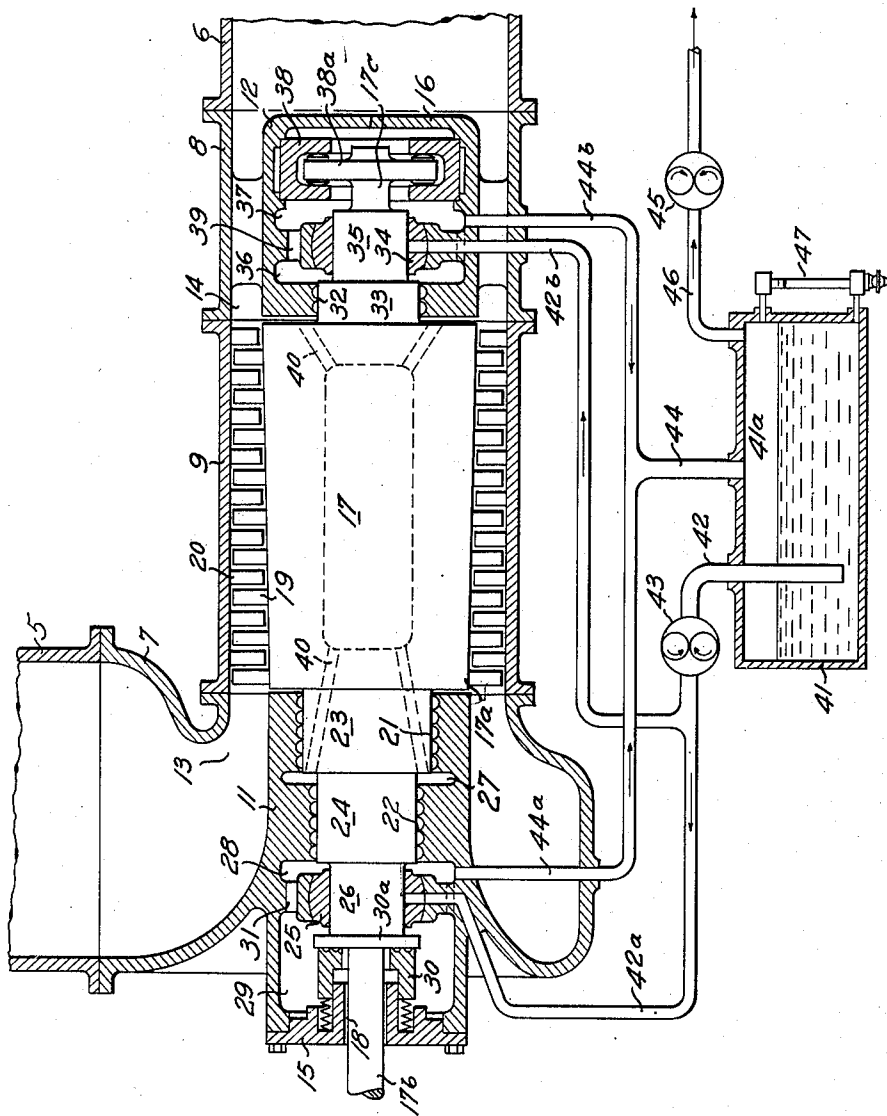


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COMPRESSOR SEALING ARRANGEMENT

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COMPRESSOR SEALING ARRANGEMENT

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The present invention relates to sealing arrangements for elastic fluid compressors of the type utilized in wind tunnels or other elastic fluid conveying systems.

In the operation of wind tunnels or like apparatus for conveying elastic fluids it is often a rigid requirement that oil vapor from the lubricating system of the compressor serving the tunnel and air from the atmosphere surrounding the tunnel should not be permitted to enter and become admixed with the air or other elastic fluid being circulated. A reason for this requirement in wind tunnel operation, for example, is that the velocity of the elastic fluid circulated is extremely high and the presence of oil vapor, dust or an excessive amount of moisture in the circulated fluid has an adverse effect on objects placed in the tunnel for test purposes. To obtain high velocities in wind tunnel operation it is the practice in some instances to operate at subatmospheric pressures such that both the inlet and discharge pressures of the compressor are below atmospheric pressure. As the rotor shaft of the compressor must extend through a shaft opening in the casing of the compressor, so that it can be coupled to suitable driving means, the opportunity for atmospheric air to enter the wind tunnel through such shaft opening is present. A sealing device at the junction of the rotor shaft and casing can only impede, not prevent, the flow of atmospheric air therethrough.

