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Description

BACKGROUND OF THE INVENTION:

Field of the Invention:

The present invention relates to a centrifugal compressor in a gas compressing system available in the field of the petrochemistry or the like.

Description of the Prior art:

Generally, regarding a centrifugal compressor, a capability of raising a pressure with one stage of impeller has a limit, and in the case where a high pressure ratio or a high pressure head is required, a multi-stage arrangement is employed. Normally, the number of stages of impellers that can be accomodated within a single casing is limited in order to insure rigidity of an axle and to realize safe operations. Accordingly, in the prior art in the case where a high pressure head was required, it was realized by arraying a plurality of casings either in series or in parallel.

DE-A-18 13 335 discloses a centrifugal compressor comprising a plurality of axles each having centrifugal impellers that can compress gas by making use of a centrifugal force exerted upon the gas, coupling means for coupling said axles with one another as arrayed in series sequentially in such order that said gas can be compressed towards one side, a casing' for supporting said plurality of coupled axis having a gas suction port at one end and a gas delivery port at the other end, and a sealing means at the drive side of said plurality of axles.

Such a compressor comprises a casing housing first and second aligned shafts each bearing a plurality of centrifugal impellers to increasingly compress gas from stage to stage. Said gas is introduced into the compressor at the low pressure side thereof through a radial suction opening, fed through the several stages of the compressor increasingly pressurized thereby and is delivered as a high pressure gas through a radial outlet port at the gas delivery side of the compressor. In between some stages the gas flow passes through external cooling means bridging adjacent stages, respectively. In order to drive both shafts of both compressor units of the centrifugal compressor through a single torque transmitting drive unit the adjacent axial ends of both shafts are coupled through a planatory gear transmission. Said multi stage centrifugal compressor including at least two compressor units housed in a common casing, however, suffers from the following drawbacks:

1. As the gas suction port of the compressor is provided in the side wall of the casing perpendicularly to the axis of the shafts bearing the impellers a considerable gas flow resistance occurs which would render such a compressor incapable to be employed for high performance systems in which a large volume of gas is to be sucked. Consequently, as the known unavoidably requires to provide a front bearing for supporting one of the shafts through the axial front end wall of the compressor opposite to the drive side thereof the compressor due to its inherent design is prevented from enabling a large volume of gas to be introduced through the end plate of the casing in the axial direction into the interior of the compressor .

2. The prior art compressor employs both impeller shafts to be supported at the opposite front end plates of the casing or associated supporting structures whereas the opposite axial ends of both shafts are linked by a gear transmission inside of the casing. Such a design, accordingly, requires precise machining and assembly of the shaft bearing structures of both ends of the compressor as the coupling means in between both shafts, applying a gear transmission, does not allow misalignment of the shafts, to arise. Accordingly, increased manufacturing expense and inferior durability of the system must be expected.

3. Due to the definite bearing structure for the shafts gas sealing means for the shafts are required to be provided at four locations of the known compressor which, undoubtedly also results in increasing manufacturing costs.

4. Finally, the support structure for the shafts according to the prior art applying contact bearings results in increased friction loss and maintenance costs during the lifetime of the compressor comprised in the art.

Fig. 3 illustrates another example of the arrangement in the prior art, in which in order to realize a high pressure head, a gas compressing system was constructed by arraying three casings of a first compressor 49, a second compressor 50 and a third compressor 51 in series as numbered sequentially from the suction side. The interior of the individual compressor casing is composed of a multiple stages of centrifugal compressors. Driving power fed from a driving machine is transmitted via a drive shaft 57, and it is distributed from the third compressor 51 to the second compressor 50, and from the second compressor 50 to the first compressor 49, respectively by the intermediary of an intermediate coupling.

The gas is sucked through a gas suction pipe 41, then it is compressed by the first compressor 49, and it is delivered through a gas delivery pipe 42. The delivered gas passes through an intermediate gas cooler 43, in which heat-exchange is effected between the gas and a coolant water introduced from the outside through a coolant water feed pipe 58, and thereby the gas is cooled. Again the gas is sucked through a gas suction pipe 44 of the second compressor 50, and it is delivered through a gas delivery pipe 45. Further again, the gas cooled by an intermediate gas cooler 46 in a similar manner is sucked through a gas suction pipe 47 and compressed by the third compressor 51, then it is delivered from a final gas delivery port 48, and it is used as a high-pressure gas.

In the respective compressors, bearings are disposed in the proximities of the opposite axial end surfaces of the casing, and in order to prevent the gas enclosed within the casing from leaking out, gas seal means are disposed at the locations where the drive shaft penetrates the end plates of each casing.

In the case of the illustrated example, use of a film seal or a mechanical seal as the gas seal means is illustrated, and sealing oil appropriately adjusted so as to meet the order of the gas pressure within the casing, is fed through sealing oil feed tubes 52, 53 and 54, respectively. Though these mechanisms for feeding sealing oil are constructed so as to follow the change of the pressure within the casing, if the feed of sealing oil should become faulty, the sealing capability would be lost, and hence, the gas seal means per se as well as the sealing oil feed mechanism are respectively required to individually have a high reliability, and their manufacturing expense would become high.

