July 14, 1953 S. G. NORDSTRAND 2,645,350

FLOTATION APPARATUS

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FIG. 1.

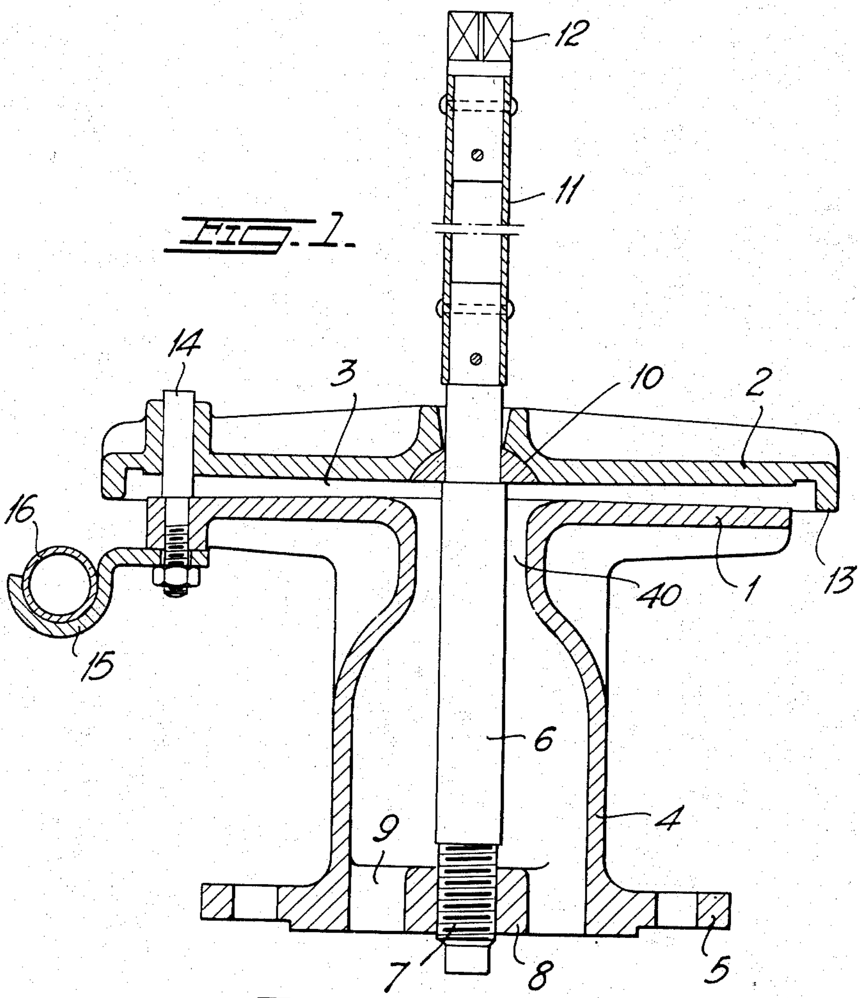
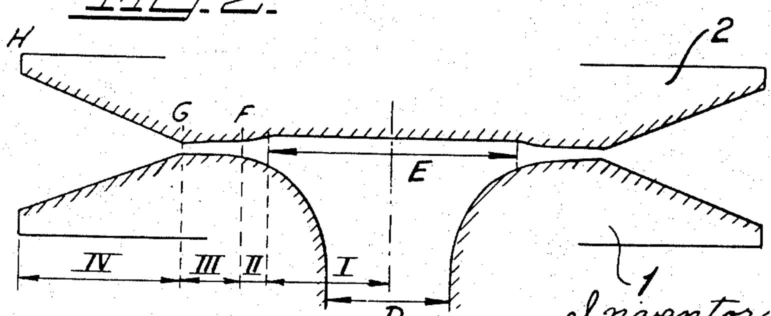


FIG. 2.



