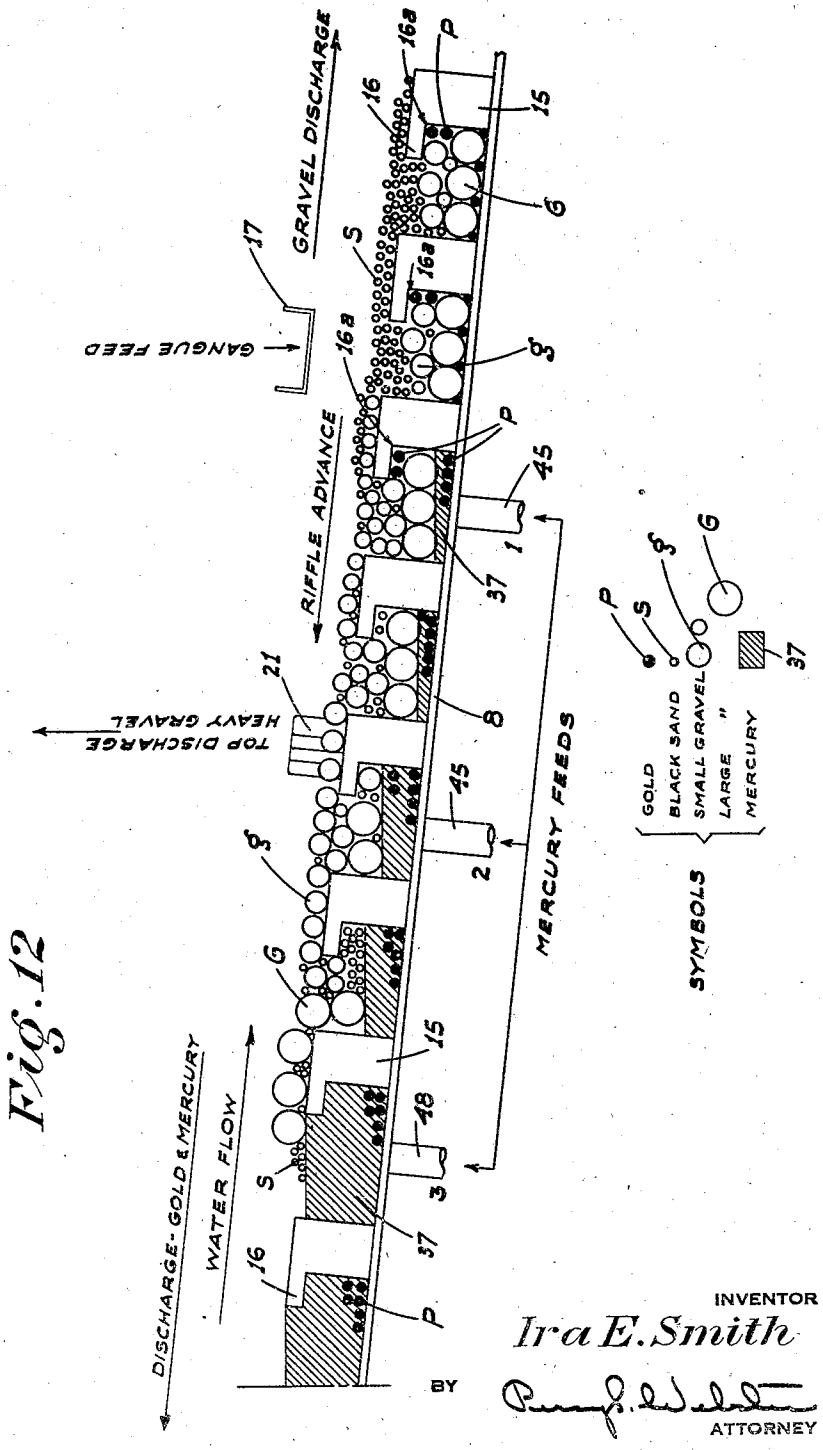


Fig. 12

INVENTOR
Ira E. Smith
BY
ATTORNEY

June 15, 1937. I. E. SMITH 2,083,674

SEPARATOR

Filed June 26, 1934 10 Sheets-Sheet 7

Fig. 14

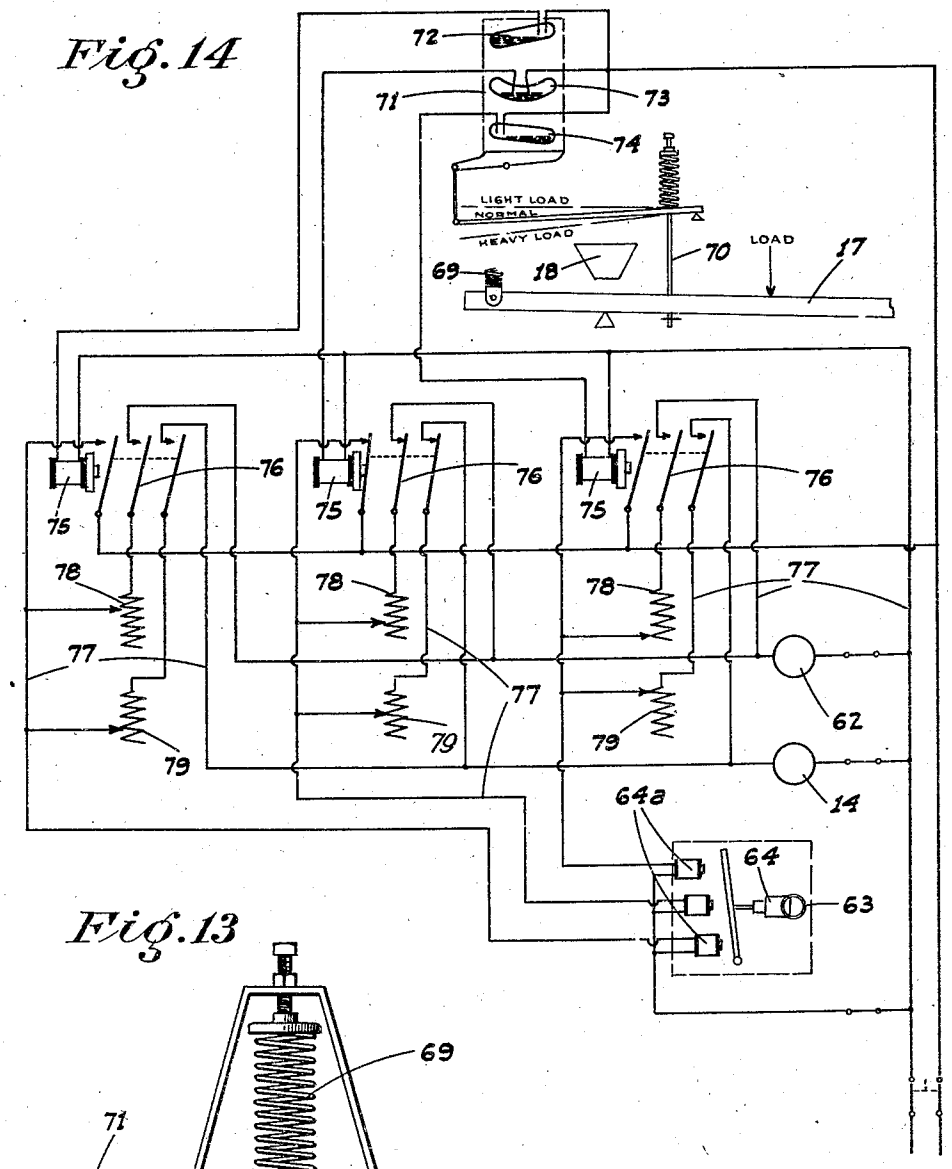
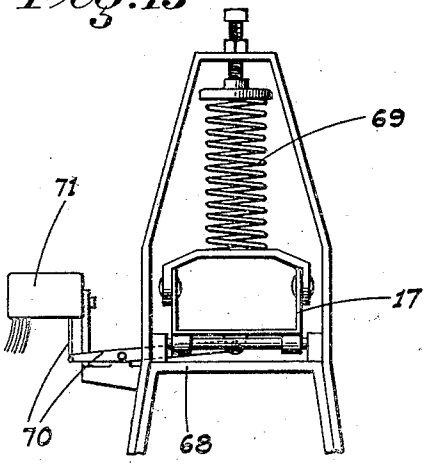