It is therefore an object of the present invention to provide a new and improved sealing arrangement for a compressor adapted to service an elastic fluid conveying system.

Another object of the invention is to provide a new and improved sealing arrangement for a compressor which, upon installation of the compressor in an elastic fluid conveying system, will prevent atmospheric air as well as oil vapor from the compressor bearings from entering such system when the pressure of the fluid circulated in the system is below atmospheric pressure.

Other objects will appear hereinafter as the description of the invention proceeds.

The novel features of the invention and how the objects are attained will appear more fully from this specification and the accompanying drawing showing one embodiment of the invention and forming a part of this application, and all these novel features are intended to be pointed out in the claims.

In the drawing, the figure is a vertical sec-

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tional view of an axial flow compressor embodying my new and improved sealing arrangement.

Referring to the drawing, a compressor embodying the present invention is shown installed between conduit portions 5 and 6 of an elastic fluid conveying system which, for example, may be a closed circuit wind tunnel. The compressor has a casing, completing the circuit between conduit portions 5 and 6, which comprises inlet and discharge portions 7 and 8 and a generally cylindrical central portion 9 defining the interior of the casing. Formed or mounted respectively in casing portions 7 and 8, in axially spaced and axially aligned relation, are two hub members 11 and 12 which form, respectively with casing portions 7 and 8, an annular inlet passage 13 and an annular discharge passage 14.

Hub members 11 and 12 are each formed with a generally annular portion adjacent the interior of the casing and an enclosing end wall portions, 15 and 16 respectively, at the opposite end from the interior of the casing. Rotatably disposed in the casing is a rotor 17 having a blade carrying portion 17a which extends axially between hub members 11 and 12, a shaft portion 17b which extends into the bore of the annular portion of hub member 11 and through a shaft opening 18 in end wall portion 15, and a shaft portion 17c which extends into the annular portion of hub member 12 but terminates short of end wall portion 16. Shaft portion 17b may be coupled with any suitable driving means (not shown) for rotating rotor 17. A plurality of blades 19 extend in a generally radial direction from the periphery of blade carrying portion 17a of rotor 17 for cooperation in elastic fluid compressing relation with a plurality of blades 20 mounted to the internal surface of casing portion 9.

The internal surface or bore of the annular portion of hub member 11 is provided, adjacent the blade carrying portion 17a of rotor 17, with a pair of axially spaced labyrinth sealing surfaces 21 and 22 which cooperate respectively, in elastic fluid sealing relation, with cylindrical surfaces 23 and 24 on shaft portion 17b of rotor 17. Positioned axially between sealing surface 22 and end wall portion 15 is a bearing 25 which cooperates with a journal surface 26 on shaft portion 17b. Hub member 11 further defines, in conjunction with shaft portion 17b, an annular chamber 27 between sealing surfaces 21 and 22, an annular chamber 28 between sealing surface 22 and bearing 25, and an annular chamber 29 between bearing 25 and

end wall portion 15. During normal operation of the compressor a partial vacuum exists in chamber 29 and, to impede the flow of atmospheric air into chamber 29, a suitable sealing device 30 is provided between end wall portion 15 and shaft portion 17b; the sealing device is shown by way of example as an axial contact type seal which abuts a collar 30a on shaft portion 17b. A plurality of ports 31 circumferentially surrounding bearing 25 provide for communication between chambers 28 and 29 for a reason appearing hereinafter.

The internal surface of hub member 12 is provided, adjacent the blade carrying portion 17a of rotor 17 with a labyrinth sealing surface 32 which cooperates, in elastic fluid sealing relation, with cylindrical surface 33 on shaft portion 17c of rotor 17. Positioned axially between sealing surface 32 and end wall portion 16 is a bearing 34 which cooperates with a journal surface 35 on shaft portion 17c. Hub member 12 further defines, in conjunction with shaft portion 17c, an annular chamber 36 between sealing surface 32 and bearing 34 and an annular chamber 37 between bearing 34 and end wall portion 16. A suitable thrust bearing 38, which cooperates in axial thrust bearing relation with a collar 38a on shaft portion 17c, is housed in chamber 37. A plurality of ports 39 circumferentially surrounding bearing 34 provide for communication between chambers 36 and 37 for a reason appearing hereinafter.

