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(54) CONTINUOUS DEHYDRATION APPARATUS FOR TREATMENT OF SLUDGE /

(71) I, TORU SEKI, a Japanese Citizen of 558 Kami-Kizaki, Urawa-shi, Saitama-ken, Japan, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an apparatus for separating sludge concentrates with the use of fine dust coal or lignite. More specifically, the invention relates to apparatus for separating sludge solids in the highly concentrated state by employing fine dust coal or lignite having a specific size distribution.

In general, solid contents of sludges, which may be concentrated, discharged from the process of the aerobic activated sludge treatment of sewage and waste water are about 4,000 to 13,000 ppm. For the treatment of such excessive sludges or concentrated sludges, various methods have been proposed. For instance, there has been proposed a method comprising incorporating into such sludge 5 to 30% by weight of a iron-compound coagulant such as iron chloride or iron sulfate and 5 to 30% by weight of a neutralizing agent such as lime, dehydrating the admixture by employing a dehydrating apparatus and recovering the solids in the form of a cake. Incorporation of a carbonaceous substance such as naphtha carbon in conducting the above method has also been proposed as means for imparting the combustibility to the recovered cake.

However, in such a conventional method employing a coagulant which has heretofore been used for cleaning city water, it is difficult to separate solids of the sludge from water, because solids of the sludge are present in the form of a very stable sol well-admixed with water which acts as a dispersion medium. More specifically, in the above conventional method, when the sludge is incorporated with the above chemicals and the admixture is allowed to stand still, it takes a very long time for solids of the sludge to coagulate and sediment, and since the

phase separation between the sludge solids and the supernatant liquor proceeds under such conditions that the solids contain a great quantity of water therein, attainment of effective separation cannot be expected. Furthermore, in this conventional method, even when the coagulated sediments are subjected to a dehydration treatment such as filtration, the water content is still as high as 83—92% by weight; therefore, the drying treatment of the recovered solids is not easy in many cases.

In the concentration and separation of sludges, it is desired that the following two conditions are satisfied; one being that when an admixture of a sludge and a coagulant is allowed to stand still, the resulting sediment of the coagulated sludge solids is recovered in a short period of time in the form of a non-bulky compact mass while the supernatant liquor is so cleaned that it can be discharged directly without any further cleaning treatment; and the other being that the dehydration of the coagulated sediment can be accomplished very easily with cakes of a very low water content being obtained. It is also desired that the cost of the coagulant is low.

It has now been found that in the treatment of sludges, when fine dust coal or lignite having such a specific size distribution that it comprises predetermined proportions of particles of specific finer and coarser sizes is used as a coagulant, the coagulation and sedimentation of the sludge solids can be accomplished very promptly while keeping the solids in the very highly concentrated state, and that the resulting coal-containing sludge concentrate has characteristics facilitating filtration such that its water content can readily be reduced to 42 to 60% by weight.

In this specification of my copending Application No. 6744/74 (Serial No. 1,380,592) there is described and claimed a process for concentrating and separating solids of sludge obtained from the treatment of sewage

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⑥ which comprises incorporating into such sludge 2 to 10% by weight of fine dust coal or lignite having such a size distribution that 30 to 50% by weight of the whole particles have a size not greater than 100 mesh Tyler) and 70 to 50% by weight of the whole particles have a size exceeding 100 mesh, mixing them under agitation, allowing the resulting admixture to stand still to separate the coal-containing concentrated sludge from the supernatant liquor, and if desired, filtering the coal-containing concentrated sludge to remove water therefrom.

I have found that in filtering and dehydrating the above-mentioned coal-containing concentrated sludge by feeding it onto the surface of a filter cloth, it is possible to accomplish filtration and dehydration of the coal-containing concentrated sludge with very high efficiency regardless of variation of properties of the starting sludges.

