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A. BAUMANN

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MULTISTAGE CENTRIFUGAL COMPRESSOR

Filed May 2, 1941

3 Sheets-Sheet 1

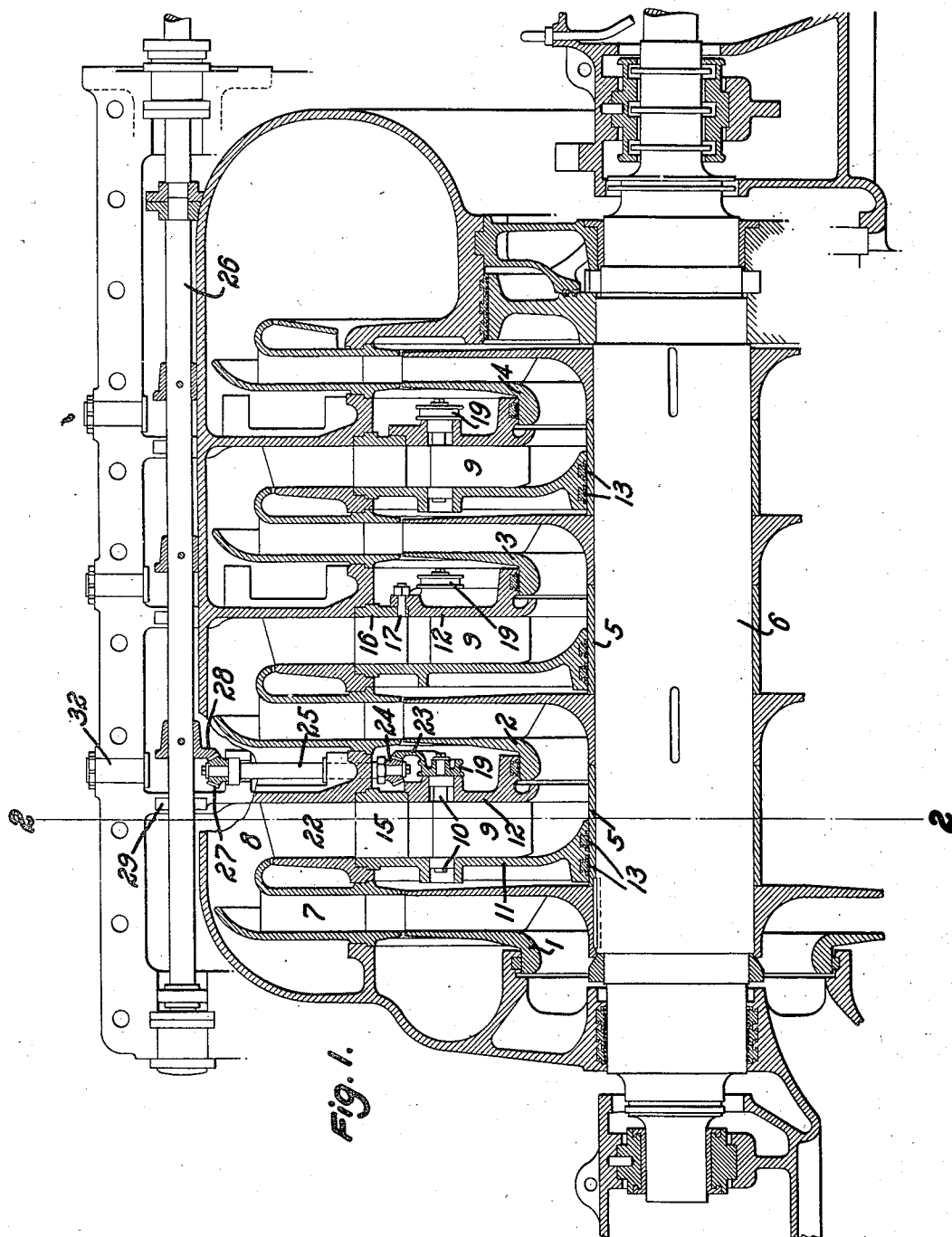


Fig. 1.