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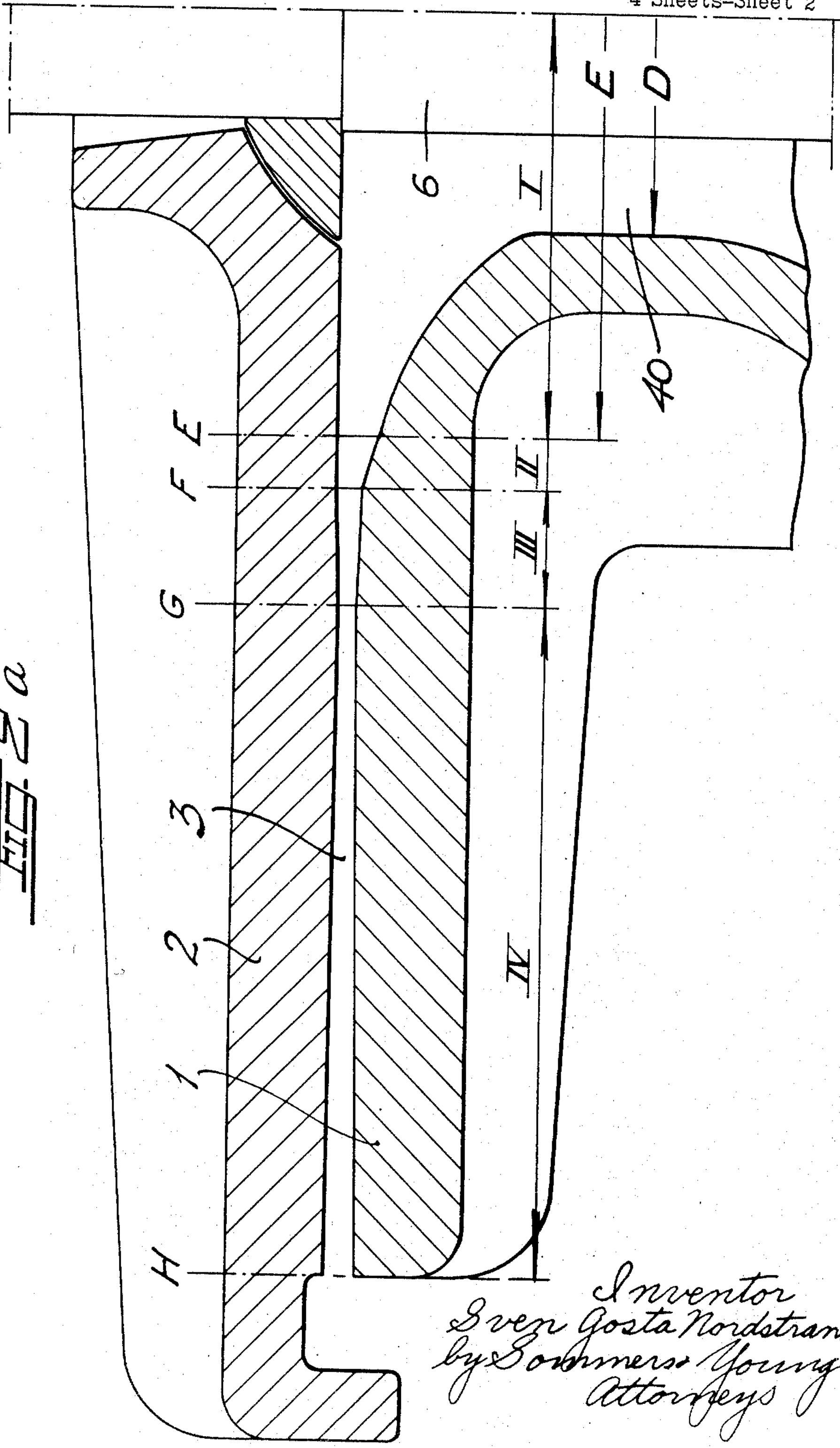

