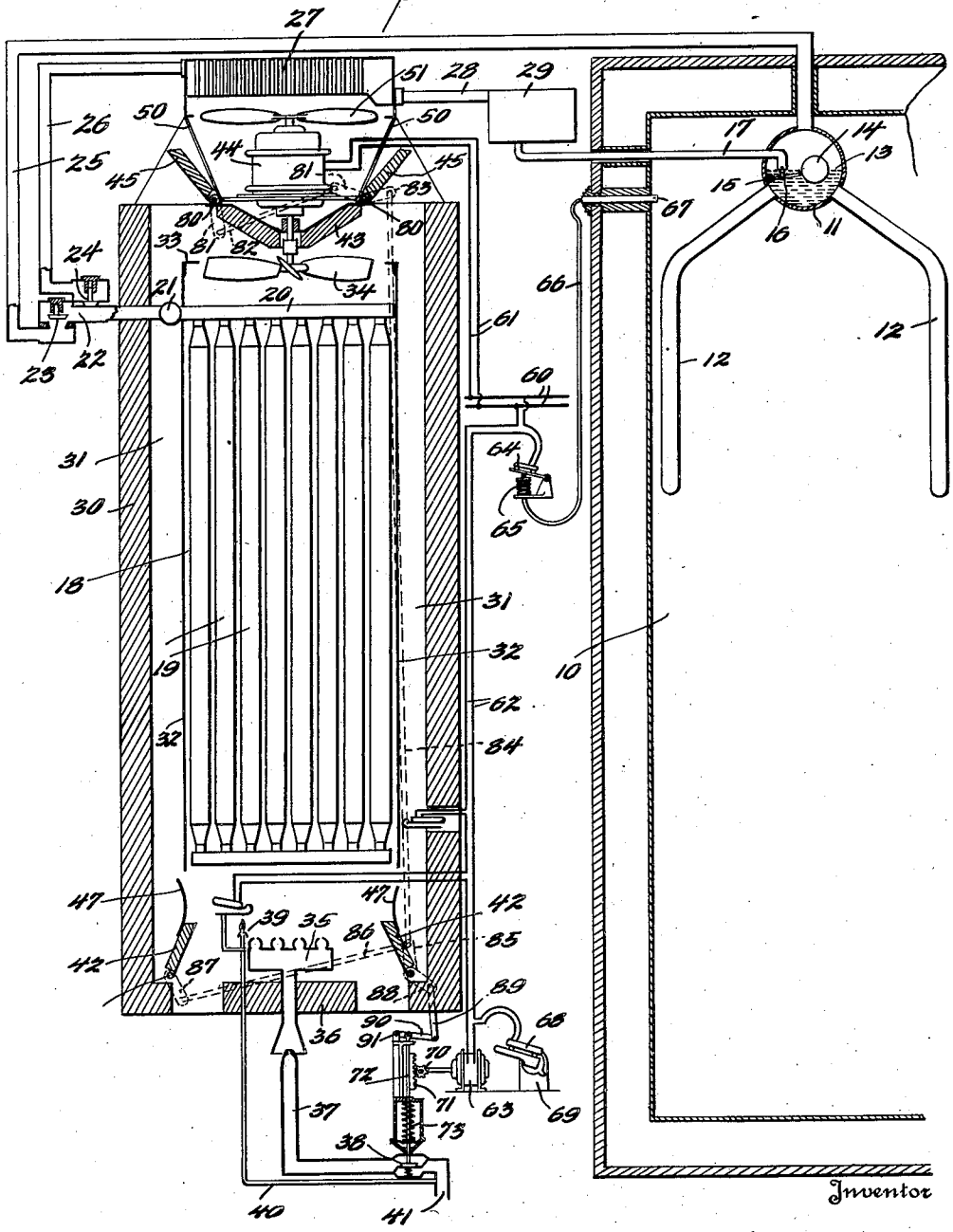
Jan. 23, 1934. E. B. MILLER 1,944,799

REFRIGERATION

Filed March 14, 1929 6 Sheets-Sheet 1

FIG. 1.



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REFRIGERATION

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FIG. 2.

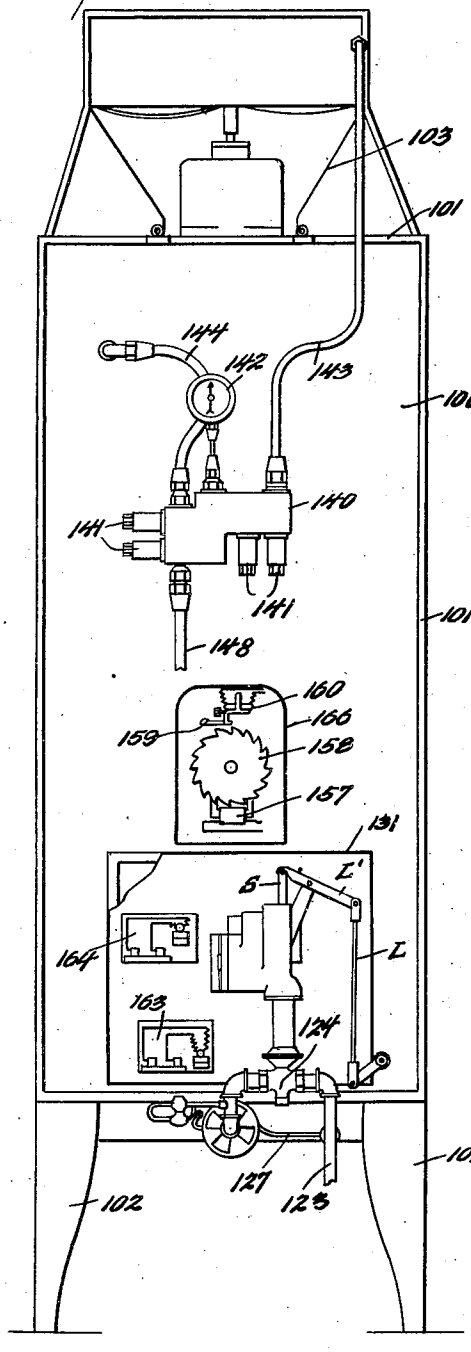
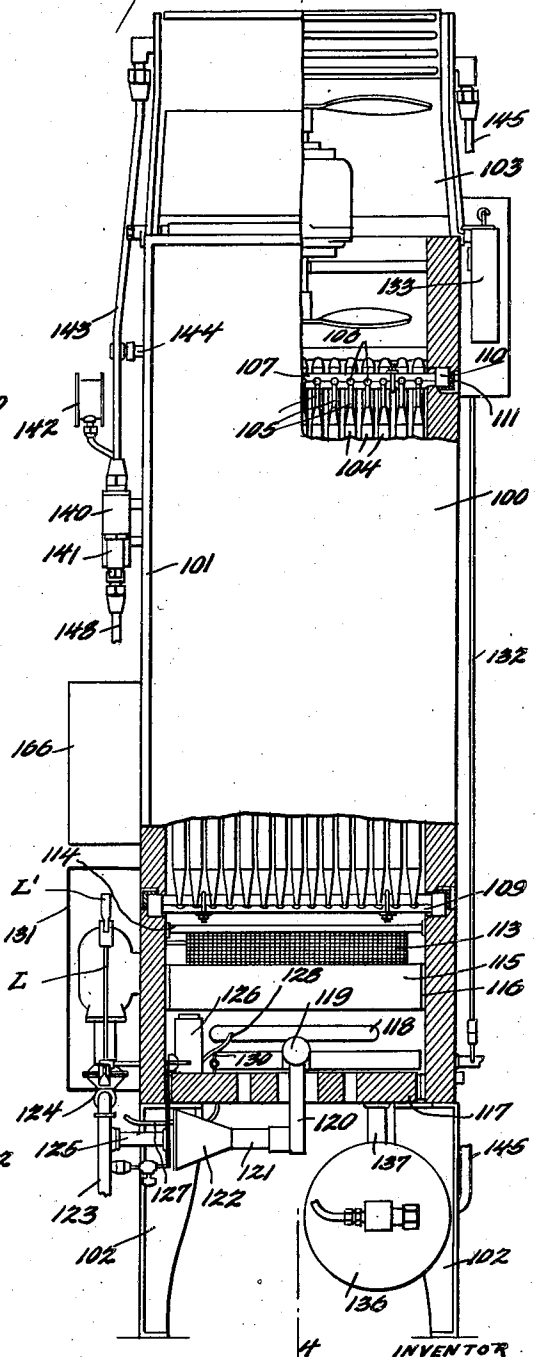


FIG. 3.