Inventor:

Adolf Baumann,

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Pierce & Scheffler,
Attorneys.

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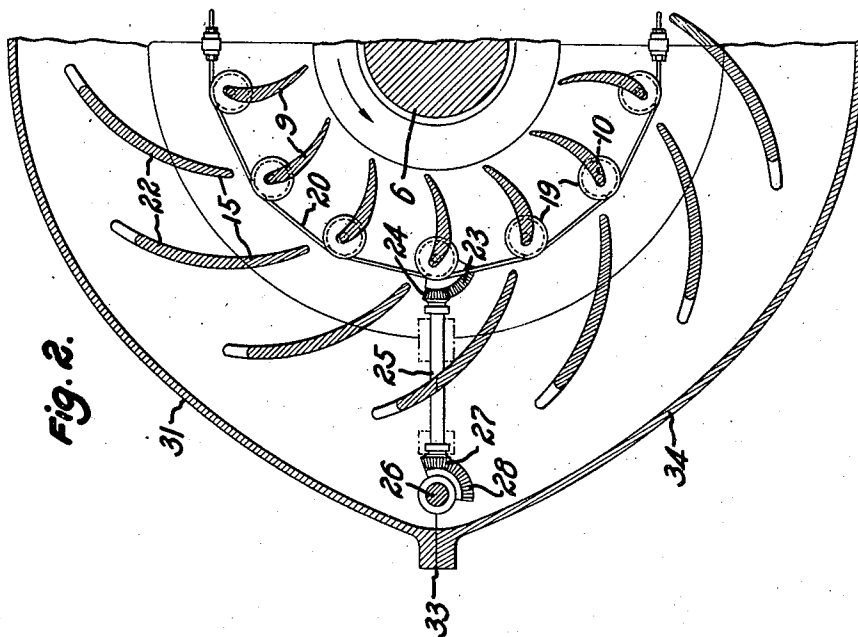
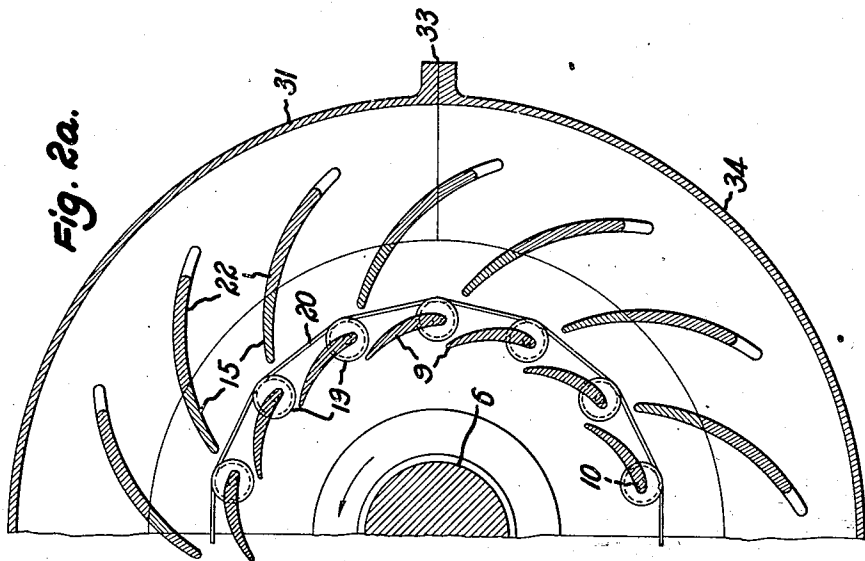
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Adolf Baumann,

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Pierce & Scheffler,

Attorneys.