Fig. 2a

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FLOTATION APPARATUS

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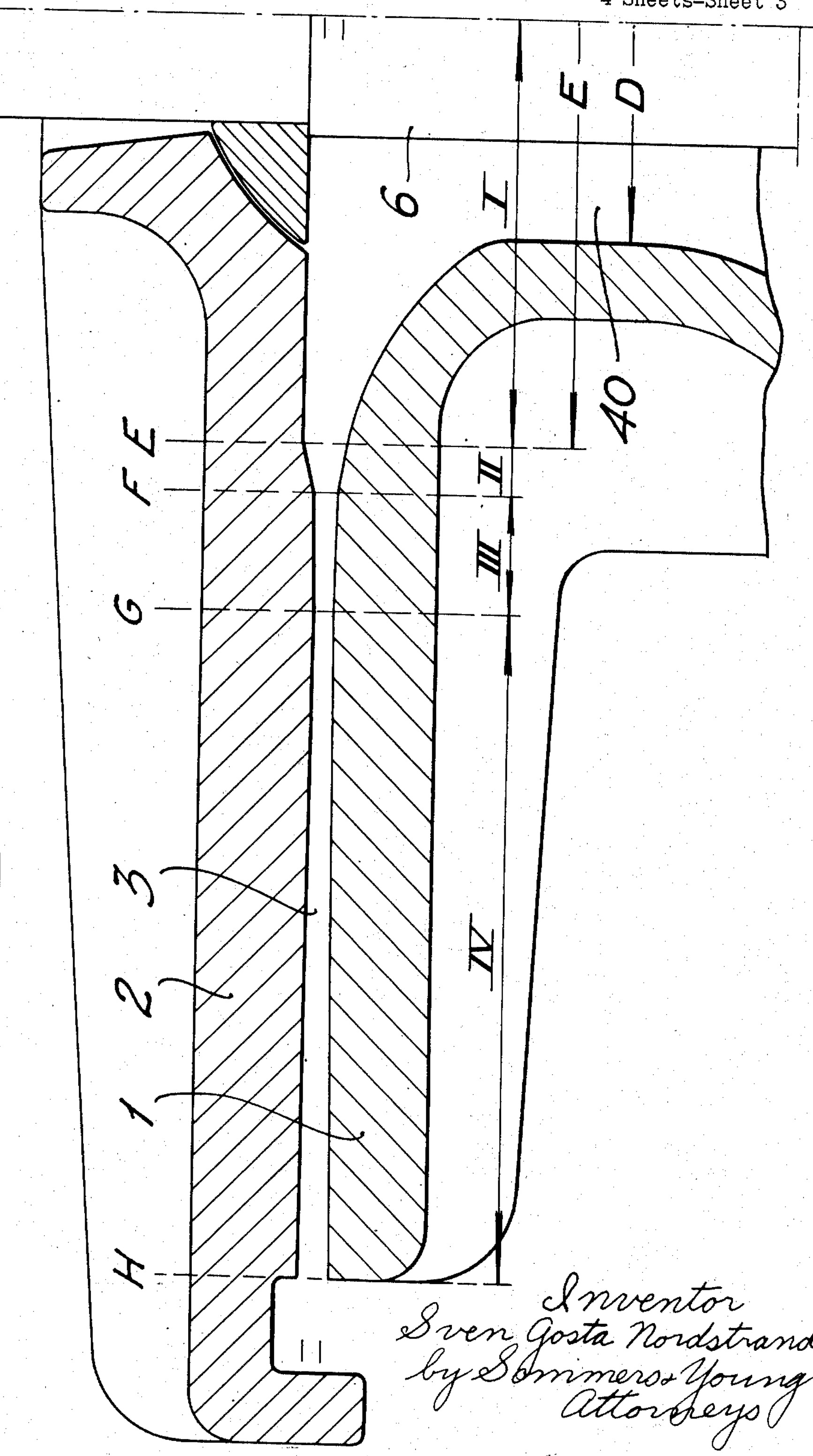