In accordance with this invention, there is provided apparatus for the continuous dehydration of sludges, which comprises a liquid reservoir for receiving an admixture of fine dust coal and a sludge, a filtering zone connected with the liquid reservoir, in which vacuum suction filtration is to be effected, and an endless filter cloth with means for continuously forwarding it to the liquid reservoir and the filtering zone, the liquid reservoir being provided with a bottom portion inclined to the horizontal and extending to the surface level of the reservoir at least at the portion thereof where the liquid reservoir is connected to the filtering zone; the filtering zone being constructed of a vacuum chamber provided with roll bars at the upper portion thereof; the endless filter cloth being so disposed that it is at first introduced into the deepest portion of the liquid reservoir while being kept in contact with the bottom portion along a length sufficient for a precoat layer to lie on the surface thereof during use of the apparatus, and is then introduced on the roll bars of the filtering zone; and said liquid reservoir being connected pivotably with the filtering zone, means being provided for adjusting the inclination to the horizontal of the bottom of the liquid reservoir.

The apparatus may be used when treating various sludges, for instance, sludges discharged from the treatment of various waste waters e.g. city sewage water, excrement, waste water from livestock farms, waste water from marine product factories, waste water from butcheries, waste water from dye works, waste water from chemical-manufacturing factories and waste water from other ordinary factories or works. In general, sludges discharged from the treatment of such waste waters contain water at a content of 90 to 99% by weight, the remainder being composed of ashes and combustible com-

ponents (which will be referred to inclusively as "solids" hereinbelow). As mentioned above, these solids are present in the form of a very stable sol well-admixed with water acting as a dispersion medium. It is possible to separate effectively and promptly solids present in the state stably dispersed in the sludge. Solids can be effectively separated also from a secondary sludge concentrate (having a water content of 90 to 95%) formed by concentrating the sludge by a conventional method such as mentioned above and then using the process of my above-mentioned copending Patent Application.

The invention will be further described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a graph illustrating the size distribution (referring to Tyler standard mesh) in the size-adjusted fine dust coal (1) to be used in the process of copending Application No. 6744/74 (Serial No. 1,380,592) and comparative fine dust coals (2) and (3);

Fig. 2 is a graph illustrating the relation between the height of the sedimented solids and the sedimentation period, attained when a sludge is treated with above fine dust coals (1), (2) and (3) shown in Fig. 1; and

Figs. 3-A and 3-B are side views illustrating the arrangement of the apparatus of this invention.

In Fig. 1 there are shown size distribution curves of the size-adjusted fine dust coal (1) to be used in the process of the above mentioned copending Application and fine dust coals (2) and (3) in which the size distribution requirement of this process is not satisfied. As is seen from the curve (1), the size-adjusted fine dust coal to be used is characterized in that two peaks corresponding with finer and coarser particles, respectively, appear in its size distribution curve.

In Fig. 2 there are illustrated results obtained when the above fine dust coals (1), (2) and (3) are separately added to an excessive sludge having a solid content of 9500 ppm in an amount of 5% by weight and the sludge is allowed to stand still in a precipitation tank having a liquid surface height of 1050 cm. The curve C-1 of Fig. 2 illustrates the result obtained when the coal-free starting sludge is allowed to stand still. In this case, sludge solids are not effectively coagulated or precipitated. As is seen from curves (2) and (3) of Figure 2, when non-size-adjusted fine dust coals (2) and (3) are incorporated into the sludge, the solids are concentrated only to such a degree that the volume of the sedimented solids is about $\frac{1}{2}$ of the volume of the starting sludge. In contrast, in the case of the size-adjusted fine dust coal (1) comprising finer particles and coarser particles at a specific ratio, as is seen from the curve (1) of Fig. 2, the sludge solids are coagulated, sedimented and con-

centrated in a short time so effectively that the volume of the solids is less than $\frac{1}{3}$ of the volume of the starting sludge.

