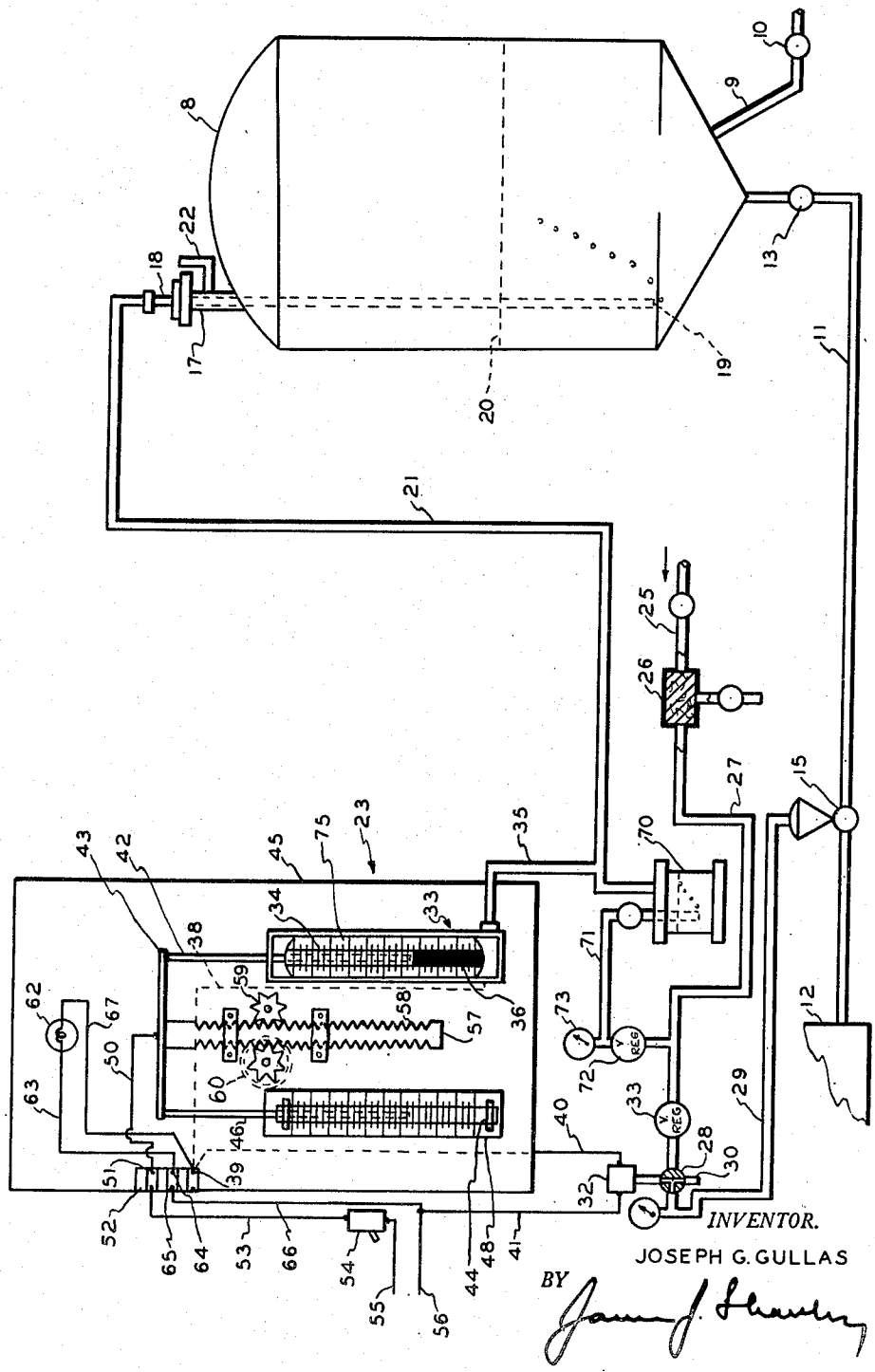
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APPARATUS FOR DISPENSING MEASURED VOLUMES OF LIQUID

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APPARATUS FOR DISPENSING MEASURED VOLUMES OF LIQUID

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The present invention relates to apparatus for dispensing a measured quantity of liquid and is particularly concerned with apparatus for dispensing a measured quantity of pickling acid to apparatus for pickling articles of ferrous metal or other metal to remove oxide or other material from the surfaces of the articles. The present invention also relates to an improved method of dispensing pickle liquor.

