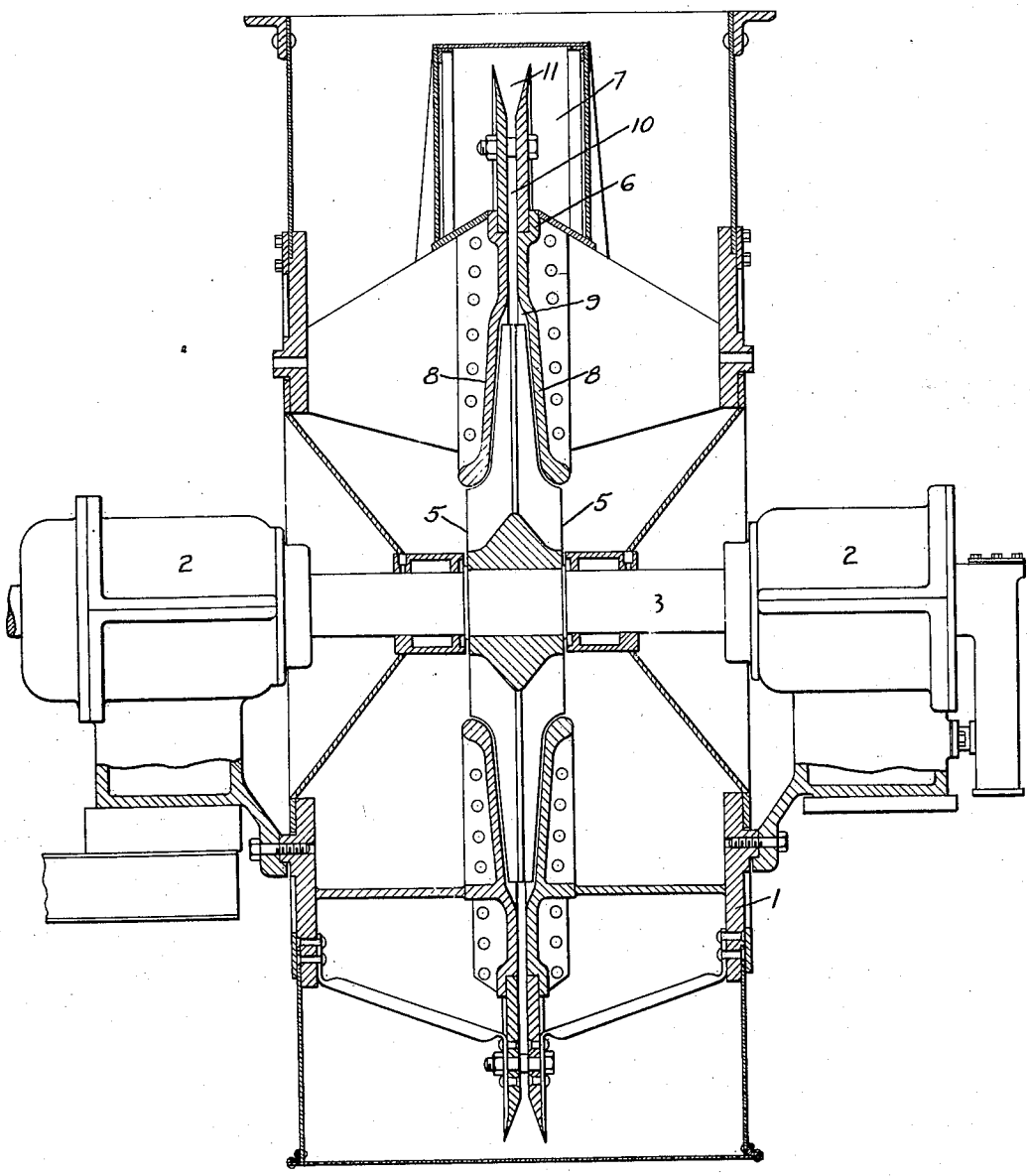
Feb. 8, 1927. 1,617,133

S. A. MOSS ET AL

CENTRIFUGAL PUMP AND COMPRESSOR

Filed May 23, 1925 2 Sheets-Sheet 1

Fig. 1.



Inventor:
Sanford A. Moss,
Manuel G. Robinson,
by Alexander S. Lamb.
Their Attorney.

Feb. 8, 1927. 1,617,133

S. A. MOSS ET AL

CENTRIFUGAL PUMP AND COMPRESSOR

Filed May 23, 1925 2 Sheets-Sheet 2

Fig. 2.

