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COMPRESSOR FOR REFRIGERATION SYSTEM

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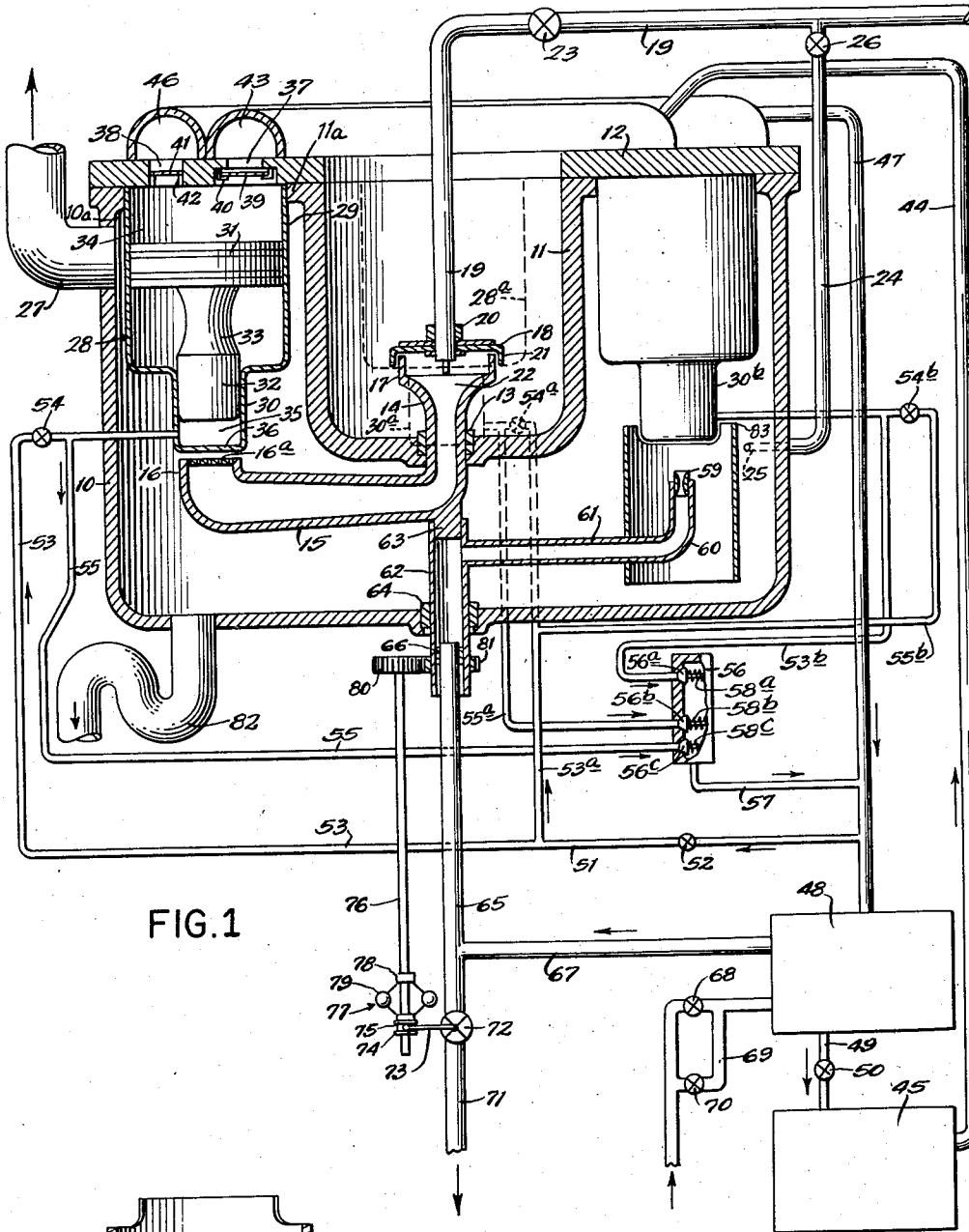


FIG. 1

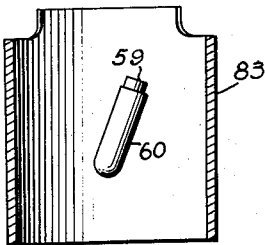


FIG. 2

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COMPRESSOR FOR REFRIGERATION SYSTEM

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13 Claims. (Cl. 230—53)

This invention relates to a refrigeration system, and more particularly to compressor apparatus adapted for use therein.