In addition, lubricant oil is fed to the bearings through a lubricant oil feed tube 55, and drain oil in the bearing boxes is drained through a lubricant oil pipe 56.

In the case where a compressor is composed of a large number of casings as is the case with the abovedescribed centrifugal compressor in the prior art, a large number of seals for preventing the internal gas from leaking out to the atmosphere are necessitated at the locations where the axle penetrates through the opposite axial end surfaces of the respective casings. As the method for sealing the axle, various methods such as an oil film seal method, a mechanical seal method, a gas seal method, etc. can be employed depending upon the respective uses. However, in any event, the gap space between the axle rotating at a high speed and a seal ring mounted to a stationary portion is necessitated to be held narrow, and so, manufacture, assembly and maintenance are necessitated to be paid with careful caution. Even if it were to be done, a possibility that one of the large number of seal means may become faulty is large, and so, in order to insure high reliability, it is necessary to use expensive materials and perform machining at a high precision for the respective seal means.

Accordingly, in the case where a compressor is constructed by making use of a large number of casings and employing a large number of seals as in the above-described case, it is difficult to economically insure stable operations for a long period of time.

In addition, in the case where a compressor is constructed of a large number of casings, it is necessary to maintain the axes between the casings invariant during an operation, hence the structures of the mounting tables of the respective casings would become complex, moreover contrivance is made for the method of supporting the suction and delivery pipings of gases to and from the respective casings, and a complex method is employed for mounting the pipings so that forces generated by deformation of the pipings may not be unnecessarily applied to the casings. In addition, since cooling of gas for the purpose of efficiently compressing the gas is effected between delivery from one casing and suction into the next casing, a gas cooler disposed separately outside of the casings is employed, and hence, high-pressure gas pipings between the respective implements would become long and complex.

As these disadvantages in the prior art would overlap on one another, a compressing system for realizing compression of high pressure head is complicated in structure and apt to have its reliability lowered, but nevertheless it was difficult to provide the compressing system at a low cost.

Furthermore, since the volume of gas sucked into the first compressor is large, in order to compress the gas efficiently, suction through an axial end surface is desirable, but in the prior art, as oil-lubricated bearings are used, a complicated seal for preventing oil from mixing into the gas is necessitated, and therefore, an extension length of the axle to the outside of the bearing becomes too large, and there was difficulty in a stable operation.

SUMMARY OF THE INVENTION:

It is therefore one object of the present invention to provide an improved centrifugal compressor, that is free from the above-mentioned shortcomings in the prior art.

A more specific object of the present invention is to provide a centrifugal compressor, in which stable operations over a long period time can be insured in an economical manner.

Another object of the present invention is to provide a centrifugal compressor which does not necessitate a large number of seal means.

Yet another object of the present invention is to provide a centrifugal compressor which can be constructed in a less expensive manner without necessitating expensive materials nor machining at a high precision.

Still another object of the present invention is to provide a centrifugal compressor which does not necessitate a complicated mounting structure for maintaining axial alignment of a plurality of axles having impellers thereon.

According to one feature of the present invention, there is provided a centrifugal compressor as described above, wherein said casing comprises electro magnetic bearings for radially supporting said plurality of axles integrally at their respective opposite ends, the casing defines said gas suction port to extend axially through a front wall of the casing, and said coupling means are adapted to allow misalignment of said axles.

The centrifugal compressor according to the invention offers the following advantages over the prior art compressor.

The coupling means according to the present invention inter-linking the respective axles are designed to allow a certain misalignment of the axles, i.e. a radial deviation of each of the axles from a notional common center axis of the plurality of axles.

The compressor according to the present invention provides an axial suction opening to enable a large volume of gas to be sucked into the compressor with minimal flow resistance loss.

Each of the axles is supported through contact free electric magnetic bearings resulting in minimal friction loss and wear and, moreover, avoiding lubricating oil to be necssary and, consequently, avoiding the sealing problems to occur between pressurized gas and lubricating oil inside the compressor;

Finally the compressor according to the present invention requires only one gas sealing means to be provided in between an axle and the casing so that manufacturing and maintenance of the compressor becomes easy.

Further, according to the present invention, owing to the above-described construction that a plurality of axles are disposed in series within a single casing and the respective axles are supported by magnetic bearings at their opposite ends, bearing oil is not necessitated. And, by disposing the bearings in the gas, the location where the axle penetrates through the end surface on the high pressure side of the casing becomes only one location on the side for transmitting driving power, and so, the number of places where counter-measure for leakage of gas must be taken is greatly reduced, and high reliability can be realized.

The above-mentioned and other objects, features and advantages of the present invention will become more apparent by reference to the following description of one preferred embodiment of the invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS:

In the accompanying drawings:

Fig. 1 is a longitudinal cross-section view of a centrifugal compressor according to one preferred embodiment of the present invention;

Fig. 2 is a detailed longitudinal cross-section view of an intermediate coupling employed in the same embodiment; and

Fig. 3 is a plan view of one example of a centrifugal compressor in the prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENT:

Now, one preferred embodiment of the present invention will be described with reference to Figs. 1 and 2.