4

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REFRIGERATION

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FIG. 4.

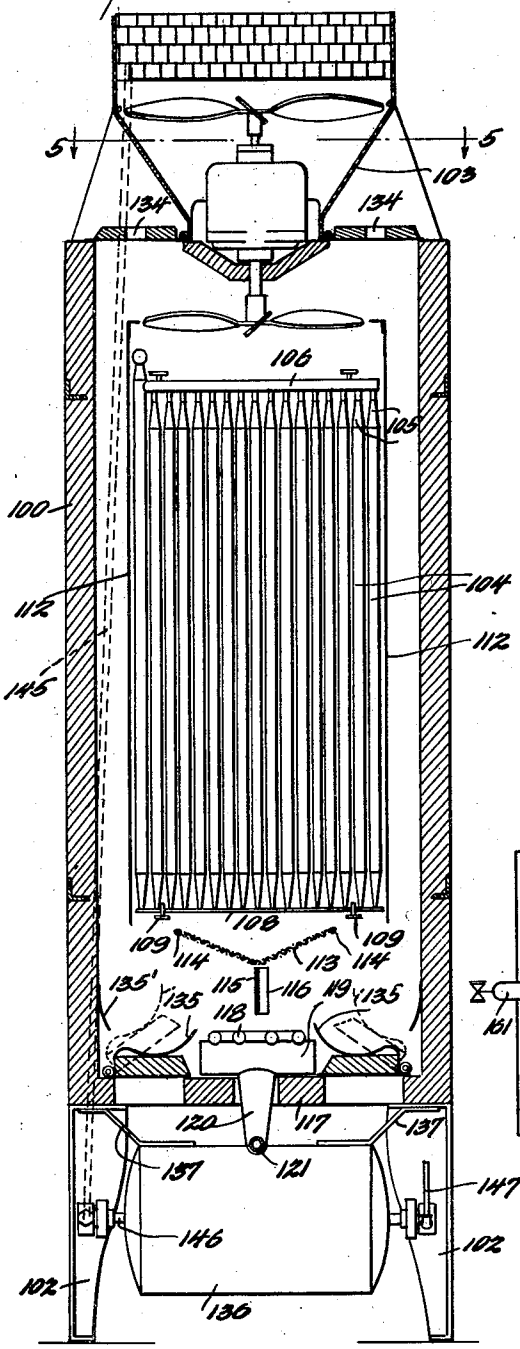


FIG. 5.

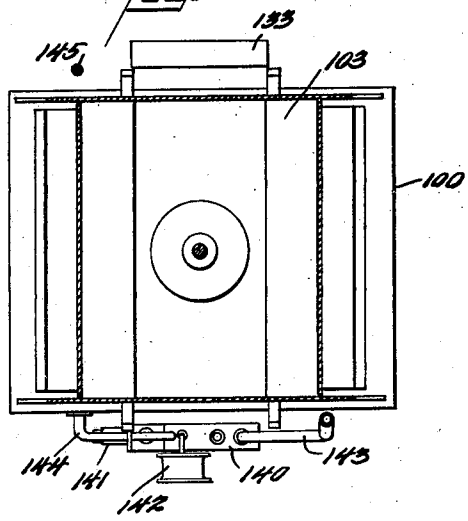
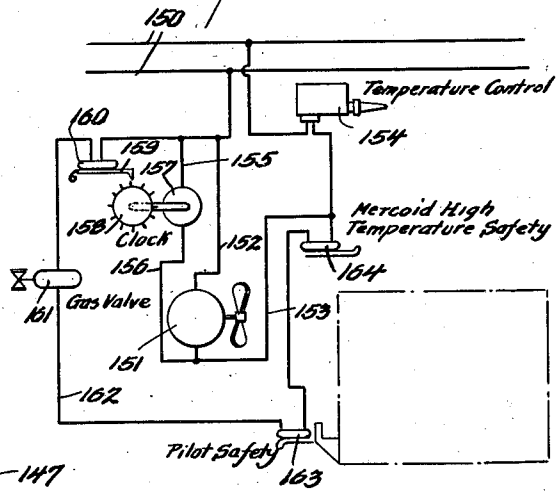


FIG. 6.



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REFRIGERATION

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FIG. 7.

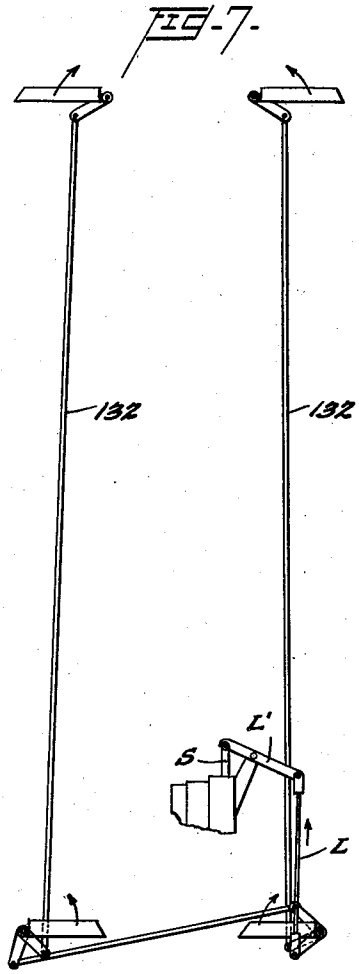
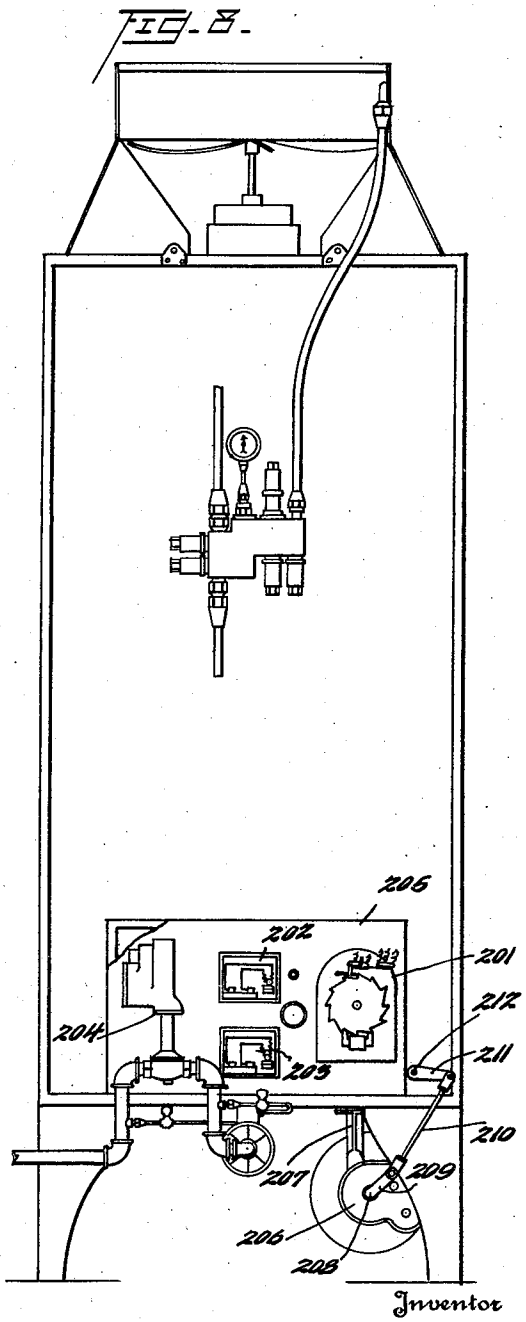


FIG. 8.



