

Feb. 5, 1957

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2,780,415

HEAT PUMP OPERATED SYSTEM FOR HOUSE HEATING

Filed Feb. 23, 1952

7 Sheets-Sheet 1

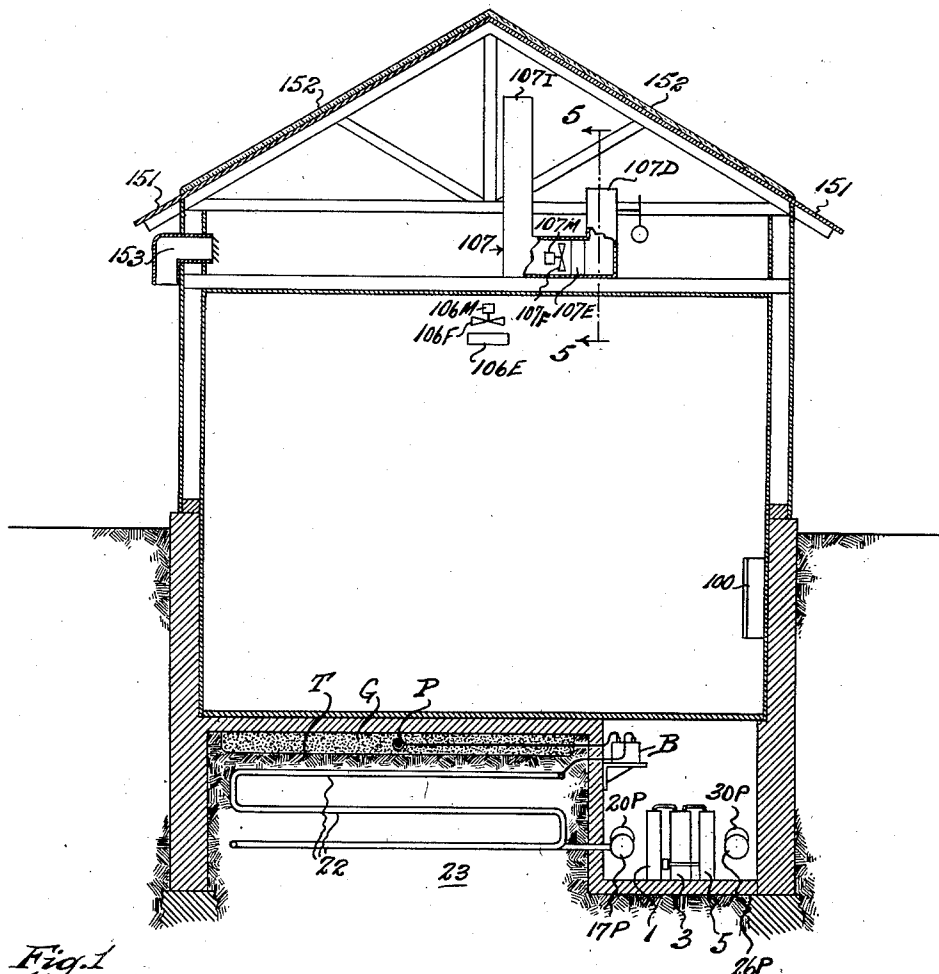


Fig. 1

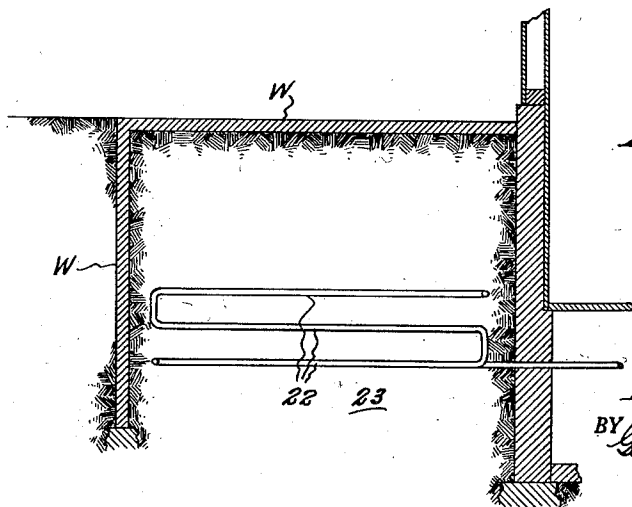


Fig. 1A

