Nov. 9, 1948. P. KOLLSMAN 2,453,373

COMPRESSOR

Filed Aug. 28, 1944 2 Sheets-Sheet 1

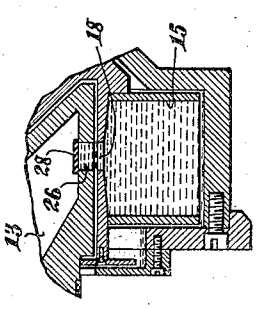


Fig. 3

Fig. 1

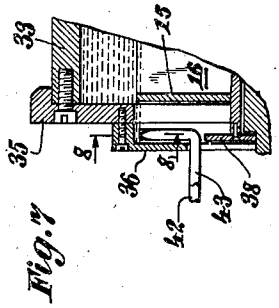


Fig. 7

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Fig. 4

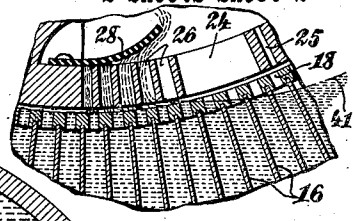


Fig. 2

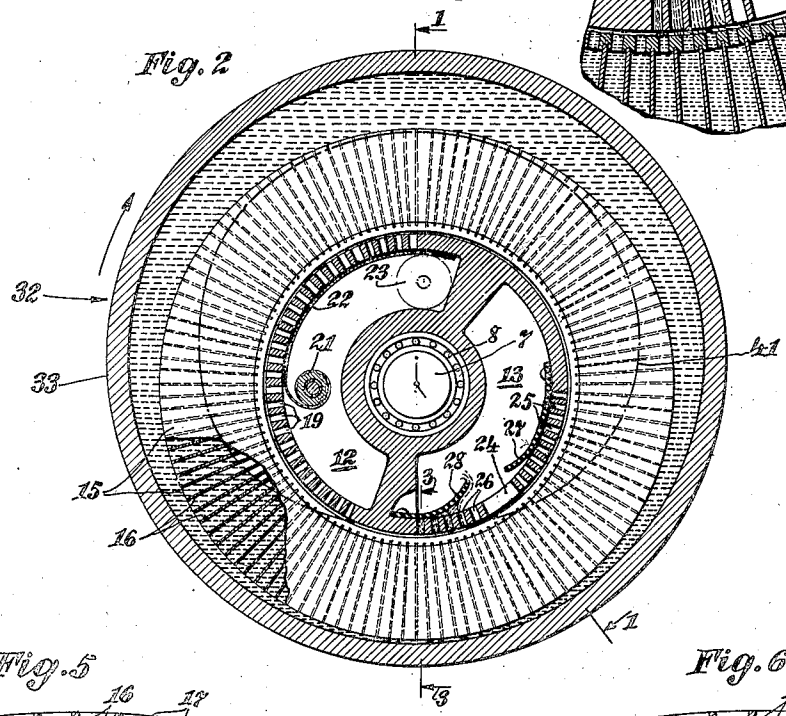


Fig. 5

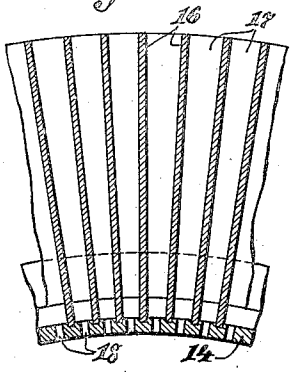


Fig. 11

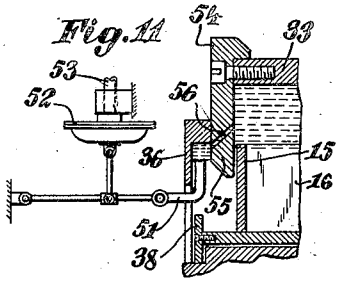


Fig. 6

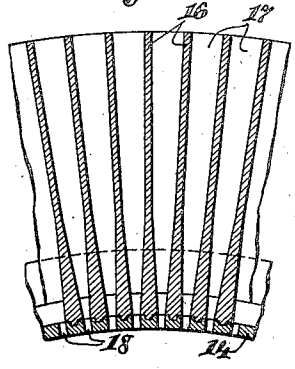


Fig. 8

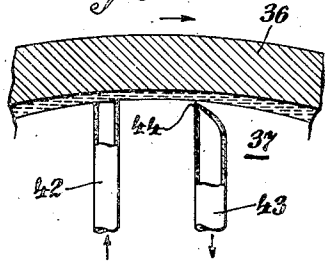


Fig. 9

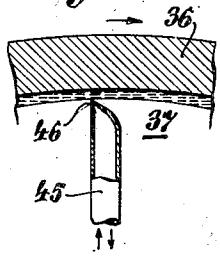
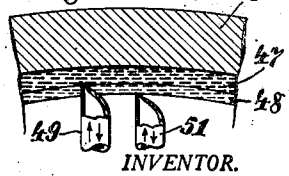


Fig. 10



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2,453,373

COMPRESSOR

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Application August 28, 1944, Serial No. 551,509

19 Claims. (Cl. 230—79)

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This invention relates to a rotary, liquid piston machine, and more particularly, to a rotary compressor using a liquid as the compressing medium.

One object of the invention is the provision of a rotary compressor or other machine using a liquid as a compressing medium characterized by a high efficiency.

Another object of the invention is to provide a rotary compressor using a liquid as a compressing medium in which the compressed gas is entirely removed from the compression chambers and in which any liquid expelling therefrom is carried away with the compressed gas.

Another object of the invention is to provide a liquid level control for the compressing liquid of a rotary liquid piston machine.

Another object of the invention is to provide a rotary compressor using a liquid compressing medium with pockets or chambers into which the gas is drawn and the liquid moves to compress the gas in which the gas flows smoothly in contact with the chamber walls and is completely evacuated by the entering liquid.

Other objects and features of the invention will be readily apparent to those skilled in the art from the specification and appended drawings illustrating certain preferred embodiments in which:

Figure 1 is a sectional view on the line 1—1 of Figure 2.

Figure 2 is a transverse sectional view on the line 2—2 of Figure 1.

Figure 3 is a partial sectional view of line 3—3 of Figure 2.