An object of this invention is to provide a refrigeration system having novel compressor apparatus therefor. Another object of the invention is to provide a compressor for compressing fluids and that is actuated by heat. Still another object is the provision of apparatus wherein the alternate condensing and evaporation of a suitable fluid is operative to power the apparatus whereby it is adapted to function as a compressor for gaseous fluids. Yet another object is in providing compressor apparatus having a piston and cylinder, the piston being reciprocated within the cylinder by the change of state of fluids therein; the piston being operative during its reciprocatory cycle to compress fluids such as, for example, a refrigerant.

A further object of this invention is to provide compressor apparatus having a plurality of cylinders equipped with pistons mounted for reciprocation therein, the lower end portion of each of the cylinders being arranged to receive an expansible fluid therein; means being furnished to alternately heat and cool the lower cylinder ends, with the result that the expansion and contraction of the fluid causes the pistons to reciprocate within the cylinders and to thereby compress a fluid in the upper ends of the cylinders. Still a further object is to provide a plurality of spaced-apart piston-equipped cylinders as described above and to provide a heater adapted to be brought successively into heat-exchange relation with each of the cylinders; jet coolant means also being provided for successively impinging a jet of coolant upon the cylinders subsequent to the heating thereof.

Still a further object is in the provision of apparatus as described wherein the means for providing the jet coolant is angularly oriented and the impingement of the coolant upon the cylinders is operative to move the jet and the heater operatively arranged therewith. Yet a further object is in providing governor means for automatically controlling the rate of movement of the heater and jet. A further object is to provide a refrigeration system wherein the refrigerant after expansion is compressed by a heat-actuated pump, the pump comprising a piston mounted for reciprocation within a cylinder, a suitable fluid being provided at one end of the cylinder, and means also being provided to alternately heat the cylinder to evaporate the fluid and cool the cylinder to condense the fluid whereby the piston is reciprocated within the cylinder. Additional objects and advantages will appear as the specification proceeds.

An embodiment of the invention is illustrated in the accompanying drawing, in which

Figure 1 is for the most part a side view in elevation of apparatus incorporating my invention and wherein portions of the system are shown diagrammatically and Fig. 2 is an enlarged fragmentary view, partially in section, of the coolant portion structure of Fig. 1.

Referring now specifically to the drawing, it is seen

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that a refrigeration system is illustrated that incorporates a compressor embodying my invention. The compressor includes a casing 10 that is substantially hollow throughout the interior thereof but which has aligned centrally therein a hub or mounting member 11 rigidly secured at its upper end to an annular top wall or closure member 12 which in turn is rigidly secured to the vertical walls of the casing 10. The hub 11 has side walls and a bottom wall and is open at the top thereof. Preferably the hub 11 is annular and it may be secured to the closure member 12 by any suitable means such as welding or, if desired, cap screws, etc., may be employed to provide a releasable mounting for the closure member 12 upon the hub. Similarly, the member 12 about its outer edge thereof may be permanently secured to the vertical walls of the casing as by welding but preferably is releasably secured thereto by cap screws (not shown).

The bottom wall of the hub 11 is provided with a central opening therethrough and a bearing 13 mounted within the bottom wall of the hub rotatably receives the stem 14 of a burner 15 therein. As is illustrated in the drawing, the stem 14 of the burner assembly is hollow to permit the passage therethrough of a fuel which is ignited and burned at the burner plate 16a of the burner head 16. Preferably, burner head 16 is arcuate and covers a substantial arc so that a sufficient heating time is provided. Since burner assemblies of this general character are well known in the art it is believed unnecessary to herein describe the burner in further detail.