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7 Sheets-Sheet 2

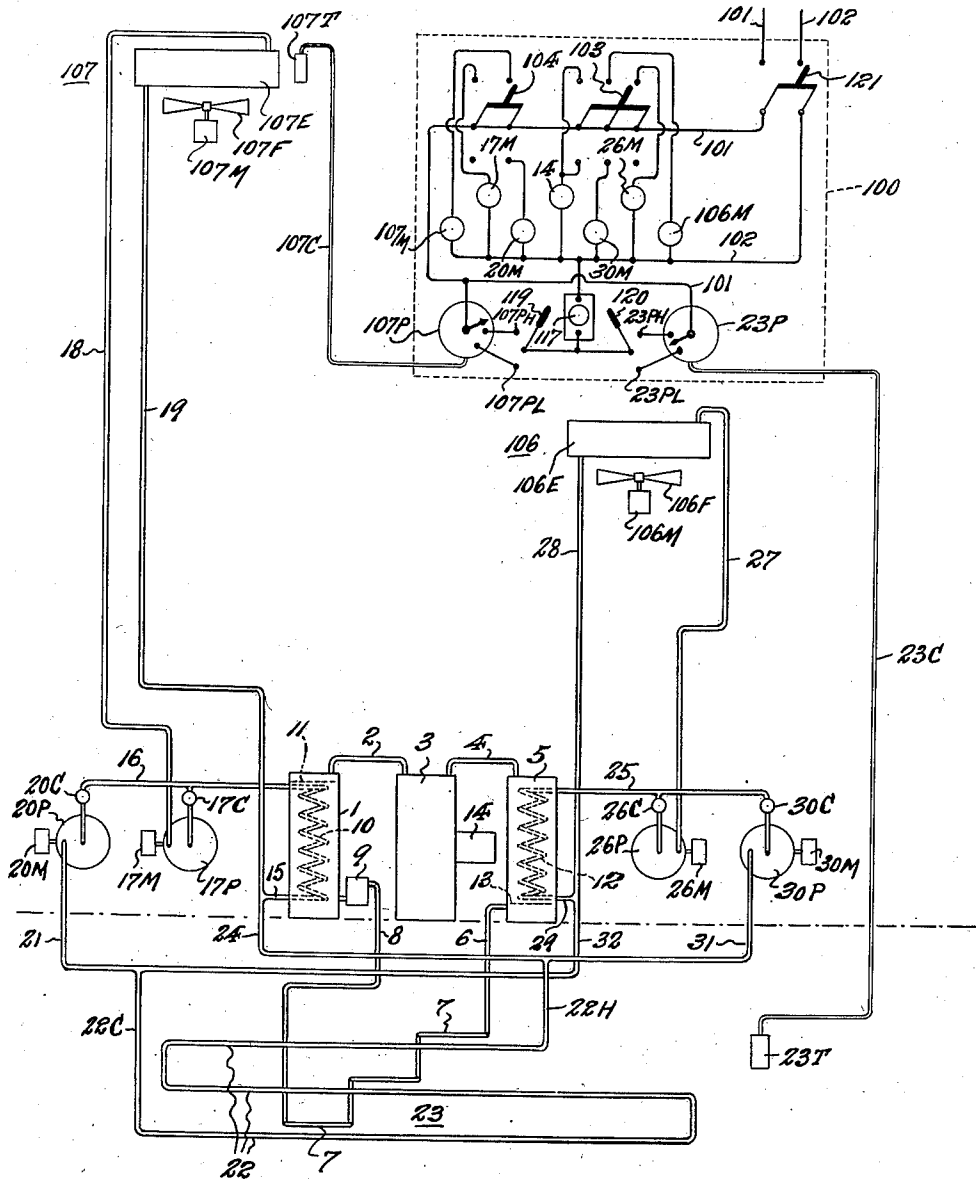


Fig. 2

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7 Sheets-Sheet 3

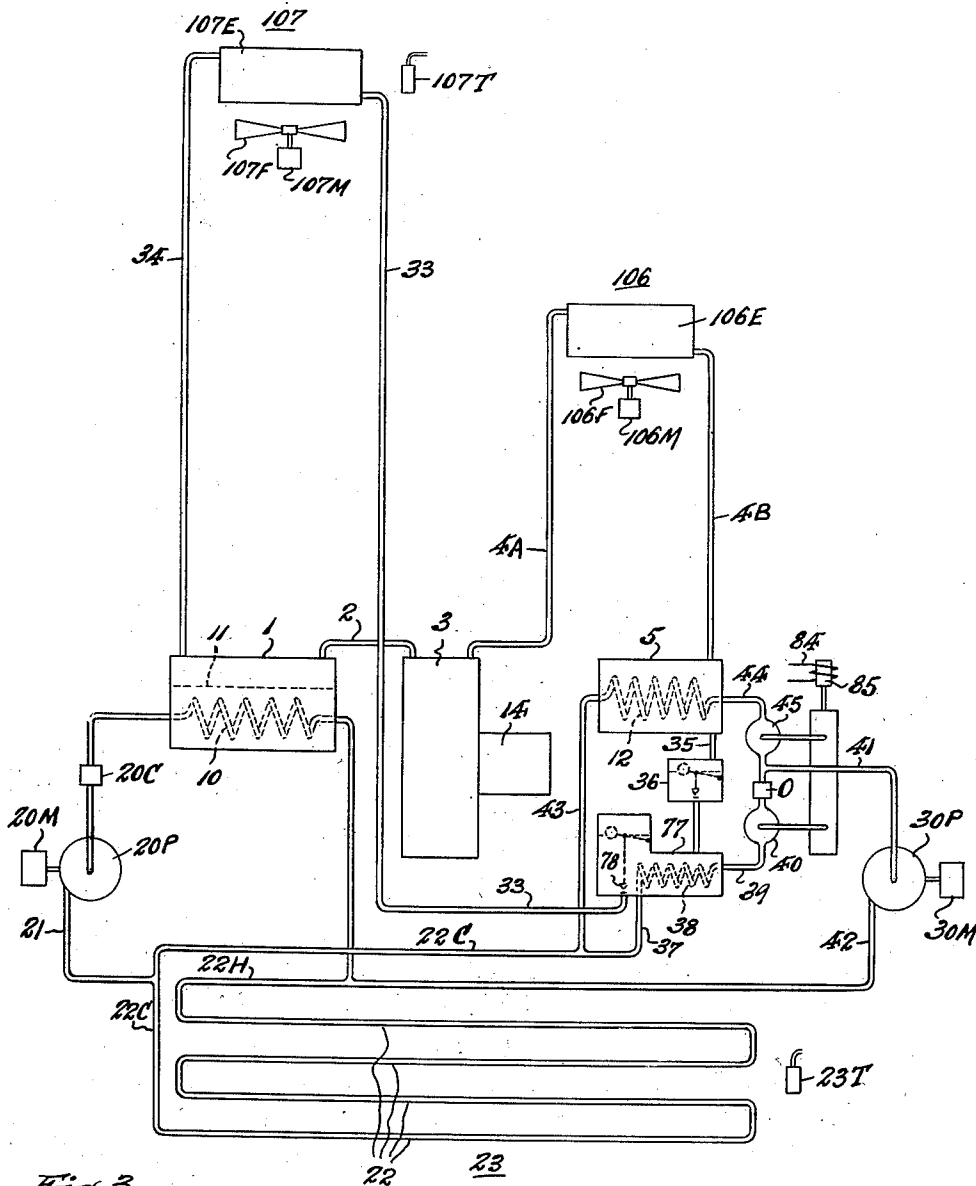


Fig. 3

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7 Sheets-Sheet 5

