June 9, 1953 A. BUCHI 2,641,191

GUIDE MEANS ON IMPELLER FOR CENTRIFUGAL PUMPS OR BLOWERS

Filed Nov. 18, 1947 4 Sheets-Sheet 1

Fig. 1

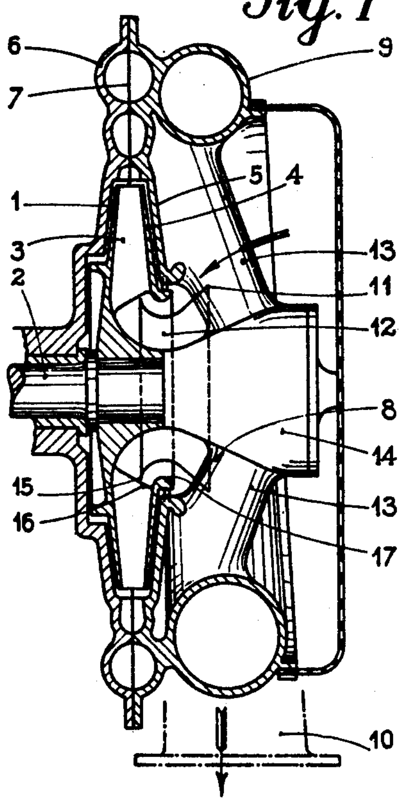

Fig. 2

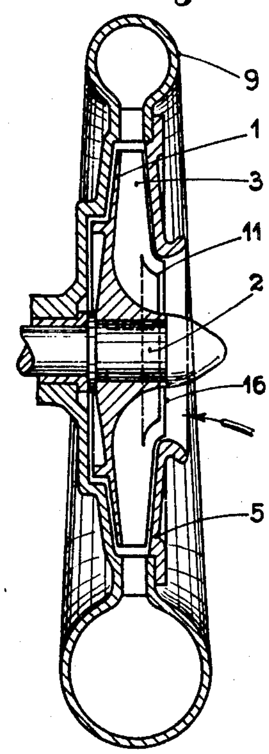

Fig. 8

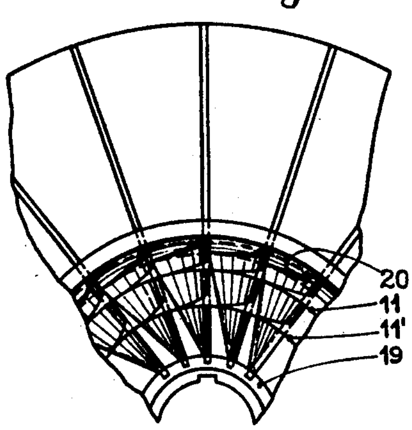

Fig. 7

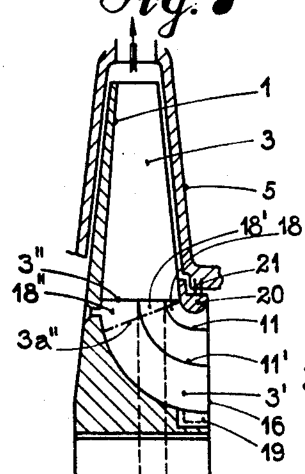

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Fig. 3

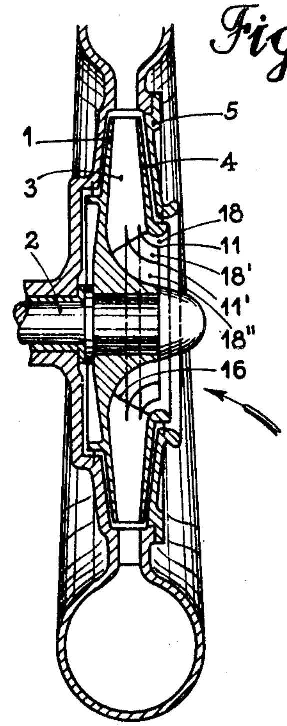