The upper end of the stem 14 within the hub 11 is enlarged and is equipped with an upwardly-extending annular flange 17 that is covered by an air shutter 18 that is rigidly secured to a fuel conduit 19 and in sealing relation therewith by a collar 20. The flange 17 is intended to rotate relative to the cap 18, and any air admitted between the parts merely mixes with the combustible fuel and main air supplied through air shutter 18.

The conduit 19 is equipped at its lower end with an orifice 22 through which the fuel must flow in its passage into the burner assembly 15. The conduit 19 at its opposite end leads to a source of fuel which may be any one of a number of fuels but is preferably gas. A valve 23 interposed in the conduit 19 and is preferably adapted for automatic control of the flow of gas to the burner assembly 15.

A branch conduit 24 extends downwardly from the main supply conduit 19 and leads to a pilot burner 25 that communicates with the interior of the casing 10 through an aperture in the side wall thereof. A valve 26 inserted in the branch conduit 24 permits manual control of the flow of fuel to the pilot burner 25 which can be equipped with a conventional safety device (not shown). In the installation illustrated the pilot burner is stationary and as the burner assembly 15 rotates within the casing 10, in a manner to be hereinafter described, the pilot burner is effective to ignite the fuel present at the burner plate 16. It will be appreciated, however, that other pilot structures may be employed and, for example, a pilot designed to rotate with the burner assembly 15 and to perhaps be carried thereby might well be substituted for the specific structure illustrated.

The casing 10 is equipped with a flue 27 that communicates with the interior thereof and extends outwardly and away from the casing and provides an escape for the products of combustion resulting from the burning of the fuel at the burner plate 16 and pilot 25.

It is seen that a plurality of cylinders 28 are mounted within the interior of the casing 10 and may be rigidly secured within the annular channel provided between the inwardly-extending projections 11a and 10a provided respectively by the hub 11 and casing 10. The cylinders

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are rigidly secured to the casing and hub and are held stationary within the casing. Any number of cylinders 28 may be provided and in the sectional illustration given, three are shown—namely, the cylinder 28 shown at the left in section, the cylinder 28a shown centrally by dotted lines, and the cylinder 28b shown in elevation at the right of the drawings. The construction of each of the cylinders is substantially identical and in setting out such construction attention will be directed specifically to the sectional showing at the left of the illustration.

Each cylinder 28 is provided with an enlarged upper portion 29 and a lower portion of reduced diameter 30. Mounted for reciprocatory movement within each of the cylinders is a piston 31 of relatively large diameter and that sealingly engages the walls of the enlarged cylinder portion 29 and a piston 32 of reduced diameter that reciprocates within and in sealing engagement with the walls of the reduced cylinder portion 30. A piston rod 33 is rigidly secured to the piston 31 and piston 32 so that these members move in unison.

The space 34 between the upper surface of the piston 31 and closure member 12 may be referred to as the compression space, while the space 35 between the lower surface of the piston 32 and bottom wall 36 of the cylinder may be referred to as the work space. Upon reciprocation of the pistons, a fluid is intended to be compressed within the space 34 while the expansion and contraction of a fluid within the work space 35 is adapted to power the apparatus and bring about the reciprocatory movement of the pistons.

It will be appreciated that the annular closure member 12 provides a top wall for each of the cylinders and is, therefore, in sealing engagement with the vertical walls thereof. The closure 12 is provided with an inlet port 37 communicating with the interior of the cylinder 28 and a discharge port 38 similarly communicating with the interior of the cylinder 28. It should be understood that similar inlet and discharge ports are provided for each cylinder in the structure. The inlet port 37 is adapted to be closed by a recessed valve 39 during the compression stroke of the piston 31 and the valve is supported in normally open position upon a retainer 40. The discharge port 38 is equipped with a valve 41 adapted to sealingly engage the valve seat 42 during the suction or intake stroke of the piston 31. The inlet port 37 is in open communication with a suction manifold 43 which may communicate through a conduit 44 with an evaporator 45 which provides a source of expanded fluid and fluid which is to be compressed. The discharge port 38 communicates with a discharge manifold 46 which is in open communication through a conduit 47 with a condenser 48 that forms a part of the refrigeration system. To complete the refrigeration system a conduit 49 equipped with an expansion valve 50 connects the condenser 48 and evaporator 45. Thus it will be apparent that compressed fluid is fed through the discharge manifold 46 and conduit 47 to the condenser 48 where, after being cooled, it is expanded through the valve 50 and into the evaporator 45 from which it is drawn into the compression space 34 through the conduit 44 and suction manifold 43.

