O. B. BROWN, H. K. MOORE, H. PARKER, AND H. M. MARTINSON.

METHOD OF AND APPARATUS FOR WASHING PULP.

APPLICATION FILED OCT. 22, 1919.

1,421,664.

Patented July 4, 1922.

6 SHEETS—SHEET 1.

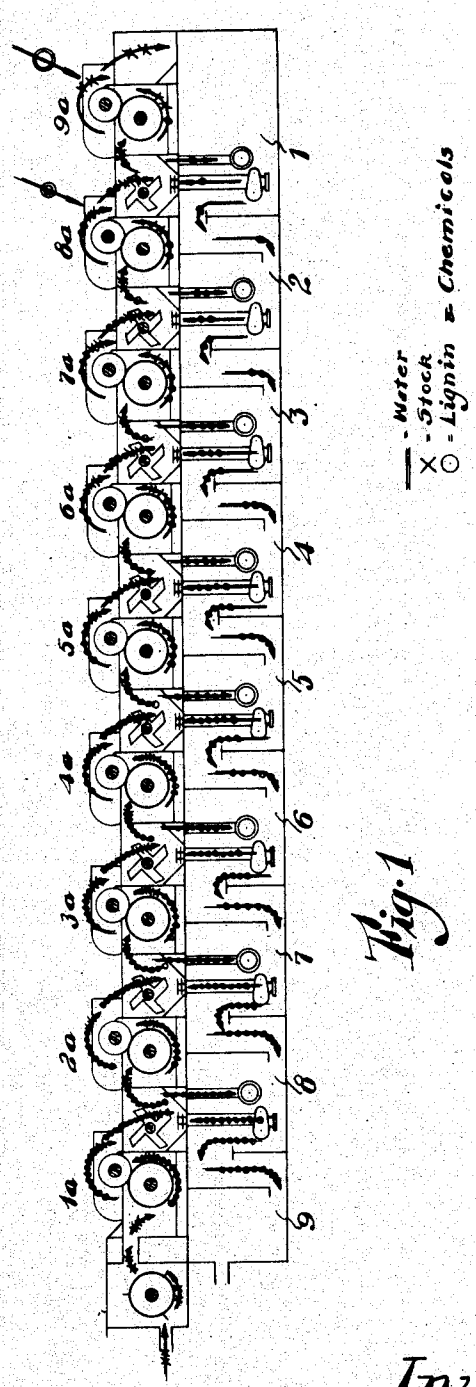


Fig. 1

Inventors
Orton B. Brown
Hugh K. Moore
Howard Parker
Herman M. Martinson
by Albright Brown Dunlap & Albright
Attorneys

O. B. BROWN, H. K. MOORE, H. PARKER, AND H. M. MARTINSON.

METHOD OF AND APPARATUS FOR WASHING PULP.

APPLICATION FILED OCT. 22, 1919.

1,421,664.

Patented July 4, 1922.

6 SHEETS—SHEET 2.

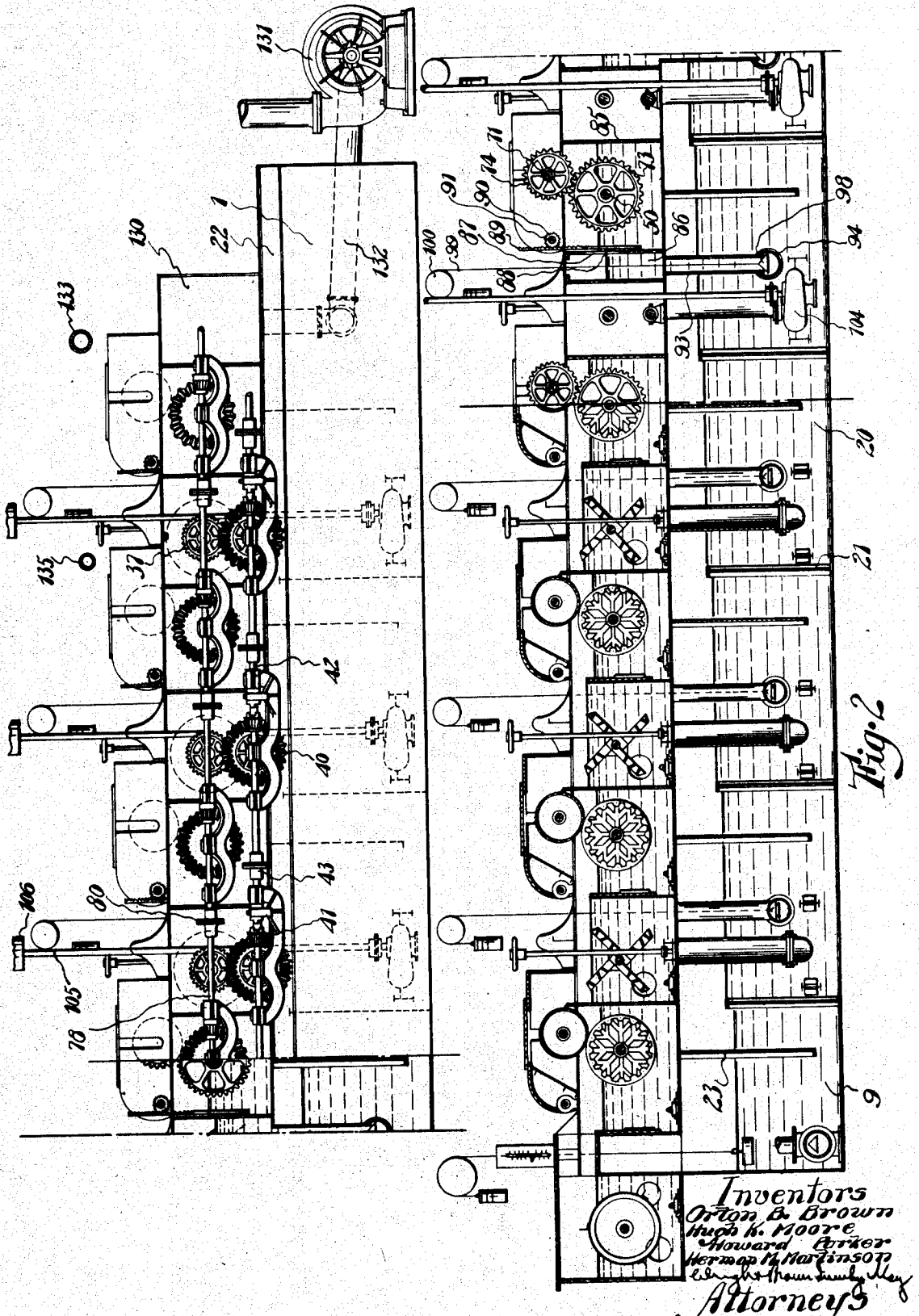


Fig. 2

Inventors
Orton B. Brown
Hugh K. Moore
Howard Parker
Herman M. Martinson
Edwards Thomas Lindsey & Lindsey

Attorneys

O. B. BROWN, H. K. MOORE, H. PARKER, AND H. M. MARTINSON.

METHOD OF AND APPARATUS FOR WASHING PULP.

APPLICATION FILED OCT. 22, 1919.

1,421,664. Patented July 4, 1922.

6 SHEETS—SHEET 3.

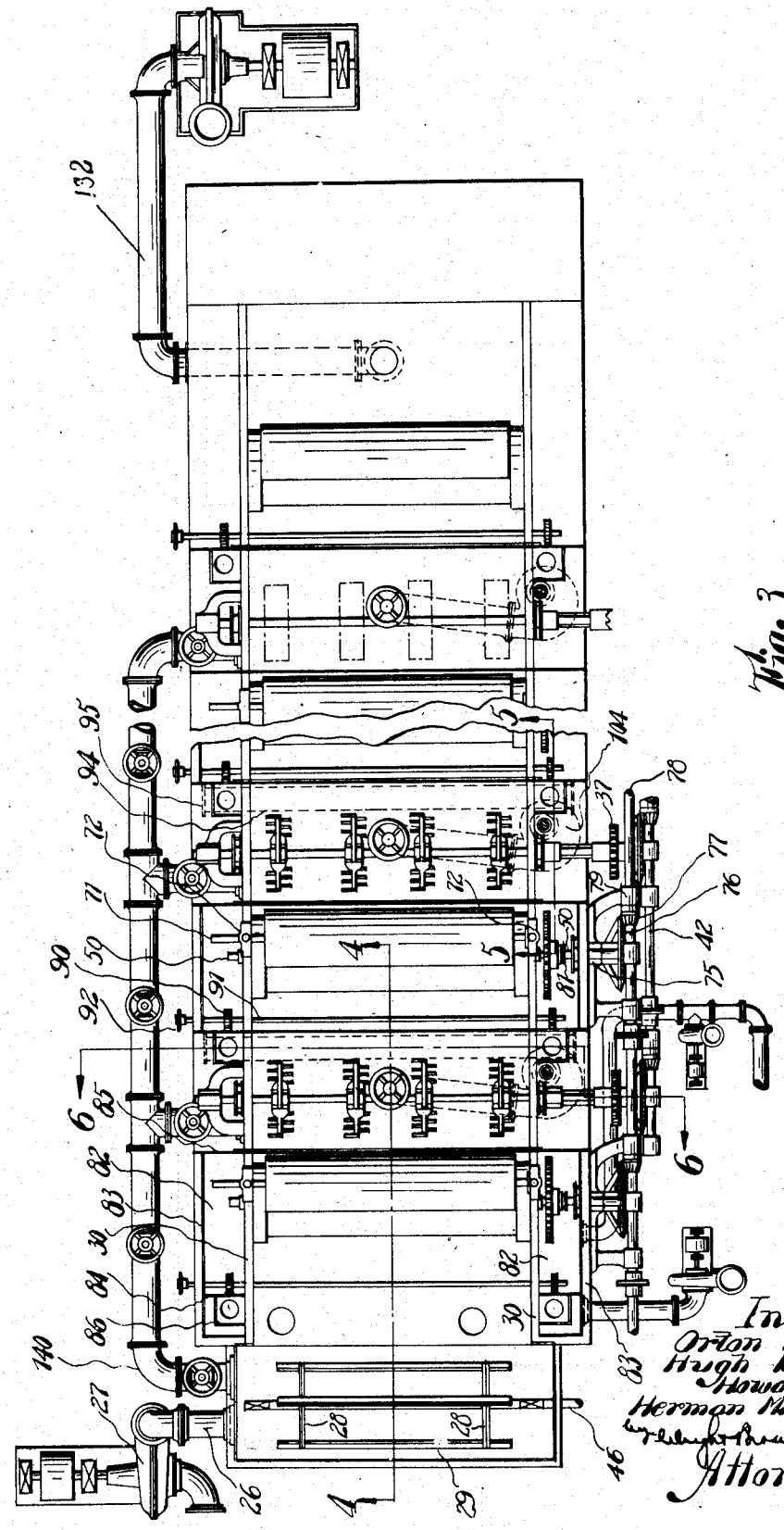


Fig. 3

Inventors
Orton B. Brown
Hugh K. Moore
Howard Parker
Herman M. Martinson
by Clarke & Brown Sandy & Clay
Attorneys