It is customary to pickle articles of ferrous metal to remove from their surfaces any oxide that may be present. When such articles are pickled, they are placed in or passed through an acid bath. Sulphuric acid is commonly used, although hydrochloric acid and other acids or mixtures of such acids may be used. It is necessary to periodically replenish the baths with additional pickling acid to replace that which has been used. It also is necessary from time to time to make up fresh pickling baths by adding a certain quantity of acid to a known quantity of water to produce a bath having the correct acidity. Pickling acid, either in dilute or concentrated form, is highly corrosive and is difficult to handle. When replenishing or making up a new pickling bath, a quantity of concentrated acid may be added to the bath and then additional water added to bring the bath up to volume or a volume of dilute acid may be added that will contain both the acids and water necessary to replenish the bath. For best results, the acidity of the pickling bath should be controlled accurately. In commercial practice, the amount of acid to be used has, in general, been controlled or determined in a haphazard manner. The feeding of acid to the pickling tanks has given considerable trouble and there has been a long felt need for a method and apparatus for accurately dispensing the desired amount of acid in either dilute or concentrated form.

Accordingly, it is an object of the present invention to provide an improved method and apparatus for feeding a measured quantity of liquid from a source of supply, such as a tank, to the point of use.

It is an object of the present invention to provide an improved method and apparatus for dispensing a measured quantity of liquid pickling acid either in dilute or concentrated form to pickling apparatus.

It is an object of the present invention to provide an improved apparatus for dispensing a measured quantity of liquid, such as pickling acid, that will be accurate, free of operational difficulties and that will not become clogged or damaged after a short period of use.

It is an object of the present invention to provide in combination with apparatus for pickling metal articles, an improved device for feeding a measured quantity of pickling acid to the pickling apparatus to replenish the pickling acid bath.

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In accordance with the present invention, there is provided a novel means for feeding a certain quantity of pickling acid to the pickling apparatus from a supply tank. The supply tank is adapted to contain a body of pickling acid of varying depth and the acid is discharged from the bottom of the bank through a conduit and to the pickling apparatus. A valve in the conduit controls the flow of pickling acid. A closed conduit means terminating in an outlet below the surface of the pickling acid in the tank is provided and the pressure in this conduit varies in proportion to the depth of pickling acid in the tank. A control device is connected to the valve in the outlet conduit and to the conduit means and this control device is responsive to the pressure in the conduit so that the depth of liquid in the tank by its variation in pressure in the closed conduit causes the control device to actuated the valve to permit the desired volume of pickling acid to flow from the tank to the outlet conduit to the pickling apparatus. Thus, the desired amount of acid is dispensed automatically to the pickling apparatus.

Preferably gas, for example air, is continuously flowed through the closed conduit to prevent clogging of the conduit, particularly that portion which is submerged in the pickling acid.

These and other objects and advantages will become more readily apparent from the following description taken with the accompanying drawing which is a diagrammatic representation of a preferred embodiment of the present invention.

Referring to the drawing, the relatively large supply tank 8 is adapted to contain enough pickling acid to repeatedly replenish a pickling bath. Pickling acid is supplied periodically to the tank through an inlet conduit 9 which is connected to a suitable source of pickling acid. A normally closed valve 10 in the conduit 9 controls the supply of pickling acid. An outlet conduit 11 is connected to the lower portion of the tank 8 and is connected to the pickling apparatus diagrammatically indicated at 12. A manually operable, safety valve 13 is provided in conduit 11. Valve 13 normally is open. A control valve 15 is provided in conduit 11 and this valve normally controls the flow of acid from the tank. At the top of the tank 8 there is a header 17 which may be fastened in place by welding or any other suitable means. Header 17 in turn supports a tube 18 which extends through the header down into