Figure 4 is an enlarged detailed view of the outlet ports of the compressor.

Figure 5 is an enlarged detail sectional view showing the compression pockets or chambers.

Figure 6 is a view similar to Figure 5 but of a slightly modified chamber form.

Figure 7 is a detail view showing the liquid level control.

Figure 8 is an enlarged view on line 8—8 of Figure 7 showing the liquid level control.

Figure 9 is a view similar to Figure 8 of a modified form of liquid level control.

Figure 10 is a view similar to Figures 8 and 9 but showing the control of the levels of dissimilar liquids used in the compressor.

Figure 11 is a view showing the automatic regulation of the liquid level in accordance with the compressor outlet pressure.

The compressor, as specifically illustrated, comprises a bed plate 1 on which are mounted supports 2 and 3. Within the support 3 is mounted

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the bearing support 4 having an exterior cylindrical surface and an interior cylindrical bore 5 on an eccentric axis. Within the bore 5 on the roller bearings indicated at 6 is rotatably supported the drive shaft 7. The interior end of the shaft 7 is also rotatably connected by roller bearing 8 to stationary structure 9 mounted in the support 2 and containing the compressor outlet 11 and intake and outlet chambers 12 and 13. On the shaft 7 is mounted a rotor 14 having a pair of spaced peripheral annular plates 15 mounted thereon between which extend separator plates 16 dividing the space between the plates 15 into a large number of peripheral pockets 17. Each of the pockets 17 has a small opening 18 through the rotor 14 for the drawing in of air or other gas to be compressed at the intake and the expelling of the compressed gas into the compressor outlet chamber.

The openings 18 are disposed opposite the inlet and outlet ports of the compressor shown more particularly in Figure 2. The wall of the intake chamber 12 is provided with a plurality of ports or openings 19 through which air or other gas to be compressed is drawn into the pockets 17 through their interior openings 18. A rolling type valve 21 is provided having a strap 22 for closing a desired number of the ports 19 to determine the amount of air drawn within the chamber 17. The dotted line position 23 indicates the position of the valve for full opening of the ports 19.