O. B. BROWN, H. K. MOORE, H. PARKER, AND H. M. MARTINSON.

METHOD OF AND APPARATUS FOR WASHING PULP.

APPLICATION FILED OCT. 22, 1919.

1,421,664.

Patented July 4, 1922.

6 SHEETS—SHEET 4.

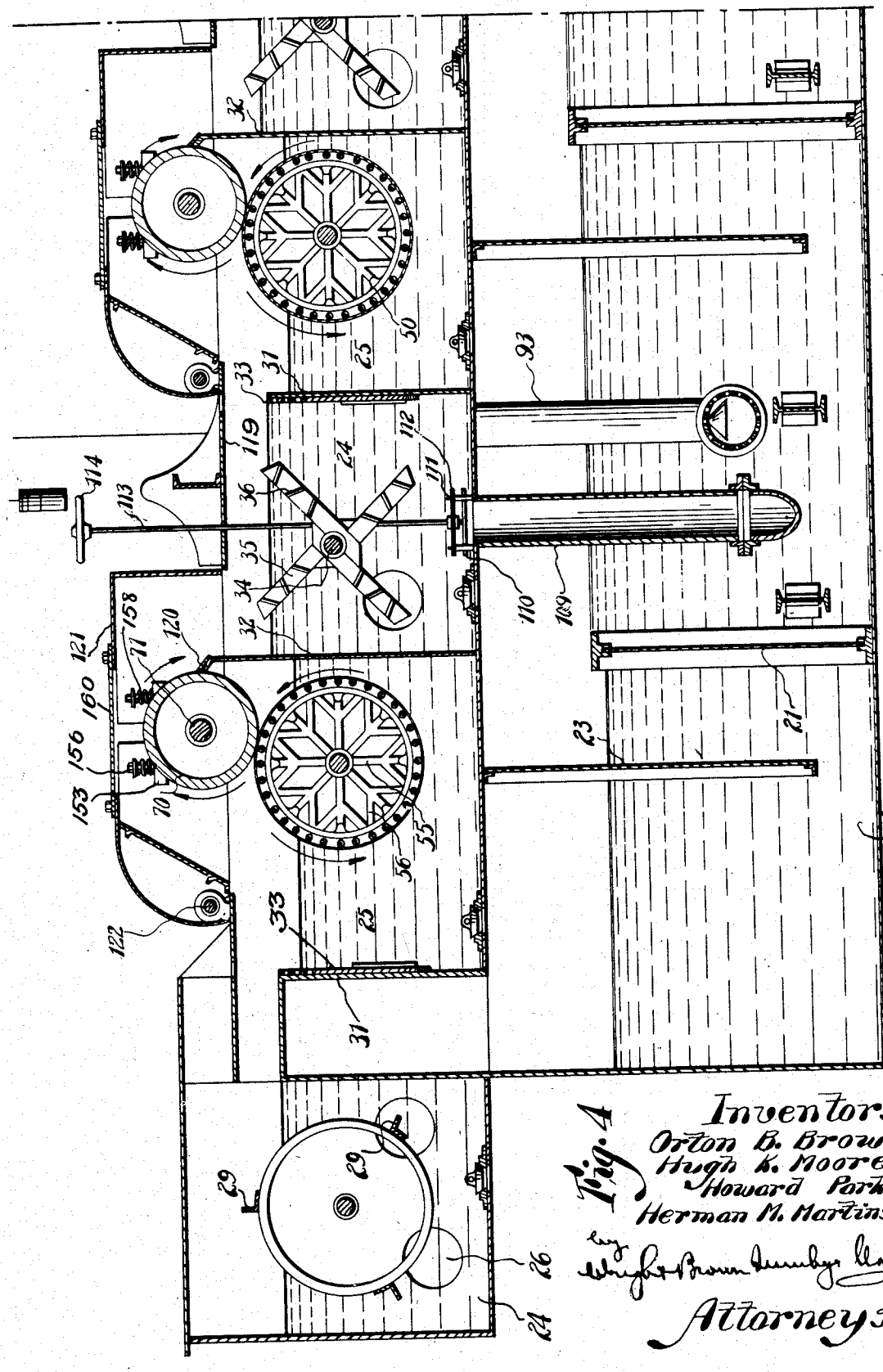


Fig. 4

Inventors
Orton B. Brown
Hugh K. Moore
Howard Parker
Herman M. Martinson

by Wright Brown Quinby & Clay

Attorneys

O. B. BROWN, H. K. MOORE, H. PARKER, AND H. M. MARTINSON.

METHOD OF AND APPARATUS FOR WASHING PULP.

APPLICATION FILED OCT. 22, 1919.

1,421,664. Patented July 4, 1922.