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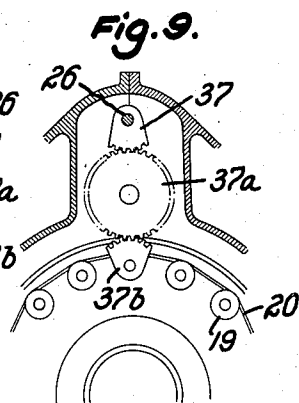
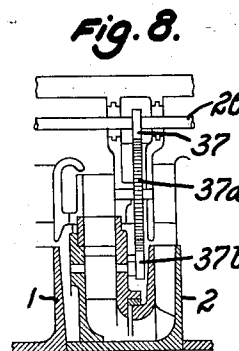
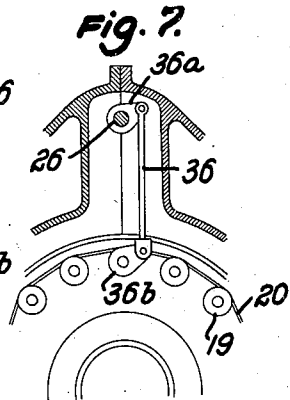
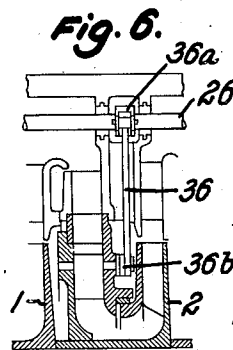
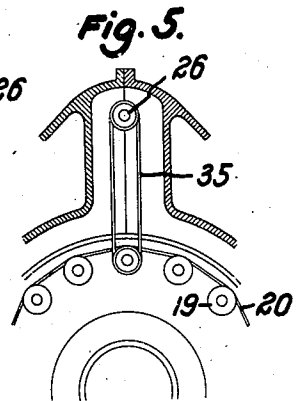
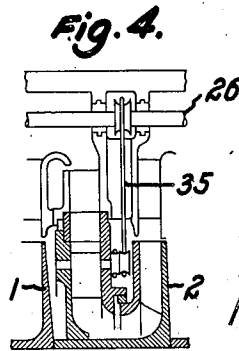
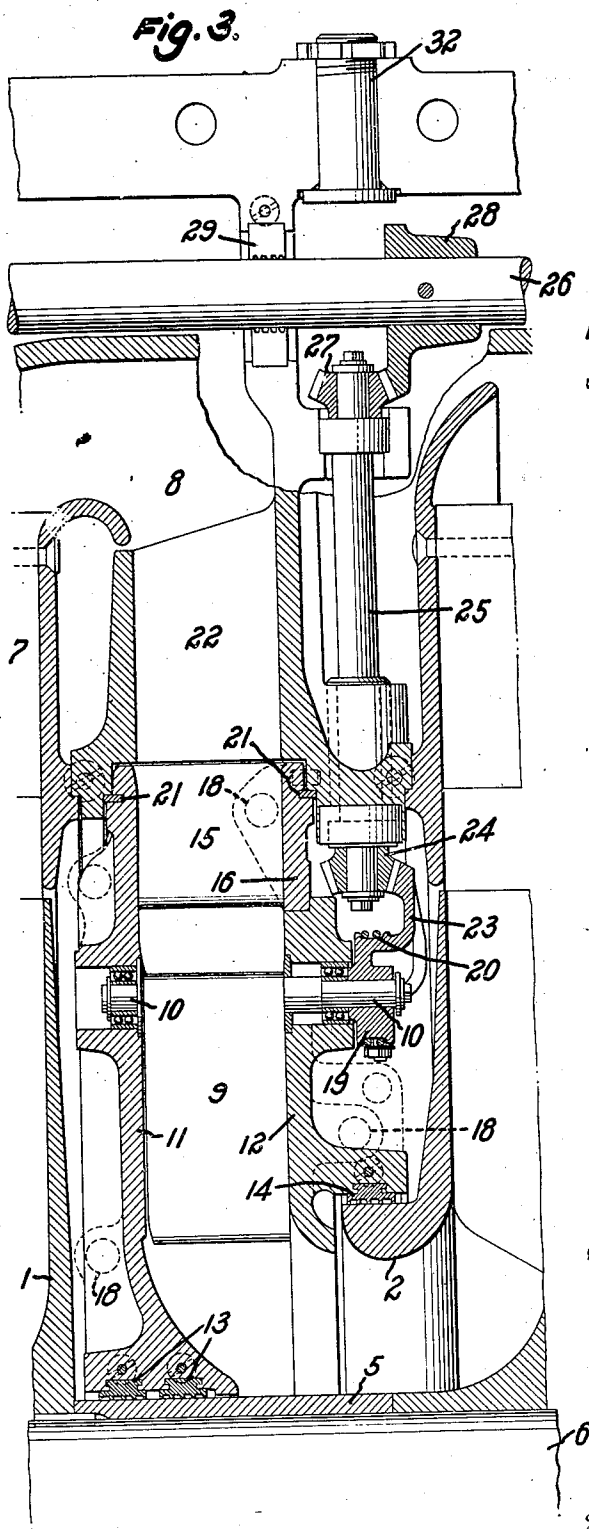
A. BAUMANN

