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Ahlquist

[11] **3,724,668**

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[54] **ADJUSTABLE SKIP BRIDGE VALVING MECHANISM FOR DISC FILTER**

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[73] Assignee: **Erie Development Company,** Cleveland, Ohio

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[52] **U.S. Cl.** **210/331,** 210/347

[51] **Int. Cl.** **B01d 33/26**

[58] **Field of Search**...............210/331, 333, 347, 486

[56] **References Cited**

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Primary Examiner—Frank A. Spear, Jr.

Attorney—Roy Davis, John C. Tiernan and Wm. A. Skinner

[57] **ABSTRACT**

In operating a disc filter an improved control of the dryness of the filtercake is obtained when the vacuum bridging is extended to the extremity of the sector being totally out of the slurry and then "skipping" a portion of vacuum bridging at the lower (i.e., submerged) level of the sector.

2 Claims, 17 Drawing Figures

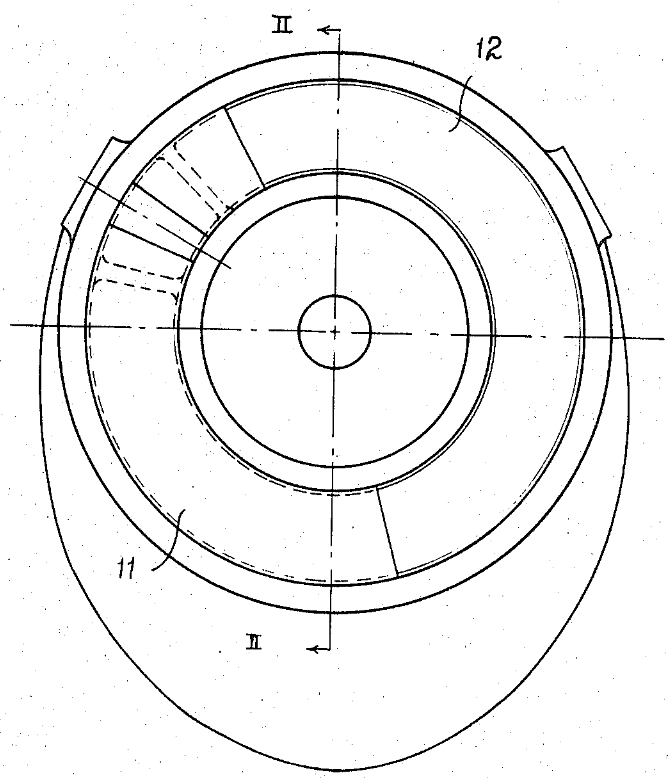

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Fig. 1

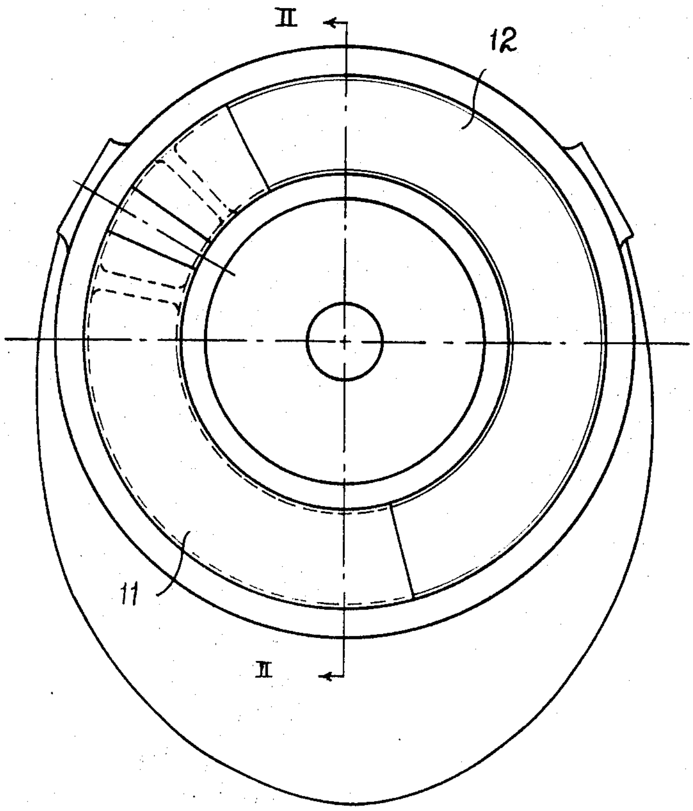


Fig. 2

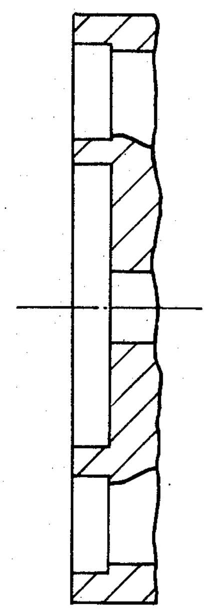
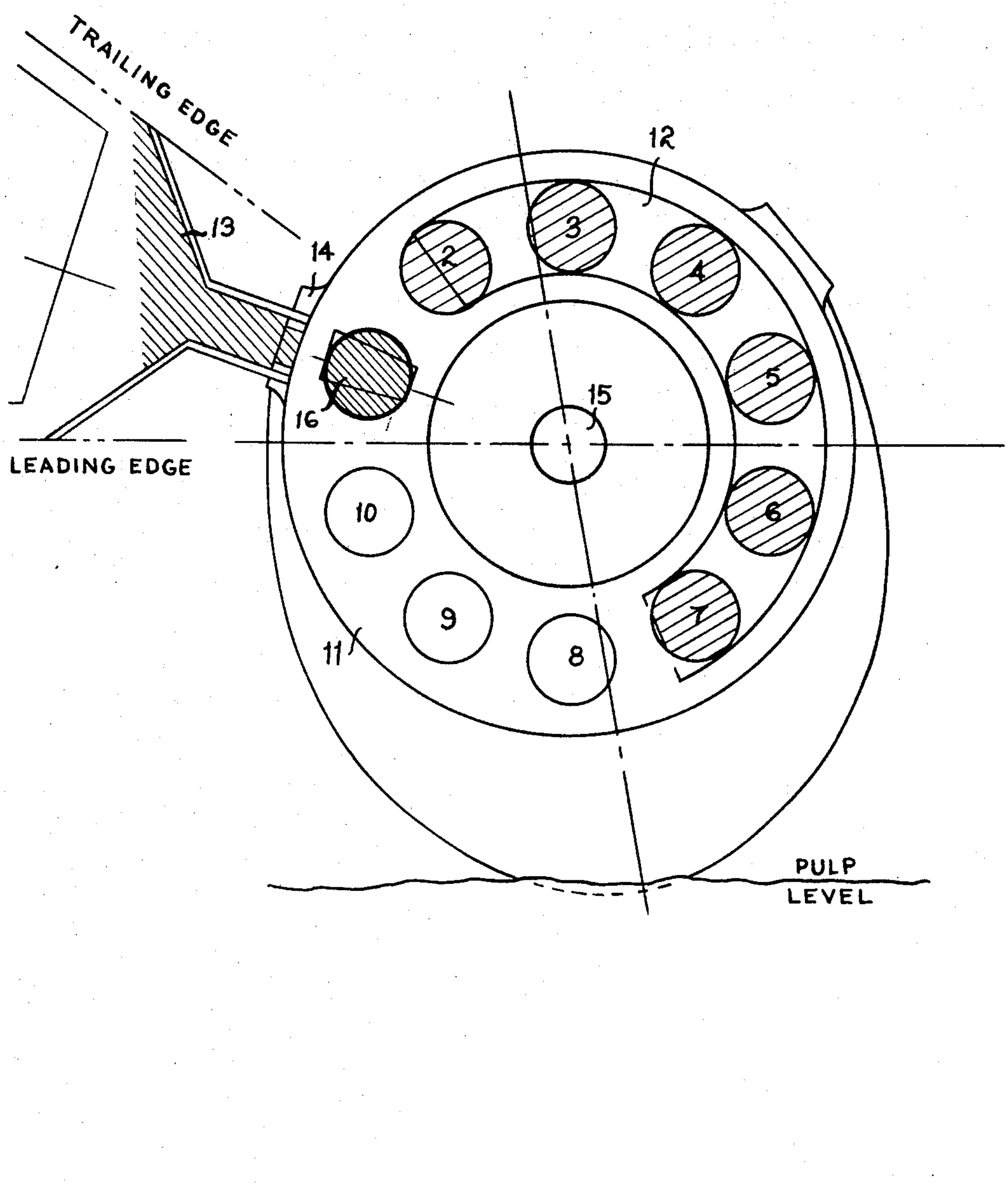