6 SHEETS—SHEET 5.

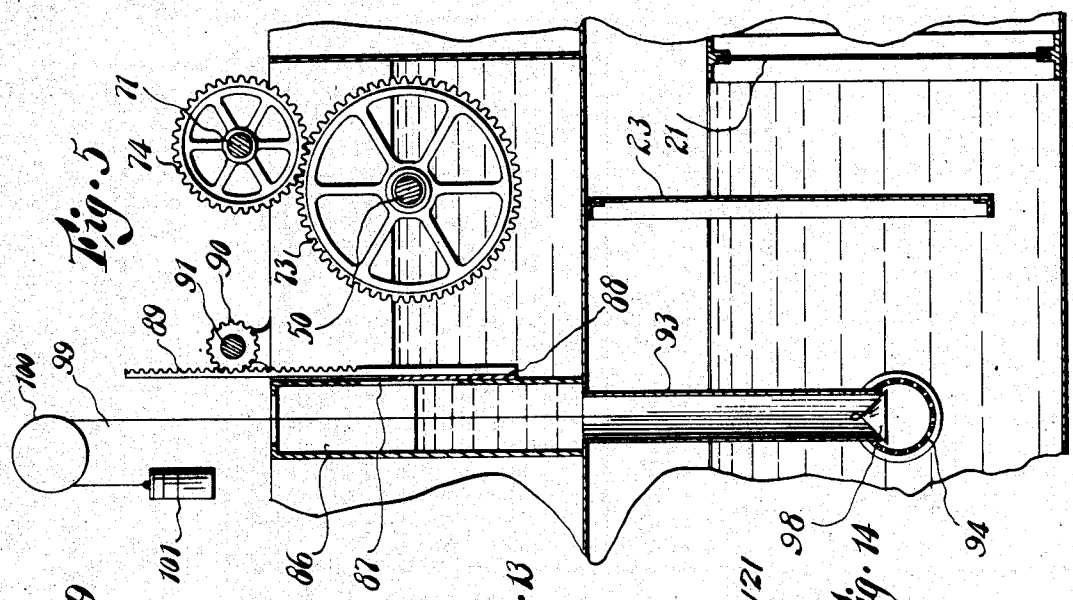


Fig. 5

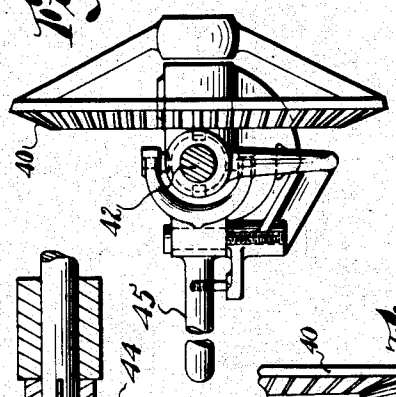


Fig. 9

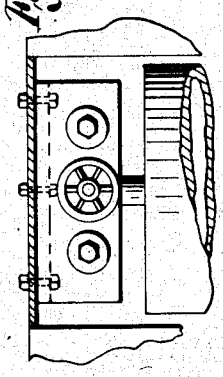


Fig. 13

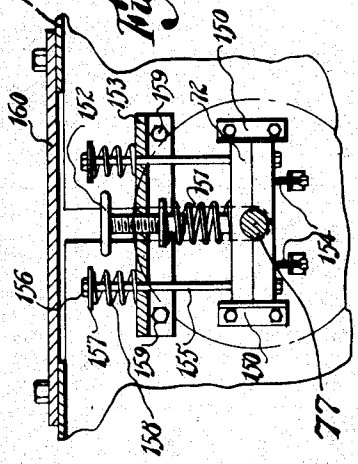


Fig. 14

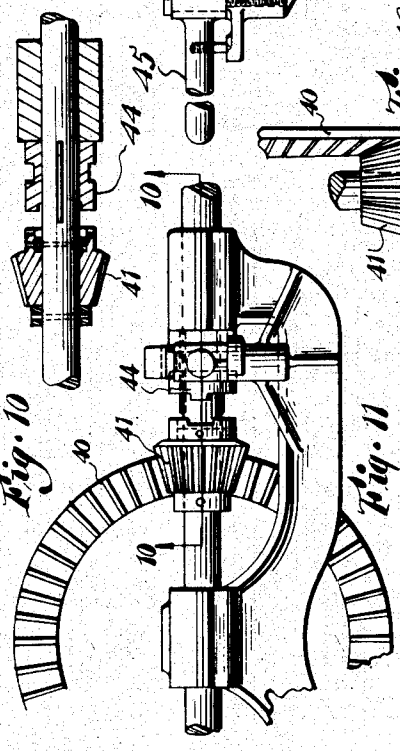


Fig. 10

Fig. 11

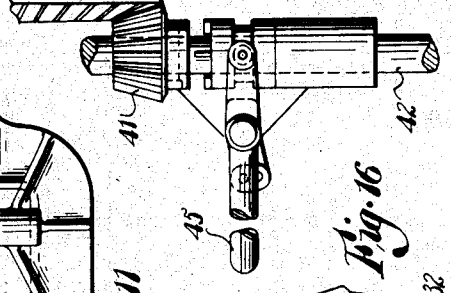


Fig. 12

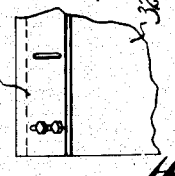


Fig. 16



Fig. 15

Inventors
Orton B. Brown
Hugh K. Moore
Howard Parker
Herman M. Martinson
by Ridgway Brown Dunlap & Clay
Attorneys

O. B. BROWN, H. K. MOORE, H. PARKER, AND H. M. MARTINSON.

METHOD OF AND APPARATUS FOR WASHING PULP.

APPLICATION FILED OCT. 22, 1919.

1,421,664.

Patented July 4, 1922.

6 SHEETS—SHEET 6.

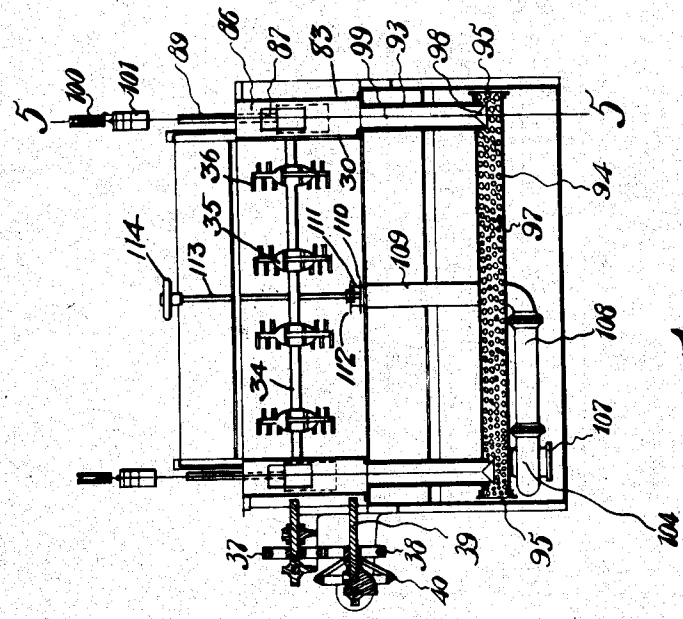


Fig. 6

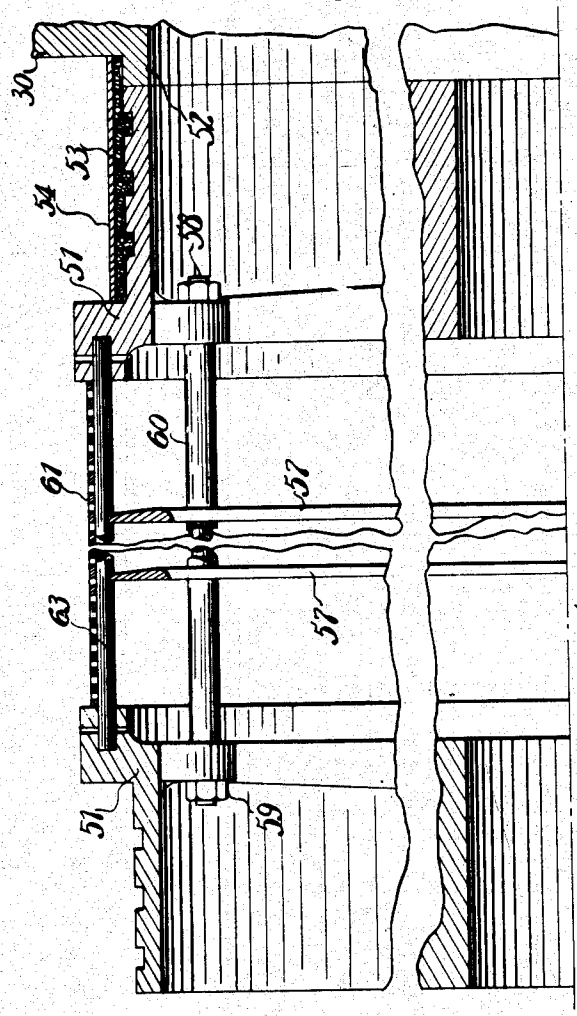


Fig. 7

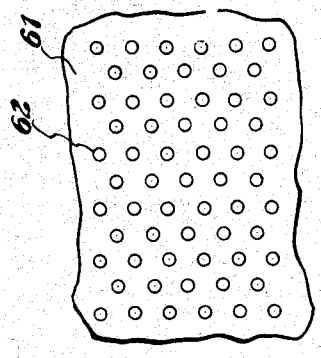


Fig. 8

Inventors
Orton B. Brown
Hugh K. Moore
Howard Parker
Herman M. Martinson
by Delaney Brown Dunlap & May
Attorneys

UNITED STATES PATENT OFFICE.

ORTON B. BROWN, HUGH K. MOORE, AND HOWARD PARKER, OF BERLIN, NEW HAMPSHIRE, AND HERMAN M. MARTINSON, OF LA TUQUE, QUEBEC, CANADA, ASSIGNORS TO BROWN COMPANY, OF PORTLAND, MAINE, A CORPORATION OF MAINE.

METHOD OF AND APPARATUS FOR WASHING PULP.

1,421,664. Specification of Letters Patent. Patented July 4, 1922.

Application filed October 22, 1919. Serial No. 332,402.

To all whom it may concern:

Be it known that we, ORTON B. BROWN, HUGH K. MOORE, and HOWARD PARKER, all citizens of the United States, and residents of Berlin, in the county of Coos and State of New Hampshire, and HERMAN M. MARTINSON, a subject of the King of Sweden, and resident of La Tuque, Province of Quebec, Dominion of Canada, have invented new and useful Improvements in Methods of and Apparatus for Washing Pulp, of which the following is a specification.

The object of this invention is to provide a method and apparatus for effectively washing pulp, and while we shall describe them in connection with the washing of sulphate pulp so-called, it will be apparent to those skilled in the art, after reading this specification, that they may be used with advantage in the washing of soda or sulphite pulp or any other fibrous material, from which it is desired to remove impurities of one kind or another.

The washing of pulp, produced by the sulphate process, is rendered especially difficult because of the viscous nature and high surface tension of the black liquor resulting from the digestion of the wood which is mixed intimately therewith. The agitation, which is necessary thoroughly to mix the pulp in the liquor in which it is washed, is frequently attended by foaming of the liquor to such an extent as to make a continuous process of washing exceedingly difficult to accomplish. In commercial operation, it is desirable for various reasons to accomplish the washing operation while the pulp and liquor are at a fairly high temperature in order to avoid the expense necessary to chill these products or to store them in large storage tanks until the products have cooled under ordinary atmospheric conditions. Furthermore, as it is customary to subject the black liquor to evaporation and smelting processes in the recovery of the soda products, it is desirable to prevent excessive loss of heat between the cooking operation and the evaporating operation. Again it may be pointed out that this black liquor, to which we have referred, is more easily filtered when it is heated than when it is at atmospheric temperature. As the liability of the black liquor to foam, however, is greater when it is heated than when it is cold, it is apparent that the washing is usually carried on under the worst conditions as to foaming.

In general, in accordance with the process which we shall hereinafter describe in detail, there is a counter-flow of the pulp and the washing liquor; that is to say, the pulp to be washed is fed into one end of the apparatus and passes through successive baths in which it is washed; whereas the washing water, which forms the baths, is fed into the other end of the apparatus and passes from bath to bath, and the two pass during the operation, the strongest liquor being discharged from that end of the apparatus into which the pulp is initially fed, and the washed pulp emerging from the bath into which the clear washing liquor is fed.

The apparatus, which we shall describe for carrying on the continuous process of washing, by which the pulp which is strongly impregnated with the black liquor is finally discharged in a substantially pure condition free from all but small traces of impurities, comprises a series of sections each consisting of a storage tank for containing a pool of the wash liquor, an agitator tank containing the bath in which the pulp is agitated and washed, and a cylinder through which the liquor passes and by which the pulp is strained therefrom and delivered to the next adjacent agitator tank or bath. The various storage tanks are so arranged to form successive pools of washing liquor, and so to provide for a substantially continuous flow of the washing liquor from pool to pool from the end to which it is fed to the other end of the apparatus. In these several baths and pools, the liquor gradually increases in strength and density, the pool and bath into which the pure water is initially fed having the least strength and density and those from which it is finally delivered from the apparatus being of the greatest density and containing the greatest amount of the original black liquor and lignin content and other impurities which were fed with the pulp to the apparatus from the digester.

