July 28, 1964 C. E. BAER ETAL 3,142,639

APPARATUS AND PROCESS FOR NEUTRALIZING ACID MINE DRAINAGE WATER

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Fig. 1

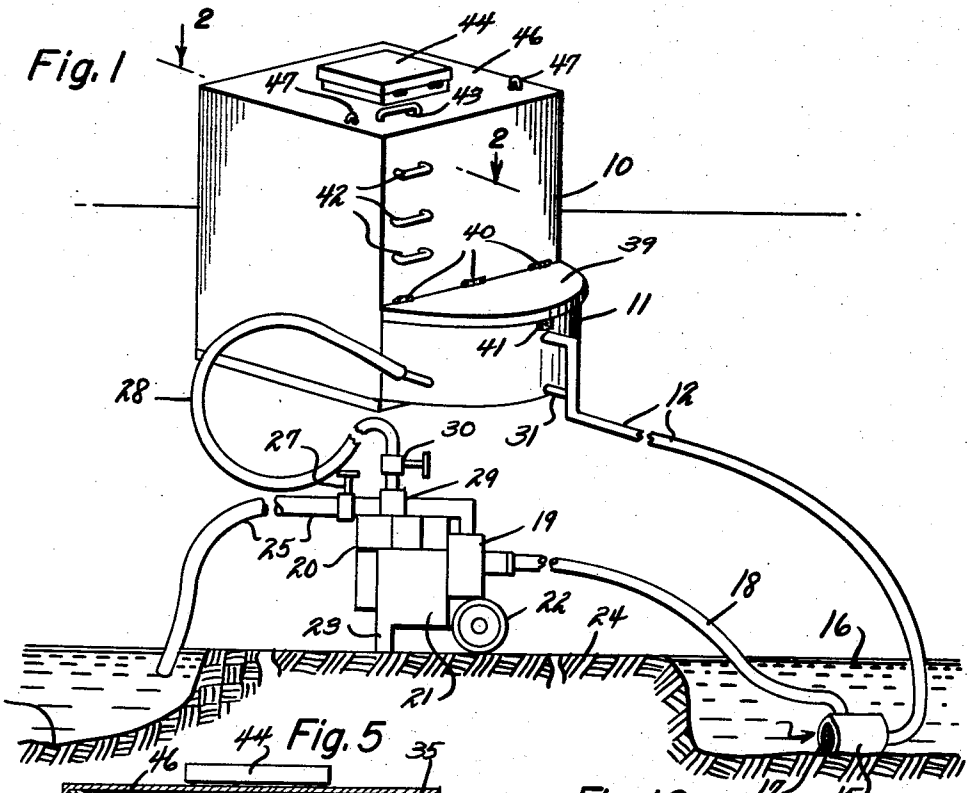



Fig. 5

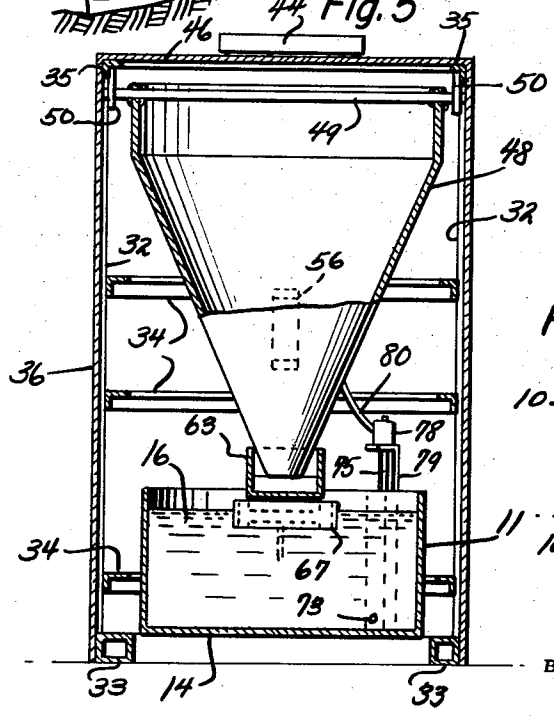



Fig. 10

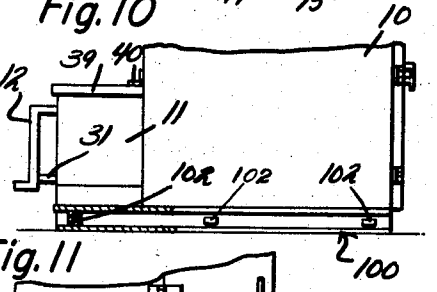
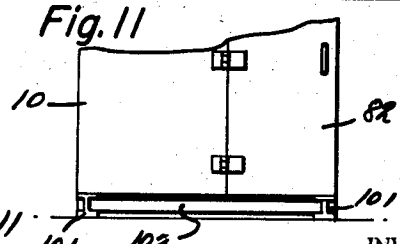



