Dec. 23, 1941. L. F. BAST 2,267,262

COMPRESSOR AND VACUUM PUMP

Filed May 1, 1940 2 Sheets-Sheet 1

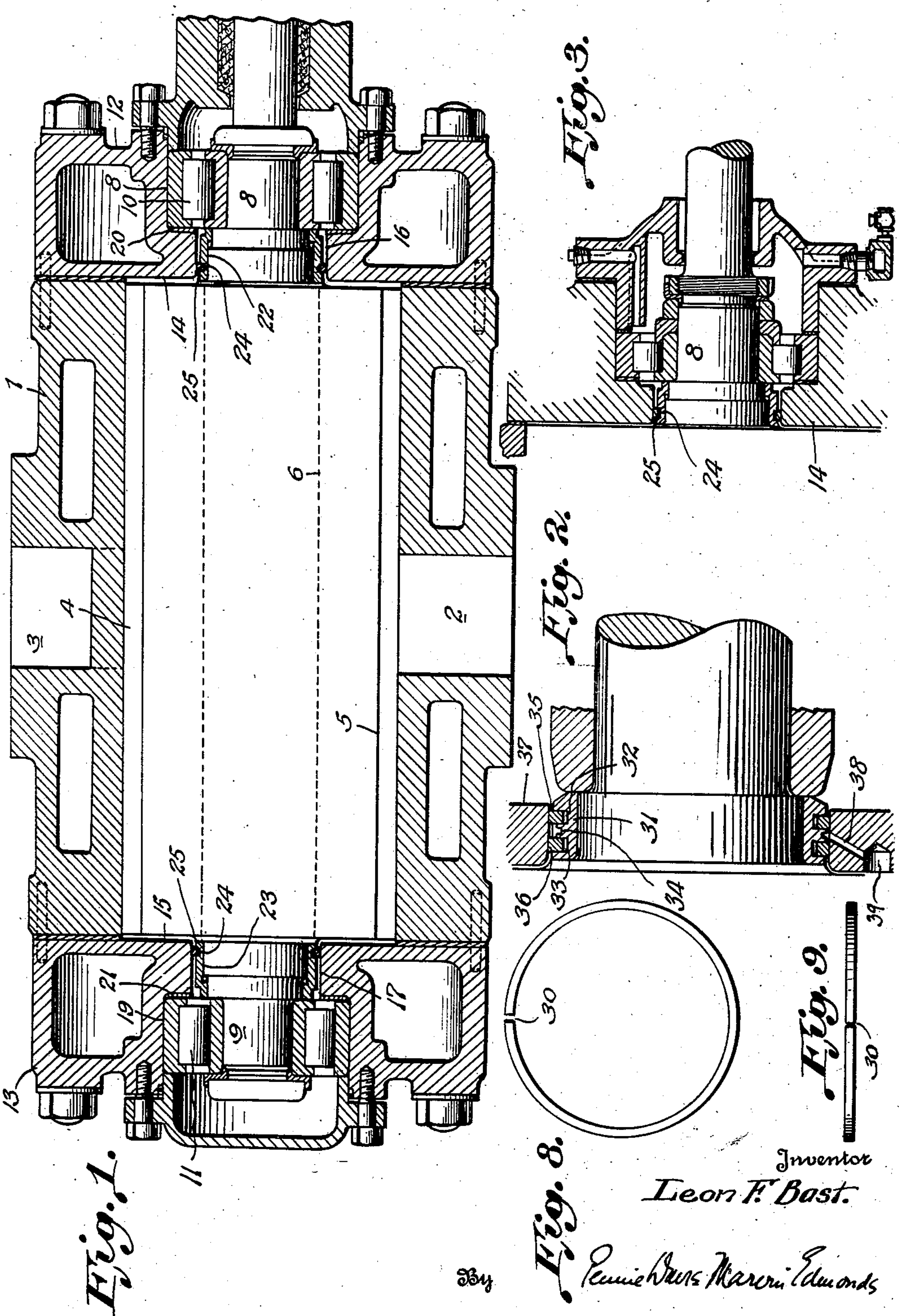

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Fig. 4.

