

April 28, 1959

C. P. PIKEY

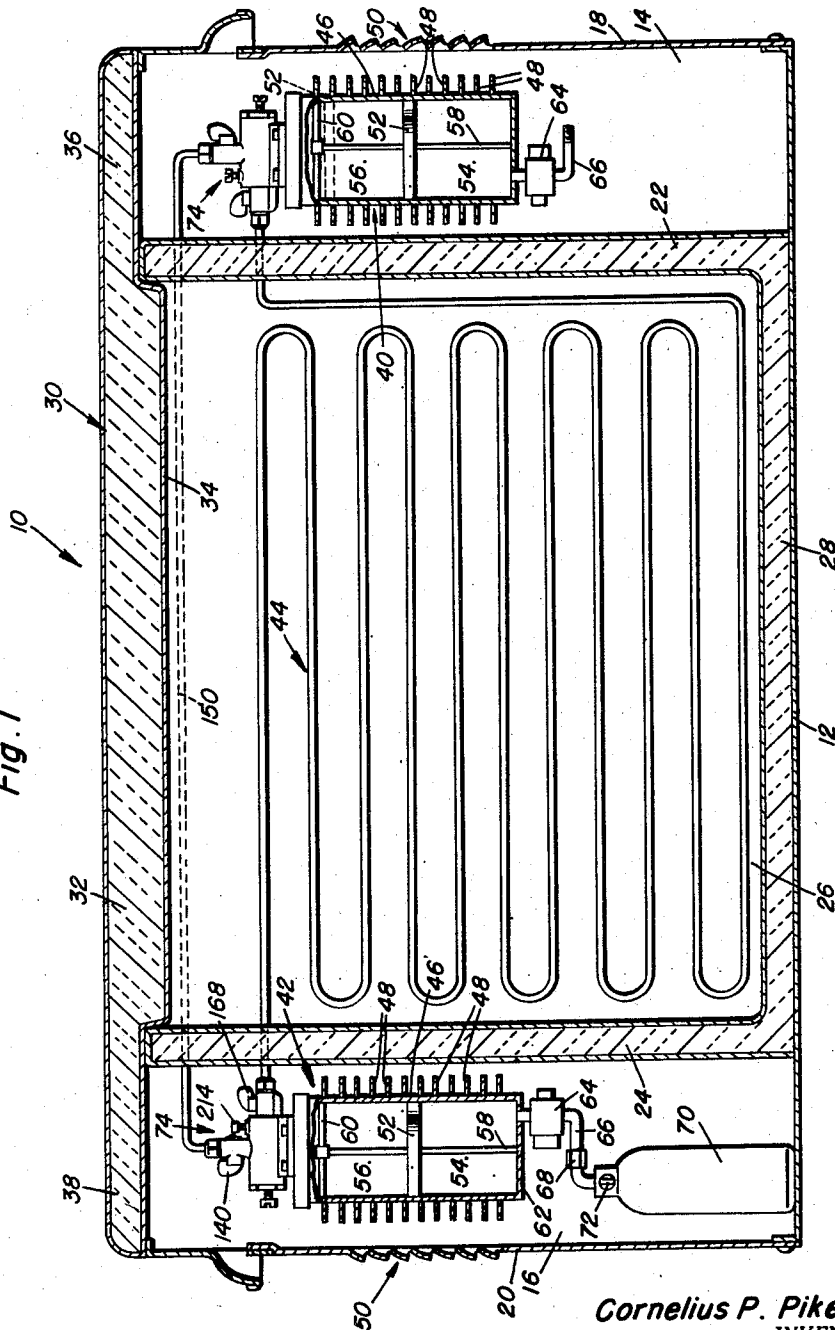
2,883,835

METHOD AND APPARATUS FOR PORTABLE REFRIGERATION CYCLE

Filed Oct. 5, 1955

4 Sheets-Sheet 1

Fig. 1



Cornelius P. Pikey
INVENTOR.