Fig. 11




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APPARATUS AND PROCESS FOR NEUTRALIZING ACID MINE DRAINAGE WATER

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Fig. 2

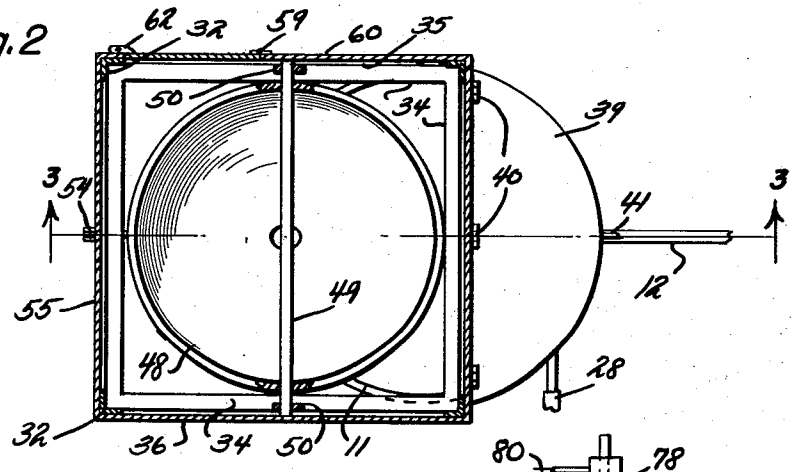



Fig. 3

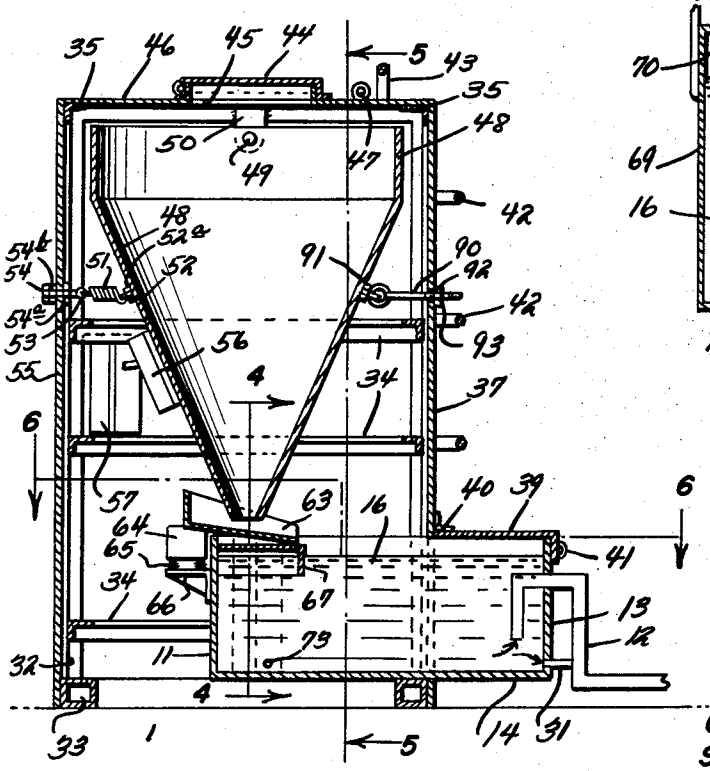
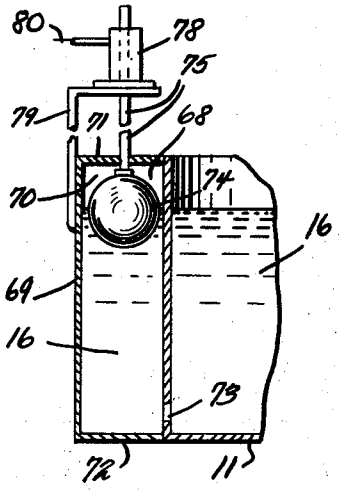



Fig. 4




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APPARATUS AND PROCESS FOR NEUTRALIZING ACID MINE DRAINAGE WATER

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Fig. 6

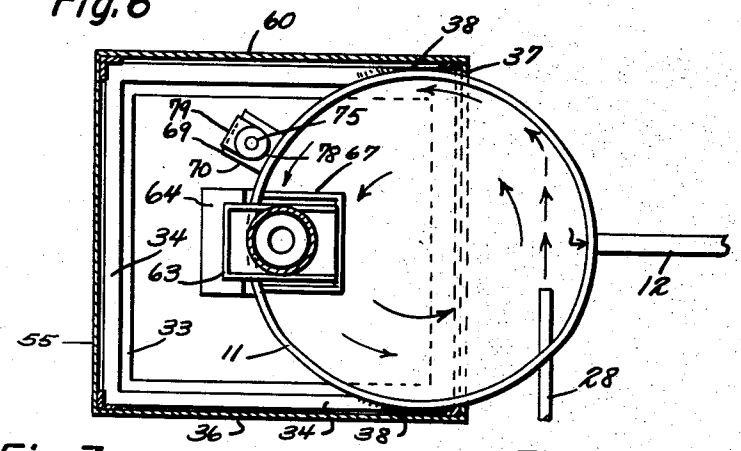



Fig. 7

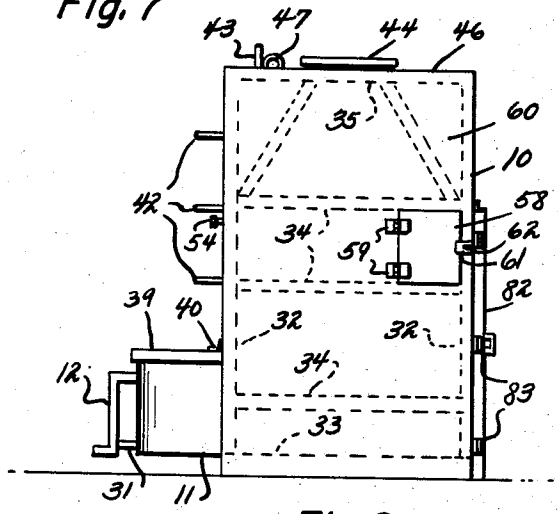



Fig. 8

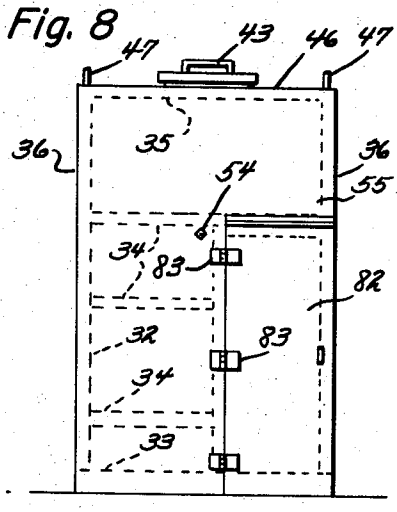
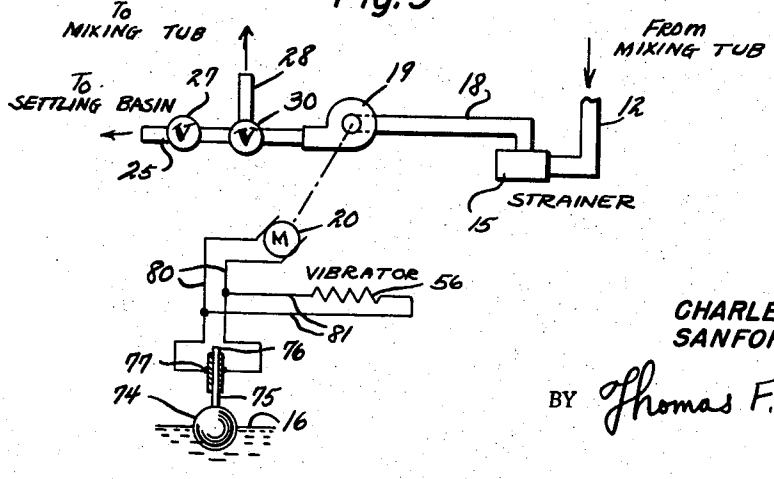



