March 23, 1954 S. RABKIN ET AL 2,672,946

HOPPER WASHING

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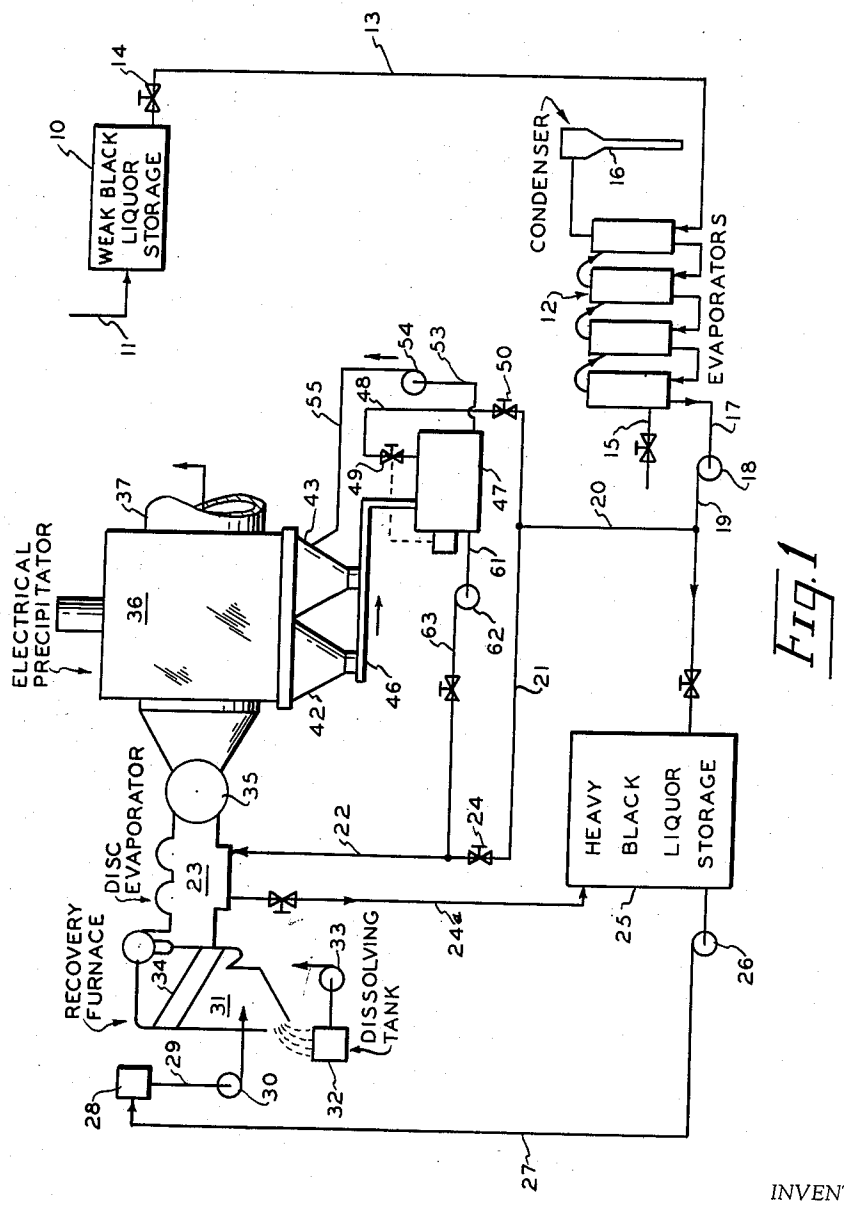