BY *Chance A. Olson*
and *Harvey B. Jackson*
Attorneys

April 28, 1959

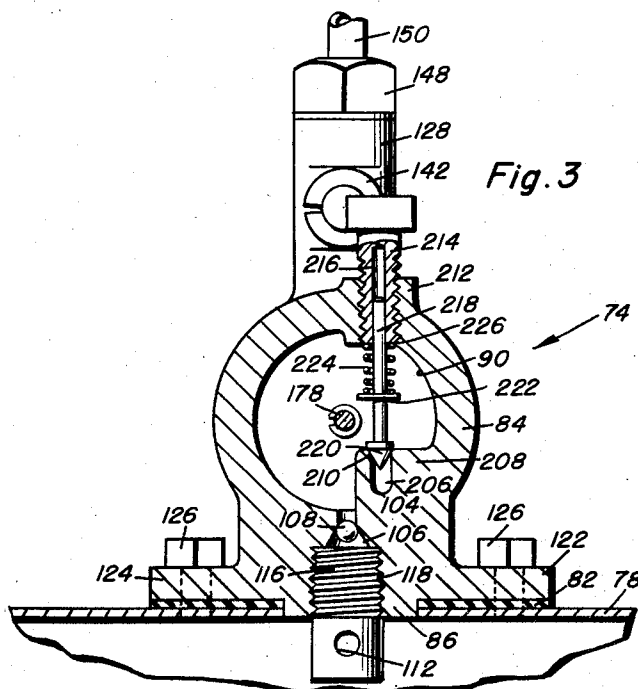
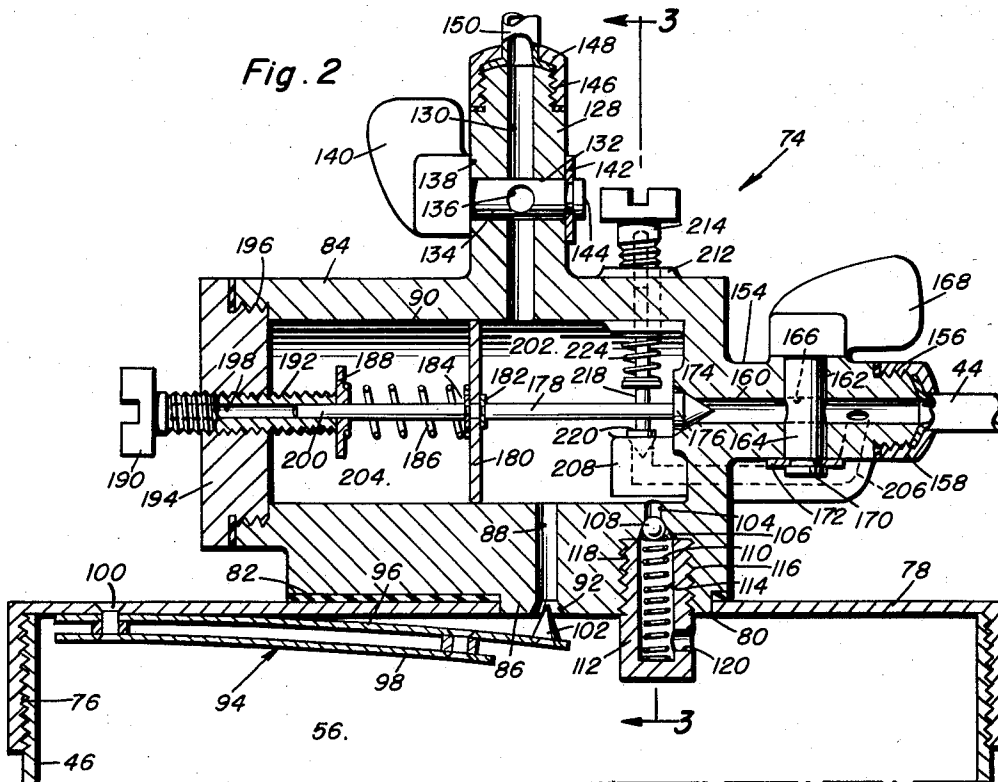
C. P. PIKEY

2,883,835

METHOD AND APPARATUS FOR PORTABLE REFRIGERATION CYCLE

Filed Oct. 5, 1955

4 Sheets-Sheet 2



Cornelius P. Pikey
INVENTOR.

BY *Chance W. O'Brien*
and Harvey B. Jacobson
Attorneys

April 28, 1959

C. P. PIKEY

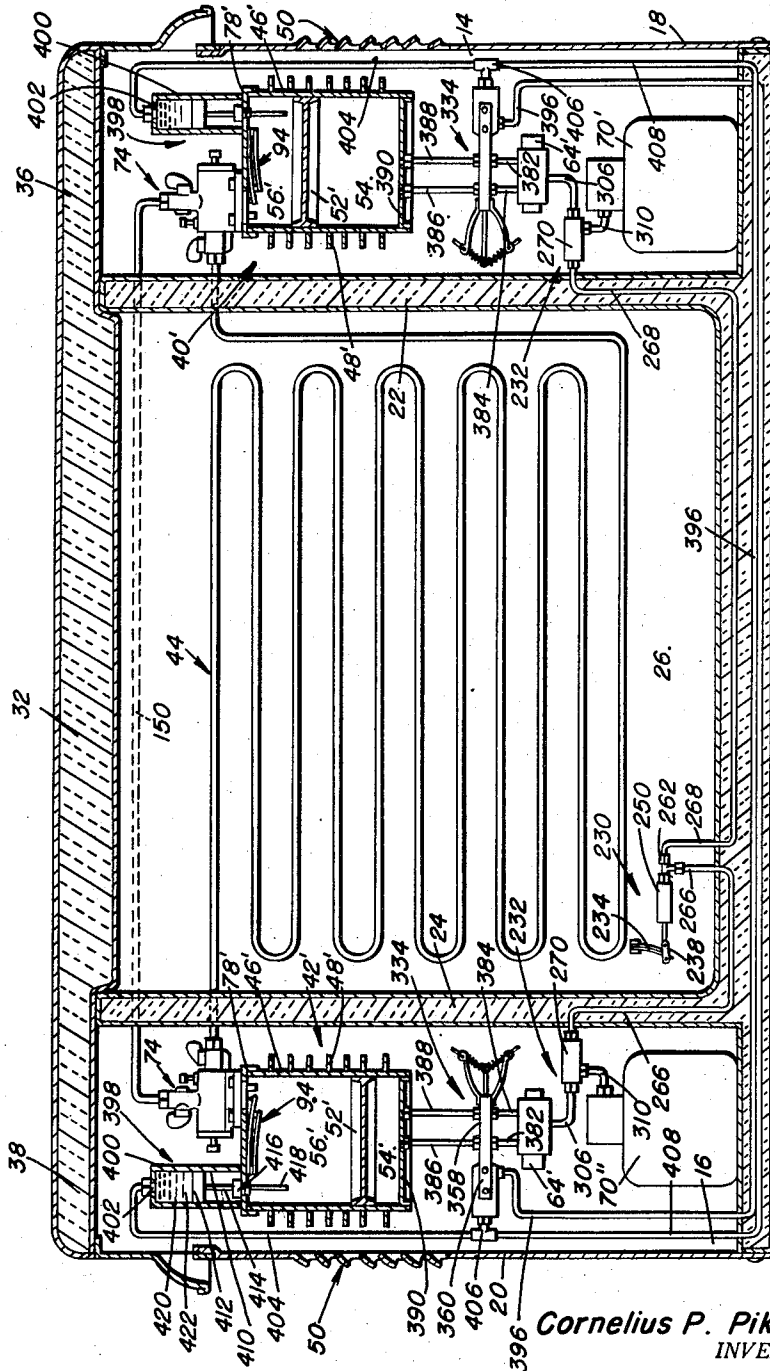
2,883,835

METHOD AND APPARATUS FOR PORTABLE REFRIGERATION CYCLE

Filed Oct. 5, 1955

4 Sheets-Sheet 3

Fig. 4



Cornelius P. Pikey
INVENTOR.