Fig. 9




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APPARATUS AND PROCESS FOR NEUTRALIZING ACID MINE DRAINAGE WATER

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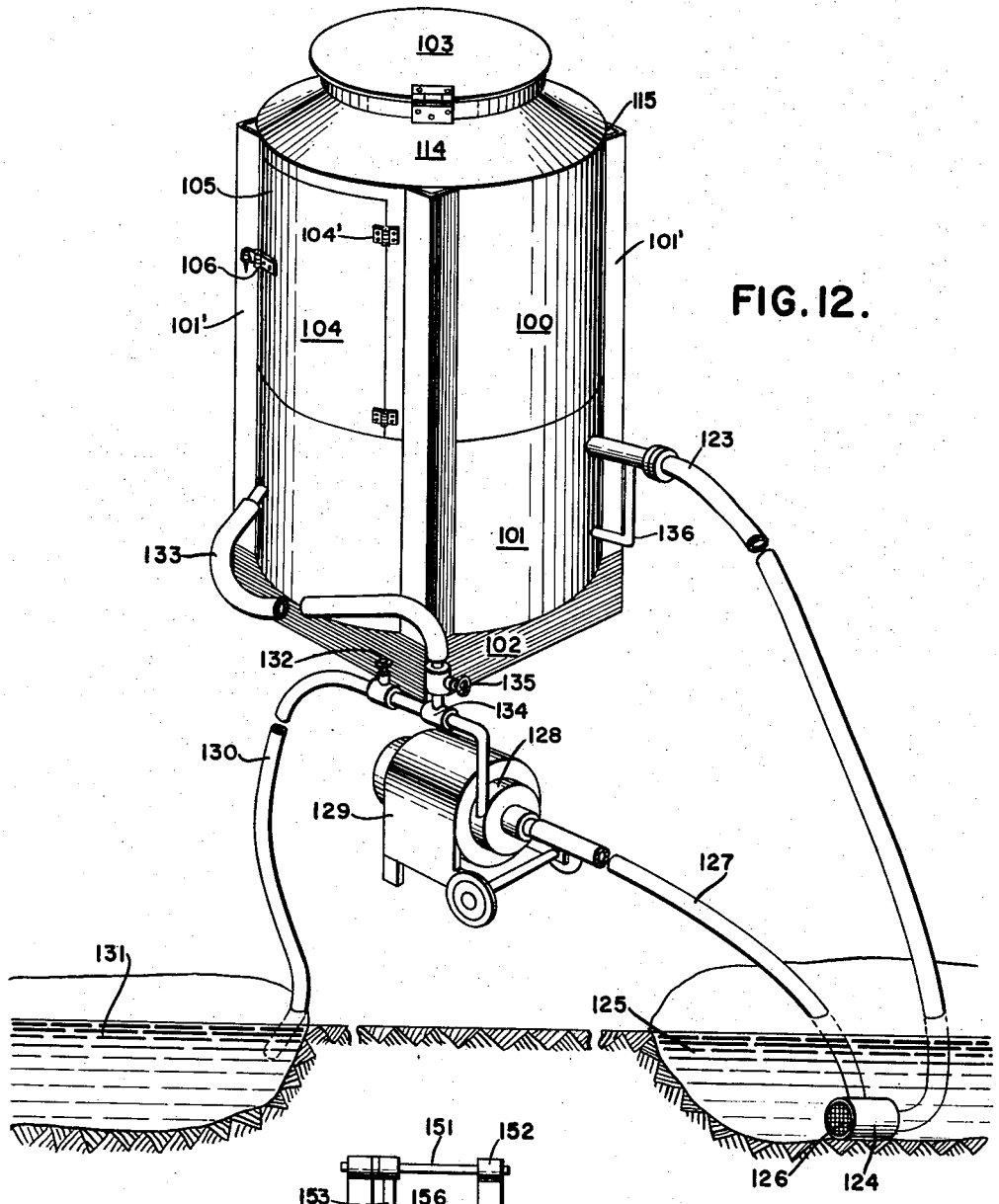



FIG. 12.

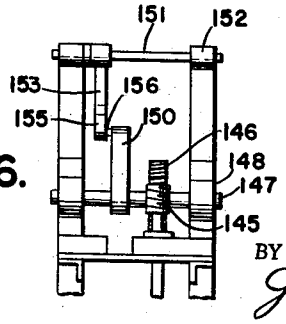



FIG. 16.

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APPARATUS AND PROCESS FOR NEUTRALIZING ACID MINE DRAINAGE WATER

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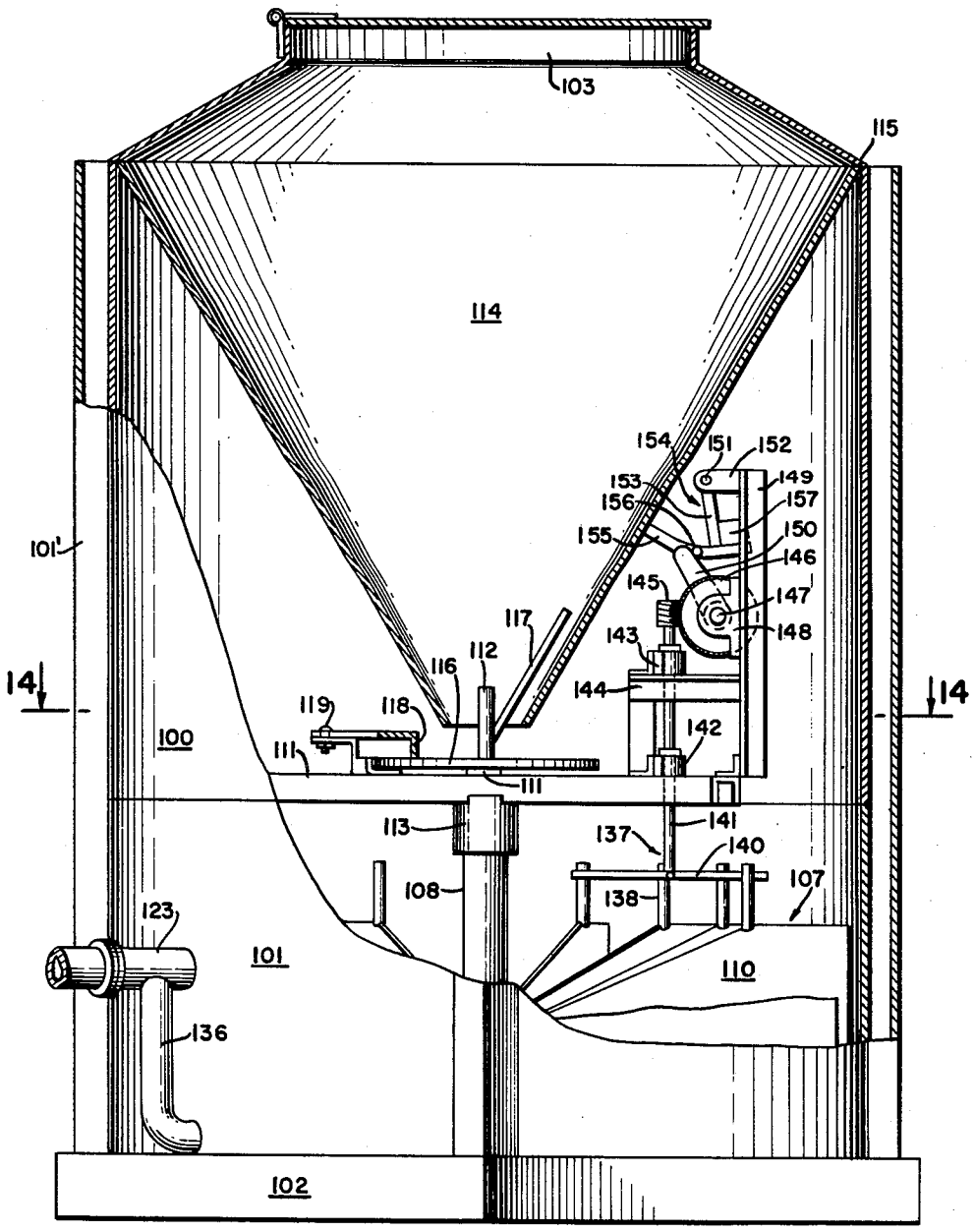



FIG. 13.