Communication between annular discharge passage 14 and annular chamber 27 may be provided by way of conduits 40 in rotor 17.

An arrangement for supplying lubricating oil to bearings 25 and 34 includes a pneumatically sealed tank 41, a conduit 42 having at one end thereof a trunk extending into the tank and at the other end thereof branches 42a and 42b leading to bearings 25 and 34 respectively, and an oil pump 43 in conduit 42 for supplying oil from the tank to the bearings.

It was mentioned hereinabove that a main object of the present invention is to provide a sealing arrangement which prevents atmospheric air, as well as oil vapor from the lubricating system, from entering the compressing chamber of the compressor when the pressure of the elastic fluid in inlet and discharge passages 13 and 14 is below atmospheric pressure, during operation of the compressor. To accomplish this object annular chambers 28 and 36 are operatively connected to a fluid exhausting device, shown herein as a vacuum pump 45, for maintaining a predetermined subatmospheric pressure in chambers 28 and 36. Conduit means for connecting chambers 28 and 36 to pump 45 may comprise, for example: an intermediate conduit portion 44 communicating at one end thereof with an upper portion 41a of the interior of tank 41 and at the other end thereof with branches 44a and 44b leading to annular chambers 28 and 37 respectively, and a conduit portion 43 operatively connecting vacuum pump 45 with the upper portion 41a of the interior of tank 41; ports 39, circumferentially surrounding bearing 34, connect chamber 37 to chamber 36. A quantity of lubricating oil is normally maintained in tank 41 at a level low enough to permit air to be drawn from the intermediate conduit portion 44 to conduit portion 46 and at a level high enough to submerge the inlet to conduit 42. The oil level indicated by gauge 47 in the drawing would be suitable for example.

The mode of operation of a compressor pro-

vided with a sealing arrangement according to the present invention will be explained, for the sake of convenience, with the aid of assumed fluid pressures in various parts of the system described hereinabove. It will be understood, however, that the particular pressures referred to hereinafter are not intended to limit the present invention but are referred to merely by way of example to facilitate an explanation of its mode of operation.

When a compressor embodying the present invention is installed in a closed circuit wind tunnel, represented by conduit portions 5 and 6 in the drawing, the quantity of air in the wind tunnel and the speed of rotor 17 may be selected such that the pressure in the inlet passage 13 will be 2 p. s. i. a. (pounds per square inch absolute) and the pressure in the discharge passage 14 will be 6 p. s. i. a. Atmospheric air pressure is about 14.7 p. s. i. a. and the sealing arrangement of the present invention functions to prevent atmospheric air from leaking through seal 30 into the wind tunnel in the following manner.

Vacuum pump 45 may be operated to maintain a pressure of 5.8 p. s. i. a. in chambers 28, 29, 36 and 37. As the air pressure in discharge passage 14 is 6 p. s. i. a., air will flow therefrom through seal 32 to chamber 36, where vacuum pump 45 maintains a pressure at 5.8 p. s. i. a., and from passage 14 through conduits 40 to chamber 27 where, because of the pressure drop occurring in conduits 40, the air pressure will be 5.9 p. s. i. a. Air will flow from chamber 27 through seal 21 to inlet passage 13, where the pressure is only 2 p. s. i. a., and from chamber 27 through seal 22 to chamber 28 where vacuum pump 45 maintains the pressure at 5.8 p. s. i. a. It is thus seen that the sealing arrangement of the present invention causes atmospheric air at 14.7 p. s. i. a. to flow through seal 30 to chamber 29 and from there through ports 31 to chamber 28 from which it is exhausted to the atmosphere by exhaust pump 45.

Excess oil which flows out of bearings 25 and 34 into chambers 28, 29, 36 and 37 returns by gravity through conduit branches 44a and 44b to tank 41. Oil vapors emerging from bearings 25 and 34 into chambers 28 and 36 are of course prevented from entering the wind tunnel in that air which seeps into chambers 28 and 36 is continuously exhausted to the atmosphere as explained above.

It will be understood that the present invention is applicable to elastic fluid compressors generally and is not limited particularly to an axial flow type compressor. Also, that a compressor embodying the present invention may be utilized in various elastic fluid conveying systems, other than wind tunnels, when it is desirable to prevent atmospheric air or other elastic fluids from leaking into such systems.