In Fig. 2, the Curve C-2 illustrates the result obtained when as a comparative finely divided carbon, naphtha carbon formed as a by-product in the petrochemical industry (having an average particle size of 40μ at a content of 80%) is incorporated in the sludge in an amount of 5% by weight. If the coagulation and sedimentation of solids in the sludge be influenced merely by the surface area of a carbonaceous substance used as the coagulant, it may be expected that the above naphtha carbon will be able to coagulate and sediment the sludge solids more promptly at a higher concentration. However, contrary to the above expectation, only in the case of the size-adjusted fine dust coal comprising specific proportions of finer particles and coarser particles can prompt coagulation and sedimentation of sludge solids at a high concentration be attained.

In practising the process, a fine dust coal or lignite having a size distribution adjusted as mentioned above is incorporated in an excessive or partially concentrated sludge in an amount of 2 to 10% by weight, preferably 2 to 7% by weight, especially preferably 3 to 5% by weight, based on the sludge, and the admixture is agitated sufficiently to bring about a homogeneous, well-compounded state between the coal and sludge. Then, the admixture is introduced into a concentration or separation tank, and it is allowed to stand still for between 20 minutes and 2 hours, preferably between 40 minutes and 50 minutes. Thus, substantial portions of the solids contained in the sludge are separated from the supernatant liquor, and are sedimented and deposited as coal-containing concentrated sludge.

Thus, the starting sludge is separated into two phases, one of the supernatant liquor and the other of the coal-containing concentrated sludge. The supernatant liquor is taken out from the top, or the coal-containing concentrated sludge is withdrawn from the bottom. The so-separated coal-containing concentrated sludge may now be subjected to a filtration treatment to remove water therefrom.

Suitably this filtering step can be practised by employing the apparatus of Figs. 3-A and 3-B for the continuous dehydration of sludges.

In Figs. 3-A and 3-B illustrating the arrangement of the apparatus of this invention, a liquid reservoir indicated as whole by symbol "A" and a filtering zone indicated as a whole by symbol "B" are disposed in the longitudinal direction of the apparatus. An endless filter cloth C (shown by the chain dotted line in the drawings) is disposed so that it is continuously forwarded to liquid

reservoir A and filtering zone B where vacuum suction filtration is effected.

The liquid reservoir A is provided with a bottom 2 disposed so that it is inclined to the liquid surface of the coal-containing concentrated sludge (which will be referred to merely as "coal-containing sludge" hereinafter) fed to the liquid reservoir A and it crosses the liquid surface 1 at least at the portion connecting the liquid reservoir A with the filtering zone B. On the deepest side of the inclined bottom 2 there is provided a weir or barrier 3 for overflowing excess of the input coal-containing sludge, and a pond 5 of the coal-containing sludge is retained by the bottom 2, the overflowing dike barrier 3 and both side planks 4. An overflow-receiving box 8 is provided beyond of the deepest side of the pond 5 to receive the excess sludge which overflows the barrier 3. A pipe 9 is mounted on the overflow-receiving box 8 to take out the overflow sludge. Above the deepest side of the pond 5 of the coal-containing sludge is mounted a feed box 12 provided with a feed pipe 10 and a discharge opening 11. Between the feed pipe 10 and discharge opening 11 of the feed box 12 a plurality of downwardly inclined guide flaps 13 extend alternately in opposite directions for providing a long flow passage to the stream of the coal-containing sludge while inhibiting occurrence of turbulence in the sludge stream. An overflow-discharge pipe 14 is mounted at the upper portion of the feed box 12 to provide for the overflow of excess coal-containing sludge and discharge it from the feed box 12. The lower end of this overflow-discharge pipe 14 opens into the overflow-receiving box 8.

It is preferred that a box 15 for filtrate water is provided below the lower side of the bottom 2 of the liquid reservoir A. In this case, filtering holes 16 are provided throughout the bottom 2 or at least at that portion of the bottom 2 where the liquid depth in the pond 5 is small. Thus, filtrate water passes through the filter cloth C and the holes 16 into the box 15. A pipe 17 is provided for discharging filtrate water from the filtrate water box 15. The inside of the filtrate water box 15 may be maintained under atmospheric pressure or under slightly reduced pressure.