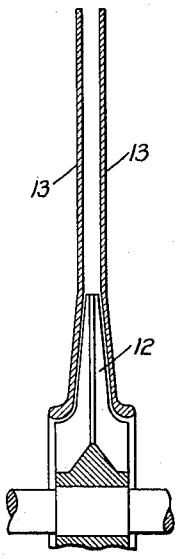


Fig. 3.

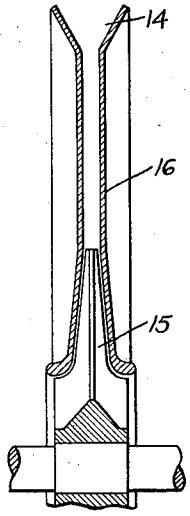
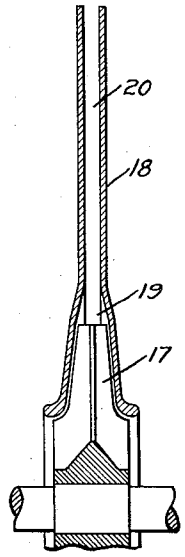


Fig. 4.



Inventor:
Sanford A. Moss,
Manuel G. Robinson,
by Alexander S. Lunt.
Their Attorney.

Patented Feb. 8, 1927. 1,617,133

UNITED STATES PATENT OFFICE.

SANFORD A. MOSS AND MANUEL G. ROBINSON, OF LYNN, MASSACHUSETTS, ASSIGNORS TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

CENTRIFUGAL PUMP AND COMPRESSOR.

Application filed May 23, 1925. Serial No. 32,490.

The present invention relates to centrifugal pumps and compressors of the type comprising an impeller which receives the fluid to be pumped at its central portion and discharges it at its periphery, and wherein means are provided around the periphery of the impeller for converting into pressure the velocity of the fluid discharged from the impeller.

As is well known, in all centrifugal pumps for incompressible fluids, such means, commonly called a "diffuser" comprises a divergent passage through which the fluid flows. Also, as is pointed out in the Reissue Patent to Moss, 13,665, dated December 30, 1913, in a centrifugal compressor for a compressible fluid, such means comprises a passage which is first convergent and then divergent for the case of comparatively high impeller speed and pressure ratio, or a passage which is wholly divergent for more usual cases.

The object of our invention is to provide an improved means, or construction and arrangement, for providing the passage in the foregoing instances, for converting velocity into pressure, with a high degree of efficiency, and at the same time maintaining a construction which is simple in structure and capable of being manufactured at a low cost, and for a consideration of what we believe to be novel and our invention, attention is directed to the accompanying description and the claims appended thereto.

In the drawing, Fig. 1 is a sectional view of a centrifugal machine (here shown as being a centrifugal compressor) embodying our invention, illustrating it in its preferred form and that which it usually assumes in actual practice, and Figs. 2, 3 and 4 illustrate modifications.

When an impeller is running, the fluid being handled is discharged from its periphery at a constant angle, and it is known that if the discharge takes place into a diffuser formed of two circular parallel plates, the fluid will pass outward in a spiral path from the inner to the outer circumference of the plates and will maintain this constant angle, forming what is called a free vortex. By the angle of the fluid in such a case is meant the angle between the direction of a stream line at any point and the tangent to a circumference passing through that point.

In this connection, it is pointed out that since the plates extend radially outward and the angle of the fluid remains constant, there results an area of discharge for the fluid which increases continuously from the radially inner edge of the passage to its radially outer edge. In other words, there results a divergent discharge passage which functions to convert velocity into pressure.

The area of flow at any circumference is given by the formula:

$$\text{Area} = 2\pi r W \sin a$$

where

2 = radius of any circumference.

W = distance between the plates.

a = the angle of the fluid.

From this formula it will be clear that if the angle a remains constant the area increases with the radius.

Now, although this property of the formation of a free vortex has been known, so far as we are aware little practical use of it in centrifugal pumps and compressors has ever been made, this being due, we now believe, to the fact that because of the naturally low angle of the fluid, the path of travel of the fluid in the vortex was so long that the friction losses made the conversion of velocity into pressure exceedingly inefficient. As a result, it has been the practice, in constructing such centrifugal machines, to provide discharge vanes with a divergent passage for directing the flow of the fluid radially outward, the velocity of the fluid being at the same time converted into pressure.

