F. K. WOODROFFE & H. C. HODGSON.
CENTRIFUGAL LIQUID PUMP.
APPLICATION FILED SEPT. 22, 1913.

1,167,241.

Patented Jan. 4, 1916.

2 SHEETS—SHEET 1.

FIG. 1.

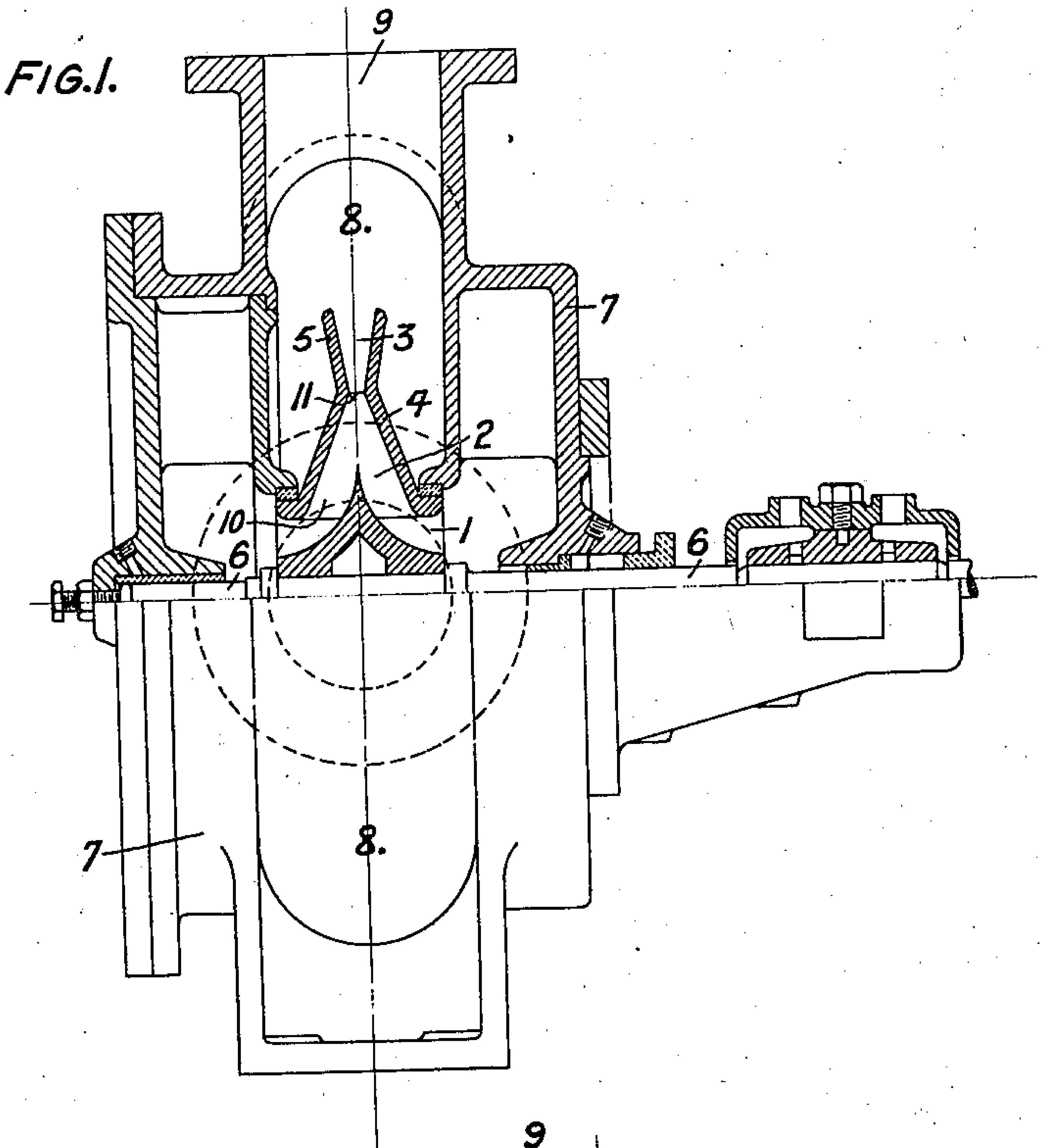
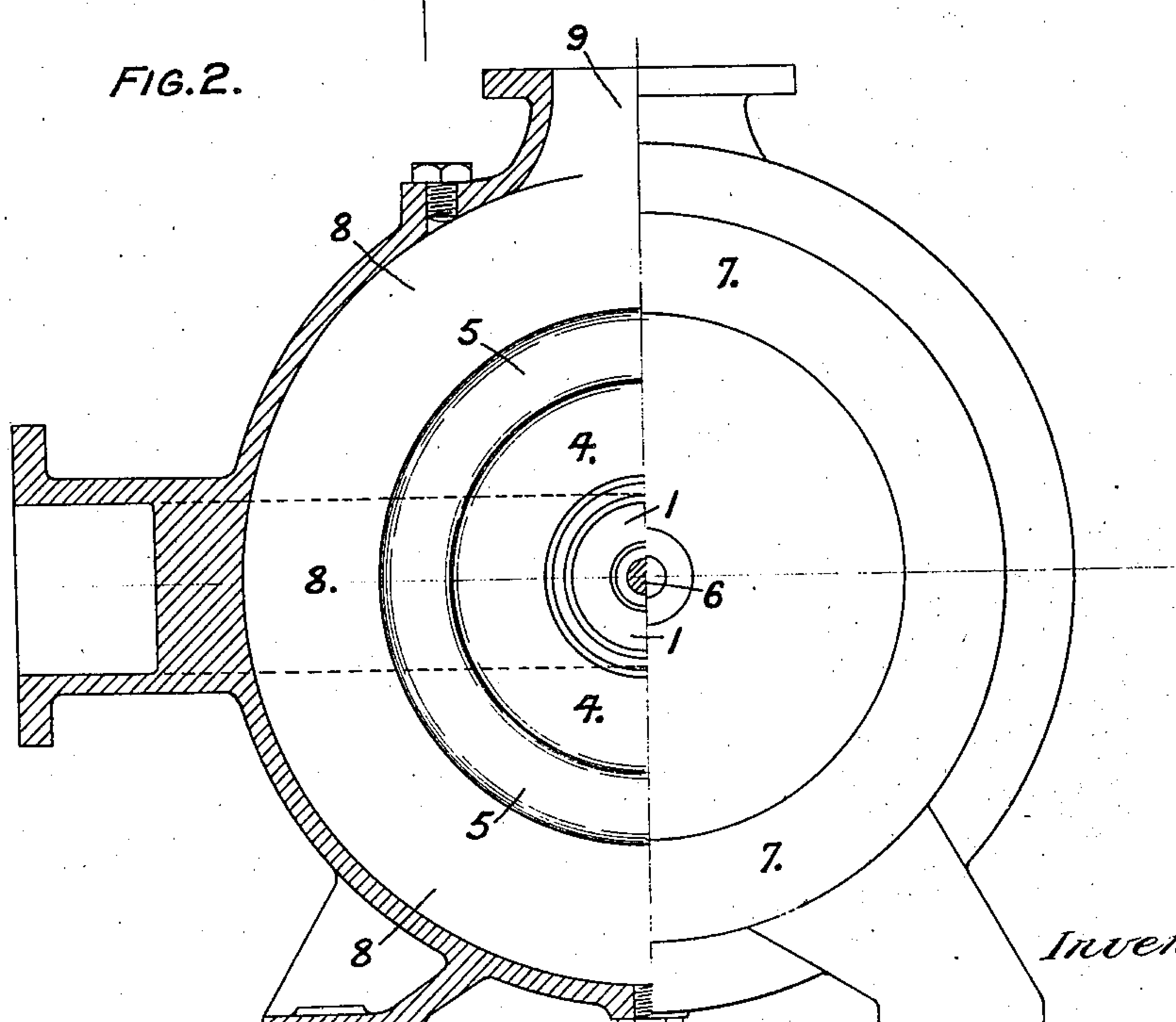