In the apparatus, a filtering zone B where vacuum suction filtration is effected is provided subsequently to the liquid reservoir A. The filtering zone B is constructed of a vacuum chamber 18 provided with a plurality of roll bars at the upper portion thereof. Roll bars 19 are rotatably supported on a machine frame and they are disposed so that filtrate water can pass into the vacuum chamber 18 through clearances between adjacent roll bars 19. It is preferred that each roll bar 19 comprises a plurality of ridges

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disposed spacedly from each other, so that filtrate water is effectively forwarded through clearances formed between adjoining ridges. Below the vacuum chamber 18, a liquid discharge pipe 20 is mounted to discharge filtrate water stored in the vacuum chamber.

In a preferable embodiment of the apparatus of this invention, a plurality of vacuum chambers 18, 18¹, 18¹¹ . . . , especially two or three vacuum chambers, are provided in the longitudinal direction of the apparatus, and the degree of vacuum is heightened along the direction of the advance of the filter cloth. For instance, the dehydration efficiency can be heightened by maintaining the negative pressure (difference of the reduced pressure from atmospheric pressure) at 80—100 mm Hg (absolute) in the first vacuum chamber 18, 120—200 mm Hg (absolute) in the second vacuum chamber 18¹ and 250—400 mm Hg (absolute) in the third vacuum chamber 18¹¹. Further, a negative pressure of up to 600 mm Hg may be provided in a final filter drum 34¹.

During use of the apparatus the endless filter cloth C is continuously forwarded to the liquid reservoir A having the inclined bottom 2, the cloth crossing from the liquid surface in the reservoir to the filtering zone B. The endless filter cloth C is so disposed that it is first introduced to the bottom 2 of the liquid reservoir A while being kept in contact with the bottom 2 along a length sufficient to form a precoat layer of coarser particles of the size-adjusted fine dust coal or lignite on the surface of the endless filter cloth. The filter cloth is then taken out of the liquid reservoir A and introduced on the roll bars 19 of the filtering zone B. The liquid reservoir A is pivotably connected at 33 with one end of the filtering zone B to permit adjusting of the slope of the bottom 2 of the liquid reservoir A. When the apparatus of such structure is employed, it is made possible to form in advance a precoat layer of coarser particules contained in the coal-containing sludge on the filter cloth and to deposit on the precoat layer agglomerates of finer particles and the sludge solids coagulated thereon, regardless of any variation in properties of the sludge, by appropriately adjusting the slope of the filter cloth, the liquid depth in the liquid reservoir, the length of the pond of the stored sludge and/or the storing capacity of the liquid reservoir.

The filtering zone B for vacuum suction filtration is fixed almost horizontally in the longitudinal direction of the apparatus by means of supporting stanchions 21 and 22. That end of the liquid reservoir A where the liquid has the shallowest depth is connected with one end of the filtering zone B by means of the pivot or hinge 23. The other end of the liquid reservoir A where the liquid

depth is greatest is attached to a liquid reservoir-supporting stanchion 24, and this stanchion 24 is supported by an extendable supporting stanchion 26 through a supporting hinge 25. A curved guide stay 27 is mounted on sides 4 or on the filtrate water box 15. At the end portion of the angle-changing guide stay 27, a plurality of adjusting holes 28 are provided to adjust the slope of the bottom 2 of the liquid reservoir A. To the stanchion 21 is fixed an adjusting plate 29 provided with holes 28¹ corresponding with adjusting holes 28 of the angle-changing guide stay 27.

