Oct. 21, 1952 H. A. WINTERMUTE 2,614,651

METHOD AND APPARATUS FOR RECOVERING GAS SUSPENDED LIQUID-SOLUBLE MATERIAL

Filed Feb. 7, 1951 3 Sheets-Sheet 1

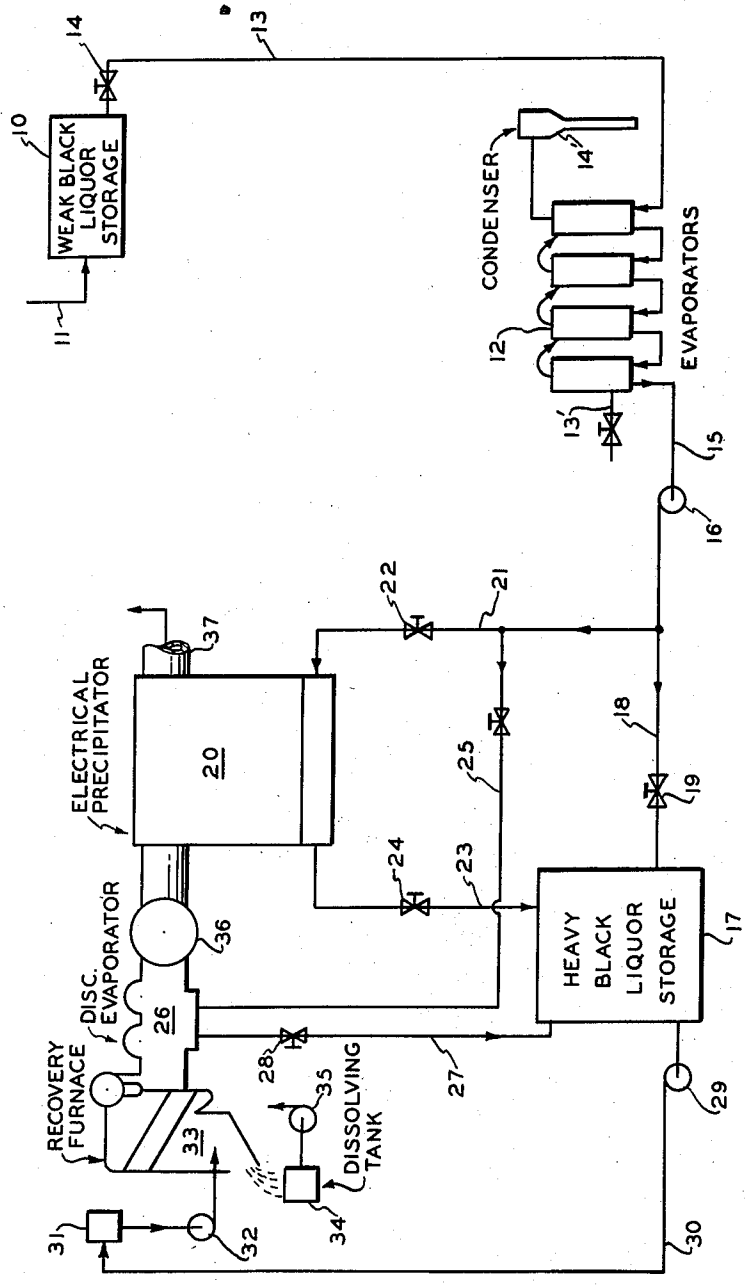


FIG. 1

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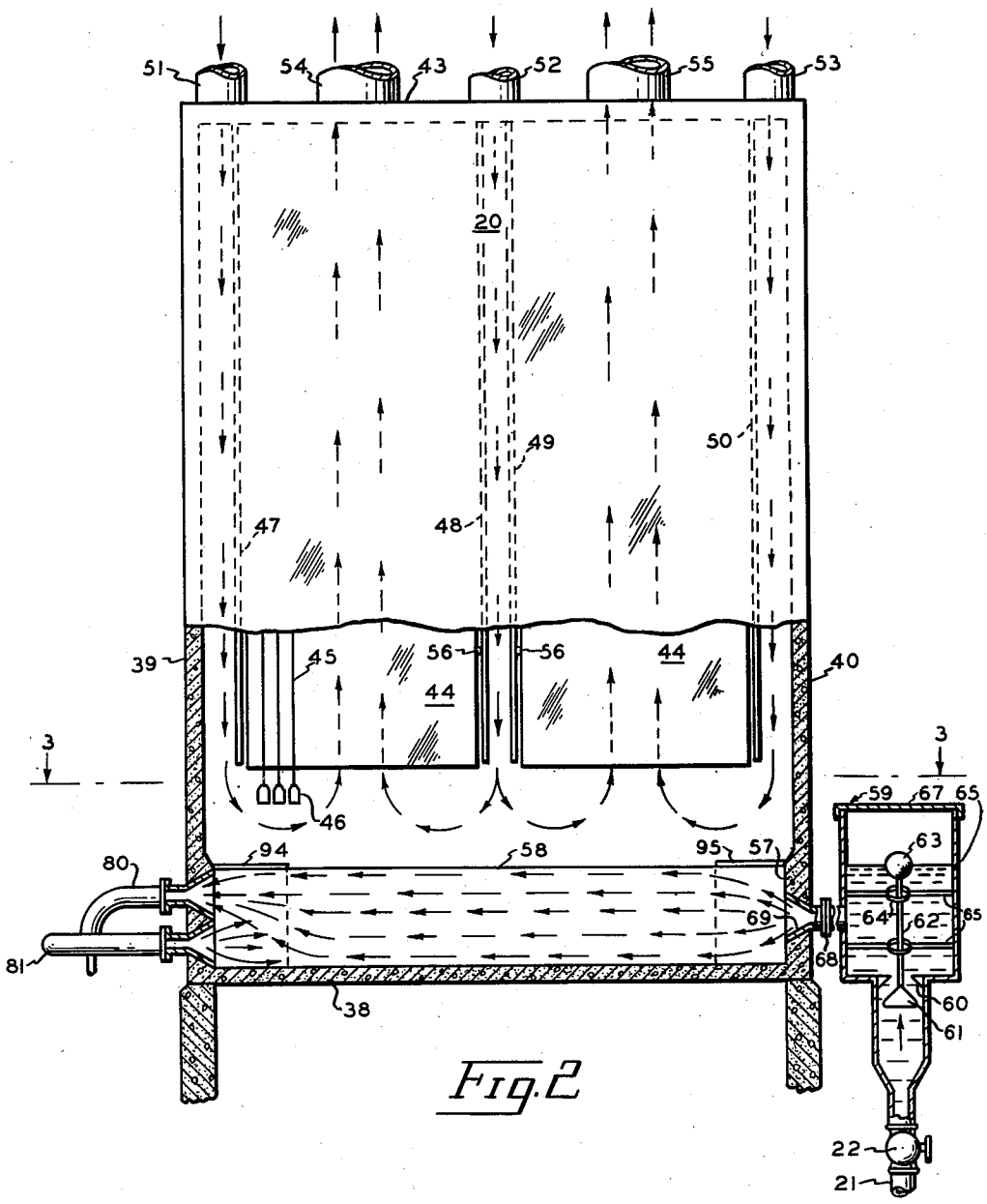