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MULTISTAGE CENTRIFUGAL COMPRESSOR

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Inventor:

Adolf Baumann,

Pierce & Scheffler,
Attorneys.

Attorneys.

UNITED STATES PATENT OFFICE

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MULTISTAGE CENTRIFUGAL COMPRESSOR

Adolf Baumann, Wettingen, Switzerland, assignor
to Aktiengesellschaft Brown, Boveri & Cie,
Baden, Switzerland, a joint stock company of
Switzerland

Application May 2, 1941, Serial No. 391,581
In Switzerland May 10, 1940

9 Claims. (Cl. 230-114)

The present invention relates to multistage centrifugal compressors and in particular to regulating means therefor.

It has previously been proposed to provide adjustable guide vanes in the gas passages between successive impellers of multistage centrifugal compressors in order to divert the fluid stream more or less from a helical path into a radial path as it enters the intake of each succeeding impeller. The amount of adjustment of these guide vanes in one direction or another determines the pressure output of the compressor, depending upon whether the adjustment of the guide vanes results in fore-rotation or counter-rotation of the air stream.

In the prior proposals the means for adjusting the movable guide vanes, usually arranged behind the impellers, are not adaptable to the adjustment of guide vanes immediately in advance of the axial intake of the impellers but are confined to use with guide vanes adjacent the circumference of the passages between the diffuser of one impeller and the entrance of the intake passage of the next. Heretofore it has not been considered practical to build a multistage centrifugal compressor with adjustable guide vanes immediately adjacent the axially located intake ports of the impellers because of the resultant undue lengthening of the compressor to provide sufficient space between adjacent impellers to accommodate the vane mounting and adjusting mechanism.

It is an object of the present invention to provide a multistage centrifugal compressor with adjustable guide vanes immediately in advance of the axially disposed intakes of the respective impellers and to provide novel mounting and adjusting mechanism for the guide vanes which does not result in increase in the over-all length of the compressor.

More specifically, it is an object of the invention to provide a compressor of any desired number of stages with adjustable guide vanes in advance of the intake of the impellers in which the adjustable guide vanes are built or mounted in a cage or unit separate from the housing of the compressor, such cages being mounted on the rotor shaft between the impellers and assembled therewith in the housing and forming with portions of the housing the continuation of the fluid reversing passages between the rotors, whereby the vanes mounted in said cages form, in effect, continuations of the guide vanes mounted in the housing itself.

It is also an object of the invention to provide

novel transmission connections for regulating the adjustable guide vanes.

Other objects and advantages of the invention will become apparent during the course of the following detailed description of the same and reference to the accompanying drawings referred to therein.