BY *Charles A. O'Brien*
and Harvey R. Jackson
Attorneys

April 28, 1959

C. P. PIKEY

2,883,835

METHOD AND APPARATUS FOR PORTABLE REFRIGERATION CYCLE

Filed Oct. 5, 1955

4 Sheets-Sheet 4

Fig. 5

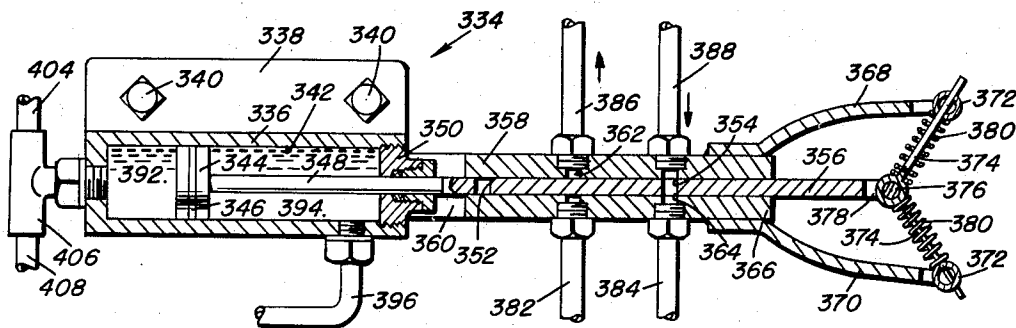


Fig. 6

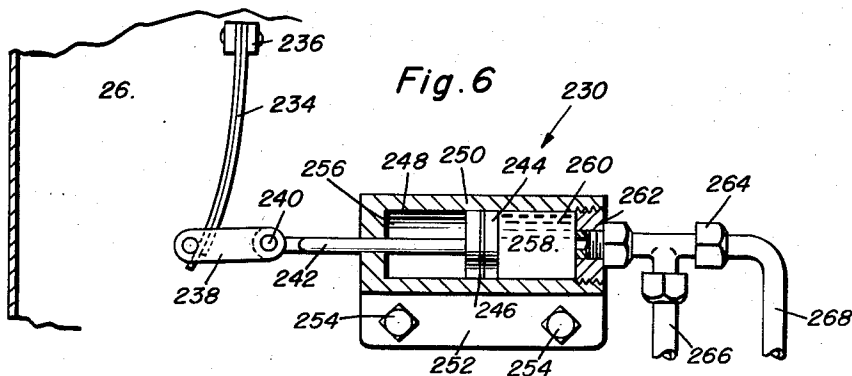


Fig. 7

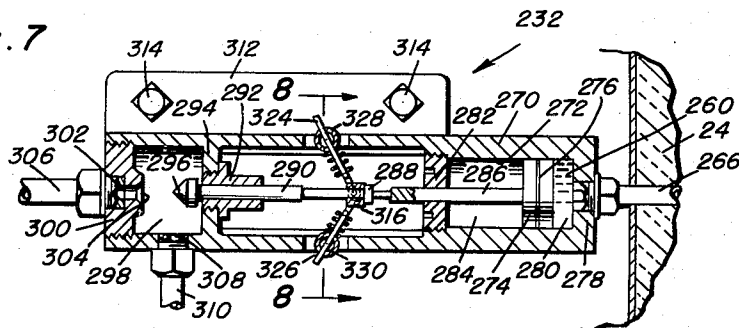
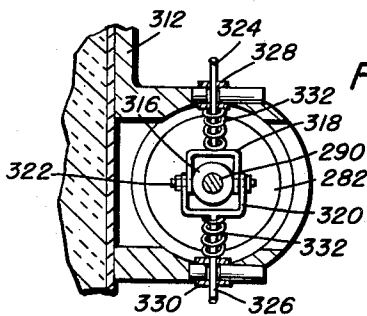


Fig. 8



Cornelius P. Pikey
INVENTOR.

BY *Albance A. O'Brien*
and *Harvey E. Jacobson*
Attorneys

1

2,883,835

METHOD AND APPARATUS FOR PORTABLE REFRIGERATION CYCLE

Cornelius P. Pikey, Sanborn, N. Dak.

Application October 5, 1955, Serial No. 538,615

7 Claims. (Cl. 62-161)

This invention relates generally to refrigeration systems and is more particularly concerned with a novel refrigeration system usable in portable refrigerators which includes a pair of refrigeration compressors connected in series to a refrigeration coil and providing a closed refrigeration system which includes dual reversible refrigeration cycles.

A further object of the invention in conformance with that set forth above is to provide in a refrigeration system of the character set forth a novel refrigeration compressor which serves as an expansion chamber and refrigeration compressor in the dual reversible refrigeration cycles.

Another object of the invention in conformance with that set forth above is to provide in a refrigeration system of the character set forth means for controlling the temperature to be maintained by the dual reversible refrigeration cycles.