FIG. 2

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Fig. 3

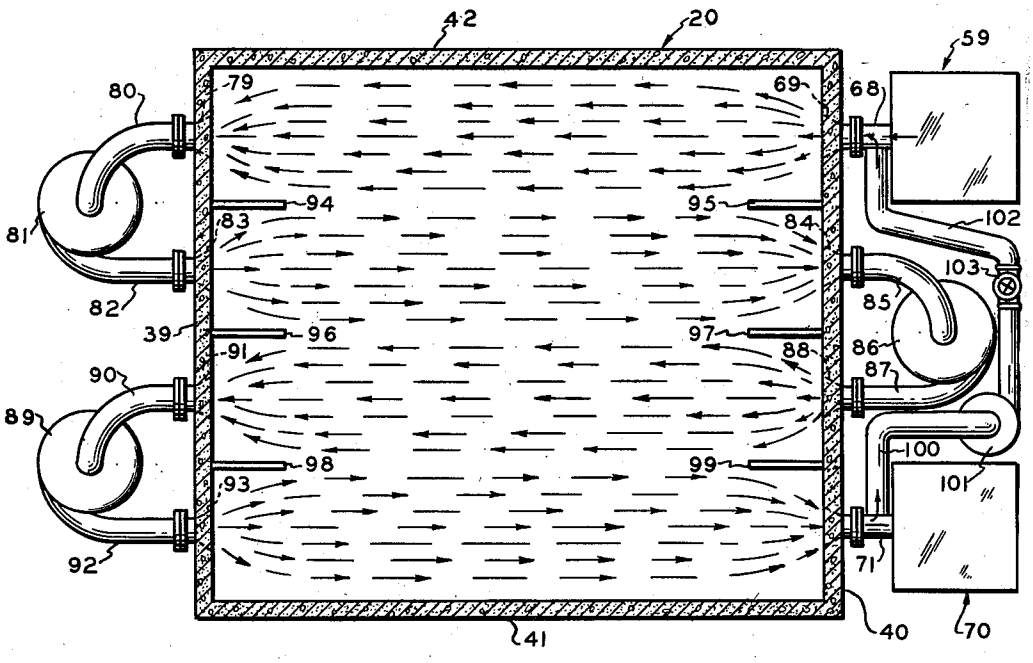
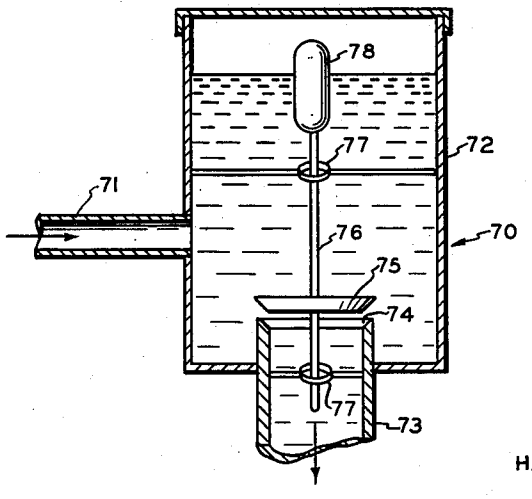


Fig. 4



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2,614,651

METHOD AND APPARATUS FOR RECOVERING GAS SUSPENDED LIQUID-SOLUBLE MATERIAL

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Application February 7, 1951, Serial No. 209,825

5 Claims. (Cl. 183—7)

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This invention relates to a method and apparatus for recovering gas-suspended liquid-soluble material and more particularly to a method and apparatus for recovering sulfate ash from the exhaust gases of a furnace used to recover values from black liquor in the sulfate kraft paper industry.

An object of the invention is to provide a method and apparatus for efficiently and economically collecting liquid-soluble material, especially finely divided material, from a stream of gases bearing the same.

Another object is to provide an improved electrical precipitator that will remove such material from a stream of gases and dissolve it in a liquid solvent without the necessity of employing any internal agitating device.

Another object is to provide an electrical precipitator that is relatively simple to construct, and easy to operate and maintain.

Still another object is to provide apparatus and a method for increasing the efficiency and economy of operation of the sulfate paper process.

In accordance with the invention, a process is provided for recovering liquid-soluble material from a stream of gas in which such material is suspended which includes electrically precipitating the material from the stream of gas upon an extended surface in a precipitating zone. A pool of liquid solvent for the material is established in a dissolving zone subjacent to and in communication with the precipitating zone. At one side of the pool a stream of liquid solvent is introduced into the pool and a stream of solvent is withdrawn from the pool at an opposite side thereof, preferably at a rate substantially equal to the rate of introduction of the solvent, to establish a stream of solvent flowing across the pool. The withdrawn solvent is reintroduced into the pool at a point adjacent to the point of withdrawal and caused to flow back across the pool in a stream flowing parallel and countercurrently to the first stream to a point of withdrawal adjacent to the point of original introduction of the solvent. The electrodes, especially the collecting electrodes, are rapped or otherwise operated upon to dislodge precipitated material therefrom, which material falls into the pool of solvent and is dissolved in the countercurrently flowing streams therein.