the tank 10 and terminates in an opening at 19 which is in position to be submerged below the level of the liquid in the tank which is indicated by the broken line 20. A pipe or conduit 21 is connected to the upper end of the tube 18 and this conduit is a closed conduit in that the pressure in the conduit is controlled or proportional to the depth of liquid in the tank 8. In other words, the deeper the liquid in the tank the higher the pressure in the conduit 21 and vice versa. Preferably the tank is vented to the atmosphere and for this purpose a vent pipe 22 is connected to header pipe 17 so that the pressure in the upper portion of the tank above the pickling acid is atmospheric pressure. The tube 18 is smaller than header pipe 17 so that air can flow from tank 8 through pipe 17 and out vent 22. With the vent pipe 22 in place, the pressure in conduit 21 is directly proportional to the depth of liquid in the tank 8 and there is a straight line relationship between these two factors. If the upper portion of the tank were not vented, then the pressure in conduit 21 would be the sum of the pressure in the top of the tank above the liquid plus the pressure exerted by the liquid. With this arrangement the pressure in conduit 21 would be proportional to the depth of liquid in the tank but the relationship between these two factors would not be a straight line relationship.

A control device 23 is connected to conduit 21 and to valve 15 to open and close the valve in response to variations in pressure in conduit 21. The connection to valve 15 may be direct or indirect. As shown, valve 15 is a diaphragm type valve operable by air pressure. Air under pressure from a suitable source is supplied through conduit 25 to cleaner 26 in which any particles of dirt are removed. Cleaner 26 is connected through a conduit 27 to a three-way valve 28 which is in turn connected through conduit 29 to valve 15. Valve 28 is also connected through tube 30 to the atmosphere. As shown, valve 28 is in the closed position so that conduit 29 is vented to the atmosphere. Valve 15 is normally closed and is of the type that closes when no pressure is applied to the valve through conduit 29. The valve 28 is operated by a solenoid 32 constructed and arranged so that when the solenoid 32 is de-energized the valve 28 is held in the closed position to effect closing of valve 15 and is so constructed and arranged that when the solenoid 32 is energized the valve 28 is turned to connect conduits 29 and 26 so as to supply air under pressure to valve 15 and open the valve. Preferably a pressure regulator 33 is provided in conduit 27 so that the air supply for conduit 29 and valve 15 is maintained at a constant pressure.

The solenoid 32 and the valve 15 are controlled by the controller 23 which is responsive to the pressure in conduit 21. The control device 23 includes a manometer 33 having a tube 34 of glass or other suitable material. The manometer is connected through conduit 35 to conduit 21. The manometer 33 contains a conductive liquid, such as mercury, which is indicated at 36. The height of the mercury in tube 34 is proportional to the pressure in conduits 35 and 21. The higher the pressure and the greater the depth of liquid in tank 8, the higher the column of mercury in tube 34. The mercury is connected through a wire 38 to post 39 which is in turn connected through wire 40 to one side of the solenoid 32. The controller 23 includes a conductive member or rod 42 suspended from a cross member 43. The rod 42 extends down into tube 34. A transparent guide tube 44 is mounted on the control panel 45 adjacent the manometer tube 34. A rod 46 is suspended from the cross member 43 and extends down into the tube 44. The tube 44 is mounted on a plate 48 which is calibrated as will be subsequently described. The cross member 43 is connected through wire 50 to post 51 which is in turn electrically connected to post 52 which is connected through wire 53 to switch 54. The switch 54 is connected to wire 55 which is in turn connected to one side of a source of electric current. With the switch 54 closed, the cross member 43 and contact member 42 are connected to one side of a source of electric current. The solenoid 32 is connected through wire 41 to wire 56 which is connected to the other side of the source of electric currents so that when member 42 touches the mercury 36 in the tube 34, the circuit to solenoid 32 is closed and the solenoid is energized.