In each section of the apparatus the commingled pulp and washing liquor flow from the agitator or wash tank into the cylinder

tank in which is located the rotary filtering screen or cylinder, and the liquor which emerges from the end of the cylinder is passed back to the storage tank to be commingled in the pool from which it is again pumped into the agitator tank, so that there is a constant circulation of liquor from each storage tank, through the agitator tank, the cylinder tank, the cylinder, back to the storage tank. The pulp, however, as has been stated, which is mixed with and washed in the bath of washing liquor in the agitator tank of one section and flows into the cylinder tank, is picked up by the cylinder, and, after being removed therefrom by the couch roll, is deposited or scraped into the purer bath contained in the agitator tank of the next adjacent section, this all occurring at a level above the level of the storage tanks, so that the pulp travels in one direction at one level and the washing liquor travels in the opposite direction at the lower level, from one end of the machine to the other. In order to ensure this flow of the washing liquor, the partitions between the storage tanks decrease in height from the end of the machine to which the washing water is fed to the end of the apparatus from which it is delivered, such partitions, however, being of sufficient height to ensure the formation of a pool consisting of a considerable quantity of the washing liquor and to prevent the formation of counter-currents.

In orderd to overcome the difficulty experienced from the liability of the washing liquor to foam, due to the incorporation of air or gas therein by the agitation of the commingled pulp and liquor, the rotation of the cylinder therein and the flow of the screened liquor from the cylinder to the storage tank, we have provided an instrumentality into which the strained liquor flows as it is discharged from the cylinder, this comprising an upright conduit or well whose lower end communicates with a perforated pipe submerged in the storage tank with automatically controlled valves to maintain a column of liquor in and to regulate the height thereof in the well. The upper end of each of the wells is exposed to the atmosphere so that whatever foaming occurs is within the well, and the air or other gas of the bursting bubbles may pass into the atmosphere without passing into the storage or other tanks. There is a pump for the storage tank of each section, the function of which is to supply each relatively shallow agitator tank with the requisite amount of washing liquor from the large pool in the associated storage tank. In order to prevent any foaming, due to the passage of the liquor from the storage tank to the agitator tank, the conduits are so arranged that the liquor is delivered to the bottom of the agitator tank, the delivery end of the conduit being thus submerged in the agitator tank and there being a solid column of liquor in the conduit. Preferably the delivery end of the conduit is provided with a check valve which is lifted by the incoming liquor but which prevents the back-flow of liquor and pulp in the event that the pump is not in operation.

We provide what we believe to be a novel construction of the cylinder in order to secure the squeezing and compression of the pulp so as to express therefrom so far as possible any of the liquor that may be mixed therewith as the pulp is carried on the surface of the cylinder. That is to say, we provide a cylinder which is of rigid construction, consisting preferably of a cylindrical metallic shell capable of withstanding relatively high pressure and having perforations formed in the metal for the passage of the liquor. The couch roll is so adjusted and located in reference to the shell that the pulp is compressed at the nip and the liquor squeezed therefrom. The cylinder is so reinforced internally as to prevent any undue yielding of the metallic shell. By the employment of a substantially rigid cylinder, in which the relatively thick shell is provided with relatively large perforations, say approximately $\frac{1}{16}$ to $\frac{1}{8}$ of an inch in diameter, more or less, we have secured surprising results in the output of the apparatus. The use of a perforated substantially-rigid metallic shell is of material assistance in decreasing the foaming of the liquor, and yet at the same time the matting of the fibrous pulp upon the cylinder takes place in such way as to prevent any material portion of the pulp flowing through the perforations into the cylinder even though the perforations be of relatively large size as $\frac{1}{8}$ of an inch or greater, of course within reasonable limits. Even should a small quantity of pulp pass through the perforations in the metallic shell with the liquor, it is again pumped with the liquor back from the pool into the agitator tank and subsequently recovered.

On the accompanying drawings, we have shown a washing apparatus which may be utilized in practicing our process and which itself embodies various features of the present invention.

Referring to the drawings,—

Figure 1 illustrates diagrammatically the operation of the apparatus, showing the flow of the pulp and of the washing liquor through the apparatus and indicating graphically the gradual removal of the black liquor and lignin material from the pulp, and the increasing density of the washing liquor as it is passed through the apparatus.

Figure 2 represents partially in side elevation and partially in section an apparatus embodying the invention. In this figure,

different portions of the apparatus are shown in different vertical planes.

Figure 3 represents a plan view of the apparatus, certain of the sections being omitted for lack of space.

Figure 4 represents a longitudinal section on the line 4—4 of Figure 3, through two adjacent sections of the apparatus, on a larger scale.

Figure 5 represents a similar section on the line 5—5 of Figure 3.

Figure 6 represents a transverse section through the apparatus on the line 6—6 of Figure 3.

Figure 7 illustrates in section a portion of one of the cylinders.

Figure 8 illustrates a small portion of the metallic casing forming a component of the cylinder.

Figures 9 to 12 illustrate various details of one of the clutches.

Figures 13 and 14 show the details for adjustably mounting the couch roll.

Figures 15 and 16 illustrate the doctor or scraper for removing the pulp from the couch roll.

Before proceeding to describe the process and the apparatus which is illustrated upon the drawings, we desire to have it understood that the drawings are more or less conventional because of their small scale, that various changes may be made in the apparatus without departing from the spirit and scope of the invention as expressed in the claims, and that, while the apparatus and the process are described more especially in connection with the washing of sulphate pulp, they are equally available for washing other fibrous material.

Before proceeding to describe the apparatus in detail, we may explain, with the aid of Figure 1, the principles involved in the process and in the operation of the apparatus. In this figure, the storage tanks, in the order of the direction in which the washing liquid passes from pool to pool therein, are indicated at 1, 2, 3, 4, 5, 6, 7, 8 and 9. Associated with each tank and located conveniently above it, there is an agitator tank and a cylinder tank, with the necessary agitator, cylinder and couch roll, all of which are generally indicated in the order of the direction of the flow of stock at 1^a, 2^a, 3^a, 4^a, 5^a, 6^a, 7^a, 8^a and 9^a. The washing water is indicated by parallel lines and the arrows indicate the direction of flow thereof from tank 1 to tank 9; and, as indicating the increasing density of the water due to the addition thereto of the black liquor and lignin material and other impurities contained in the pulp, we have superimposed upon the parallel lines indicating the water, small circles which gradually increase in number.

The stock is indicated by the small crosses and its direction of flow from the agitator at 1^a to 9^a is indicated by the arrows. The stock, of course, is constant but more or less water passes with it from bath to bath as it travels from the first agitator tank to the last couch roll, and we have therefore indicated the passage of a small quantity of water with the pulp over the couch roll. The third constituent of the mixture, to wit, the lignin, is indicated by circles. It will be observed from the diagram that the quantity of lignin, that passes with the pulp through the series of baths in the agitator tanks and cylinder tanks, gradually decreases, so that, as the pulp is finally delivered from the couch roll at 9^a, it is substantially free from lignin, soda content or other impurities. The water, lignin and other impurities, which pass with the pulp in each instance over the couch rolls in gradually diminishing proportion, are delivered to the pool in the storage tank from which they are fed to the cylinder, and so pass with the main flow of water or washing liquor from the tank 1 to the tank 9. As a practical matter, to ensure the best commerical desirable results, we prefer to employ nine sections or effects, in washing sulphate pulp, as we find that, by so doing, the pulp, when delivered from the apparatus, is substantially free of foreign material; but, of course, it will be understood that the number of sections or effects may be increased or decreased as may be desired, or as may be required by the particular material which is being washed. While it is not necessary, we find it commercially desirable to feed the pulp into the initial agitator tank with a certain quantity of black liquor as delivered from the digester to cause it to flow readily through the conduits, but, if desired, the pulp, after the black liquor has settled and roughly strained therefrom, may be fed to the bath in the initial agitator by any other suitable means.

In using the term "black liquor," we of course refer to the mixture or solution of water, the cementitious or the lignin content of the wood or the lignin soaps and such free or combined chemicals or other impurities as may pass with the pulp from the digester, after the chips have been subjected to the sulphate cooking process; and consequently in using the term "lignin" we mean roughly to include not only the cementitious content of the wood but also the chemicals, free or combined, and other impurities which are in admixture therewith.

Referring now to the apparatus as illustrated upon the other figures of the drawings,—20 indicates an elongated trough or body sufficient in length for the number of sections which are to be employed. The ends of the trough are closed and it is divided into storage tanks by a series of vertical transverse partitions 21 which are graduated in height to provide for a series of pools

of wash liquor from which the liquor overflows from pool to pool. The several storage tanks are indicated at 1 to 9 inclusive. Around the outside of the trough and at the upper edge thereof, there is a channel iron 22 to stiffen it, for upon the trough are preferably supported the various other tanks and instrumentalities to which reference will be made. In each of the storage tanks there is a depending baffle 23.