The wall of the outlet chamber 13 for the compressor has a large port 24 and a plurality of small ports 25 and 26 on opposite sides thereon. The ports 25 and 26 are provided with flexible flaps 27, 28 permitting flow through the ports 25 and 26 in only the proper outlet direction.

The connection through roller bearing 8 between shaft 7 and stationary structure 9 results in properly locating the walls of the inlet and outlet chambers 12 and 13 with respect to the interior surface of the rotor 14 and insures proper operation of the parts regardless of the operating pressure.

On the exterior of the bearing support 4, by means of roller bearings 31, is mounted an exterior rotor 32 on an axis eccentric with the axis of the shaft 7 and with the interior surface of the rotor 32 having only a mechanical clearance from the periphery of the rotor 14 at their adjacent surfaces as shown in Figures 1, 2 and 3. The rotor 32 has a cup portion 33 about the chambers 17 and an elongated cylindrical portion 34 carrying the seats of the bearings 31. The cup portion

33 is closed by the plate 35. The side walls of the cup 33 are disposed closely adjacent the annular plates 15 on the rotor 14 so that adjacent the exit or outlet port of the compressor a long thin film of liquid of restricted thickness is provided to inhibit the outward flow of water. Upon the plate 35 is mounted an annulus 36 forming a well or trap 37 within which any compressor liquid which escapes will be caught and maintained by the centrifugal force resulting from the rotation. An annular closing plate 38 is mounted on the rotor 14. A liquid source indicated at 39 is provided to supply water or other compressor liquid lost in the operation of the machine.

The compressor is illustrated under operating conditions in which the water or other liquid is maintained in position shown by centrifugal force. The water line is indicated by the broken line 41 in Figure 2 and is not circular but takes substantially the position shown due to the space required by the metal walls 15 and 16 forming the chambers 17. The rotation is clockwise as shown in Figure 2 by the driving of the shaft 7. The rotor 32 is an idler rotor and follows along with the rotation of the rotor 14 with only negligible slip. The chambers 17 in the lower left quadrant in Figure 2 are being emptied of the compressor liquid and air is sucked in through the openings 18 and the ports 19 in the inlet chamber 12. In the position of the rolling valve 21, as illustrated in full lines, the ports 19 are blocked off adjacent the division line between the upper and lower left quadrants of the drawing and this will determine the amount of air drawn in and hence the delivery at the outlet chamber. As a chamber 17 passes into the upper right hand quadrant, the compressor liquid enters the chambers through their peripheral openings and compresses the gas trapped within the chambers. In the position of the rolling valve as illustrated in full lines, there will be a lowering of the gas pressure in the upper left hand quadrant and a return to normal pressure in the upper right hand quadrant, actual compression above intake pressure occurring only in the lower right hand quadrant. If the roller valve 21 were in fully open position as shown in dotted lines in Figure 2, the compression above intake pressure will be effected through both of the right hand quadrants. The compressed gas within the chamber 17 will be expelled through the openings 18 and the outlet ports 24, 25 and 26. As the chambers move in the lower right hand quadrant, the flexible flap 27 will permit passage of gas from chambers 17 through ports 25 when the pressure of the gas becomes greater than the back pressure in the chamber 13, in which case, the flap 27 opens to uncover those ports 25 opposite such chambers 17. The large port 24 is entirely open since at this position the operation of the compressor is such as to insure that the gas in the compression pockets or chambers 17 will be at a pressure higher than the back pressure of the compressor. Any additional gas and possibly small amount of compressor fluid will be expelled through the ports 26, the flap 27 preventing passage in the reverse direction.

In Figures 2 and 4, a small quantity of water or other compressor liquid is shown spilling out into the outlet chamber 13. In theoretical operation for maximum efficiency, it is desired to have the compressing liquid completely expel the gas from the chambers 17 since any gas remaining will represent a loss in the efficiency of operation. To insure the complete removal of

gas in practical operation, it may be desirable to provide for the spilling over of a small amount of water which can be carried off with the outlet gas.