The cross member 43 and the rods 42 and 46 are vertically adjustable in unison. Cross member 43 is mounted on the upper end of a rack member 57 having a rack 58 on each side with each rack meshing with a pinion 59. One of the pinions 59 is connected to a knob 60 so that upon rotation of the knob 60 the rack is moved upwardly or downwardly, depending upon the direction of rotation of the knob. As previously mentioned, the indicator plate 48 on which tube 44 is mounted is calibrated or marked and these markings indicate the volume of liquid in tank 8 and the level of the mercury in tube 34. It will be noted that the lower end of rod 42 is at but not touching the upper surface of the mercury column 36. The lower end of the rod 56 indicates on the calibrated indicator 48 the volume of liquid in the tank 8. Assuming that this volume is 50 gallons, and that the operator wants to add 10 gallons to the pickling apparatus 12, then the knob 60 is turned to lower the rod 42 into the mercury 36. This will also lower the rod 46 and when the lower end of the rod is at the position indicating a volume of 40 gallons in the tank 10, the lowering of the cross member 43 is discontinued. When the switch 54 is closed, the rod or contact member 42 is in contact with the mercury 36 to close the circuit to solenoid 32 which opens the valve 28 to in turn open valve 15. As the pickling acid flows out of the tank, the depth of the liquid in the tank drops which in turn lowers the pressure in conduit 21 and the mercury in tube 34 falls. When the volume in the tank 8 drops to 40 gallons, the column of mercury 36 will no longer make contact with rod 42 and the circuit to solenoid 32 is opened to de-energize the solenoid and effect the closing of valve 15. The transparent tube 44 and the calibrated dial 48 is used primarily for the reason that it is difficult, if not impossible, to see the position of the rod 42 in the tube 34 and in the mercury column 36.

Preferably visual means, such as a light 62, is provided to indicate to the operator when acid is flowing through conduit 11. The light 62 is connected through wire 63, posts 64 and 65 and wire 66 to wire 56 which is connected to one side of a source of electric current. The bulb is also connected through wire 67 to post 39 which, as previously described, is connected through wire 38 and mercury column 36 to rod 42. Rod 42 is, in turn, connected to wire 55 and the opposite side of a source of electric current. With wire 67 connected to post 39 and when the rod 42 engages the mercury column 36, the circuit to the

light 62 is closed and the light is lit. Thus, the light 62 is lit when the solenoid 32 is energized and acid is flowing through conduit 11.

Preferably, gas, such as air, is blown through the conduit 21 and tube 18 to maintain the passages clear of obstructions. Especially when handling acids, there is a tendency for the interior of the tube 18 to become clogged with incrustations resulting from attack of the acid on the tube or from settling out in the tube of compounds carried in the acid solution. Sulphuric acid pickling solutions, for example, tend to contain a certain amount of copperas which in turn tends to precipitate out in quiescent liquid in the tube 18 and clog the tube. The conduit 21 is connected to a bubbler 70 which is in turn connected through a conduit 71 to conduit 27. A pressure regulator is provided to control the pressure of the air supplied through conduit 71 to conduit 21. A pressure regulator 73 indicates the pressure in conduit 71. The air flowing through the conduit 21 and down through tube 18 maintains the tube 18 clear at all times. This air bubbles up through the bath of pickling acid and the tank 10 and flows out the vent 22 so that the pressure in the tank does not vary. When air is blown in through the tube 18 in this manner it is essential that the tank be vented. While air is blown into and through a conduit 21, the conduit 21 is a closed conduit in that the pressure in the conduit is directly proportional to the depth of liquid in the tank. While it is true that there is a slight pressure drop along the conduit 21, caused by the resistance of the flow of gas through the conduit, this resistance is constant so that the pressure existing in conduit 35 and conduit 21 is proportional to the back pressure which is caused by the liquid in the tank 8.

As previously indicated, the switch 54 is normally open except when it is desired to feed pickling acids to the pickling apparatus 12. Assuming that switch 54 is open, the operation of the apparatus is carried out in the following manner. At the start of the operations or at relatively widely spaced intervals of time, it is necessary to fill the tank 12 with a supply of pickling acid. When this is to be done, the valve 15 is opened, the pickling acid flows into the tank and when the tank is full, the valve 15 is closed. The fact that the tank 12 is full will be indicated by the level of the top of the column of mercury 36. Before the apparatus is ready for operation, the operator will rotate knob 60 to raise the cross member 43 until the lower end of the rod 42 is just above the surface of the mercury 36. Normally the operator can determine this by looking through the tube 34 but if the tube 34 is clouded, the operator can raise the rod 42 and simultaneously rapidly open and close the switch 54. Flashing of light 62 will indicate that the rod 42 and mercury are in contact. When these members are no longer in contact with each other, the light 62 will not flash.