Fig. 13



INVENTOR

Ira E. Smith

BY

ATTORNEY

June 15, 1937. I. E. SMITH 2,083,674

SEPARATOR

Filed June 26, 1934 10 Sheets-Sheet 8

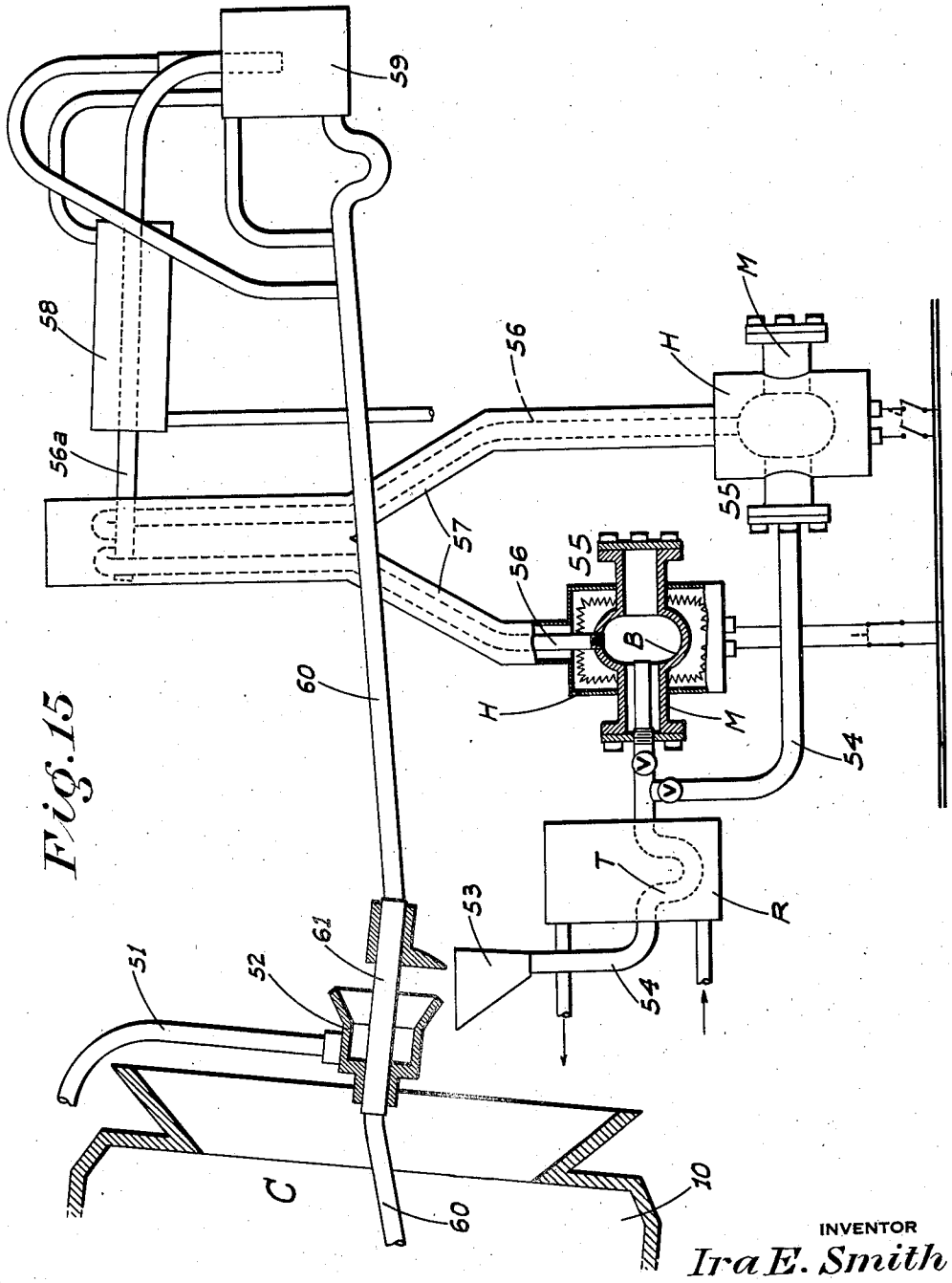


Fig. 15

INVENTOR

Ira E. Smith

BY

ATTORNEY

June 15, 1937. I. E. SMITH 2,083,674

SEPARATOR

Filed June 26, 1934 10 Sheets-Sheet 9

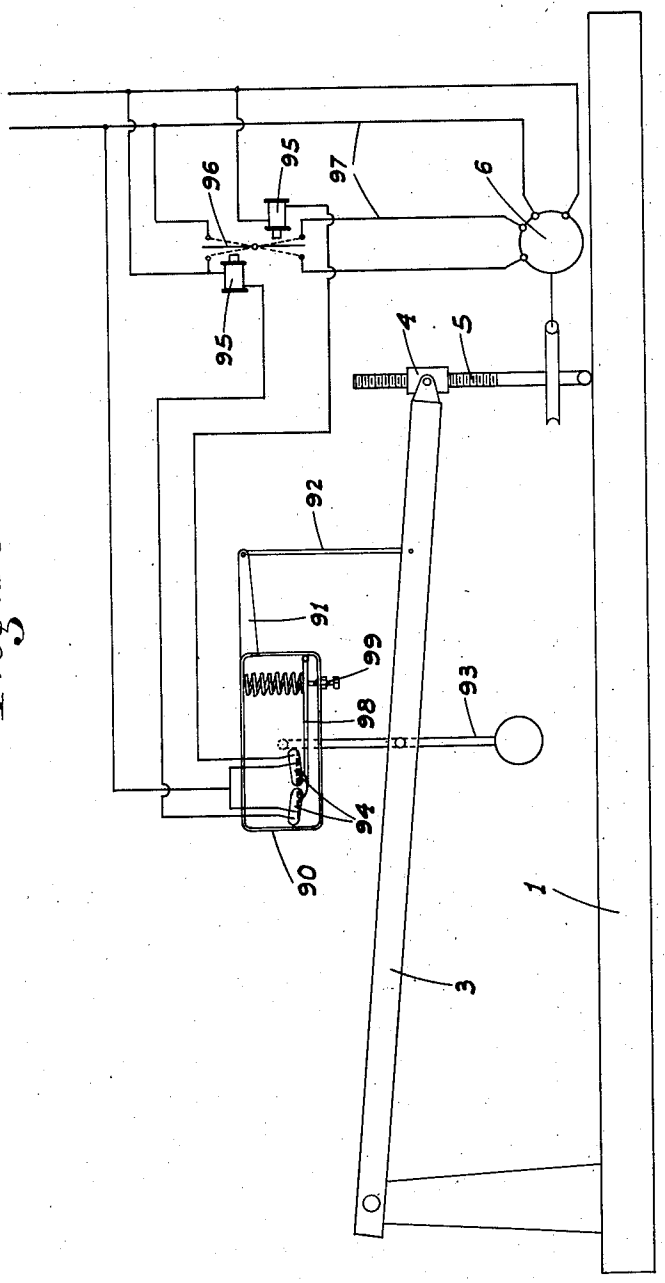


Fig. 16

INVENTOR
Ira E. Smith

BY
ATTORNEY

June 15, 1937. I. E. SMITH 2,083,674

SEPARATOR

Filed June 26, 1934 10 Sheets-Sheet 10

Fig. 17

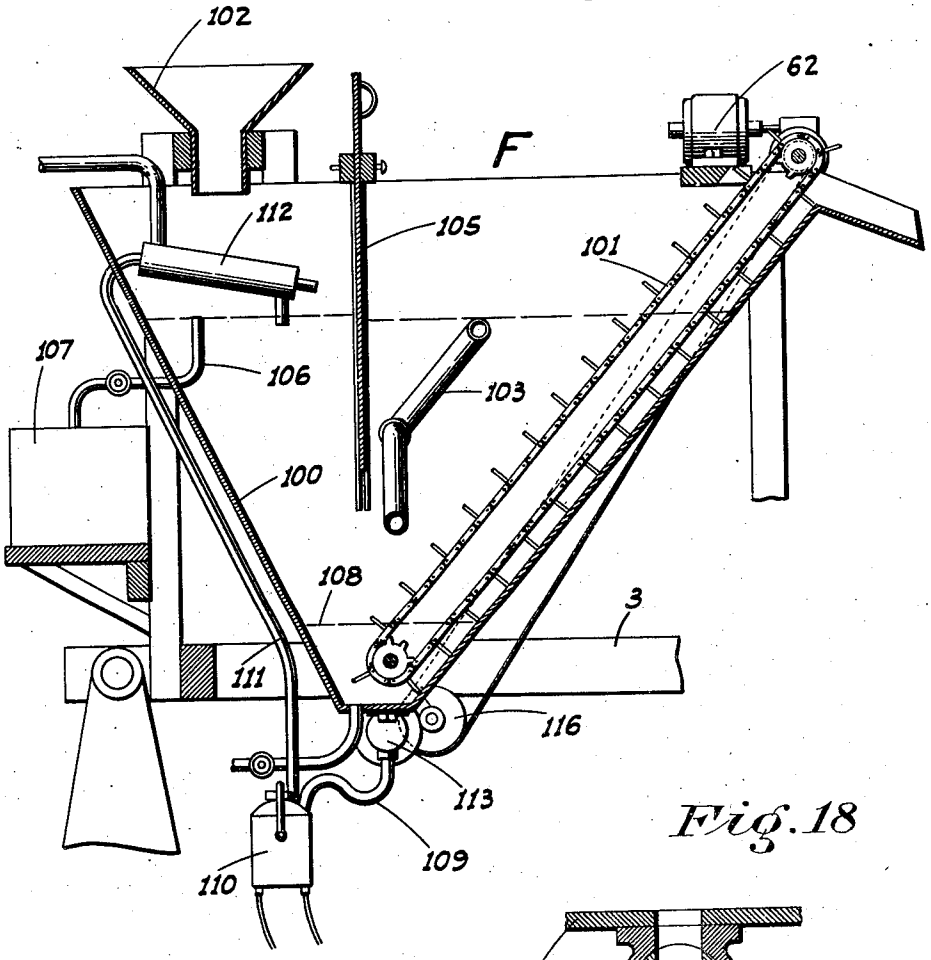
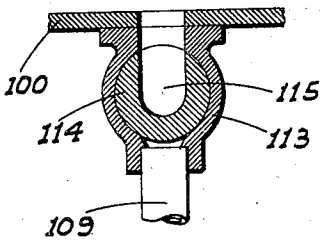


Fig. 18



INVENTOR

Ira E. Smith

BY

ATTORNEY

Patented June 15, 1937 2,083,674

UNITED STATES PATENT OFFICE

2,083,674

SEPARATOR

Ira E. Smith, Stockton, Calif., assigned by decree of court to Lillian M. Smith, surviving widow

Application June 26, 1934, Serial No. 732,428

17 Claims. (Cl. 209—200)

This invention relates to separators for precious metals, and particularly to one adapted to handle a gangue of gravel, sand, and a mass of similar relatively small particles in connection with a flow of water and a quantity of a circulating nondisplaceable medium such as mercury or other liquid which is nonsoluble in water and which will retain the precious metal particles with which it comes in contact.

The principal object of my invention is to provide a machine of this general character arranged to separate all precious particles from the gangue fed to the machine from the size of nuggets or the like to those of infinitesimal size. Another object is to provide means for automatically withdrawing a certain portion of the amalgam periodically from the machine, retorting it to remove its precious content, and redelivering the mercury back to the machine at predetermined points for further use to again catch the precious content of the mass of material being treated.

Once the necessary amount of mercury is provided for the proper working of the machine, none is permanently removed from the machine proper and the supply need never be replenished since it may be used over and over without possible loss.

The machine includes a revolving internally riffled cylinder or drum, means to feed the gangue into the drum, and a means to feed a flow of water into the drum. In connection with this general arrangement, another object of my invention is to provide a means, controlled by the weight and volume of the gangue as fed into the cylinder, for automatically controlling the amount being fed, the speed of the cylinder and the amount of water being supplied to the same. In this manner the volume of the gangue mass is properly coordinated to the capacity of the drum, while at the same time it is subjected to the proper agitating action and the necessary amount of water for proper washing and separation of the precious content from the gangue.

Once the machine is started, its operation as to the amount of material treated, the water feed, the speed of the separating action, and other features, are automatically taken care of, while at the same time said features may be selectively and individually adjusted as conditions of operation and the type of material being treated necessitates. As a result I have provided an extremely efficient machine, one able to handle all classes of material, which is inexpensive to operate and with which, as previously stated, all the precious content in the gangue will be separated and recovered from the worthless mass. Also if desired this relatively worthless mass may itself be segregated into different graded masses, in the event that it is desired to dispose of this matter for building or road making purposes, or all or certain portions of the mass believed to still contain values may be separated while still in the machine, crushed or otherwise treated, and again passed through the machine for recovery of the values.