In the drawings

Fig. 1 is an axial section through a multistage compressor embodying the invention;

Fig. 2 is a section on the line 2-2 of Fig. 1;

Fig. 3 is an enlarged fragmentary detail view on the same section as Fig. 1;

Figs. 4 and 5 are axial and transverse sections, respectively, illustrating a modified drive arrangement for the adjustable guide vanes;

Figs. 6 and 7 are axial and transverse sections, respectively, illustrating another modified drive arrangement for the adjustable guide vanes; and

Figs. 8 and 9 are axial and transverse sections respectively, illustrating still another modified drive arrangement for the adjustable guide vanes.

Referring more particularly to the drawings, in which a four-stage compressor is shown by way of illustration, 1, 2, 3 and 4 indicate the successive impellers which are retained in spaced relation on the compressor shaft 6 by means of spacing bushings 5. It will, of course, be understood that the impellers are keyed or otherwise rigidly fastened on the shaft 6 which is driven by a suitable prime mover, not shown. The first impeller 1 discharges circumferentially into a diffuser 7 in which the velocity of the gas is converted into a pressure head. The diffuser leads into a reversing passage 8 into which the fluid is turned to flow radially inwardly to the intake of the next impeller wheel 2 where the cycle is repeated. Adjustable guide vanes 9 are mounted adjacent the inner portion of the reversing passage 8 on pivots 10 journaled respectively in spaced disk members 11 and 12. The disk 11 is provided with a central aperture receiving the shaft 6 and with suitable packing 13 which seals the same against the bushing 5. The disk 12 is provided with a flange overlapping the adjacent rotor wheel and carries a suitable packing 14 for sealing the joint. The disk 11 adjacent its periphery carries fixed guide vanes 15 through which it is connected to a counter-ring 16 which is secured peripherally on the disk 12 by screws or bolts 17. It will thus be seen that the disk 11 and the disk 12 and the peripheral ring 16 form an annular cage or housing with definitely spaced side walls between which the adjustable guide vanes are mounted,

preferably with the pivots thereof journaled in ball bearings, as shown. This cage forms the inner portion of the radial passage leading from reversing passage 8 to the intake side of the rotor wheels. For convenience in assembling, the cage is split radially into two parts which are bolted together when assembled in position on the shaft 6 by means of screws 18, as seen clearly in Fig. 3. The two-part construction of the cages made up of the split disks 11 and 12 permits the assembling thereof between the rotor wheels after the latter have been fixed in position on the shaft and also facilitates the insertion of the packings 13 and 14 into position. The cage formed by the disks 11 and 12 is centered in position with respect to the main casing and is held in proper registry with the same by means of mating shoulder portions between which the packing 21 is inserted. The passage provided by the compressor casing, which is aligned with the passage provided by the disks 11 and 12 when the casing is assembled in position, is provided with fixed reversing vanes 22 which, as seen more clearly in Fig. 2, align with the fixed guide vanes 15 so that each of the latter constitutes the tail end or tip of one of the vanes 22.

The fixed guide vanes 22 and the adjustable guide vanes 9 are so shaped and mounted relative to each other that in all positions of adjustment of the vanes 9 the fluid pumped is guided in the desired path to the impellers with the least possible loss. The fixed vanes 22 and 15 are curved in the direction of fluid flow from the diffusers 7 and are set to provide guideways in which the fluid is turned toward the axis and its circumferential component of movement reduced.

The adjustable vanes 9 are streamlined and curved in cross-section from leading to trailing edge and the pivotal axis 10 thereof is positioned at the leading edge in spaced relation to the tip of the rigid vane sections 15 so that the vanes 9 define guideways leading from the guideways between the vanes 22—15 and adjustable as to direction of discharge with respect to the axis of rotation of the impellers.