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APPARATUS AND PROCESS FOR NEUTRALIZING ACID MINE DRAINAGE WATER

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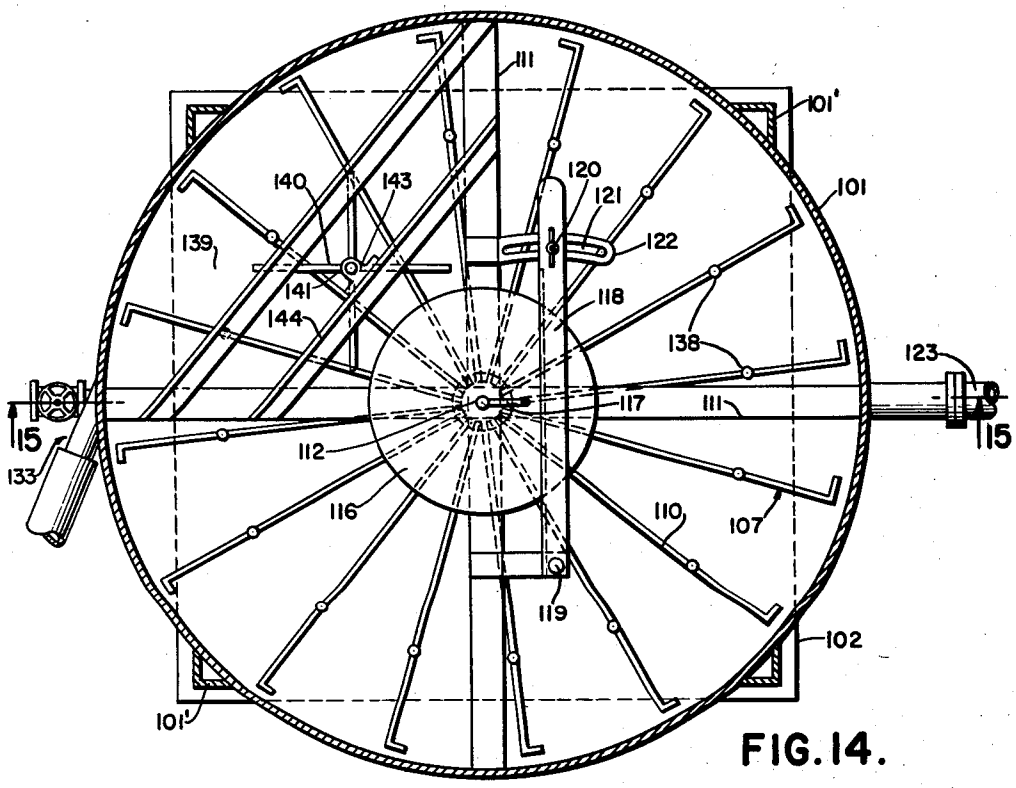



FIG. 14.

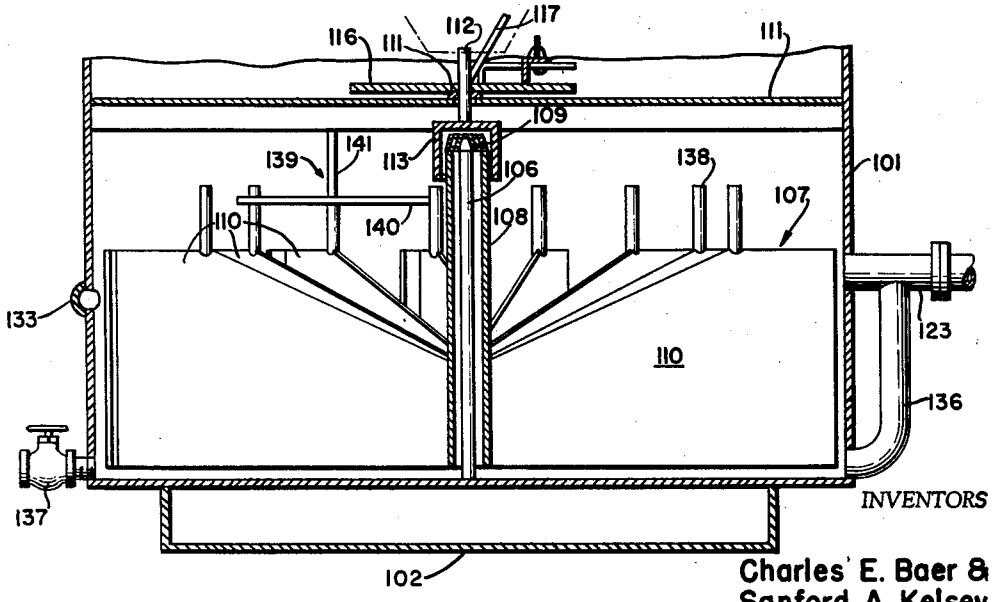



FIG. 15.

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United States Patent Office 3,142,639 Patented July 28, 1964



3,142,639

# APPARATUS AND PROCESS FOR NEUTRALIZING ACID MINE DRAINAGE WATER

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Filed Mar. 10, 1961, Ser. No. 94,941
20 Claims. (Cl. 210—60)

The present invention relates to Apparatus and Process for Neutralizing Acid Mine Drainage Water and has for an object the provision of an apparatus of this type which will neutralize acid mine drainage water to the extent necessary to meet the legal requirements before it can be discharged into the "clean streams."

This invention is a continuation-in-part of our application for patent on an apparatus and process for neutralizing acid mine drainage water, Serial No. 476,322 filed December 20, 1954 now abandoned.

Some States, for example, Pennsylvania, have a law to the effect that no acid mine drainage shall be discharged into the clean streams of the State.

The water draining from bituminous coal mines in western Pennsylvania nearly always contains sulfuric acid. This acid is formed by the oxidation of the sulfur occurring in the coal and in the rock and clay found above and below the coal seams. This sulfur is in part combined with the coal, but by far the greater part is a sulfide of iron, known variously as "fool's gold," pyrite, iron pyrites, or "sulfur balls." In the presence of water, and under the influence of oxygen in the air of the mine, the sulfur is oxidized and, still combined with iron, dissolves in the water as copperas, more properly called ferrous sulfate.

Flowing from the mine, and still in the presence of air, and sometimes under the influence of other agents, the copperas is oxidized to ferric sulfate. The iron after this oxidation has a weakened affinity for sulfuric acid, and in various forms is partially separated as a sediment, brownish yellow in color, frequently called "yellow boy." Sulfuric acid, accompanied by some iron, remains in the water. In some cases in Pennsylvania there is enough limestone in associated rocks to neutralize the acid almost as rapidly as formed, whereupon the water flowing from the mine may be neutral or have even the natural alkalinity of ground water. But the rocks and clays of the Pennsylvania coal seams seldom are of alkaline character, so that acid drainage prevails in most of the mines of the Commonwealth of Pennsylvania.

It is an object of the present invention to provide a machine and a process which can be used to neutralize acid mine drainage water at both deep mines and strip mines where bituminous coal is mined and also at other desired locations.

While electricity may be used as the source of operating power at both deep and strip mines, yet in many instances available sources of electricity are remote, especially to the strip mines, in view of which fact another object is to provide the invention in one or more forms which do not require the use of electrical power for operation.

*Definitions*

To neutralize—In this case, it is desired to change the acid water in acid mine drainage water to an alkaline water.

When a water is neutral the acidic and alkaline substances in the water balance or cancel each other.

Alkalinity—The condition of water containing dissolved alkaline substances, like lye.

The acid in acid mine drainage water is sulphuric acid, $H_2SO_4$.



Another object of the present invention is to provide a machine of this character which has been designed to use hydrated lime as the neutralizing chemical and which will operate unattended for as long as twenty-four hours when it may be necessary to replenish the supply of lime or lubricate the suction pump.