Associated with each storage tank there is an agitator tank 24 and a cylinder tank 25 for a bath of wash liquor. These two tanks are made of metal and are supported upon the top of the main trough. As shown, the first agitator tank 24 may be located at the end of the main trough where it may conveniently receive the pulp and black liquor which is fed thereto. From this tank the mixture of pulp and black liquor flows into the next succeeding cylinder tank 25. As indicated in Figure 3, the mixture of pulp and black liquor is fed into the first agitator tank 24 through a conduit 26 and a pump 27, the latter being connected by conduits with the source of supply. One of the advantages in employing a pump for supplying the pulp to be washed is that it ensures a regular flow thereof to the initial receiving and agitator tank 24. Within this agitator tank there is located any suitable form of agitator, such for example as that shown, which comprises a shaft 46 having disks 28 thereon with longitudinal blades or stirrers 29. Except for the initial receiving and agitator tank, the remainder of the tanks for the cylinders and the agitators may all, for convenience, be provided with common end walls 30 which are spaced apart a distance somewhat less than the width of the main trough, and between these end walls there are located the suitable partitions 31, 32. The partitions or walls 31 between the agitator tank and the associated cylinder tank of each section are only of sufficient height to maintain the desirable body of the mixture in the agitator tank and so as to permit the flow of a steady stream of the mixture therefrom to the associated cylinder tank 25. We should not regard it as a departure from the spirit and scope of the invention if the partitions 31 were omitted, so that the agitator and the storage screen or cylinder would be located in one compartment, although we should regard such an omission as highly undesirable in a pulp washer for reasons which will be apparent to those skilled in the art. Each of the walls or partitions 31 is provided with a movable and adjustable dam 33, which may, under the circumstances subsequently to be explained, be adjusted to a height which will prevent the passage of the material from the agitator tank to the associated cylinder tank of the same section. Any suitable means for effecting the vertical adjustment and final securement after adjustment of the dam 33 may be utilized.

In each of the agitator tanks succeeding the initial agitator tank, there is an agitator, of any suitable or desirable construction, for washing the batch of pulp therein. For example, we have illustrated a shaft 34 provided with a series of spiders, each comprising a plurality of radial arms 35 having angularly arranged blades 36. The shafts 34 extend at one end through stuffing boxes in the front wall 30 and are provided with spur gears 37 which intermesh with and are driven by complemental spur gears 38 journaled upon a stud shaft 39, see Figure 6. Journaled on each shaft 39 there is a bevel gear 40, all of said bevel gears being driven by complemental bevel gears 41 on a shaft 42, which latter is mounted in suitable bearings afforded by brackets attached to the front wall of the main trough. The shaft 42 has power imparted thereto by any suitable means from a convenient source of power. As shown in Figure 2, the shaft 42 may be with convenience made in relatively short lengths, one length for each section of the apparatus, independently driven or all may be secured together by couplings 43. Each bevel gear 41 is loose upon the shaft 42 but may be connected thereto by a sliding clutch member 44 splined upon the shaft and moved into and out of engagement with the bevel gear by a clutch lever 45, as shown in Figures 9 to 12 inclusive. By this construction, it is apparent that the agitators may be all driven simultaneously, but, if desired, any one of them may be disconnected or unclutched from the driving shaft 42. While a batch of pulp is being agitated in one bath to effect the washing of the pulp, there is at the same time a constant flow of pulp and liquor from the agitator tank 24 over the dam 33 into the cylinder tank 25.

Located within the cylinder tank, there is the cylinder the function of which is twofold, namely to strain the pulp from the liquor and remove the pulp from the bath so that it may be passed into the bath in the next succeeding agitator tank, and also to permit the expression therefrom of a large proportion of the liquid which is mixed therewith. Each cylinder is mounted upon a shaft 50, the said shafts being journaled in suitable bearings supported by the end walls 30, 30. The cylindrical cylinder heads, as shown in Figure 7, are indicated at 51, 51, and they have substantially tubular hubs or flanges so as to permit the passage therethrough of the liquor which passes through the perforated shell of the cylinder. Each cylinder head terminates at a point closely adjacent the wall 30 and registers

with an annular flange 52 thereon. Suitable packing 53, held in place by a metallic sleeve 54, encircles the tubular portions of the cylinder heads and the annular flanges 52 to prevent the escape of liquor at the joint. The sleeve 54 is preferably provided with means whereby it may be contracted as the packing wears. Each cylinder head is provided with a plurality of radiating spokes 55 with angular braces 56 so as to furnish an effective support for the shell of the cylinder, as will be explained. Between the cylinder heads there are numerous spiders indicated as a whole at 57 which are provided with spokes and braces similar to those at 55 and 56. The several spiders are spaced apart by any suitable means. Connecting the ends of all of the spokes and braces as at 55, 56, on the cylinder head and spiders, there are longitudinal rods 58 secured at their ends to the cylinder head by nuts 59, and on these rods there are tubular spacers or sleeves 60. Between the cylinder heads the cylinder is provided with a cylindrical shell 61 which is preferably of such thickness that it will not yield materially under pressure. As giving some indication of the character of this shell, we have found that a curved steel plate, approximately $\frac{1}{8}$ of an inch in thickness, may be employed and the desirable results secured. This shell is provided with numerous spaced perforations, 62, which, as previously stated, may vary from $\frac{1}{16}$ to $\frac{1}{8}$ of an inch in diameter. Of course these several dimensions may be varied in accordance with circumstances or requirements of the particular material being washed. The shell is rigidly reinforced, the spacers preferably being at a distance of approximately 2.5 inches. Supported at the extremities of the spokes and braces 55, 56, of the spiders, there are rods 63, the ends of which are inserted in sockets in the confronting faces of the cylinder heads. These rods are spaced but a short distance apart, and between their ends are rigidly braced by the spiders. By this construction, it will be seen that the perforated shell is so supported and braced that it is substantially incapable of yielding under pressure. The ends of the shell are, as shown in Figure 7, clamped between the confronting faces of the cylinder heads, the rods 58 and nuts 59 being utilized to secure this clamping action.

Each of the cylinders is so located in the cylinder tank 25 that it is partially submerged in the mixture contained therein, and so that the liquid may be strained from the pulp and flow through the perforations 62 in the shell into the interior of the cylinder and pass outwardly through the cylinder heads, the matted fibers being carried on the upwardly moving side of the cylinder to a point above the level of the mixture in the tank. Associated with each cylinder, there is a couch roll 70 secured upon a shaft 71 mounted in suitable bearings at its ends. Each couch roll is preferably made of iron or steel and is of such length that it will engage only the perforated shell of the associated cylinder. The bearings for the shaft 71 are indicated at 72, and are supported by the ends of a cover to be described. They are preferably adjustable so that the yielding pressure of the couch roll upon the cylinder may be increased or decreased as desired to secure the required expressing action upon the pulp carried upwardly by the cylinder. In Figures 13 and 14, we have illustrated the bearing 72 (located at each end of the shaft) as being movable in guides 150 and as being under the pressure of a spring 151. The pressure may be varied by adjusting the screw 152 which is in threaded engagement with the removable angle bar 153. Abutment screws 154 are employed to limit the movement of the couch roll toward the cylinder. The bearings are hung on rods 155 which pass loosely through the angle bar 153 and have adjustable nuts 156 and washers 157 between which and the angle bar are located springs 158. By removing the bolts 159, the angle bars, the bearings and the roll may be removed. The cover has a detachable plate 160 covering a large slot therein and which may be removed when the couch roll is to be adjusted or to be taken from the machine.

To prevent the mechanical crushing of the pulp, the couch roll and the cylinder must be driven at the same peripheral speed, and for this purpose they are geared together. It will be observed that the shaft 50 of each cylinder is provided with a gear 73 intermeshing with a gear 74 on the shaft 71. The ratio of these gears is the same as the diametrical ratio of the cylinder shell and the couch roll, but the intermeshing teeth of the gears 73, 74, are of sufficient length to permit the requisite adjustment of the couch roll. The shafts 50 at their front ends are projected forwardly through stuffing boxes and are journaled in suitable bearings. Said shafts are sectional, the front sections being journaled in bearings indicated at 75, and being provided on their extremities with bevel gears 76 intermeshing with and driven by complemental bevel gears 77 on a shaft 78 which extends lengthwise of the trough and is mounted in suitable bearings indicated at 79. The shaft 78, like that at 42, is preferably made in short lengths, one for each section of the apparatus, and these short lengths of the shaft may be driven separately or may be connected together by couplings indicated at 80. Preferably each gear 73 is fast on the front section of the associated shaft 50, and between the sections of the shaft 50 is a movable clutch 81 fast on the front section

of the shaft 50 and operated by any convenient means to connect or disconnect the sections. Ordinarily the clutches 81 are in clutched relation and are only moved into inactive position when it is desired to throw the cylinder out of operation.

The strained liquor, which passes through the shells of the cylinders and out from the ends thereof, is delivered into compartments or outlet boxes indicated at 82, 82, which are located in front and in rear of the walls 30 at the ends of the respective cylinders. Each of these outlet boxes is formed by an outer wall 83, the end walls 84, 85, and the wall 30. Each of these boxes may be of the same depth as the associated cylinder tank, and provision is made, as will be explained, for permitting the strained liquor received by these boxes to pass therefrom to the pool in the storage tank from which it was drawn into the associated agitator tank. For this purpose, as shown in Figures 2, 3, 5 and 6, there is located adjacent each box a well 86 which consists of a vertical casing, one side of which is formed by the end wall 84. In said end wall there is a vertically elongated port 87, so that the liquor may flow from the chamber or compartment 82 into the well. Associated with this port, there is a sliding gate or dam 88, having connected thereto a rack 89 by which it may be raised and lowered. The rack intermeshes with a pinion 90 on a shaft 91. This shaft extends across the top of the cylinder chamber so that the gates 88 for each section may be adjusted simultaneously. Upon the rear end of the shaft 91 there is a hand wheel 92 by which it may be rotated. Extending downwardly from each of the wells 86 into the storage tank immediately below it, there is a vertical stand-pipe 93 (of which the well is practically an extension) which terminates in a horizontally arranged conduit 94 submerged in the pool of liquor contained in the said tank. This conduit 94 is provided with numerous perforations for the emission of the liquor, its ends being closed by caps 95 as shown in Figure 6. The perforations in the conduit are indicated at 97. It will now be seen that the liquor which passes out of the cylinder of any one section into the chambers or compartments 82, flows into the wells 86 and down through the vertical stand-pipes 93 thereof into the conduit 94, whence it emerges in the storage tank of the same section of the apparatus below the level of the pool therein. The wells 86 are open to the atmosphere at their upper ends, so that the entrained gas, escaping from the foam or bubbles in the well, may escape into the atmosphere.