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REFRIGERATION

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FIG. 9.

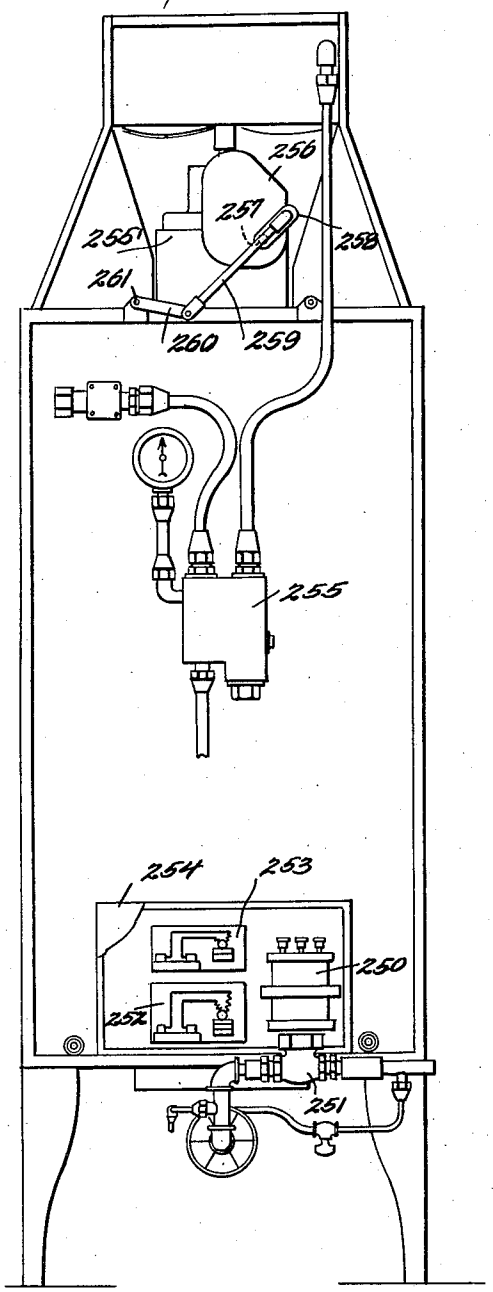
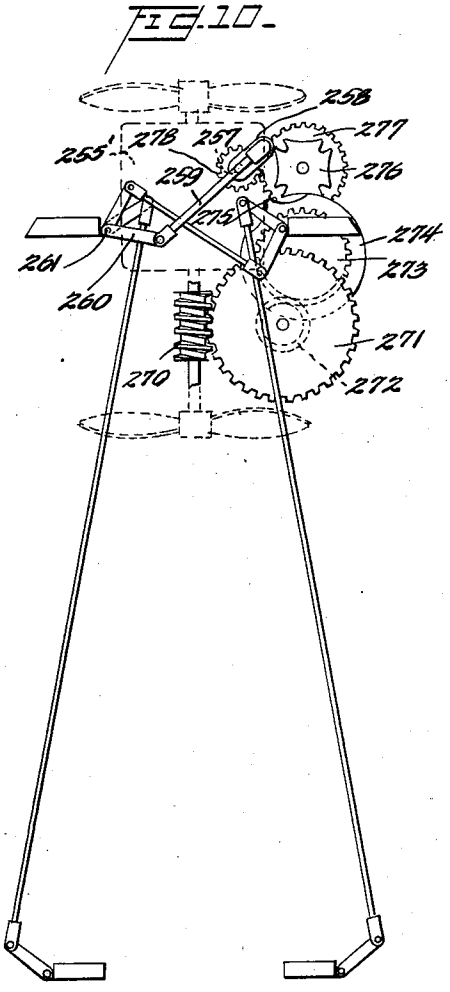


FIG. 10.



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REFRIGERATION

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FIG. 11.

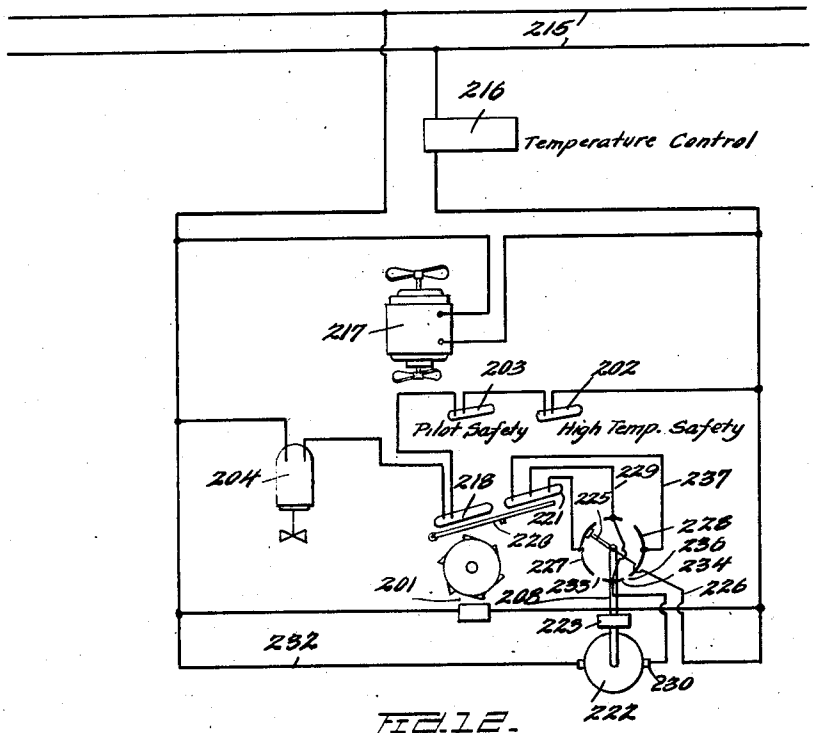
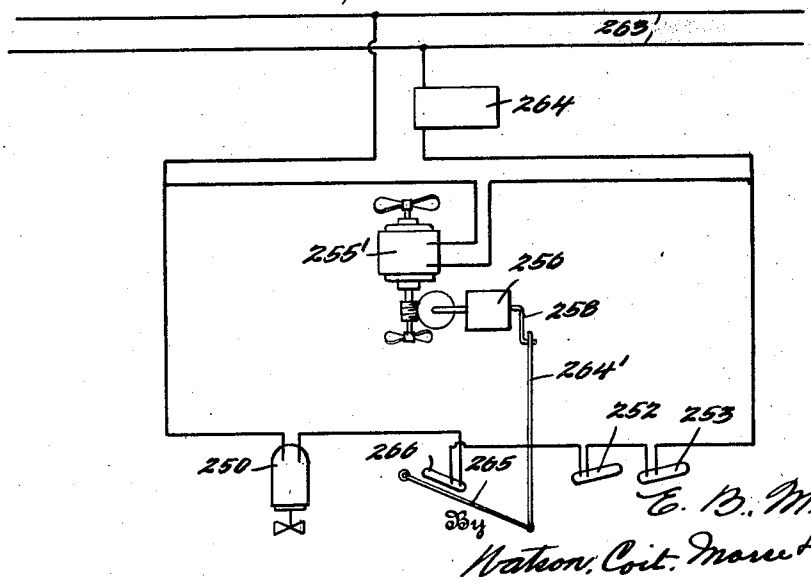


FIG. 12.



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Patented Jan. 23, 1934 1,944,799

UNITED STATES PATENT OFFICE

1,944,799

REFRIGERATION

Ernest B. Miller, Baltimore, Md., assignor, by mesne assignments, to Chester F. Hackley, receiver for The Silica Gel Corporation, Baltimore, Md., a corporation of Maryland

Application March 14, 1929. Serial No. 347,032

42 Claims. (Cl. 62—5)

This invention relates to refrigeration apparatus and particularly to apparatus for refrigerating by the adsorption principle.

It is a general object of the present invention to provide novel and improved refrigeration apparatus.

More particularly it is an object of the invention to provide automatic, self-contained refrigeration apparatus for refrigeration by intermittent adsorption and evaporation.