It will be appreciated that the compressor apparatus so far described and which will be hereinafter further described may be employed in the compression of fluids in numerous systems and that the refrigeration system herein illustrated is exemplary only.

The lower ends of the cylinder portions 30 must be provided with an expansible fluid and I prefer to provide and maintain the supply of such fluid through a conduit 51 which at one end is in open communication with the high pressure side of the condenser 48 through the bleed valve 52. Branching upwardly from the high pressure supply conduit 51 are a plurality of conduits 53, 53a, 53b, etc., that in turn communicate through the check valves 54, 54a and 54b respectively with the cylinder por-

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tions 30, 30a and 30b. It will be apparent that the branch conduits must enter the casing 10 and extend to the lower cylinder portions at an elevation sufficiently high to prohibit interference with the free rotation of the burner assembly 15.

It is also desired to prevent excessive accumulation of fluid within the lower cylinder portions, and to prevent such accumulation branch conduits 55, 55a and 55b are provided that are in open communication at one end with their respective cylinder portions and at their opposite ends communicate with a high pressure bleed valve unit 56 that in turn communicates with the high pressure side of the condenser 48 through the main return conduit 57. The bleed valve unit 56 is arranged so that the valves therein permit the flow of fluid from the branch conduits and into the main return conduit 57 when the pressure of the fluid within the lower cylinder portions reaches some predetermined value. In the illustration given, valve unit 56 contains three separate valves 56a, 56b, 56c, respectively controlling the flow through lines 53b, 55a, and 55. These valves are backed by compression springs 58a, 58b, and 58c. As already indicated, the operation of these valves is to permit bleeding in and out from the actuating cylinders. In other words, valve unit 56 provides means for removing refrigerant in controlled amounts from the reduced lower portions 30 of cylinders 28.

In the compressor of this invention, it is desired to alternately heat the lower cylinder portions and then cool the same following the heating thereof. I prefer to cool the cylinders by spraying a coolant thereagainst through the nozzle 59. While any suitable coolant may be used to bring about the relatively rapid cooling of the heated cylinder portions, I have found that the same coolant, which is preferably water, used to cool the refrigerant within the condenser 48 may be advantageously employed. Therefore the nozzle 59 is rigidly mounted within the end portion of an elbow 60 that is extended at one side and forms a coolant line 61 and which is rigidly secured to a depending sleeve 62 which at its upper end receives and is rigidly secured to a plug 63 that may be an integral part of the burner assembly 15. The sleeve 62 should sealingly engage the plug 63 to prevent the flow of coolant from the upper end of the sleeve. The sleeve 62 is rotatably supported within a bearing 64 mounted centrally within the bottom wall of the casing 10. The sleeve extends downwardly through the bearing and casing and rotatably receives therein the coolant supply conduit 65 which has interposed between it and the inner surface of the sleeve a bearing seal 66. Thus, the burner assembly 15, coolant conduit 61 and sleeve 62 are free to rotate relative to the coolant supply conduit 65.

Coolant is supplied to the conduit 65 through the supply line 67 which winds through the condenser 48 in a conventional manner and extends outwardly therefrom and communicates at its lower end with a source of coolant which, as hereinbefore indicated, may be relatively cool water. The water pressure control valve 68 is preferably interposed in the coolant supply line leading to the condenser 48 and is operative to prevent the flow of coolant to the condenser until the system is operating at sufficient capacity to require the cooling of the condenser. A bypass 69 equipped with a bypass control valve 70 is placed about the control valve 68 and permits a limited flow of coolant to the condenser 48 until the main control valve 68 has opened.