Fig. 3


TRAILING EDGE
12
13
14
2
3
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5
15
16
LEADING EDGE
10
6
7
9
8
11
PULP
LEVEL

Fig. 4

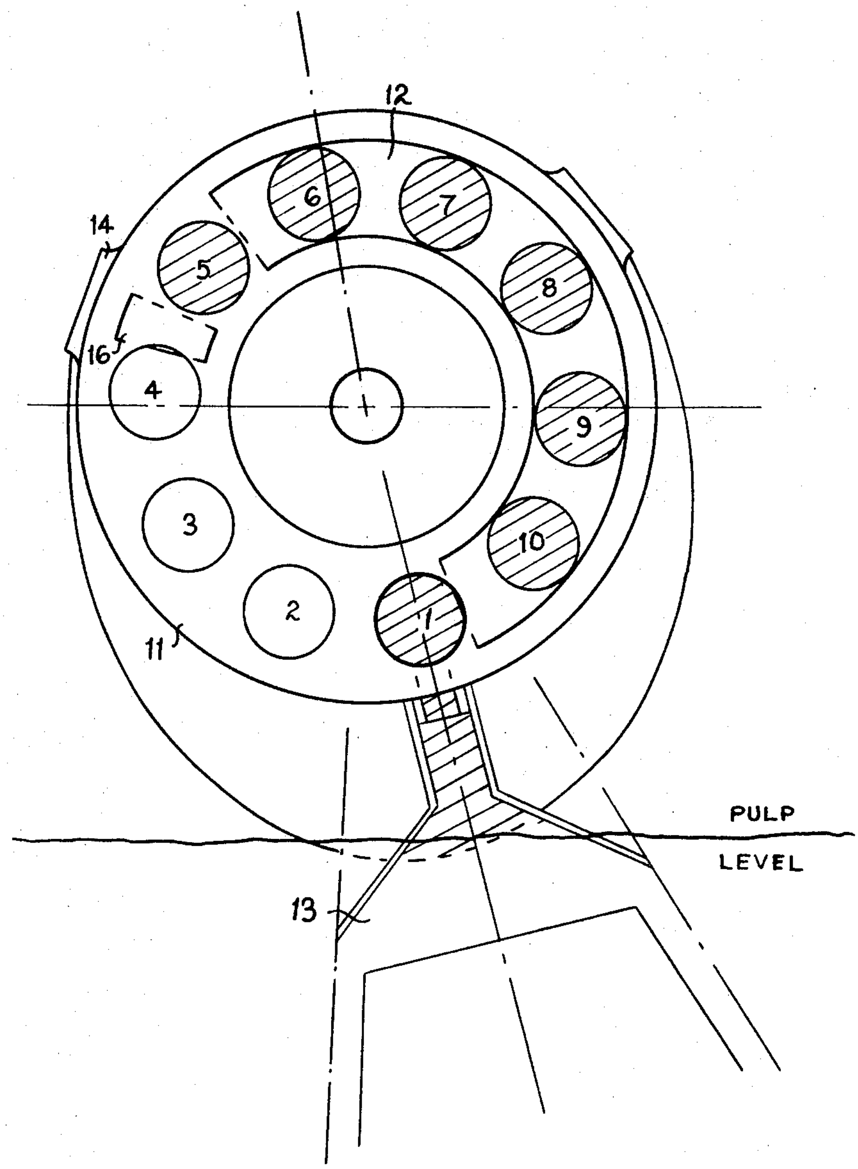


Fig. 5

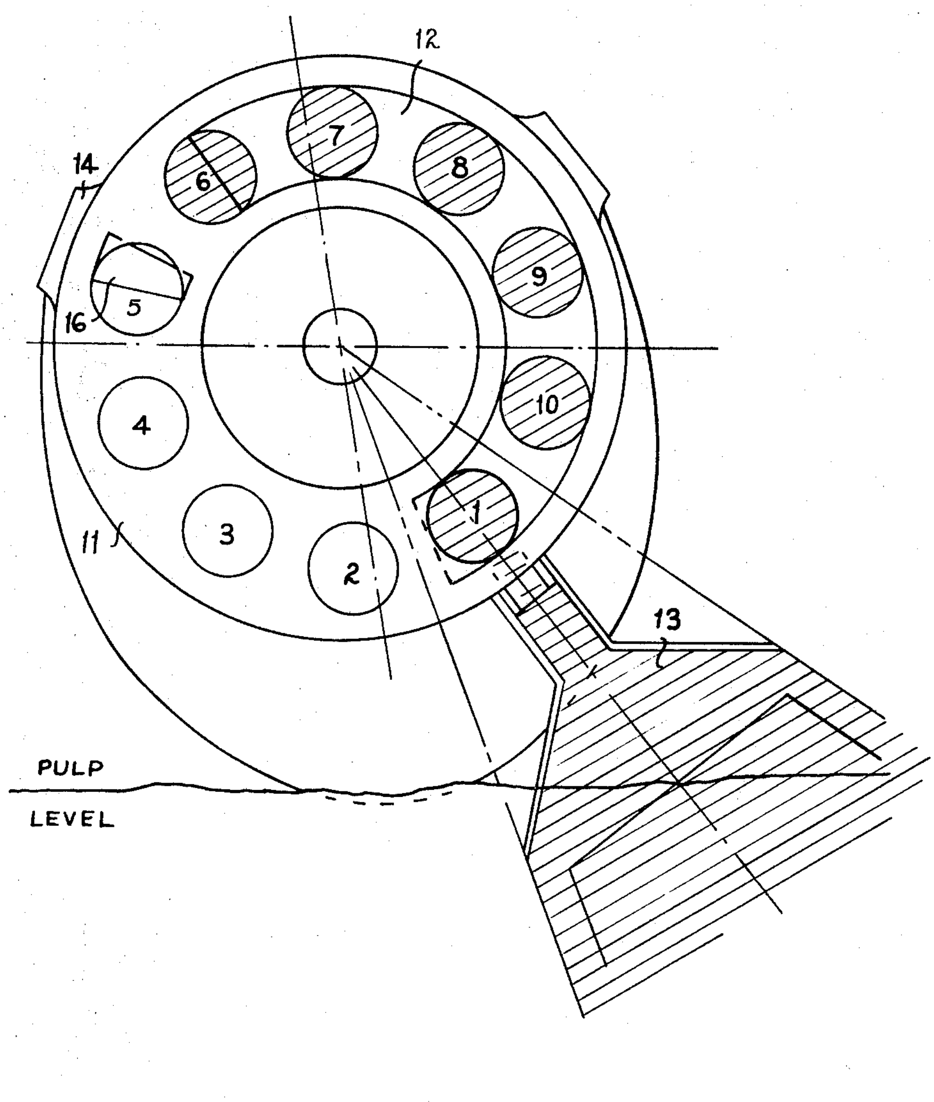


Fig. 6

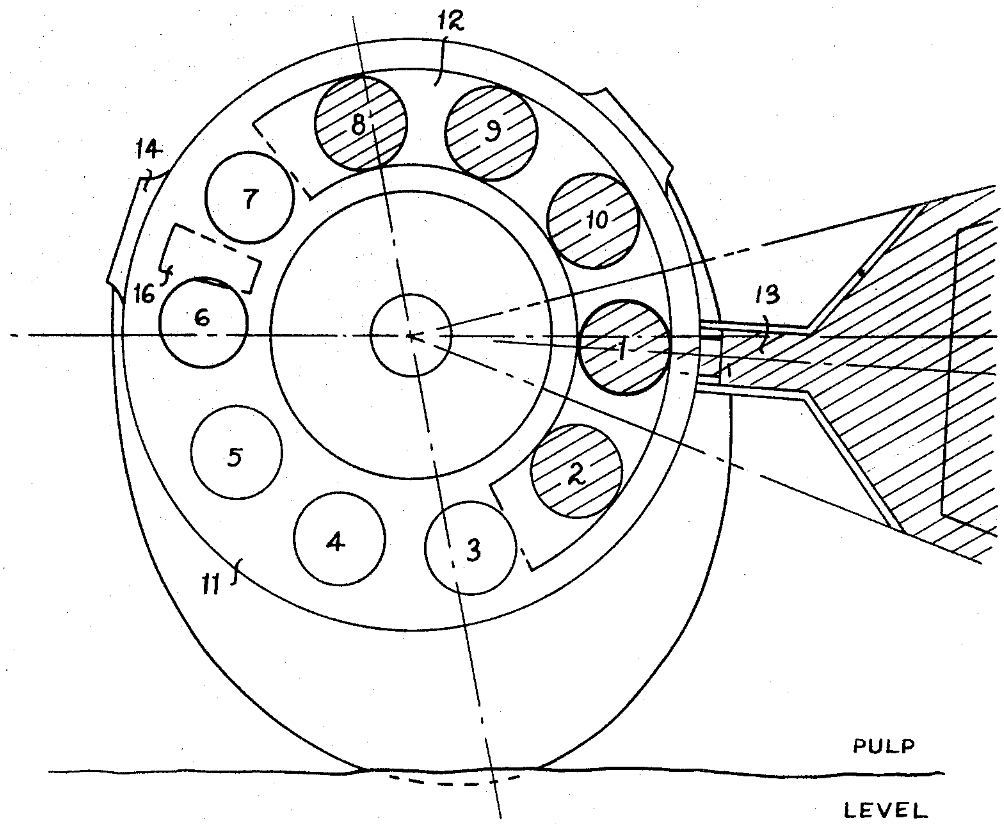
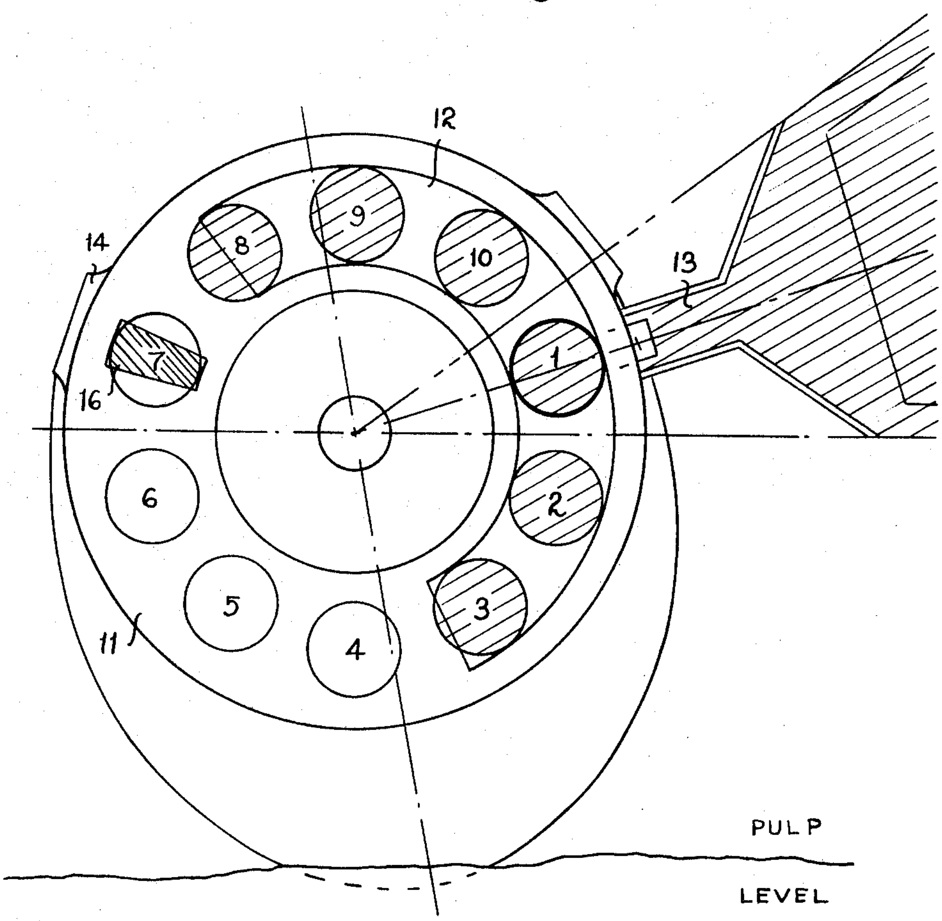