The various features of novelty of the invention may be enumerated as follows:

A. An adsorber arranged in a closed casing with a heater together with damper mechanism for controlling the flow of heat and cooling air over the adsorber.

B. The use of a single driving means to circulate air in the adsorber casing and air over a condenser.

C. The provision of an adsorber in a substantially tight casing with dampers at the two ends of the casing, and means for closing the dampers when heat is applied to the adsorber and opening them when no heat is being applied.

D. The arrangement of an adsorber in an enclosing casing with a heater and means for causing the heated air to pass in one direction over the adsorber and then reversely within the casing and over the heater in a continuous circulation.

E. The arrangement of an adsorber in a substantially closed casing with a heater together with a by-pass from end to end of the casing.

F. The arrangement of an adsorber within a substantially closed casing and dampers for opening and closing the ends of the casing, with means on the dampers to substantially close off a by-pass through the casing when the dampers are opened.

G. The arrangement of various automatic control and safety means; for timing the periods of adsorption and activation; for opening and closing dampers; for starting and stopping the action of the heater and for protection against overheating, escape of fuel and the like.

H. The various novel features of construction; assembly; arrangement and association of parts; the arrangement of various means for operation of the dampers simultaneously with control of the flow of fuel to the burner; and means for timing these operations.

Various methods of refrigerating have been proposed, and among them may be mentioned the adsorption of vapor from a liquid into a solid porous adsorbent with such rapidity that the evaporation of the liquid reduces its temperature and affords cooling. Such a system is disclosed in U. S. Patent No. 1,729,081 to E. B. Miller. In such systems the evaporator or tank containing the refrigerant to be adsorbed may be arranged in the space to be cooled, conveniently a refrigerator. This evaporator may be of any conventional form. The present invention contemplates the provision of all apparatus, except the evaporator, for automatically and intermittently evaporating and returning liquid to the evaporator so that refrigeration can be carried on without manual attention. Devices of the present type may be built in various sizes for household and commercial uses and may be associated with one or a plurality of evaporators. They may be used alone or en banc. In the illustrative disclosures, fuel gas of any desired type is used as a means for heating the adsorber and a condenser cooled by air is shown as the device for condensing the liquid driven off from the adsorber by heating. Obviously the various well-known substitutes for these features may be made use of without departing from the spirit of this invention.

The invention will be best understood by those skilled in the art upon a consideration of the accompanying drawings and following specification, wherein are disclosed several exemplary embodiments of the invention, with the understanding however that such changes may be made therein as fall within the scope of the attached claims without departing from the spirit of the invention.

In said drawings:

Figure 1 is a diagrammatic and schematic arrangement of a refrigeration system and apparatus constructed in accordance with the present invention;

Figure 2 is a front elevation of a commercial embodiment of the device;

Figure 3 is a side elevation showing the housing partially broken away to better disclose internal parts;

Figure 4 is a central vertical section taken on line 4—4 of Fig. 3;

Figure 5 is a horizontal section taken on line 5—5 of Fig. 4;

Figure 6 is a wiring diagram of the various parts of the apparatus shown in Figs. 2 to 5 inclusive;

Figure 7 is a diagrammatic showing of the arrangement of the dampers in the device of Figs. 2 to 6;

Figure 8 is a view similar to Fig. 2 but of a slightly modified form of construction;

Figure 9 is a view similar to Fig. 2 showing a further modified form of the device;

Figure 10 is a diagrammatic showing of the arrangement of the dampers in the construction of Fig. 9;

Figure 11 is a wiring diagram of the device of Fig. 8; and

Figure 12 is a wiring diagram of the device of Figs. 9 and 10.

Referring now to the drawings and in particular to Figure 1 for a general idea of the invention, there is disclosed by way of example at 10, a suitable refrigerator or storage compartment for any articles desired to be kept at a temperature lower than that of the atmosphere. Within this compartment is arranged an evaporator which comprises a suitable container for a liquid refrigerant. In the drawings this is shown as comprising a cylindrical header tank 11 and a plurality of depending tubular members 12 giving additional surface. The device is intended to be filled with a refrigerant liquid, such for instance as SO_2, to the level shown at 13 which is maintained by means of a float 14 secured to an arm pivoted at 15 and carrying a valve 16 adapted to close the end of a pipe 17 which normally tends to supply an excess of refrigerant liquid. It will be obvious that if the vapor above the liquid is rapidly adsorbed the liquid will evaporate and in so doing will lower its temperature. The comparatively large surface at low temperature, provided by means of the tubes 12, cools the air in the compartment 10 and maintains the material therein at the predetermined desired temperature. This part of the refrigeration apparatus is well-known and need not be further referred to.

In order to adsorb the vapor above the surface of the liquid in the evaporator there is provided an adsorber 18 which in the present instance is comprised of a plurality of rows of vertical tubes 19 filled with a suitable porous adsorbent such, for instance, as silica gel. The tubes of each row are inserted into sub-headers 20, which in turn are connected into a main header 21. This main header leads to a valve assembly 22 containing the check valves 23 and 24 leading respectively to the conduits 25 and 26. The conduit 25 enters the top of the chamber 11 of the evaporator so that it may carry off vapor therefrom through the check valve 23 into the adsorber. When the adsorber is saturated heat is applied and the adsorbed vapor is liberated, its pressure closing the valve 23 and opening the valve 24 so that the vapor passes into the pipe 26 and flows into the condenser 27 where it is liquefied and flows by gravity into the pipe 28 and condensate receiver 29, whence it feeds into the pipe 17, and back into the evaporator. Neither the condenser nor the receiver need be elevated above the evaporator since the liquid therein is at a higher pressure than that existing in the evaporator. Flow of the liquid to the evaporator is thus always assured.

The adsorber assembly is supported by suitable means within a substantially closed casing 30 formed of heat insulating material. Preferably this casing fits closely to two sides of the adsorber but is spaced away from the other two sides, leaving the by-pass passages 31. Between these passages and the adsorber are the baffle walls 32, the edges of which are supported from the two walls of the casing which are close to the adsorber. At the bottom these walls 32 stop at about the level of the bottom of the adsorber, but at the top they extend a distance above the tubes and are provided with the end member 33 having a circular aperture to form a shroud for the fan 34 which is adapted to rotate in such a direction as to move air upwardly over and around the adsorber tubes.

Beneath the adsorber is arranged a heater, here shown as a burner 35, supported above the closed bottom portion 36 of the casing 30 and provided with fuel through the pipe 37 controlled by the valve 38. A pilot burner 39 receives its fuel through a tube 40 leaving the fuel main 41 ahead of the valve 38 so that the pilot can always remain burning.

It is desirable to maintain the casing substantially closed when heat is being applied to the adsorber in order to reduce the wastage of heat to a minimum and to prevent heating the surrounding air any more than is necessary. The casing is therefore arranged to be closed at the bottom in addition to the portion 36 by the two movable dampers 42. The top of the casing is closed by the support 43 for the motor 44 which drives the fan 34 and the two hinged dampers 45. When these dampers are closed and the burner is burning the fan delivers heated air from the burner up around the adsorber tubes where it gives up some of its heat and is returned to the burner through the by-pass passages 31 for reheating and is thus continuously circulated from the burner over the adsorber and back to the burner. The dampers may be purposely fitted loosely or may be provided with openings or other suitable means may be provided to admit sufficient air to support combustion and to allow for expansion of the air within the casing.

When activation of the adsorbent material is complete or is advanced sufficiently far for economical purposes the burner is shut off and the dampers are opened to the position shown in the figure. Under these conditions the fan 34 draws in cold air from the atmosphere through the passages controlled by the bottom dampers and up around the adsorber tubes and drives it out through the passages controlled by the upper dampers, thus rapidly cooling the adsorbent. It also carries off the exothermic heat of adsorption after the adsorbent cools down to a point where it begins to adsorb vapor from above the liquid in the tank 11. This permits adsorption to go ahead more rapidly. The deflectors 47 on the lower dampers are so positioned that when these dampers are opened they substantially shut off the by-pass passages so that all of the cool air is forced to circulate over the adsorber tubes. It will be understood that the dampers are of rectangular form and extend the full width of the casing. The deflectors are curved so that they guide the air coming down the by-passes when the dampers are closed, and deflect it away from the burner so as not to interfere with the flames.