The machine operates through a combination and synchronization of various natural forces such as gravity and the laws covering the displacement of mass by reason of its density per unit of volume, and other factors, together with water pressure and flow and mechanical movements which enable said natural forces to be effective for the desired purpose. The machine also operates without the use of screens, grizzlies, sluice boxes, under-currents or a violent shaking motion which is hard on the machine.

The machine is arranged either as a stationary or as a complete unitary portable apparatus, capable of performing all its functions while moving along the ground and I have particularly shown the machine as being of this portable character. The machine may therefore work along gravel beds without the necessity of conveying the material to be treated from any distance. In connection with the portable machine, a further object of the invention is to provide a means for enabling the separating drum to be automatically maintained at a predetermined level relative to a horizontal plane as it moves along the ground regardless of irregularities in the contour of the ground over which the machine is traveling.

The constructional features by which the above ends are attained will now be fully described, and it is here noted that in the interests of brevity in said description, the word "gold" is intended to include all precious minerals, and the word "mercury" is used to include any circulating and nondisplaceable medium suitable for the purpose.

Also, the term "riffle groove" is used to designate the space or enclosure between adjacent turns of the spiral riffle, whether said space is actually of groove-like form as it would be in a small machine, or is of considerable width and depth as in a large machine.

In the drawings similar characters of reference indicate corresponding parts in the several views:

Figure 1 is a side elevation of the complete machine.

Figure 2 is a longitudinal section of the separating cylinder or drum.

Figure 3 is a top plan view of the same.

Figure 4 is a similar diagrammatic view showing the various water feed pipes.

Figures 5, 6 and 7 are cross sections of the cylinder on the lines 5—5, 6—6, and 7—7 respectively of Figure 2.

Figure 8 is a fragmentary plan view of a cylinder riffle showing the position of the gravel elevating means relative to the direction of flow of the water and the movement of the riffle.

Figure 9 is a fragmentary enlarged longitudinal section on the line 9—9 of Figure 5.

Figure 10 is a fragmentary longitudinal section of the cylinder showing a special mercury intake pipe.

Figure 11 is a fragmentary cross section showing a typical control valve arrangement in the mercury distributing line.

Figure 12 is a fragmentary longitudinal diagrammatic section of the cylinder showing various steps in the separating action of the material being treated.

Figure 13 is an end view of the gangue feed chute showing the mounting of the same.

Figure 14 is a diagram of the circuits for the material feed motor, the cylinder rotating motor, the water feed control, and the connections controlling the energizing of the circuits by reason of the weight and volume of the gangue being fed to the cylinder.

Figure 15 is a side view somewhat diagrammatic of a retorting and mercury return arrangement for the amalgam.

Figure 16 is a diagram of the separate means for automatically controlling the level of the cylinder.

Figure 17 is a sectional elevation of the initial feeding and dewatering unit of the machine.

Figure 18 is an enlarged cross section of the mercury removing and meter valve of said unit.