By the perforated pipe 94, which is kept full of liquor flowing therethrough, and the perforations in the pipe, we prevent the formation of foam or bubbles in the storage tanks, and ensure the delivery of the strained liquor in small streams into the main body of liquor in the tanks, so as to effect a much more thorough mixture than if the vertical stand-pipes merely delivered a large unbroken stream into the tanks.

Means are provided for maintaining a constant column of liquid in the stand-pipes 93 and well 86, as will now be explained. On reference to Figures 2 and 6, it will be observed that the lower end of each stand-pipe 93 extends a short distance into the interior of the horizontal conduit 94 so as to constitute, as it were, a valve seat. For cooperation with each seat, there is a conical valve 98, which at its apex is suspended upon a chain or other flexible member 99. This chain passes over the pulley 100, located at some distance above the apparatus, and on its other end has attached thereto a counterbalancing weight 101. These weights are of such size as to hold the valve in closed position until a column of the desired height is formed in the wells and stand-pipes. As the liquor increases in density or specific gravity, the counterbalancing weights 101 are correspondingly heavier. Preferably the parts are so adjusted and related that the column of the liquor in each well is normally at a level slightly below the upper end of the gate or dam 88.

We have found by practical experience, by the provision of the instrumentalities which we have described, that foaming of the liquor in the storage tanks and in other parts of the apparatus is substantially prevented, even though the liquor be at a temperature of 160° F., more or less.

From the pool in each storage tank the liquor is supplied to the bath in the agitator tank associated in the same section therewith. For this purpose, there may be immersed in each storage tank a horizontally-arranged pump 104 which is driven by a vertical shaft 105 extending above the apparatus and equipped with a pulley 106 by which it may be rotated. The inlet of the pump is indicated in Figure 6 at 107, and communicating with the outlet thereof there is a conduit 108 having an upright limb 109 terminating in the bottom of the agitator tank which is immediately thereabove. At the upper end of this conduit, there is a circular check valve 110 movable on vertical guides 111, as shown in Figure 4. Above the check valve, there is a stationary plate 112 in which there is threaded a vertical rod 113 provided at its upper end with a hand wheel 114. By adjustment of this rod 113, the extent to which the check valve may be permitted to open may be regulated, and, in fact, the check valve may be secured in its closed position by screwing the rod home. It will be seen that in each section of the

apparatus the liquor is pumped from a storage tank up into the bottom of the agitator tank, thence passes with the pulp into the associated cylinder tank, out through the ends of the cylinder into the compartments 82, thence through the well and stand-pipe, back into the storage tank from whence it started, so that there is a constant circulation of the wash liquor in each section.

Of course it will be understood that the apparatus is provided with all of the necessary cross braces to give it sufficient rigidity, and with other details of construction which are not necessary to describe.

Across portions of each agitator tank, there is preferably a cover indicated at 119, which may be removably bolted in place, adjacent which there is a hinged section of the cover indicated at 121 which covers the remainder of the agitator tank and the adjacent cylinder tank. This hinged section of the cover may be made of a casting and the pivots therefor are indicated at 122. On swinging this section 121 of the cover upwardly and to the left (see Figure 4), the interior of the portion of the agitator tank and of the cylinder tank are exposed, the couch roll being carried upwardly with the cover so that the surface of the cylinder is exposed.

It will doubtless be understood from the explanation thus far given that, as the cylinder of one section rotates in the mixture of washing liquor, lignin and pulp, on the up-moving portion of its periphery it carries a relatively thick mat of pulp which is passed between the nip of the cylinder and the couch roll and is subjected to compression for expressing a greater portion of the liquid from the pulp. The couch roll removes the pulp from the cylinder and carries it in the direction of the arrow in Figure 4. From the couch roll the pulp is stripped by a blade or doctor 123 and is discharged into the bath contained in the adjacent agitator tank of the next adjacent section. Each doctor or scraper 123 is located at the upper end of the wall 32 of the agitator tank and is preferably adjustable in reference to the couch roll, as indicated in Figures 15 and 16, so as to bear thereagainst with the necessary pressure.

The pulp, which is continuously fed into the first agitator shown at the left end of Figure 1, passes with the black liquor, which is fed into the tank therewith, into the associated cylinder tank, and emerging from the ends of the cylinder passes through the instrumentalities described into the storage tank 9. The pulp, which is removed from the cylinder tank by the cylinder and the couch roll, is dropped into the next bath contained in the adjacent agitator tank where it is mixed with liquor which is of less density and is less impregnated or mixed with lignin, and is again agitated and washed. Thus the pulp is carried through the successive baths in which it is washed and from which it is then removed, and is finally received in a tank indicated at 130 in Figure 2, from which the now thoroughly washed pulp may be withdrawn by a pump 131, the inlet port of which communicates with the bottom of the tank 130 by the conduit 132. Tracing now the path of the washing water or liquor, it will be observed that above the last couch roll there is located a water pipe 133 which directs a stream of water upon the doctor or scraper so that this fresh water delivered from the pipe 133 is received in the tank 130 and does not pass through the apparatus. Water at seasonable temperatures may be employed for this purpose, although we preferably use the white water from a paper machine. In lieu of this method of procedure, however, we may dispense with the pump 131, the conduit 132 and the water pipe 133, since the pulp is dry enough, after being passed between the last cylinder and the couch roll, so that it may be conveyed from the tank 130 by any suitable conveyor. In fact, in lieu of the tank 130, the pulp from the last couch roll may be delivered into a screw conveyor for delivery at a point desired.

Above the next to the last couch roll, there is located a pipe 135 for delivering upon the doctor or scraper a stream of warm or hot water which is utilized for washing the pulp and which passes therefrom into the bath and thence into the pool in the storage tank therebeneath, and finally through the various baths, and the pools in the storage tanks numbered consecutively 1 to 9. The volume of fresh water, which is utilized for this purpose, is relatively small and is delivered in quantities much less than has heretofore been possible for a given amount of stock. The water, of course, is fed continuously so that the water in storage tank 1, which is utilized for the bath in which the pulp before its final delivery from the last or associated cylinder is washed, is practically clear water and free from all but traces of lignin, chemicals or other impurities.

As it sometimes happens in the commercial operation of the apparatus that it is necessary to effect minor repairs upon the instrumentalities included in one or the other section of the apparatus, it is desirable that such repairs may be effected without throwing the entire apparatus out of action. We have provided, therefore, means by which any one of the sections may be by-passed. For this purpose, we have provided a by-pass pipe 140 leading from the agitator tank of one section to the agitator tank of the second section therefrom. Each such pipe is preferably provided with suitable gate

valves which are normally closed. In the event that it be desired to cut out any one section, the valve of the by-pass pipe 140 around such section is opened and the dam or gate 33 leading from the agitator tank of such section to the cylinder tank is raised to a height sufficient to cut off the flow from the one to the other. By means of the clutches which have been previously described, the shaft 34 for the agitator and the shafts 50 for the cylinder of that section are unclutched from their respective driving shafts. The pump for the storage tank of the section, which is being thrown out of action, of course is stopped by removing the driving belt or otherwise. If desired, by-passes may be arranged for the storage tanks, but we have not deemed it necessary to show these as their construction and use will be apparent.

Reference has been made to the fact that a relatively small amount of water can be used for washing a relatively large amount of pulp. This is rendered possible by the use of cylinders having the construction which we have herein described. Heretofore it has been universally the practice, so far as we are aware, in single or double-effect machines for washing pulp, to employ cylinders which are covered with wire gauze such as Fourdrinier wire. One might logically conclude that, by having a foraminous surface with a multiplicity of relatively small apertures or interstices for the passage of the water, the water might flow more readily into the cylinder and the pulp caught on the surface thereof. Our experience has shown, however, that the opposite is true. Where the main body of the cylinder consists of wire gauze, the pulp mats thereon and is more or less carried into the interstices so as to prevent the free flow of the water through the wire gauze into the interior of the cylinder. The ends of the fibers tend to pass lengthwise into these small interstices so as to choke them and finally practically the entire surface of the gauze is coated with a layer of pulp interlocked with the wires in such way that it is almost impossible to remove it. By employing a rigid shell formed of a relatively thick plate provided with relatively large perforations or openings, all of the troubles that are encountered in the use of a wire gauze cylinder are obviated. We have found, to our surprise, that the production of the machine is increased many times by the employment of a cylinder such as herein described, and that, in addition, by employing a cylinder of proper rigidity, the pulp, which is passed between the nip of the cylinder and the couch roll, has expressed therefrom the greater portion of the liquid that was commingled therewith as the pulp was carried upwardly by the cylinder. Consequently, as the pulp travels from the receiving end to the delivery end of the machine, in passing from one bath to the next succeeding bath, it carries with it a minimum proportion of lignin and chemicals. Inasmuch as the surface of the cylinder is fairly smooth and the holes relatively large, the layer of pulp thereon is removed in practically continuous slab by the couch roll, so that air is not carried down into the cylinder tank by the entrainment with projecting fibers as in the case where a wire cylinder is employed. The apertures in the cylinder are sufficiently large to permit the escape of air from the apertures and from the interior of the cylinder without being carried down into the liquor.