In the position of adjustment of the vanes 9 shown in Fig. 2, the fluid is fed substantially radially into the eye of the succeeding impeller without any appreciable tangential component, whereas, with the vanes 9 in the position shown in Fig. 2a, the fluid is given a fore-rotation or tangential component in the direction of rotation of the impellers. In these, as well as in all other positions of adjustment, it will be observed that the relation and shape of the adjustable vanes 9 with respect to the fixed vanes 22—15 is such that the guideways formed by the vanes effect the desired directional feed to the impellers without production of eddy currents and with a minimum of loss of efficiency.

The vanes 9 are interconnected for simultaneous adjustment through the medium of suitable drive connections which, as shown, may consist of cable connections. The pivot shaft 10 of each vane extends at one end through the disk 12 and has a pulley 19 mounted on the projecting end thereof. The pulleys 19 are driven by a cable or rope 20 which makes a turn around each pulley in succession and has its ends joined by connectors which can be tightened to keep the cable tensioned. A gear segment 23, which may constitute part of one of the pulleys 19, is mounted on one of the pivot shafts 10 and meshes with a bevel gear 24 carried by a radially extend-

ing shaft 25 mounted in suitable bearings in the casing between the wall defining one side of the passage 8 beyond the disk 12 and the adjacent wall of the next diffuser 7. The shaft 25 carries a bevel gear 27 at its outer end which is driven from control shaft 26 by a gear 27 mounted thereon. The control shaft 26 is disposed in a recess 30 formed by a bulge in the mating halves 31 and 34 of the casing and in its passage from one stage to the next is provided with packing 29. Pins 32 are for the purpose of closing drilled openings in the casing opposite the ends of the shafts 25.

It will be noted that the shaft 25 and other driving parts of the vane adjusting mechanism lie in the plane of separation 33—33 of the casing halves 31—34 and that the shaft mountings are carried half by each of the casing sections so that the same are exposed for removal upon lifting of the top casing half 31.

It will be noted that with this construction the normal distance between impellers is not increased as compared with pumps without adjustable guide vanes, since there is necessarily a space between the wall of the reversing passage leading to an impeller and the wall of the diffuser leading therefrom due to the hub shape of the impellers and the sealing at 14.

The operation will be obvious from the above. The adjusting shaft 26, rotated by suitable means externally of the casing, drives the shaft 25 when adjustment of the guide vanes to a different setting is desired and the cable and pulley connections effect the same adjustment of all of the vanes to effect the desired directional flow through the reversing guideways to the eye of the respective succeeding impellers.

In the embodiment shown in Figs. 4 and 5, the shaft 25 is replaced by a belt, chain or cable 35 which drives one of the pulleys 19 from a pulley on the shaft 26.

In the embodiment shown in Figs. 6 and 7, a link and lever connection is employed for transmitting motion from the shaft 26 to the pivot shafts 10 of the vanes 9, the connecting link 36 being connected at its ends to crank levers 36a and 36b on the shaft 26 and one of the pivot shafts 10, respectively.

In the embodiment shown in Figs. 8 and 9, a segmental spur gear 37 carried by the shaft 26 drives a larger intermediate spur gear 37a journaled in the casing and the latter drives a spur gear segment 37b mounted on one of the pivot shafts 10.

While preferred embodiments of the invention have been shown and described by way of illustration, it will be understood that other modifications in the details of construction may be made without departing from the spirit of the invention within the scope of the appended claims.

I claim:

1. A multistage centrifugal compressor comprising a casing, a rotor shaft extending longitudinally within said casing, impellers mounted in spaced relation on said rotor shaft, means carried by said casing providing a diffuser for each of said impellers and said casing including spaced wall portions defining the outer portion of a reversing fluid passage to convey fluid from a diffuser chamber to a next succeeding impeller; a cage unit mounted between adjacent impellers and assembled with said rotor shaft and impellers in said casing, said cage unit comprising spaced disk members each having an axial opening for passage of said rotor shaft therethrough

and defining the inner portion of the reversing fluid passage leading to a next succeeding impeller, means rigidly connecting said disk members in spaced relation including rigid guide vanes extending between the same adjacent the circumferential portions thereof, adjustable guide vanes pivotally mounted on pivot shafts between said disk members inwardly of said rigid guide vanes and drive connections between the pivot shafts of said adjustable guide vanes; a control shaft extending longitudinally within said casing and driving means effective to establish a drive between said control shaft and the drive connections of said pivoted vanes when said cage unit is assembled in said casing.

