This invention relates to a novel guiding means for liquids and gases or for mixtures thereof with particles of matter carried along thereby.

The means in question serve to produce or to guide annular flow, in particular in centrifugal engines, such as hydraulic turbines and pumps, gas turbines and ventilators, centrifuges and the like.

The requirements which the guiding means employed in the construction of centrifugal engines must meet are manifold and they must be such as to guide a gas or liquid with a definite tangential component along a solid of revolution. They must in addition form or produce a uniform flow with full admission about the entire circumference and if necessary convert potential energy into kinetic energy and vice-versa.

In addition, it must be possible to vary by means of regulating means the admission and the area of through-flow while maintaining the angle of flow constant, and in certain cases it must be possible to vary at will the tangential component of the flow, hereinafter referred to as the "twist," by further regulating means which are separately applied.

With the known guiding means, there is no satisfactory method of fulfilling these requirements simultaneously, and in addition existing constructions, those employing adjustable guide vanes, and the like, have still further constructional disadvantages, such as the multiplicity of the parts to be moved by regulating means, difficulty of packing guide means which are to be actuated by regulating devices, and the clearance losses thereof, compromise by limitation of the number of blades, and so on.

In view of this fact, various attempts have been made to provide guiding means without the disadvantages referred to. In particular, annular slide valves have been proposed with which a greater or smaller area of through-flow is freed by axial displacement of the annular slide valve. With these arrangements, it was desired to produce the tangential flow by the spiral inflow form the spiral casing, and by providing spirally curved guide surfaces with parallel axes, which were disposed in the path of the inflow directly in front of the annular slide valve. These proposals, however, do not provide the desired constant "twist" over the entire periphery and for all opening positions, owing to the fact that at the time when the annular slide valve begins to open a more meridional outflow occurs instead of the outflow with a predetermined tangential component, at all points where there is no spiral guide surface. Only when the annular valve is fully opened will the tangential component also reach its full uniform degree.

The regulability of the area of an annular flow with full admission over the entire circumference and with constancy of the desired "twist" is obtained in accordance with the invention owing to the fact that a spiral flow-guiding surface having at least a single thread and with a pitch ranging from approximately but more than zero to approximately but less than 90 degrees, is situated within two surfaces of revolution limiting an annular flow, and that at least annular parts of one flow-limiting surface of revolution can be displaced in the axial direction in order to adjust the area of through-flow.

The invention will be better understood from a consideration of the following description in conjunction with the accompanying drawings, in which:

Figs. 1, 2 and 3 show annular nozzles and parts thereof respectively in vertical central section;

Fig. 4 shows in vertical center section of a centrifugal engine.

Figures 1 and 2 show constructional examples of annular nozzles or diffusers in vertical centre section. In these figures, numerals 1 and 2 and 2' represent the flow-limiting surfaces in section, the area of through-flow being varied by variation of the position of 2 in the direction of the double arrow. 3 is the single threaded or multi-threaded spiral surface determining the direction of flow and in particular the rotational component, in section. It is to be considered as geometrically formed from a spiral movement of a line or—as in the figure—of a straight line passing through the axis. According to requirements, it is possible also to make only the part 2 movable, while its extension 2'' may be rigidly connected to the remaining part of the guide means. The forward edges of 2 and 2'' would then coincide at complete opening. The pitch of the spiral surface and its profile need only be constant in so far as this is necessary with a view to obtaining a constant outlet angle, while it can gradually
change to infinite outside 2, that is to say within the range of 2°. The flow freely leaving in the direction of the arrow 4 has the form of a hyperboloid, the generatrices of which constitute the rectilinear out-flow jets.

The position of the annular slide in Fig. 1 for obtaining the regulating movement may be effected by turning the turnable but not axially displaceable spindle 8a in the threaded boss 2a of the annular slide, turning motion of the latter being prevented by the spline 8c which permits an axial movement of the slide only. The spindle 8a is turned by means of bevel wheels 8c and a handwheel 10.