While one embodiment of the invention has been described for the purpose of illustration, it should be understood that the invention is not limited to the exact apparatus illustrated in the modifications thereof, within the scope of the appended claims, may be suggested by those skilled in the art without departure from the essence of the invention.

It is claimed and desired to secure by Letters Patent:

1. An elastic fluid compressor comprising: a rotor; a casing enclosing said rotor in a manner providing fluid inlet, compressing and discharge sections disposed in series flow relation, said cas-

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ing including a hub portion at its inlet end presenting a continuous interior surface surrounding the corresponding end portion of said rotor and including a pair of axially spaced continuous cylindrical surfaces having a sealing coaction with said end portion of said rotor; a bearing structure carried by said interior surface in spaced axially outward relation with respect to the outer one of said pair of surfaces, and rotatably supporting the adjacent end of said rotor; a first means placing said discharge section in communication with the space between said pair of surfaces; and a second means for exhausting gas entering the space between said bearing structure and the outer one of said pair of surfaces.

2. An elastic fluid compressor comprising: a rotor; a casing enclosing said rotor in a manner providing fluid inlet, compressing and discharge sections disposed in series flow relation, said casing including a first hub portion at its inlet end and a second hub portion at its discharge end each presenting a continuous interior surface surrounding first and second end portions of said rotor respectively, said surface of said first hub member including a pair of axially spaced continuous cylindrical surfaces having a sealing coaction with said first end portion of said rotor and said surface of said second hub member including a continuous cylindrical surface coacting with said second end portion of said rotor; a first bearing structure carried by said interior surface of said first hub member in spaced axially outward relation with respect to the outer one of said pair of surfaces and a second bearing structure carried by said interior surface of said second hub member in spaced axially outward relation to said cylindrical surface of said second hub member for rotatably supporting the respective ends of said rotor; a first means placing said discharge section in communication with the space between said pair of surfaces; second means for exhausting gas entering the space between said first bearing structure and the outer one of said pair of surfaces; and third means for exhausting gas entering the space between said second bearing structure and said cylindrical surface of said second hub member.

3. An elastic fluid compressor comprising: a casing; first and second axially spaced and axially aligned hub members mounted with respect to said casing so as to form inlet and discharge passages respectively therewith and an interior space between said hub members, said hub members each having a shaft receiving portion; a rotor mounted in said casing having a blade carrying portion extending axially between said hub members, a first shaft portion extending into said shaft receiving portion of said first hub member, and a second shaft portion extending into said shaft receiving portion of said second hub member; said shaft receiving portion of said first hub member having an interior surface providing a pair of axially spaced sealing portions operatively associated with said first shaft portion and a bearing operatively supporting said first shaft portion disposed in axially outward relation with respect to the adjacent one of said pair of surfaces; said first hub member shaft receiving portion defining internally thereof in cooperation with said first shaft portion a first annular chamber between said sealing surfaces and a second annular chamber between said bearing and the adjacent one of said pair of sealing surfaces; conduit means connecting said

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discharge passage with said first annular chamber; and conduit means for connecting said second annular chamber to fluid pumping means for maintaining a predetermined pressure therein.

4. An elastic fluid compressor comprising: a casing; first and second axially spaced and axially aligned hub members mounted with respect to said casing so as to form inlet and discharge passages respectively therewith and an interior space between said hub members; said first and second hub members each having an annular shaft receiving portion closed at its furthest end from said interior space by an end wall portion, said wall portion of said first hub member defining a shaft opening; a rotor mounted in said casing having a blade carrying portion extending axially between said hub members, a first shaft portion extending into said annular portion of said first hub member and through said shaft opening in sealing arrangement therewith, and a second shaft portion extending into said annular portion of said second hub member; said shaft receiving portion of said first hub member having an interior surface providing a pair of axially spaced sealing portions operatively associated with said first shaft portion and a bearing operatively supporting said first shaft portion disposed between said first hub member wall portion and the adjacent one of said pair of surfaces; said first hub member annular portion defining internally thereof in cooperation with said first shaft portion a first annular chamber between said sealing surfaces and a second annular chamber between said bearing and the adjacent one of said pair of sealing surfaces; conduit means in said rotor connecting said discharge passage with said first annular chamber; and conduit means in said first hub member for connecting said second annular chamber to fluid pumping means for maintaining a predetermined pressure therein.