It has already been pointed out that, by the process and apparatus which we have herein described, we are able to wash a maximum quantity of pulp with a minimum quantity of water, notwithstanding that the materials being washed from the pulp are of a nature which render the washing exceedingly difficult. Black liquor, resulting from the digestion of wood by the sulphate process, is, as has been stated, of a highly viscous nature and has a high surface tension. These conditions are not met with in those machines or processes in which a small quantity of fiber is washed with an excess or maximum amount of water. In such latter case, the considerations of viscosity and surface tension are not compelling; whereas, in the washing of sulphate with a relatively small quantity of water, the washed liquor as it passes through the apparatus becomes increasingly dense and viscous and its surface tension gradually increases. So far as we are aware, we are the first to have provided a multiple-effect apparatus for continuously washing sulphate pulp and delivering it in a constant stream practically free from foreign substances. In accordance with the present process, there is in the storage tank, from which the washing liquor is delivered from the machine, a liquor of maximun concentration which, under some circumstances, may be concentrated and evaporated for the recovery of the soda in its various forms or else may be employed for partially filling the digesters preparatory to cooking a fresh batch of wood.

Having thus explained the nature of our said invention and described a way of making and using the same, although without attempting to set forth all of the forms in which it may be made or all of the modes of its use, what we claim is:—

1. A continuous process of washing fibrous material, which consists in continuously feeding said material to and agitating and washing it in successive baths of wash liquor, straining the liquor therefrom as it passes from bath to bath, and causing the liquor to

flow in the opposite direction to form such successive baths for the on-coming fibrous material.

2. A continuous process of washing fibrous material, which consists in circulating the wash liquor in a series of baths, causing such liquor to flow successively from one bath to the next adjacent bath, agitating and washing the fibrous materials in said baths, successively feeding said material from bath to bath in a direction opposite to the main flow of liquor, and in its passage from bath to bath squeezing such fibrous material for the expression of liquor therefrom.

3. A process of washing fibrous material, which consists in simultaneously agitating and washing a plurality of batches of said fibrous material in baths of washing liquor, successively feeding the said material from bath to bath and straining the washing liquor therefrom, collecting such strained liquor in separate pools and conveying portions thereof back to the baths whence they come, and causing the liquor to flow from pool to pool in a direction opposite the direction of travel of the fibrous material.

4. A process of washing fibrous material, which consists in forming a succession of pools of wash liquor, causing the liquor to flow successively from pool to pool, supplying relatively pure liquor to the first pool and withdrawing the liquor from the last pool, circulating wash liquor from each pool through a bath, continuously feeding fibrous material through the successive baths but in a direction opposite the main flow of said liquor through said pools, simultaneously agitating and washing the batches of fibrous material in the said baths, and expressing from said fibrous material as it is being fed from bath to bath, a portion of the liquor mingled therewith, to restore such liquor to the bath whence it came.

5. A process of washing fibrous material, which consists in forming a pool and a bath of wash liquor, the bath being at the higher elevation, continuously supplying such liquor from said pool to said bath, continuously supplying said fibrous material to said bath, continuously delivering the washed material from said bath and straining the liquor therefrom, causing such strained liquor to flow back to said pool, and maintaining a column of such strained liquor with its surface exposed to the atmosphere for the escape of gas mixed or entrained therewith prior to its delivery to the pool.

6. A process of washing fibrous material, which consists in forming a pool and a bath of wash liquor, the bath being at a higher elevation, continuously supplying such liquor from said pool to said bath, continuously supplying said fibrous material to said bath continuously delivering the washed material from said bath and straining the liquor therefrom causing such strained liquor to flow back to said pool, maintaining a column of such strained liquor with its surface exposed to the atmosphere for the escape of gas mixed or entrained therewith, and delivering such strained liquor from such column into the pool at a point below the level thereof.

7. A process of washing fibrous material, which consists in forming a pool and a bath of wash liquor, the bath being at the higher elevation, continuously supplying fresh liquor to and delivering the more impure liquor from said pool, continuously feeding the fibrous material to and washing it in said bath, continously delivering the washed material from said bath and straining the liquor therefrom, causing such strained liquor to flow back to the pool while maintaining a column thereof with its surface exposed to the atmosphere, and continuously supplying the wash liquor from said pool to the bottom of said bath, whereby the liquor is circulated continuously through the pool and the bath, and excessive foaming is avoided.

8. An apparatus for washing fibrous material, which comprises a series of associated washing and screening tanks provided with agitators and rotary screens, means for causing the wash liquor to be passed continuously and successively therethrough in one direction, and means for causing the fibrous material to be passed therethrough in the opposite direction, whereby the said fibrous material and the wash liquor are delivered at opposite ends of the apparatus.

9. An apparatus for washing fibrous material, which comprises a plurality of sections arranged in series, each section including a washing tank having an agitator and a tank having a rotary screen, means for causing the washed pulp to be delivered successively from the screen of one section to the agitator tank of the next section, and means for causing the passage of the wash liquor in the opposite direction through the agitator and cylinder tanks of the successive sections.

10. An apparatus for washing fibrous materials, comprising a plurality of sections arranged in series, each consisting of a storage tank, a washing and agitator tank and a cylinder tank, said storage tanks being arranged for the flow of wash liquor successively therethrough, means for ensuring the passage of the fibrous material in the opposite direction through said agitator and cylinder tanks successively, and means at each section for causing a circulation of the liquor through the storage, agitator, and cylinder tanks.

11. An apparatus for washing fibrous material, comprising a series of sections each having a storage tank, an agitator tank, a

communicating cylinder tank, means for feeding wash liquor from the storage tank to the agitator tank, and means for conducting the screened water from the cylinder tank to the storage tank, means for feeding the stock through the agitator and cylinder tanks of the successive sections, and means for ensuring the flow of wash liquor in the opposite direction through the storage tanks of said sections.

12. An apparatus for washing fibrous material, comprising a plurality of sections arranged in series, each having an agitator tank with an agitator therein, a cylinder tank with a screen cylinder therein, a storage tank below said first-mentioned tanks, and means for circulating the wash liquor through said tanks; means for delivering the stock from each cylinder to the agitator tank of the next succeeding section; and means whereby the wash liquor is caused to flow through the storage tanks successively.

13. An apparatus for washing fibrous material, comprising a plurality of sections arranged in series, each having an agitator tank with an agitator therein, a cylinder tank with a screen cylinder therein, a storage tank below said first-mentioned tanks, outlet boxes for receiving the screened liquor from the cylinder, communicating with the storage tank, and means for pumping liquor from the storage tank to the agitator; and means for feeding the washed stock from each cylinder to the agitator tank of the next succeeding section.

14. An apparatus for washing fibrous material, comprising a plurality of sections arranged in series, each having an agitator tank with an agitator therein, a cylinder tank with a screen cylinder therein, a storage tank below said first-mentioned tanks, outlet boxes for receiving the screened liquor from the cylinder, communicating with the storage tank, and means for pumping liquor from the storage tank to the agitator tank; means for feeding the washed stock from each cylinder to the agitator tank of the next succeeding section; and means whereby the liquor is caused to flow in the opposite direction through the storage tanks.

15. An apparatus for washing fibrous material, comprising a plurality of sections arranged in series, each having an agitator tank with an agitator therein, a cylinder tank with a screen cyinder therein, a storage tank below said first-mention- tanks, means for pumping the wash liquor from the storage tank to the bottom of the agitator tank, and means for delivering the screened liquor from the cylinder to the storage tank; means for transferring the stock from each cylinder to the agitator tank of the next succeeding section; and means for causing the liquor to flow through the storage tanks in succession.

16. An apparatus for washing fibrous material, comprising a plurality of sections arranged in series, each having an agitator tank with an agitator therein, a cylinder tank with a screen cylinder therein, a storage tank below said first-mentioned tanks, outlet boxes at the ends of the cylinder to receive the screened liquor, open conduits for conducting such liquor to the storage tanks, means for maintaining a column of liquor in said conduits above the level of the liquor in the storage tanks, and means for pumping liquor from the storage tank to the agitator tank; and means for transferring the fibrous material from each cylinder to the agitator tank of the next succeeding section.

17. An apparatus for washing pulp, comprising a series of agitator tanks with agitators therein, and cylinder tanks with screen cylinders therein, all arranged in alternation, with means for permitting the flow of washed material from each agitator tank to the next cylinder tank; means for transferring the washed pulp from each cylinder to the next succeeding agitator tank, and means for supplying wash liquor to the successive agitator tanks.

18. An apparatus for washing pulp, comprising a series of agitator tanks with agitators therein, and cylinder tanks with screen cylinders therein, all arranged in alternation, with means for permitting the flow of washed material from each agitator tank to the next cylinder tank; means for transferring the washed pulp from each cylinder to the next succeeding agitator tank, a plurality of storage tanks; means for circulating the wash liquor from each storage tank through an agitator tank and a cylinder tank; means for supplying to the storage tank, at the end of the apparatus at which the washed pulp is delivered, a stream of reltively pure wash liquor; and means for conducting from the storage tank at the other end of the apparatus the liquor containing the impurities washed from the fibrous material.

19. An apparatus for washing fibrous material, comprising a series of washing and screening instrumentalities arranged in alternation, means for transferring a constant stream of washed fibrous material from each screening instrumentality to the next succeeding washing instrumentality; means for continuously circulating wash liquor through each pair of washing and screening instrumentalities; and means for causing the body of wash liquor to flow in a constant stream in a direction opposite that in which the body of fibrous material travels.

20. An apparatus for washing fibrous material, comprising a series of washing and screening instrumentalities arranged in alternation, means for transferring a constant

stream of washed fibrous material from each screening instrumentality to the next succeeding washing instrumentality; means for forming successive pools of wash liquor and causing the wash liquor to flow through pools, in a direction opposite the direction of travel of the body of fibrous material; and means for circulating wash liquor from the series of pools through the respective washing and screening instrumentalities.

21. An apparatus for washing fibrous materials, comprising a storage tank for containing a pool of wash liquor, an agitator tank thereabove, a screen tank communicating with the agitator tank to receive the washed pulp and the liquor, means for feeding fibrous material continuously to said agitator tank, means for transferring the washed pulp from said screen tank, a pump for continuously feeding liquor from said storage tank to said agitator tank, an outlet box to receive the screened liquor, and an open conduit for conveying the screened liquor from the outlet box and having its delivery end submerged in the liquor in the storage tank.