Referring now more particularly to the characters of reference on the drawings, the machine comprises a main frame 1 supported on endless tracks, indicated at 2, or similar means so that said frame may travel along the ground. Pivoted at one end on the adjacent end of the frame 1 in raised relation thereto is an auxiliary frame 3 which at its free end is provided with a vertical tapped, swivelly mounted sleeve 4 engaging a screw 5 which is supported from the main frame and is operatively connected to a reversible electric motor 6. The motor and screw are mounted as a unit on a rock frame 7 swivelly mounted on the frame 1 so that the screw can yield as the frame 3 moves vertically. The means for automatically controlling the operation of the motor so as to rotate the screw one way or the other and thus alter the tilt of the frame 3, will be described later.

The separator cylinder unit indicated generally at C extends lengthwise of and is rotatably mounted on the frame 3 in a manner to be described shortly, while a special feed unit indicated generally at F, and also described in detail later, is likewise mounted on the frame 3 beyond the upper end of the cylinder to feed thereto.

The cylinder unit which is the heart of the machine comprises a main cylinder 8 preferably disposed parallel to the frame 3 and set with a downward slant from its end adjacent the feed unit F. At its upper end a longitudinally separated pair of enlarged annular reservoirs 9 are rigidly connected to the cylinder, said reservoirs being substantially of U-shaped form in cross section, as plainly shown in Figures 2 and 3. Said reservoirs, while separate from each other, are disposed in close relationship, the separating means being a common ringlike wall 9a therebetween, the bore of which is substantially the same as that of the cylinder 8. At its other end the cylinder is connected to a row of annular reservoirs 10 of the same general size, shape and arrangement as the reservoirs 9. Track bands 11 are provided with the cylinder unit adjacent its ends and of course concentric therewith, which bands are engaged by transversely spaced pairs of rollers 12. The rollers of one pair are connected in driving relation by a chain 13 or the like, as shown in Figure 7, and one of said rollers is driven by a non-reversible variable speed electric motor 14 whose speed of operation is controlled as will be seen hereinafter. In this manner the cylinder unit may of course be rotated in one direction only but at varying speeds.

Secured inside the cylinder and extending from end to end thereof is a spiral riffle 15, the pitch of which is relatively small and the direction of which relative to the direction of rotation of the cylinder is such as to convey material toward the upper end of the cylinder. The riffle is preferably made of semi-hard rubber and is rectangular in cross section, with a flange or lip 16 projecting from its leading side along its inner face and forming a sharp corner 16a. The riffle is thus L-shape, though one of T form may be used if desired. The outer face of the riffle contacts with the bore of the cylinder throughout its length so that there will be no possible leakage therebetween.

Extending a certain distance into the cylinder from its upper end is a feed chute 17 for a gangue, which is mounted in a special manner as will be shown later. The material is deposited in this chute outside the cylinder from a fixed hopper 18 into which the unit F discharges (see Figure 1). A water pipe 19 discharges lengthwise into the chute adjacent the point of feed and in the direction of the lower end of the chute. Said lower end terminates in a laterally extending portion 20 which delivers into the cylinder adjacent the riffle a certain distance above the bottom and on the side of the cylinder which is moving down, and from which the material as fed is being constantly withdrawn by the rotating movement. In this manner the fresh material as deposited in the cylinder will always fall into an unoccupied and clean zone.

At a certain point in the length of the cylinder between the discharge end of the chute and the upper end of the cylinder, the riffle for about one complete turn is provided with circumferentially spaced inwardly projecting radial gravel elevator members 21, which I term buckets, and which preferably consist of a number of spaced pins disposed at a slight acute angle to the axis of the cylinder as shown in Figure 8. Said buckets are also at an angle to the longitudinal flow of water delivered into the upper end of the cylinder adjacent the bottom by a plurality of circumferentially spaced nozzles 22. This form and arrangement of the buckets insures that the material engaged by the same will be properly elevated without being swept away by the flow of water; the lumps being wet tend of themselves

to cling to the buckets as the latter move with the spiral and sweep the lumps out of the flowing water.

The material as elevated toward the top of the cylinder drops into a chute **23** which leads to the lower end of the cylinder with a downward slant and terminates in a lateral portion **24** discharging into that reservoir **10** which is nearest the cylinder and delivering into said reservoir above the bottom and on its downwardly moving side, the same as the discharge from the chute **17**. A water pipe **25** projects into the cylinder from its upper end and above the chute **23** and terminates in a spray nozzle **26** discharging lengthwise of the chute and also radially upward against the riffle and buckets, to dislodge any material tending to hang onto the same.

One or more elevator or bucket units may be employed at various points in the length of the cylinder, as the class of material being worked, or the extent of separation desired, may determine.

I have found from experience that any lumps of iron sulphide, which may form part of this discharged mass and which may contain hidden values, ultimately collect in the reservoir **10** furthest from the cylinder where they sink to the bottom, while the relatively light waste matter is flowed over by the water. To withdraw these lumps, I may place a row of bucket elements **21***a* about the bottom of this reservoir, to engage and elevate the lumps and discharge them into a separate chute **23***a*. From this chute, the lumps may be passed to a crusher, and the crushed mass returned to the feed chute **17** and thence to the cylinder for further separation.

Extending lengthwise in the cylinder below the chute **23** is a water pipe **27** having a row of jets **28** projecting radially therefrom and discharging into the cylinder a certain distance above the bottom and against its upwardly moving side. Similarly positioned spray pipes **29** and **30** are disposed to discharge into the various reservoirs **9** and **10** respectively. In order to enable the angle of the jets **28** to be altered if desired, to alter the height to which the water will strike the cylinder wall and riffle, the pipe **27** may be connected to the main supply pipe with a swivel joint **31** of any suitable type as indicated in Figure 4.

The water in these various pipes is under pressure and if the water issuing from the jets **28** in the plane of the buckets was allowed to strike the same, this water would tend to wash away the material being elevated before it reaches the chute **23**. In order to prevent this I provide a shield **32** which extends in front of those jets which are transversely alined with the buckets and which is mounted on a sleeve **33** slidable on the pipe **27** without interfering with the other jets and which extends to the upper end of the cylinder. A laterally extending arm **34** is secured to the sleeve adjacent its outer end, which supports a roller **35** whose axis is disposed circumferentially radial of the cylinder. This roller engages the leading face of the endmost turn of the riffle, and is held in contact therewith by a tension spring **36** suitably applied to the sleeve. It will thus be seen that with the rotation of the cylinder, the sleeve and shield move lengthwise of the cylinder, the shield retaining its covering relation to the jets alined with the row of buckets which extends about the turn of the riffle and is of course also spirally arranged.

When the roller reaches the upper end of the riffle, the shield covers those jets alined with the adjacent endmost bucket, and as the riffle at its termination moves clear of the roller the latter suddenly shifts back to engage the next turn of the riffle due to the action of the spring **36**. This places the shield over the jets then alined with the inner endmost bucket and the movement of the shield is then repeated as before.

With the above arrangement of parts, and assuming that a certain amount of mercury **37** (see Figures 2 and 12) is retained between the turns of the riffle from the buckets to the upper end of the cylinder (the manner of doing which being explained later), the following separating action takes place on the gangue delivered into the cylinder from the chute **17**.

The gangue as deposited in the cylinder comprises large gravel G, small gravel *g*, black or other sand S, and the precious metal particles P, these different sized types of material being shown in symbolic form in Figure 12. The separating action which I use recognizes the well-known fact that particles of low specific gravity but of large size area and weight will crowd out particles of high specific gravity but of small size area and weight in a flowing stream of water unless they are prevented from so doing. In this connection it may be observed that all precious minerals have a higher specific gravity than any non-precious minerals.