And yet another object of the invention in conformance with that set forth above is to provide in a refrigeration system of the character set forth means for automatically reversing the dual reversible refrigeration cycles to provide continuous operation of the refrigeration system.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

Figure 1 is a longitudinal sectional view showing diagrammatically the novel refrigeration system as incorporated in a portable refrigerator;

Figure 2 is an enlarged fragmentary sectional view of the metering and pressure valve structure of the compressors of Figure 1;

Figure 3 is a sectional view taken substantially on line 3-3 of Figure 2;

Figure 4 is a longitudinal sectional view similar to Figure 1 showing diagrammatically a refrigeration system affording constant control temperature and continuous operation of the novel refrigeration system;

Figure 5 is an enlarged longitudinal sectional view of an automatic switch-over control valve of Figure 4;

Figure 6 is an enlarged fragmentary sectional view of the temperature control valve of Figure 4;

Figure 7 is an enlarged longitudinal sectional view of the control valve assembly cooperating with the temperature control valve for controlling compression fluid to the compressor; and,

Figure 8 is a sectional view taken substantially on line 8-8 of Figure 7.

Indicated generally at 10 is a portable refrigerator including a cabinet 12 having suitable end compartments 14 and 16 which are defined by an end wall 18 and 20, respectively, which cooperate with inwardly spaced insulated walls 22 and 24, respectively, for defining an inner refrigeration chamber 26 with the lower insulated wall portion 28. A suitable cover member 30 insulated at 32 and having a downwardly extending central portion 34

2

fitting within the refrigeration chamber 26 is provided, it being noted that end portions 36 and 38 cover the tops of the compartments 14 and 16, respectively.

A pair of combined compressor and expansion chamber assemblies 40 and 42 are suitably mounted in the compartments 14 and 16, respectively, and are in communication with a refrigeration coil 44 of any suitable character for cooling the refrigeration chamber 26.

The combined expansion chamber and compressors 40 and 42 each include a cylinder housing 46 having a plurality of exterior heat dissipating annular baffles 48 which are operable to conduct heat from the interior of the cylinder body 46 through the contact with air communicating in the chambers 14 and 16 through a louvred portion 50 in the side walls 18 and 20 of the refrigerator. The cylinders 46 each include therein a suitable free floating piston or pressure responsive movable wall element 52 having conventional peripheral seals providing two separate variable volume chambers 54 and 56, when the pressure responsive movable wall 52 reciprocates on a suitable guide rod 58 suitably supported in the cylinder 46 by means of a transverse brace element 60, for example.

The lower chamber 54 of the cylinder 46 has a suitable apertured bottom wall portion 62 communicating with a metering valve 64 of any suitable character which includes a lower threaded nipple portion 66 connectible by means of a suitable nut 68 to a source of compression fluid such as carbon dioxide, nitrogen, etc., contained in the tank 70, said tank including a conventional control valve 72.

Although not shown, it is to be understood that the end compartments 14 and 16 will include suitable access portions by which the tank 70 may be replaced once the pressure therein has been dissipated.

The upper portion of the cylinder 46 incorporates thereon a metering and pressure control valve assembly indicated generally at 74 which is suitably connected to a refrigeration coil 44, and thus when the pressure responsive movable walls 52 of the assemblies 40 and 42 are in the position shown in Fig. 1, pressure exerted in the variable volume chamber 54 to which the tank 70 is in communication with by means of the metering valve 64, causes pressure to be exerted on the chamber 56 thereabove. The chambers 56 and the refrigeration coil containing a suitable readily compressible refrigerant of any suitable character, and when the aforementioned compression takes place, if movement of the refrigerant through the valve assembly 74 is prevented, the refrigerant will be compressed within the chamber 56 and become heated up, the heat being dissipated by the annular fins 48 as previously mentioned. A refrigerant will then assume a liquid form after cooling off, and will be ready for distribution in the refrigeration system, passage through the refrigeration coil for cooling and picking up the heat contained in the refrigeration chamber 26, after which said refrigerant passes through a valve assembly 74 in the other compartment and the other variable volume chamber 56 will perform as an expansion chamber. When the chamber 56 functions as an expansion chamber, pressure is exerted on the adjacent chamber 54 and movement thereof of any air contained therein is restricted by control of the valve 64, thus preventing an excessive movement of a refrigerant through the system.

As most clearly seen in Figs. 2 and 3 the cylinder 46 includes an upper threaded end portion 76 threadedly receiving a support cap element 78 comprising the base or support for the metering and pressure control valve assembly 74. The cap member 78 includes a suitably apertured portion 80 surrounded by a suitable seal 82 and receiving therein a valve body member 84 which includes a projecting portion 86 received in said aperture 80. The portion 86 of the valve body 84 includes a vertically dis-

3

posed bore portion 88 communicating with an internal transverse or horizontally disposed cylindrical bore 90, said bore portion 88 terminating exteriorly in a conical valve seat 92. A temperature responsive bimetallic elongated control element 94 comprised of the dissimilar metals 96 and 98 is secured by means of a suitable rivet 100, for example, within the variable volume chamber 56, the distal end of the portion 96 including a conical valve element 102 engageable within the conical valve seat 92 of the valve body 84. The valve element 102 will be seated on the valve seat 92 and the temperature in the chamber 56 is raised due to the compression caused by the pressure responsive movable wall 52, and until the heat of compression of the refrigerant contained in the chamber 56 is dissipated by the baffles or fins 48 communication between the bore 88 and the interior of the valve body will be prohibited.

The valve body 84 includes a bore portion 104 substantially parallel to the bore 88, said bore portion 104 communicating with the interior bore 90 of the valve body terminating in conical valve seat 106 receiving therein a ball check element 108 spring urged by means of a compression spring 110 into sealing and seating engagement in the valve seat 106, the spring being supported in a nipple element 112 in a central bore portion 114 thereof, said nipple element being exteriorly threaded at 116 and being secured in a suitably threaded aperture portion 118 defining a continuation of the valve seat 106, said nipple element 112 including a transverse lateral bore portion 120 communicating with the bore portion 114 in which the spring 110 is supported. Thus, communication between the interior of the variable volume chamber 56 to the bore 90 of the valve body 84 will be permitted when the compressive pressure of the spring 110 on the ball check 108 is overcome.