Extending downwardly from the junction of the coolant lines 65 and 67 is a coolant control conduit 71 that at its opposite end is preferably connected to a drain for carrying away coolant that flows therethrough. A metering valve 72 is interposed in the control conduit 71 and is equipped with a valve arm 73 extending laterally therefrom. The arm 73 has a bifurcated end portion that is received between the flanges 74 of a sliding sleeve 75 mounted for reciprocation upon a shaft 76 and which has

its position determined by a governor 77. The governor 77 may be conventional in all respects and may include a collar 78 rigidly constrained against longitudinal movement upon the shaft 76 and the conventional fly balls 79, the position of which is determined by the speed of rotation of the shaft 76 and which are rigidly secured to the sleeve 75 and thereby determine its position upon the shaft.

At its upper end the shaft 76 has rigidly secured thereto a spur gear 80 which meshes with the drive gear 81 rigidly carried by the sleeve 62. Rotation of the sleeve 62, then, is operative through the gears 80 and 81 to rotate the shaft 76.

The bottom wall of the casing 10 has mounted in an aperture provided thereby a water trap 82 that at its opposite end communicates with a drain whereby the coolant sprayed against the cylinders and which collects upon the bottom wall of the casing is disposed of. To prevent excessive spray throughout the interior of the casing 10, a shield 83 is carried by the conduit 61 and extends upwardly and about the nozzle 59 and is adapted to partially enclose the lower end portions 30 of the cylinders. It will be apparent that the shape of the shield 83 must be such that the reduced end portions 30 of the cylinders will not impede movement of the shield as the conduit 60 rotates within the casing.

The nozzle 59 should be angularly disposed within the end of the elbow 60 so that the reaction of the coolant forced through the nozzle will cause the nozzle and conduit 60, as well as the burner assembly 15 and sleeve 62, to rotate by jet action.

Operation

In operation of the apparatus, the fuel supply valves 26 and 23 are opened and the pilot 25 ignited. Simultaneously therewith the bypass valve 70 is opened and water or other coolant flows through the bypass 69, condenser 48, and upwardly through the conduits 67, 65 and 61, to the nozzle 59 where it is forced outwardly at relatively high velocity and impinges against the bottom walls of the lower cylinder portions and thereby sets up rotation of the coolant assembly and burner assembly. Eventually in its rotary movement the burner 16 is ignited and the heat developed by the burning of the fuel heats the expansible fluid within the lower portion of the reduced cylinder ends and brings about a change of state of such fluid.

As the fluid evaporates within the work space 35, the piston 32 is forced upwardly as is the rod 33 and piston 31. The volume of work space 34 is thereby decreased and fluid, which may be refrigerant, within such compression space is compressed and is forced outwardly through the discharge port 38, into the discharge manifold 46, and in compressed condition through the conduit 47 and into the condenser 48. As the burner assembly rotates from beneath the cylinder, the nozzle 59 is eventually brought into position therebelow and the spray of coolant from the nozzle chills the lower end portion 30 of the cylinder and causes the gas therein to condense. The pressure exerted by such fluid upon the piston 32 is thereby decreased and the piston 32, rod 33 and piston 31 move downwardly within the cylinder.

As the pistons move downwardly within the cylinder, the valve 39 is opened while the valve 41 is closed and fluid is drawn into the compression space 34 through the inlet port 37 and from the suction manifold 43, refrigerant suction conduit 44 and evaporator 45. When the burner is again brought into heat-exchange relation with the cylinder, the fluid within the cylinder portion 30 is evaporated and the refrigerant within the compression space 34 is condensed, and the cycle is repeated.

Since a plurality of cylinders are provided, compression of some refrigerant and the forcing of the compressed refrigerant into the condenser 48 is carried on simultaneously with the suction of expanded refrigerant from the evaporator 45. Thus the compression of refrigerant

is carried on at a relatively even rate. The spray of coolant coming from the nozzle 59 cools the cylinder portion it impinges against, while the shield 83 tends to collect the liquid and to channel it downwardly to the bottom of the casing 10 whereby the trap 82 carries it to a suitable drain. At the same time, the jet from the nozzle that cools the cylinders also imparts rotary movement to the coolant assembly and burner assembly rigidly secured thereto. The combustion gases are taken from the interior of the casing through the flue 27.