22. An apparatus for washing fibrous materials, comprising a storage tank for containing a pool of wash liquor, an agitator tank thereabove, a screen tank communicating with the agitator tank to receive the washed pulp and the liquor, means for feeding fibrous material continuously to said agitator tank, means for transferring the washed pulp from said screen tank, a pump for continuously feeding liquor from said storage tank to said agitator tank, an outlet box to receive the screened liquor, an open conduit for conveying the screened liquor from the outlet box, and a substantially horizontal perforated conduit connected to the delivery end of said first-mentioned conduit and submerged in the pool in the storage tank.

23. An apparatus for washing fibrous materials, comprising a storage tank for containing a pool of wash liquor, an agitator tank thereabove, a screen tank communicating with the agitator tank to receive the washed pulp and the liquor, means for feeding fibrous material continuously to said agitator tank, means for transferring the washed pulp from said screen tank, a pump for continuously feeding liquor from said storage tank to said agitator tank, an outlet box to receive the screened liquor, an open conduit for conveying the screened liquor from the outlet box and having its delivery end submerged in the liquor in the storage tank, and means for automatically maintaining in said conduit a column of liquor above the level of the pool in the storage tank.

24. An apparatus for washing fibrous materials, comprising a storage tank for containing a pool of wash liquor, an agitator tank thereabove, a screen tank communicating with the agitator tank to receive the washed pulp and the liquor, means for feeding fibrous material continuously to said agitator tank, means for transferring the washed pulp from said screen tank, a pump for continuously feeding liquor from said storage tank to said agitator tank, an outlet box to receive the screened liquor, an open conduit for conveying the screened liquor from the outlet box and having its delivery end submerged in the liquor in the storage tank, a valve for the submerged end of said conduit, and weighted means for regulating said valve to maintain a column of liquor in said conduit above the level of the pool in said storage tank.

25. An apparatus for washing fibrous materials, comprising a storage tank for containing a pool of wash liquor, an agitator tank thereabove, a screen tank communicating with the agitator tank to receive the washed pulp and the liquor, means for feeding fibrous material continuously to said agitator tank, means for screening and transferring the washed pulp from said screen tank, an outlet box to receive the screened liquor, an open conduit for conveying the screened liquor from the outlet box and having its delivery end submerged in the liquor in the storage tank, and means for pumping the liquor from said pool into the agitator tank and having its delivery end submerged in the mixture of fibrous material and liquor therein.

26. A machine for washing paper pulp, comprising a tank, a couch roll, and a rotary screen cylinder, said cylinder having a rigid perforated metallic shell with an exposed smooth cylindrical surface.

27. A machine for washing paper pulp, comprising a tank, a couch roll, and a rotary screen cylinder, said cylinder having open heads, and an intervening rigid perforated relatively thick exposed smooth metallic shell.

28. A machine for washing paper pulp, comprising a tank, a couch roll, and a rotary screen cylinder, said cylinder having open heads, an intervening rigid perforated relatively thick metallic shell with an exposed smooth surface, and spaced means for bracing said shell internally against yielding under pressure of the couch roll.

29. A machine for washing paper pulp, comprising a tank, a couch roll, and a rotary screen cylinder, said cylinder having open heads, and an intervening exposed or uncovered relatively thick cylindrical metal shell, said shell having perforations therein formed in the solid metal.

30. A machine for washing paper pulp, comprising a tank, a couch roll, and a rotary screen cylinder, said cylinder having

open heads, an intervening exposed or uncovered relatively thick cylindrical metal shell, said shell having perforations therein formed in the solid metal, and closely spaced longitudinal bars or rods and spiders within the shell for preventing said shell from yielding under pressure of the couch roll.

31. In a machine for washing pulp, in combination a cylindrical roll and a couch roll for carrying the pulp from a bath and subjecting it to relatively severe compression at the nip to express the wash liquor therefrom, said cylinder having a substantially unyielding relatively outer exposed thick metal shell with perforations therethrough for the passage of the wash liquor, in combination with means for removing the pressed pulp from said couch roll.

32. An apparatus for washing paper pulp, comprising a series of sections, each having a storage tank for a pool of wash liquor, an agitator tank with a rotary agitator, a cylinder tank with a rotary open-end screen cylinder, out-flow boxes at the ends of said cylinder, vertical standpipes whose lower ends are submerged in the pool in the storage tank and whose receiving ends are open to the atmosphere and communicate with said out-flow boxes, and a pump for conveying liquor from said pool to said agitator tank; means for delivering fresh liquor to the storage tank of an end section and for discharging the liquor with its contained impurities from the storage tank at the other end section; means for causing the liquor to flow through the tanks in succession; means for transferring the washed pulp in the opposite direction from the cylinder of one section to the agitator tank of the next section; and means, graduated according to the density or specific gravity of the liquor in the several pools, for maintaining in said standpipe columns of liquor above the levels of the respective pools.

33. An apparatus for washing sulphate pulp, comprising a series of sections, each including a washing instrumentality, a screening instrumentality and a storage tank for containing a pool of wash liquor; means for transferring the pulp progressively in one direction from the screening instrumentality of one section to the washing instrumentality of the next adjacent section; means for circulating the wash liquor from the pool of each section through the washing and screening instrumentalities thereof; and means for preventing the passage of foam into the pools.

34. An apparatus for washing sulphate pulp, comprising a series of sections, each including a washing instrumentality, a screening instrumentality and a storage tank for containing a pool of wash liquor, means for transferring the pulp progressively in one direction from the screening instrumentality of one section to the washing instrumentality of the next adjacent section; means for circulating the wash liquor from the pool of each section through the washing and screening instrumentalities thereof; means for preventing the passage of foam into the pools; and means for causing the flow of wash liquor progressively from pool to pool in a direction opposite the direction of travel of the pulp through the said sections.

35. An apparatus for washing paper pulp, which comprises a series of communicating tanks for containing pools of wash liquor; means for delivering pure liquor to the pool at one end of the series and withdrawing the liquor from the pool at the other end of the series, a series of associated tanks for containing baths of liquor; means for circulating liquor from said pools through said baths; means for transferring the pulp progressively through said baths in a direction opposite the direction of travel of the wash liquor through said pools; and instrumentalities in said bath for washing the pulp therein.

36. An apparatus for washing paper pulp, which comprises a series of communicating tanks for containing pools of wash liquor; means for delivering pure liquor to the pool at one end of the series and withdrawing the liquor from the pool at the other end of the series, a series of associated tanks for containing baths of liquor; means for circulating liquor from said pools through said baths; means for transferring the pulp progresively through said baths in a direction opposite the direction of travel of the wash liquor through said pools; instrumentalities in said baths for washing the pulp therein, and means for by-passing the mixture of pulp and liquor around any one of said baths to the next succeeding bath.

37. An apparatus for washing pulp, comprising an elongated trough having partitions of decreasing height dividing it into communicating storage tanks for pools of wash liquor; a series of associated washing and screening tanks supported on said trough having instrumentalities for washing the pulp and rotary screens for screening the pulp from the wash liquor; means for circulating wash liquor from each storage tank through its associated tanks; and means for transferring the pulp from the rotary screens of each washing tank to the next succeeding washing tank.

38. An apparatus for washing pulp, which comprises a storage tank for a pool of wash liquor; an agitator tank and a cylinder tank thereabove having an agitator and an open-end rotary screen or cylinder respectively; means for removing the stock from said cylinder, a pump and conduit for supplying liquor from the storage tank to the agitator tank; out-flow boxes at the ends

of the cylinder to receive the screened wash liquor, vertical conduits arranged to receive the liquor from the out-flow boxes and having their upper ends exposed to the atmosphere and their lower ends submerged in the wash liquor in the storage tank; valves located at the submerged ends of said vertical conduits; flexible members sustaining said valves and passing through said vertical conduits; pulleys over which said members pass; and weights on the free ends of said members to maintain said valves closed until columns of liquor of the desired height are formed in said vertical conduits.

39. An apparatus for washing pulp, which comprises a storage tank for a pool of wash liquor; an agitator tank and a cylinder tank thereabove having an agitator and an open-end rotary screen or cylinder respectively; means for removing the stock from said cylinder, a pump and conduit for supplying liquor from the storage tank to the agitator tank; out-flow boxes at the ends of the cylinder to receive the screened wash liquor, vertical conduits arranged to receive the liquor from the out-flow boxes and having their upper ends exposed to the atmosphere and their lower ends submerged in the wash liquor in the storage tank; valves located at the submerged ends of said vertical conduits; flexible members sustaining said valves and passing through said vertical conduits; pulleys over which said members pass; weights on the free ends of said members to maintain said valves closed until columns of liquor of the desired height are formed in said vertical conduits; and a perforated pipe or manifold submerged in the liquor in said storage tank for receiving the liquor delivered from said vertical conduits.

40. An apparatus for washing pulp, which comprises a storage tank for a pool of wash liquor; an agitator tank and a cylinder tank thereabove having an agitator and an open-end rotary screen or cylinder respectively; means for removing the stock from said cylinder, a pump and conduit for supplying liquor from the storage tank to the agitator tank; out-flow boxes at the ends of the cylinder to receive the screened wash liquor, vertical conduits arranged to receive the liquor from the out-flow boxes and having their upper ends exposed to the atmosphere and their lower ends submerged in the wash liquor in the storage tank; and adjustable gates or dams between said out-flow boxes and said vertical conduits.

In testimony whereof we have hereunto affixed our signatures.

ORTON B. BROWN.
HUGH K. MOORE.
HOWARD PARKER.
HERMAN M. MARTINSON.