2. A multistage centrifugal compressor comprising a casing, a rotor shaft extending longitudinally within said casing, impellers mounted in spaced relation on said rotor shaft, means carried by said casing providing a diffuser for each of said impellers and said casing including spaced wall portions defining the outer portion of a reversing fluid passage to convey fluid from a diffuser chamber to a next succeeding impeller, rigid guide vanes mounted between said spaced wall portions, a cage unit mounted between adjacent impellers and assembled with said rotor shaft and impellers in said casing, said cage unit comprising spaced disk members each having an axial opening for passage of said rotor shaft therethrough and defining the inner portion of the reversing fluid passage leading to a next succeeding impeller, means rigidly connecting said disk members in spaced relation including rigid guide vanes extending between the same adjacent the circumferential portions thereof, adjustable guide vanes pivotally mounted on pivot shafts between said disk members inwardly of said rigid guide vanes, drive connections between the pivot shafts of said adjustable guide vanes; a control shaft extending longitudinally within said casing, driving means effective to establish a drive between said control shaft and the drive connections of said pivoted vanes when said cage unit is assembled in said casing and means for positioning said cage unit in said casing so that the rigid guide vanes of said cage unit form continuations of the rigid guide vanes mounted between said wall portions of the casing.

3. In a multistage centrifugal compressor, a rotor shaft; a plurality of impellers mounted in spaced relation on said rotor shaft; a cage unit disposed between adjacent impellers, said cage units comprising spaced disk members each having an axial opening for passage of said rotor shaft therethrough, means rigidly connecting said disk members in spaced relation including rigid guide vanes extending between the same

adjacent the circumferential portion thereof, adjustable guide vanes pivotally mounted between said disk members radially inwardly of said rigid guide vanes and means interconnecting said adjustable guide vanes for effecting simultaneous adjustment thereof; a longitudinally split casing comprising two halves formed with seating portions for each cage unit and with wall portions defining a diffuser chamber for the impeller in advance of each cage unit and a fluid passage leading from said diffuser chamber to the circumference of each cage unit when said casing halves are joined, with said rotor shaft, impellers and cage units enclosed therein, a control shaft mounted in said casing adjacent the circumferential wall thereof, and drive connections between said control shaft and the interconnections between said adjustable vanes.

4. A centrifugal compressor according to claim 3 in which the casing members are formed to provide a longitudinally extending recess within the casing for mounting said control shaft and said control shaft extends parallel to the axis of said rotor shaft.

5. In a compressor as defined in claim 3, said drive connections being disposed in the plane of separation of said casing, and the halves of said casing having complementary bearing portions for mounting said control shaft and drive connections.

6. A compressor according to claim 3 in which said interconnecting means comprise a cable and pulley connection between the pivot shafts of said adjustable vanes and said drive connections comprise a radial connecting shaft geared to said control shaft and to the pivot shaft of one of said adjustable vanes.

7. A compressor according to claim 3 in which said interconnecting means comprise a cable and pulley connection between the pivot shafts of said adjustable vanes and said drive connections comprise a link and the crank connection between said control shaft and pivot shaft of one of said adjustable vanes.

8. A compressor according to claim 3 in which said interconnecting means comprise a cable and pulley connection between the pivot shafts of said adjustable vanes and said drive connections comprise a pulley and cable drive between said control shaft and one of said pivot shafts.

9. A compressor according to claim 3 in which said interconnecting means comprise a cable and pulley connection between the pivot shafts of said adjustable vanes and said drive connections comprise a gear drive between said control shaft and one of said pivot shafts.

ADOLF BAUMANN.