FIG. 2b

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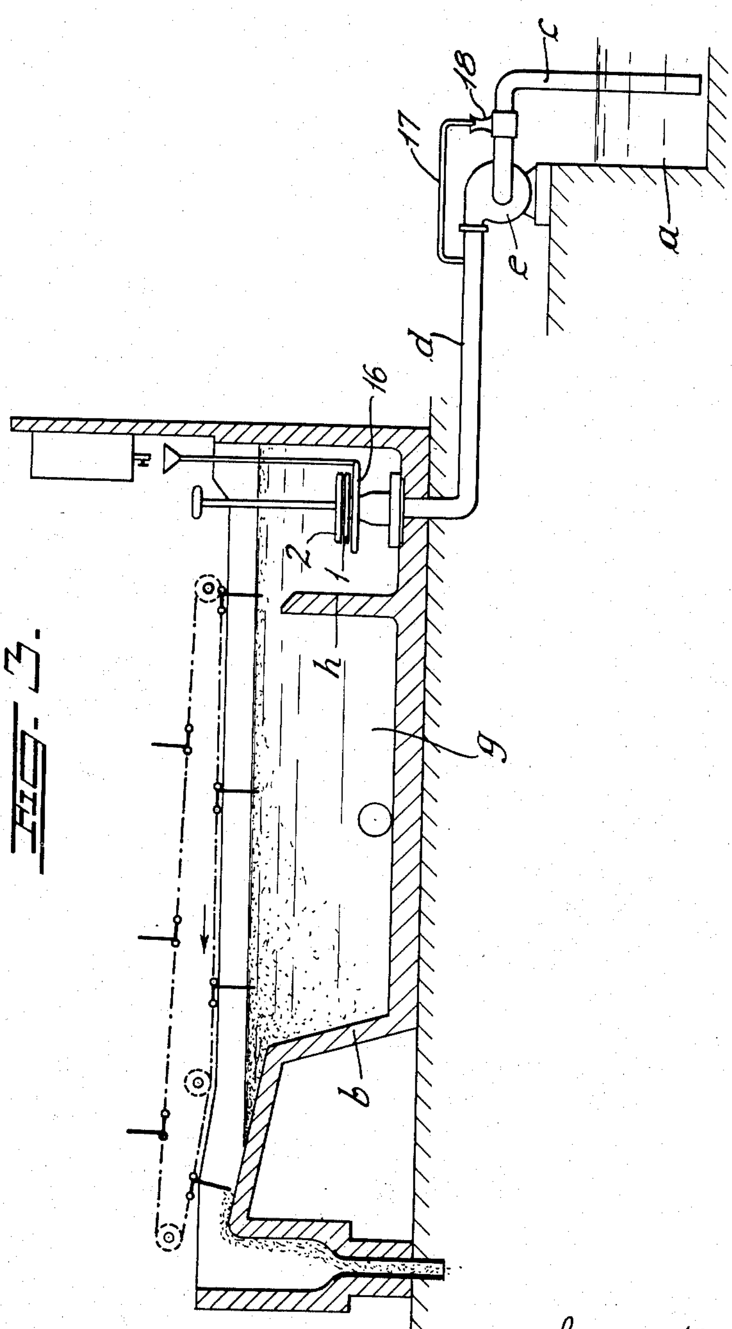

FIG. 3.

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FLOTATION APPARATUS

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Application April 13, 1948, Serial No. 20,782

4 Claims. (Cl. 210—53)

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In order to recover solid substances suspended in a liquid as water, by a flotation process, it is already known to dissolve a gaseous medium, usually air, under pressure in the liquid and then let the suspension with the gaseous medium dissolved therein pass through a nozzle in which the pressure energy of the liquid is transformed into kinetic energy while producing a pressure below atmospheric which is gradually equalized during the passage of the suspension through the nozzle, so that the suspension when leaving the nozzle holds a pressure equal or substantially equal to the atmospheric pressure. Under the influence of this pressure below atmospheric the gaseous medium separates itself from the liquid as fine bubbles which escape from the liquid substantially after the suspension has come to rest in a flotation chamber in which the suspension discharged from the nozzles collect. When rising to the surface of the liquid in said chamber the gas bubbles take suspended solid particles with themselves, especially when there is a flocculating agent added to the suspension. A flotation apparatus circulatory system of this kind is disclosed in U. S. patent to Fredrik Juell, No. 2,330,589, September 28, 1943.

It is already known to construct a nozzle of the above said type as a pair of relatively adjustable discs having parallel or substantially parallel opposed surfaces, one of said discs having further a central inlet leading to the nozzle channel formed by the space between said opposed surfaces. In such a known construction the distance between the parallel surfaces of the discs may be adjusted so that a liquid which enters the inlet of the nozzle under a pressure above atmospheric, will be subjected to a sudden great increase of speed when passing from the inlet to the nozzle channel proper, said increase of speed giving rise to a decrease of the pressure of the liquid to a value below atmospheric, which reduced pressure gradually rises again during the passage of the liquid towards the periphery of the discs. The gas bubbles as formed under the influence of said reduction of pressure will be compressed during the passage through the nozzle channel according as said channel widens towards the periphery of the discs with a resulting decrease of speed and a corresponding increase of pressure.

Owing to the fact that the distance between the opposed surfaces of the discs of the nozzle structure above outlined is equal or substantially equal at all radii, the area of passage of the nozzle channel widens almost uniformly from the centre towards the periphery.

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As a result of thorough experiments, however, I have found that important advantages over the method and apparatus according to the Juell Patent No. 2,330,589 may be gained by dimensioning the nozzle channel between the discs in such a way as to obtain defined zones with each zone having a function of its own different from those of the other zones.

An essential advantage obtained as a result of the present invention resides in that owing to the independent dimensioning of the individual zones, for obtaining an optimal action of each separate zone, I may considerably reduce the diameter of the discs for a given capacity.

In the accompanying drawing the invention is illustrated by way of example.