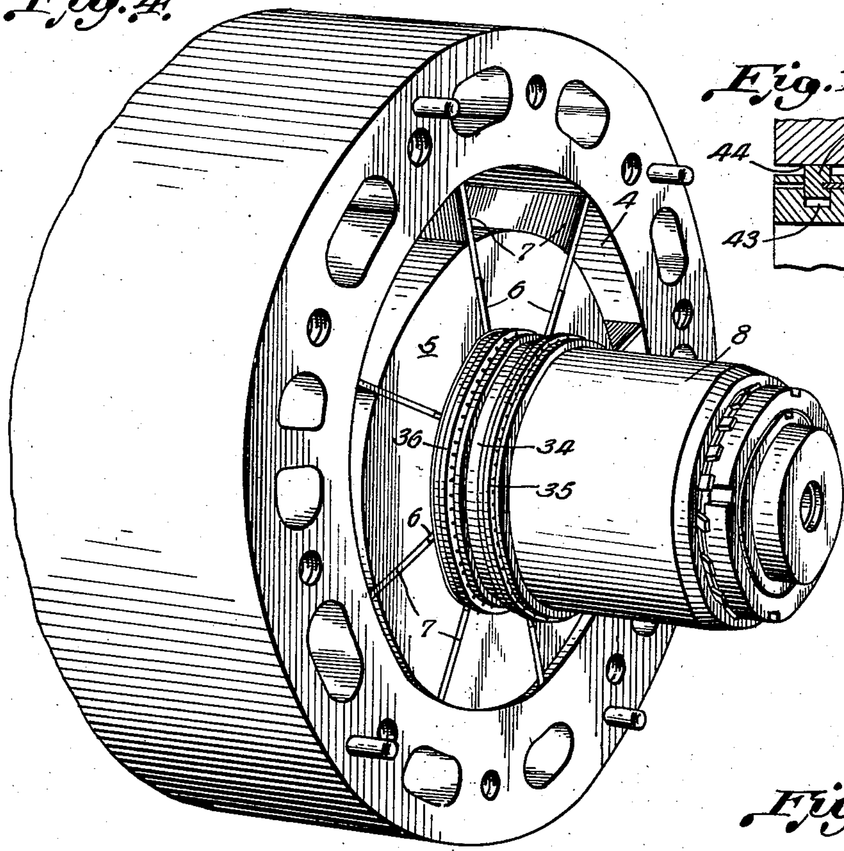


Fig. 10.

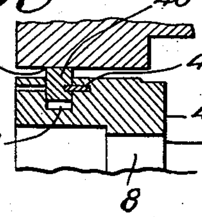


Fig. 6.

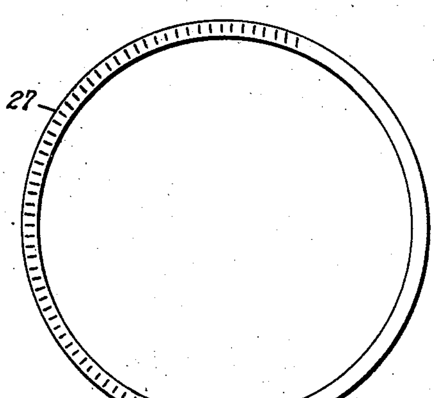


Fig. 5.

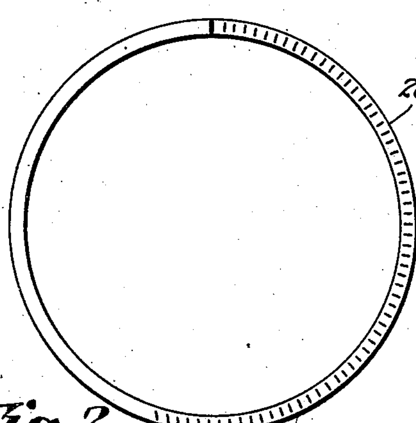
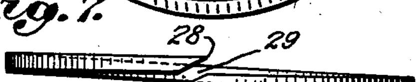


Fig. 7.