Fig. 1

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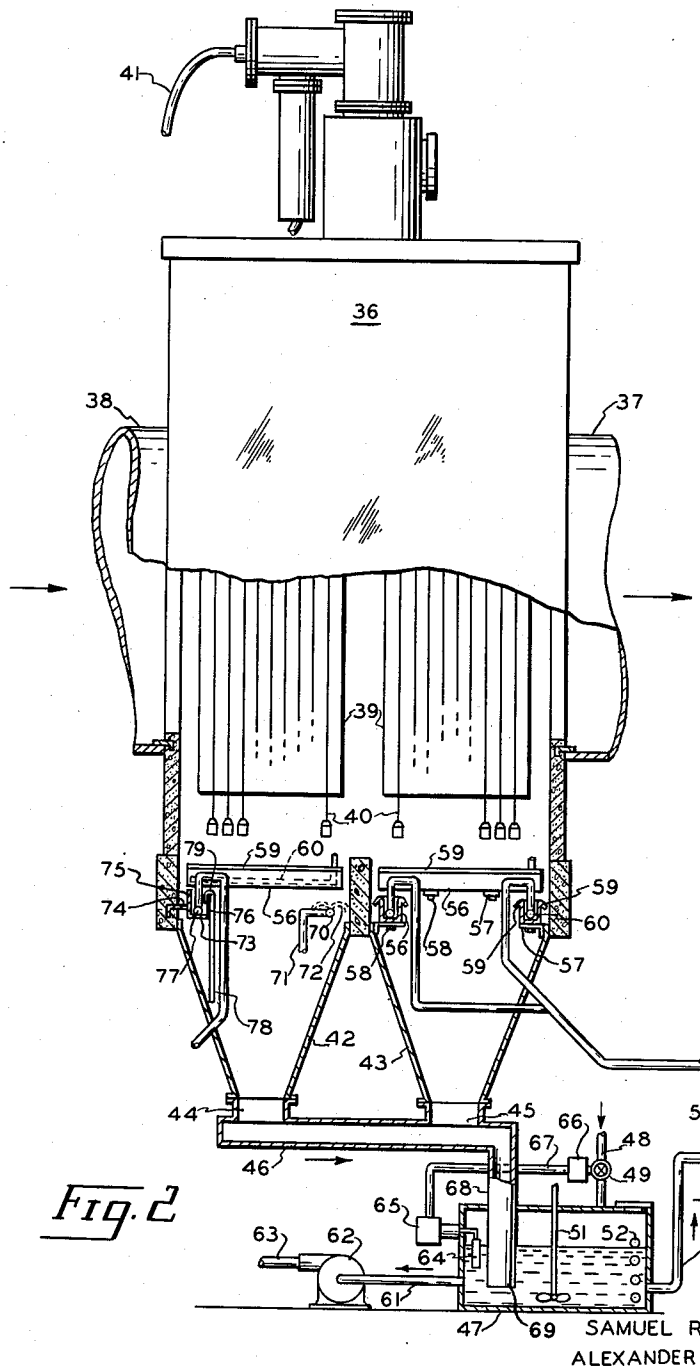


Fig. 2

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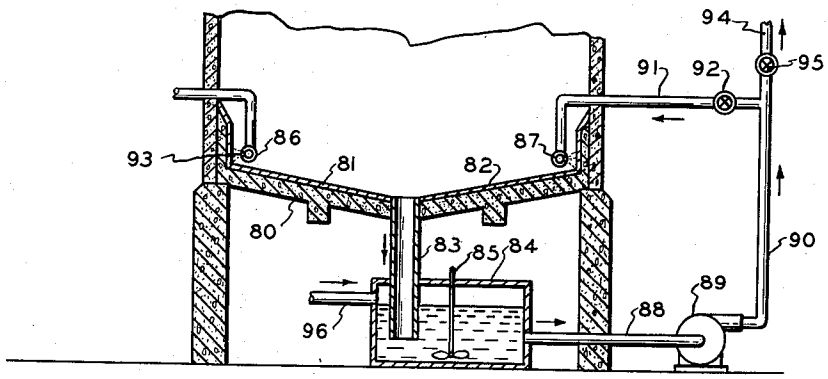