In Fig. 1, gas sucked through a gas suction port 2 provided at one end of a casing 1 for sucking gas in the axial direction, is compressed by an impeller 26 mounted to the tip end of a first axle 3. This gas passes along the outer circumference of a bearing body supporting the axle 3, and while it is being compressed by a multiple stages of centrifugal impellers, it is delivered from the last stage centrifugal impeller mounted to the axle 3, and it flows out through a first delivery port 38. Thereafter, the gas flows into a gas cooling section 4 mounted on the outer circumference of the casing 1, where it passes through the interstices in a cooling tube group 6 which is cooled by an externally supplied coolant water 5, and after it has been cooled down to a predetermined temperature, it is led to a gas suction port 8 of a multistage compressor assembly mounted to a second axle 7. The gas compressed again and delivered through a delivery port 9 is again introduced into the gas cooling section 4 on the outer circumference of the casing 1, and it is cooled there. The gas side chamber in the gas cooling section 4 is partitioned into two chambers for use with the axle 3 and for use with the axle 7. The cooled gas is again introduced to a gas suction port 10 of a multi-stage compressor assembly constructed by a third axle 12, and it is again compressed there by a compressing action consisting of the action of the impeller and the already known diffuser effect, in combination. The gas compressed up to the final stage is delivered through a final delivery port 11 at a predetermined pressure.

As described above, within a single casing 1 is disposed a compressor assembly composed of a plurality of axles 3, 7 and 12 each having impellers mounted thereon, and a stationary member for forming gas passageways to properly compress gas.

The axle 3 is supported by radial bearings 13 and 14, the axle 7 is supported by radial bearings 15 and 16, the axle 12 is supported by radial bearings 17 and 18, and all these axles are supported independently in a non-contact manner by an electromagnetic effect making use of magnets. Since these bearings do not necessitate lubricant oil as is the case with the bearings in the prior art, they could be disposed even in gas without being accompanied by any problem. The respective axles 3, 7 and 12 are connected with each other via an intermediate coupling 19 as will be described later, and a necessary torque is transmitted through the intermediate coupling 19. This intermediate coupling 19 has the function that it allows relative displacement in the radial direction freely among the axles 3, 7 and 12, but among the relative displacement in the axial direction, it restrains the relative displacement in the direction of the respective axles approaching to each other.

The necessary input torque to this compressor is applied externally via a drive coupling 20 by means of a drive machine such as an electric motor or a turbine. In this way, the above-mentioned respective axles 3, 7 and 12 would rotate at the same speed.

Owing to the above-described construction, the compressor can tightly seal the gas by disposing a gas seal device 23 for preventing gas within the casing from leaking out to the outside, only at the location where the third axle 12 for transmitting a torque transmitted from the drive coupling 20 to the respective axles 3, 7 and 12 within the casing 1, penetrates the casing end plate 22 forming a part of the casing 1. In other words, as compared to the centrifugal compressor in the prior art, the number of locations of gas seal devices is remarkably reduced.

Behind the final stage impeller on the axle 12 is disposed a pressure balancing disc 25 mounted to the axle 12, and a high-pressure gas is reduced in pressure toward a pressure balancing chamber 24 via labyrinth fins to make the gaseous forces in the axial directions applied to the axle 12 appropriately balance with each other. The pressure balancing chamber 24 is connected through a pressure balancing tube 21 additionally provided on a casing end plate 22 to a low-pressure environment at the gas suction port 2.

At one end of the axle 12 is additionally provided a thrust collar 28, an electromagnetic thrust bearing 29 sandwiching this thrust collar 28 from the opposite sides in the axial direction is fixedly secured to the stationary side, and this electromagnetic thrust bearing 29 operates to detect the position in the axial direction of the axle 12 via a control device disposed externally and to return the axle 12 to a predetermined position. At one end of the first axle 3, a suction magnetic bearing 27 is provided on the back surface of an impeller 26 which achieves initial gas suction effects. The suction force of this suction magnetic bearing 27 acts upon the first axle 3 and the second axle 7. By making this suction magnetic bearing 27 have a capability of generating a suction force exceeding the sum of the unbalanced forces caused by gas pressure directed towards the gas suction port, the first and second axles 3 and 7 are always applied with a force tending to move them towards the gas delivery side. Since the intermediate coupling 19 has a structure adapted to prevent the axles from approaching to each other as described above, this force is transmitted to the third axle 12, but as the position in the axial direction of the axle 12 is controlled by the action of the electromagnetic thrust bearing 29, the axles 3, 7 and 12 are all fixed in position in the axial direction, and so, their relative positions with respect to the stationary structure are maintained at predetermined positions. While provision was made so as to suck the impeller 26 on the axle 3 in the above-described case, the object to be sucked need not be the impeller 26, but so long as it is a disc-shaped one rotatable integrally with the axle, anything could be employed, and in essence, if the object is adapted to generate a force based on a magnetic effect which sucks the first axle 3 towards the delivery port side, the desired purpose can be achieved.