Fig. 7



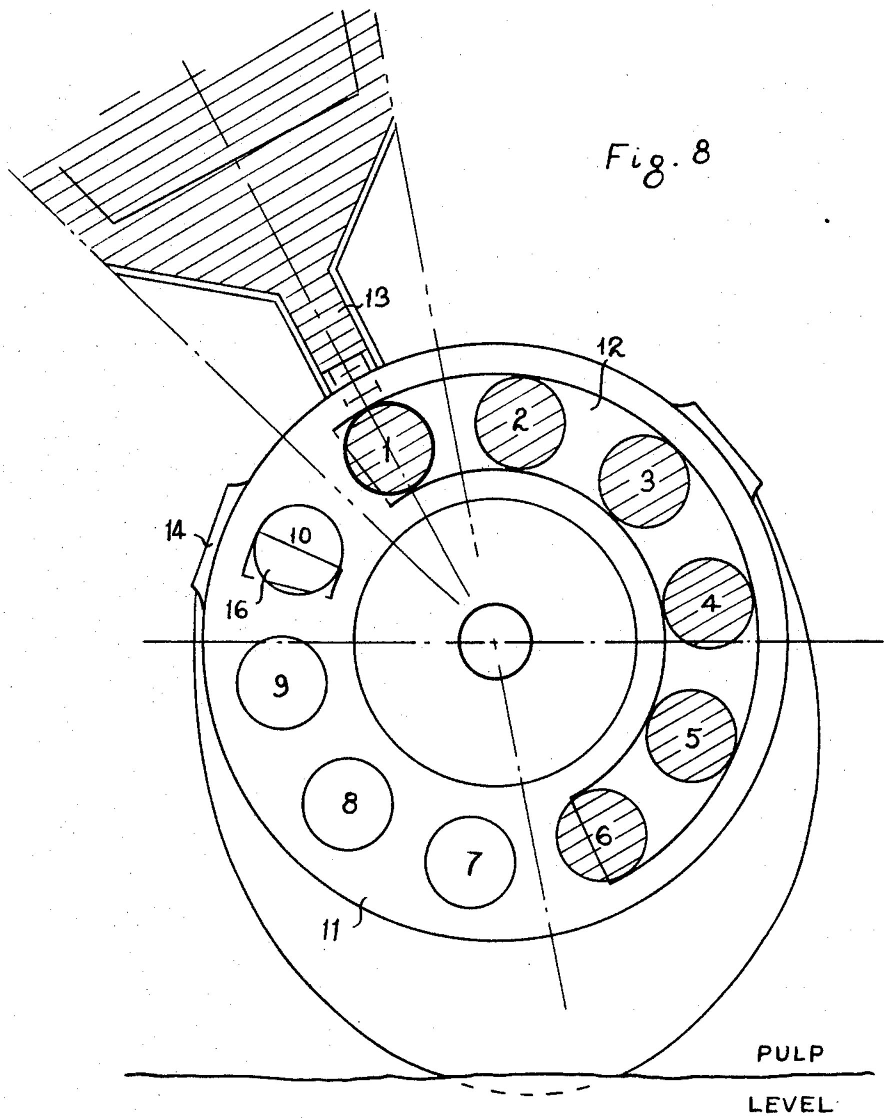


Fig. 8

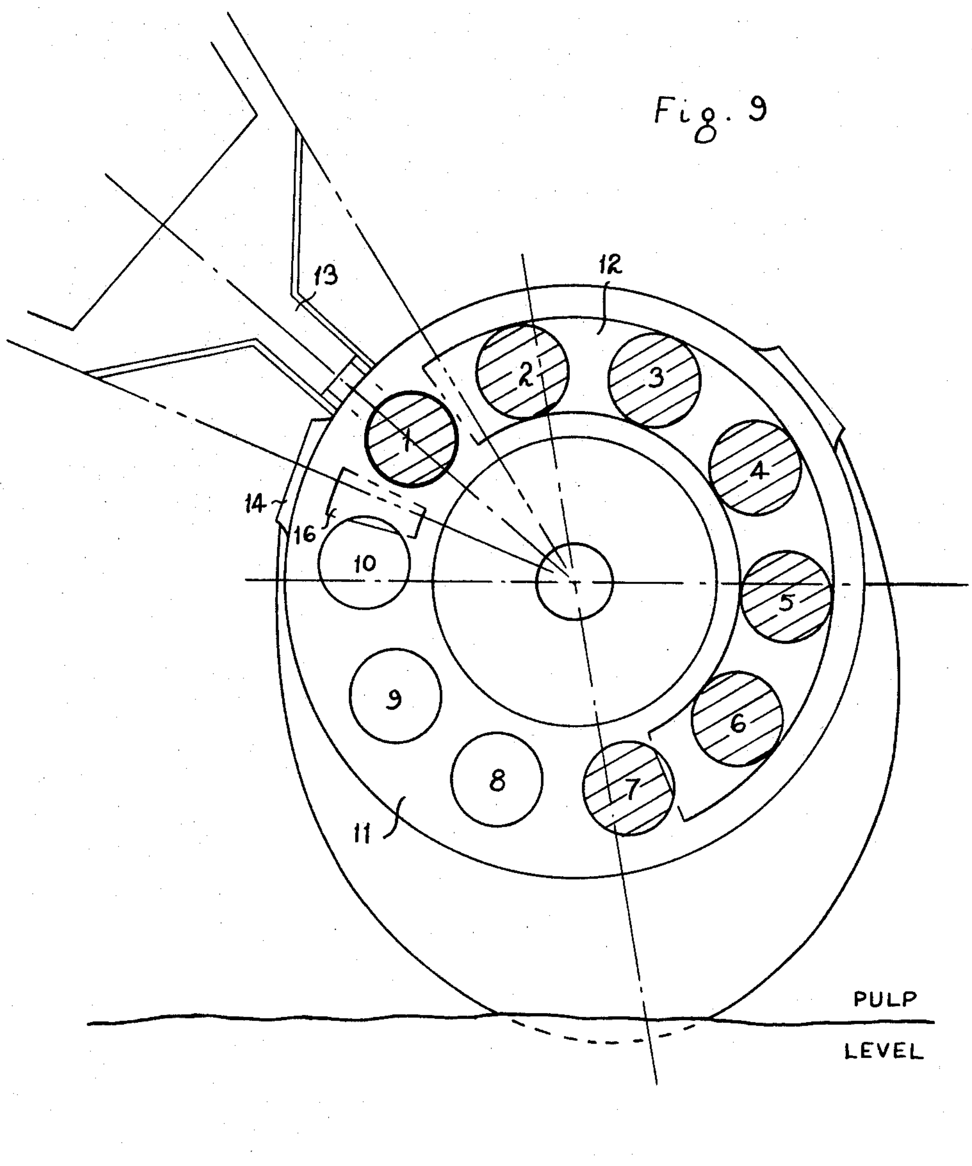


Fig. 9

Fig. 10

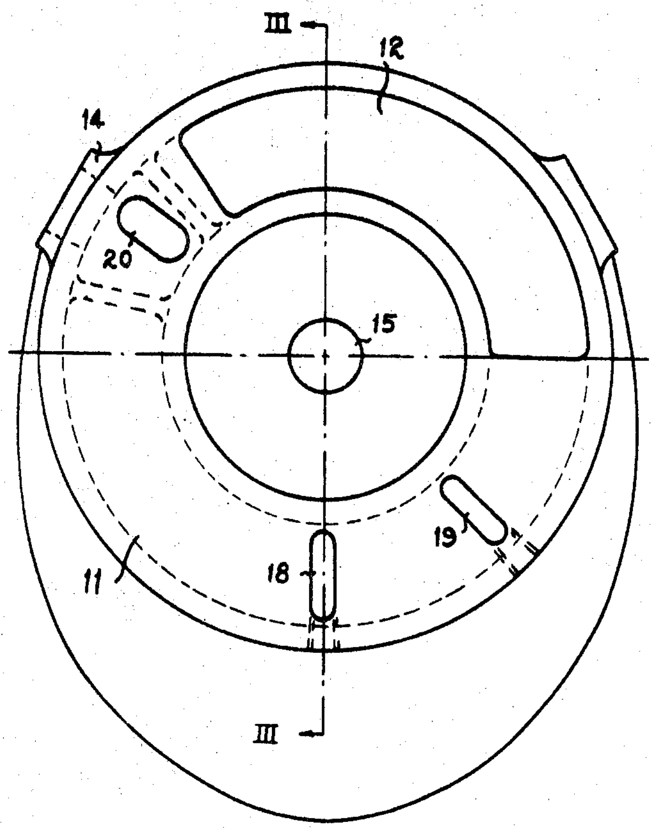


Fig. 11

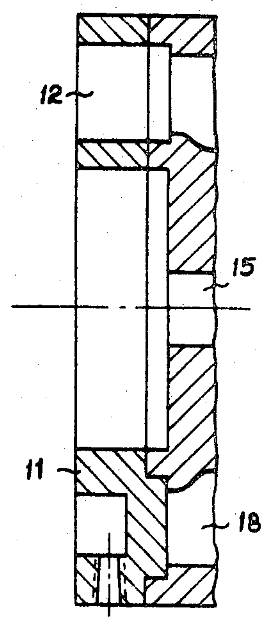


Fig. 12

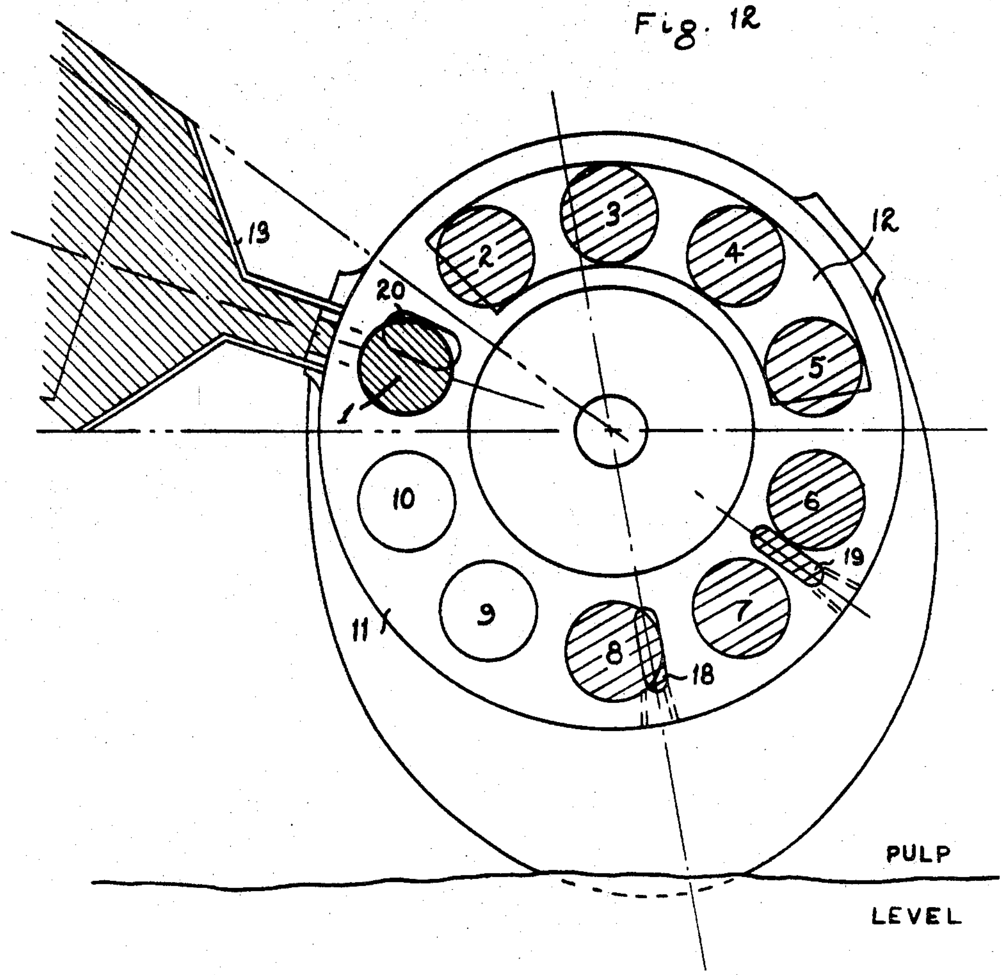


Fig. 13

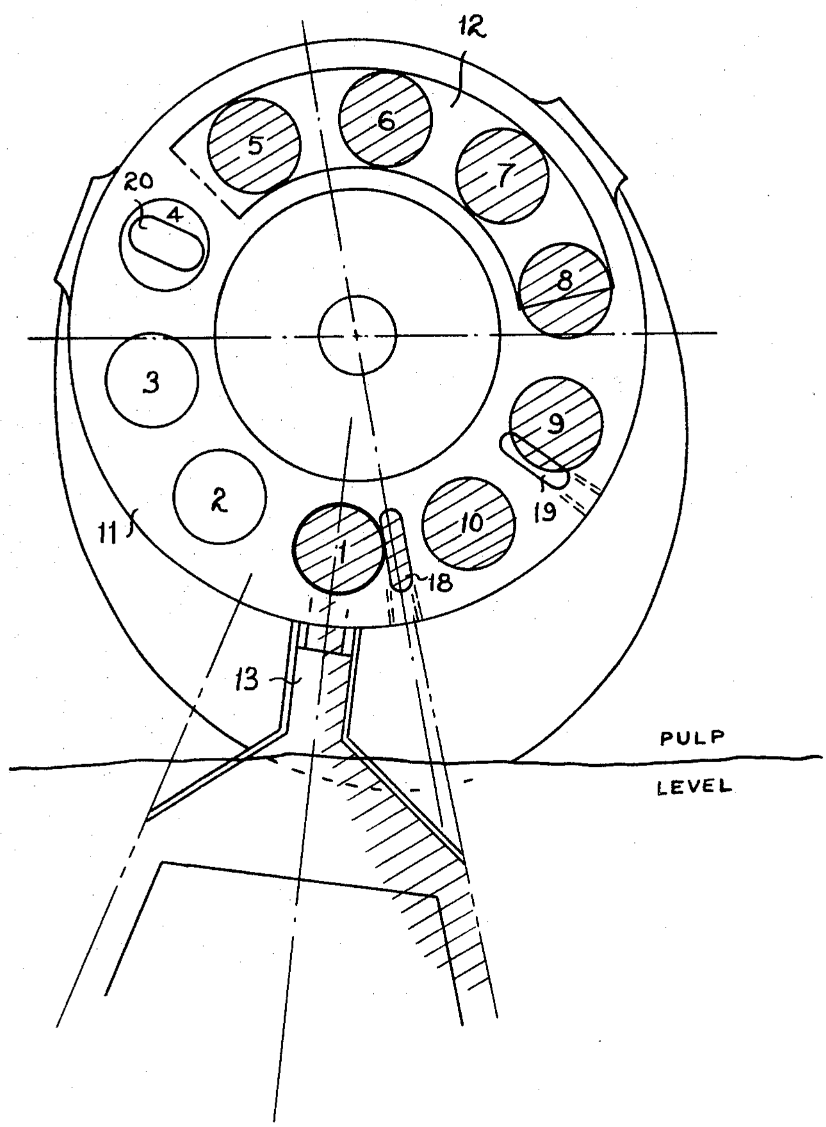


Fig. 14

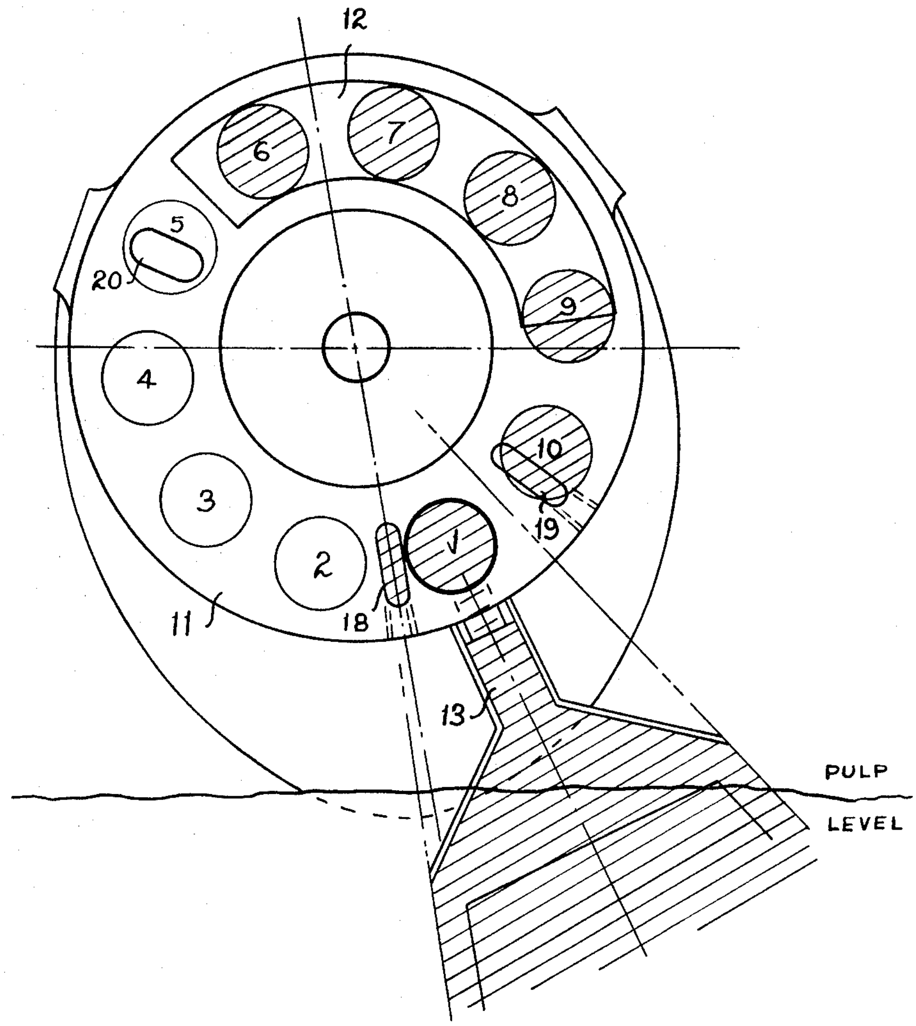


Fig. 15

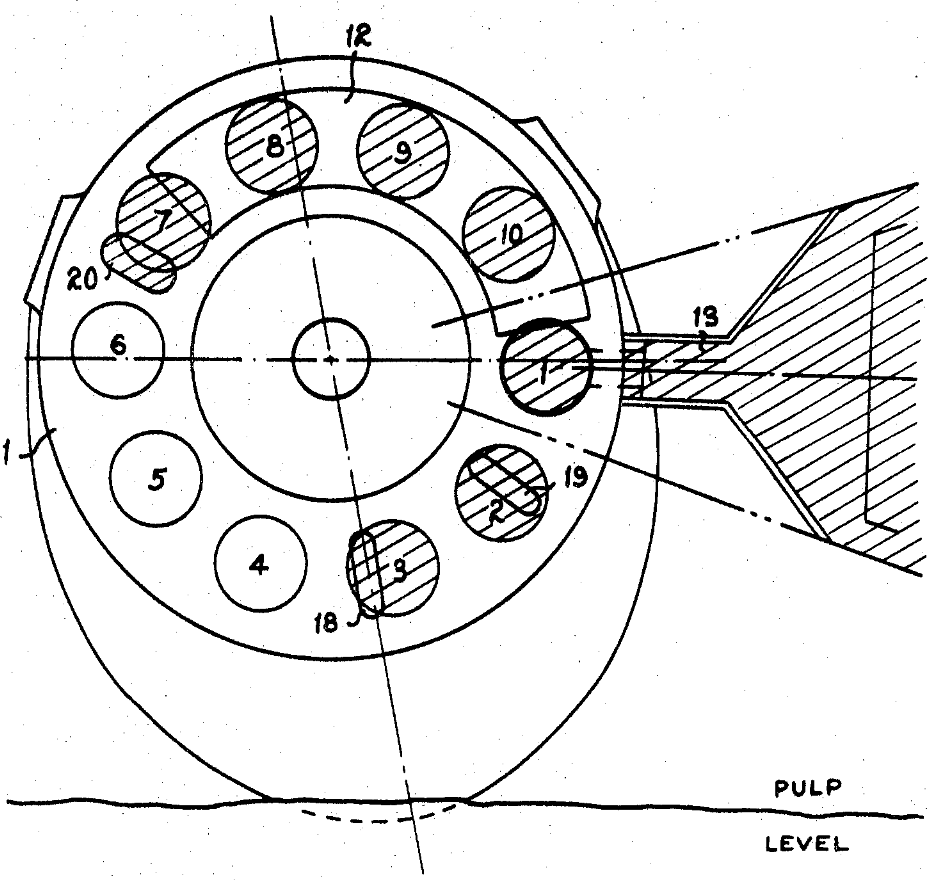
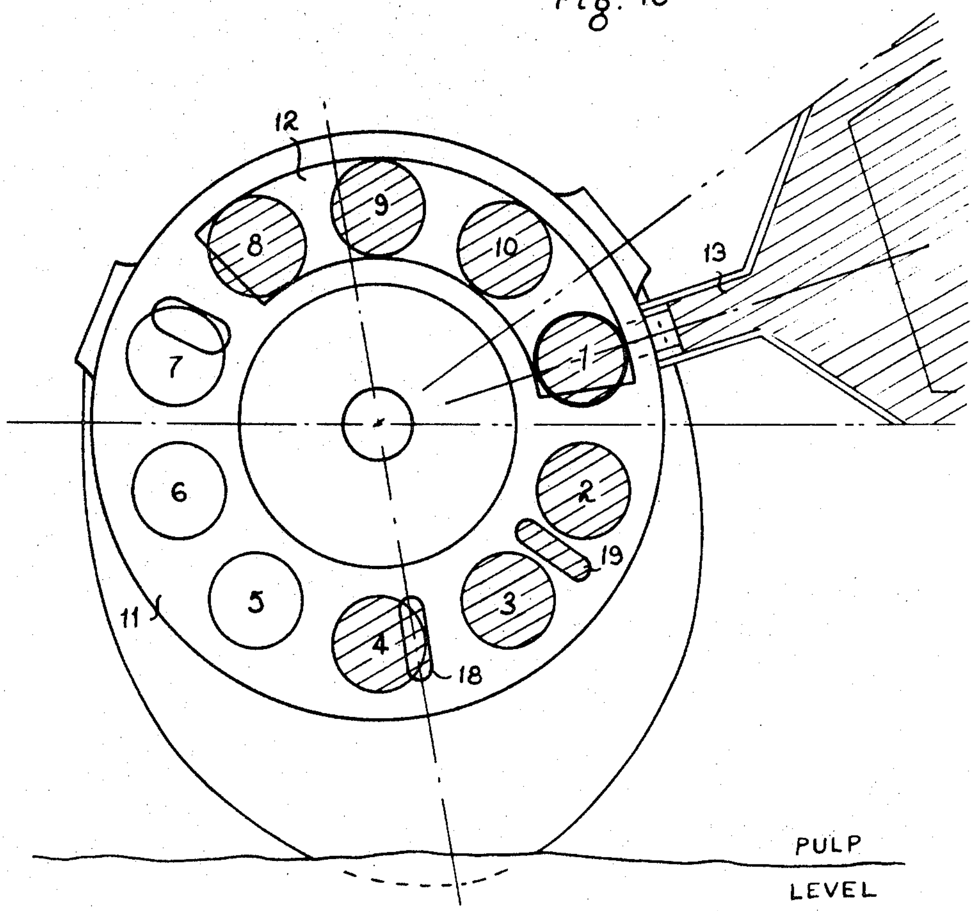


Fig. 16



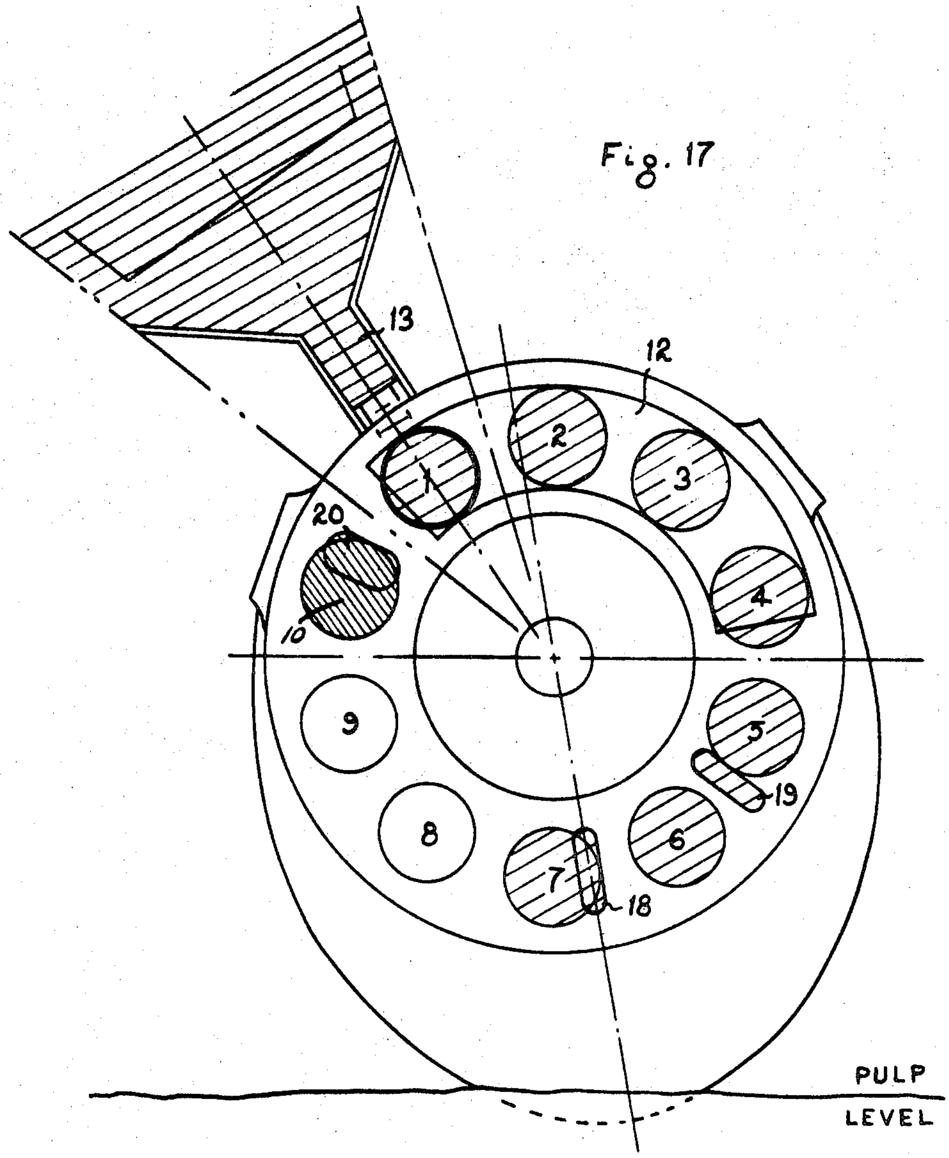


Fig. 17

ADJUSTABLE SKIP BRIDGE VALVING MECHANISM FOR DISC FILTER