The volume of acid in the tank will be indicated by the position of the lower end of rod 46 on dial 48. In addition, a dial 75 in back of tube 34 may indicate the volume of acid in the tank with the indicator being the upper surface of the column of mercury. If the operator wants to add 20 gallons or any other predetermined quantity of pickling acid to the pickling apparatus, he then rotates knob 60 to lower rod 46 until the lower end by its position on dial 48 indicates a volume 20 gallons less than the volume actually in the tank 8. The switch 54 is closed and the

control device automatically turns on the light 62 and energizes solenoid 32 to open valve 15. Acid continues to flow out of the tank 8 until the pressure in the conduit 21 drops sufficiently so that the top of the mercury column 36 moves out of contact with the rod 42. This breaks the circuit and closes valve 15 and turns off the light 62. Normally the operator will then open switch 54 as a safety measure. Switch 54 also permits the operator to adjust the rod 42 upwardly and downwardly to the desired position without prematurely opening the valve.

In operation, the mercury column is an electrical contact member movable along a path, that is, tube 34, in response to and according to the pressure in the closed conduit 21. The rod 42 is a second contact member manually adjustable along a path to any one of a number of predetermined positions corresponding to various depths of liquid in tank 8. The two contact members maintain contact with each other as long as the depth of liquid in tank 8 is greater than a predetermined depth corresponding to the position to which the rod has been adjusted. The electrical circuit is opened and the electrically actuatable means, which is solenoid 32, is de-energized to effect closing of the valve 15 when the mercury column is no longer in contact with the rod 42 and this break in the electrical circuit takes place as soon as the depth of liquid in the tank falls to the previously mentioned predetermined depth. Thus, it is believed obvious that the present invention is not limited to the manometer 33 but other equivalent means could be utilized. In addition, it is believed clear that the control device 23 is connected to the valve 15 in such a manner as to effect closing of the valve when the level of liquid in the tank 8 falls to a predetermined point, and to effect opening of the valve 15 as long as the level of the liquid in the tank 8 is above this predetermined point. Other indicating means beside the light 62 may be used to indicate to an operator when the control device is functioning properly and acid is flowing through the outlet conduit 11.

Preferably, air is constantly blown through conduit 21 and tube 18. It is more important that the air be blown through tube 18 than conduit 21. If desirable, the blowing of this air through conduit 21 may be eliminated.

While the present device has been described most particularly in connection with the feeding of the predetermined quantity of pickling acid to pickling apparatus, it may be used for dispensing other liquids.

I claim:

1. Apparatus for dispensing a quantity of liquid comprising, in combination, tank means adapted to contain a body of liquid, outlet means for discharging liquid from the tank means whereby the depth of liquid in the tank means is reduced, valve means for controlling the flow of liquid through the outlet means, closed conduit means terminating in an opening in the lower portion of the tank means so that the pressure in the closed conduit means is proportional to the depth of liquid in the tank means, and control means including means responsive to the pressure in the closed conduit means, manually adjustable means movable to any one of a plurality of positions each corresponding to a certain depth of liquid in the tank means, and means for effecting the opening and closing of the valve means, said last-mentioned means being connected to the manually adjustable means and to the pressure re-

sponsive means to effect opening of the valve means upon movement of the manually adjustable means to a position corresponding to a depth of liquid less than is in the tank means and to effect closing of the valve means when the depth of liquid in the tank means falls to a level corresponding to the position of the manually adjustable means.

2. Apparatus for feeding a quantity of liquid comprising, in combination, tank means adapted to contain a body of liquid of varying depth, outlet conduit means connected to the lower portion of the tank means for discharging liquid from the tank means, valve means interposed in the outlet conduit means for controlling the flow of liquid through the outlet conduit means, passage means extending down into the tank means and having an opening in the lower portion of the tank means in position to be submerged in the body of liquid, closed conduit means connected to the passage means constructed and arranged so that the pressure in said closed conduit means is proportional to the depth of liquid in the tank means, and control means connected to the valve means and to the closed conduit means, the control means being responsive to the pressure in the conduit means and operable to effect closing of the valve means upon lowering of the pressure in the closed conduit means and the lowering of the liquid in the tank means to a predetermined lower depth.