It will be noted in Fig. 3 that the valve body 84 includes a pair of outwardly extending flanges 122 and 124 which are suitably apertured to receive suitable fastening screws 126 for securing the valve body 84 to the cap member 78.

The valve body 84 includes an upper vertically extending projection 128 having a vertical bore portion 130 extending therethrough and communicating with the internal bore 90, the bore 130 being intersected by a transverse bore portion 132 rotatably supporting a rotatable shaft 134 having a transverse bore portion 136 for communicating with the bore 130 and permitting communication between opposite sides thereof, the shaft 134 terminating in a shoulder portion 138 engageable on one side of a projecting portion 138 and terminating in a transverse manually engageable handle 140, the other end of the shaft 134 including a circumposed washer element 142 and an enlarged end portion 144 for retaining said shaft in the bore portion 132. The projection 128 is threaded at 146 at its upper end for receiving a connecting element 148 for securing thereon one end of a purge line 150, the line 150 and the apertured shaft 134 being utilized to neutralize the pressure between the compressors 40 and 42 when the compressing tank 70 is being switched from one side to the other, or when the refrigeration system is being started.

The valve body 84 includes at one end a projecting nozzle portion 154 externally threaded at the end 156 for receiving a suitable connecting element 158 for connecting the refrigeration coil 44 thereto, the projection 154 including a centrally bored portion 160 in coaxial alignment with the bore portion 90 of the valve body member, and said projection portion 154 includes a transverse bore portion 162 receiving the rotatable shaft 164 of a valve element having a transverse aperture portion 166 alignable with the bore portion 160 for permitting communication between the refrigeration coil 44 and the interior of the valve body, said shaft 164 including an adjusting handle element 168 and being secured to the projection 154 by means of an enlarged end portion 170 in circumposed washer element 172.

4

The bore portion 160 terminates interiorly in an annular conical valve seat portion 174, said valve seat and movement of refrigerant through the bore portion 160 being controlled by a valve element 176 carried on an elongated arm 178 reciprocally supported in the housing bore portion 90 by means of a pressure responsive movable wall 180, said rod 178 extending through the pressure responsive movable wall 180 and including fixedly secured washer elements 182 and 184 secured on opposite sides thereof. Pressure responsive movable wall element 180 is engaged by one end of a compression spring element 186 circumposed on the rod element 178, the other end of the spring being engaged with a suitable abutment washer element 188 reciprocally carried on the rod 178, tension on the spring 186 being adjusted by means of a suitable adjusting screw 190 exteriorly threaded at 192 and supported in a suitable cap element 194 threadedly secured at 196 in the opposite end of the housing member 84. The screw element 190 includes an internal bore portion 198 reciprocally receiving the end 200 of the rod 178.

Thus, after the valve element 102 in the temperature responsive bimetallic element 94 moves away from its valve seat 90, compressed refrigerant will enter the chamber 202 formed on one side of pressure responsive movable wall 180, and after the pressure therein is great enough to overcome the spring pressure 186 which has been adjusted by the screw 190, the pressure responsive movable wall 180 will move to the left toward the chamber 204 formed thereby, and with such movement the rod 178 and the valve element 176 thereon will move away from the valve seat 174 permitting the movement of the refrigerant into the coil 44.

Provided in the body portion 84 in the extension 154 thereof is an internal passage portion 206 which communicates with the passage portion or bore portion 160 thereof outwardly of the valve shaft 164, said bore portion terminating in an internal abutment portion 208, see Fig. 3, in the valve body 84 and including a horizontally disposed valve seat 210. The valve body 84 includes a vertically disposed internally threaded boss portion 212 threadedly receiving an adjusting screw 214 having a central bore 216 reciprocally receiving a rod element 218 which includes conical valve element 220 engageable in the valve seat 210, said rod element 218 including fixedly secured annular abutment washer element 222 engageable with a compression spring 224 which engages the inner lower end portion 226 of the adjusting screw 214.

When one of the compressors functions as an expansion chamber, the refrigerant will be urged through the passage 206 fulcruming the spring pressure 224 on the valve element 220 and then pass into the chamber 202, and inasmuch as the spring pressure 186 is greater than that of the spring 110 on the ball check 108, the refrigerant will pass through the bore 104 into the variable volume chamber 56 of that compressor which is acting as an expansion chamber. Additionally, the passage 206 may serve as a bypass for the chamber acting as the refrigerant compressor, when the compressor acting as the expansion chamber has its adjusting screw 214 so adjusted as to prevent the rapid movement of the refrigerant in the system, thus the refrigerant would circulate through the passage 206 past the valve seat 174 and through the bore 160 forming a complete cycle within the metering and pressure control valve assembly per se.

As will be seen in Fig. 1, the tank 70 including the compression gas is used with compressor assembly 42, and after the pressure responsive movable wall 52 has been urged upwardly to a position approximating the dotted line position shown relative to the assembly 40 in Fig. 1, the tank 70 may be moved to the compartment 14 and the refrigeration cycle will be reversed in a readily apparent manner thus affording a readily available and highly expeditious portable refrigeration cycle usable for picnics, and the like, or usable in larger installations if desirable.