This invention relates to the vacuum filter art, and is concerned with an improved valving mechanism for a continuous vacuum filter of the disc type.

The filtering apparatus to which the present invention relates as an improvement is a continuous vacuum disc filter such as is described under the designation "American Filter" on pages 1008 **rotatable et seq. of Taggart "Handbook of Ore Dressing,"** 1927 edition. A plurality of discs are disposed in spaced relation along a hollow shaft, each such disc being composed of a plurality of radially extending filter cloth-covered, (textile or metal), filtering sectors ("paddles") the hollow interiors of which communicate with suction lines located within the hollow shaft. The suction lines are independent from each other, and are connected each to a row of sectors (one from each disc) and terminate at one or both ends of the shaft with matched valve heads. The shaft being rotatable and the valve heads stationary and connected to vacuum and air supplies, rotation causes the sectors of the discs to be successively dipped into a slurry (pulp) for cake deposition by vacuum application and rotationally lifted out of the slurry for dewatering ("drying") by vacuum application and then removal of the filtercake by suitable means for capture and transportation away from the filter.

There are three major methods of cake removal all of which are usable with the present invention:

1. Scraper — simply a blade that scrapes or shears the cake from the sector surface.
2. Continuous Blow — involves insufficient bridging between the vacuum and pressurized blow port to prevent mingling of the two.
3. Snap Blow — the blow air is only introduced for a very short duration and timed through a cam actuated switch and solenoid valve.