3. Apparatus for feeding a quantity of liquid comprising, in combination, tank means adapted to contain a body of liquid of varying depth, outlet conduit means connected to the lower portion of the tank means for discharging liquid from the tank means, valve means interposed in the outlet conduit means for controlling the flow of liquid through the conduit means from the tank means, vent means for venting the upper portion of the tank means to the atmosphere, passage means extending down into the tank means and having an opening in the lower portion of the tank means in position to be submerged in the body of liquid, closed conduit means connected to the passage means and constructed and arranged so that pressure in said closed conduit means is directly proportional to the depth of liquid in the tank means, and control means connected to the valve means and to the closed conduit means, the control means being responsive to the pressure in the conduit means and operable to effect opening of the valve means when the depth of liquid in the tank means is greater than a predetermined depth and operable to close the valve means when the depth of liquid in the tank means falls to said predetermined depth.

4. Apparatus for feeding a quantity of liquid comprising, in combination, tank means adapted to contain a body of liquid of varying depth, outlet conduit means connected to a lower portion of the tank means for discharging liquid from the tank means, valve means interposed in the outlet conduit means for controlling the flow of liquid from the tank means, vent means venting the upper portion of the tank means to the atmosphere, passage means extending down into the tank means and having an opening in the lower portion of the tank means in position to be submerged in the body of liquid, closed conduit means connected to the passage means and constructed and arranged so that the pressure in said closed conduit means is proportional to the depth of liquid in the tank means, means for discharging gas under pressure into the closed conduit means whereby gas flows through the passage means and out the vent means, and control means connected to the valve means and to the closed conduit means, the control means being responsive to the pressure in the conduit means and operable to effect opening of the valve means when the depth of liquid in the tank means is greater than a predetermined depth and operable upon lowering of the liquid in the tank means to said predetermined depth to close the valve means.

5. Apparatus for feeding a quantity of liquid comprising, in combination, tank means adapted to contain a body of liquid of varying depth, outlet conduit means connected to the lower portion of the tank means for discharging liquid from the tank, valve means interposed in the outlet conduit means for controlling the flow of liquid from the tank means, passage means extending down into the tank means and having an opening in the lower portion in position to be submerged in the body of liquid, closed conduit means connected to the passage means and constructed and arranged so that the pressure in said closed conduit means is proportional to the depth of liquid in the tank means, electrically actuatable means operable upon energization to open the valve means and operable upon deenergization to close the valve means, an electrical control circuit for controlling the energizing and deenergizing of the electrically actuatable means, the electrical control circuit including a first electrical contact member connected to the closed conduit means and movable along a path by variations in pressure in the closed conduit means so that the first contact member is positioned along the first path according to the depth of liquid in the tank means, a second contact member adjustable along a path to a predetermined position corresponding to a predetermined depth of liquid in the contact means, said contact members being connected to the electrically actuatable means and to a source of electric current and being constructed and arranged to maintain electrical contact with each other only when the depth of liquid in the tank means is greater than said predetermined depth so that the electrical circuit is opened and the electrically actuatable means is deenergized to close the valve when the depth of liquid in the tank drops to said predetermined depth.

6. Apparatus for feeding a quantity of liquid comprising, in combination, tank means adapted to contain a body of liquid of varying depth, outlet conduit means connected to the lower portion of the tank means for discharging liquid from the tank means, valve means interposed in the outlet conduit means for controlling the flow of liquid through the outlet conduit means, passage means extending down into the tank means and having an opening in the lower portion of the tank means in position to be submerged in the body of liquid, closed conduit means connected to the passage means constructed and arranged so that the pressure in said closed conduit means is proportional to the depth of liquid in the tank means, electrically operable means operable to effect closing of the valve means and operable to effect opening of the valve means, an electrical control circuit for controlling operation of the electrically operable means, a manometer tube containing an electrically conducted liquid and being connected to the closed conduit means so that the depth of liquid in the

manometer tube is proportional to the depth of liquid in the tank means, a conductive member movable upwardly and downwardly in the manometer tube, the conductive member and the conductive liquid being interposed in the electrical control circuit so that the control circuit is open when the conductive liquid and the conductive member are not in contact with each other.