Fig. 4

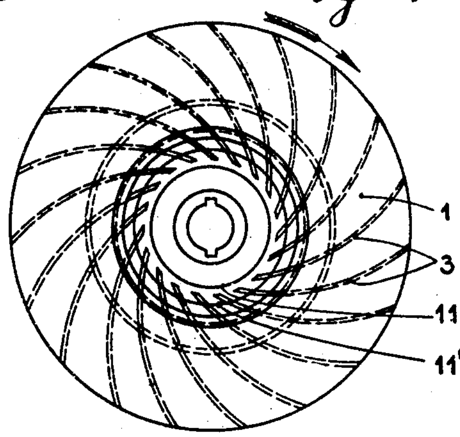


Fig. 5

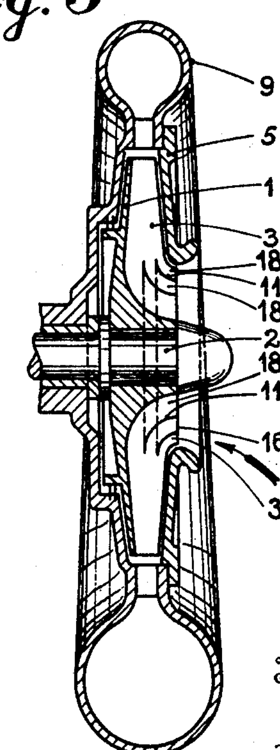
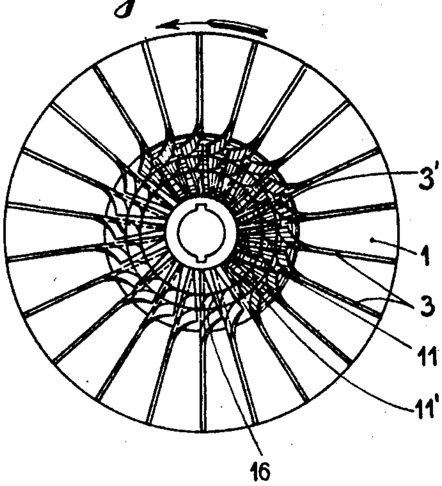


Fig. 6



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GUIDE MEANS ON IMPELLER FOR CENTRIFUGAL PUMPS OR BLOWERS

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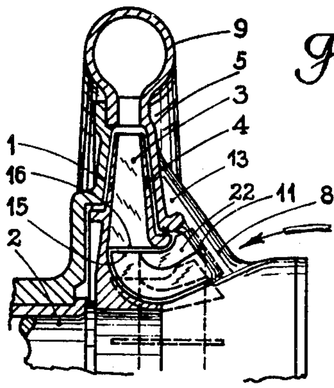
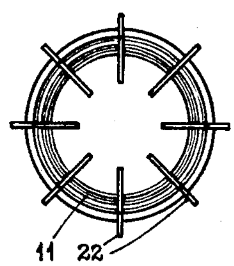