The present invention will be described with particular reference to a series of FIGS. of drawing beginning with FIG. **10** and extending to FIG. **17** inclusive. This showing is prefaced by a explanation of what occurs in the operation of a conventional disc filter as represented in FIGS. **1–9** inclusive.

FIG. **1** represents a vacuum valve of a conventional vacuum disc filter;

FIG. **2** is a cross-sectional view taken along line II—II of FIG. **1**;

FIGS. **3–9** inclusive sequentially represent the course of a revolution of the filter about the axis of the filter shaft, in which

FIG. **3** shows the attitude of the filter at the moment when sector I is about to have the filtercake removed from the filtering surface;

FIG. **4** shows the attitude at the moment when the filter "paddle" of sector I is fully submerged in the slurry;

FIG. **5** represents the situation at the moment that sector I is being lifted from the slurry;

FIG. **6** shows the condition in which cake deposition has been completely stopped at sector I and the leading edge of the sector already has begun to undergo drying;

FIG. **7** shows the attitude of the subject sector when filtrate starts to flow from the interior of the sector;

FIG. **8** shows the condition at which the subject sector has traversed the most nearly ideal internal drainage phase;

FIG. **9** represents a possible variant wherein bridging between vacuum ducts is reduced from the conventional;

FIG. **10** represents the valve head of a vacuum disc filter in accordance with the present invention;

FIG. **11** is a cross-sectional view of the valve head shown in FIG. **10**, taken on line III—III of FIG. **10**;

FIGS. **12–17** inclusive parallel FIGS. **3–9** inclusive but differ therefrom solely in an exposition of the application of the principles of the present invention to the valve head of an otherwise conventional vacuum disc filter.

In these figures of drawing, the several reference numerals have the following meanings:

1 – 10 represent a series of ten sector apertures;
11 — wear plate;
12 — drying zone;
13 — a filtering sector;
14 — blow air connection;
15 — tubular journal;
16 — blow port.

THE PRESENT ART OF FILTERING

FIG. **1** shows a general form of vacuum valve (the opposite end of the filter shaft uses configuration of the opposite hand) with its inserted bridge blocking. The extension or arc length of the bridge blocking depends on the filterability of the material as determined by bench test or experience. Its primary purpose is to limit the arc time of cake formation and is obviously alterable but not adjustable.

Sequential FIGS. **3–9** inclusive are used to explain the main action of the conventional machine and point out advantages and disadvantages. The figures are elevated views from the disc side of the shaft-vacuum valve contact and emphasize the affect on a single row of sectors and indicate the subsequent effects occurring simultaneously on the other nine rows. A portion of the involved sector, as well as the slurry or pulp level, is shown to provide a degree of relativity. The cycle will be started at the blow or cake removal position.

FIG. 3

The entire valve head (stationary portion) is positioned to provide filter cake release when the backing edge of the sector is horizontal, at which point the cake will fall clear of the filter tube slots. Standard practice dictates that the shaft tube be centered on the blow slot. [It has been judged that a better timing places the slot high to the shaft tubing exposure when the "snap blow" air is applied to minimize transportation of any accumulated filtrate back to the filter-cake.] The duration of the timed compressed air application is sufficiently short to permit full explosure of the blow port to the shaft tube.

FIG. 4

With the assembled bridging of 130° measured from the blow port, the subject row of sectors reaches this relative position at the moment the vacuum begins to be admitted to the sectors for the cake formation or pickup phase. Tube **1** has transversed the bridged-off vacuum arc of contact, with which latter tubes **2, 3** and **4** are in contact. As indicated, tube **1** is commencing exposure to vacuum at this point, and cake formation does begin and advances at a rate commensurate with the disc speed, pulp solids, particle size, etc.

FIG. 5

The subject row of sectors has advanced to full exposure to vacuum. The size of the shaft tube and the "hole circle" equates to 26° of rotation. It is evident that in this much advance, part of the leading edge of the sector has already parted from the pulp and no additional cake can be acquired or deposited on any portion not exposed to pulp with or without vacuum. This then represents the maximum to which the bridging can be advanced. It also helps to explain why the 130° or more extended bridging actually begins to produce wetter cake but not necessarily thicker (or, more) cake. With vacuum continuously applied (once started), and only the trailing edge exposed to pulp, the leading edge has thinner cake and the trailing edge acquires thicker cake. Thicker cake being the wetter cake as well as proportionally more of it, the weighted average moisture of the total sector (or filter) output is higher than if all cake thickness were equal. It has been found that the extra drying arc of the leading edges lesser material does not compensate for the excessive thickness differential.

It then follows that the bridging does reach an allowable maximum and pulp solids and disc speed must be adjusted to provide the material production within the limits of installed filter area (size and number of sectors). Moisture would then be consequent to those adjustments; or, moisture could be adjusted and capacity consequent.

It should be pointed out that there is a masking effect due to a preformation of cake caused by a hydrostatic difference between the pulp in the filter tank and the empty sector interior, though no vacuum has been applied. Also, due to relative movement of the sealing of the bridge is not absolute and some leakage of vacuum to the tubes does occur. Further, reduction in rotational speed increases the time or effect of this leakage. The leading edge shown above the pulp layer actually does not present a naked surface, but does have some filter cake deposition because of this preformation.

FIG. 6

At this position the subject row of sectors has just completely exited from the pulp and thus all cake deposition has stopped. The leading edge has been drying (dewatering) provided the sector interior has not been flooded by filtrate excess (by pulp dilution and/or cake quantity deposition relationship), while the trailing edge has not been drying due to the accumulation by gravity of filtrate in the sector interior.

FIG. 7

At this point the trailing edge sector interior has reached the horizontal and filtrate can start to flow away internally from contact with the external filter-cake. The amount of filtrate, of course, is dependent on the amount of cake deposited and the degree of dilution the slurry had before forming the cake. It is then obvious that the highest degree of solids (lowest volume of filtrate) possible would provide the longest total drying time.

There is an additional compounding effect which makes high dilution (low solids) operation or control by dilution undesirable. That is the fact that there is an increasing rate of filtrate production over and above the plain proportional increase of the increased dilution. This can be explained by the fact that the last incremental layer of solid particles is furthest away from the vacuum source and closest to the stripping action of the attrition and turbulence of the slurry. The more dilute the slurry the faster the vacuum is reduced for holding the cake and the more disturbing is the slurry for removing the last layer of the cake.

FIG. 8

The sectors have traversed through the most ideal internal drainage phase; that is, vertical, which can only be improved by extension of time by lower disc speed or reduction of filtrate quantity by higher slurry percent solids. However, at this point the shaft tube commences to dam up against the bridging and filtrate can accumulate in the shaft tube to be blown back as described under FIG. **3**.

The shaft tube in actuality becomes a horizontal launder at this point because it is or should not be full of filtrate. Draining a horizontal launder produces the least amount of filtrate by high slurry solids and provides the most time for drainage by operating at the lowest disc speed.

In a competitive unit test, this physical condition became obvious. The competitive unit manufacturer had claimed improved drainagle through enlarged tubes. In reality, this would only be true on a full volume capacity, but would reverse the gain on the final drainage of the open launder condition of the larger tube at the end of the drying vacuum phase.

FIG. 9

This figure illustrates a possible variant. As provided, the original vacuum valves had full 28° bridging ahead of blow port to provide complete separation between vacuum ducting and compressed blow air ducting. However, this is only necessary when continuous blow air is used. When snap or cam/solenoid timed compressed air is applied, this bridging can be reduced to an arc degree equal to the "lands" between the shaft tube openings. This amounts to approximately 15° increase in the drying (dewatering) arc over an original 100° or so depending on where the drying is considered to have started (compare FIGS. **7** and **8**).

It has been shown with consistency, then, that low disc speed and high slurry percent solids are the real factors that provide the best drainage of the disc filter interiors. To permit the highest slurry percent solids operation the formation time must be reduced, but simple extension of the bridging beyond allowing the sector full immersion actually causes increase in the moisture. The interrelationship of the factors in the present art have also been shown to prevent independent control of cake quantity and cake moisture.

The purpose of this invention is to permit the use of optimum levels of those factors, as well as to provide independent control of quantity and moisture of filtercake to provide a means of adjusting to the many other variables which effect filtercake moisture and quantity; in part such as:

a. Particle size and distribution
b. Particle shape
c. Particle metallurgy and/or chemistry
d. Vacuum supply level
e. Air temperature and humidity
f. Slurry temperature (filtrate viscosity)
g. Slurry density (percent water)
h. Slurry homogeneity (agitation)
i. Filter media
j. Time
k. Internal hydraulic design
l. Effective filter area, without or with combination effects of two, three or more levels of interaction.