When it is desired to stop the system, the main valve 23 may be closed so that the pistons can no longer be heated. Selectively the pilot may be permitted to continue burning or it, too, may be shut off, as well as the bypass control valve 70.

The burner 15 may occupy an arc ranging from, for example, 120° to 240°, as desired. Thus a rather prolonged heating of each cylinder is provided during movement of the burner assembly and if the cylinders are sufficiently close together at least two cylinders may be heated substantially simultaneously.

The governor mechanism 77 automatically regulates the speed with which the burner assembly 15 and coolant unit rotate. For example, if the valve 68 in the coolant supply line to the condenser 48 is open to a considerable extent, a large amount of coolant will flow upwardly and through the nozzle 59. Thus the greater flow of liquid from the nozzle would tend to speed up rotation of the burner assembly and coolant assembly, while if the valve 68 were not open to a great extent, less liquid would flow through the nozzle and the speed or rotation of the burner and nozzle assembly would tend to decrease. With the valve 72 and governor assembly 77 controlling the same, the speed of rotation can be held fairly constant, for if the tendency of the assembly is to rotate at a greater velocity the governor opens the valve 72 to a greater extent and more of the coolant flows to drain through the conduit 71. Therefore less liquid is present at the nozzle 59 and the speed of rotation will not be greatly increased. On the other hand, if the rotary speed tends to decrease, the governor 77 closes the valve 72 and more of the coolant flows to and through the nozzle 59 whereby the rotary speed of the burner assembly, etc., is maintained at the preselected speed.

Fluid and lubrication for the piston 32 is supplied to the cylinder portion 30 through the bleed valve 52, conduit 51 and branch conduit 53. When the pressure within the cylinder portion 30 is low, the bleed valve 52 permits some high pressure fluid to flow from the high pressure side of the condenser 48 to the piston 30. On the other hand, excessive accumulation of the fluid within the cylinder portion 30 is checked by return flow through the branch conduit 55 and bleed valve 56 if the pressure within the lower cylinder portion 30 exceeds by a preselected differential, for which the bleed valve 56 is set, the pressure of the refrigerant at the return side of the condenser 48. For example, the bleed valve 52 may be designed to bleed a small amount of high pressure refrigerant from the condenser and into the lower cylinder portions when the pressure in the condenser is approximately 150 pounds per square inch and when the pressure within the evaporator is approximately 40 pounds per square inch. At the fully retracted position or lowermost position of the piston 32, most of the expansible fluid within the lower cylinder portion 30 will have been condensed and the pressure therein may be about 125 pounds per square inch when heat is supplied to the cylinder and the fluid begins to evaporate. If the valve 52 is set to open at a pressure of about 130 pounds per square inch, each of the lower cylinder portions 30 will be fed a small amount of refrigerant during the time the pressure therein is below the 130 pounds per square inch level. Similarly, the bleed valve 56 may be set to open whenever the pressure within the cylinder portions 30 exceeds a value such as 300 pounds per

square inch, which will be attained during some portion of the cycle.

While in the foregoing specification an embodiment of the invention has been set out in considerable detail for purposes of illustration, it will be apparent to those skilled in the art that considerable deviation may be made in these details without departing from the spirit and principles of the invention.

I claim:

1. In apparatus of the character described, at least one cylinder having an enlarged end portion and a reduced end portion, an enlarged piston mounted for reciprocatory movement in the enlarged end portion of said cylinder, a piston of reduced diameter mounted for reciprocatory movement in the reduced end portion of said cylinder, means rigidly connecting said pistons together, said cylinder being provided with a valve-equipped inlet port and a valve-equipped outlet port both adjacent the upper end of said enlarged end portion of the cylinder, means for providing a heat-expansive fluid in the cylinder portion of reduced diameter, and means for alternately heating and cooling said cylinder at the end thereof of reduced diameter.