The condenser 27 which is in the form of an automobile radiator is supported by suitable brackets above the motor 44. The deflectors 50 prevent the heated air from the casing from coming in contact with the condenser. A second fan 51 is driven by the motor 44 and serves to force cold air from the atmosphere through the condenser passages to condense vapor in the condenser tubes and liquefy the same.

The whole device is adapted for electric operation and control. A suitable source of electric current is connected to the conductors 60 which are branched at 61 to lead directly to the fan motor which is adapted to run at all times. A

second branch 62 leads to the motor 63 which controls the gas valve and the dampers, and in this branch is interposed the switch 64 controlled by the bellows mechanism 65 connected by means of the tube 66 to the thermostat element 67 in the cooled compartment. The parts 65, 66 and 67 are filled with a volatile liquid so that when the temperature becomes too high in the cooled compartment this liquid expands and closes the circuit at the switch 64. When the temperature is sufficiently low this circuit is opened by a reverse action. A second switch 68 is interposed in the circuit 62 and is adapted to be closed for a definite interval and then opened for a definite interval by means of the electrically driven clock 69 or any other suitable timing means. Assuming that the thermostat 67 maintains the circuit closed at 64 it will be seen that there is a definite interval of time when current can be supplied to the motor 63 and a definite time when it cannot be by virtue of the switch 68. The switch 64 is permitted to shorten or completely eliminate the time interval when current can be supplied to the motor 63.

The motor 63 is part of what is commonly known as a Honeywell valve. In other words it drives a pinion 70 which acts on a rack 71 connected to the stem 72 of the gas valve 38. The spring 73 normally holds this valve closed. When current is supplied to the motor it moves the rack 71 in opposition to the spring and opens the valve and holds the valve open as long as current is supplied. Upon the opening of the circuit supplying current to the motor, the spring closes the valve by rotating the motor in the reverse direction. Thus the gas burner burns during the interval that current is supplied to the motor and is idle at all other times.

It is convenient to actuate the dampers from the valve control. It will be seen that the dampers 45 are pivoted at 80 and each provided with an arm 81 connected by a link 82 and that on the right hand damper an additional arm 83 is provided and connected by a long vertical link 84 to an arm 85 on the right hand lower damper 42. This arm is connected by a link 86 to an arm 87 on the left hand damper 42. This linkage arrangement causes the movement of any one damper to move them all in a corresponding direction. An arm 88 on the right lower damper is connected by a link 89 to one end of the lever 90 pivoted at its opposite end 91 to the framework of the valve mechanism. The valve stem 72 is pivoted intermediate the ends of this link 90 so that when the valve stem moves upwardly to open the valve it closes all of the dampers, as clearly seen from the figure, and when the valve stem moves down to shut the valve it opens the dampers exactly in accordance with the requirements of the apparatus as previously described.

It will be seen from the above description of the more or less schematic arrangement of the apparatus that it performs the following functions. First it adsorbs vapor from the evaporator throughout a fixed minimum period of time and if the temperature in the compartment does not rise in that period the adsorption continues for a greater length of time. Second, if the temperature rises in the compartment above a predetermined minimum at or before the end of the minimum adsorption period, gas is turned on at the end of the period, the dampers closed and activation proceeds for a fixed period of time. Since this activation has no cooling effect obviously the switch 64 will not be opened during the activation period, which will thus continue uninterrupted for its predetermined time. Third, at the end of the activation period the gas is shut off, the dampers opened and the adsorber is cooled down until evaporation commences. The fan runs continuously and the operation of the whole device is entirely automatic so that it maintains a substantially uniform temperature in the cooled compartment without wasting fuel. The remaining figures of the drawings show various commercial embodiments of the invention with details of construction which have been omitted from the schematic showing of Figure 1.

The embodiment of the invention shown in Figures 2 to 7, inclusive, includes all of the features disclosed in connection with Figure 1 but arranged in convenient form for commercial use. In this embodiment the casing 100 is preferably vertical and is formed from slabs of insulating material such as asbestos board secured togetner at the corners and bound at the top and bottom by angle bars 101 and supported on suitable legs 102. The top of the casing has extending transversely thereof the combined motor support and deflector 103 which closes off the center section of the top and forms the horizontal edges to which the upper dampers are hinged. The mounting and construction of the condenser and its deflectors, as well as of the motor and its fans, is identical with that already described.

The adsorber is composed of a plurality of small, vertical, steel tubes 104 reduced at their ends as at 105 and each filled with a suitable adsorbent such as silica gel. The reduced ends are inserted into headers 106 at the top, which headers are received in and spaced apart by means of the split clamping members 107 seen in Figure 3. At the bottom the reduced ends of the tubes are sealed and project loosely through holes in plates 108, and the plates for the various rows of tubes are secured in clamps 109. The ends of the upper and lower clamps are secured to side rails 110 supported from the angle bars 111 embedded in the walls of the casing. By having the lower ends of the tubes loosely mounted in the plates, expansion and contraction of the individual tubes can take place without placing any strains on the other tubes.

From Figure 3 it will be seen that the tubes are arranged close to the front and back walls of the casing, whereas from Figure 4 it will be seen that they are spaced from the side walls as explained in connection with Figure 1. The thin partitions 112 spaced from the side walls of the casing form the by-passes for the heated air previously referred to. Just beneath the bottom of the adsorber assembly is the flame deflector 113 in the form of a sheet of metal gauze or screen bent along a central line to form two divergent wings. The straight edges of the gauze sheet are supported from rods 114 extending between the front and rear walls of the casing. This deflector serves to spread the flame over the whole bottom area of the adsorber so that more uniform heating of all of the tubes results. Just beneath the center of the deflector is the vertical baffle plate 115 which serves to prevent cross-currents affecting the flames in case more air passes down one by-pass than the other during the heating operation. It is supported by having its end wings 116 attached to the front and rear walls of the casing.

This bottom of the casing is closed throughout the fore and aft central section by means of the member 117, and this section carries the burner

having the main flame forming elements 118 supported from the transverse tube 119 from which depends the vertical gas conduit 120 connected to the horizontal conduit 121 carrying the air and gas mixing funnel 122. The main gas supply pipe 123 after passing through the valve 124 has the jet portion 125 which enters this mixing funnel in the customary manner. The pilot light, which burns continuously and is used to ignite gas from the main burner, is housed within the shell 126 which is substantially closed so that there is no possibility of the pilot being blown out by cooling air or due to the air circulated by the fan. This pilot receives its gas through the tube 127 which leads from the main gas conduit 123 ahead of the valve directly to the pilot so that the pilot burns at all times.

The pilot is somewhat remote from the main burner, and in order that it may ignite the gas issuing therefrom, a runner 128 is provided. This comprises a tube having a plurality of perforations and provided with a gas supply pipe 130 which leads from the gas conduit on the burner side of the valve so that the runner is only supplied with gas when the main burner is supplied with gas. One end of the runner enters the pilot casing, and the other passes above the gas outlets of the main burner. When gas is admitted to the runner, it escapes from the openings therein and is ignited by the pilot, and the flame jumps from opening to opening along the surface of the runner from which action it takes its name.

The combined gas valve and damper operating mechanism in the form of a unitary assembly is mounted on the front of the casing adjacent the burner and is conveniently covered by means of a metal housing 131. It is constructed and operates in accordance with the description of Figure 1.

A long link corresponding to that numbered 84 in Figure 1 and connecting the upper and lower sets of dampers is seen at 132 in the back of the casing, and at 133 is seen the dash pot mechanism associated with this link and damper operating mechanism to prevent sudden and noisy opening and closing of the dampers. Figure 4 shows the upper dampers provided with apertures 134 to admit a certain quantity of air to the inside of the casing when the dampers are closed and to permit of expansion of the air. The deflectors referred to in Figure 1 are seen at 135 in Figure 4, and in addition there are supplemental deflectors 135' secured to the side walls of the casing to assist the deflectors mounted on the bottom dampers.