Fig. 9

Fig. 10



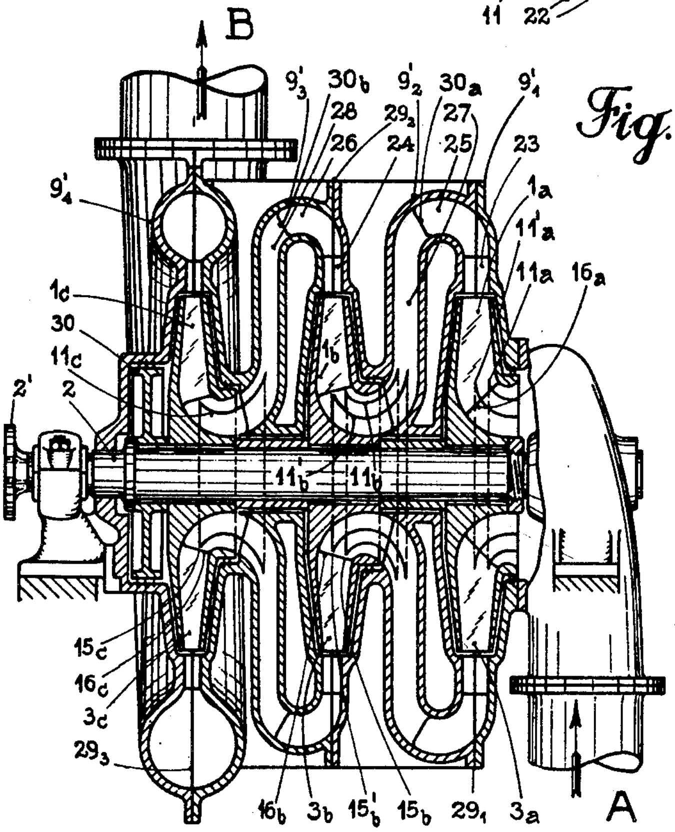


Fig. 14

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GUIDE MEANS ON IMPELLER FOR CENTRIFUGAL PUMPS OR BLOWERS

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Fig. 11

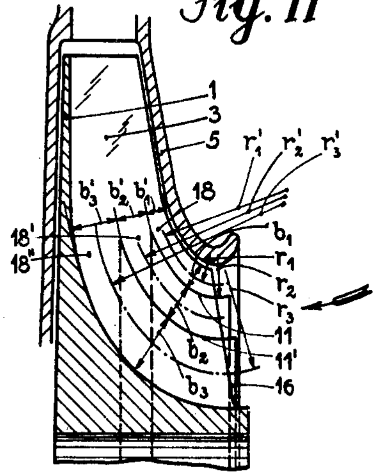


Fig. 12

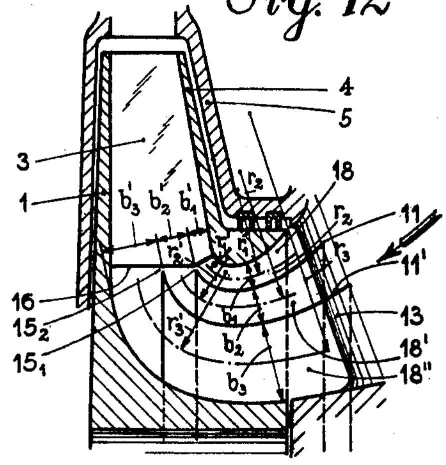
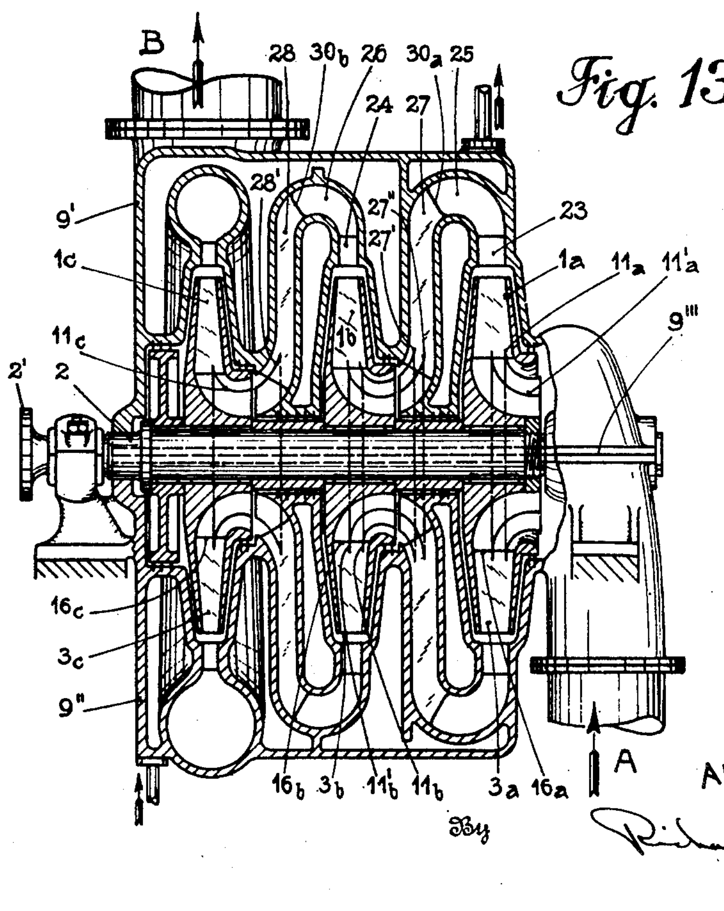


Fig. 13



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Patented June 9, 1953 2,641,191

UNITED STATES PATENT OFFICE

2,641,191

GUIDE MEANS ON IMPELLER FOR CENTRIFUGAL PUMPS OR BLOWERS

Alfred Buchi, Winterthur, Switzerland

Application November 18, 1947, Serial No. 786,605
In Switzerland November 12, 1946