5. An elastic fluid compressor for use in a wind tunnel or the like, comprising: a casing; first and second axially spaced and axially aligned hub members mounted with respect to said casing so as to form inlet and discharge passages respectively therewith and an interior space between said hub members; said first hub member having an annular portion with a pair of axially spaced internal sealing surfaces adjacent said interior space, an internal bearing surface in spaced axially outward relation with respect to the outer one of said pair of sealing surfaces, a first internal recess axially between said sealing surfaces, a second internal recess between said bearing surface and the outer one of said pair of sealing surfaces; conduit means for connecting said second recess to fluid pumping means for maintaining a predetermined pressure therein; a rotor mounted in said casing having a blade carrying portion extending axially between said hub members and a shaft portion extending into said annular portion of said first hub member; and conduit means connecting said discharge passage with said first recess.

6. An elastic fluid compressor for use in a wind tunnel or the like, comprising: a casing; first and second axially spaced and axially aligned hub members mounted with respect to said casing so as to form inlet and discharge passages respectively therewith and an interior space between said hub members; said first hub member having an annular portion with a pair of axially spaced internal sealing surfaces adjacent

said interior space, an end wall portion at the opposite end from said pair of sealing surfaces having a shaft opening, an internal bearing surface spaced axially between said wall portion and the adjacent one of said pair of sealing surfaces, a first internal recess between said sealing surfaces, a second internal recess between said bearing surface and said pair of sealing surfaces; conduit means for connecting said second recess to fluid pumping means for maintaining a predetermined pressure therein; a rotor mounted in said casing having a blade carrying portion extending axially between said hub members and a shaft portion extending into said annular portion and through said opening in said wall portion; sealing means between said shaft portion and said wall portion; and conduit means in said rotor connecting said discharge passage with said first recess.

7. An elastic fluid compressor comprising: a casing; first and second axially spaced and axially aligned hub members mounted with respect to said casing so as to form inlet and discharge passages respectively therewith and an interior space between said hub members; said first and second hub members each having an annular shaft receiving portion closed at its furthest end from said interior space by an end wall portion, said wall portion of said first hub member defining a shaft opening; a rotor mounted in said casing having a blade carrying portion extending axially between said hub members, a first shaft portion extending into said annular portion of said first hub member and through said shaft opening in sealing arrangement therewith, and a second shaft portion extending into said annular portion of said second hub member; said shaft receiving portion of said first hub member having an interior surface providing a pair of axially spaced sealing portions operatively associated with said first shaft portion and a first bearing operatively supporting said first shaft portion disposed between said first hub member wall portion and the adjacent one of said pair of sealing portions; said first hub member annular portion defining internally thereof in cooperation with said first shaft portion a first annular chamber between said sealing portions and a second annular chamber between said first bearing and the adjacent one of said pair of sealing portions; said shaft receiving portion of second hub member having an interior surface providing a sealing portion operatively associated with said second shaft portion and a second bearing operatively supporting said second shaft portion disposed between said second hub member wall portion and said sealing portion; said second hub member annular portion defining internally thereof in cooperation with said second shaft portion a third annular chamber between said second bearing and said sealing portion; conduit means connecting said discharge passage with said first annular chamber; and means for maintaining predetermined pressures in said second and third annular chambers.

8. An elastic fluid compressor comprising: a casing; first and second axially spaced and axially aligned hub members mounted with respect to said casing so as to form inlet and discharge passages respectively therewith and an interior space between said hub members, said first and second hub members each having an annular shaft receiving portion; a rotor mounted in said casing having a blade carrying portion extending axially between said hub mem-

bers, a first shaft portion extending into said annular portion of said first hub member and a second shaft portion extending into said annular portion of said second hub member; said shaft receiving portion of said first hub member having an interior surface providing a pair of axially spaced sealing portions operatively associated with said first shaft portion and a first bearing operatively supporting said first shaft portion disposed in spaced axially outward relation with respect to the outer one of said pair of sealing portions; said first hub member annular portion defining internally thereof in cooperation with said first shaft portion a first annular chamber between said sealing portions and a second annular chamber between said first bearing and said outer one of said pair of sealing portions; said shaft receiving portion of second hub member having an interior surface providing a sealing portion operatively associated with said second shaft portion and a second bearing operatively supporting said second shaft portion disposed in spaced axially outward relation with respect to said sealing portion; said second hub member annular portion defining internally thereof in cooperation with said second shaft portion a third annular chamber between said second bearing and said sealing portion; conduit means connecting said discharge passage with said first annular chamber; and means for maintaining predetermined pressures in said second and third annular chambers.