Next, details of the above-described intermediate coupling 19 will be explained with reference to Fig. 2. For example, to the axial ends of the first axle 3 and the second axle 7, respectively, are mounted coupling hubs 31 through a conventional method, and a torque transmission tube 33 is coupled to flanges formed on these hubs via thin flexible discs 32, by means of bolts and nuts 35. Reference numeral 34 designates a protective plate for the flexible disc 32.

To the axial ends of the axles 3 and 7 are mounted restraining shafts 36 and 37, respectively, directed in the axial direction. The restraining shaft 36 has a projection 39 at the center of its axial end surface, so that in the case where the respective restraining shafts 36 and 37 come into contact with each other, the contact is made at the center of their end surfaces and the respective axles cannot approach further to each other.

Owing to the above-described structure, the axles 3 and 7 would not move in the direction of approaching to each other during the operation, and even if their rotary axes should become misaligned, no reaction force is generated in the radial direction thanks to the flexibility of the flexible discs 32 and the torque transmission tube 33, so that smooth torque transmission can be achieved.

While the casing 1 is illustrated in Fig. 1 so as to be divided into parts forming gas passageways and an outside box-like part for integrally holding these parts (applied with differently directed hatchings), as a matter of course, there is no need to divide into these parts, but so long as it is possible in view of the manufacturing technique, for instance, the casing could be formed integrally as by casting. Moreover, the intermediate coupling also need not be limited to the illustrated structure, but so long as relative misalignment between the axes of the respective axles is permissible, any other structure could be employed.

Since the present invention is characterized by the structural features as described in detail above, the invention provides the following advantages:

(1) Since a compressing system realizing a high pressure head can be constructed with a single casing, a large number of seal devices as necessitated in the prior art become unnecessary, a seal device at only one location can suffice, hence dangerous locations where leakage of gas is apt to occur are reduced in number, and reliability is greatly improved.

(2) As a single casing is employed, there is no fear that misalignment of axes between the respective compressor units may arise. Even if such misalignment should occur, the novel coupling between the axles can compensate for the disadvantages.

(3) Since electromagnetic bearings not being held in contact with the axle are employed, a lubricant oil device is not necessitated, and the inconvenience that lubricant oil may be mixed in the gas, can be eliminated.

While a principle of the present invention has been described above in connection to one preferred embodiment of the invention, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted to be illustrative and not in a limiting sense.

Claims

1. A centrifugal compressor comprising a plurality of axles each having centrifugal impellers that can compress gas by making use of a centrifugal force exerted upon the gas, coupling means for coupling said axles with one another as arrayed in series sequentially in such order that said gas can be compressed towards one side, a casing for supporting said plurality of coupled axles having a gas suction port at one end and a gas delivery port at the other end, and a sealing means at the drive side of said plurality of axles, characterized in that, said casing (1) comprises electro magnetic bearings (13,14,15,16,17,18) for radially supporting said plurality of axles (3,7,12) integrally at their respective opposite ends, the casing (1) defines said gas suction port (2) to extend axially through a front wall of the casing (1), and said coupling means (19) are adapted to allow misalignment of said axles (3,7,12).

2. A centrifugal compressor as claimed in claim 1, characterized in that, a gas cooling section (4) for cooling the gas compressed by the centrifugal impellers upon the axles (3,7,12) is mounted to said casing.

3. A centrifugal compressor as claimed in claims 1 or 2, characterized in that, said coupling means (19) is adapted to restrain relative displacement of the coupled axles (3,7,12) to approach to one another in axial direction.

4. A centrifugal compressor as claimed in claim 3, characterized in that, said coupling means (19) is composed of restraining shafts (36,37) mounted to the adjacent axial ends of the associated axles (3,7,12) so as to opposed to each other, two flexible discs (32) disposed around said restraining shafts (36,37) and respectively mounted to the respective axles (3,7,12), and a torque transmission tube (33) connected to said flexible discs (32).

5. A centrifugal compressor as claimed in claim 4, characterized in that, at least one of the restraining shafts (36,37) has a projection (39) at the center of its axial end surface adapted to restrict an axial approach of the restraining shafts (36,37) to one another.

6. A centrifugal compressor as claimed in at least one of the preceding claims 1 to 5, characterized in that, said sealing means comprises a gas sealing device disposed only at the location where one (12) of the plurality of axles (3,7,12) penetrates an end plate (22) of the casing (1) to receive torque from a drive coupling (20) to transmit said torque to the other axles (3,7,12) of said plurality of axles (3,7,12).

7. A centrifugal compressor as claimed in at least one of the preceding claims 1 to 6, characterized in that, a pressure balancing disc (25) is disposed on the respective axle (12) at the downstream side of the final stage impeller in order to provide a reduction of pressure of effluent high-pressurized gas leaking from said stage towards a pressure balancing chamber (24) via labyrinth fins to appropriately balance the gaseous forces with each other acting in

axial direction to said axle (12).

8. A centrifugal compressor claimed in claim 7, characterized in that, said pressure balancing chamber (24) is communicated to a low-pressure environment at the gas suction port (2) through a pressure balancing tube (21) provided on an end plate (22) of the casing (1).