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UNITED STATES PATENT OFFICE

2,267,262

COMPRESSOR AND VACUUM PUMP

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Application May 1, 1940, Serial No. 332,627

3 Claims. (Cl. 230—151)

This invention relates to rotary air compressors and vacuum pumps which include a stator casing having a cylindrical bore closed by heads and a rotor carrying radially sliding vanes and mounted eccentrically within the bore on a shaft extending into openings in the heads. More particularly, the invention is concerned with a novel means for sealing the shaft of such a machine in order to prevent flow of fluid along the shaft to or from that part of the space within the bore not occupied by the rotor. As will be readily apparent, the new sealing means is applicable to both compressors and pumps, but in order to simplify the disclosure, its use in connection with an air compressor only will be described in detail.

Air leakage through the clearance spaces between the rotor shaft and the walls of the openings in the cylinder heads of a rotary air compressor results in a substantial loss in efficiency and although various means have been employed heretofore for reducing that leakage, those expedients have not been wholly satisfactory. The problem presented is that of obtaining substantially complete sealing of the shaft in its openings by means which will not be subjected to considerable wear and will, at the same time, permit a limited radial movement of the shaft within the openings and be unaffected by expansion of the parts as they become heated during operation.

In one prior construction, hub collars mounted on the shaft within the openings are employed to reduce the leakage, but when such collars are used, there must be clearances between them and the walls of the openings to allow for the radial movement of the shaft resulting from wear and the expansion of the parts when heated. This clearance is necessarily of such size that the collars fall far short of sealing the shaft and the efficiency of a compressor equipped with collars is substantially reduced by the leakage past them.

The present invention is, accordingly, directed to the provision of a seal for the shaft of a rotary air compressor or vacuum pump of the sliding vane type which not only effectively prevents leakage along the shaft but is also so constructed as to have a long life and be capable of use for indefinite periods without attention or replacement.

The seal of the invention comprises a split sealing ring which is mounted on the shaft to rotate therewith and has an outer peripheral surface making a sliding contact with the wall of the opening. The inner diameter of the ring is greater than that of the parts lying within it, so that radial movement of the shaft may take place and there will be no binding of the ring as a result of expansion produced by heat generated during operation. The mounting for the ring makes only lateral contact therewith under normal conditions and the preferred mounting takes the form of a retainer fast on the shaft and having a circumferential groove or channel in which the ring lies, the inner surface of the ring being spaced substantially from the bottom of the groove. The ring bears laterally against one or both side walls of the groove and is held in contact therewith either wholly by the pressure differential on opposite faces of the ring during operation or partly by that differential and partly by the inherent springiness of the metal of which the ring is made. In one form, the pressure with which the ring bears laterally against one or both faces of the groove is sufficient to overcome the friction between the peripheral surface of the ring and the wall of the opening, so that the ring rotates with the retainer. In a different form, rotation of the ring with the retainer is insured by the provision of a positive connection between these parts.

For some purposes, a single ring in each opening may be sufficient to provide a seal, but, if desired, each seal may comprise a pair of rings mounted in separate grooves in the retainer. When the double ring construction is employed, means are provided for permitting the escape from the space between the rings of fluid or other material which passes through the opening in the inner ring and enters that space.

For a better understanding of the invention, reference may be made to the accompanying drawings, in which:

Fig. 1 is a vertical section through one form of air compressor equipped with the seal of the invention;

Fig. 2 is a fragmentary vertical sectional view illustrating a seal of modified construction;

Fig. 3 is a vertical sectional view through a portion of the compressor equipped with the new seal and provided with a bearing different from that shown in Fig. 1;

Fig. 4 is a view in perspective of one end of a compressor equipped with the seal of the invention and having its adjacent head removed;

Figs. 5 and 6 are front and rear elevational views of one type of ring employed in the new seal;

Fig. 7 is an edge view of the ring shown in Figs. 5 and 6;

Figs. 8 and 9 are side and edge views, respectively, of another type of ring which may be employed in the new seal; and

Fig. 10 is a fragmentary sectional view showing a modified seal construction.