In order to reverse the above natural action of the particles when subjected to a flow of water, and to displace and crowd out the particles of low specific gravity and of large size and area and to prevent the displacement and crowding out of the relatively small particles of high specific gravity, when they are associated together, it is necessary to provide just sufficient water to keep the various particles of the mass from packing and in a semi-floating and agitated condition in the riffle grooves or enclosures of the cylinder, while subjecting them to mechanical movement. Those particles of higher specific gravity than the mercury and of small size area and weight and which can find their way through the interstices of the other particles of the mass will sink into the mercury also by displacement, this movement of such particles being obtained by reason of the mechanical agitation of the same and the flow of water. At the same time the particles P of high specific gravity but of small size that for some reason cannot at once move down between the other particles of the mass temporarily collect in the corners **16***a* of the riffles under the flange **16**, where on account of the small size of such particles, other particles of relatively low specific gravity but of large size cannot displace them. Nor can the flow of water displace the particles thus collected and they are thus positively retained in the cylinder until they are finally engaged by the mercury as will be seen.

The particles of low specific gravity but of small size and weight, such as sand and the smallest gravel particles, are forced by displacement to the top of the gangue mass and above the riffle grooves, where they are subjected to the washing action of the water and are successively carried in to and past the various riffle grooves toward the lower end of the machine. This action continues until the particles of the above character are deposited in the reservoir **10**. Here again these particles come in contact with mercury in said reservoir which catches any precious particles which may possibly have escaped the previous separating action. The water issuing from the jets **28** beats against the gangue

mass moving up the adjacent side of the cylinder with the rotation of the latter and washes the mass down and over the top of the riffles. This limits the ascent of the mass about the upper side of the cylinder and at the same time the water cleans out the riffle grooves for the treatment of the succeeding quantity of mass deposited therein.

While this washing of the gangue mass and the separating action of the small low and high specific gravity particles is going on, the gangue mass as a whole is being carried toward the upper end of the machine due to the advancing action of the spiral riffle as the cylinder rotates. As a result there is an ascending gangue mass of heavy particles, a descending gangue mass of light particles, a relatively laterally ascending stream of water in each riffle groove, and a descending stream of water flowing over the top surface of all the riffles. After a short period of operation the gangue mass thus extends the full length of the machine within the different riffle grooves, and the particles of the mass arrange themselves according to the weight of each particle, regardless of its specific gravity.

This holds true except for those particles P of high specific gravity, small size, area and weight, which have a specific gravity higher than the mercury and which find concealment in the corners **16a** under the flange **16** of the riffles as previously stated.

As a result large gravel particles which are initially at the bottom of the riffle groove are gradually displaced upwardly as they come in contact with the mercury in the grooves toward the upper end of the cylinder, the depth of which mercury gradually increases due to the constant feeding of the same into the grooves at different points in the length of the cylinder, as will be hereinafter seen. Small gravel is also displaced upwardly by the large gravel below until it reaches the row of buckets **21** which elevate the gravel to the discharge chute **23**. This gravel is then discharged from said chute into the reservoir **10** where it is subjected to a further washing, rolling and mercury contact action. Large gravel deposited in the riffle groove above the line of buckets is finally disposed above the level of the riffles due to an increasing height of the mercury in the riffle grooves, as shown in Figure 12, and which finally reaches the top level of the riffles. The gravel is then fully exposed to the longitudinal flow of water from the jets **22** which washes the gravel over the riffles toward the lower end of the cylinder.

The mercury in the uppermost riffle turns extends to the top of the spiral riffle; the exposed surface of the mercury is relatively great so that it can act on a correspondingly large amount of matter. Also the water constantly flowing over this surface tends to keep the mercury clean, and it does not become foul.

As the depth of the mercury increases it reaches the riffle flange **16**, displacing any low specific gravity particles therein and contacting with any gold particles concealed under the flange, and such particles at once drop through the mercury to the bottom of the same. The resultant amalgam is thus carried along to the upper end of the cylinder with the advancing action of the spiral riffle, where it is discharged in the adjacent reservoir **9** for retorting and redistribution. Nothing will be delivered to said reservoir but amalgam, since the continuous flow of water from the jets **22** washes away all relatively light matter displaced from the riffles and floating on the mercury, and carries such particles over the top surface of the riffles and toward the lower end of the cylinder. It will thus be seen that the gangue mass as a whole from its point of initial entry into the cylinder is subjected to a continuous agitating and rolling action, together with an advancing movement toward the upper end of the cylinder by reason of the spiral riffle unit, and to a descending action by reason of the longitudinal flow of water. As a result all the particles are moved back and forth in the cylinder for some time before they are finally discharged from the cylinder and all precious particles initially mixed with the mass will be separated from the worthless residue and brought into contact with the mercury.

With a certain amount of mercury initially deposited in the riffle grooves along the cylinder from beyond the buckets to the upper end of the cylinder, such mercury will be gradually conveyed to the upper end of the cylinder and some will be discharged into the adjacent reservoir **9**, with each revolution of the cylinder. Also with each such revolution some of the amalgam is removed from the reservoir and automatically returned to the riffle grooves at various points in the length of the cylinder by the following means.

Disposed in the side wall of the reservoir **9** a certain distance inwardly of its outermost periphery is a circumferential slot **38**, enclosed in a housing **39** formed in said reservoir and opening to the same by a circumferential slot **40** which extends along the outer periphery or bottom of the reservoir for the length of the housing. The slot **38** communicates with a sump **41** of predetermined capacity disposed outside the reservoir and extending radially and outwardly therefrom. A pipe **42** is connected to the sump at its outer end and extends with an epicycloidal curve to the periphery of the cylinder adjacent the reservoir. The pipe then extends spirally about the cylinder to its lower end and there communicates with the inner end of a sump **43**. This sump is of the same type as the sump **41** and is disposed in radial relation to the adjacent reservoir **10**. This sump **43** communicates with said reservoir in the same manner as the sump **41** with the reservoir **9**. A return pipe **44** leads from the outer end of the sump **43** toward the upper end of the cylinder with an initial epicycloidal portion and a subsequent spiral portion in the same manner as the pipe **42**.

Relatively short lateral metering pipes **45** are connected to the pipe **42** at intervals and extend about the cylinder in a direction opposite to its rotation, and communicate with the cylinder between certain turns of the spiral riffle therein as indicated at **45a**. Special T fittings **46** are disposed at the junctions of the pipes **42** and **45** and are provided with adjustable plug valves **47** so as to control the flow of mercury through said pipes. The pipe **44** is provided with similar valve controlled lateral metering pipes **48** which communicate with the cylinder at predetermined points between the pipes **45**. Preferably, but not necessarily, there are mercury intakes either from the pipes **45** or **48** adjacent the line of buckets on both sides thereof, below said line of buckets as well as about midway between the line of buckets and the upper end of the cylinder. The lowermost of these pipes **48** communicates with the cylinder in the portion thereof apt to contain the large gravel in the corresponding

riffle groove and is therefore connected to an inlet member 49 which projects inwardly of the cylinder to a point inwardly of the riffle, as shown in Figure 10, so that any such large material in the riffle cannot clog the inlet. This feature however is not necessary with the other metering pipes though it can be used if desired.

With this arrangement it will be seen that with each revolution of the cylinder and when the slot 38 is in its lowest position, a certain amount of mercury or amalgam in the reservoir 9 will flow through said slot from adjacent the upper surface of the mercury rather than the bottom, into the metering sump 41, the amount depending on the speed of rotation of the cylinder and the head pressure of the mercury. As the cylinder rotates this mercury received into the sump will flow along the epicycloidal and spirally curved pipe 42 and is not only carried toward the lower end of the cylinder but is at the same time raised relative to the sump and to the bottom of the cylinder. The mercury thus flowing is delivered in part to the lower sump 43 and in part is fed directly back to the cylinder through any or all of the various lateral feed pipes 45. This feeding depends on the setting of the corresponding valves 47 which can of course be regulated by the operator according to the requirements of any particular conditions of operation.

The mercury fed into the sump 43 from the pipe 42 may discharge into the adjacent reservoir 10 and the subsequent movement of the mercury along the pipe 44 takes place in the same manner as the mercury in the sump 41 and pipe 42, due to the epicycloidal and spirally curved form of said pipe 44. In both cases the mercury after being initially discharged from the cylinder at one certain level is returned to the cylinder at different and higher levels than the point of discharge and in timed relation to the cycles of operation of the machine. The mercury in one instance travels from the upper to the lower end of the cylinder while being raised in the riffle, while in the other instance the mercury travel is from the lower to the upper end of the cylinder.