9. A centrifugal compressor as claimed in at least one of the preceding claims 1 to 8, characterized in that, an electro magnetic thrust bearing (29) is provided supporting one end of a final high-pressure stage related axle (12) of the plurality of axles (3,7,12) to apply an axially inwardly directed thrust force to said plurality of axles (3,7,12) from the gas delivery side of the compressor whereas a magnetic tensile force bearing is associated to the first low-pressure related axle (3) of the plurality of axles (3,7,12) to apply an opposite axially inwardly directed tension force to said plurality of axles (3,7,12) from the gas suction side of the compressor.

10. A centrifugal compressor as claimed in claim 9, characterized in that, said electro magnetic thrust bearing (29) is fixed to the casing (1) and designed to sandwich a thrust collar (28) secured to said axle (12), thus enabling the axle position of the axle (12) to be detected through the thrust bearing (29) via an external control device in order to return the axle (12) to a predetermined position.

11. A centrifugal compressor as claimed in claim 9, characterized in that, said magnetic tensile force bearing (27) is provided in conjunction with the back surface of an impeller (26) which achieves initial gas suction effects to apply axial tensile force to said impeller (26).

Revendications

1. Un compresseur centrifuge comportant une pluralité d'axes ayant chacun des roues centrifuges qui peuvent comprimer le gaz en utilisant la force centrifuge exercée sur le gaz, des moyens de couplage pour coupler lesdits axes l'un avec l'autre, ces axes étant alignés séquentiellement en série de telle manière que ledit gaz puisse être comprimé vers un côté, une enveloppe pour supporter ladite pluralité d'axes couplés et présentant un orifice d'aspiration de gaz à une extrémité et un orifice de refoulement de gaz à l'autre extrémité, et des moyens de fermeture étanche du côté entraînement de ladite pluralité d'axes, caractérisé en ce que ladite enveloppe (1) comporte des paliers électro-magnétiques (13,14,15,16, 17,18) pour supporter radialement ladite pluralité d'axes (3,7,12) comme un ensemble unique à leurs extrémités opposées respectives, l'enveloppe (1) définit ledit orifice (2) d'aspiration de gaz pour qu'il s'étende axialement à travers une paroi avant de ladite enveloppe (1), et lesdits moyens de couplage (19) sont agencés pour permettre un défaut d'alignement desdits axes (3,7,12).

2. Un compresseur centrifuge tel que revendiqué dans la revendication 1, caractérisé en ce qu'une partie (4) de refroidissement du gaz pour refroidir le gaz comprimé par les roues centrifuges sur les axes (3,7,12) est montée sur ladite enveloppe.

3. Un compresseur centrifuge tel que revendiqué dans les revendications 1 ou 2, caractérisé en ce que lesdits moyens de couplage (19) sont agencés pour empêcher un déplacement relatif des axes couplés (3,7,12) pour les rapprocher l'un de l'autre en direction axiale.

4. Un compresseur centrifuge tel que revendiqué dans la revendication 3, caractérisé en ce que lesdits moyens de couplage (19) sont constitués d'arbres de retenue (36, 37) montés sur les extrémités axiales adjacentes des axes associés (3,7,12) pour être en face l'un de l'autre, deux disques souples (32) disposés autour desdits arbres de retenue (36,37) et montés respectivement sur les axes respectifs (3,7,12), et un tube (33) de transmission de couple relié auxdits disques souples (32).

5. Un compresseur centrifuge tel que revendiqué dans la revendication 4, caractérisé en ce que l'un au moins des arbres de retenue (36,37) présente une saillie (39) au centre de sa surface extrême axiale, agencée pour empêcher un rapprochement axial des arbres de retenue (36,37) l'un vers l'autre.

6. Un compresseur centrifuge tel que revendiqué dans l'une au moins des revendications précédentes 1 à 5, caractérisé en ce que lesdits moyens de fermeture étanche comportent un dispositif de fermeture étanche au gaz disposé seulement à l'emplacement où l'un (12) de la pluralité des axes (3,7,12) pénètre dans une plaque extrême (22) de l'enveloppe (1) pour recevoir le couple à partir d'un couplage d'entraînement (20) pour transmettre ledit couple aux autres axes (3,7,12) de ladite pluralité d'axes (3,7,12).

7. Un compresseur centrifuge tel que revendiqué dans l'une au moins des revendications précédentes 1 à 6, caractérisé en ce qu'un disque (25) d'équilibrage de pression est disposé sur l'axe respectif (12) du côté aval de la roue de l'étage final de manière à fournir une réduction de pression du gaz sortant à haute pression fuyant depuis ledit étage vers une chambre (24) d'équilibrage de pression à travers des ailettes de labyrinthe pour équilibrer de manière appropriée entre elles les forces gazeuses agissant en direction axiale sur ledit axe (12).

8. Un compresseur centrifuge tel que revendiqué dans la revendication 7, caractérisé en ce que ladite chambre (24) d'équilibrage de pression communique avec un environnement à basse pression dans la zone de l'orifice d'aspiration de gaz (2) à travers un tube (21) d'équilibrage de pression prévu sur une plaque extrême (22) de l'enveloppe (1).