Referring to the drawings, the compressor illustrated includes a stator casing 1 having an air inlet 2 at one side, an air outlet 3 at the opposite side, and a cylindrical bore 4 to and from which the inlet and outlet, respectively, lead. Within the bore is a cylindrical rotor 5 provided with radial slots 6 in which are slidably mounted vanes or blades 7. The rotor is mounted on a shaft and lies eccentrically within the bore so that the surface of the rotor is sufficiently close to the inner surface of the bore at one point between the inlet and outlet to form a seal opposite which is a crescent-shaped space. This space is subdivided into compartments by the vanes which are moved out of their slots centrifugally as the rotor turns and slide along the inner surface of the bore, and air entering through the inlet enters the compartments and is compressed as the compartments decrease in size as they approach the outlet.

The rotor shaft is provided with trunnions 8 and 9 which rotate in bearing assemblies 10 and 11 mounted in heads 12 and 13 which are secured to the ends of the casing and have inner faces 14, 15 closing the ends of the bore. The heads are formed with openings 16, 17 through which the shaft extends from the end of the rotor to the trunnions and the openings have enlargements with inner circumferential faces 18, 19. The outer surfaces of the bearing assemblies contact with faces 18, 19, and the bearings are axially adjustable by means of shims 20 and 21 interposed between the bearing assemblies and portions of the heads 12, 13. The bearing structure illustrated is that disclosed in Redfield Patent No. 1,994,786, issued March 19, 1935, but other types of mounting for the rotor shaft may be employed, if desired.

The diameter of the openings 16, 17 through which the rotor shaft extends is substantially greater than that of the shaft and leakage through the space around the shaft in each opening is prevented by a seal. Each of the seals illustrated comprises a retainer 22, 23 which is of cylindrical form and is mounted fast on the shaft in any suitable manner, as by being shrunk on. Each retainer has an outer diameter sufficiently less than the diameter of the opening in which it lies to permit such radial movement of the shaft in the bearings as results from wear plus expansion of the parts resulting from heat developed when running. Each retainer is formed with a circumferential groove or slot 24 which is of substantial depth and mounted within the slot is a split sealing ring 25 which has an inner diameter substantially greater than the diameter of the bottom of the groove and makes contact on its outer peripheral surface with the wall of the opening. The provision of the space between the inner surface of each ring and the bottom of the groove in which it is mounted permits the ring to move radially with respect to the retainer as radial movement of the shaft occurs and also prevents expansion of the shaft and retainer from interfering with the action of the ring.

Two general types of ring may be employed for the purpose and these rings may, for convenience, be referred to as "live" or "dead" rings.

The ring shown in Figs. 5, 6, and 7 is of the dead type and it may conveniently be made of cast iron, although other kinds of metal may be used, if desired. The ring has an outside diameter not substantially less than the diameter of the opening in the casing head so that when mounted in place in its retainer, it makes a close sliding contact with the wall of the opening. The ring has no tendency to expand or contract radially and it is peened, as indicated at 26, approximately half way around on one side and similarly treated, as indicated at 27, on the other side, the peening on opposite sides of the ring being on opposite sections thereof. The ring is cut at an angle, as indicated at 28, and the peening causes it to assume a slightly helical form so that its overlapping ends are normally spaced, as indicated at 29. In the construction described, the ring has been caused to assume a helical form, when relaxed, by peening, but it may be given the desired shape in any other way, if desired.

When this ring is mounted in the groove in the retainer, the tendency of its ends to separate causes the lateral surfaces of the ring to bear against the side walls of the groove. This pressure is supplemented by the differential pressure developed on opposite lateral surfaces of the ring during operation, and the forces thus active in holding the ring against the side walls of the groove are sufficient to overcome the friction between the outer peripheral surface of the ring and the wall of the opening. The ring, accordingly, rotates with the retainer and shaft and little or no wear occurs on the lateral surfaces of the ring. Similarly, little wear occurs on the peripheral surface of the ring, since the ring is dead and its initial outside diameter is practically the same as the diameter of the wall of the opening.