The condensate receiver is conveniently in the form of a cylindrical tank mounted horizontally beneath the bottom of the casing and is indicated by the reference character 136. It is supported from the top flanges of the casing legs by the brackets 137.

The check valves in the lines between the adsorber and evaporator, and adsorber and condenser are conveniently mounted in a unitary valve manifold shown in Figure 2 at 140. It comprises a single casting forming housings for the two check valves and housings for three manually operated valves and a check valve lifter, the stems of which are covered by the caps 141. These manually operated valves make it possible to isolate any portion of the refrigeration apparatus so that it may be opened without allowing the escape of gas from other portions. A pressure gauge 142 is conveniently mounted on this valve manifold. At 143 is seen the pipe leading from the valve manifold to the condenser, and it is adapted to be connected through the valve manifold and the pipe 144 to the adsorber. From the condenser the pipe 145 leads down behind the casing and enters the condensate receiver at 146. At 147 is seen the pipe which leads from the condensate receiver to the evaporator in the cooled compartment, and at 148 is the pipe leading from the evaporator to the valve manifold and through the proper valve to the pipe 144 and into the adsorber.

The damper arrangement is diagrammatically shown in Figure 7, and it will be seen that the top dampers open upwardly and outwardly, and the bottom dampers inwardly and upwardly as indicated by the arrows. The operation of the linkage for moving the dampers will be evident from the diagram when it is remembered that the vertical link L is lifted by the lever L' when the gas valve is closed under the action of the spring opposing the electric motor. It will be seen that this rotates the various arms so that all of the dampers are elevated. When the valve stem S moves up to open the valve, the link L moves down, and the reverse motion is imparted to the various dampers.

Referring now to Figure 6, the wiring diagram is shown, wherein 150 is any power line providing suitable current for the operation of the device. The motor 151 which drives the fans has one terminal connected by the lead 152 to one side of the power line and the other terminal connected by means of the lead 153 to the other side of the power line, the current first passing, however, through the temperature control unit 154 which is adapted to be located within the cooled compartment as described in connection with Figure 1. The motor is thus arranged to be driven at all times except when the temperature within the compartment is too low, when its circuit will be opened by means of the control 154. By means of the conductors 155 and 156, the time clock motor 157 is connected in shunt to the fan motor 151 and thus runs always and only when that motor runs. This time clock motor drives the cam wheel 158 which acts on the pivoted carrier 159 supporting the "Mercoid" switch 160. When this carrier is lifted, the mercury in 160 shifts, and the circuit is closed from one side of the line through the switch 160, through the gas valve motor 161, the conductor 162, the pilot safety 163, the high temperature safety 164, the temperature control 154, and back to the other side of the line. The gas valve is thus actuated whenever the switch 160 is closed, if the pilot and high temperature safeties are closed.

The pilot safety is a temperature controlled mercury switch mounted within the casing 131 and shown best in Figure 2. It may be any conventional form of switch adapted to be closed upon the application of high temperature to a portion thereof, and to open when this temperature falls. It may conveniently consist of a mercury switch supported on a bi-metallic loop, the bend of which is positioned above or within the housing of the pilot so that as long as the pilot burns, the circuit is closed but is immediately opened upon the extinguishing of the pilot flame. Thus gas cannot be turned on to the main burner if the pilot burner is extinguished. This is purely a safety feature.

The high temperature safety switch 164 is of a similar construction to the pilot safety switch but is arranged to open upon excessively high temperatures within the casing and to remain

closed during normal temperatures. It prevents any overheating. This high temperature safety switch is mounted within the casing 131.

The time clock is mounted in the casing 166 just above the casing 131, and in Figure 2 the cam wheel is seen at 158 and the tilting carrier at 159 carrying the switch bulb 160. The motor mechanism is illustrated at 157. It may be mentioned that this can be a motor of the induction type where alternating current is available.

The whole assembly just described in connection with Figures 2 to 7, inclusive, is compact, and yet all parts subject to any movement or wear and requiring any possible adjustment are arranged in an easily accessible position. The hot air escaping leaves from the top of the apparatus and can be conveniently deflected into a suitable hood and removed from the building if desired. The condenser is susceptible to water cooling by obvious changes, and it will be evident that the adsorber heating may be done by other means than gas in any convenient manner.

In Figures 8 and 11 there is shown a further modification which is adaptable for larger installations. Its construction is substantially identical with that just described with variations in the control and damper operating mechanisms. It will be seen from Figure 8 that the clock 201, the high temperature safety 202, the pilot safety 203, and the gas valve and its actuating mechanism indicated by the character 204 are all housed within a single housing 205 on the front of the main casing. The gas valve is constructed as previously described, but there is no extension on the valve stem since the valve operating motor is not used to control the dampers. Damper control is effected by what is commercially known as an "Arco" motor, which in the claims is termed a "one-half revolution device" or a "half revolution motor." It comprises an electric motor of the conventional form driving a power shaft through reduction gearing, which shaft delivers the power from the motor and also drives the switching mechanism so that the power shaft always makes a half revolution and then stops each time the current is turned on to the motor. The whole "Arco" motor 206 is supported by means of a bracket 207 beneath the adsorber casing, and the half revolution or power shaft is shown at 208. It carries an arm 209 which makes with the shaft a half revolution from the position shown in Figure 8 and then returns to that position upon the next operation of the motor. This shaft is connected by a link 210 to the arm 211 mounted on the shaft 212 connected to the damper operating mechanism so that this shaft 212 can be given a suitable movement each time it is required to change the position of the dampers.

Figure 11 shows the wiring of the form of the invention shown in Figure 8. The power line 215 supplies power through the temperature control 216 in the refrigerator directly to the fan motor 217 which runs at all times when the temperature control maintains the circuit closed. The gas valve 204 has its motor connected in shunt to the fan motor 217 through the switch 218 controlled by the timing motor 201 which is also connected in shunt to the motor 217. In addition, the pilot safety 203 and the high temperature safety 202 are arranged in series with the gas valve motor as in the prior form.

The rocker 220 which is actuated by the cam wheel of the timing motor not only carries the switch 218 which controls the gas valve motor circuit but also carries a three-contact mercury bulb 221 whose function is to control the operation of the half revolution motor. The half revolution or "Arco" motor includes the conventional electric motor 222 driving through suitable reducing mechanism 223 the power shaft 208 which carries a rotatable contact arm 225 connected by means of the wire 226 to one side of the power line. This arm is rotatable to play over the arcuate contacts 227 and 228, each extending for substantially 170° of arc and each connected to one of the end contacts in the switch bulb 221. The center contact of the switch bulb is connected by means of the wire 229 with the terminal 230 of the motor 222, the other terminal of which is connected back to the power line. Assuming the switch to be in the position shown in Figure 11, it will be seen that current can flow from conductor 226 through the contact arm 225, the segment 227 and to the right-hand contact in the bulb 221 which is adapted to be tilted by the timing motor. The circuit is here opened since it will be seen that the mercury drop is at present closing the circuit between the middle and the left-hand contacts. Now, however, when the switch carrier is dropped so that the mercury drop moves to the right-hand end, current will flow from the segment 227 through the drop to the center contact 229 and to the motor at the terminal 230, and thence from the motor back through the wire 232 to the line, and the motor will be driven until the contact arm 225 leaves the segment 227.

However, the momentum of the motor is such as to carry the arm 225 over the gap 233 so that it engages the short segment 234 which is connected electrically to the conductor 229, and hence the current will flow into the wire 226, the contact arm 225, the segment 234, the conductor 229, and to the motor so the motor will continue to operate until the arm leaves the segment 234, and by its momentum jumps the gap 236 and engages the segment 228. This will cause the motor to stop because the segment 228 is connected by the wire 237 to the left-hand contact in the switch bulb which, according to the assumption, is now out of contact with the mercury drop. Thus the motor will make a half revolution and will be in a position ready to make the next half revolution as soon as the mercury bulb is tilted so that the mercury therein contacts with the left-hand contact in the bulb. Thus the drive shaft 224 is given successive half revolutions each time the clock opens and closes the valve motor circuit, a half revolution taking place when the gas valve opens and the other half revolution when its closes, and thus the dampers are actuated in synchronism with the gas valve as in the previous modifications where they are controlled by the same motor. This mechanism is more successful where the dampers are large for it does not put such a strain on the gas valve motor and does not rely on springs for moving the dampers in one direction.