This spilling over of the compressor liquid also provides a means for determining the liquid level within the compressor. The liquid inlet 39 is adjusted to continuously supply a small amount of liquid to replace that lost through the compressor outlet, the amount supplied being adjusted to provide for a small spill over to insure the complete evacuation of the compressed gas. It is seen that such liquid passed to the compressor outlet port will immediately be relieved from the action of centrifugal force as its rotation ceases, so that its carrying off with the gas output will be facilitated.

As shown in Figures 1 and 3, in the position in which the gas is under appreciable compression, there is a long overlap of the annuli 15 with the plate 35 and the vertical wall of the cup plate 33 of the rotor 32. The surfaces of these elements are disposed as closely together as is consistent with mechanical clearance so that there is provided a long restricted film of liquid resisting loss of compressor fluid from the cup 33 of the rotor 32. What small amount of liquid is passed through this restricted opening is collected through centrifugal force in the trap or cup 37 and again flows into the rotor 32 adjacent the top thereof. This trapping and return of the liquid insures that all of the supplied liquid will be expelled through the compressor outlet regardless of the operating pressure or, stated otherwise, that for a given amount of supplied liquid, the liquid output through the valve will be constant.

As seen more particularly in Figure 5, the separating walls or fins 16 forming the pocket 17 are relatively close together so that the pockets are of narrow elongated form. With the location of the elongated openings 18 in the planes of the pockets, this provides for the flow of gas through the openings in intimate contact with the walls 16 to facilitate the transfer of heat and provides for the smooth flow of the gas and restricts the turbulence of the compressed liquid so that an even movement thereof is secured with the expelling of all of the compressed gas from the compression chambers. The lack of turbulence inhibits the formation of any air pockets which might retain gas within the chambers.

Figure 6 indicates a modified form in which the thickness of the separating plates 16 have been increased at the bottom to secure an entirely smooth contour which increases the tendency of the gas to flow smoothly in contact with the chamber walls.

In Figure 7 is shown a more precise liquid level control in which the level of the liquid within the trap or chamber 37 is controlled. This arrangement is shown in more detail in the enlarged view of Figure 8 in which there is provided a liquid supply pipe 42 which is continuously supplying a small quantity of liquid to the trap 37 while liquid beyond the desired predetermined level is drawn off through the pipe 43. The pipe 43 is provided with a restricted opening 44 through which any liquid coming in contact therewith is forced to remove the excess. With the arrangement of Figures 7 and 8, the liquid supply 39 is no longer utilized as any liquid deficiency will be supplied through the pipe 42.

Figure 9 shows a modified form of the water level control in which the functions of the pipes 42, 43 are combined in one pipe 45. This pipe

has a restricted opening **46** directed against the direction of rotation of the liquid and is supplied with liquid at a predetermined pressure which is less than the pressure of the liquid scooped up when its level comes in contact with the opening **46**. Thus, if the liquid level is below the opening **46**, liquid will flow out of pipe **45** into trap **37**; but when the liquid level comes in contact with the opening **46**, the excess liquid will be forced back in a reverse direction through the pipe **45**.

In Figure 10 is shown a liquid level arrangement for liquids of dissimilar density in the compressor. In this arrangement, the main portion of the liquid in the compressor will be the liquid **47** of heavier density upon which is a small quantity of a lighter density liquid **48**. One liquid level control **49** similar to the one **45** shown in Figure 9 has liquid supplied under sufficient pressure so that it will not scoop up the lighter liquid **48** but only the heavier exterior liquid **47**. The liquid level control pipe **51** will have the lighter liquid supplied under a lower pressure so that it will control the level of the liquid **48**. As a specific example, the exterior liquid may be mercury and the interior liquid water. In this case, the main working liquid is the large volume of mercury **47** within the compressor with a relatively thin layer of water thereon so that at the outlet ports for the compressor any liquid spilled over into the outlet will be constituted by the water portion of the compressor liquid.

Figure 11 shows an automatic liquid level control in which a liquid level control pipe **51**, which may be of the same construction of pipe **45** of Figure 9, is controlled in position by a bellows **52** which is connected by a pipe **53** to the compressor outlet so that the level of the liquid is controlled as a function of the compressor pressure. In the arrangement of Figure 11, a plate **54** is substituted for the plate **35** of Figure 1, the plate **54** being similar but having a smaller interior diameter to provide the extension **55** and having openings **56** therethrough providing communication between the liquid in the trap **37** and the liquid in the cup **33** of the rotor **32**, the liquid in the trap **37** replacing any deficiency in the liquid in the cup through these restricted openings.