A further object of the present invention is to provide a device of this type which can be operated at a very low cost, even as low as fifty cents per day so that mines now closed or that would be closed on account of the problem of acid mine drainage water can resume operations or remain in operation.

The present invention aims to provide an apparatus and a process which does not require the services of a highly trained technician but which can be operated by a person of ordinary skill.

In one of its broadest aspects the present invention contemplates the provision of an apparatus for neutralizing acid mine drainage water comprising a mixing container, means for supplying a neutralizing agent to said container, means for initially conducting the water to said container and subsequently conducting some of the neutralized water to said container and discharging the remainder of the neutralized water to a settling basin or the like.

More specifically, the present invention contemplates the provision of an apparatus for neutralizing acid mine drainage water comprising a cabinet, a hopper for receiving hydrated lime pivotally mounted within said cabinet, means for vibrating said hopper, a feeder trough for receiving lime from the hopper, means for vibrating said trough, a mixing tub supported by said cabinet positioned to receive lime from said trough, a strainer adapted to be positioned in the water to be treated, a discharge hose connecting said tub to said strainer, an intake hose having one end connected to said strainer, a pump having its intake side connected to the other end of the intake hose, a delivery hose connected to the delivery side of the pump and to the tub, and a discharge hose having one end connected to the delivery side of the pump and its opposite end free.

It is an aim of the present invention to provide a device of this character in which the amount of the neutralizing agent being fed to the container may be controlled.

It is also aimed especially in that form of the invention which does not require electrical operation, to include a novel means for so feeding the lime that it is less apt to become damp and lumpy and will feed in regular amounts continuously.

A further aim of the present invention is to provide means for transporting the apparatus from one location of use to another location.

The present invention contemplates the provision of a process for neutralizing acid mine drainage water comprising the steps of introducing the drainage water into a container, supplying a neutralizing agent to the container, agitating the agent and water, withdrawing the mixed agent and water, mixing the mixture with additional water to be neutralized and conducting some of the further mixture to the container and discharging the remainder thereof to a settling basin.

With the foregoing and other objects in view, the invention will be hereinafter more fully described and more particularly pointed out in the appended claims.

In the drawings in which the same parts are denoted by the same reference numerals throughout the several views,

FIGURE 1 is a perspective view of the apparatus constructed in accordance with the present invention,

FIGURE 2 is a sectional view taken on the line 2—2 of FIGURE 1,

FIGURE 3 is a sectional view taken on the line 3—3 of FIGURE 2,

FIGURE 4 is a sectional view taken on the line 4—4 of FIGURE 3,

FIGURE 5 is a sectional view taken on the line 5—5 of FIGURE 3,

FIGURE 6 is a sectional view taken on the line 6—6 of FIGURE 3,

FIGURE 7 is a side elevational view of the left side of the device,

FIGURE 8 is a rear elevational view of the same,

FIGURE 9 is a diagrammatic view of the pump and the electric circuit,

FIGURE 10 is a fragmentary side elevational view of the device with parts in section and showing a sled attached thereto,

FIGURE 11 is a fragmentary rear elevational view of the same,

FIGURE 12 is a perspective view of a modified form of the invention particularly adapted for use in strip mining at locations remote to an available source of electricity,

FIGURE 13 is a view partly in side elevation and partly in vertical section to disclose details of the modified form of FIGURE 12,

FIGURE 14 is a cross-sectional view taken on the line 14—14 of FIGURE 13,

FIGURE 15 is a vertical sectional view taken through the mixer on the line 15—15 of FIGURE 14, and

FIGURE 16 is a detail elevation of the hammer and operating mechanism which knocks against or vibrates the lime-containing hopper in the modified form.

Referring more particularly to the drawings, **10** indicates a cabinet, **11** a mixing tub or container, **12** a discharge hose or pipe having one end portion extending through the front wall **13** of the tub and extending downwardly within the tub with its open end terminating a short distance above the bottom **14** of the tub, for example, one and one-half inches from the bottom. The opposite end of the hose **12** is connected to one end of the strainer **15** which is disposed in the acid mine drainage water **16**. The opposite end **17** of the strainer is open to receive the water **16**.

One end of an intake hose or pipe **18** is connected to the strainer **15** intermediate its ends and the opposite end of the hose **18** is connected to the intake side of the suction pump **19** which may be a conventional type of self-priming centrifugal pump.

The pump **19** may be operated by a suitable source of power **20**. The pump and source of power may be mounted on a mobile frame **21** having ground wheels **22** and a supporting post **23** for resting on the ground **24**. A discharge hose or pipe **25** has one end connected to the delivery side of the pump and its opposite end is free and open and discharges into a settling basin **26**.

A valve **27** controls the flow from the delivery side of the pump to the open end of the pipe **25**. A delivery hose or pipe **28** has one end communicating with the discharge pipe **25** through a connection **29** located between the valve **27** and the delivery side of the pump. The opposite end of the hose **28** opens into the tub **11**, laterally and adjacent the bottom **14** thereof. A valve **30** controls the flow of fluid from the hose **25** through the hose **28** into the tub **11**. A short pipe **31** has one end communicating with the interior of the tub **11** adjacent the bottom thereof and its opposite end connected to the hose **12**.

The cabinet **10** comprises four vertical corner members **32** which may be of angle iron formation in cross-section. The lower ends of these corner members may be connected by rectangular hollow base members **33** to which they may be secured by welding or the like. The corner members **32** may be additionally braced or reinforced by intermediate brace members **34** which may be of angle iron shape in cross-section and to which the corner members may be welded. At their upper end portions the corner members **32** may be interconnected by upper brace members **35** of angle iron shape in cross-section to which the corner members may be secured by welding. The cabinet also comprises four sheets of material **36**, such as metal or the like, which are secured as by welding to the corner members **32**, the base members **33** and the upper brace members **35** to form an enclosure.



The front wall **37** has its lower portion cut away for receiving therethrough the tub **11**, the major portion of which is housed within the cabinet **10**. The tub is secured in position by being welded to the lowermost intermediate brace **34**, as indicated at **38** and illustrated in FIGURE 6 of the drawings. The portion of the tub **11** which projects outwardly beyond the front wall **37** of the cabinet is covered by a lid **39** which is hinged as at **40** to the front wall of the cabinet.

A hasp **41** is provided on the front wall **13** of the tub and extends through a suitable opening of the lid **39** to receive a padlock by which the lid **39** may be locked against unauthorized entry. The front wall **37** of the cabinet is provided with a ladder **42** and a hand-hold **43** by means of which access may be had to a trap door **44** which covers an opening **45** formed in the top **46**. The trap door **44** may be suitably hinged to the top **46** and may be locked in any conventional manner against unauthorized entry. A pair of eye-loops **47** are secured to the top **46** of the cabinet for receiving hooks of a derrick or the like, by means of which the cabinet may be moved from place to place.

A cone-shaped bin or hopper **48** is mounted for swinging movement within the cabinet on a pivot rod **49**. The pivot rod **49** extends transversely of the cabinet and its opposite end portions extend through plates **50** which are secured as by welding or the like to the upper brace members **35**. The swinging movement of the hopper **48** is regulated by a coil spring **51**, one end of which is attached to an eyebolt **52** secured to a nut **52***a* which is welded to the rear wall of the hopper **48**. The opposite end of the spring **51** is fastened in the eye of an eyebolt **54** which is held tight to the rear wall **55** of the cabinet by suitable locking nuts **54***a* and **54***b* on the eyebolt **54** inside and outside of the cabinet. The tension of the spring **51** will be regulated by adjusting the nuts **54***a* and **54***b*.