The apparatus of the invention includes a casing, means providing a liquid sump in the casing, complementary high tension and collecting electrodes mounted in the casing and disposed above the sump means, gas inlet and gas outlet means

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in the casing directing a stream of gas to be cleaned between the complementary electrodes, means for maintaining in the sump means a pool of liquid solvent for the material of substantially constant depth, means for introducing a stream of liquid solvent for the material into the sump means at one side thereof, means for withdrawing from the sump means at the opposite side thereof a stream of liquid solvent at substantially the same rate as the rate of introduction thereof, means for reintroducing the withdrawn solvent into the sump means at said opposite side thereof at a point adjacent to the point at which the stream of solvent is withdrawn, means for withdrawing a stream of solvent from the sump means at said one side thereof at a point adjacent to the point at which liquid is first introduced into the sump means, whereby to establish in the sump means two adjacent parallel streams of solvent flowing countercurrently to each other, and means for dislodging precipitated material from the collecting electrodes.

The objects set forth hereinbefore, and other objects and advantages as may appear herein, are realized in an exemplary form of the invention as shown in the drawings and described in the following text. In the drawings:

Fig. 1 is a diagrammatic view of a system for recovering valuable materials from black liquor obtained in the sulfate paper making process, which system includes an electrical precipitator in accordance with the invention;

Fig. 2 is an enlarged elevational view of an electrical precipitator as employed in the system of Fig. 1, parts being broken away;

Fig. 3 is a sectional view taken along the line 3—3 of Fig. 2; and

Fig. 4 is a vertical sectional view of a liquid level control device for the precipitator of Figs. 2 and 3.

Referring to the drawings, particularly to Fig. 1, the black liquor recovery system shown has a tank 10 for storage of weak black liquor commonly obtained as filtrate from digested pulp in the sulfate paper process. The weak black liquor is conveyed into the tank 10 through a pipe 11. From the tank 10, weak black liquor is conducted to a multiple effect evaporator 12 through a pipe 13 under control of a valve 14.

The multiple effect evaporator is conventional and, as indicated in the drawing, has four effects; it includes a steam supply line 13' and barometric condenser 14'. In the evaporator, the weak black liquor is concentrated to a certain degree by evaporation of water therefrom and

the thus preliminarily concentrated black liquor issues into the pipe 15 and is impelled by a pump 16 either to a heavy black liquor storage tank 17 through a pipe 18 under control of a valve 19, or to the sump of an electrical precipitator 20 through a pipe 21 as controlled by a valve 22. As will be explained in detail hereinafter, the preliminarily concentrated black liquor is further fortified in the precipitator by dissolution of sulfate ash in the liquor and the fortified liquor flows to the heavy black liquor storage tank 17 through a pipe 23 having a control valve 24.

Through a branch line 25 a regulated portion of the black liquor from the evaporator 12 may be passed through a conventional disc evaporator 26, or other waste heat evaporating device, in which this portion of liquor is concentrated to a further extent by evaporation of water. The thus concentrated liquor flows to the heavy black liquor storage tank 17 through a pipe 27 controlled by a valve 28.

It will be understood that the concentrating and/or fortifying operations are so conducted that the heavy black liquor in the storage tank 17 has a concentration sufficiently high to provide a combustible liquor.

This heavy black liquor is forced from the storage tank 17 by a pump 29 through a pipe 30 to a furnace charging tank 31 from which it is fed to a furnace charger 32 that injects the liquor into the recovery furnace 33.

The liquor is burned in the furnace, the lignin and other organic components of the liquor furnishing the necessary combustible material. The sodium sulfate fraction of the liquor is reduced to sodium sulfide and such sulfide, together with the sodium carbonate content of the liquor, is converted to a dry ash. This ash is discharged from the furnace into a dissolving tank 34 in which it is dissolved in water to provide a solution that is impelled by a pump 35 to a point at which the liquor is refined for reuse in the digestion of more wood chips.