9. Un compresseur centrifuge tel que revendiqué dans l'une au moins des revendications précédentes 1 à 8, caractérisé en ce qu'un palier de poussée électro-magnétique (29) est prévu pour supporter une extrémité d'un axe associé (12) de l'étage final à haute pression de la pluralité d'axes (3,7,12) pour appliquer une force de poussée dirigée axialement vers l'intérieur à ladite pluralité d'axes (3,7,12) à partir du côté refoulement du gaz du compresseur, tandis qu'un palier à force de traction magnétique est associé au premier axe associé à basse pression (3) de la pluralité d'axes (3,7,12) pour appliquer une force de traction opposée dirigée axialement vers l'intérieur à ladite pluralité d'axes (3,7,12) à partir du côté aspiration de gaz du compresseur.

10. Un compresseur centrifuge tel que revendiqué dans la revendication 9, caractérisé en ce que ledit palier de poussée électro-magnétique (29) est fixé à l'enveloppe (1) et conçu pour être situé de part et d'autre d'une collerette de poussée (28) fixée audit axe (12), pour permettre ainsi à la position de l'axe (12) d'être détectée à travers le palier de poussée (29) par l'intermédiaire d'un dispositif extérieur de commande, de manière à ramener l'axe (12) à une position prédéterminée.

11. Un compresseur centrifuge tel que revendiqué dans la revendication 8, caractérisé en ce que ledit palier (27) de force de traction magnétique est prévu en conjonction avec la surface arrière d'une roue (26) qui produit des effets initiaux d'aspiration de gaz pour appliquer à ladite roue (26) une force axiale de traction.

Patentansprüche

1. Zentrifugalkompressor (bzw. Kreiselverdichter), umfassend eine Anzahl von Achsen bzw. Wellen mit jeweils Zentrifugal-Verdichterrädern, welche ein Gas mittels einer auf dieses ausgeübten Zentrifugalkraft zu verdichten vermögen, Kupplungseinrichtungen zum Kuppeln der Wellen miteinander in aufeinanderfolgender Reihe in der Weise, daß das Gas zur einen Seite hin verdichtet werden kann, ein Gehäuse zur Lagerung der mehreren gekuppelten Wellen mit einer Gasansaugöffnung am einen Ende und einer Gaslieferöffnung am anderen Ende sowie eine an der Antriebsseite der mehreren Wellen vorgesehene Dichteinrichtung,
dadurch gekennzeichnet, daß das Gehäuse (1) elektromagnetische Lager (13, 14, 15, 16, 17, 18) für einheitliche radiale Lagerung der mehreren Wellen (3, 7, 12) an ihren jeweiligen gegenüberstehenden Enden aufweist, daß das Gehäuse (1) die Gasansaugöffnung (2) sich axial durch eine Stirnwand des Gehäuses (1) erstreckend festlegt und daß die Kupplungseinrichtungen (19) einen Fluchtungsfehler der Wellen (3, 7, 12) zuzulassen vermögen.

2. Zentrifugalkompressor nach Anspruch 1, dadurch gekennzeichnet, daß am Gehäuse ein Kühlabschnitt (4) zum Kühlen des durch die Zentrifugal-Verdichterräder auf den Achsen (3, 7, 12) verdichteten Gases montiert ist.

3. Zentrifugalkompressor nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die (jede) Kupplungseinrichtung (19) eine Relativverschiebung der gekuppelten Wellen (3, 7, 12) aufeinander zu in Axialrichtung zu hemmen vermag.

4. Zentrifugalkompressor nach Anspruch 3, dadurch gekennzeichnet, daß die (jede) Kupplungseinrichtung (19) aus an den benachbarten axialen Enden der zugeordneten Wellen (3, 7, 12) einander gegenüberstehend montierten Hemmachsen oder -wellen (36, 37), zwei um letztere herum angeordneten und jeweils an den betreffenden Wellen (3, 7, 12) montierten flexiblen Scheiben (32) und einem mit den flexiblen Scheiben (32) verbundenen Drehmomentübertragungsrohr (33) besteht.

5. Zentrifugalkompressor nach Anspruch 4, dadurch gekennzeichnet, daß zumindest eine der Hemmwellen (36, 37) im Zentrum ihrer axialen Stirnfläche einen Vorsprung (39) aufweist, der

eine axiale Annäherung der Hemmwellen (36, 37) aufeinander zu zu begrenzen vermag.

6. Zentrifugalkompressor nach mindestens einem der vorangehenden Ansprüche 1 bis 5, dadurch gekennzeichnet, daß die Dichteinrichtung eine Gasdichtvorrichtung aufweist, die nur an der Stelle vorgesehen ist, an welcher eine (12) der mehreren Wellen (3, 7, 12) eine Stirnplatte (22) des Gehäuses (1) durchsetzt, um Drehmoment von einer Antriebskupplung (20) für Übertragung des Drehmoments auf die anderen Wellen (3, 7, 12) der mehreren Wellen (3, 7, 12) abzunehmen.