Fig. 3

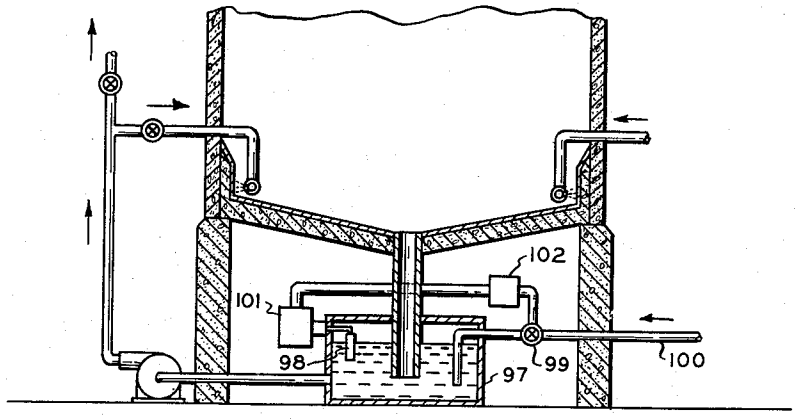


Fig. 4

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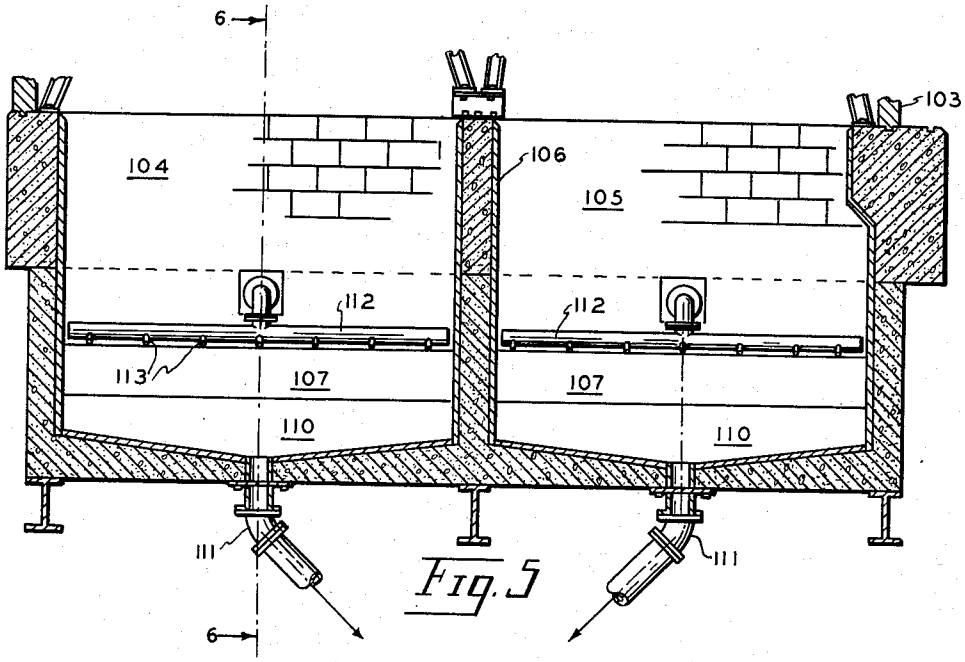


Fig. 5

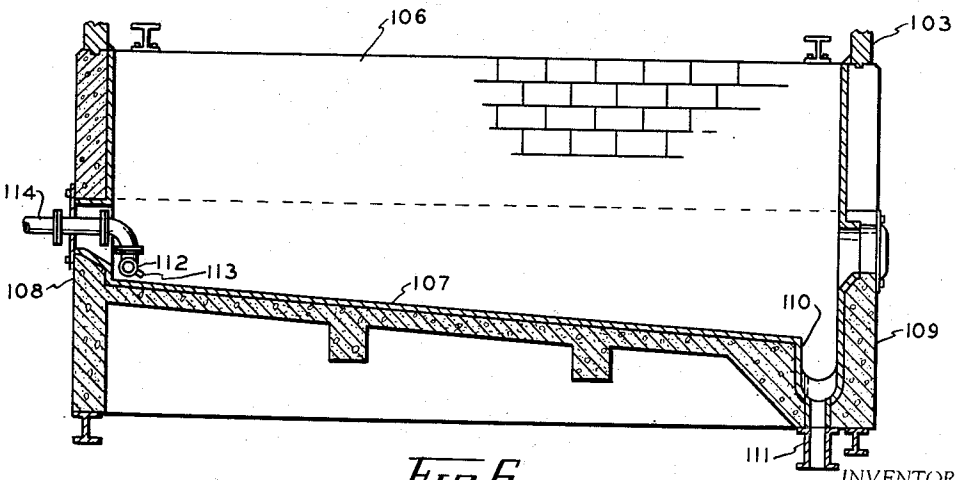


Fig. 6

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UNITED STATES PATENT OFFICE

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HOPPER WASHING

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7 Claims. (Cl. 183—7)