In order to vibrate the hopper **48**, an electric vibrator **56** of a conventional type is secured in any appropriate manner to the rear wall of the hopper. The electric vibrator **56** is controlled by a conventional type of vibrator control **57**. Access may be had to the vibrator **56** and its control through a door **58** which is hinged as at **59** to the left side wall **60** of the cabinet. An apertured strap **61** is secured to the door **58** and receives therethrough a hasp **62** carried by the side wall **60** and which is adapted to receive a padlock by which the door **58** is secured against unauthorized opening.

A discharge trough **63** is disposed below the lower restricted open end of the hopper **48** and is inclined downwardly toward the mixing tub **11**. The trough is held in this inclined position by a vibrator block **64** which is resiliently mounted upon four coil springs **65** which in turn are supported by a shelf **66** which may be welded to the rear wall of the tub **11**. The rear end portion of the bottom of the trough **63** may be secured to the upper surface of the block **64** and the forward end portion of the trough is supported by a substantially L-shaped bracket **67** which is secured by welding or the like to the inner face of the rear wall of the tub **11**.

The bracket **67** also serves as a splash guard to prevent splashing of the fluid over the top of the tub when the lime falls into the tub.

In order to adjust the set of the hopper **48** for fast or slow feed, an eyebolt **90** has its eye end fastened in a nut **91** welded to the outside of the wall of the hopper and its other end screw threaded and extending freely through a suitable opening **92** in the front wall **37** of the

cabinet to receive a nut 93 thereon. It will be noted from FIGURE 3 of the drawings that the bottom of the discharge trough 63 slopes downwardly towards the front wall 37 of the cabinet. Accordingly, when the hopper is pulled toward the front wall 37 of the cabinet the space between the bottom of the trough and the discharge end of the hopper is increased and the lime or other material in the hopper is fed faster. On the other hand, when the hopper is moved towards the rear wall 55 of the cabinet the distance between the bottom of the trough and the discharge end of the hopper decreases and the lime is fed slower. The position of the discharge end of the hopper with respect to the bottom of the trough is determined by the position of the nut 93 on the eyebolt 90. As the nut 93 is tightened or drawn up on the eyebolt 90, it pulls the hopper 48 toward the front wall 37 and when the nut 93 is screwed outwardly on the eyebolt 90 the spring 51 pulls the hopper towards the rear wall 55 of the cabinet. The spring 51 holds the hopper in any position to which it is adjusted by the nut 93 so that it is necessary to provide only one nut on the eyebolt 90.

A float chamber 68 is formed by the rear wall of the tub 11, rear wall 69, side wall 70 and top and bottom wall 71 and 72. The float chamber 68 communicates with the interior of the tub 11 by an aperture 73 formed in the lower portion of the rear wall of the tub. A float 74 is positioned within the chamber 68 and has an upwardly extending stem 75 which carries movable contacts 76 which cooperate with fixed contacts 77 of a switch 78. The switch 78 is carried by an L-shaped bracket 79 which is secured to the rear wall 69 of the chamber 68. The fixed contacts are connected to a suitable source of electric current and also to the source of power 20 for the pump 19 by means of cables 80. The cables 80 are also connected to the vibrator 56 by means of leads 81. A conventional type of mercury switch could be substituted for the switch 78.

A door 82 hinged at 83 to the rear wall of the cabinet is provided for affording access to the interior of the cabinet. This door may be locked in any conventional manner.

In the operation of the device, hydrated lime will be placed in the hopper 48, which could have a capacity of 800 pounds. The vibrator 56 will keep the hydrated lime from sticking to the sides of the hopper and the lime will fall upon the feeder or trough 63 and then drop into iron-containing water 16 in the mixing tub. At this time the pump 19 will be operating and water will enter the lower portion of the tub 11 through the hose 28. This entry of the water will cause a swirling motion of the water in the tub which mixes the lime with the water and starts the neutralization process.

When the tub is substantially full the water will be siphoned out of the tub through the discharge hose 12 and through the short pipe 31. When the mixing tub is almost empty, that is, when the water is almost one and one-half inches from the bottom of the tub, the siphon action stops and the tub begins to fill again. When the water leaves the tub it flows through the strainer 15 and the hose 18 into the intake side of the pump 19. The water which is then mixed with the lime will then go through the suction pump and a portion of it will be deposited in the settling basin 26, the remainder of the mixed lime and water 16 will be permitted to stand long enough in the settling basin for the iron to settle out before the water is allowed to be discharged to the receiving clean stream.

When the apparatus is started, the water taken through the pump has not been neutralized and should not be allowed to flow to the settling basin 26. Accordingly, the valve 27 will be closed and the valve 30 opened to permit all of the non-neutralized water to flow through hose 28 into the tub 11. When the tub is filled the valve 27 will be opened and the valve 30 will remain open. The neutralized water from the tub will be mixed with the water 16 from the sump which is drawn into the hose 18 through the open end 17 of the strainer.

In case the water stops coming into the tub, the float 74 will fall in the chamber 68 with the receding water and will disengage the contacts 76 and 77 to break the circuit and stop the engine 20, pump 19 and the vibrator 56.

The continuous flow of water from the tub 11 through the pipe 31 prevents any sediment from collecting on the bottom of the tub. This machine will operate in temperatures around 10 below zero degrees Fahrenheit.

But all the time while mixing tub 11 is filling up and emptying, the water is running out of the mixing tub through pipe 31. From the time it takes for the mixing tub to fill up and empty, if the water did not keep flowing out of the mixing tub through pipe 31, then there would be this period of time when the acid water 16 being pumped from the sump would not be neutralized. This continuous flow of water through the pipe 31 fills the gap between the time it takes for the mixing tub to fill and empty and therefore accomplishes the continuous neutralization of the acid water 16 being pumped from the sump.

Under some conditions the drainage point for the mine drainage water changes from one location to another and it is necessary to shift the apparatus. This is especially true in a strip mine in which the strip cuts may be a mile or more long. In order to facilitate the required movement of the apparatus, a sled generally indicated at 100, in FIGURES 10 and 11 of the drawings is provided. The sled comprises a pair of runners 101 which may be in the form of I-beams and a plurality of cross beams 102 which may be of channel shape in cross-section. The runners 101 are secured to the bottom of the cabinet 10 and the tub 11 adjacent the opposite sides thereof. The outside edge of each runner is flush with its side of the cabinet and tub. The cross braces 102 extend across the space between the runners in spaced apart substantially parallel relation and have their opposite end portions welded to the webs and inner flanges of the runners.

The apparatus may be moved from place to place in a coal stripping operation by pulling it on the sled 100 by a truck or bulldozer. When it is desired to move the apparatus from one operation to another operation which is a substantial distance away, for example, two miles or more over a dirt or hard to top road, it is intended that the apparatus be loaded on a truck or trailer and moved to the new location.