5

It will be noted from the arrangement of parts, note Fig. 2, that when a given charge of compressed refrigerant is permitted to pass through the bore 160, the pressure will be reduced after a given period of refrigeration, and with such reduction of pressure, the pressure responsive movable wall 180 will be urged toward the right, as seen in Fig. 2, by virtue of the adjusted compression spring 186 and the valve element 176 will again come into engagement with its cooperating valve seat 174. When the aforementioned occurs, as a result of the reduced pressure on the refrigerant in chamber 202 of the valve body 84 as well as the reduced pressure on the refrigerant in variable volume chamber 56, accordingly if the pressure available from the tank 70 is sufficient, the pressure responsive movable wall 52 in the cylinder 56 will be caused to move up an increment of travel resulting in an increase of heat on the refrigerant and accordingly operation of the temperature responsive bimetallic assembly 94 resulting in the cycle of compression of the refrigerant, cooling off of the same and subsequent release of refrigerant into the coil 44 as previously described.

The embodiment of invention disclosed in Figs. 4 through 8 incorporates in the dual cycle refrigeration system of Figs. 1 through 3, means for maintaining a constant temperature in the refrigeration compartment 26, as well as means for providing an automatic reversal of function of the pair of combined compressor and expansion chamber units, whereby each automatically operates sequentially as a compressor or expansion chamber.

As seen in Fig. 4, like parts of Figs. 1 through 3 are identified by means of similar reference characters, wherein the combined compressor and expansion chamber assemblies are identified at 40' and 42', suitably supported in the respective end compartments 14 and 16, each of the assemblies incorporating in a cylinder portion 46' a pressure responsive movable wall element 52' defining variable volume pressure chambers 54' and 56', and include on a cap member 78' a combined metering and pressure control valve assembly 74 of the identical character of that described relative to Figs. 1 through 3, said valve assembly 74 cooperating with and functioning with the refrigerator coil 44 in the identical manner previously described relative to the first embodiment of invention.

It will be noted that the cylinder member 46' includes heat dissipating annular fins 48' and when pressure is available in the variable volume chamber 54', as seen in Fig. 4 for example, the pressure responsive movable wall 52' will move upwardly toward the cover member 78', it being understood that if the pressure responsive movable wall 52' were to reach its uppermost position possible in the cylinder member 46', no further refrigeration would take place since the compressor end compartment 14 would no longer be operating, and until the compressor compartment 16 begins to operate as a compressor instead of an expansion chamber, the refrigeration system will not be operating.

Additionally, it is desirable that the refrigeration cycle is not in constant operation but rather that the temperature in the refrigeration chamber 26 be maintained constant depending on what temperature is desired, and accordingly, a temperature control valve assembly 230 is suitably mounted within the refrigeration chamber 26, and is operatively connected to a cutoff valve assembly 232 suitably mounted in the compartments 14 and 16 and operatively connected between the compression tank and the cylinder members 46' so that when the temperature in the refrigeration compartment 26 exceeds a predetermined temperature, the valve assembly 230 will function to control compression fluid in the assemblies 40 or 42'.

Although the temperature control valve assembly 230 is disclosed in Figs. 4 through 8 as being used with the embodiment of invention having an automatic reversing of the dual cycle refrigeration system, it is readily apparent that the temperature control may be utilized with the embodiment of invention disclosed in Figs. 1 through 3,

6

and the disclosure of the temperature control valve assembly with the embodiment of invention of Figs. 4 through 8 being merely by way of example.

As seen in Figs. 4, 6 and 7, the temperature control valve assembly 230 includes a bimetallic temperature responsive element 234 suitably mounted at 236 within the refrigeration compartment 26, the lower end of the bimetallic element 234 being suitably connected to one end of a linkage element 238 which is pivotally connected at its opposite end to a pivot element 240 which connects said link element 238 at a distal end of a piston rod 242 connected integrally to a piston 244 having a suitable annular seal portion 246, said piston 244 being reciprocally received within a fluid motor cylinder bore portion 248 in a fluid motor cylinder 250 which is suitably supported by means of a depending flange portion 252, for example, on one of the walls of the refrigeration chamber 26 by means of suitable fasteners 254, for example. The piston 244 defines a pair of internal variable volume chambers 256 and 258 within the bore portion 248, the chamber 258 containing therein force transmitting hydraulic fluid 260, the chamber being formed by a centrally bored plug element 262 sealingly receiving one leg of a T-pipe fitting 264 which has fluid conduits 266 and 268 extending from the opposite legs, each of said conduits being operatively connected to a remote controlled motor cylinder 270 of the cutoff valve assembly 232.

As seen in Fig. 6, the temperature control valve is intended to illustrate the piston 244 in the position obtained when the temperature in the refrigeration chamber 26 is above or higher than the desired predetermined temperature, and accordingly, when a temperature is reached which is below or lower than the predetermined temperature, the temperature responsive bimetallic element 234 will move toward the right as indicated by the direction arrow whereupon pressure will be exerted on the fluid 260 resulting in urging pressure through the fluid conduits 266 and 268 to the servo motor cylinders 270.

The cylinder 270 includes a motor bore portion 272 reciprocally supporting the piston 274 therein, said piston having an annular seal 276 forming with a centrally apertured end wall member 278 in variable volume chamber 280, and forming with a suitable transverse support plug element 282 in a second variable volume chamber 284. The variable volume chamber 280 is filled with fluid 260 and thus pressure exerted by the piston 244 will exert a similar pressure on the piston 276 moving the same toward the left as seen in Fig. 7, wherein leftward movement or suction by the piston 244 results in a similar suction in the piston 274 in the remote motor resulting in rightward movement of said piston.