5 Claims. (Cl. 103—108)

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The invention relates to a special embodiment of the inlet device on impellers for single-stage or multi-stage centrifugal pumps or blowers. According to this invention, at least one funnel-shaped annular vane is arranged into the intake throat of the impeller which guides the pressure medium from the axial to the radial direction, so that said annular vane, together with the confining surfaces of the intake throat, guides the pressure medium from the axial to the radial flow direction. The object of the invention may be so chosen and dimensioned that the funnel-shaped annular vane or vanes are fastened in the static section of the inlet casing, surrounding the impeller inlet, and the actual impeller blading starts only beyond the approximately radial exit of the annular vane or vanes. However, the annular vane or vanes may also be built into the centrifugally-acting impeller blading proper, extending inwardly towards the inlet throat for the pressure medium. Aside from the annular vane or vanes, additional vanes may be built into the entrance section of the impeller, e. g. vanes which impart a radial flow direction to the entering pressure medium, ahead of the centrifugally-acting impeller blades. If the embodiment is such that the annular vanes are to rotate with the impeller and the additional vanes are fixed in the static casing, then the additional vanes have to be slotted. The object of the invention can also be so arranged that in case of impellers with impeller blade tips extended axially towards the entrance throat for the pressure medium, the annular vane or vanes are built at least into the impeller section which guides the pressure medium from axial to radial direction. The annular vanes may extend, in this case, up to the inner ends of the impeller blades, or they may be shorter or longer with reference to the latter. In the latter case, the pressure medium does not enter both blade types simultaneously. The annular vanes may also extend more or less into the centrifugally-acting section of the impeller blading. The confining walls of the impeller, and the annular vane or vanes arranged at its inlet throat, may be so dimensioned and arranged that the velocity of the pressure medium in the passages located between the axial inlet and the radial section of the impeller remains constant or increases. The object of the invention may also be so formed that the radii of curvature of the passages created between the impeller walls and the annular vane or vanes, vary from the inlet in the direction of the pressure medium flow, i. e. they decrease or increase.

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The impeller walls, as well as the built-in annular vane or vanes, may on one hand be so dimensioned and shaped that the velocity of the pressure medium increases from the entrance towards the radial section of the impeller, and that on the other hand, in the same section, the radii of curvature of the passages which are created between the walls of the impeller and the annular vane or vanes, vary in the direction of the pressure medium flow, so, that despite the necessary curvature of said passages into radial direction there will be no substantial flow detachment of the pressure medium from the walls.

The annular vane or vanes may be divided (i. e. made in several parts) in at least one plane through the blower axis. The static annular vane or vanes may be cast or welded into the static entrance section of the pump or blower. The rotating type of annular vane or vanes may also be cast or welded into the impeller blading.

Furthermore, the arrangement with axially protruding impeller blade ends and with annular vane or vanes extending into the impeller blading, may also be made so that the thus formed passages for the pressure medium in the impeller have approximately square cross section, to keep the losses in these passages to a minimum. A sufficient number of annular vanes may be built in, that the thus determined radii of curvature of the passages between the confining walls of the impeller and the walls of the built-in funnel-shaped annular vanes are at least greater than the width of the corresponding, curved passages for the pressure medium.

The annular vanes may, however, also be made curved and built-in so that the radii of curvature, in relation to the width of the passages for the pressure medium created between the impeller walls and the annular vanes, are approximately equal for all passages.

At least two annular vanes may be built into the intake means of the impeller. In this way the passages confined between the impeller walls and the annular vanes can be made to have relatively large radii of curvature—e. g. of twice or more times the passage width—whereby the flow deflection losses are reduced. In these cases the arrangement is made preferably so that the ratio of radius of curvature to width of passage is approximately equal for all passages. The number of the impeller blade ends and of the annular vanes may be chosen so—for the sake of reduction of losses—that the thus created passages have approximately square cross section.

The intake means may also contain a sufficient number of annular vanes so formed and dimensioned that in all the inlet ducts thus created the sum total of all losses through friction, flow deflection and energy transition in the various separate entrance passages up to the proper centrifugally-acting impeller blading will be about equal and/or will be a minimum.

In case of multi-stage centrifugal pumps or blowers, whereby the pressure medium is guided from one impeller to the next impeller by means of fixed, inwardly-leading guide ducts in radial and then axial direction, at least one annular vane deflecting the pressure medium by approximately 180 degrees may be built in. In case of such centrifugal pumps or blowers, whereby impellers receive their pressure medium direct from a prior stage, there may be arranged at least one annular vane each, providing approximately 90 degrees flow deflection, in the fixed, curved intake passage, and/or in the corresponding impeller intake passage.

There may also be arranged a sufficient number of annular vanes in at least one of the two guide- and impeller-sections equipped with such annular vanes, and the vanes be so shaped and located, that the velocity and pressure conditions over the whole admission area for the pressure medium leading to the centrifugally-acting impeller blading will be at least approximately equal. In case of centrifugal pumps or blowers with divided (two-piece) guide casings, the built-in annular vanes may also be of divided construction.

In case of multi-stage centrifugal pumps or blowers, too, the built-in annular vanes may be arranged on constructed in such numbers, shapes and with such radii of curvature that there will be minimum flow losses in the thus created guide passages and/or all losses in these guide passages being about equal.