In this manner and by suitable adjustment of the various valves 47 I maintain a constant circulation of the mercury along the cylinder so that as the mercury is automatically and naturally discharged from the cylinder at the upper end of the riffle groove, the supply is being constantly replenished in the riffle grooves at various points in the length of the cylinder. The mercury is thus used over and over again without any possibility of loss and without the vital zones in the length of the cylinder being ever exhausted of the necessary supply of mercury for proper separating purposes.

Besides the means for constantly circulating and redistributing the mercury as above described, I provide a means for retorting the amalgam with the rotation of the cylinder, condensing the mercury after it is retorted and redelivering the same to the cylinder. This means includes a metering sump 50 projecting radially from the reservoir 9 and communicating therewith at its outermost circumference or at the bottom when the sump is disposed in depending relation to the cylinder. The sump communicates with a combined epicycloidal and spirally curved pipe 51 of the same size as the pipe 42, and which leads to the lower end of the cylinder and beyond the reservoir 10 to a cup 52 disposed axially of the cylinder and reservoir externally of the same.

On account of the head of the mercury in the lower end reservoir the amount of mercury returned to the cylinder will be in proportion to that discharged from the upper end of the cylinder, so that the quantity in the various riffle grooves will always be balanced. If this head increases, due to a heavy discharge from the upper end of the cylinder, more mercury will flow into the sump 43 and be redistributed to the cylinder with each rotation of the same, and vice versa.

This cup discharges into a hopper 53 which is connected to a valved branched pipe unit 54 leading to separate electric or other retorts 55, described more in detail later, and arranged so that one retort can be in operation while the other one is being cleaned out. The mercury vapors pass from the retorts through conduits 56 which extend for some distance inside the stacks 57 of the retorts and finally discharge into a single conduit 56a. This conduit leaves the stack unit and passes through a water cooled condenser 58 and the mercury in condensed form, together with the water from the condenser, discharge into a tank 59. From this tank the mercury flows by gravity through a pipe 60 back into the machine.

The pipe 60 has a portion 61 axially alined with the cylinder which passes through the cup 52, said cup turning about said portion as the cylinder rotates. In this manner neither the pipe 51 nor the return pipe 60 interferes with each other with the rotation of the cylinder. Ahead of the cup the pipe 60 bends down to discharge into the cylinder 8 near the bottom and the adjacent end, so that the mercury will be delivered into said cylinder between certain turns of the spiral riffle. The mercury thus delivered into the cylinder then of course works along and finally is redistributed to various points in the length of the cylinder with the rotation of the latter, as previously explained.

The retort 55 above mentioned and the retorting system as a whole are preferably of special construction and arrangement. Each retort comprises a relatively long tubular member M closed on its ends and formed centrally of its length with an enlargement providing a settling bowl B. The pipe 54 projects into said member through one end to a termination adjacent the bowl.

The member M projects diametrally through a housing H in which a suitable heating means is located and to the top of which the escape flue 57 is connected. The bowl and the adjacent portions only of the member 16 are enclosed in the housing and are thus subjected to the retorting heat, thus leaving the end portions of said member relatively cool so that there is no tendency for the mercury to be vaporized before it is discharged from the pipe 54 and a back pressure in said pipe would be possibly set up.

To further insure the retention of the mercury or amalgam in a liquid condition until the retorting or settling bowl is reached the pipe 54 ahead of the retort passes through a water cooled receptacle R. Said pipe also has a trap T preferably inside the receptacle so as to retain a column of mercury therein of a height and constant weight more than sufficient to offset any vapor pressure likely to be generated within the retort. In this manner, even though the feeding of the mercury into the hopper 53 ceases, while

the retort is still operating on the amount of mercury remaining in the pipe **54**, there is no possibility of any mercury vapor escaping through the hopper instead of through the proper pipe **56**.

The vapor pipe **56** extends as stated upwardly through the flue so that the mercury vapor is still surrounded by hot air or gases rising from the housing H and thus preventing any possibility of the mercury condensing before the vapors are discharged into the actual condenser itself.

This continuous mercury circulating and retorting system is a very important feature in the continuous and successful operation of the machine.

The mercury or amalgam being constantly retorted before it is returned to the cylinder for further use, saturation of the mercury and the fouling of the same which would affect its efficiency, is prevented.

The mercury redistributing system insures a practically gradual increase of depth in the various riffle grooves from the lower to the upper end of the cylinder, as shown in Figure 2, so as to increasingly crowd the matter out of the grooves and prevent the relatively valueless matter from being carried to the extreme upper end of the cylinder and being discharged into the reservoir **9** with the mercury.

As stated in the preamble of this specification, means controlled by the volume and weight of the mass fed into the cylinder is provided for automatically governing the speed of such feed, the speed of rotation of the cylinder, and the volume of water flowing through the cylinder so as to maintain a circumferentially even feed and even conditions of operation in the cylinder. When the feed mass is in excess to a predetermined normal it is desired to slow down the motor **62** of the unit F which controls the initial feed of the material to the hopper **18**, while at the same time temporarily increasing the speed of rotation of the cylinder so as to take care of the large amount being fed, and also increase the volume of water flowing into the cylinder along with the mass. Conversely when the feed is less than normal it is desired to increase the speed of the motor **62** and decrease the speed of rotation of the cylinder and the volume of the water flow.

To control the water flow the main water supply pipe **63** has a mechanically operated valve **64** therein which is of the same type as shown in my Patent No. 1,594,021. This valve is disposed between the header **65** from which the various cylinder feed pipes take off and a hand valve **66** in the pipe **63**. Said valve in turn is disposed between the valve **64** and the pressure pump **67**. (see Figure 4). The various cylinder feed pipes also have individual hand valves V therein so that the flow through said pipes may be individually adjusted.

The operation of the motors **14** and **62** and the mechanical valve **64** is controlled for the above purpose in the following manner:

The feed chute **17** is pivoted outside the cylinder and preferably directly under the hopper **18** on a supporting frame **68**, its weight and that of a predetermined normal amount of mass on the chute beyond the pivot being counterbalanced by a suitably disposed spring **69**. A weight of mass on the chute less than the spring pressure will therefore cause the chute to tilt upwardly, while a weight of mass sufficient to overcome this spring will cause the chute to tilt down.

This tilting movement is transmitted by suitably arranged linkage **70** which connects the chute **17** to a tilting switch unit **71** which is of the same type as shown in my Patent No. 1,667,056. This tilting switch contains three separate mercury switches **72**, **73** and **74**. The switch **72** is set to close only when the chute **17** is tilted with an excess of material thereon; the switch **73** closes only when the weight conditions on the chute are normal; while the switch **74** closes only when an insufficient mass weight is present on the chute. The switch **73** is designed so as to remain closed while the switches **72** or **74** are initially closed so that there will be no actual cutting off of power when the change is being made from one switch to the other.

These switches are connected to separated delayed relays **75**, each of which actuates a three contact switch **76**. These switches **76** are interposed in circuits **77** connected to the motors **62** and **14** and to separate ones of the magnets **64***a* of the switch **64**. The circuits to the two motors include separate adjustable resistances **78** and **79** for the motors **62** and **14** respectively, which resistances of course provide an additional and selective control of the speed of the motor in the corresponding circuits.

In accordance with the desired end the resistances **78** in the circuits controlled by the switches **72**, **73** and **74** are set to provide high, medium and low resistance respectively to the flow of current to the corresponding motor. Finally the resistances **79** in the circuits of said switches are set to provide low, medium and high resistance respectively to the current.

The circuits to the magnetic valve **64** are controlled by the switches **72**, **73** and **74** connected to those magnets **64***a* which give wide, medium and small openings respectively of said valve.