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This invention relates to the washing of hoppers of electrical precipitators, especially the hoppers of precipitators employed to collect ash from the gases resulting from the burning of black liquor in the sulfate paper making process. The invention is particularly concerned with apparatus for supplying and applying washing liquid to the interior surfaces of the hoppers to maintain them in a clean condition and to flush out collected material.

An object of the invention is to provide apparatus for washing or flushing the hoppers of electrical precipitators effectively, simply and economically.

Another object of the invention is to provide a hopper washing system wherein the washing liquid not only flushes the interior surfaces of the hopper but also flushes those parts of the washing system that are exposed to dust fall within the hopper and thus are prone to collect deposits of precipitated material.

Another object is to provide in such a washing system a sealing device whereby flushing liquid and collected material is removed from the hoppers without escape of gas through the liquid outlet.

Still another object is to provide a hopper washing system for electrical precipitators that greatly improves the collection and disposition of water soluble precipitated material such as ash borne in gases from recovery furnaces in which black liquor is burned.

These and other objects of the invention, as may appear hereinafter, are realized in an electrical precipitator having the usual casing, complementary high tension and extended surface electrodes in the casing, and gas inlet and gas outlet means in the casing directing a stream of gas to be cleaned between the electrodes, a hopper in the bottom of the casing receiving precipitated material removed from the electrodes and discharge means in the hopper, washing means for the hopper including a liquid conduit extending substantially along an upper edge of the hopper, the conduit having liquid outlet means positioned to discharge washing liquid against an upper interior surface of the hopper, and means supplying washing liquid to the conduit.

The liquid conduit and liquid outlet means therefor, may take a variety of forms. For example, the liquid conduit may be an open top trough, the lips of which form liquid outlet means spilling washing liquid over the outside of the trough and over the hopper surfaces to be washed.

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Or, the liquid conduit may be a pipe extending around the top of the inside of the hopper and having holes or nozzles directing sprays of washing liquid over the surfaces to be cleaned.

The sealing device of the invention includes a discharge conduit leading from the hopper of the precipitator to a tank through which liquid flows by gravity. The discharge conduit terminates in the tank below the normal level of liquid therein whereby escape of gas from the precipitator through the hopper and the discharge conduit is prevented.

These and other features of the invention will be described with particularity in the following detailed description of several embodiments as shown in the drawings in which:

Fig. 1 is a diagrammatic illustration of a black liquor recovery system employing an electrical precipitator and washing system in accordance with the invention;

Fig. 2 is an enlarged, vertical, partial sectional view of an electrical precipitator and hopper washing apparatus suitable for use in the system of Fig. 1;

Fig. 3 is a partial vertical sectional view of another precipitator according to the invention;

Fig. 4 is a view similar to Fig. 3 of another form of the invention;

Fig. 5 is a vertical sectional view through the lower portion of still another form of precipitator; and

Fig. 6 is a sectional view taken along the line 6—6 of Fig. 5.

The invention will be described by way of example with reference to a black liquor recovery system forming an important part of a sulfate process paper mill. Such a recovery system is shown in Fig. 1 in which a weak black liquor storage tank 10 receives weak black liquor through the pipe 11 from the pulp digesters (not shown) after the usual filtration operation. The weak black liquor is an aqueous solution containing about 15% solids, a large part of the solids content being organic in nature, including sodium sulfate. In the recovery system, the weak black liquor is concentrated to a solids content of about 58% and burned in a furnace to oxidize and drive off most of the organic material, to evaporate the water and to reduce the sodium sulfate to sodium sulfide which is purified and reused in the pulp digesters.