In connection with a diffuser in the form of two spaced annular plates, we have found that, other things being equal, the closer the plates are brought together, the higher the angle of the fluid will be, and that if the plates are brought together close enough so that the angle of the fluid is greater than 25°, and preferably of the order of 35° at normal load on the compressor, there results a construction wherein the path of travel of the fluid becomes short enough to make practical the use of a diffuser comprising spaced annular plates even though the radial depth of the diffuser must be increased somewhat in order to provide for the diffusion neces-

sary to effect conversion of the velocity into pressure.

In other words, we have discovered that if the plates defining the diffusers are brought close enough together to effect an initial directioning of the fluid discharged from the impeller at an angle of the fluid greater than 25°, and then are made of a radial depth to provide a final discharge area sufficiently great to effect the required conversion of velocity into pressure, that efficient operation of the machine is obtained. The correct relative positioning of the plates to give the desired angle of the fluid can be determined experimentally by positioning the plates and then measuring the angle of flow by inserting a freely moving vane in the stream and reading the angle which it assumes. Or, it may be determined by calculation from the quantity of flow, speed of the machine, and its dimensions. The required radial depth for the plates forming the diffuser can be determined also by experiment and measurements.

In connection with the foregoing, it is pointed out that the angle of the fluid varies with the quantity of the fluid delivered by the impeller which means that, in any construction embodying our invention, if the quantity of the fluid being handled increases, the angle of the fluid increases, and that if such quantity decreases the angle decreases. In carrying out our invention we provide an arrangement such that for the loads which the machine will be required to carry ordinarily under normal operating conditions, the angle of the fluid will not fall below 25° for the least value of such load. Preferably we construct the machine so that at normal rated load the angle of the fluid will be of the order of 35°, which means that at normal load the highest efficiency will be obtained. Under these circumstances, the angle of the fluid will remain greater than 25°, and so give efficient operation of the machine at loads of the order of one-half normal rated load.

If the tip of the impeller is sufficiently narrow in width, the plates of the diffuser may be parallel throughout their length, but ordinarily such a condition is not met with, so that in carrying out our invention we provide plates which approach each other and then are parallel, or substantially parallel, the approaching portion being such that the desired high angle of the fluid is obtained. However, the arrangement is always such that the discharge area is always increasing so as to at all times form a divergent passage, unless conditions are such as to require a preliminary converging portion to effect the conversion of velocity into pressure.

Where the plates are parallel and close enough together to give the desired angle of flow, the result may obtain that, in order to provide the necessary discharge at the periphery of the diffuser, it assumes a circumference too large for practical purposes, and to avoid this, the parallel portion may be followed by a final portion wherein the plates recede from each other. In the preferred and usual form of our invention, therefore, we have a diffuser structure wherein the plates first approach each other, then are parallel, and finally recede from each other. This provides a passage of a length such as to give small friction losses and at the same time provide the desired final discharge area without undue outer diameter of the diffuser.

Referring to the drawing, 1 indicates the casing of a centrifugal compressor attached to which are bearings 2 in which a shaft 3 is mounted. On shaft 3 is an impeller which receives fluid at its central portion through the inlets 5 and discharges it at its periphery to a discharge ring 6 from whence the fluid passes to a discharge scroll 7. The compressor illustrated is shown only by way of example and is not described in detail, since its specific structure forms no part of our present invention, our invention relating particularly to the discharge ring 6.

Referring now particularly to the discharge ring, it is shown as comprising walls formed in continuation of the side walls 8 for the impeller, and as comprising a section 9 wherein the walls approach each other, then a section 10 wherein the walls are parallel or substantially parallel, and finally a section 11 wherein the walls recede from each other.

In constructing the section 9 it is desirable to make the slope of the walls quite steep so as to rapidly increase the angle of the fluid, which may be termed the vortex angle. Ordinarily, however, the slope should not be so steep that the walls approach each other with a rapidity such that the decrease in width reduces the effective discharge area faster than the increase in diameter increases it. If such were the case, there would result a converging passage which under operating conditions usually met with would effect a conversion of pressure into velocity which would have to be reconverted into pressure whereby a double energy conversion would take place. However, if the conditions are such as to require a preliminary converging portion for conversion of velocity into pressure, then a slope so steep as to give this preliminary converging passage is necessarily used. The sloping walls are extended radially to a point where they come close enough together to give the desired vortex angle or angle of the fluid, (i. e., an angle of the fluid of at least 25°) and then they merge into the parallel or substantially parallel walls which form the section 10. The angle of the fluid is