Special impellers with axially-acting blading may be arranged ahead of the centrifugally-acting impellers, whereby the former guide the pressure medium to the latter with a minimum of shock losses. Also, at least one axially-acting impeller may be arranged ahead of the centrifugally-acting impeller so that it transmits the pressure medium to the latter via a guide wheel. In this case, too, the inlet section of the blading of the centrifugally-acting impeller is to be shaped accordingly.

The object of the invention is illustrated in the enclosed figures in several examples of centrifugal blowers. Same numbers or letters mean same or similar parts. The application of the invention on centrifugal pumps can easily be deducted therefrom, since those machines contain similar parts.

Figs. 1 and 2 show sections through single-stage centrifugal blowers wherein the invention is embodied in the simplest form.

Fig. 3 illustrates a section through a shrouded impeller of a single-stage blower, whereby the object of the invention is applied in a different form on an impeller with backward-curved vanes.

Fig. 4 shows a view upon the impeller as illustrated in Fig. 3, seen from the pressure-medium intake side.

Fig. 5 shows a section through an open (unshrouded) centrifugal blower wheel with radial impeller vanes in which the impeller vanes extend axially in front as far as the inlet edge.

Fig. 6 is axial view upon an impeller of the type illustrated in Fig. 5, seen from the inlet side.

Figs. 7 and 8 show a different embodiment of the invention on an impeller similar to the one shown in Figs. 5 and 6, except that here the inner inlet section of the impeller is made in a piece separate from the impeller proper.

Fig. 9 illustrates a section through a still further embodiment of the invention, and

Fig. 10 is an axial view of the corresponding inlet device after it is removed outside of the impeller, viewed in a direction opposite to the pressure medium flow.

Figs. 11 and 12 show possible forms and arrangements of annular vanes built into the inlet opening of the impeller; Fig. 11 shows an open impeller with vanes extended as far as the inlet opening of the impeller, and Fig. 12 shows a shrouded impeller.

Figs. 13 and 14 show vertical sections through the axis of multi-stage centrifugal blowers. In Fig. 13 the casing of this blower is divided lengthwise (in axial direction) into two parts. Fig. 14 shows a multi-stage blower where the casing parts and the impellers are designed to be assembled axially and successively, so that the casing joints are vertical.

In Fig. 1, **1** is the impeller of the centrifugal blower, keyed upon shaft **2**. The impeller **1** has centrifugal vanes **3** and a shroud **4**. The two-piece blower casing **5** and **6** encloses the impeller **1** and has a joint **7**. The pressure medium enters the casing at **8** and is led into the blower casing **9**; from there it is fed through pressure tube **10** to its destination.

The object of the invention is the annular vane **11**, which juts into the inlet section **12** of the impeller **1** and aids the flow deflection of the pressure medium in this section from the predominantly axial direction to the at least approximately radial direction of the centrifugal impeller vanes **3**. In the illustrated example, the one-piece annular vane **11** is cast into the ribs **13** of the blower casing which connect the fixed central section **14** with the blower volute **9**. The inner diameter **15** of the annular vane **11** is just large enough to avoid touching the inner edges **16** of the impeller vanes **3** by said annular vane **11**, and to permit detachment of casing part **5**, with the thereto-attached annular vane **11**, from casing part **6** without blocking by the inlet edge **17** of the impeller shroud **4**. In the shown example the annular vane **11** is arranged relatively closely to impeller shroud **4**.

In Fig. 2 the impeller **1** has vanes **3** but no shroud, so that casing part **5** laterally encloses the vanes **3** with small clearance. The impeller vanes **3** are extended axially towards the inlet of the impeller and terminate in the approximately radially-arranged inlet edges **16**. An annular vane **11** is so arranged that it is set back some distance from the impeller vane inlet edges **16**, and that it provides the flow deflection of the pressure medium from axial to radial direction. This annular vane **11** may be cast into impeller blades **3**, or fixed therein in some other manner. It is arranged, as seen from the figure, more closely towards the outer side of the impeller vanes. This is done to avoid serious discrepancies in the ratios between radius of curvature and passage width, and the consequent discrepancies in losses.

In Fig. 3, **1** is the impeller with shroud **4** and impeller vanes **3**. The latter terminate inwardly at the edges **16**. In this example, two annular vanes **11** and **11'** are built-in; their outer ends are cast into the impeller vanes **3**. The inner ends of the annular vanes, i. e. the ones towards the inlet opening of the impeller, jut freely into said inlet opening.