The adjustment of the elevation angle of the bottom 2 of the liquid reservoir A can be easily accomplished by moving vertically the extendable supporting stanchion 26 so that the bottom 2 has a desired slope, fixing the stanchion 26 at this position, and inserting angle-adjusting bolts 30 into adjusting holes 28 of the angle-changing guide stay 27 and corresponding holes 28¹ of the adjusting plate 29 fixed to the supporting stanchion 21, thereby to fix them. Of course, simultaneously with the adjustment of the elevation angle of the bottom 2, adjustment of the depth of the pond 5 for the coal-containing sludge and the horizontal storage length may be accomplished. In general, it is preferred that the inclination of the bottom 2 of the liquid reservoir A may be adjusted within a range of 0° to 20° to the horizontal.

In order to forward the filter cloth C along the bottom of the liquid reservoir A for a distance sufficient for a precoat layer of coarser particles of the fine dust coal or lignite to be formed on the filter cloth C, a roll bar 31 is provided at the deepest portion of the pond 5 for the coal-containing sludge, the filter cloth C passing around this roll bar 31. The endless filter cloth C is introduced into the bottom of the pond 5 by means of this pressing roll bar 31, and advances along the bottom 2 of the liquid reservoir A toward the shallower portion. During this passage, water is spontaneously removed through the holes 16 in the bottom 2. The filter cloth leaves the liquid surface and is forwarded on the roll bars 19 of the filtering zone B. The pressing roll bar 31 is attached rotatably to the apparatus frame, and a sprocket or pulley 32 may be mounted on the shaft of the roll bar 31 for positively rotating it by means of a suitable power-transmitting mechanism (not shown). It is also possible to dispose the pressing roll bar 31 in a lower position so that the periphery of the pressing roll bar 31 extends below the line of the bottom 2, whereby a closer contact between the bottom 2 and filter cloth C can be made. A rubber seal 33 may be provided on the hinge 23 in order to maintain the liquid-tight state at the connection between the liquid reservoir A and the filter-

ing zone B. For adjustment of the thickness of the layer of the coal-containing sludge on the filter cloth, it is possible to mount a slit controller or doctor blade 34 at the point where the filter cloth C is taken up from the liquid surface of the coal-containing sludge. Thus, the thickness of the coal-containing sludge on the filter cloth may be adjusted as required.

In order to pull the filter cloth C forward on roll bars 19 of the filtering zone B for vacuum suction filtration, it is preferred that a drive drum 34¹ (see Fig. 3-B) be provided on the forward side of the filtering zone B. As the drive drum 34¹ there may be employed either an ordinary drum having a smooth surface or a drum filter installed with a vacuum suction filtering device herein. A discharge chute 35 is provided in the position neighbouring the side or bottom of the drum 34¹ to collect filter cakes. Filter cakes on the filter cloth C are exfoliated therefrom by means of a suitable scraper (not shown) and then collected in the discharge chute 35. In the embodiment illustrated in Fig. 3-B, in order to exfoliate filter cakes from the filter cloth effectively, the filter cloth C coming from the drum 34¹ is introduced to an auxiliary roll 34¹¹, and during this passage exfoliation of filter cakes from the filter cloth C is accomplished completely.

In order to impart a constant tension to the filter cloth C forwarded to the pressing roll bar 31 even when the elevation angle of the bottom 2 of the liquid reservoir A is changed, an arm 36 is attached to the end point of the liquid reservoir-supporting stanchion 24, a suspension rod 37 is attached to this arm 36 so that it may move vertically, and a feed roll 39 is mounted rotatably on the end point of this suspension rod 37. It is desired that a worm screwed outwardly from the centre is mounted on the feed roll 39 so that an extension force is given in the width direction of the filter cloth C. Thus, the filter cloth C is forwarded along the bottom 2 from the pressing roll bar 31 mounted at the deeper portion of the pond 5 while being maintained under a constant tension by means of the feed roll 39. Then, the filter cloth C passes over the roll bars 19 of the filtering zone B and is advanced toward the drive drum 34¹ at the discharge side of the filtering zone. Then, the filter cloth C passes to the discharge chute 35 where filter cakes are exfoliated from the filter cloth C. A water-washing tank 40 installed with a washing roll 41 is provided to wash the filter cloth C from which filter cakes have been exfoliated. The filter cloth C coming from the auxiliary roll 34¹¹ is introduced into the washing roll 41 in the water-washing tank 40 through a tension roll 42 and a guide roll 43, and then, it is forwarded again to the feed roll 39

via a guide roll 43¹, and guide rolls 44, 44¹, 44¹¹...