then maintained constant through this section, the fluid flowing in a free vortex toward the periphery of the discharge ring. The effective area of the passage between the parallel portions of the plates increases continuously from its radially inner edge to its radially outer edge, as already explained. This results in a divergent passage, and the fluid in flowing through this divergent passage has its velocity converted into pressure, as is well understood. The parallel portion of the plates of the diffuser may be made of a radial depth to give a final effective area such as to effect the desired conversion of velocity into pressure. However, in actual practice, this may result in a structure of too great diameter, and to avoid this we preferably construct the final portion of the diffuser with diverging walls so as to provide the section 11 wherein the conversion of velocity into pressure takes place at a more rapid rate. Of course, the angle of the fluid or vortex angle is less in this section, but as such section is of small radial depth, the increase in friction loss over what it would otherwise be is not great.

In Fig. 2 is illustrated a form of the invention wherein the tip of the impeller 12 is narrow and wherein the two plates 13 which form the diffuser are parallel throughout their radial depth, and are so close together that the angle of the fluid is greater than 25°. This forms an efficient diffuser, but as already stated, leads ordinarily to a construction wherein the diffuser is of considerable radial depth.

Fig. 3 shows a modification of the Fig. 2 arrangement wherein the radial depth of the diffuser is shortened by providing at its periphery a section 14 wherein the walls recede from each other. In this figure, 15 is the impeller and 16 the diffuser.

Fig. 4 illustrates an arrangement similar to Fig. 1, except that the receding walls at the periphery of the diffuser are omitted and the required discharge area is obtained by increasing further the diameter of the diffuser. In this figure, 17 is the impeller and 18 the diffuser, and as will be noted, the diffuser comprises, first a portion 19 wherein the walls approach each other, and then a portion 20 wherein they are parallel.

What we claim as new and desire to secure by Letters Patent of the United States, is:—

1. A centrifugal machine having a diffuser comprising two spaced walls between which the fluid flows radially outward, said walls being so close together that the angle of the fluid at normal load is greater than 25° throughout the major portion of its travel.

2. A centrifugal machine having a diffuser comprising two spaced walls between which the fluid flows outward, said walls being so shaped that they first approach each other, then extend substantially parallel to each other, and then recede from each other.

3. A centrifugal machine having a diffuser comprising two spaced walls which provide a discharge passage which continuously effects conversion of velocity into pressure, said walls first approaching each other to an extent such as to provide at normal load an angle of the fluid greater than 25°, and then extending substantially parallel to maintain such angle of the fluid.

4. A centrifugal machine having a diffuser comprising two spaced walls which provide a discharge passage of continuously increasing effective area, said walls first approaching each other to an extent such as to provide at normal load an angle of the fluid greater than 25°, and then extending substantialy parallel to maintain such angle of the fluid.

5. A centrifugal machine having a diffuser comprising two spaced walls between which the fluid flows radially outward, said walls being so close together that the angle of the fluid at normal load on the machine is of the order of 35° throughout the major portion of its travel.

6. A centrifugal machine having a diffuser comprising two spaced walls between which the fluid flows radially outward, said walls being so close together that the angle of the fluid at normal load is greater than 25° throughout the major portion of its travel, and the peripheral portion of said walls receding from each other.

7. A centrifugal machine having a diffuser comprising two spaced walls which provide a discharge passage which continuously converts velocity into pressure, said walls first approaching each other to an extent such as to provide an angle of the fluid at normal load greater than 25°, then extending substantially parallel to maintain such angle of the fluid, and finally receding from each other.

8. A centrifugal machine having a diffuser comprising two spaced walls between which the fluid flows outward, said walls first extending substantially parallel to each other and then receding from each other at their peripheral portions.

9. A centrifugal machine having a diffuser comprising two spaced walls which provide a discharge passage which continuously converts velocity into pressure, said walls approaching each other to an extent such as to provide at normal load an angle of the fluid of the order of 35°; and then extending substantially parallel to maintain such angle of the fluid throughout the major portion of its travel.

10. A centrifugal machine having a dif-

fuser comprising two spaced walls which provide a discharge passage which continuously converts velocity into pressure, said walls first approaching each other to an extent such as to provide at normal load an angle of the fluid of the order of 35°, then extending substantially parallel to each other to maintain such angle of the fluid, and finally at their peripheral portions receding from each other.

In witness whereof, we have hereunto set our hands, this 21st day of May 1925.

SANFORD A. MOSS.
MANUEL G. ROBINSON.