Fig. 1 is a longitudinal section of a nozzle constructed in accordance with this invention and adapted for use in the system disclosed in U. S. Patent No. 2,330,589.

Fig. 2 is a fragmentary diagrammatic view showing the opposed outlines of the discs 1 and 2 with a larger scale used for the axial than for the radial dimensions to clearly indicate the various zones of the nozzle channel.

Figures 2*a* and 2*b* are cross sections on enlarged scale of the one half of the discs 1 and 2 with practically the same scale for the radial and the axial dimensions.

Fig. 3 is a diagrammatic cross-sectional view showing an apparatus with the present invention installed.

The nozzle apparatus shown in Fig. 1 which is adapted for use in place of nozzle 16 of the aforesaid Juell patent, consists, essentially of two discs arranged in superimposed relation to each other, viz. a lower disc 1 and an upper disc 2 located so as to form a space 3 between themselves acting as a nozzle channel for the liquid adapted to undergo flotation. The lower disc 1 is supported by a hollow leg 4 formed at its lower end with an outwardly projecting flange 5 for attaching the leg 4 with the disc 1 to a suitable support, not shown. The interior of the hollow leg 4 forms a liquid inlet adapted to communicate at its lower end with a conduit, not shown, for supplying the liquid with a gaseous medium dissolved therein under a pressure above atmospheric. At its upper end the interior of the leg 4 communicates through a restricted passage 40 with the centre of channel 3.

The upper disc 2 is supported by a vertical stem or spindle 6 extending centrally through the leg 4 and adjustably connected at its lower end to the leg 4. To this end the lower end portion 7 of the stem is screw-threaded, as shown at 7, and engages a nut 8, connected by a set of arms 9 to the wall of leg 4. To support the upper disc 2 the stem 6 carries a supporting body 10 resting on a shoulder of the stem which is formed by a spherical upper surface engaging a corresponding spherical recess formed centrally in the lower surface of disc 2. The stem projects above the disc 2 through a central opening therein and is further extended by a, preferably, tubular member 11 adapted to project with its top above the liquid mass in which the nozzle is located when in use. The extension 11 carries at its top a square head 12 for the receipt of a key. By rotating the stem by means of this key the discs 1 and 2 may be brought closer together or removed from each other.

The discs 1 and 2 are assumed to be circular. The upper disc 2 is greater diameter than the lower disc so as to project with its periphery beyond the periphery of the lower disc, the projecting portion of disc 2 being formed with a depending flange 13 for downwardly deflecting the liquid discharged from the nozzle channel 3.

In order to guide the discs axially with relation to each other at their circumference, a number of guide pins are provided one of which is shown at 14 in the drawing where it is shown as connected to the lower disc by means of a nut screwed on the reduced lower end of the pin, so as to clamp the disc between the nut and a shoulder on the pin, whereas the upper portion of the pin is smooth and slidably engages a boring in the upper disc. In Fig. 1 the guide pin is also used for fastening a support 15 for a pipe 16 adapted to supply a flocculation agent to the suspension. In the above description with reference to Fig. 1 I have only explained the structural elements of the nozzle. Hereinafter I shall more nearly explain the novel features of the invention with reference to Fig. 2.

In the over-dimensional scale diagram of the nozzle shape shown in Fig. 2 the reference character D indicates the diameter of the inlet, as 40, Fig. 1 under the assumption that the inlet is not traversed by any stem, as 6, Fig. 1. The diameter D may be regarded as the minimum diameter of the inlet zone of the apparatus while the diameter designated by the reference character E may be regarded as the maximum diameter of the inlet zone. In other words, the inlet zone comprises the portion of the apparatus the radial extension of which is indicated by the Roman number I, Fig. 2. Within this zone the wall of the inlet passage forms a uniform transition between the diameter D and the diameter E thereby securing a quiet transformation of the axial flow of the liquid into a radial flow. A preferred relation between the diameters D and E under the condition stated, viz. that there is no traversing stem, is=1:2. A main rule in dimensioning and shaping the inlet portion I is that the liquid may be allowed to pass through this zone substantially without change of pressure or speed. In determining the dimensions of zone I it is advisable first to estimate a certain pressure above atmospheric of the liquid passing through the inlet portion for compensating the loss of pressure to which the liquid may be subjected during its continued passage through the nozzle channel.