In the application of the apparatus of this invention to the filtration and dehydration of coal-containing sludges, a fine coal dust (fine dust coal of low grade or powdery lignite) in which finer particles having a size ranging from 100 Tyler standard mesh to 325 mesh comprise 30 to 50% by weight, preferably 40 to 50% by weight of the total weight of the particles and the remaining particles have a size exceeding 100 mesh, is incorporated in overflow sludge or concentrated sludge discharged from a plant for treatment of waste waters in an amount of 2 to 10% by weight, preferably 3 to 5% by weight, based on the fine coal dust, and the admixture is allowed to stand still for between 30 minutes and two hours to effect coagulation and sedimentation of sludge solids, whereby the supernatant liquor is separated from the coal-containing concentrated sludge at a volume ratio of about 7:3. The coal-containing concentrated sludge is fed to the feed box 12 through the feed pipe 10, and it is fed to the deepest portion of the pond 5 through the discharge opening 11 of the feed box 12. The coagulation state of the fine coal dust and sludge solids is partially destroyed during the pipe transportation and the sludge undergoes a turbulent action. However, this turbulent state is partially relaxed in the feed box 12 and the sludge solids settled in the pond 5, whereby re-coagulation and sedimentation of finer particles of the fine coal dust and the sludge solids can be accomplished. At first coarser particles of the fine coal dust are deposited on the filter cloth C moving upwardly along the inclined bottom 2 of the pond 5 to form a precoat layer, and then, coagulates composed of finer particles and sludge solids or coagulates of sludge solids alone are sedimented and deposited on the precoat layer. At this time, the filter cloth C is pressed against the bottom 2 by means of the pressing roll bar 31 and weight of the coal-containing sludge stored in the pond 5 is imposed on the filter cloth C. Therefore, in general, no vertical wavy movement of the filter cloth C is observed. Part of the water is removed in the pond 5 by passing through the precoat layer, the filter cloth C and the filtering holes 16 into the filtrate water box 15 from which it is collected through the pipe 17.

The slope of the bottom 2 is most preferably adjusted in the following manner depending on the kind of the sludge to be treated:

A. In the case of a dense and close sludge having a high viscosity, the angle of the bottom 2 is adjusted to 5° to 15° to the horizontal.

B. In the case of a dense and close

sludge having a medium viscosity, the angle of the bottom 2 is adjusted to 3° to 7° to the horizontal.

5 C. In the case of a sludge having a low viscosity, the elevation angle of the bottom 2 is adjusted to 0° to 5° to the horizontal.

10 However, it is of course possible to adopt slopes for the bottom other than mentioned above depending on the kind of the waste water from which the sludge to be treated has been derived.

15 An assembly of the precoat layer and layers of coagulated sludge solids or of the sludge, which has been formed on the filter cloth C in the pond 5 for the coal-containing sludge, is forwarded onto the roll bars 19 of the filtering zone B after its thickness is uniformized and adjusted to 5 to 10 mm by means of the slit controller or doctor blade 34. In the filtering zone B, dehydration of the assembly is effectively accomplished by suction filtration.

25 Cakes from which water has been removed are exfoliated from the filter cloth by means of a scraper and are collected in the chute 35 for discharge of the filter cakes.