2. In apparatus of the character described, at least one cylinder having an enlarged end portion and a reduced end portion, and enlarged piston and a reduced piston rigidly connected together and mounted respectively for reciprocatory movement in the enlarged end portion and reduced end portion of said cylinder, means for providing a heat-expansive fluid in the reduced end portion of said cylinder, and means for alternately heating and cooling the reduced end portion of said cylinder comprising a fuel burner for heating and a liquid spray for cooling said reduced end portion.

3. In compressor apparatus, a plurality of spaced-apart cylinders each equipped with a piston mounted therein for reciprocatory movement, means for providing an expansible fluid in one end of said cylinders, a burner adapted to move successively into heat-exchange relation with said one end portion of each cylinder, means for supplying fuel to said burner, and means for successively cooling each of said cylinders following the heating thereof by said burner.

4. Apparatus according to claim 3 in which each of said cylinders is equipped with an enlarged end portion and a reduced end portion, said expansible fluid being provided in said reduced end portion.

5. The structure of claim 4 in which said means for cooling each of said cylinders comprises a water spray arranged to discharge thereagainst.

6. The structure of claim 5 in which said water spray is provided through an angularly oriented nozzle communicating with a source of water under pressure.

7. In compressor apparatus, a casing providing a chamber therein, a plurality of cylinders mounted in spaced-apart relation about an arc within said casing, piston means in each of said cylinders for reciprocatory movement, means for providing an expansible fluid beneath each piston means, a burner mounted within said casing for rotary movement with respect to said cylinders in an arcuate path of travel therebeneath, a coolant supply means adapted to communicate with a source of coolant under pressure and being mounted for rotation within said casing and being rigidly secured to said burner assembly, and a nozzle carried by said coolant assembly and being angularly oriented with respect to the cylinders

and adapted to discharge liquid coolant under pressure thereagainst.

8. The apparatus of claim 7 wherein a valve-equipped conduit supplies coolant to said coolant assembly, and governor means arranged with said coolant assembly and with said last-mentioned valve controls the opening of said valve and thereby the supply of coolant to said nozzle.

9. The structure of claim 8 in which a pilot is provided for igniting said burner assembly, and in which a safety control valve is arranged with said burner assembly for controlling the flow of fuel thereto.

10. In engine-compressor apparatus of the character described, a cylinder, a piston mounted for reciprocatory movement within said cylinder, means for providing a heat expansible fluid within said cylinder at one end thereof, heating means supported for movement with respect to said cylinder and being movable into heat exchange relation with the end thereof having the heat expansible fluid therein, and a coolant device mounted for movement with respect to said cylinder for movement into heat exchange relation with the end thereof having said heat expansible fluid therein, said heater and coolant device being arranged for successive movement into the aforesaid relations with said cylinder.

11. In a compressor structure, a plurality of cylinders each having a piston reciprocable therein, said cylinders being spaced apart and each being adapted to have a heat expansible fluid introduced into one end thereof, a burner and a liquid spray device supported for movement successively into substantial alignment with the aforesaid one end of each cylinder, said burner being adapted to heat that end of each cylinder to expand a fluid contained therein and said liquid spray device being adapted to impinge liquid on that end of each cylinder to cool such fluid contained in the aforesaid one end.

12. The apparatus of claim 11 in which said liquid spray device comprises a nozzle for discharging liquid under pressure against said cylinders, said burner and liquid spray device being connected together and said nozzle being angularly oriented with respect to said cylinders whereupon the impingement of liquid discharged therefrom against the cylinders is effective to move the burner and liquid spray device successively into alignment with the various cylinders.

13. In compressor apparatus of the character described, at least one cylinder equipped with a piston mounted therein for reciprocatory movement, means for providing a heat-expansible fluid in one end of said cylinder, a burner movable into heat exchange relation with the said one end of said cylinder, means for supplying fuel to said burner, and cooling means for cooling said one end operatively associated with said burner, said cooling means successively moving said burner into said heat exchange relation with said cylinder and itself into cooling relation with said cylinder.

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