The exhaust gases from the recovery furnace are hot and contain considerable moisture and some sulfate ash in suspension. This ash consists chiefly of sodium sulfate and sodium carbonate in finely divided form and is known as sulfate ash.

The exhaust gases are passed through the disc evaporator 26, in which some of the heat of the gases is utilized to concentrate a portion of the black liquor as explained hereinbefore. The gases are next blown by a fan 36 into and through the electrical precipitator 20 in which they are largely relieved of their burden of sulfate ash. Cleaned gases are exhausted from the precipitator through a duct 37.

Turning to Figs. 2 and 3 of the drawings, showing the electrical precipitator 20 in enlarged detail, this precipitator has a casing including a bottom 38, side walls 39, 40, 41 and 42, and a top 43. As shown by way of illustration, the precipitator is of the vertical gas flow type. Suspended from the upper part of the precipitator are vertically extending parallel plates 44 that function as collecting electrodes and provide ducts therebetween for the passage of gas. In the ducts between the plates are suspended parallel curtains of discharge wire electrodes 45 tensioned by weights 46 attached to the bottoms of the wires. It will be understood that in operation a high electrical potential is applied between the discharge and collecting electrodes to provide ionizing and precipitating conditions in the precipitating zone occupied by the assembly of electrodes. When gas bearing suspended particulate material is caused to flow between the electrodes, the suspended particles are charged and attracted to and deposited upon the plates 44.

The precipitator is divided into two parallel gas treating sections. The left-hand section is included between the partitions 47 and 48 and the right-hand section is included between the partitions 49 and 50. Gas inlet passages are provided between side wall 39 and partition 47, between partitions 48 and 49, and between partition 50 and side wall 40. Gas inlet pipes 51, 52 and 53 communicate with the tops of the inlet passages and gas outlet pipes 54 and 55 communicate respectively with the left-hand and right-hand gas treating sections, as clearly shown in Fig. 2.

Rapper bars 56 operatively engage the collecting plates 44 and the bars are vibrated to shake the plates for the purpose of dislodging precipitated material therefrom.

In the bottom of the precipitator there is provided a sump 57 in which is maintained a pool 58 of liquid solvent. Solvent is admitted to the pool from the pressure pipe 21 through a level control device designated by the general reference numeral 59. This device has an inlet valve including a valve seat 60 and cooperating valve 61. The valve has a stem 62 supported by a float 63. The stem is substantially restricted to vertical movement by the ring guides 64 carried by brackets 65 affixed to the casing 66 of the device. The casing has a top 67 that preferably is sealed to the casing sidewalls and the interior of the casing communicates with the precipitator sump 57 through a pipe 68 that has an outwardly flaring nozzle 69.

In operation, as the level of the pool 58 of liquid in the sump falls, the level of liquid in the control device 59 also falls. This action causes the float 63 to descend and opens the valve 61 to increase the rate of flow of solvent into the pool and thus to restore the level of the liquid. Conversely, if the level of the pool rises, the valve 61 closes thus reducing the flow of liquid into the pool and tending to lower the surface of the liquid to its desired level.

Solvent is discharged from the precipitator sump through another level control device designated by the general reference numeral 70. This device is indicated in Fig. 3 and shown in detail in Fig. 4. The device has a pipe 71 receiving solvent from the precipitator sump and a casing 72 having an outlet pipe section 73 at the bottom. This pipe section discharges into the line 23 of Fig. 1. The pipe 73 provides a valve seat 74 and a valve 75 cooperates therewith. The valve has a stem 76 constrained to vertical motion by guide rings 77 and a float 78 supports the valve stem.

It will be readily seen that a lowering of the liquid level in the sump 57 moves the outlet valve towards closed position allowing the liquid level to rise to its desired point while a raising of the liquid level opens the valve and permits the liquid level to descend to normal.