Initial concentration of the weak black liquor is done in a multiple effect evaporator 12 to which the weak black liquor flows through a pipe 13

under control of a valve 14. The evaporator 12 is of well-known design and has a steam line 15 supplying steam to the calandria of the last effect and a condenser, such as the barometric condenser 16, receiving vapors from the first effect. The weak black liquor flows through the effects from right to left, as seen in Fig. 1, in countercurrent relation to the vapor flow, the latter being indicated by the arrows at the top of the effects. Preliminarily concentrated black liquor issues from the last effect of the evapator 12 into the line 17 and is forced by the pump 18 through pipes 19, 20, 21 and 22 to a conventional disc evaporator 23. Valve 24 in the line 21 controls the flow of black liquor to the disc evaporator.

In the disc evaporator, the preliminarily concentrated black liquor is concentrated to a further extent by evaporation of water and the heavy black liquor so produced flows through the pipe 24a to the heavy black liquor storage tank 25.

Heavy black liquor from the tank 25 is forced by a pump 26 through the pipe 27 to a recovery furnace charging tank 28 from which it flows through the pipe 29 to a furnace charger 30 that delivers the combustible heavy black liquor to the recovery furnace 31.

The black liquor is burned in the furnace 31 to ash consisting chiefly of sodium sulfide and sodium carbonate, which ash is discharged from the furnace into a dissolving tank 32 wherein it is dissolved in water and from which it is forced by a pump 33 to a point of disposition. After purification, the solution of sodium sulfide is reused in the pulp making process.

Furnace gases that contain a heavy burden of moisture and not inconsiderable amounts of sodium sulfate and sodium carbonate in suspension are passed at high temperature through a waste heat boiler 34 in the furnace 31 where some of the sensible heat is recovered. The partially cooled furnace gases then are passed through the disc evaporator 23 where some of the additional heat thereof is utilized to evaporatively concentrate black liquor flowing from the multiple effect evaporator 12 to the storage tank 25.

A fan 35 blows the furnace gases through an electrical precipitator 36 and thence through the exhaust duct 37 to atmosphere. In the precipitator, the furnace gases are substantially cleaned of their ash content, as will be explained in detail hereinafter, and the precipitated ash is returned to the process.

Referring to Fig. 2, the precipitator 36 is shown in enlarged detail together with certain components of the washing system. Gas flows through the precipitator from left to right in the direction of the arrows, entering the precipitator through the duct 38 and leaving through the duct 37. Within the precipitator there are extended surface collecting electrodes 39 and complementary discharge electrodes 40 in the form of fine wires insulatedly suspended in parallel relation to the collecting electrodes. The discharge electrodes are supplied with high voltage current, usually direct current, by means of a high tension cable 41 to which the wire electrodes are conventionally connected. Thus a high electric potential is maintained between the fine wire electrodes 40 and the collecting electrodes 39 whereby corona discharge occurs at the fine wire electrodes. The gas to be cleaned of ash passes between the curtains of discharge electrodes and the collecting plates and in these zones the suspended particles become charged and are attracted to and deposited upon the collecting electrodes. Precipitated ash is removed from the electrodes by any suitable electrode cleaning device, such as a rapper (not shown).

Beneath and communicating with the precipitating zone is a plurality of hoppers 42 and 43 into which falls the ash dislodged from the electrodes. This ash, as has been indicated, is soluble in water or black liquor. It is removed from the hopper by hopper washing devices, three forms of which are shown by way of illustration in Fig. 2.

As seen in Fig. 2, the hoppers 42 and 43 have outlet openings 44 and 45 communicating with a discharge header 46 conveying discharged material to a tank 47. The tank receives preliminarily concentrated black liquor from the evaporators 12 through a pipe 48 under control of automatic valve 49 and a manually controlled valve 50 shown in Fig. 1.

The tank has an agitator 51, driven by conventional means (not shown) and a heating coil 52. An outlet pipe 53 conducts liquid from the tank to a pump 54 that forces liquid through the line 55 to the hopper washing devices.