While the invention has been specifically illustrated in connection with a gas compressor, it will, of course, be obvious that certain features thereof are applicable to engines and other forms of liquid piston machinery and, while certain preferred embodiments of the invention have been specifically disclosed, it is understood that the invention is not limited thereto as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation within the terms of the following claims:

What is claimed is:

1. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, the exterior surface of said interior rotor and the interior surface of said exterior rotor being substantially tangent at one point, means for driving said rotors to effect rotation thereof, openings in the bases of said pockets for the passage of gas therethrough, gas inlet and outlet ports for said openings, means providing for the passage of a small amount of compressing liquid through said openings at the end of the compression stroke to insure the complete evacuation of said pockets, and means for leading off any such passed liquid with the delivered gas.

2. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, the exterior surface of said interior rotor and the interior surface of said exterior rotor being substantially tangent at one point, means for driving said rotors to effect rotation thereof, openings in the bases of said pockets for the passage of gas therethrough, gas inlet and outlet ports for said openings, means providing for the passage of a small amount of compressing liquid through said openings at the end of the compression stroke to insure the complete evacuation of said pockets, and means for relieving said liquid from the action of centrifugal force immediately after it passes through said openings to facilitate its being carried off with the delivered gas.

3. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, means for driving said rotors to effect rotation thereof, openings in said pocket walls for the passage of gas therethrough, gas inlet and outlet ports for said openings, means providing for the passage of a small amount of compressing liquid through said openings at the end of the compression stroke, and means for insuring that all of the liquid supplied to said annular portion after the filling thereof will, in the operation of the machine, be removed only through said pocket openings.

4. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, means for driving said rotors to effect rotation thereof, openings in said pocket walls for the passage of gas therethrough, gas inlet and outlet ports for said openings, means providing for the passage of a small amount of compressing liquid through said openings at the end of the compression stroke, and means providing for a constant discharge of compressing liquid through said openings for a given amount of supplied liquid irrespective of the pressure developed by the machine.

5. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, the exterior surface of said interior rotor and the interior surface of said exterior rotor being substantially tangent at one point, means for driving said rotors to effect rotation thereof, openings in the bases of said pockets for the passage of gas therethrough, gas inlet and outlet ports for said open-

ings, means determining the liquid level within the machine, said last mentioned means being adjusted to insure the complete evacuation of gas from said pockets by providing for the discharge of liquid through the pocket openings at the end of the compression stroke, and means for relieving said liquid from the action of centrifugal force immediately after it passes through said openings to facilitate its being carried off with the delivered gas.

6. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, the exterior surface of said interior rotor and the interior surface of said exterior rotor being substantially tangent at one point, means for driving said rotors to effect rotation thereof, openings in the bases of said pockets for the passage of gas therethrough, gas inlet and outlet ports for said openings, and means determining the liquid level within the machine, said means being connected to automatically vary said liquid level in response to change in the pressure developed by the machine.

7. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, means for driving said rotors to effect rotation thereof, openings in the bases of said pockets for the passage of gas therethrough, gas inlet and outlet ports for said openings, said inner and outer rotor having a close fitting, relatively long side wall overlap adjacent the high pressure portion of the machine to provide a long restricted passage inhibiting passage of compressor liquid, and an annular well at the exterior of said annular portion receiving any liquid bled through said restricted passage, said well being in communication with said annular portion adjacent the compressor inlet to return liquid thereto.

8. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, means for driving said rotors to effect rotation thereof, openings in the bases of said pockets for the passage of gas therethrough, gas inlet and outlet ports for said openings, an annular well communicating with said annular portion at a point remote from the high pressure part of the machine, and means feeding liquid to said well for passage into said annular portion.

9. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, gas inlet and outlet ports for said pockets, means for driving said rotors to effect rotation thereof, an annular well communicating with said annular portion at a point remote from the high pressure part of the machine, and means controlling the level of liquid within the well to control the level of liquid within the machine.

10. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, gas inlet and outlet ports for said pockets, means for driving said rotors to effect rotation thereof, an annular well communicating with said annular portion at a point remote from the high pressure part of the machine, and means controlling the level of liquid within the well to control the level of liquid within the machine including means to supply liquid in the event of a deficiency and to remove any excess liquid which may occur.

11. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, means for driving said interior rotor to effect rotation thereof and of said outer rotor, openings in the bases of said pockets for the passage of gas therethrough, an arcuate inlet port for said machine communicating with said openings, an outlet port communicating with said openings, and valve means controlling said inlet port to determine the arc of rotation over which gas is drawn into the pockets and hence the volume delivered to the compressor outlet.

12. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, means for driving said rotors to effect rotation thereof, openings in the bases of said pockets for the passage of gas therethrough, an inlet port for said machine communicating with said openings, an outlet port communicating with said openings, and means for closing a portion of said inlet port in advance of the maximum pocket volume to restrict the volume of gas drawn into the pockets.

13. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, means for driving said rotors to effect rotation thereof, openings in the bases of said pockets for the passage of gas therethrough, an outlet port for said machine communicating with said pocket openings, an inlet port communicating with said openings, said outlet port including a constantly open opening and openings disposed on the lead and trail sides thereof, and means for closing said lead and trail outlet openings if the machine back pressure is greater than the pressure within the adjacent pockets.

14. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, means

for driving said rotors to effect rotation thereof, openings in the bases of said pockets for the passage of gas therethrough, gas inlet and outlet ports for said openings, said pockets being of deep, elongated, narrow construction with their depth many times greater than their width and said openings being symmetrically disposed in said pocket bases to provide for smooth, non-turbulent flow of gas within the pockets in intimate heat transfer contact with the pocket walls.

15. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, means for driving said rotors to effect rotation thereof, openings in the bases of said pockets for the passage of gas therethrough, gas inlet and outlet ports for said openings, said pockets being of deep, elongated, narrow construction with said openings disposed substantially symmetrically in the bottoms of the pockets and elongated in the direction of the pocket elongation to provide for the complete evacuation of gas from the pockets without the compressor liquid trapping undelivered gas therein.

16. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, means for driving said rotors to effect rotation thereof, openings in walls of said pockets for the passage of gas therethrough, gas inlet and outlet ports for said openings, said pockets being of deep, elongated, narrow construction, and with said openings elongated in transverse cross-section with the elongated axes disposed substantially parallel to the bottom walls of the pockets.

17. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, gas inlet and outlet ports for said pockets, the exterior surface of said interior rotor and the interior surface of said exterior rotor being substantially tangent at one point, means for driving said rotors to effect rotation thereof, said inner and outer rotors having a close fitting, relatively long side wall overlap adjacent the high pressure portion of the machine to provide a long restricted passage inhibiting passage of compressing liquid,

and means for returning to said annular portion any liquid which escapes through said restricted passage.

18. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, gas inlet and outlet ports for said pockets, said inner and outer rotors having a close fitting, relatively long side wall overlap adjacent the high pressure portion of the machine to provide a long restricted passage inhibiting passage of compressing liquid, and an annular well at the exterior of said annular portion receiving any liquid bled through said restricted passage and returning it to said annular portion adjacent the low pressure portion of the machine.

19. In a rotary, liquid piston machine, an exterior rotor having an annular portion for the reception of a compressing liquid, a compressing liquid in said portion, an interior rotor in said portion mounted on an axis eccentric to the axis of said exterior rotor and having a plurality of open pockets about the periphery thereof, means for driving said rotors to effect rotation thereof, openings in the bases of said pockets for passage of gas therethrough, stationary inlet and outlet chambers within said interior rotor communicating with said openings, the exterior periphery of said chambers being closely adjacent the interior periphery of the interior rotor, means at one side of said machine for supporting said stationary chambers, bearings at the opposite side of said machine independent of said stationary chambers for supporting said interior rotor, and a bearing interconnecting said chambers and interior rotor to maintain their proper alignment irrespective of the pressure developed in the machine.

PAUL KOLLSMAN.

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