The liquid level control devices 59 and 70 may be used conjointly as shown and described or they may be used independently of one another to control the level of liquid in the precipitator sump.

Directly across the sump 57 from the solvent inlet 69 is a solvent outlet 79 that communicates through a pipe 80 with the suction side of a pump

81. The pressure side of the pump is returned through a pipe 82 to a nozzle 83 positioned to direct liquid back into the sump at a point in the casing wall 39 that is spaced somewhat from the outlet 79.

A similar recirculating device is positioned opposite the pump 81. It includes an offtake nozzle 84 aligned with the nozze 83, the former communicating through a pipe 85 with the suction side of a pump 86 that discharges through a pipe 87 to a return nozzle 88.

Further recirculation is provided by another pump 89 having an intake 90 communicating with the sump through a pipe terminating in an intake nozzle 91 aligned with the opposed nozzle 88. Pump 89 returns liquid to the sump through a pipe 92 terminating in a nozzle 93 positioned opposite the final discharge pipe 71.

As best seen in Fig. 3, solvent is admitted to the sump through the inlet 69, flows across the sump as indicated by the arrows and is drawn into the pump 81 through the outlet 79. A cross-flowing stream of solvent is thus established in the sump. Liquid withdrawn by the pump 81 is reintroduced into the sump through the inlet 83 and this reintroduced liquid flows across the sump to the outlet 84 in the form of a second stream flowing parallel, adjacent and countercurrently to the first stream. A third stream is established between the inlet 88 and outlet 91 which stream flows countercurrently to the second stream. Similarly, a fourth countercurrent stream is established between the inlet 93 and the final outlet pipe 71.

The pumps 81, 86 and 89 preferably are operated to provide identical rates of flow of liquid therethrough.

Aligned vertical baffles 94 and 95 project outwardly for a short distance from the walls 39 and 40 into the sump 57. These baffles together with the rear wall 42 assist in directing the first stream of liquid to flow rectilinearly across the sump. These baffles cooperating with the spaced baffles 96 and 97 similarly give direction to the second adjacent cross-flowing stream. Other baffles 98 and 99 and the front wall 41 assist in maintaining rectilinearity of flow of the third and fourth streams.

Overall recirculation of a part or all of the solvent may be effected through a branch pipe 100 receiving liquid from the outlet pipe 71 and forcing it by means of a pump 101 through the pipe 102 to the inlet pipe 68. The proportion of solvent that is recirculated is regulated by a valve 103 in the pipe 102. By employing overall recirculation, the velocity of the cross-flowing streams of liquid in the sump may be maintained even though the throughput from the inlet level control device 59 to the outlet level control device 70 is reduced.

The velocity of the counter-flowing streams in the sump preferably is maintained high enough to provide a certain amount of turbulence, especially in the zones between adjacent streams. Such turbulence facilitates dissolution of soluble material that enters the pool 58.

Operation of the precipitator will be described by way of example in connection with its use in a black liquor recovery system such as is shown in Fig. 1. Hot gases from the recovery furnace 33 are passed through the precipitator. The complementary discharge and collecting electrodes are energized and sulfate ash borne by the gases is precipitated on the collecting plates. Precipitated material is dislodged from the plates

and falls into the cross-flowing streams of black liquor in the sump 57. The sulfate ash dissolves in the liquor to fortify the same, and the fortified liquor that is discharged from the sump is conducted to the heavy black liquor storage tank 17. It will be observed that in the particular type of precipitator shown the incoming hot gases sweep over the surface of the pool 58 of liquor thereby effecting some evaporation of water from the solution and thus further concentrating the solution.

From the foregoing description, a variety of modifications that does not depart from the invention will readily occur to those skilled in the art. For example, horizontal gas flow precipitators may be employed to advantage with means providing alternate, countercurrent streams in a sump beneath the electrodes. Substantially vertically extending tubular collecting electrodes may also be used.