As is visible from Fig. 4, an embodiment according to Fig. 3 has backward-curved impeller vanes 3. The annular vanes 11 and 11′ are so located that three annular passages 18, 18′ and 18″ are created between the confining walls of the impeller and the two annular vanes. These annular passages have different widths, so that passage 18 is narrowest, and passage 18″ is widest. Thus, the mean radii of curvature of the three passages can be made to have approximately equal ratio to the widths of the corresponding ducts. With a given angle of deflection, the deflection losses in the three annular passages can therefore be kept about equal, so that approximately equal pressure and velocity conditions will prevail over the whole cross section at the exit of said annular passages towards the centrifugally-acting section of the impeller.

Figs. 5 and 6 show an open centrifugal blower impeller 1 in which the impeller blades 3 are radially arranged on their centrifugal part, and axially so extended at 3′ and bent around at their inlet edges 16 that they admit the axially-inrushing pressure medium approximately shock-free. Two annular vanes 11 and 11′ are also arranged here in the impeller blading section towards the pressure medium entrance. They may be cast-in or welded-in, for example.

The inner part of the impeller blading with the axially extended inlet edges 16 and with the annular vanes 11 and 11′ may, on the other hand, also be built as a part containing the inner passages 18, 18′ and 18″. The outer ends of vanes 3′ may be held in a ring 20. Such a vane part is illustrated in a section in Fig. 7 and in axial view in Fig. 8. In this case the inner part of the impeller is separated from the centrifugal impeller proper. This piece may be fastened at the hub section of impeller 1, e. g. by means of ring 19. It is built in at 3″ inside of the outwardly-located impeller vanes 3. Between the ring 20 and casing part 5, seals 21 may be arranged. By these means, both the pressure medium delivery and the blower efficiency are improved in comparison to the ones on previously-known constructions where no such cover ring nor seals are used. Ring 20 may be seated, as shown on Fig. 7, directly upon the vanes 3 of an open impeller, or it may be fastened there. The vanes 3′ abutting against impeller disc 1 may also have axially-directed protrusions 20′ which may reach e. g. into the impeller disc 1, or they may be riveted or welded, etc. thereon. The inset blading section may also be so shaped that it reaches up to the inclined edges 3_a″ of the impeller vanes 3.

In Figs. 9 and 10, an embodiment similar to the one in Fig. 1 is shown. The annular vane 11 is also here fastened in the ribs 13 of the blower casing 9. Aside from the annular vane 11, however, eight thin, radial vanes 22 are also fastened in the ribs 13. These annular vanes, together with the eight radial vanes 22 and with the confining walls of impeller 1 and shroud 4, enclose sixteen radially-curved guide passages for the pressure medium. The annular vane is preferably so located that the ratio between the radius of curvature and the width of the passages is so chosen that the inner and outer passages have approximately equal pressure and velocity losses. Thus, the pressure medium is made to enter the centrifugally-acting impeller blade 3 under approximately equal pressure and velocity over the whole width of blade edge 16. In this type of construction, a certain optimal inlet angle to the impeller blading 3 can be maintained. The ribs 22, as well as the annular vane 11 may be cast, welded, or soldered, etc., into the ribs 13.

Figs. 11 and 12 illustrate, on two construction examples, the variety of shapes that can be given to the annular vanes and impeller walls at their inlet ends. Fig. 11 shows an open impeller 1. It is equipped with vanes 3 which extend axially up to edge 16. 5 is the casing part which encloses or covers the impeller blading on the outside. The annular vanes 11 and 11′, located in the inlet section of the impeller blading, show sharper curvature at the inlet ends, and reduced curvature towards the radial part of the impeller. Furthermore, the widths of the ducts created between the confining walls of the impeller and the annular vanes 11 and 11′ are larger at the pressure medium intake b_1, b_2, b_3 than at the exit b'_1, b'_2, b'_3. The annular vanes 11 and 11′ are unevenly placed so that the ratio of the mean radii of curvature r_1, r_2, r_3 of the passages to the mean passage widths b_1, b_2, b_3 is at least approximately larger than unity at the entrance, and increases to still higher values toward the exit b'_1, b'_2 and b'_3. By this means, the deflection losses in the three passages 18, 18′ and 18″ are kept relatively small. It is even possible, according to this invention, to locate the annular vanes 11 and 11′ so, and provide them with such curvatures and such length that the velocity and pressure losses will be equal in all the three passages 18, 18′ and 18″. The pressure medium enters therefore the centrifugally-acting blade section 3 of the impeller 1 with even velocities and under even pressure. This, of course, results in optimum admission of the pressure medium and, consequently, optimum effect of the impeller blading and of the whole machine. The annular vanes 11 and 11′ may be of different length on their intake or on their exit, as visible in Fig. 11.