One such hopper washing device is shown in the hopper 43. It has troughs 56 supported on brackets 57 carried by the precipitator casing structure. Leveling screws 58 are threaded in the brackets, bear on the bottoms of the troughs, and are adjusted to level the troughs. The edges of the troughs that run parallel to the sides of the hopper are bent downwardly to provide overflow lips 59. Lying along or close to the bottoms of the troughs 56 are header pipes 60 connected at one end with washing liquid supply pipe 55 and being capped at the other end. The header pipes have spaced holes through which washing liquid is introduced into the troughs.

In operation, the troughs fill with washing liquid which flows over the edges of the troughs, down the lip portions 59 and is spilled upon the sides of the hopper. The liquid flows down the walls of the hopper washing them free from precipitated material that has fallen thereon, and the washings are returned to the tank 47 through the pipe 46.

It is seen that the flushing liquid washes not only the sides of the hopper but also the lips and sides of the troughs. The tops of the troughs present a horizontal free liquid surface. Thus it is evident that substantially all of the surfaces upon which falling precipitated material can impinge are subjected to the action of washing liquid.

If, as in the exemplary case, the precipitated material is soluble in the washing liquid, such liquid becomes more concentrated in solute as washing progresses and the concentration of solute in the tank 47 is also progressively increased. When the concentration of the solution in the tank reaches a desired value, some of the solution is drawn off through the outlet pipe 61 to a pump 62 that forces it through a pipe 63 to the disc evaporator 23, as seen in Fig. 1.

The level of the liquid in the tank 47 is maintained constant by the automatic admission of fresh liquor through the inlet pipe 48. Such admission of liquor is controlled by a liquid level sensitive device 64 in the tank actuating a control motor 65 that operates a valve actuating motor 66 through the usual connection 67 to admit

fresh liquor as required and to stop the influx of fresh liquor when the desired level in the tank is attained.

As best seen in Fig. 2, the hopper discharge header 46 has a downturned leg 68 extending into the pool of liquid in the tank 47 and discharging therein at the open end 69 located substantially beneath the surface of the liquid pool. The precipitator 36 operates at superatmospheric pressures of from a fraction of an inch to a few inches of water and the submerged outlet of the discharge header 46 provides a liquid seal whereby such operating pressure is maintained while permitting outflow of washings from the hoppers.

Other forms of hopper washing devices are shown in the hopper 42 of Fig. 2. One form comprises a horizontal pipe 70 extending over the side of the hopper to be washed. This pipe is connected with a source of washing liquid under pressure through the pipe 71. The horizontal pipe 70 has a plurality of longitudinally spaced holes providing jets directing sprays 72 of washing liquid upwardly a short distance into the air. At least a substantial part of the upwardly projected spray falls back upon the pipe 70 thereby flushing the outside of the pipe as well as the hopper surface.

Another form of flushing device is also shown in the hopper 42 of Fig. 2. This form has a trough 73, similar to the trough 56 described hereinbefore, supported on brackets 74 on the precipitator casing structure. The side wall 75 of the trough that is adjacent the wall of the precipitator or hopper is higher than the side wall 76 that faces the center of the hopper. Liquid fed to the trough from the header 77 thus flows over the top of the wall 76 only. An apron 78 having a hook-shaped upper portion 79 is engaged over the top edge of the trough wall 76 and hangs downwardly substantially into engagement with an inner surface of the hopper 42. This apron extends for substantially the full length of the trough wall 76 and provides a surface down which the washing liquid flows and from which the liquid is distributed to the hopper surface.

From a consideration of Fig. 1, it is seen that sulfate ash recovered in the precipitator 36 is returned to the system in solution in black liquor. This recovered ash is carried to the furnace 31 and again reduced to sulfide form.

It will be understood that the black liquor employed for washing the precipitator hoppers may be drawn not only from the evaporators 12 but also from any other convenient source such as the weak black liquor storage tank 10, from the disc evaporator 23 or from the heavy black liquor storage tank 25. A mixture of black liquors from these sources also may be used as make up liquor for the hopper washing tank 47. Also, black liquor discharged from the washing tank 47 may be conveyed directly to the recovery furnace 31 or to the heavy black liquor storage tank 25 instead of being conducted to the disc evaporator 23.