It is clear from the above description that the present invention provides an apparatus for neutralizing acid mine drainage water comprising a mixing tub, means for supplying a neutralizing agent to said tub, means for conducting the water to the tub for mixing with said agent, means for subsequently withdrawing the mixture from the tub and returning some of it to the tub and discharging the remainder to a settling basin or the like.

Referring now to one form of the invention which does not require the use of electricity for operation, that is the form of FIGS. 12 through 16, the lower portion of a suitable vertical enclosure or housing 100 is located above a mixing container or basin 101 which is either integral with or separate from the container. Such receptacle 101 is supported on an appropriate base 102 from which uprights or risers 101' extend to confine the container thereon. Said container at the top has a filler opening with which the hinged or other replaceable or removable closure 103 is associated. Said container 100 has a suitable door 104 hinged at 104' in place over the doorway at 105, and is adapted to be latched or locked closed as at 106.

Reverting to the mixing basin 101, it has rigidly mounted therein a central vertical bearing rod 106 (FIG. 15) on which a suitable mixing rotor 107 is journalled,

said rotor having an inverted hollow hub 108 closed at its top and containing a ball or tapered bearing at 109 engaging and suspending the rotor from the top of said rod 106. The mixing rotor 107 has mixing vanes or blades 110 radiating from the hub 108.

Slightly above said hub 108 is a spider consisting of crossed structural or reinforcing bars 111 in and centrally of which a post 112 is journalled. Post 112 rises from a cap 113 fastened onto the upper end of hub 108 whereby it will rotate with the rotor.

Within the housing 100 and occupying the upper portion thereof is a generally conical hopper 114 which is pivotally, flexibly or otherwise suspended from the top of the houisng 100 at 115. Said hopper 114 is adapted to contain a supply of hydrated lime and is open at the bottom whereby the hydrated lime will feed by gravity onto a spreader plate 116 fast on the post 112 above the bars 111. Said hydrated lime is adapted to be centrifugally dispersed by or spread from the plate 116 and fall from its periphery into the mixing basin or container 101. The post 112 has an arm or agitator 117 extending upwardly and diagonally therefrom into the hopper so as to agitate or scrape the hydrated lime at said outlet opening through the rotation of rotor 107. The amount or quantity of hydrated lime which may be discharged from the plate 116 is regulable according to the position of an arm 118 which is adjustable radially of the plate, the same being pivoted at 119 (FIG. 14) to one of the bars 111 and adjustably fastened by a suitable bolt 120 carried by the bar 118 and movable in an arcuate slot 121 of an arm 122 fastened to one of the bars 111.

The acid mine drainage water passes through the mixing basin or container 101 and is neutralized therein by admixture or solution with the hydrated lime.

One end of a discharge conduit or hose 123 extends from the mixing basin or container 101 (FIG. 12) and its opposite end is connected to a strainer 124 which is disposed in the acid mine drainage water 125, the opposite end 126 of the strainer being open to receive the water 125, and intake conduit or hose 127 is connected to the strainer 124 intermediate its ends, and the opposite end of the conduit 127 is connected to the intake side of a suction pump 128 which may be a conventional mobile type of self-priming centrifugal pump, usually operable by steam, an internal combustion engine or any equivalent 129 as in connection with the pump 19 of the previous form. A discharge conduit or hose 130 has one end connected to the delivery side of the pump 128 with its opposite end free and open to discharge into a settling basin 131.

A valve 132 controls the flow from the delivery side of the pump 128 to the open end of the conduit 130. A delivery conduit or hose 133 has one end in communication with the discharge pipe 130 through a connection 134 located between the valve 132 and the delivery side of the pump. The opposite end of the conduit 133 opens into the basin or container 101 adjacent the bottom thereof, and a vlave 135 controls the flow of fluid from the conduit 130 through the conduit 133 into said basin or container. A short pipe 136 functioning like pipe 31 in the first form has one end communicating with the interior of the mixing basin or container 101 adjacent the bottom thereof and its opposite end connected to the conduit 123.

Said mixing basin or container 101 has a normally closed valve drain outlet 137. The fluid which enters the mixing basin or container 101 through the action of pump 128 has considerable force and so acts against the blades 110 as to rotate the mixing rotor 107. Rising from each or a suitable number of said blades 110 and equidistantly spaced in an annular path, are lugs 138 which intermesh or move into and out of the spaces provided by a wheel 139 having a suitable number of tines 140 radiating from a vertical shaft 141 journalled in and suspended from a suitable bearing 142 attached to one of the bars 111, and also journalled in and suspended from another bearing 142 mounted by a diagonal skeletonized superstructure 144 suitably connected to the container 101 and the bars 111 therein.

At the upper end of shaft 141 is a worm-gear 145 intermeshed with a worm gear wheel 146 mounted on a horizontal shaft 147 in turn journalled in a bearing 148 carried by an upright member 149 of the skeletonized structure 144. Rigid on shaft 147 is a radial arm 150. Pivoted at 151 to a lug 152 fastened at the upper end of the upright member 149 is an arm 153 forming part of a hammer 154 whose head 155 is generally arcuate and is provided with a lateral lug 156. Said hammer-head 155 preferably carries a weight 157. Thus, as the arm 150 rotates clockwise, it will at the proper times in its cycles of rotation engage the lug 156 and thus move the left hand or free end of the hammer head 155 upwardly and away from the hopper 114 and past lug 156 to release the same, whereupon the weight 157 impels the free end of said hammer to knock against the hopper 114, and thus vibrate or agitate the same and the hydrated lime therein to assist in its discharge therefrom onto the plate 116.

Presuming operation of the modified form of FIGS. 12–16 to neutralize acid mine drainage water effected other than by the use of electricity, for instance by steam power or an internal combustion engine, the acid mine drainage water 125 is passed to the container 101 by means of the strainer 124–126, conduit 127, pump 128 and conduit 133. Hydrated lime is supplied to the mixer or container 101 from hopper 114, agitated or vibrated by means of the hammer 155. The fluid flowing into the mixer container 101 will agitate the lime and water and will engage the vanes 110 and operate the rotor 107 so that hub 108 through cap 113 and post 112 will rotate plate 116 and agitator 117, thus facilitating the discharge of the hydrated lime into the mixing basin, the quantity of discharged lime being governed through the adjustment of the arm 118. The mixed water and lime in mixing basin 101 is withdrawn from that basin by suction of the pump 128 siphonically acting through the pipe 127, strainer 124–126, and pipe 123. The mixed water and lime are mixed with additional water drawn through strainer 124 due to the action of pump 128. A portion of the mixture is conducted to the bottom of the mixing basin 101 by way of conduit 133, and the remainder of the mixture is discharged to a settling tank or reservoir 131 similar to that at 26 of the first form of the invention.

It is obvious that various other changes and modifications may be made in the details of construction and design of the above specifically described embodiment of this invention without departing from the spirit thereof, such changes and modifications being restricted only by the scope of the following claims.

What is claimed is:

1. An apparatus for neutralizing acid mine drainage water comprising a cabinet, a hopper for receiving hydrated lime pivotally mounted within said cabinet, means for vibrating said hopper, a feeder trough for receiving lime from the hopper, means for vibrating said trough, a mixing tub supported by said cabinet positioned to receive lime from said trough, a strainer adapted to be positioned in the water to be treated, a discharge hose connecting said tub to said strainer, an intake hose having one end connected to said strainer, a pump having its intake side connected to the other end of the intake hose, a delivery hose connected to the delivery side of the pump and to the tub, and a discharge hose having one end connected to the delivery side of the pump and its opposite end free.