In contrast to an embodiment shown in Fig. 11, Fig. 12 shows annular vanes so shaped that at the inlet ends they have relatively large, though uneven, radii of curvature r_1, r_2, r_3 compared to the passage widths b_1, b_2, b_3, and have relatively small radii of curvature r'_1, r'_2, r'_3, compared with the passage widths b'_1, b'_2, b'_3 at the exit ends. The passage widths b_1, b_2, b_3 and b'_1, b'_2, b'_3, respectively, are chosen uneven, too. They are larger at the pressure medium inlet than at its exit, so that an accelerated flow through the passages is achieved. The inner ends 15_1 and 15_2 of the annular vanes 11 and 11′ are so dimensioned that they do not touch the impeller vanes 3 and 16, but still provide most complete flow deflection to radial direction. With the type of annular vanes shown in Fig. 12, as contrasted to an embodiment according to Fig. 11, the ratio of radius of curvature to passage width is large at the pressure medium intake, and smaller at the rear end of the annular vanes 11 and 11′.

Through the insertion of these annular vanes, the ratio of radius of curvature to width of the guide passages can be made much larger than in case of no such annular vanes. Thus the losses through flow deflection of the pressure medium from axial to radial direction can be greatly reduced. By proper choice of the radii of curvature of the annular vanes and of the confining walls of the impeller at the pressure medium intake, and by suitable shaping, length and location of the annular vanes, the intake flow losses to the impeller can be reduced to a minimum, and/or the intake velocities to the centrifugal impeller blading, measured over the whole intake cross section, can be made equal, at equal pressure.

This permits more perfect filling of the impeller blading proper than would be possible without built-in annular vanes, resulting in greater output and higher efficiency of such centrifugal impellers.

Fig. 13 shows a section through the axis of a multi-stage centrifugal blower. It contains three impellers 1_a, 1_b, and 1_c arranged in series. The pressure medium enters at A and is discharged at B. All the three impellers 1_a, 1_b, and 1_c are keyed upon shaft 2, which is driven through coupling flange 2'. The casing 9', 9'' which encloses all the impellers, is divided into two sections at the horizontal plane 9'''. The object of the invention is incorporated in impeller 1_a in similar manner as in the embodiment shown in Fig. 3. Two annular vanes 11_a and $11'_a$ are built into the impeller vanes 3_a. They terminate at 16_a about parallel to the blower axis, however. The annular vanes 11_a and $11'_a$ jut a little beyond the inlet edge of impeller 1_a.

The impellers 1_a and 1_b discharge the pressure medium first to one guide device each, 23 and 24, where velocity is converted to pressure. Then the pressure medium is led through receivers 25 and 26, respectively, to the passages 27 and 28 which guide it radially inward again. The latter are equipped with vanes 30_a and 30_b which impose a predominantly radial flow direction to the pressure medium, particularly near the blower shaft. The pressure medium is led axially towards the inlet of the adjacent impeller 1_b or 1_c, respectively, by means of the casing walls which are curved, near the axis, from radial to axial direction. The flow deflection from space 27 into the impeller interior 1_b, which amounts to nearly 180 angular degrees, can be aided greatly by an embodiment of this invention. As seen in Fig. 13, it consists in at least one annular vane each (27', 27'' and 28', respectively) built into the exits of the transmitting pieces 27 and 28. They guide, together with the rounded confining walls of the guide parts 27 and 28, respectively, the pressure medium to the inlet of the adjacent impellers 1_b and 1_c, respectively, with a possible minimum of losses through deflection, friction, etc. Additional annular vanes 11_b, $11'_b$ and 11_c of a type hereinabove described are built into the impeller inlets. The annular vanes 27', 27'' and 28', respectively, are preferably so shaped and arranged in relation to the annular vanes 11, $11'_b$ and 11_c in the impellers 1_b and 1_c, that the full deflection of the pressure medium from radially-inward direction via axial to radially-outward direction is accomplished with minimum velocity and pressure losses, and/or with even velocity and pressure distribution of the pressure medium over the whole inlet cross section of the centrifugally-acting impeller blading.