The piston 274 has secured thereto a piston rod element 286 extending through the plug element 282 and which has threadedly connected at 288 in any suitable manner to a valve rod 290 reciprocally supported in a suitable wheeling bushing 292 secured in a partition wall 294 of the cylinder 270, said valve rod 290 including on the end thereof a valve seal element 296 which is received within the compression fluid chamber 298 formed in the cylinder 270 by means of a centrally apertured plug element 300 secured in the end of the cylinder 270. The plug element 300 as mentioned is centrally apertured at 302 and includes an inner valve seat portion 304 engageable with the valve seal element 296, said central aperture portion 302 communicating with a suitably secured pressure fluid conduit 306 which communicates with a conventional metering valve 64' of a character similar to that used in the embodiment of Figs. 1 through 3, chamber 298 also communicating with a bore portion 308 to a fluid conduit 310 communicating with a compression fluid supply tank 70'.

A second supply tank 70'' may be provided in communication with the cutoff valve assembly 170, see Fig. 4, and if desired (although not shown) the single supply

tank of compression fluid may be utilized in the refrigerator.

The cylinder 270 may incorporate thereon an integral flange 312 and accordingly be secured on an adjacent support wall of the refrigerator by means of suitable fastening elements 314. The valve rod 290 has fixedly secured on an intermediate portion thereof an annular collar element 316 which has pivotally secured thereto a pair of diametrically opposed U-shaped support bracket elements 318 and 320 which have their leg portions overlapping and pivotally secured together by means of a transverse pivot pin element 322 extending through the rod 290 and the legs of the aforementioned bracket elements, said bracket elements having extending laterally from their web portions spring support rods 324 and 326, respectively, the ends of which being reciprocally received within suitable apertured diametrically opposed tubular pivot elements 328 and 330, respectively, suitably supported in respectively parallel relationship on opposite sides of the rod 290, the rods 324 and 326 having circumposed thereon compression spring elements 332, see Fig. 8, which have opposite ends in abutting engagement with the U-shaped support elements thus providing an off-center toggle arrangement which positively urges the valve element 296 into sealing engagement with the valve seat 304 by virtue of movement of the piston 274 so that compression fluid may travel from the fluid conduit 310 to the conduit 306 for permitting the compression step of the refrigeration system to function, or to positively urge a sealing relationship between the elements 296 and 304 for cutting off the passage of compression fluid through the conduit 310.

The portion of the cylinder 270 defined by the partition 294 and element 282 is open in order to permit the ready maintenance and assembly of the remote motor device.

The automatic switch-over control valve is indicated generally at 334 and includes a cylinder portion 336 having a suitable integral connecting flange 338 for accommodating suitable fastening elements 340 for securement in the refrigerator, said cylinder incorporating an internal lower portion 342 reciprocally supporting a piston element 344 having a suitable annular seal 346, the piston 344 including an integral piston rod 348 extending through a suitable partition plug element 350 in the cylinder 336, said rod 348 including a pair of transverse longitudinally spaced bore portions 352 and 354, said bore portions being contained in a portion 356 of the piston rod 348 which extends outside of the cylinder 336. The portion 356 of the piston rod is reciprocally and sealingly supported in a surrounding bracket element 358 which includes a pair of spaced bifurcated leg portions 360 secured on diametrically opposite sides of the cylinder body 336, said portion 358 including a pair of longitudinally spaced bore portions 362 and 364. The portion 358 has secured at its distal end 366 in any suitable manner a pair of outwardly outstanding legs 368 and 370 rotatably supporting diametrically apertured tubular elements 372 which reciprocally receive in the diametrically apertured portion thereof rod elements 374 which are pivotally connected at their inner ends to a suitable pivot element 376 on the distal end 378 of the piston rod portion 356. Suitable compression spring elements 380 are circumposed on the rod elements 374 between the element 372 and the pivot portion 376 providing an off-center toggle similar to that described relative to Fig. 7, for the purpose of positively aligning apertures 352 and 354 of the piston rod portion 356 with either the aperture portion 362 or 364, respectively, in the portion 358.

The aperture portions 362 and 364 are respectively suitably connected at one side to fluid conduits 382 and 384 which communicate with the control valve 64' and which respectively permit the flow of compressing fluid toward or away from the supply tanks 70' or 70". It

is to be understood that when flow is permitted through the conduit 382' in the compartment 14 which accordingly results in urging the pressure responsive movable wall 52' upwardly for compressing the refrigerant in the variable volume chamber 56', the conduit 384 will be closed. Additionally, considering compartment 16, a comparable conduit 382 will be closed as seen in Fig. 5, and the conduit 384 will communicate with the variable volume chamber 54' by virtue of the association of the portions 354 and 364, and whatever compressing fluid is used in the variable volume chamber 54' will be urged back through control valve 64' and may be released into compartment 14 or 16 for aiding in cooling assemblies 40' and 42'. It will be noted that the bore portions 362 and 364, respectively, are connected to suitable fluid conduits 386 and 388 suitably connected to a bottom portion 390 of the cylinder members 46'.

The piston 344 in the cylinder 336 defines opposite variable volume chambers 392 and 394 filled with a suitable force transmitting fluid of any suitable character, chamber 394 suitably communicating with a fluid conduit 396. Thus it will be seen in Fig. 4, for example, the compartments 394 of each of the cylinders 336 are in direct communication with each other and accordingly movement toward the right of the piston 344 in the variable volume chamber 394 the switch-over assembly and compartment 16, for example, results in leftward movement of the piston 344 of the similar variable volume chamber 394 of the switch-over assembly and refrigerator compartment 14.

The switch-over valve assemblies are actuated by the pressure responsive movable walls 52' reaching an uppermost position in the cylinders 46'. The cap members 78' each include an integral cylinder chamber of a fluid motor 398, said fluid motor including a cylinder 400 suitably secured in vertically extending relationship at one end to the cap member 78', the other end of which being suitably apertured at 402 being in communication with a fluid conduit 404 connected to a suitable T-fitting 406 which has one leg in communication with a variable volume fluid chamber 392 in the switch-over control valve cylinder 336, the other leg being in communication with a fluid conduit 408, thus the variable volume fluid chambers 392 of the switch-over valve control assemblies 334 in each of the compartments 14 and 16 are in communication with each other and the previously mentioned piston elements 344 will be reciprocated in opposite directions for the purpose previously mentioned, by actuating structure to be subsequently described.