Following the inlet zone I is a zone II between the diameters E and F, the dimensions of which are selected with a view to accelerating the speed of the liquid up to such a value that the static pressure of the liquid entering zone II sinks nearly down to the vapour pressure of the liquid,

as the liquid leaves zone II and enters zone III. Zone III, which extends between the diameters F and G, is so calculated and designed that the vapour pressure will be substantially maintained during the entire zone, that is to say, until the liquid reaches the diameter G. It is thus seen that, during its passage through zone III the liquid maintains not only its pressure but also its speed approximately constant, a possibly appearing increase of volume being due to gas bubbles and eventually produced vapour.

The zone IV next following is the last zone of the channel which extends between the diameters G and H. In this case the discs are assumed to be the same diameter. Zone IV is designed with a view to increasing the pressure of the liquid from the vapour pressure at the diameter G to the atmospheric pressure at the diameter H, and allowing a resulting compression of the gas bubbles to a very small order of size. In order that this increase of pressure may be obtained with a minimum distance between the diameters G and H, that is to say, with a minimum radial extension of zone IV, the area of passage of zone IV increases towards the periphery of the discs not only as a result of the gradually increasing diameter but also by using, preferably, conically diverging surfaces on the discs within this zone.

It is considered that the operation of the apparatus may be clearly understood from the above description, so that it need not be explained separately.

Figure 3 is a longitudinal sectional view of an apparatus according to Juell Patent No. 2,330,589 but equipped with a valve having a passage according to this invention.

In Figure 3 *a* denotes the container for suspension, *b* is the flotation tank, *c* is a conduit leading from the container *a* to a pump *e* and *d* is a conduit leading from pump *e* to the valve device according to the invention which is indicated by the reference numerals 1 and 2. From the pressure side of the pump a return pipe 17 leads to an injector 18 on the suction side. This injector forces finely distributed air into the fibrous water, this air being then more or less completely dissolved in the water under pressure produced by the pump *e*. The valve device is located in a compartment *f* of the tank which is separated from the main chamber *g* of the tank by a partition *h*.

It is to be noted that the apparatus shown in Fig. 1 is an example only of a preferred embodiment of the apparatus and that the invention is not restricted to this construction, inasmuch as modifications may be made within the limits determined by the following claims.

What I claim is:

1. In a flotation system for separating particles suspended in a liquid of the type which comprises the combination of a container for the suspension, a flotation tank under atmospheric pressure, a conduit connecting said container to said tank, means for passing the suspension through said conduit from the container to the tank, means for pressing air into said conduit to dissolve in the suspension, a nozzle device at the tank end of said conduit consisting of two coaxial discs formed of imperforate material outwardly of their central portions, said discs being axially spaced so as to form between themselves a closed flow passage having an outer peripheral discharge opening, one of said discs being provided with a central axial inlet connected with said conduit and leading to the inner end of said pas-

sage, and means for supporting the discs in axially spaced relationship, the improvement comprising that the surfaces of the discs exposed to said passage approach relatively to each other in the radially outward direction in an annular zone at a rate which reduced the flow area and accelerates the speed of flow of the suspension and reduces the static pressure of the suspension to approximately the vapor pressure of the liquid of the suspension.

2. A system according to claim 1 and in which the said surfaces outwardly of said zone continue in axially spaced relationship such as to provide a second zone in which the suspension flows outwardly at a rate which continues to maintain the suspension approximately at the vapour pressure of the liquid of the suspension.

3. A system according to claim 1 and in which before the said annular zone there is an initial zone which has a diameter substantially twice that of the inlet conduit at its connection with the nozzle device, and wherein the surfaces converge outwardly at a rate which maintains speed and static pressure of the suspension therein substantially equal to the speed and static pressure thereof in the inlet conduit at the point of connection with the nozzle, and in which there is a third zone in said passage in which the surfaces of said discs in contact with the suspension are so shaped as to maintain the static pressure of the suspension at substantially the vapor pressure of said liquid, and a fourth zone in said passage extending to the outer periphery of the de-

vice in which the said surfaces of the discs are so shaped that the static pressure of the suspension increases to approximately atmospheric pressure at said periphery.

4. A system according to claim 1 and in which said surfaces outwardly of said zone continue in axially spaced relationship such as to provide another zone in which the suspension flows outwardly at a rate which continues to maintain the suspension approximately at the vapour pressure of the liquid of the suspension, said surfaces then diverging outwardly through a further annular zone in which the speed of flow of the suspension is reduced and the static pressure increased to approximately atmospheric at the outer periphery of the nozzle device.

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