I claim:

1. A process for recovering liquid-soluble material suspended in a stream of gas which comprises electrically precipitating said material from a stream of such gas upon an extended surface in a precipitating zone, establishing a pool of liquid solvent for said material in a dissolving zone subjacent to and in communication with said precipitating zone, introducing a stream of solvent into said pool at one side thereof and withdrawing a stream of solvent from said pool at an opposite side thereof to establish a cross-flowing first stream of solvent in said pool, reintroducing said withdrawn solvent as a stream into said pool of solvent at said opposite side thereof at a point adjacent to the point at which said first stream is withdrawn from said pool, withdrawing a stream of solvent from said pool at said one side thereof at a point adjacent to the point at which said stream of solvent is first introduced into said pool to establish a second stream of solvent in said pool flowing adjacent to, parallel with and countercurrently to said first stream of solvent, and transferring precipitated material from said precipitating zone to said dissolving zone wherein it is dissolved in said counterflowing streams of solvent.

2. A process for recovering sulfate ash suspended in a stream of exhaust gases from a sulfate pulp process recovery furnace which comprises electrically precipitating said sulfate ash from a stream of such exhaust gases upon an extended surface in a precipitating zone, establishing a pool of black liquor in a dissolving zone subjacent to and in communication with said precipitating zone, introducing a stream of black liquor into said pool at one side thereof and withdrawing at substantially the same rate a stream of black liquor from said pool at an opposite side thereof to establish a cross-flowing first stream in said pool, reintroducing said withdrawn black liquor as a stream into said pool of black liquor at said opposite side thereof at a point adjacent to the point at which said first stream is withdrawn from said pool, withdrawing a stream of black liquor from said pool at said one side thereof at a point adjacent to the point at which said stream of black liquor is first introduced into said pool to establish a second stream of black liquor in said pool flowing adjacent to, parallel with and countercurrently to said first stream of black liquor, and transferring precipitated sulfate ash from said precipitating zone to said dissolving zone wherein it is dissolved in said counter-flowing streams of black liquor.

3. A process as defined in claim 2 wherein said extended surface is vibrated to remove precipitated sulfate ash therefrom and the ash transferred from said precipitating zone to said dissolving zone drops into said pool of black liquor by gravity.

4. Apparatus for recovering liquid-soluble material suspended in a stream of gas which comprises a casing, means providing a liquid sump in said casing, complementary high tension and collecting electrodes mounted in said casing and disposed above said sump means, gas inlet and gas outlet means in said casing directing a stream of gas to be cleaned between said complementary electrodes, means for maintaining in said sump means a pool of liquid solvent for said material of substantially constant depth, means for introducing a stream of liquid solvent for said material into said sump means at one side thereof, means for withdrawing from said sump means at the opposite side thereof a stream of liquid solvent at substantially the same rate as the rate of introduction thereof, means for reintroducing the withdrawn solvent into said sump means at said opposite side thereof at a point adjacent to the point at which said stream of solvent is withdrawn, means for withdrawing a stream of solvent from said sump means at said one side thereof at a point adjacent to the point at which liquid is first introduced into said sump means, whereby to establish in said sump means two adjacent parallel streams of solvent flowing countercurrently to each other, and means for dislodging precipitated material from said collecting electrodes.

5. Apparatus for recovering liquid-soluble material suspended in a stream of gas which comprises a casing, means providing a liquid sump

in said casing, complementary high tension and collecting electrode mounted in said casing and disposed above said sump means, gas inlet and gas outlet means in said casing directing a stream of gas to be cleaned between said complementary electrodes, means for maintaining in said sump means a pool of liquid solvent for said material of substantially constant depth, means for introducing a stream of liquid solvent for said material into said sump means at one side thereof, a pump having a liquid intake means communicating with said sump means at the opposite side thereof and liquid output means communicating with said sump means at said opposite side thereof and adjacent to the point at which said liquid intake means communicates with said sump means, means for withdrawing a stream of solvent from said sump means at said one side thereof at a point adjacent to the point at which liquid is first introduced into said sump means, whereby to establish in said sump means two adjacent parallel streams of solvent flowing countercurrently to each other, and means for dislodging precipitated material from said collecting electrodes.

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