2. An apparatus for neutralizing acid mine drainage water comprising a cabinet, a hopper for receiving hydrated lime pivotally mounted within said cabinet, means for vibrating said hopper, a feeder trough, for receiving

lime from the hopper, means for vibrating said trough, a mixing tub supported by said cabinet positioned to receive lime from said trough, a strainer adapted to be positioned in the water to be treated, a discharge hose connecting said hub to said strainer, an intake hose having one end connected to said strainer, a pump having its intake side connected to the other end of the intake hose, a delivery hose connected to the delivery side of the pump and to the tub, a discharge hose having one end connected to the delivery side of the pump and its opposite end free, and resilient means for regulating the amplitude of the swinging movement of the hopper.

3. An apparatus for neutralizing acid mine drainage water comprising a cabinet, a hopper for receiving hydrated lime pivotally mounted within said cabinet, means for vibrating said hopper, a feeder trough for receiving lime from the hopper, means for vibrating said trough, a mixing tub supported by said cabinet positioned to receive lime from said trough, a strainer adapted to be positioned in the water to be treated, a discharge hose connecting said tub to said strainer, an intake hose having one end connected to said strainer, a pump having its intake side connected to the other end of the intake hose, a delivery hose connected to the delivery side of the pump and to the tub, a discharge hose having one end connected to the delivery side of the pump and its opposite end free, electrically controlled means for controlling said hopper vibrating means, electrically controlled means for operating said pump, and float means operated by the level of the water in the tub for controlling said electric means.

4. An apparatus for neutralizing said mine drainage water comprising a cabinet, a hopper for receiving hydrated lime pivotally mounted within said cabinet and having a discharge outlet, a feeder trough having a bottom inclined with respect to said hopper discharge outlet for receiving lime from the hopper, a mixing tub supported by said cabinet and positioned to receive lime from said trough, means for setting the hopper about its pivot so as to vary the space between the hopper discharge outlet and the inclined bottom of the trough to vary the amount of lime being fed by the hopper to the trough, a discharge hose for connecting the tub to the drainage water, an intake hose having one end adapted to be connected to the drainage water, a pump having its intake side connected to the other end of the intake hose, a delivery hose connected to the delivery side of the pump and to the tub, and a discharge hose having one end connected to the delivery side of the pump and its opposite end free.

5. A process for neutralizing acid mine drainage water comprising the steps of introducing the water to a container, supplying hydrated lime to the container, agitating the lime and water, positively withdrawing the mixed lime and water from the container by suction, utilizing the same suction to draw in additional water to be neutralized and mix it with the mixed lime and water, and conducting some of the further mixture to the container and discharging the remainder thereof to a settling basin.

6. A process for treating acid mine drainage water comprising mixing the water and a neutralizing agent in a container, withdrawing the mixture from the container by suction, utilizing the same suction to draw in additional acid mine drainage water to be neutralized and mix it with the withdrawn mixture, and while the container has a neutralizing agent therein returning part of the last-mentioned mixture into the container and discharging the remainder thereof short of the container.

7. A process for treating acid mine drainage water comprising mixing the water and a neutralizing agent in a container, withdrawing the mixture from the container by suction, utilizing the same suction of said withdrawn mixture to draw in additional acid mine drainage water to be neutralized and mix it with the withdrawn mixture, and while the container has a neutralizing agent therein returning part of the last-mentioned mixture into the container and discharging the remainder thereof short of the container.



8. An apparatus for neutralizing acid mine drainage water comprising a mixing container, means for supplying a neutralizing agent to said container, pumping means for conducting the water to the container for mixing with said agent, means operatively associated with said pumping means for subsequently sucking the mixture from the container and also sucking in additional acid mine drainage water to be neutralized, returning some of it to the container and discharging the remainder to a settling basin, and means for rendering the subsequent means inoperative.

9. An apparatus for neutralizing acid mine drainage water comprising a mixing container, means for supplying a neutralizing agent to said container, pumping means for conducting the water to the container for mixing with said agent, means operatively associated with said pumping means so that unneutralized acid mine drainage water is drawn into said mixture by said pumping means, and means for subsequently sucking the mixture from the container and also sucking in additional acid mine drainage water to be neutralized, returning some of it to the container and discharging the remainder to a settling basin.

10. An apparatus for neutralizing acid mine drainage water comprising a hopper for receiving hydrated lime, a receptacle to receive lime from said hopper, a strainer for positioning in the said water to be treated, a discharge conduit connecting said receptacle and said strainer, an intake conduit having one end connected to said strainer, a pump having its intake connected to the other end of said intake conduit, a delivery conduit connected to the delivery side of the pump and to the receptacle, and a discharge conduit having one end connected to the delivery side of the pump and its opposite end free.

11. Apparatus according to claim 10 having a mixer in said receptacle movable through the impact of entering acid mine drainage water.

12. Apparatus according to claim 10 having a mixer in said receptacle movable through the impact of entering acid mine drainage water, and means operable through motion of said mixer to vibrate or knock said hopper to facilitate discharge of the lime therein.

13. Apparatus according to claim 10 having a mixer rotatable in said receptacle, and means operable through the rotation of said mixer to vibrate or hammer said hopper to facilitate the discharge of the lime therein.

14. Apparatus according to claim 10 having a mixer in said receptacle, a hub rising from the base of said receptacle on which said mixer is journalled, operating means for said mixer, and means intergeared with said mixer movable to knock against said hopper to facilitate the discharge of the lime.

15. Apparatus according to claim 10 having a mixer in said receptacle, a hub rising from the base of said receptacle on which said mixer is journalled, operating means for said mixer, means intergeared with said mixer movable to knock against said hopper to facilitate the discharge of the lime, said operating means including a vertical part, a rotatable arm operable by said part, and means adjacent said hopper including hammer mechanism operable through rotation of said arm to hammer against said hopper.

16. Apparatus according to claim 10 including a mixer in said receptacle, and a plate to receive lime from said hopper rotatable with said mixer to discharge the lime into said receptacle.

17. Apparatus according to claim 10 including a mixer in said receptacle, a plate to receive lime from said hopper rotatable with said mixer to discharge the lime into said receptacle, and means to regulate the quantity of lime dischargeable from said plate.

18. Apparatus according to claim 10 including a mixer

in said receptacle, and a plate to receive lime from said hopper rotatable with said mixer to discharge the lime into said receptacle including a bar adjustably movable over the plate between its periphery and axis.

19. Apparatus according to claim 10 having a mixer operable in said receptacle, said mixer having a vertical hub, said receptacle having a post on which said hub is journalled, frame means within the receptacle, a part rising from the hub journalled in the frame means, and a lime receiving and discharging plate carried by the said part and arranged below the hopper.

20. A process for neutralizing acid mine drainage water comprising the step of introducing the water to a container, supplying hydrated lime to the container, agitating the lime and water, withdrawing the mixed lime and water



from the container by suction, utilizing the same suction to draw in a limited additional amount of the water to be neutralized and mix it with the withdrawn mixture, and conducting some of the further mixture to the container and discharging the remainder thereof to a settling basin.

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