The development of the differential pressure on opposite lateral surfaces of the ring above referred to occurs because during operation, a minor quantity of fluid escapes from the compressor chamber between the ends of the ring to the rear surface thereof. If the bearing chamber is closed, as in the construction shown in Fig. 1, back pressure is built up in that chamber on the rear lateral surface of the ring and tends to force the ring against the lateral surface of the groove near the compressor chamber. If the bearing chamber is vented to the atmosphere, the pressure within the compressor chamber forces the ring against the outer surface of the groove.

As an example of the conditions of operation, the following may be given. In a single stage compressor with a closed bearing chamber and operating to develop 50# line pressure per sq. in., the air at the compressor inlet is at atmospheric pressure and at the outlet, its pressure is 50#, so that on the side of the ring facing the compressor, the pressure varies from zero to 50#. Because of the leakage between the ends of the seal, a pressure of approximately 45# is built up in the bearing chamber and this pressure acts uniformly over the entire outer surface of the ring exposed beyond the groove.

The back pressure is opposed by that within the compressor chamber, but is exceeded thereby only in a region near the outlet. The result is that throughout the greater portion of its circumference, the inner lateral face of the ring is held against the inner face of the groove and through a minor portion of its circumference near the outlet, the ring is exposed to a pressure tending to force it against the outer lateral face of the groove. Accordingly, the differential pressure plus that produced by the ends of the ring being forced into contact with the walls of the groove by the inherent springiness of the metal causes the ring to rotate with the shaft. As there is no substantial relative movement between the lateral surfaces of the ring and the walls of the groove, there is no lateral wear on the ring. Also, since the ring is dead and its initial outside diameter is substantially that of the diameter of the opening, only a slight amount of wear takes place on the peripheral surface of the ring before the ring reaches a condition in which it makes a smooth running fit with the wall of the opening and thereafter, the ring continues to rotate with the retainer with practically no wear.

Instead of using the ring of helical form illustrated in Figs. 5, 6, and 7, a dead ring of the plane type shown in Figs. 8 and 9 and having a radial cut **30** may be employed for low pressure operation. This ring is mounted in a groove in the retainer and at low pressures probably has a floating action so as to rotate intermittently with the retainer without being subjected to substantial wear. However, when such a ring is used in a compressor developing higher pressure, a force may be exerted in the space between the inner surface of the ring and the bottom of the groove sufficient to expand the ring and cause it to be held in such firm contact with the wall of the opening that the ring remains stationary. In that case, the ring is worn on its lateral surfaces and for that reason, the plane type of ring is not desirable for high pressure operation. The expansion referred to also takes place with a helical ring, but the differential pressure plus that resulting from the springiness of the metal is sufficient to overcome the peripheral friction and the ring, accordingly, continues to rotate.

When it is desired to use a pair of rings in the seal, a retainer **31** may be employed having a pair of grooves **32**, **33**, the surface of the retainer between the grooves being channeled to provide a discharge groove **34**. In the main grooves are mounted seal rings **35**, **36** which contact peripherally with the wall of the opening in the head **37**. The head is then provided with a bore **38** leading from groove **34** to an opening **39** so that any material which is entrained with the air and passes through the opening in ring **36** enters the discharge groove and escapes through the bore.

The live type of ring, which may be used in the new seal, is similar to that shown in Figs. 8 and 9 and has a radial opening **30**. This ring has a tendency to expand radially and may be given that characteristic by peening the ring on its inner face. When such a ring is employed, as indicated at **40** in Fig. 10, provision is made for positively connecting the ring to the retainer. For this purpose, the retainer **41** may be bored so that a pin **42** may be driven through an opening in the ring or between the ends thereof and into a recess **43** in the wall of the groove. The forced rotation of such a ring causes its peripheral face **44** to wear away until the inherent radial expansion of the ring is so slight that the friction between the peripheral surface and the wall of the opening is insufficient to cause additional wear. A live ring may be employed in either high or low pressure machines and the positive connection between the ring and retainer may be used both with a live ring and also with the dead rings described. The helical dead ring and the live ring positively connected to the retainer may, accordingly, be used interchangeably in machines operating at all pressures while the plane type of dead ring is useful in low pressure devices only.