In Figure 9 is seen a modification particularly adapted for small units. It is more simplified than the others and makes use of a solenoid 250 or other suitable magnet for actuating the gas valve 251. This solenoid as well as the pilot safety 252 and the high temperature safety 253 are mounted in the casing 254 on the front of the main casing. It will be seen that the valve manifold 255 has been materially simplified by the elimination of a number of manually controlled valves and thus is cheapened. There is

no electric clock, and the timing is effected entirely by the fan motor 255'. This motor will normally run at substantially constant speed, and it is provided with a gear mechanism 256 which causes it, at the end of a definite and predetermined number of revolutions, to rotate the shaft 257 through a half revolution carrying with it the arm 258 connected by the link 259 to the damper actuating arm 260 on the shaft 261. This shaft 261 as shown in Figure 10, forms the support for one of the upper dampers and is connected by suitable links and bell cranks to the other dampers which will be actuated in unison with the one mounted on the shaft 261 as will be clear from the diagram.

Figure 10, in addition to showing the linkage mechanism for operating the dampers, also shows more or less schematically a simple form of mechanism for connecting the motor shaft to the connecting rod 259, whereby steady rotation of the motor shaft produces periodic half revolutions of the crank arm 258. While any form of mechanism may be used for this purpose, that illustrated is a simple way of performing the operation. The motor shaft carries a worm 270 driving a worm wheel 271 which has secured thereto a pinion 272 driving the gear 273 having secured to the same shaft a disk 274 provided with the single tooth 275 adapted to cooperate with the star wheel 276 so that each revolution of the disk 274 imparts a quarter revolution to the star wheel and holds it stationary between movements. The star wheel is secured to a gear 277 which is twice the diameter of the pinion 278 to which the crank 258 is attached, so that each quarter revolution of the star wheel imparts a half revolution to the pinion and the crank. If it is further desirable, additional speed reducing gearing may be inserted to effect the proper time relationship.

Figure 12 shows the wiring diagram of this modification wherein the motor 255' is directly driven from the power circuit 263 through the temperature control switch 264, as previously explained. The speed reducing and half revolution mechanism for the motor is shown diagrammatically at 256 in this figure, and in addition to the crank arm 258 actuating the dampers, it also moves a link 264' connected to a tilting switch carrying arm 265 which carries a mercury bulb switch 266 which is in circuit between the power supply and the gas valve magnet 250 so that the circuit of this magnet is opened and closed in unison with the actuation of the dampers. The pilot safety 252 and the high temperature safety 253 are also in series with this gas valve magnet.

The invention just discussed in its various modifications provides a highly compact and effective refrigeration apparatus which is entirely simple and foolproof in its operation and which will operate for long periods without any attention. It operates in exact accordance with the needs of the refrigerating space and thus provides maximum economy. It is susceptible to temperature regulation so that any desired temperature may be maintained in the cooled compartment. It can be controlled in a number of ways as already described, and it may obtain its heat from any well known heating device. Thus it is of almost universal use for it can be made from the small sizes for household use up to large sizes for stores, butcher shops, and the like and may even be used in multiple units as has been already done in supplying a plurality of refrigerators in apartments and the like. Its control is particularly susceptible to convenient ganging, and its safety features insure against any danger from lack of gas or dangerously high temperatures.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. Refrigeration apparatus comprising a condenser, an adsorber, a heater for said adsorber and single means to circulate heat from said heater over said adsorber and air independently over said condenser.

2. Refrigeration apparatus comprising a condenser, an adsorber, a heater for said adsorber and single means to simultaneously circulate a stream of air over said adsorber and an independent stream over said condenser.

3. In a refrigerating unit, in combination, a condenser, an adsorber closely adjacent said condenser, a heater at the end of said adsorber remote from said condenser and air circulating means between said condenser and said adsorber.

4. In a refrigerating unit, in combination, a condenser, an adsorber adjacent said condenser, a heater at the end of said adsorber remote from said condenser, a motor between said condenser and said adsorber, a fan on said motor to circulate air over said condenser for cooling and a fan on said motor to circulate heated air between said heater and said adsorber.

5. In a refrigerating unit, in combination, a casing, a heater in one end thereof, a fan at the opposite end of said casing, an adsorber between said heater and fan and means to cause said fan to recirculate heated air within said casing over said adsorber.

6. In a refrigerating unit, in combination, a casing, a burner in one end thereof, a fan at the opposite end of said casing, an adsorber between said burner and fan, means to cause said fan to recirculate heated air within said casing over said adsorber, and means to supply sufficient air for combustion within said casing.

7. In a refrigerating unit, in combination, a casing, a heater in one end thereof, a fan at the opposite end of said casing, an adsorber between said heater and fan, means to cause said fan to recirculate heated air within said casing over said adsorber, and means to cause said fan to move atmospheric air through said casing and over said adsorber when said heater is not in operation.

8. In a refrigerating unit, in combination, a casing, a heater in one end of said casing, means to turn said heater on and off, a constantly driven fan at the opposite end of said casing, an adsorber between said heater and fan, dampers adapted to close said casing when said heater is in operation to permit the fan to recirculate heated air over said adsorber and means to open said dampers when the heater is inoperative to cause the fan to move atmospheric air through the casing to cool the adsorber.

9. In a refrigerating unit, in combination, a heat insulating casing, an adsorber therein, a burner in the casing at one end thereof, air circulating means at the opposite end of said casing and means to conduct air within said casing from end to end thereof by-passing said adsorber.

10. In a refrigerating unit, in combination, an elongated casing, a burner at one end thereof, a fan at the opposite end thereof, an adsorber between the burner and fan, a passage by-passing said adsorber, damper means at each end of said casing interconnected to simultaneously close said dampers to enclose the fan, adsorber and burner whereby air is drawn over the adsorber

from the burner and returned through said passage for reheating.

11. In a refrigerating unit, in combination, an elongated casing, a burner at one end thereof, a fan at the opposite end thereof, an adsorber between the burner and fan, a passage by-passing said adsorber, damper means at each end of said casing interconnected to simultaneously close said damper means to enclose the fan, adsorber and burner whereby air is drawn over the adsorber from the burner and returned through said passage for reheating, and means to simultaneously open said dampers and shut off said burner.

12. In a refrigerating unit, in combination, an elongated casing, a burner at one end thereof, a fan at the opposite end thereof, an adsorber between the burner and fan and baffle means adjacent said adsorber extending to shroud the fan and forming with the casing a by-pass around the adsorber.

13. In a refrigerating unit, in combination, an elongated casing, a burner at one end thereof, a fan at the opposite end thereof, an adsorber between the burner and fan, baffle means adjacent said adsorber extending to shroud the fan and forming with the casing a by-pass around the adsorber, and damper means adapted to close the fan end of said casing so that heat is circulated from the heater over the adsorber and returned through said by-pass.

14. In a refrigerating unit, in combination, an elongated casing, a burner at one end thereof, a fan at the opposite end thereof, an adsorber between the burner and fan, baffle means adjacent said adsorber extending to shroud the fan and forming with the casing a by-pass around the adsorber, and damper means adapted to close the burner end of said casing, said damper means when open substantially closing off said by-pass.

15. In a refrigerating unit, in combination, an elongated casing, a burner at one end thereof, a fan at the opposite end thereof, an adsorber between the burner and fan, baffle means adjacent said adsorber extending to shroud the fan and forming with the casing a by-pass around the adsorber, damper means adapted to close the fan end of said casing, damper means adapted to close the burner end of said casing, and means connecting said damper means for simultaneous operation.