THE NEW MODE OF FILTERING

FIGS. **10** and **11** show a general view of the skip bridge plate (the opposite end of the filter shaft again would use a configuration of the opposite hand) according to the invention. The distinct design characteristic is involved in the two slots in the lower portion of the bridge plate. The width of the slots must be less than the effective (allowance for worn or rounded edges) width of the solid spaces between the shaft tubes of the matching faces. The lower port is the primary control point for cake deposition while the upper port is primarily used for a reapplication of vacuum under adverse condition when vacuum depreciates too rapidly before the sector has rotated enough to receive the full vacuum of the drying port. If the vacuum depreciates too much, a condition of "cake slipping" occurs where the filtrate in the sector interior washes back through the sector face and the formed cake slips off into the slurry.

In addition to the unique position and width of the "-pick up" ports, there is additional control of cake formation by installation of a throttling valve in the ducting between the main vacuum supply and the individual port. This permits independent control of the vacuum applied through the port to the particular row of sections singly under that port's influence. This then permits independent control of cake thickness with respdct to disc speed at maximum slurry density and cake thickness control can be used for moisture control and disc speed for quantity control.

The skip bridge cycle will be traced by Figures, in the same manner as hereinabove.

FIG. 12

The subject (no. **1**) row of sectors is again in position with the leading edge horizontal to permit cake removal to the bin below. The blow porting, however, is located high with respect to the tube to minimize the blow back of the filtrate that may accumulate in the shaft tubing. Here again the "snap blow" cake removal is used which has already been explained.

FIG. 13

The shaft tube has just breached the pick-up port while the sector is totally submerged in the pulp. Due to fluid (gas) flow, the vacuum is applied to the sector row gradually; and with any chosen mechanical configuration, the rate of vacuum application would be dependent on shaft rotational speed. There are also interrelating effects on cake formation by such variables as slurry density, slurry temperature (filtrate viscosity), particle size, and so forth.

To separate these uncontrollable interrelating and dependent effects, a throttling valve is introduced between the vacuum supply and the pick-up port to control cake thickness independent of those other forces.

Consequently the "skip bridge" confines the cake formation so as to provide minimum variation and the vacuum throttling valve provides independent cake formation control adjustment.

FIG. 14

The shaft tube has traversed the pick-up port and reentered a vacuum bridged portion while still at the totally submerged state. Though the cake formation applied vacuum is throttled, the sector has been exposed for an arc distance of *twice* the diameter of the shaft tube plus one width of the pick-up port, or approximately 62°.

FIG. 15

The full vacuum is reapplied just as the trailing corner of the sector leaves the pulp. The no. **2** tube is shown traversing the upper port. It is readily seen that should this port be used the sector is again only partially submerged when the vacuum is applied and differential cake thickness would result. However, situations of abnormal bag failure, bag replacement, or poor sector to shaft sealing will cause critical vacuum losses and some replenishment of vacuum by the upper port becomes a necessary evil. If it is not replenished, the cake will slip or be washed from the sector and the naked cloth remaining will allow even greater vacuum losses which will progress towards further slipping and loss of production and dryness.

FIG. 16

Drying or drainage again cannot be accomplished until the trailing edge has risen above the horizontal, so that filtrate can flow away from proximity with the filtercake.

FIG. 17

Again this is the point at which the accumulation of filtrate in the shaft tube occurs, though the vertical aspect of the sector still permits it to drain into the tube. However, the bridging between drying vacuum port and blow port has been reduced to an equivalent to the space between the shaft tubes. This extends the major drying arc by about 15° which is roughly a 15° increase from the starting point shown in FIG. **16**.

THE ADVANTAGE OF THE PRESENT INVENTION

From the detailed description of the conventional filter (FIGS. **1–9** inclusive) and the new filter (FIGS. **10–17** inclusive) it is realized that a disc filter operation can best be optimized with high feed slurry density and low disc rotational speed. Differently expressed, to affect the best dewatering, one should allow more time for less filtrate to drain from the mechanism. There are, of course, physical limits — such as too high a slurry density for flow, or too low a disc speed for reasonable capacity, and so forth.

Experimental results, within normal limits of disc speed and slurry density, indicated that the filtercake moisture varied directly as the cake thickness, and that disc speed and slurry density had no direct significant effect. This is not to mean that disc speed or slurry density did not affect filtercake moisture content: They do affect the moisture content, but only as they affect cake thickness. For example, by diluting the filter feed a temporary reduction in moisture can be obtained because of the reduced thickness of the filter-cake so formed. The effect is called "temporary" because the reduced cake thickness forces an increase in disc speed to produce the prescribed capacity and the end point of too much filtrate with too little time for drainage is quickly reached.

Of more significant concern was the variation of filtercake thickness formed on each and every sector (**10**) making up the full disc or multiple discs. It was found that simple extension of the vacuum bridging (FIGS. **1–9** inclusive) reduced the filtercake moisture — by reason of reducing the cake formation time and thus cake thickness — to a point and then reversed the condition and actually increased the filtercake moisture by expansion of the cake thickness differential (FIGS. **4** and **5**). The operation had become involved in the weighted average principle.

If the thicker cake formed on a part of the filter is wetter cake, it is also more cake than the thinner dryer cake and the average moisture of the total filter production will be wetter than if the total filter product were of even cake thickness to meet the same total output. Due to the differentially shorter draining and drying time of the trailing edge (FIGS. **6** and **7**) the condition was further aggravated into greater differential moisture.

The "skip bridge" resulted from the desire to reduce the cake formation arc time without increasing the differential in cake thickness as was occurring with extension of the standard vacuum valve bridging. It was affected by extending the vacuum bridging to the extreme point of the sector being totally out of the slurry and then "skipping" a portion of vacuum bridging at the lower or submerged level of the sector, thus the naming of the "skip bridge".

Experimentally this "skipping of a portion of the bridge," which by good reason was confined to the "lands" between the shaft tubes in width (as has been explained), still allowed thicker cake formation than tonnage required. From this fact developed the addition of the control or throttling valve between the vacuum supply and the pick-up port(s). The terminology of "Adjustable Skip Bridge" was then applied to this development to define and yet disguise the actual inner workings of the invention.

In the final analysis, the "adjustable skip bridge" provides controlled cake thickness independent of the disc speed and/or slurry density (within the limits of all variables and their interactions as previously noted) for the purpose of controlling the entrained moisture in the cake consistent with good balling (subsequent processing) and will permit use of variable disc speed specifically for control of production quantity.

As was noted, hereinabove, in connection with description re "The New Mode of Filtering", the valve head of the present invention may be installed at either end of the filter shaft.

I claim:

1. In a vacuum disc filter having a plurality of discs disposed in spaced relation along a rotatable hollow shaft each disc being composed of a plurality of radially extending, filter media-covered filtering sectors whose hollow interiors communicate with suction lines located within the hollow shaft and extending to a valving mechanism at one end of said shaft, said valving mechanism consisting of a multi-ported vlave head in communication with vacuum lines and with compressed air lines, said valving mechanism being programmed to effect sucking in sectors which are immersed in slurry and sectors undergoing drying and to effect an application of air at superatmospheric pressure in sectors withdrawn from slurry and about to be rotatably returned to such slurry, the improvement whereby overall dryness of filter-cake can be enhanced which improvement consists in that said valving mechanism includes a skip bridge valve head comprising (a) a stationary bridge plate having slots for a lower pick-up port and an upper pick-up port, a drying port and a snap blow port, and (b) a wear plate fixed to the end of the shaft and rotatable therewith in sliding engagement with said bridge plate there being in said wear plate as many spaced peripheral apertures as there are sectors per disc each said peripheral aperture being associated with at least one of the aforesaid lines and said peripheral apertures being separated from each other by intervening lands, said peripheral apertures registering with said slots, said slots being so much narrower than are the lands between the peripheral apertures of the wear plate as to prevent overlap or sharing between any two adjacent tubes and to ensure that application of vacuum to the pick-up ports is confirmed to only one line or row of sectors, at a time.

2. The invention defined in claim **1**, wherein improved timing is secured by placing the slot high with respect to the shaft tubing exposure when "snap blow" air is applied whereby to minimize return of filtrate to the filtercake.

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