7. Zentrifugalkompressor nach mindestens einem der vorangehenden Ansprüche 1 bis 6, dadurch gekennzeichnet, daß an der betreffenden Welle (12) an der Stromabseite des Verdichterrads der letzten Stufe eine Druckausgleichscheibe (25) zur Gewährleistung einer Drucksenkung des ausströmenden hochverdichteten Gases, das aus dieser Stufe zu einer Druckausgleichkammer (24) über Labyrinthrippen heraussickert, angeordnet ist, um die in Axialrichtung der Welle (12) wirkenden Gaskräfte zweckmäßig gegeneinander auszugleichen.

8. Zentrifugalkompressor nach Anspruch 7, dadurch gekennzeichnet, daß die Druckausgleichkammer (24) an der Gasansaugöffnung (2) über ein Druckausgleichrohr (21), das an einer Stirnplatte (22) des Gehäuses (1) vorgesehen ist, mit einer Umgebung niedrigen Drucks in Verbindung steht.

9. Zentrifugalkompressor nach mindestens einem der vorangehenden Ansprüche 1 bis 8, dadurch gekennzeichnet, daß ein elektromagnetisches Schub- oder Axiallager (29) vorgesehen ist, welches das eine Ende einer letzten hochdruckstufenseitigen Welle (12) der mehreren Wellen (3, 7, 12) abstützt unter Ausübung einer axial einwärts gerichteten Schubkraft auf die mehreren Wellen (3, 7, 12) von der Gaslieferseite des Kompressors her, während ein magnetisches Zugkraftlager der ersten niederdruckseitigen Welle (3) der mehreren Wellen (3, 7, 12) zugeordnet ist, um eine entgegengesetzte, axial einwärts gerichtete Zugkraft auf die mehreren Wellen (3, 7, 12) von der Gasansaugseite des Kompressors her auszuüben.

10. Zentrifugalkompressor nach Anspruch 9, dadurch gekennzeichnet, daß das elektromagnetische Schub- oder Axiallager (29) am Gehäuse (1) befestigt und so ausgelegt ist, daß es eine an der Welle (12) befentigte Schubmanschette (28) umschließt, so daß die (Axial- oder) Wellenstellung der Welle (12) durch das Schub- oder Axiallager (29) (hindurch) mittels einer externen Steuervorrichtung zum Rückführen der Welle (12) in eine vorbestimmte Stellung detektierbar ist.

11. Zentrifugalkompressor nach Anspruch 9, dadurch gekennzeichnet, daß das magnetische Zugkraftlager (27) in Zuordnung zur Rückseite eines Verdichterrads (26), welches anfängliche Gasansaugwirkungen erzielt, vorgesehen ist, um eine axiale Zug- oder Ziehkraft auf das Verdichterrad (26) auszuüben.