16. In a refrigerating unit, in combination, an elongated casing, a burner at one end thereof, a fan at the opposite end thereof, an adsorber between the burner and fan, baffle means adjacent said adsorber extending to shroud the fan and forming with the casing a by-pass around the adsorber, damper means adapted to close the fan end of said casing, damper means adapted to close the burner end of said casing, means connecting said damper means for simultaneous operation and means to actuate said damper means and control the flow of fuel to said burner simultaneously.

17. In a refrigeration unit, in combination, a casing, a motor support extending across and closing the center portion of one end of said casing and a damper at each side of said support to close the remainder of said end.

18. In a refrigeration unit, in combination, a casing, a motor support extending across and closing the center portion of one end of said casing, a damper at each side of said support to close the remainder of said end, each damper being hinged at its edge adjacent said support and adapted to open outwardly.

19. In a refrigeration unit, in combination, a casing, a motor support extending across and closing the center portion of one end of said casing, a damper at each side of said support to close the remainder of said end, each damper being hinged at its edge adjacent said support and adapted to open outwardly, a condenser supported beyond said end and baffles extending from said motor support to the edges of said condenser.

20. In a refrigeration unit, in combination, a casing, a motor support extending across and closing the center portion of one end of said casing, a damper at each side of said support to close the remainder of said end, each damper being hinged at its edge adjacent said support and adapted to open outwardly, a condenser supported beyond said end and a fan driven by said motor between said condenser and support.

21. In a refrigeration unit, in combination, a casing, a motor support extending across and closing the center portion of one end of said casing, a damper at each side of said support to close the remainder of said end, each damper being hinged at its edge adjacent said support and adap ed to open outwardly, a condenser supported beyond said end, a fan driven by said motor between said condenser and support, and a fan driven by said motor on the casing side of said support.

22. In a refrigeration apparatus, in combination, a casing of heat-insulating material, an adsorber within said casing, a burner in said casing, a condenser beyond the opposite end of said casing and a refrigerant receiver below said casing.

23. In a refrigeration unit, in combination a casing, an adsorber in said casing, a burner in one end of said casing, an air circulating device in said casing, dampers to open and close the ends of said casing, a valve to control the flow of fuel to said burner, automatic means to regulate the active and inactive periods of said burner, means to open and close said dampers and mechanism to cause said means to open the dampers when said automatic means initiates an inactive period of said burner.

24. In a refrigeration unit, in combination, an adsorber, a motor driven fan therefor, a burner for said adsorber, a valve for said burner biased to a closed position, electric means to open said valve, a source of current, a circuit connecting said source to said motor and said valve operating means and timing mechanism in said circuit to control only said valve.

25. In a refrigeration unit, in combination, an adsorber, a motor driven fan therefor, a burner for said adsorber, a valve for said burner biased to a closed position, electric means to open said valve, a source of current, a circuit connecting said source to said motor and said valve operating means, timing mechanism in said circuit to control only said valve, and a temperature controlled device to open the circuit to both said motor and said valve operating means.

26. In a refrigeration unit, in combination, an adsorber, a motor driven fan therefor, a burner for said adsorber, a valve for said burner biased to a closed position, electric means to open said valve, a source of current, a circuit connecting said source to said motor and said valve operating means, timing mechanism in said circuit to control only said valve, a low temperature controlled device to open the circuit to both said motor and said valve operating means and a high

temperature responsive device to open the circuit to the valve operating mechanism only.

27. In a refrigeration unit, in combination, an adsorber, a burner for said adsorber, a valve for said burner, electric means to actuate said valve, a source of current, an electric timing means connected to said source of current, a circuit connecting said valve actuating means to said source of current and means controlled by said timing means to open said circuit.

28. In a refrigeration unit, in combination, an adsorber, a burner for said adsorber, a valve for said burner, electric means to actuate said valve, a source of current, an electric timing means connected to said source of current, a circuit connecting said valve actuating means to said source of current, means controlled by said timing means to open said circuit, and means responsive to low temperatures to open the circuit to both the timing means and the valve actuating means.

29. In a refrigeration unit, in combination, an adsorber, a burner for said adsorber, a valve for said burner, a pilot burner adapted for continuous burning, electric means to actuate said burner valve, a source of current, electric timing means connected to said source of current, a circuit connecting said valve actuating means to said source of current, means controlled by said timing means to open said circuit and a temperature responsive means to open said circuit, said temperature responsive means being in position to be heated by said pilot burner.

30. In a refrigeration unit, in combination, an adsorber, a burner for said adsorber, a valve for said burner, a fan to circulate air over said adsorber, a motor adapted to drive said fan continuously and means operatively associating said motor and valve to actuate the valve after a predetermined number of revolutions of said motor.

31. In a refrigeration unit, in combination, a casing, an adsorber in said casing, a burner in said casing to heat said adsorber, a fan to circulate air over said adsorber, dampers to close said casing when the burner is operating and vice versa, a motor for said fan adapted to run substantially continuously, a valve for said burner, mechanism associating said motor and dampers to actuate the dampers after a predetermined number of revolutions of the motor.

32. In a refrigeration unit, in combination, a casing, an adsorber in said casing, a burner in said casing to heat said adsorber, a fan to circulate air over said adsorber, dampers to close said casing when the burner is operating and vice versa, a motor for said fan adapted to run substantially continuously, a valve for said burner, electric means to actuate said valve, mechanism associating said motor and dampers to actuate the dampers after a predetermined number of revolutions of said motor and a switch actuated by said mechanism in the circuit of said valve actuating means.

33. In a refrigeration unit, in combination, a casing, an adsorber in said casing, a burner in said casing to heat said adsorber, dampers to close said casing when the burner is operating and vice versa, a valve for said burner, operating mechanism for said dampers, including a motor and a half revolution switch driven by said motor, a timing mechanism and means actuated thereby to control said valve and said motor.

34. In a refrigeration unit, in combination, a casing, an adsorber in said casing, a burner in said casing to heat said adsorber, dampers to close said casing when the burner is operating and vice versa, a valve for said burner, operating mechanism for said dampers, said mechanism including a motor, a shaft driven by said motor and adapted for connection to said dampers and a switch mechanism operated by said shaft to stop said motor after each half revolution of said shaft.

35. In a refrigeration unit, in combination, a casing, an adsorber in said casing, a burner in said casing to heat said adsorber, dampers to close said casing when the burner is operating and vice versa, a valve for said burner, operating mechanism for said dampers, said mechanism including a motor, a shaft driven by said motor and adapted for connection to said dampers, a switch mechanism operated by said shaft to stop said motor after each half revolution of said shaft, a timing mechanism, means associated with said timing mechanism to successively open and shut said valve and means associated with said timing mechanism to start said motor each time the valve is actuated.

36. In a refrigeration unit, in combination, a casing, a motor support extending across and closing a portion of one end of said casing and a damper adjacent the support to close the casing beside the support.

37. Refrigeration apparatus comprising an adsorber including a plurality of tubes, a heater for said adsorber beneath a portion of said tubes, and means to distribute heat from said heater uniformly over all of said adsorber tubes.

38. In a refrigeration unit, in combination, a sorber, a heater therefor, air circulation means for said sorber and heater and heater timing mechanism controlled by said circulation means.

39. In adsorption refrigeration apparatus, in combination, an adsorber, a casing surrounding said adsorber, a fan in said casing, shutter means to close the casing for air circulation therein by said fan and to open the casing for flow of air therethrough under the action of said fan and timing means to periodically change the position of said shutter means.

40. In adsorption refrigeration apparatus, in combination, an adsorber, a casing surrounding said adsorber, a heater for the air in said casing, shutter means to close the casing for heating and to open the casing for flow of air therethrough and timing means to periodically change the position of said shutter means and the condition of said heater.

41. In a device of the class described, a refrigerant transformer and a refrigerant condenser, a motor, a fan driven by said motor for causing a flow of a cooling medium through said condenser, and a fan driven by said motor for causing a flow of a heat transferring medium through said transformer.

42. In a device of the class described, a refrigerant transformer including a container, a condenser connected to said transformer and positioned in adjacent relationship with respect thereto, a motor, a fan on said motor outside of said container and adjacent said condenser, and a second fan on said motor within said container.

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