FIG. 2.



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2 SHEETS—SHEET 2.

FIG. 3.

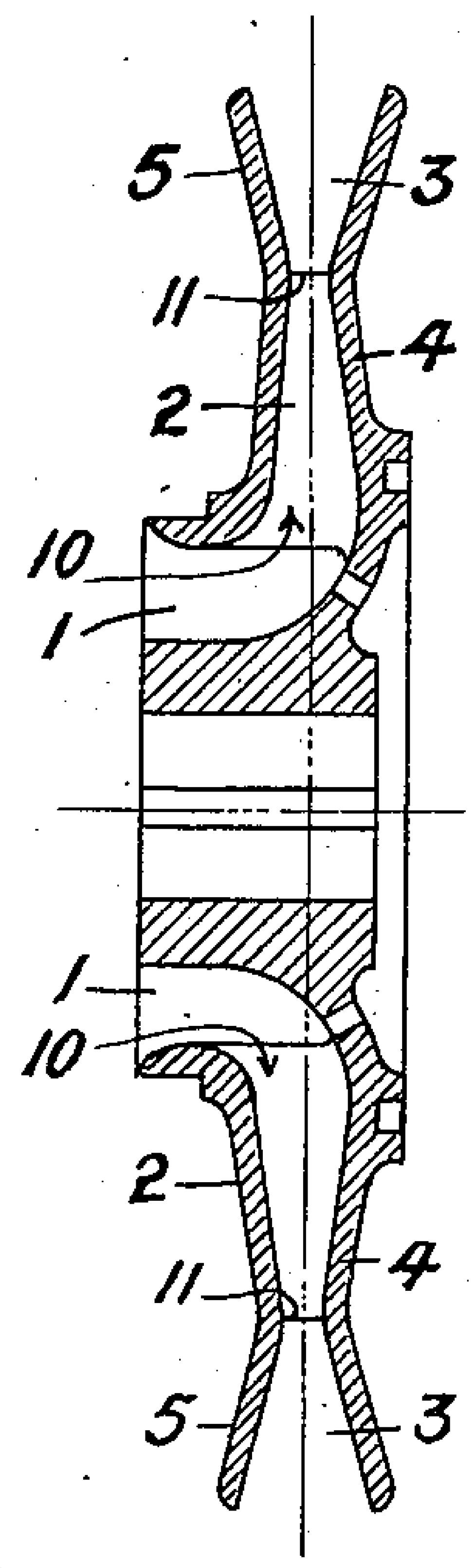


FIG. 4.