7. Apparatus for feeding a quantity of liquid comprising, in combination, tank means adapted to contain a body of liquid of varying depth, outlet conduit means connected to the lower portion of the tank means for discharging liquid from the tank means, valve means interposed in the outlet conduit means for controlling the flow of liquid through the outlet conduit means, vent means for venting the upper portion of the tank means to the atmosphere, passage means extending down into the tank means and having an opening in the lower portion of the tank means in position to be submerged in the body of liquid, closed conduit means connected to the passage means constructed and arranged so that the pressure in said closed conduit means is proportional to the depth of liquid in the tank means, and electrically operable means operable to effect closing of the valve means and operable to effect opening of the valve means, an electrical control circuit for controlling the operation of electrically operable means, a manometer tube containing an electrically conductive liquid connected to the closed conduit means so the depth of liquid in the manometer tube is proportional to the depth of liquid in the tank means, a conductive member movable upwardly and downwardly in the tube, the conductive member and the conductive liquid being interposed in the control circuit so that the electrical control circuit is open when the conductive liquid and the conductive member are not in contact with each other, and means for blowing gas through the closed conduit means and the passage means.

8. Apparatus for feeding a quantity of liquid comprising, in combination, tank means adapted to contain a body of liquid of varying depth, outlet conduit means connected to the lower portion of the tank means for discharging liquid from the tank means, valve means interposed in the outlet conduit means for controlling the flow of liquid through the outlet conduit means, passage means extending down into the tank means and having an opening in the lower portion of the tank means in position to be submerged in the body of liquid, closed conduit means connected to the passage means constructed and arranged so that the pressure in said closed conduit means is proportional to the depth of liquid in the tank means, electrically actuatable means operable upon energization to effect opening of the valve means and operable upon deenergization to effect closing of the valve means, an electrical control circuit for energizing and deenergizing the electrically actuatable means, a manometer tube containing an electrically conductive liquid connected to the closed conduit means so the depth of liquid in the manometer tube is proportional to the depth of liquid in the tank means, a conductive member movable upwardly and downwardly in the tube, the conductive member and the conductive liquid being interposed in the electrical control circuit to open the control circuit when the conductive liquid and the conductive member are not in contact with each other.

9. The apparatus claimed in claim 8 which includes an indicator member, means for moving the indicator member and the conductive member upwardly and downwardly in unison whereby both members may be moved to a position corresponding to a predetermined lower depth of liquid in the tank means.

10. Apparatus for feeding a quantity of liquid comprising, in combination, tank means adapted to contain a body of liquid of varying depth, outlet conduit means connected to the lower portion of the tank means for discharging liquid from the tank means, valve means interposed in the outlet conduit means for controlling the flow of liquid through the outlet conduit means, passage means extending down into the tank means and having an opening in the lower portion of the tank means in position to be submerged in the body of liquid, closed conduit means connected to the passage means constructed and arranged so that the pressure in said closed conduit means is proportional to the depth of liquid in the tank means, means venting the upper portion of the tank means to the atmosphere, means for forcing air under pressure into the closed conduit means so that air flows through the passage means to maintain the passage means open, electrically actuatable means operable upon energization to effect opening of the valve means and operable upon deenergization to effect closing of the valve means, an electrical control circuit for energizing and deenergizing the electrically actuatable means, a manometer tube containing an electrically conductive liquid connected to the closed conduit means so the depth of liquid in the manometer tube is proportional to the depth of liquid in the tank means, a conductive member movable upwardly and downwardly in the tube, the conductive member and the conductive liquid being interposed in the electrical control circuit to open the control circuit when the conductive liquid and the conductive member are not in contact with each other.

11. Apparatus comprising ferrous metal pickling apparatus, tank means for holding a body of pickling acid, and means for adding a predetermined quantity of pickling acid from the tank means to the pickling apparatus, said last mentioned means including an outlet conduit for discharging acid from the bottom portion of the tank means into the pickling apparatus, normally closed valve means in the conduit means, means movable from a first position corresponding to the depth of liquid in the tank means to a second position corresponding to a lower depth of liquid in the tank means, closed conduit means terminating in an opening in the lower portion of the tank means, the closed conduit means being constructed and arranged so that the pressure in the closed conduit means is proportional to depth of liquid in the tank means, means responsive to the pressure in the closed conduit means, and means connected to the movable means and to the responsive means and to the valve means and operable to effect opening of the valve means upon movement of the movable means to the second position and operable to effect closing of the valve means when the depth of liquid in the tank means falls to the depth corresponding to the second position of the movable means.

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No references cited.