Fig. 1

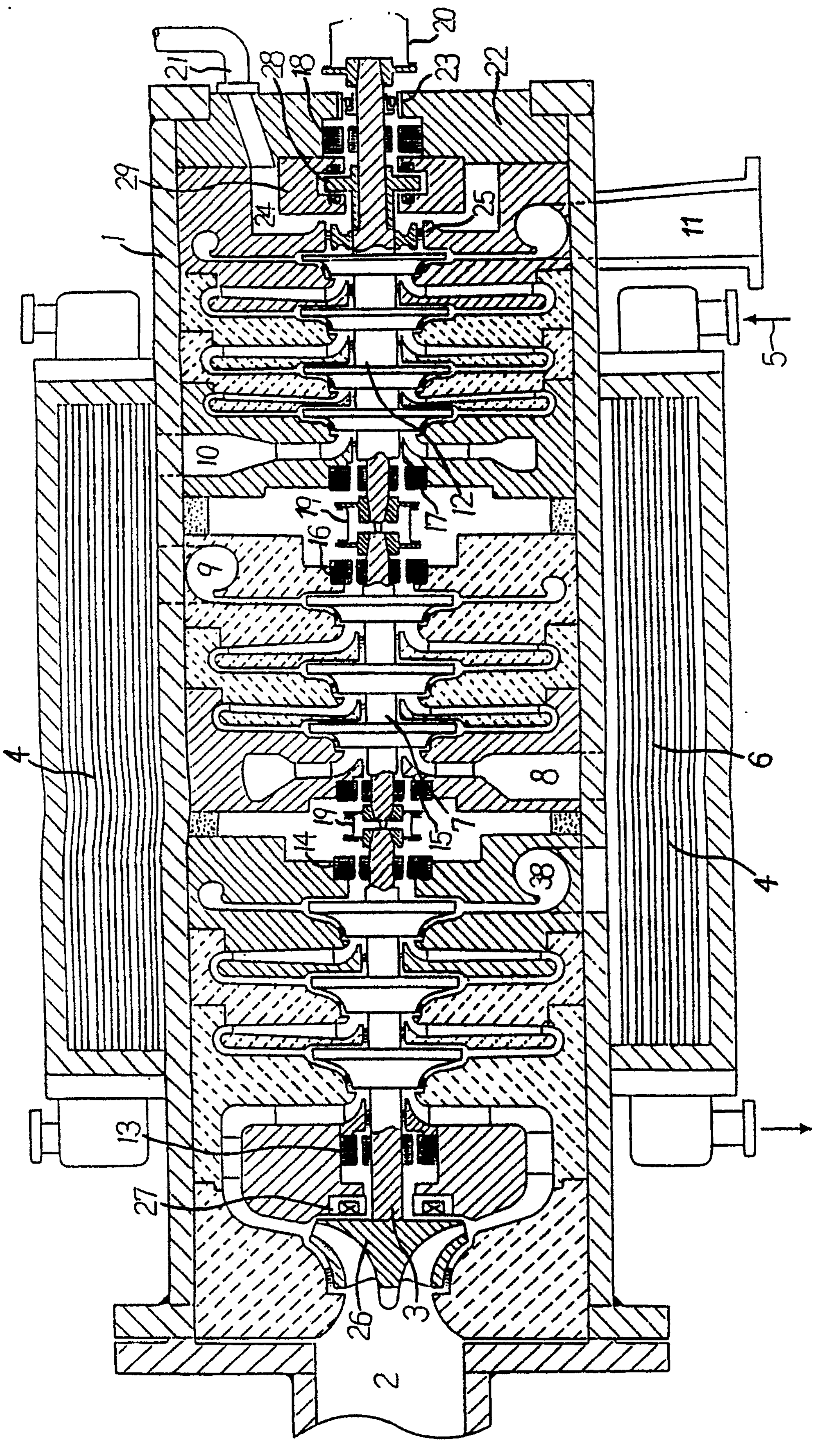

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Fig. 2

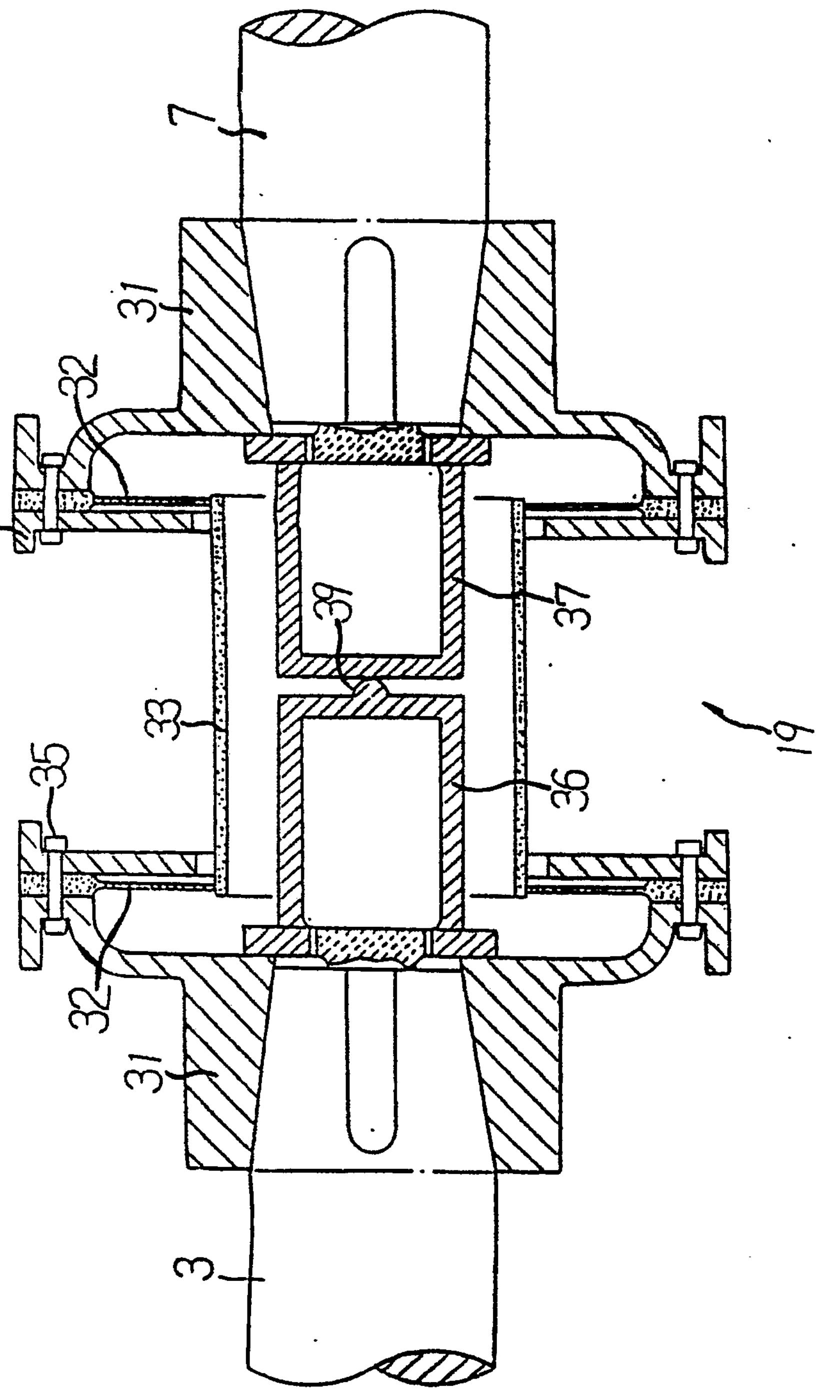

Fig. 3

(Prior Art)