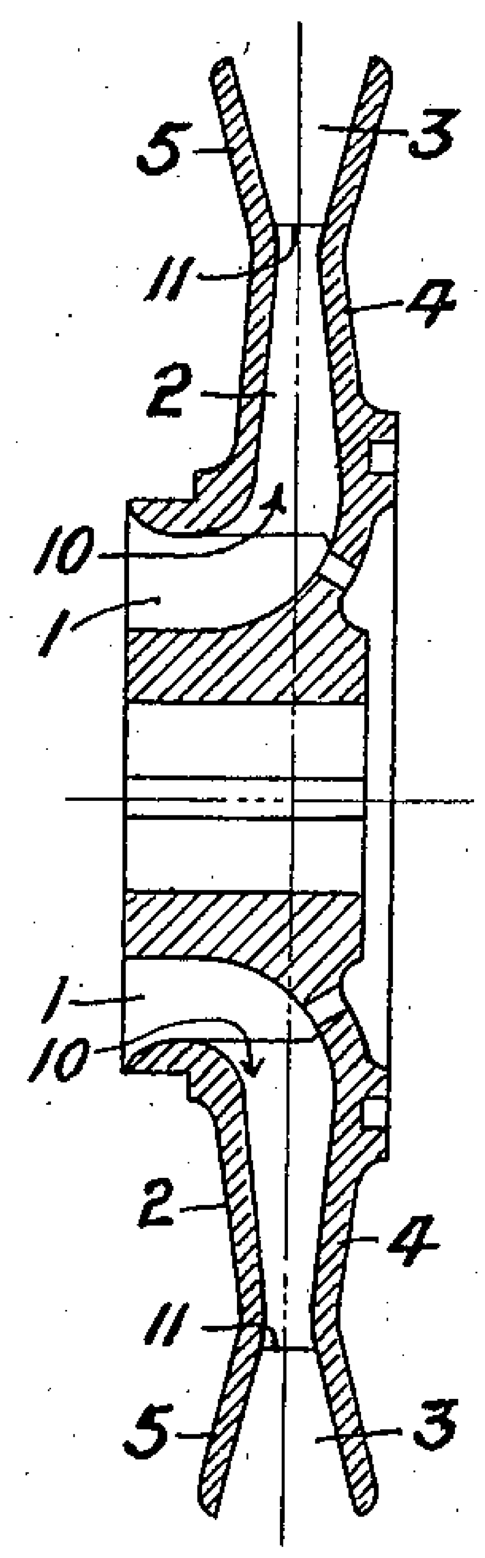
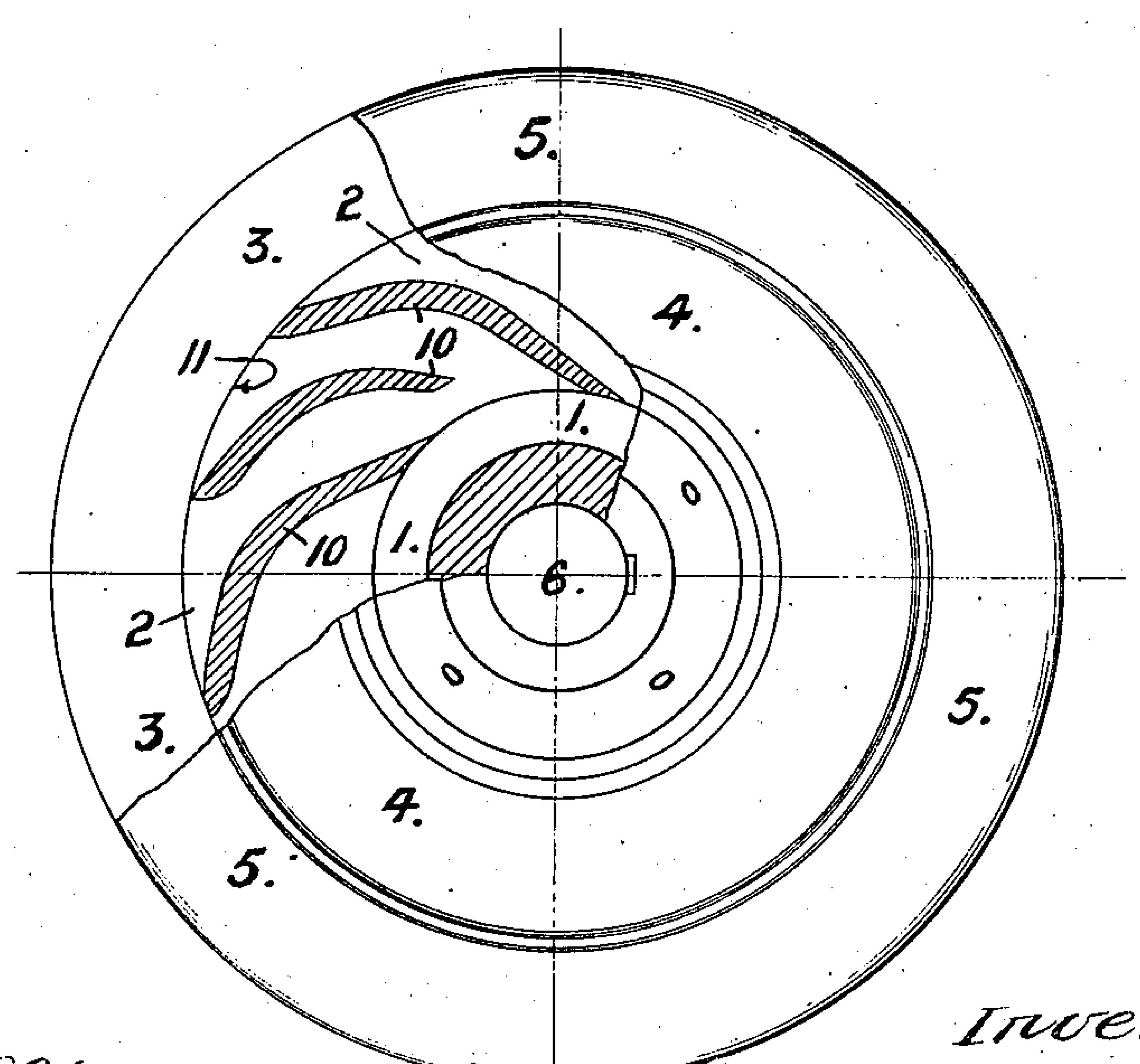


FIG. 5.



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UNITED STATES PATENT OFFICE.

FRANK KNIGHT WOODROFFE, OF CHESTER, AND HAROLD C. HODGSON, OF EGREMONT, ENGLAND.

CENTRIFUGAL LIQUID-PUMP.

1,167,241. Specification of Letters Patent. Patented Jan. 4, 1916.

Application filed September 22, 1913. Serial No. 791,176.

To all whom it may concern:

Be it known that we, Frank Knight Woodroffe and Harold Cecil Hodgson, subjects of the King of England, and residents of Chester, in the county of Chester, England, and Egremont, in the county of Chester, England, respectively, have invented new and useful Improvements in Centrifugal Liquid-Pumps, of which the following is a specification.