30 In the described apparatus, by adjusting the angle of the bottom of the liquid reservoir, namely the moving angle of the filter cloth, a precoat layer of coarser particles of the fine coal dust can be formed uniformly on the filter cloth regardless of variety of properties of sludges to be treated, and at 35 the same time coagulates of finer particles of the fine coal dust and sludge solids, or sludges per se, can be deposited or coated on the precoat layer. Accordingly since filtration of sludges is accomplished through the precoat layer of finer particles of the fine 40 coal dust and the layer of coagulates containing finer particles of the fine coal dust, the specific filtration resistance is extremely low (the coefficient of filtration resistance $\gamma=1 \times 10^6$ to 3×10^6). As a result, the filtration can be performed very easily and the water content of the resulting filter cake is as low as 42 to 60% by weight. Thus, filter 45 cakes discharged from the apparatus can be effectively used as fuel for incineration of rubbish and refuse, as they are or after they have been dried slightly.

WHAT I CLAIM IS:—

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1. Apparatus for the continuous dehydration of sludges, which comprises a liquid reservoir for receiving an admixture of fine dust coal and a sludge, a filtering zone connected with the liquid reservoir, in which vacuum suction filtration is to be effected, and an endless filter cloth with means for continuously forwarding it to the liquid re-

servoir and the filtering zone, the liquid reservoir being provided with a bottom portion inclined to the horizontal and extending to the surface level of the reservoir at least at the portion thereof where the liquid reservoir is connected to the filtering zone; the filtering zone being constructed as a vacuum chamber provided with roll bars at the upper portion thereof; the endless filter cloth being so disposed that it is at first introduced into the deepest portion of the liquid reservoir while being kept in contact with the bottom portion along a length sufficient for a precoat layer to lie on the surface thereof during use of the apparatus, and is then introduced on the roll bars of the filtering zone; and said liquid reservoir being connected pivotably with the filtering zone, means being provided for adjusting the inclination to the horizontal of the bottom of the liquid reservoir.

2. Apparatus according to claim 1, 85 wherein a box for receiving filtrate water is disposed beneath the bottom of the liquid reservoir, a plurality of filtering holes being perforated through at least that portion of the bottom of the reservoir where the liquid depth is small to permit filtrate water to pass into the box through the filter cloth and the filtering holes during use of the apparatus. 90

3. Apparatus according to claim 1 or 2, wherein the rolls bars are rotatably supported 95 on a machine frame.

4. Apparatus according to claim 3, wherein a plurality of roll bars are mounted rotatably on the upper side of a vacuum chamber, each roll bar comprising a plurality of 100 ridges disposed spacedly from each other whereby filtrate water can be discharged through clearances formed between adjoining ridges.

5. Apparatus according to any one of 105 claims 1 to 4, wherein the filtering zone comprises a plurality of vacuum chambers provided longitudinally of the apparatus.

6. Apparatus according to claim 5, wherein three vacuum chambers are provided 110 in the longitudinal direction of the apparatus, and the negative pressure is maintained at 80 to 100 mm Hg in the first vacuum chamber, at 120 to 200 mm Hg in the second vacuum chamber and at 250 to 400 mm Hg 115 in the third vacuum chamber.

7. Apparatus according to any preceding claim, wherein a drive drum filter is provided on the discharge side of the filtering zone, the filter cloth passing from the filtering zone onto the drum filter. 120

8. Apparatus according to claim 7, wherein a negative pressure of up to 600 mm Hg is applied to the drum filter.

9. Apparatus for the continuous dehydration of sludges constructed and arranged 125



sludge having a medium viscosity, the angle of the bottom 2 is adjusted to 3° to 7° to the horizontal.

C. In the case of a sludge having a low viscosity, the elevation angle of the bottom 2 is adjusted to 0° to 5° to the horizontal.

However, it is of course possible to adopt slopes for the bottom other than mentioned above depending on the kind of the waste water from which the sludge to be treated has been derived.

An assembly of the precoat layer and layers of coagulated sludge solids or of the sludge, which has been formed on the filter cloth C in the pond 5 for the coal-containing sludge, is forwarded onto the roll bars 19 of the filtering zone B after its thickness is uniformized and adjusted to 5 to 10 mm by means of the slit controller or doctor blade 34. In the filtering zone B, dehydration of the assembly is effectively accomplished by suction filtration.