It will therefore be seen that the motors will be speeded up or slowed down, and the flow of water finally controlled with and by reason of the tilting of the chute **17** as governed by the weight of a mass fed thereon. The switch **71** as a whole is naturally very sensitive so that in operation there may be a continuous fluctuation in the operation of the motors and the water flow as the weight of the feed correspondingly varies. As a result the feed is maintained substantially constant at all times and regardless of any variations in the amount and weight of feed which may initially be discharged in the hopper **18**.

When the apparatus is constructed as a portable machine adapted to move over the ground which is being worked, it is desirable that the cylinder shall always remain with the same slope at which it has been initially set and which has been found most suitable for the particular material being worked.

To maintain this slope automatically as the apparatus moves along and irrespective of irregularities in the ground contour which of course disturb this slope, I provide the arrangement shown diagrammatically in Figure 16. This arrangement comprises a switch box **90** extending lengthwise of and above the frame **3** and having an arm **91** projecting rigidly from one end of the box, said arm being pivoted to the frame **3** by a depending link **92**. A pendulum **93** is pivoted intermediate its ends on the frame **3** and at its upper end on the switch box, so that as the slope of the frame **3** is altered while the pendulum maintains a vertical position, the switch box will be tilted to an event greater extent.

The switch box contains a pair of mercury switches 94 set at opposed angles, the switch contacts projecting into the switch tubes adjacent their ends. These switches are connected to separate relays 95 which actuate the normally open reversing switch 96 in the circuit 97 of the reversible motor 6, which motor as previously described controls the rotation of the frame adjusting screw 5. With this circuit arrangement the motor is normally idle but as soon as the switch box is tilted to one side or the other, the switch 96 is closed by the action of the corresponding relay to place the motor in operation to raise or lower the frame 3.

With such movement of the frame the pendulum again causes the switch box to tilt until that switch 94 which has just been closed will be returned to its normal open position. This opening of course takes place when the frame 3 is restored to the slope which it initially possessed. It is of course appreciated that the switches 94 are connected to operate the switch 96 so that as the frame 1 is tilted down toward its forward end, the motor 6 will be actuated to tilt the frame 3 in the opposite direction and vice versa. The switches 94 are mounted on the pivoted arm 98 within the switch box, in substantially the same manner as shown in my Patent No. 1,667,056, which arm is capable of vertical adjustment by means of an external adjusting screw 99 so as to actuate the motor 6 one way or the other. In this manner the tilt of the switches 94 relative to the frame 3, and consequently the normal tilt of said frame, may be adjusted by hand. Alteration of tilt of the frame transversely due to transverse ground irregularities of course has no effect on the position and action of the separating cylinder, owing to the natural shape and rotation of the latter.

The unit F which initially received the gangue mass before the same is fed to the separating cylinder, comprises a tank 100 which is V-shaped lengthwise of the cylinder. The motor 62 which is mounted on top of the tank drives an endless drag bucket conveyor 101 which extends up the side of the tank nearest the cylinder and discharges into the hopper 18. A water and gangue mass intake hopper 102 is positioned to discharge into the top of the tank adjacent the end opposite the conveyor 101. The water fed into the tank with the mass is continually drained off when it reaches a certain level by means of a vertically adjustable drain pipe 103 which leads to a water tank 104 which is connected to the intake of the water circulating pump 67.

Between the hopper and the drain pipe the tank is provided with a transverse vertically adjustable partition 105 which extends below the water line a certain distance. This partition retards the flow of water from the intake hopper to the drain pipe, causing the backing up of the water on the hopper side of the partition and raising the level of the water slightly on said side as indicated in Figure 17. Also this high level water is not subjected to the suctional action of the drain pipe nor to the agitating action of the conveyor, and is nonflowing and quiet at the surface. A light scum or slime from the gangue mass, and which has frequently been found to contain precious particles so fine that they float on the water, will therefore collect on the surface of this quiet body of water and will be drawn off through a special pipe 106. This pipe terminates at the level of the water on the hopper side of the partition and leads to a small hopper of the high speed centrifugal type which is mounted on the outside of the tank and contained within a housing 107.

The conveyor 101 extends to the bottom of the tank in which mercury is placed to a certain level, as indicated at 108, so that a certain percentage of the precious particles in the gangue mass may be immediately reclaimed. A pipe 109 leads from the bottom of the tank to an electric retort 110, the mercury vapor pipe 111 from which leads back to the interior of the tank. This pipe terminates in a downwardly sloping portion in the tank above the water level line which passes through a condenser 112. The condensed mercury will therefore be again deposited in the tank to drop to the bottom of the same and the total amount of mercury in the tank will never be permanently altered.

Disposed between the pipe 109 and the bottom of the tank is a valve 113 having a rotary plug 114 therein provided with a radial pocket 115 instead of a continuous passage therethrough. This plug is slowly rotated in conjunction with the driving of the conveyor 101 by a suitable driving connection 116 therebetween. In this manner a measured quantity of mercury or amalgam will be withdrawn from the tank with each revolution of the plug and will be fed to the retort.

The gangue mass is thus subjected to the desired wetting action before it is delivered to the cylinder. The mass will drop through the water and come to rest on the mercury in the bottom of the tank, from which the said mass is removed by the dragging action of the conveyor which projects below the level of the mercury. Any freely exposed gold particles in the mass will thus be immediately engaged and retained by the mercury. None of the mercury will be drawn up to any height by the conveyor, since on account of the nature of mercury it will immediately roll off the conveyor elements and return to the bottom of the tank. The mass is moved up the corresponding side of the tank and drawn out of and above the water before being dumped into the hopper 18. This initial feed unit is therefore an important feature of the apparatus, not only in properly preparing the material for treatment in the cylinder, but in saving values of a very fine nature (by means of the separator 107) which would otherwise be carried away and lost.

From the foregoing description it will be readily seen that I have produced such a device as substantially fulfills the objects of the invention as set forth herein.

While this specification sets forth in detail the present and preferred construction of the device, still in practice such deviations from such detail may be resorted to as do not form a departure from the spirit of the invention, as defined by the appended claims.

Having thus described my invention what I claim as new and useful and desire to secure by Letters Patent is:

1. A mineral separator comprising a separating cylinder, means to rotate the cylinder, means in the cylinder whereby a separating action will be imparted to material fed into the cylinder, a feed chute leading into the cylinder, driven means to feed material onto the chute, a water pipe leading into the cylinder, control means to govern the volumetric flow through the pipe, means controlled by a certain normal volume and weight of material on the chute for maintaining the cylinder rotating means, the driven feed means and the water control means operating at a predetermined normal tempo, and means included in

part with said last named means and controlled by a weight of material on the chute in excess of the normal to cause the driven means to function to deliver less material to the chute, the cylinder to be rotated at a greater speed, and the water control means to provide a greater volumetric flow through the water pipe; and by a weight of material on the chute less than normal to cause the driven means to function to deliver more material to the chute, the cylinder to be rotated at a lower speed and the water control means to provide a lesser volumetric flow through the water pipe.

2. A mineral separator including a rotary separating cylinder disposed at a flat slope, means to rotate the cylinder in one direction, a spiral riffle inside the cylinder extending from end to end thereof and arranged to cause matter engaged thereby to be conveyed to the upper end of the cylinder, means to feed material into the cylinder intermediate its ends whereby material caught between turns of the riffle will be moved toward the upper end of the cylinder, means in the cylinder between the point of feed and the upper end of the cylinder to engage and elevate matter projecting above the riffle, and a chute to receive and convey such elevated matter clear of the lower end of the cylinder.

3. A structure as in claim 2, such last named means comprising a spirally arranged row of bucket elements projecting inwardly from the inner face of the riffle in spaced relation about one turn of the same; the chute being disposed at its upper end to catch matter dropping from the uppermost bucket elements and extending to a point beyond the lower end of the cylinder.

4. A mineral separator including a rotary separating cylinder disposed at a flat slope and into which the material to be treated is fed, means to rotate the cylinder in one direction, a riffle element in the cylinder in contact with the inner surface thereof and extending spirally of the cylinder from end to end and whose pitch relative to the direction of rotation of the cylinder is such as to cause the spiral riffle to convey matter engaged thereby to the upper end of the cylinder, means to maintain mercury between adjacent turns of the riffle element at the upper end of the cylinder for the full depth of the element, and a continuous flange projecting forwardly from the leading face of the element in the plane of its inner periphery; the under face of the flange and the adjacent face of the element forming a sharp corner with each other.