This invention has reference to centrifugal pumps for forcing and supplying liquids at considerable or high pressures, wherein the liquid is drawn in through openings at the center of a revolving "impeller", and is discharged at or near the periphery of the same. The liquid so discharged is, in many cases, conducted to a second impeller or successive impellers in series, and similarly operated upon; and the impeller or impellers is or are mounted on a shaft or axis, and revolved within an outer casing, in which the impelled or moved liquid is received, and conducted in the desired manner through the pump.

In the design of centrifugal pumps of the kind concerned, it has, in many cases, been the desire to create a high velocity of discharge of liquid from the impellers, and to convert this high velocity of flow into pressure, as by an expanding part of the impeller nozzles, or by providing a chamber or passage—or a plurality of them—external to the impeller, into which the liquid thrown off and impelled by the impellers is delivered; and more often than not, this chamber or passage is provided with guide plates or vanes having for their object to attain as high an efficiency as possible. In other cases, the water is introduced into a revolving barrel with nozzles, in it, in which the centrifugal force produces pressures in the water, and under this pressure it passes through the nozzles; while as regards air fans, the rotatable part has been proposed to be provided with a converging and diverging annular part outside the blades on its periphery.

According to this invention, the object and effect desired to be attained, is to provide a liquid pump of the kind referred to, by which a higher efficiency and effect is obtained as regards the conversion of the kinetic velocity imparted to the liquid in its passage through an impeller into static pressure or head; to provide a pump of the character concerned which is capable of being worked at varying velocities, other than those for which it may be particularly designed for, at an efficiency which is approximately equal to that produced when being worked at its normal velocity or range of velocities; and to enable a pump of this kind to be started and set in action by an electrical motor with the discharge valve open, without abnormal or dangerous overload on the motor.

The objects and ends of the invention are attained by constructing the impeller with a flat sided annular diverging discharge part at its periphery, extending directly from the smallest part of the liquid passage within the periphery, and beyond the point where the vanes or nozzles of the impeller terminate, or where they exist; the area of this portion being a contracted one, namely, less than that of the eye or intake opening, (which say is of the area usually employed), from which, preferably, the sectional area of the liquid passage will gradually diminish; while directly from this part of contracted area, where the vanes terminate or exist, without hiatus, by the provision of the said annular diverging discharge part, the area gradually and uniformly increases.

By this construction, in flowing from the contracted portion, through the flat sided diverging passage portion of the impeller, the kinetic velocity of the liquid is converted into static pressure or head, and it tends to create a diminution of pressure, or a minus pressure, at the point or line of change from the contracted area, to the extending area toward the periphery, and thereby assists in promoting an increase of velocity of flow of water through this contracted part; the rate of the flow gradually increasing from the inlet eye, where it is at a minimum, to a maximum at the point of the greatest contraction of passage area. By this gradual choking or construction of the part of the passage lying concentrically within the annular diverging part of the impeller, and extending from the inlet or eye to the point of greatest contraction, and by the use of this diverging part, the high velocity of flow is enabled to be obtained.

The degree of diminution of the area of this part of the passage, in relation to the inlet may be varied in different cases, say from two to six times smaller than the area at the eye or entrance, which, as stated, may be of normal area. By these proportions and construction, the velocities of flow between that at the eye or inlet, and that at the point of greatest constriction, can be several times multiplied. With the existence of this condition and action, if the contra pressure or head against which the pump is delivering liquid, is reduced or lessened, by reason of the constricted outlet area and the relative high normal velocity of flow at this part, very large accessions of volume discharged through this constricted part is prevented; and by this checking of the volume moved, in impellers of the kind herein described, any great or dangerous overload is prevented from coming on the motor of the pump; and, as stated, if this motor be an electric motor, the breaking down of it, due to an abnormal overload suddenly coming upon it, is obviated. This machine therefore, having the effects, and acting in the manner described, in the respects specified, constitutes a self-regulating centrifugal pump.

In this impeller, curved vanes will be employed between the eye, and the part of the passage of greatest contraction.

The invention is illustrated in the accompanying drawings, in which—

Figure 1 is a side elevation partly in section, and Fig. 2 a transverse section, showing a single impeller centrifugal pump, according to it; the impeller of which is one having an inlet or eye on each side. Figs. 3 and 4 show slightly modified forms of impellers, with the inlet eye at one side, such as would be used in a centrifugal or turbo pump having a plurality of impellers, forcing water in stages or steps, successively, from one to the other; and Fig. 5 shows a side sectional view of the impeller.