A further mode of actuating the annular slide 2 is diagrammatically shown in Fig. 2 by way of example and comprises a hydraulic means. In this design the position of the annular slide is determined by the position of the lever 20 provided with a pawl 21 which cooperates with notches provided in a guidance 22 for the lever, and engages a notch corresponding to the desired position of the annular slide. Upon a displacement of the lever 20 the pin 23 on the latter, which is guided in a fork 24, turns the fork 24 pivoted at 25 toward the right or the left. By this turning motion of the fork the piston 26 in the cylinder 27 is displaced by a certain amount in the right-hand lever 24 and the piston 26 is moved toward the right by a lifting motion of the lever 20 the annular chamber 28 is connected via the tube 20 and the tube 30 with the water under pressure derived in front of the annular nozzle. The water pressure in the chamber 28 causes a lifting of the annular slide until after the lever 20 has returned into its horizontal position or, respectively, until the pin 23, the fork 24 and the piston 26 have been returned into their medium positions. The opposite displacement of the lever 20 in the downward position causes movements which are opposite to those described above and the annular chamber is connected to the outlet 31 for the pressure water. The slide valve is lowered until the desired position depending on the adjustment of the lever 20 by pawl and notch is reached.

Figures 1 and 2 show the application of the guiding means as an annular nozzle for converting pressure energy into velocity energy. Figure 1 shows an annular flow directed inwardly with respect to the axis and Figure 2 an annular flow directed outwardly with respect to the axis.

When the flow is reversed, and thus is opposite to the direction of the arrow 4, the guiding means work as diffusers, that is to say they convert velocity into pressure energy, in opposite directions—outwardly in Figure 1 and inwardly in Figure 2.

In Figures 1 and 2, the cross-sectional area of the annular flow has been regulated by a cylindrical control member exactly at the outlet from the spiral flow-guiding surface 3 (and in the case of reversal of the direction of flow at a certain distance outside the spiral surface), and consequently the admission to the guiding means has been altered while the outlet and inlet angles have been maintained constant.

However, if the area of through-flow is narrowed by a further regulating member situated at a certain distance outside the spiral surface and the guiding the annular flow, a possibility is provided of reducing or regulating the tangential component of the annular flow by further regulating means additionally applicable.

Figure 3 shows, by way of example, in contrast to Figure 1 an additional regulability of the tangential component or of the twist of the annular flow set up. In Figure 3, numeral 5 refers to the control member for varying the annular area of through-flow outside the range of the spiral flow-guiding surface 3.

When the control member 5 is completely withdrawn and the area is completely free, the maximum "twist" produced by the spiral surface will be present as the fluid leaves the guide means. However, in proportion as the area is narrowed by the filaments of the stream will be deflected in a meridional direction. In the extreme case, directly before the annular outlet aperture is closed by the control member 5, the tangential component of the filaments will be equal to zero and will be a meridional out-flow.

The displacement of the control members or annular slides 2 and 5 may be effected, as is shown in Figure 3, by means of toothed rims 32 and 33 respectively cooperating with screw wheels 34 and 35. As the two annular slides are prevented from rotation by the outlines 36 and 37 but are axially displaceable a turning of the screw wheels 34 and 35 in the one or the other direction of rotation will cause a forward or backward movement of the annular slides. The screw wheel 34 is turned by the handwheel 30. The handwheel 30 is turned by the hand wheel 39 and the spindle 40. If a simultaneous displacement of both annular slides 2 and 5 is desired for varying the through-flow area the clamping device 41 is tightened so that both hand wheels turn together. If, however, a displacement of the annular slide 2 relative to 5 is desired for varying the tangential component, the clamping device 41 is lifted and the screw wheel 34 is turned by turning the hand wheel 38, whereas the hand wheel 39 is kept stationary.