5. A separator comprising a rotary cylinder set on a slope into which the material to be treated is fed, a spiral riffle element extending lengthwise in said cylinder and forming separate riffle enclosures, mercury in said enclosures, the spiral element advancing toward one end of the cylinder whereby the mercury will be moved toward said end, an annular reservoir rigid with said one end of the cylinder in which the mercury drops from the spiral riffle, a sump projecting radially from the reservoir and in communication therewith, and a conduit connected to the sump at its outer end and leading along the cylinder to discharge into the same at a predetermined point, said conduit being formed with an initial epicycloidal curve relative to the cylinder followed by a spiral curve extending about the cylinder and disposed relative to the direction of rotation of the cylinder to cause the mercury flowing into the conduit from the sump to be conveyed along the conduit toward the other end of the cylinder.

6. A mineral separator including a rotary separating cylinder disposed at a slope and into which the material to be treated is fed, means to rotate the cylinder in one direction, a spiral riffle inside the cylinder extending from end to end thereof and arranged to cause matter engaged thereby to move to the upper end of the cylinder, there being mercury in the cylinder between the turns of the riffle along a certain portion of the length of the cylinder whereby the mercury will be conveyed by the riffle to and discharged from the upper end of the cylinder as the latter rotates, annular reservoirs rigid with the cylinder at its opposite ends, the mercury discharging from the upper end of the cylinder being received by the adjacent reservoir, means functioning with the rotation of the cylinder to convey the mercury from the upper end reservoir to the lower end reservoir, and means likewise functioning with the rotation of the cylinder and separate from the riffle to convey the mercury from the lower end of the cylinder and discharge such mercury into the cylinder at predetermined points in the length thereof.

7. A separator comprising a cylinder to receive material to be separated, means to rotate the same, mercury in the bottom of the cylinder, means in the cylinder to move the mercury from one end to the other of the cylinder, means outside but mounted as a unit with and actuated by the rotation of the cylinder for returning the mercury from said other end to the one end thereof, and additional means outside and also actuated by the rotation of the cylinder to convey some of the mercury thus returned lengthwise of and discharge the same into the cylinder at a point intermediate the ends thereof.

8. A separator comprising a rotary cylinder set on a slope and into which the material to be treated is fed, a spiral element extending lengthwise in said cylinder to form separate riffle enclosures, mercury in said enclosures, the spiral advancing toward the upper end of the cylinder whereby the mercury will be moved toward said upper end, a sump on the cylinder at its upper end into which the mercury intermittently falls, and a conduit mounted on and rotating with the cylinder and leading from the sump to the lower end of the cylinder, said conduit being shaped to cause the mercury received in the sump to drain therefrom and be conveyed to said lower end of the cylinder with the rotation of the latter.

9. A structure as in claim 8, with separate valved passages between said conduit and predetermined ones of the riffle enclosures intermediate the ends of the cylinder.

10. A separator comprising a rotary cylinder set on a slope and into which the material to be treated is fed, a spiral element extending lengthwise in said cylinder to form separate riffle enclosures, mercury in said enclosures, the spiral advancing toward the upper end of the cylinder whereby the mercury will be moved toward said upper end, a sump on the cylinder at its upper end into which the mercury intermittently falls, a conduit mounted on and rotating with the cylinder and leading from the sump to the lower end of the cylinder, said conduit being shaped to cause the mercury received in the sump to drain therefrom and be conveyed to said lower end of the cylinder with the rotation of the latter, another sump projecting radially from the lower end of the cylinder and into which said conduit delivers, and another conduit connected to said sump and extending along the cylinder and dis-

charging into the same intermediate its ends, said other conduit being shaped to cause the mercury received in the lower end of the same from the sump to be conveyed upwardly of the cylinder with the rotation of the latter.

11. A separator comprising a rotary cylinder set on a longitudinal slope and into which the material to be treated is fed, a spiral element extending lengthwise in said cylinder and forming separate riffle enclosures, said spiral advancing toward the upper end of the cylinder, mercury in the riffle enclosures in increasing depth from the lower toward the upper end of the cylinder, and means functioning with the rotation of the cylinder to maintain such relative distribution of the mercury substantially constant.

12. A separator comprising a rotary cylinder set on a longitudinal slope and into which the material to be treated is fed, a spiral element extending lengthwise in said cylinder and forming separate riffle enclosures, said spiral advancing toward the upper end of the cylinder, mercury in the riffle enclosures in increasing depth from the lower toward the upper end of the cylinder, means functioning with the rotation of the cylinder to maintain such relative distribution of the mercury substantially constant, and means incorporated in part with said last named means to selectively alter such relative distribution of the mercury.

13. A separator comprising a rotary cylinder set on a slope and into which the material to be treated is fed, a spiral element extending lengthwise in said cylinder to form separate riffle enclosures, mercury in said enclosures, the spiral advancing toward the upper end of the cylinder whereby the mercury will be moved toward said upper end, a sump on the cylinder at its upper end into which the mercury intermittently falls, a conduit mounted on and rotating with the cylinder and leading from the sump to the lower end of the cylinder, said conduit being shaped to cause the mercury received in the sump to drain therefrom and be conveyed to said lower end of the cylinder with the rotation of the latter, means to convey the mercury as delivered to said upper end of the cylinder and discharge the same into the cylinder between predetermined spaced turns of the spiral element, and also into the cylinder at its lower end, and means to reconvey some of the mercury thus discharged into the lower end of the cylinder and again discharge such mercury into the cylinder between other predetermined spaced turns of the spiral element.

14. A separator comprising a rotary cylinder, means to rotate the same in one direction, means to feed material into the cylinder, a continuous spiral riffle element in the cylinder, a row of buckets projecting inwardly from the element in spaced relation about one full turn of the same, a chute in the cylinder positioned to catch the elevated matter, a fixed water pressure pipe extending lengthwise in the cylinder inwardly of the plane of the buckets, closely spaced spray nozzles projecting from and along said pipe to direct sprays against the upwardly moving face of the cylinder and riffle element, and means functioning with the rotation of the cylinder to block off those nozzles which become directly alined with individual buckets in the spirally arranged row thereof.

15. A structure as in claim 14, in which said last named means comprises a shield disposed over those nozzles which are in longitudinal alinement with an adjacent bucket, and means to shift the shield lengthwise of the pipe in proportion to the pitch of the spiral whereby said shield will always be disposed in between said nozzles and the successive buckets.

16. A separator comprising a rotary cylinder, means to rotate the same in one direction, means to feed material into the cylinder, a continuous spiral riffle element in the cylinder, a row of buckets projecting inwardly from the element in spaced relation about one full turn of the same, a chute in the cylinder positioned to catch the elevated matter, a fixed water pressure pipe extending lengthwise in the cylinder inwardly of the plane of the buckets, closely spaced spray nozzles projecting from and along said pipe to direct sprays against the upwardly moving face of the cylinder and riffle element, the latter terminating abruptly at one end of the cylinder, a shield disposed over those nozzles which are in longitudinal alinement with an adjacent bucket, a sleeve slidably mounted on the pipe and from which the shield projects, a roller mounted on the sleeve and engaging the forward face of the spiral element at said end of the cylinder, and a spring acting on the sleeve to pull the same in the opposite direction from that imparted thereto by engagement of the rotating spiral with the roller.

17. A separator comprising a rotary cylinder set on a slope and into which the material to be treated is fed, a circular reservoir on the cylinder at its upper end, means to feed mercury into the cylinder toward its lower end, means functioning with the rotation of the cylinder to convey such mercury to the reservoir, means functioning with the rotation of the cylinder to discharge measured amounts of mercury from the reservoir and including a sump projecting radially from the same and communicating therewith through an opening in the sidewall of the reservoir above the bottom thereof, a housing in the reservoir enclosing said opening; the housing being spaced from the reservoir only along the bottom thereof to form a slot for the entry of mercury into the housing.

IRA E. SMITH.