9. An elastic fluid compressor comprising: a rotor; a casing enclosing said rotor in a manner providing fluid inlet, compressing and discharge sections disposed in series flow relation, said casing including a hub portion at its inlet end presenting a continuous interior surface surrounding the corresponding end portion of said rotor and including a pair of axially spaced continuous cylindrical surfaces having a sealing coaction with said end portion of said rotor; a bearing structure carried by said interior surface in spaced axially outward relation with respect to the outer one of said pair of surfaces, and rotatably supporting the adjacent end of said rotor; said interior surface of said hub portion defining in cooperation with said corresponding end portion of said rotor a first annular chamber between said pair of surfaces and a second annular chamber between said bearing structure and the outer one of said pair of surfaces; a passage means placing said discharge section in communication with said first annular chamber; a pneumatically sealed lubricant confining tank disposed below said second annular chamber, means for delivering lubricant under pressure from said tank to said bearing structure, a gravity return conduit means placing said second chamber in communication with a portion of said tank above the level of lubricant confined therein, and a fluid exhausting device communicating with said portion of said tank.

10. An elastic fluid compressor comprising: a rotor; a casing enclosing said rotor in a manner providing fluid inlet, compressing and discharge sections disposed in series flow relation, said casing including a hub portion at its inlet end presenting a continuous interior surface surrounding the corresponding end portion of said rotor and including a pair of axially spaced continuous cylindrical surfaces having a sealing coaction with said end portion of said rotor; a bearing structure carried by said interior surface in spaced axially outward relation with respect to

the outer one of said pair of surfaces, and rotatably supporting the adjacent end of said rotor; said interior surface of said hub portion defining in cooperation with said corresponding end portion of said rotor a first annular chamber between said pair of surfaces and a second annular chamber between said bearing structure and the outer one of said pair of surfaces; a passage means placing said discharge section in communication with said first annular chamber; a lubricant confining tank, means for delivering lubricant under pressure from said tank to said bearing structure, a return conduit means placing said second annular chamber in communication with said tank, and a fluid flow inducing device operatively associated with said return conduit means for effecting a withdrawal of fluids therethrough from said second chamber.

11. An elastic fluid compressor comprising: a rotor; a casing enclosing said rotor in a manner providing fluid inlet, compressing and discharge sections disposed in series flow relation, said casing including a hub portion at its inlet end presenting a continuous interior surface surrounding the corresponding end portion of said rotor and including a pair of axially spaced continuous cylindrical surfaces having a sealing coaction with said end portion of said rotor; a bearing structure carried by said interior surface in spaced axially outward relation with respect to the outer one of said pair of surfaces, and rotatably supporting the adjacent end of said rotor; said interior surface of said hub portion defining in cooperation with said corresponding end portion of said rotor a first annular chamber between said pair of surfaces and a second annular chamber between said bearing structure and the outer one of said pair of surfaces; a passage means placing said discharge section in communication with said first annular chamber; a lubricant confining tank, means for delivering lubricant under pressure from said tank to said bearing structure, a conduit means having an intermediate portion

thereof placing said second chamber in communication with said tank at a point above the level of lubricant confined therein, and a fluid flow inducing device operatively associated with said conduit means at point disposed in downstream relation to said portion thereof.

12. An elastic fluid compressor comprising: a rotor; a casing enclosing said rotor in a manner providing fluid inlet, compressing and discharge sections disposed in series flow relation, said casing including a hub portion at its inlet end presenting a continuous interior surface surrounding the corresponding end portion of said rotor and including a pair of axially spaced continuous cylindrical surfaces having a sealing coaction with said end portion of said rotor; a bearing structure carried by said interior surface in spaced axially outward relation with respect to the outer one of said pair of surfaces, and rotatably supporting the adjacent end of said rotor; said interior surface of said hub portion defining in cooperation with said corresponding end portion of said rotor a first annular chamber between said pair of surfaces and a second annular chamber between said bearing structure and the outer one of said pair of surfaces; a passage means placing said discharge section in communication with said first annular chamber; a lubricant confining tank, means for delivering lubricant under pressure from said tank to said bearing structure, a conduit means having an intermediate portion thereof placing said second chamber in communication with said tank and a fluid flow inducing device operatively associated with said conduit means at a point intermediate the ends thereof.

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