The cylinders 400 have an internal bore portion 410 reciprocally receiving a suitably sealed piston element 412, said piston element including an integral piston or actuating rod 414 reciprocally received in a suitable support bushing 416 threadedly secured in the cap member 78', said rod 414 including a distal end portion 418 depending into the variable volume chamber 56' for engagement by the pressure responsive movable wall 52' when the same is reached at the upper end of the cylinder 46' whereby pressure exerted on the actuating rod 418 results in upward movement of the piston 412 applying pressure on a force transmitting fluid 420 contained in the variable volume chamber 422 formed in the cylinder 400 by the piston 412, the fluid 420 filling conduits 404 and 408 as well as the variable volume chamber 392 of the cylinder 336 of the switch-over control valve, and thus when either of the pressure responsive movable walls 52' approach the uppermost limits of the cylinder 46', it being understood that the assemblies 40' and 42' alternately provide compressors and expansion chambers of a dual cycle reversible refrigeration system, said pressure responsive movable walls 52' will result in actuation of the switch-over control valve assemblies 334.

Thus there has been disclosed a dual cycle reversible refrigeration system which readily conforms with the objects of invention heretofore set forth, incorporating the

features of a pair of combined compressor and expansion chamber assemblies in conjunction with a refrigeration coil, the reversal of a refrigeration cycle may be accomplished by applying a pressure source of compression fluid to oppositely disposed combined compressor and expansion chamber assemblies, and there has further been disclosed features permitting automatic control for a predetermined temperature in a refrigeration compartment as well as an automatic switch-over assembly for automatically reversing the dual refrigeration cycles.

Numerous position and directional terms, such as top, bottom, side, etc. are utilized here and have only a relative connotation to aid in describing the device and are not intended to require any particular orientation with respect to any external elements.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention as claimed.

What is claimed as new is as follows:

1. A dual cycle closed non-circulating reversible refrigeration system for a wholly portable refrigerator, said system comprising a refrigeration coil, a pair of refrigerant compressors, each compressor including a cylindrical member, a pressure responsive movable wall separating said cylindrical member into an adjacent pair of variable volume chambers in said cylindrical member, means connecting each refrigerant compressor to one end of the refrigeration coil for causing flow of refrigerant therethrough, means for controlling and causing alternate operation of the compressors to provide reversing flow of refrigerant through said coil between said compressors, a first of said chambers operatively connected to said means controlling and causing alternate operation of the compressors, a second and a third of said chambers connected to opposite ends of said refrigeration coil, and means communicating between said compressors for neutralizing the pressure differential of refrigerant between said compressors and refrigeration coil.

2. A dual cycle closed non-circulating reversible refrigeration system of claim 1 wherein said cylinder members each include heat dissipating means for removing heat from the refrigerant and condensing the same.

3. A dual cycle closed non-circulating reversible refrigeration system of claim 1 wherein said cylinder members each include heat dissipating means for removing heat from the refrigerant and condensing the same, the means controlling and causing alternate operation of the compressors comprising valve means in communication with one of said variable volume chambers of the cylinder members, and a source of gas under pressure alternately communicable between each of the one of said variable volume chambers.

4. A dual cycle closed non-circulating reversible refrigerating system of claim 1 wherein said cylinder mem-

bers each include heat dissipating means for removing heat from the refrigerant and condensing the same, the means controlling and causing alternate operation of the compressors comprising valve means in communication with one of said variable volume chambers of the cylinder members, and a source of gas under pressure alternately communicable between each of the one of said variable volume chambers including temperature responsive control means operatively associated between the source of fluid pressure and one of the variable volume chambers for inhibiting said fluid pressure and maintaining a predetermined temperature in the refrigerating coil.

5. A dual cycle closed non-circulating reversible refrigeration system of claim 1 wherein said cylinder members each include heat dissipating means for removing heat from the refrigerant and condensing the same, the means controlling and causing alternate operation of the compressors comprising valve means in communication with one of said variable volume chambers of the cylinder members, a container of gas under pressure alternately communicable between each of the one of said variable volume chambers including temperature responsive control means operatively associated between the source of fluid pressure and one of the variable volume chambers for inhibiting said fluid pressure and maintaining a predetermined temperature in the refrigerating coil wherein said temperature responsive control means comprise a thermally actuated fluid motor, and a fluid operated slave motor control valve operatively connected to said source of fluid pressure.

6. A dual cycle closed non-circulating reversible system of claim 1 wherein there are automatically operated switch means contained in said cylinder member and engageable by said pressure responsive movable walls for reversing the refrigerating cycles between said compressors.

7. A dual cycle closed non-circulating reversible closed refrigerating system of claim 1 wherein there are alternately operable fluid pressure source control means in communication with said container of compressed gas, an automatically operated switch means contained in said cylinder member and engageable by said pressure responsive movable walls for reversing the refrigerating cycles between said compressors, said automatically operated switch means comprising a fluid motor including a reciprocable piston rod element movable by said pressure responsive movable walls, and slave motor operated valve means operatively connected to the fluid pressure source for reversing flow of refrigerant in said coil.

References Cited in the file of this patent

UNITED STATES PATENTS

1,508,833	Weber et al. -----	Sept. 16, 1924
2,256,139	Craig -----	Sept. 16, 1941
2,638,123	Vargo -----	May 12, 1953
2,723,537	Clark -----	Nov. 15, 1955
2,772,543	Berry -----	Dec. 4, 1956