Cakes from which water has been removed are exfoliated from the filter cloth by means of a scraper and are collected in the chute 35 for discharge of the filter cakes.

In the described apparatus, by adjusting the angle of the bottom of the liquid reservoir, namely the moving angle of the filter cloth, a precoat layer of coarser particles of the fine coal dust can be formed uniformly on the filter cloth regardless of variety of properties of sludges to be treated, and at the same time coagulates of finer particles of the fine coal dust and sludge solids, or sludges per se, can be deposited or coated on the precoat layer. Accordingly since filtration of sludges is accomplished through the precoat layer of finer particles of the fine coal dust and the layer of coagulates containing finer particles of the fine coal dust, the specific filtration resistance is extremely low (the coefficient of filtration resistance $\gamma=1 \times 10^6$ to 3×10^6). As a result, the filtration can be performed very easily and the water content of the resulting filter cake is as low as 42 to 60% by weight. Thus, filter cakes discharged from the apparatus can be effectively used as fuel for incineration of rubbish and refuse, as they are or after they have been dried slightly.

WHAT I CLAIM IS:—

1. Apparatus for the continuous dehydration of sludges, which comprises a liquid reservoir for receiving an admixture of fine dust coal and a sludge, a filtering zone connected with the liquid reservoir, in which vacuum suction filtration is to be effected, and an endless filter cloth with means for continuously forwarding it to the liquid re-

servoir and the filtering zone, the liquid reservoir being provided with a bottom portion inclined to the horizontal and extending to the surface level of the reservoir at least at the portion thereof where the liquid reservoir is connected to the filtering zone; the filtering zone being constructed as a vacuum chamber provided with roll bars at the upper portion thereof; the endless filter cloth being so disposed that it is at first introduced into the deepest portion of the liquid reservoir while being kept in contact with the bottom portion along a length sufficient for a precoat layer to lie on the surface thereof during use of the apparatus, and is then introduced on the roll bars of the filtering zone; and said liquid reservoir being connected pivotably with the filtering zone, means being provided for adjusting the inclination to the horizontal of the bottom of the liquid reservoir.

2. Apparatus according to claim 1, wherein a box for receiving filtrate water is disposed beneath the bottom of the liquid reservoir, a plurality of filtering holes being perforated through at least that portion of the bottom of the reservoir where the liquid depth is small to permit filtrate water to pass into the box through the filter cloth and the filtering holes during use of the apparatus.

3. Apparatus according to claim 1 or 2, wherein the rolls bars are rotatably supported on a machine frame.

4. Apparatus according to claim 3, wherein a plurality of roll bars are mounted rotatably on the upper side of a vacuum chamber, each roll bar comprising a plurality of ridges disposed spacedly from each other whereby filtrate water can be discharged through clearances formed between adjoining ridges.

5. Apparatus according to any one of claims 1 to 4, wherein the filtering zone comprises a plurality of vacuum chambers provided longitudinally of the apparatus.

6. Apparatus according to claim 5, wherein three vacuum chambers are provided in the longitudinal direction of the apparatus, and the negative pressure is maintained at 80 to 100 mm Hg in the first vacuum chamber, at 120 to 200 mm Hg in the second vacuum chamber and at 250 to 400 mm Hg in the third vacuum chamber.

7. Apparatus according to any preceding claim, wherein a drive drum filter is provided on the discharge side of the filtering zone, the filter cloth passing from the filtering zone onto the drum filter.

8. Apparatus according to claim 7, wherein a negative pressure of up to 600 mm Hg is applied to the drum filter.

9. Apparatus for the continuous dehydration of sludges constructed and arranged



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to operate substantially as hereinbefore described, with reference to and as shown by Figures 3A and 3B of the accompanying drawings.

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