Referring now to the drawings, 1 represents the eyes or inlets of the impellers; 2 is the part of the passage through the impeller from the eye to the part of greatest constricted area; and 3 is the diverging outlet part. 4 and 5 represent the walls of the parts of the passage 2 and 3.

The depth of the annulus constituting the passage part 3, and the angle of divergence shown in the drawing, is one which will accomplish the ends referred to, but the dimensions of this part, as regards depth, and the angle of divergence, may be varied, namely, the angle of divergence may vary from about $12\frac{1}{2}°$ to $35°$, the particular angle adopted in any pump, depending upon the average conditions of head and delivery it is required to operate against. While as regards the depth of this annular discharge channel, it will be such as will reduce the velocity of flow, but that requisite to produce the effects above described.

In Figs. 1 and 2, 6 is the shaft of the impeller; 7 designates generally the case in which it works; and 8 is the annular chamber or space into which the liquid is discharged by the impeller, from which it is carried off by the outlet branch 9. 10 are the vanes of the impeller, extending between the eye 1 and the point of greatest restriction 11, and the ends of these vanes may, as shown in Fig. 3 be terminated at this annular line of greatest restriction; while in Fig. 4, they are carried slightly beyond it.

With regard to the particular form and disposition of the blades or vanes 10 shown in Fig. 5, these may be of any suitable type and blades or vanes radial or curved forward in the direction of rotation may be used.

In this pump, the presence of vanes or cut-waters in close proximity to the periphery of the vanes of the impeller, does not exist, although such vanes in certain cases may be used for determining the flow of water whose velocity has been reduced in the manner described.

In practice, it has been found that by this impeller, the high rate of flow through the most restricted part of the channel 2, promoted by the manner of construction and characteristics above described, may be so high at a normal head and delivery, that at a reduced head, even proximating to zero head, the volume of delivery is increased but comparatively slightly; being in some cases less than double the normal. As a consequence, the power required to operate the pump at greatly reduced heads, at a constant speed, is not increased; and it may be even somewhat lessened, and a complete self-regulation, that is, balance of head, delivery, and power, obtained. And this self-regulation is not obtained at the expense of effective head, and approximates to the known law, head $= \frac{V^2}{2g}$, but is largely promoted by the application of the Venturi character of diffusion of the impeller in the discharging annular conduit 3, which tends to create a high rate of flow through the passage 2, and particularly at the most constricted part 11, between the vanes 10 in this passage 2, without loss of efficiency.

As stated, the absence of guide vanes or cut-waters in the discharge of liquid flowing at a high rate, enables the pump to be operated at various speeds, under varying heads, and delivery, without the losses above specified, and with wide range of efficiency.

With regard to the case shown in Fig. 4, where the vanes or plates 10 are carried slightly beyond the smallest part of the diverging discharge passage 6, this construction increases the effective radius of peripheral discharge, and thereby the effective head, without increasing the diameter of the impeller.

What is claimed is:

1. In a centrifugal pump, an impeller wheel having a central inlet and a plurality of spaced blades which form a plurality of passages which communicate with said inlet, the outer ends of the blades terminating at a distance from the periphery of the impeller wheel, each of said passages being of gradually diminishing area from the inlet to the outer ends of the blades, and the side walls of the impeller wheel from the outer ends of the blades to the periphery thereof flaring outwardly to form a space of gradually increasing area and with which all the passages communicate, the smallest area of the passages and the space beyond same being adjacent, and means for permitting the outlet of fluid flowing through said passages.

2. In combination, a casing, an impeller wheel mounted in the casing comprising two circular spaced plates having alined central inlet openings, said side plates having inwardly inclined portions and outwardly inclined portions extending from said inwardly inclined portions, spaced blades between the two plates to provide a plurality of passages, said blades terminating at the point of juncture of the inwardly and outwardly inclined portions, the inwardly inclined portions of the plates and the blades forming a plurality of passages of gradually diminishing area and the outwardly inclined portions of the plates forming a space of gradually increasing area common to all the passages, the smallest area of each inclined passage and the space being adjacent.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

FRANK KNIGHT WOODROFFE.
HAROLD C. HODGSON.

Witnesses:
SOMERVILLE GOODALL,
FRANK E. FLEETWOOD.