Fig. 14 illustrates also a section through a three-stage blower with impellers 1_a, 1_b, 1_c. The blower casing consists here of four disc-shaped parts $9'_1$, $9'_2$, $9'_3$ and $9'_4$ which may be separated from each other along radially-extended joints 29_1, 29_2 and 29_3 upon loosening of the corresponding flange connections. Assembly of the blower is accomplished by first mounting the blower part $9'_4$ on the shaft 2 from the left-hand side, then sliding the balancing piston 30 on the shaft from the right-hand side, followed by impeller 1_c, and then fastening the blower casing part $9'_3$ on casing part $9'_4$. Thereupon the impeller 1_b, casing part $9'_2$, impeller 1_a, and, last, the inlet casing part $9'_1$ are assembled in that order.

According to the invention, deflecting vanes 11_a and $11'_a$ are built into the inlet section of the blading 3_a of impeller 1_a. The annular vanes 11_a and $11'_a$ are built into impeller 1_a similarly as illustrated already in Fig. 3.

Annular vanes 11_b and $11'_b$ are arranged in the intake section of impeller 1_b, and an annular vane 11_c is installed in the inlet of impeller 1_c. Installation of the annular vanes 11_b and $11'_b$ and 11_c, respectively, is done by insertion or by casting-in into vanes 30_a and 30_b, respectively, which subdivide the guide passages 27 and 28. These annular vanes are thus rigidly connected to the casing parts $9'_2$ and $9'_3$, and extend into the inlet sections of the impellers 1_b and 1_c, close to the inner impeller blade edges 16_b and 16_c. The outer diameters 15_b, $15'_b$ and 15_c of the annular vanes 11_b, $11'_b$ and 11_c, respectively, are chosen just large enough that the casing parts $9'_2$ and $9'_3$ can be readily withdrawn axially from the impeller inlet openings.

Similar as on the other shown embodiments, the shape, radii of curvature, and position of the annular vanes can be so chosen that minimum velocity and pressure losses will occur in the deflecting passages between the guide passage sections 27 and 28, respectively, and the impeller inlet 1_b and 1_c, respectively. The annular vanes may also be arranged in such numbers, shapes, and positions, that the inlet conditions will be approximately equal over the whole inlet cross sections of impeller blades 3_b and 3_c.

The invention provides improved inlet conditions on centrifugally-acting impellers. There, the pressure medium has to be deflected by about 90 degrees from axial to radial direction in case of single-stage blowers or pumps or on the first stages of multi-stage blowers or pumps. The deflection amounts to nearly 180 degrees in case of the subsequent stages of multi-stage blowers or pumps. This sharp deflection causes losses through deflection, friction, and—if the passage areas are variable—also through energy transition. These losses, or their sum total, are to be reduced by the insertion of the proposed annular vanes. The latter may be so shaped and located that throughout the whole inlet section for the pressure medium to the centrifugally-acting impeller blades there will prevail approximately equal velocity and pressure conditions. Since the deflection losses, in particular, take up a relatively large share of the total losses, it follows that the number and design of the annular vanes should be so chosen that the ratio of curvature radius to width of passage, for the passages so formed, will be as large as possible. This ratio is to be chosen differently for the individual guide passages so that the sum total of all losses therein is equal and/or is a minimum.

I claim:

1. A centrifugal pump or blower having an axial inlet eye and a blade supporting wheel, impeller blading on said wheel, a casing about said wheel and said blading, said casing having an annular portion defining the outer perimeter of said eye, said wheel having a portion beginning near the center of said eye, extending axially inwardly and curving from axial to radial direction to define with the inner portion of said casing a curved annular passage subdivided by said blading whereby the fluid to be pumped or blown is admitted axially through said eye and is forced centrifugally radially outwardly of said blower wheel, and funnel shaped annular vane means disposed in said passage beginning at least within said eye and curving with the blower wheel

portion and inner portion of said casing defining said passage to subdivide said passage into a plurality of smaller annular passages, said vane means being of such progressive diameters that the resulting ratios of the mean radii of curvature to the mean widths of said last mentioned subdivisions, measured in axial planes, are approximately equal for all said passages.

2. The pump or blower as defined in claim 1 wherein the blading on the blower wheel begins within the radially outer area of said annular passage and extends outwardly therefrom in a direction having a substantial radial component, and the annular vane means extends into said passage only up to the beginning of said blading and said vane means is secured to the blower casing so as to prevent rotation thereof with the blower wheel.

3. The pump or blower as defined in claim 2 wherein there is additionally provided a series of axially extending inlet blades, said blades being fixed to the blower casing and extending from a point outside the inlet eye into said passage up to the beginning of the wheel blading.

4. The pump or blower as defined in claim 1 wherein the blading extends into the inlet eye and the vane means are secured to said blading so as to rotate therewith.

5. The pump or blower as defined in claim 1

wherein the annular vane means are secured to said blading so as to rotate therewith.

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