The seal of the invention has proven highly satisfactory in practice and tests have demonstrated its marked superiority over close fitting hub collars on the shaft as a means for reducing leakage. In those tests involving the use of a two-stage compressor, it was found that the machine, when provided with hub collars, operated with a volumetric efficiency around 85% and that its efficiency increased to over 90% when the new seals were installed, the efficiency reaching 94% in one of the tests. During those tests, the seal rings showed no appreciable wear and had an indicated life of indefinite duration.

I claim:

1. In a rotary compressor or vacuum pump which includes a casing having a cylindrical bore closed at its ends by heads having aligned openings, and a rotor provided with sliding vanes and mounted eccentrically within the bore on a shaft extending into the openings, the improvement in sealing means for the shaft in one opening which comprises a ring retainer fixedly secured on the shaft within the opening and spaced therefrom, the retainer having a groove in its outer periphery, and a seal ring in the groove, said ring being in its relaxed condition and making a close sliding contact with the wall of the opening and having no tendency to expand radially outwardly or to contract radially inwardly, the ring having a radial thickness less than the radial distance between the base of the groove and the wall of the opening, whereby the ring is floatingly carried in said groove and has a limited freedom of movement radially in the retainer and is free to travel with the retainer when the pressures upon the opposite sides thereof are sufficiently unbalanced to cause the frictional contact between at least one side of the ring and at least one side of the groove to be greater than the frictional contact between the periphery of the ring and the wall of the opening.

2. In a rotary compressor or vacuum pump which includes a casing having a cylindrical bore closed at its ends by heads having aligned openings, and a rotor provided with sliding vanes and mounted eccentrically within the bore on a shaft extending into the openings, the improvement in sealing means for the shaft in one opening which comprises a ring retainer fixedly secured on the shaft within the opening and spaced therefrom, the retainer having a groove in its outer periphery, a seal ring in the groove, said ring being in its relaxed condition and making a close sliding contact with the wall of the opening and having no tendency to expand radially outwardly or to contract radially inwardly, the ring having a radial thickness less than the radial distance between the base of the groove and the wall of the opening, whereby the ring is floatingly carried in said groove and has a limited freedom of movement radially in the retainer and is free to travel with the retainer when the pressures upon the opposite sides thereof are sufficiently unbalanced to cause the frictional contact between at least one side of the ring and at least one side of the groove to be greater than the frictional contact between the periphery of the ring and the wall of the opening, and a pin having a portion extending into the groove to prevent relative rotation of the ring and shaft while permitting said limited radial movement.

3. In a rotary compressor or vacuum pump which includes a casing having a cylindrical bore

closed at its ends by heads having aligned openings, and a rotor provided with sliding vanes and mounted eccentrically within the bore on a shaft extending into the openings, the improvement in sealing means for the shaft in one opening which comprises a ring retainer fixedly secured on the shaft within the opening and spaced therefrom, the retainer having a groove in its outer periphery, and a seal ring in the groove, said ring being peened on at least one of its lateral sides to give it a helical form and having an outside relaxed diameter such that it is maintained in close sliding contact with the wall of the opening and has no tendency to expand radially outwardly or to contract radially inwardly, the ring having a radial thickness less than the radial distance between the base of the groove and the wall of the opening, whereby the ring is floatingly carried in said groove and has a limited freedom of movement radially in the retainer and is free to travel with the retainer when the pressures upon the opposite sides thereof are sufficiently unbalanced to cause the frictional contact between at least one side of the ring and at least one side of the groove to be greater than the frictional contact between the periphery of the ring and the wall of the opening.

LEON F. BAST.