Figure 4 shows an example of the embodiment of the new annular-flow guiding means for centrifugal engines, wherein the function of the flow-limiting surface of revolution of one guiding means with its control edge determining the area of through-flow is taken over by the other guiding means rotating relatively thereto, owing to a suitable series arrangement of guiding means rotating in opposite direction to one another.

Figure 4 shows, by way of example, a centrifugal engine which can be employed either as a pump or as a turbine. When it is employed as a pump, 5 (Figure 4) constitutes a fixed outwardly directed annular nozzle, as in Figure 2, as an entrance for the transition of the suction pipe into the rotor part. Situated above this annular nozzle is the cylindrical, also fixed, guide member 8.

Mounted over 5 and 8 in the manner of a bell is the rotor with its lower cylindrical guide surface 9 and 9', its lower flow-limiting surface of revolution 10 of saddle shape, its flow-guiding surfaces 11, its upper flow-limiting rotary surface of revolution 12, its upper central guide surface 13 and 12', its hub 14 and the shaft 15. Mounted on the fixed casing 16 is the distributor 17, which again constitutes a guide means similar to that shown in Figure 1, except that the axial delivery and discharge here take place through a spiral pipe 16. Referring again to the function of the spiral surface of a pump (similar to that shown in Figure 2), it is to be noted that the function of the annular control member 2 adjusting the area of through-flow (Figure 2) is in this case taken over by a part of the rotor, namely the inner guide sur-
face 9, and that the entire rotor is axially displaceable together with the shaft 15 to carry out the adjusting movement. The same applies to the distributor 17, corresponding to an annular diffuser as shown in Figure 1, which is here adjusted by the guide surface 2' rotating with the rotor, instead of 2 (Figure 1). 9' is therefore also adjusted by the same axial displacement of the rotor simultaneously with 9, so that all conditions of opening can be achieved simultaneously at all points of transition between the suction pipe 4 and the rotor, and also between the rotor and the distributor merely by axial displacement of the rotor, the inlet and outlet angles being maintained constant.

The aforementioned axial displacement of the rotor may for example be effected by hydraulic means, diagrammatically shown in Fig. 4, by admitting water under pressure to the annular space 42 or respectively by letting the water escape from that space. To that end a movement of the valve piston 43 in the cylinder 44 towards the left, in Fig. 4, case the annular space 42 to be supplied with water under pressure from the spiral tube 18 via the supply pipe 45, whereas the opposite movement of the valve piston connects the annular space 42 via the pipe 46 to the suction tube. A means has thus been found for the first time of providing the possibility, so desirable in hydraulics, of so regulating the areas of through-flow through the centrifugal engine with strict accuracy from both the hydraulic and the solid geometric viewpoint that the tangential components of the flow at the inlet to and the outlet from the runner wheel are so constant that impact losses and losses due to rough "twist" at the outlet from the centrifugal engine are absolutely avoided over any load range and under any opening conditions of the centrifugal machine.

It will be readily understood that the adjustment by axial displacement of the rotor is mechanically substantially simpler and much more efficient than the known adjustments with centrifugal engines, for example the adjustment by means of adjustable guide vanes, not to mention the general trend of pumps by means of regulating slide valves. A further advantage of the type of pump according to the invention is that if the pump is connected to a pipe system under pressure the danger does not arise of the pump entering the so-called unstable range of the load diagram, as do pumps with forward or radial discharge from the runner wheel.

This unstable condition in the delivery pressure from the moment when a pump is started up arises owing to the fact that the pump at first runs with the slide valve closed, that is to say, with zero through-flow. There is thus set up at the outer edge of the rotor a pressure corresponding to the centrifugal action of the rotating liquid ring in the rotor, while the actual pressure of the conveying pump is still higher by the degree of velocity

\[ \frac{v^2}{2g} \]

times the efficiency of the distributor-diffusor.

The type of pump according to the invention on the other hand, can start with the slide valve open so that the rotor, at zero through-flow and therefore starts to deliver immediately the areas of through-flow are freed by axial displacement of the rotor, with the full dynamic pres-
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