A somewhat modified form of hopper washing system is shown in Fig. 3. Referring to this figure, the precipitator hopper 80 has walls 81 and 82 that slope at a small angle towards the center where there is located a drain pipe 83 emptying into a mixing tank 84 having an agitator 85. Washing liquid is circulated to spray pipes 86 and 87 that extend along the hopper walls 81 and 82 through the pipe 88, the pump 89 and pipes 90 and 91, the latter being under control of a valve 92. Spray pipes 86 and 87 are provided with spaced holes 93 that direct jets of washing liquid against the sides of the precipitator and down over the hopper surfaces 81 and 82. A branch pipe 94 under control of a valve 95 is used to bleed off fortified liquor. Make up liquor is supplied in equal volume to the mixing tank 84 through a pipe 96.

The washing system shown in Fig. 4 is similar to that shown in Fig. 3. It differs essentially from the system of Fig. 3 in that the liquid level in the mixing tank 97 is automatically maintained at a predetermined level by means of a control system including a level sensing device 98 in the tank controlling a valve 99 in the make up liquid supply pipe 100. The sensing device operates through conventional motors 101 and 102 to admit liquid through valve 99 as needed to restore liquid level in the tank.

In Figs. 5 and 6, still another form of hopper arrangement and washing device is shown. The lower portion of the precipitator 103 is divided into two similar hoppers 104 and 105 by a vertical wall 106. The bottoms 107 of the hoppers have substantially plane surfaces sloping downwardly from one side 108 to the other side 109. At the lower ends of the hopper surfaces 107 are located transverse troughs 110, the bottoms of which slope towards drain pipes 111. At the upper ends of the sloping surfaces 107 there are positioned transverse header pipes 112 having nozzles 113 positioned to direct jets of washing liquid down and over the bottoms of the hoppers. Washing liquid is supplied to the headers through pipes 114.

In the washing system of Figs. 5 and 6, a copious flow of washing liquid is maintained over the surfaces 107 of the hoppers whereby they are maintained in clean condition.

We claim:

1. In an electrical precipitator including a casing, complementary discharge and extended surface dry electrodes in said casing and gas inlet and gas outlet means in said casing directing a stream of gas to be cleaned between said electrodes, a hopper spaced from said electrodes in the bottom of said casing receiving precipitated material removed from said electrodes, and discharge means in said hopper, washing means for said hopper comprising a liquid conduit extending substantially along the top edge of said hopper, said conduit having liquid outlet means positioned to discharge washing liquid against an upper interior surface of said hopper, and means supplying washing liquid to said conduit.

2. In an electrical precipitator including a casing, complementary discharge and extended surface dry electrodes in said casing and gas inlet and gas outlet means in said casing directing a stream of gas to be cleaned between said electrodes, a hopper spaced from said electrodes in the bottom of said casing receiving precipitated material removed from said electrodes, and discharge means in said hopper, washing means for said hopper comprising a liquid conduit extending substantially along the top edge of said hopper, said conduit having liquid outlet means positioned to discharge washing liquid over said conduit and against an upper interior surface of said hopper, and means supplying washing liquid to said conduit.

3. An electrical precipitator as defined in claim 2 wherein said liquid conduit comprises a hori-

zontal trough open at the top and said liquid outlet means is provided by a lip of said trough.

4. An electrical precipitator as defined in claim 3 wherein said trough has lips on opposite sides thereof positioned at the same level.

5. An electrical precipitator as defined in claim 2 wherein said liquid conduit comprises a horizontal trough open at the top thereof and having an overflow lip along one side, and apron means extending from said overflow lip into substantial contact with a wall of said hopper.

6. An electrical precipitator as defined in claim 2 wherein said liquid conduit comprises a pipe and said liquid outlet means comprises spaced holes located in the upper portion of said pipe.

7. An electrical precipitator as defined in claim 1 wherein said hopper has not more than two interior walls having substantial horizontal area components, each of said walls sloping downwardly towards said hopper discharge means,

said liquid conduit comprises a pipe, and said liquid outlet means comprises nozzle means spaced along said conduit.

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