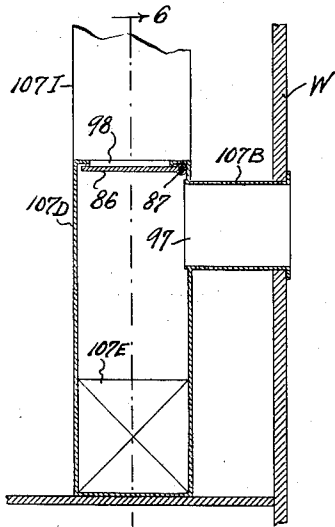


Fig. 5

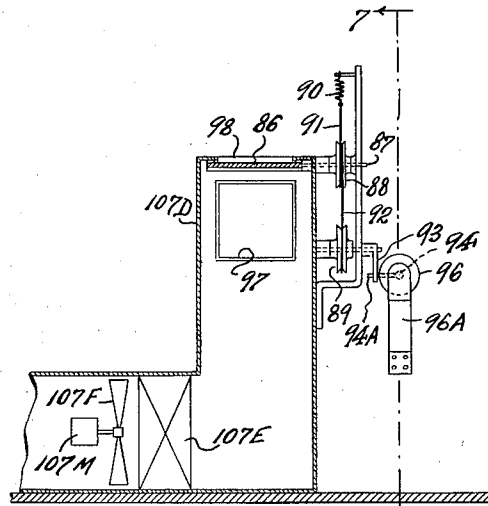


Fig. 6

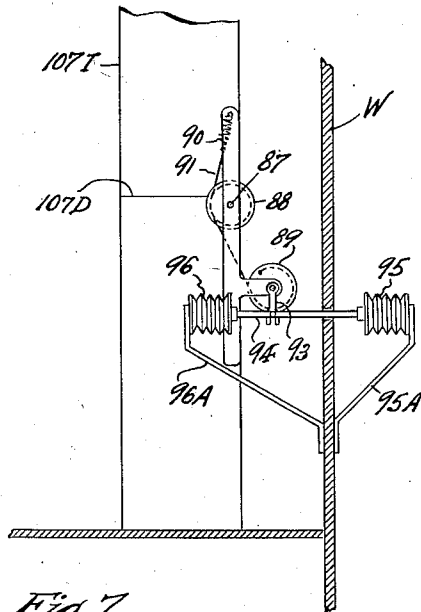


Fig. 7

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HEAT PUMP OPERATED SYSTEM FOR HOUSE HEATING

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7 Sheets-Sheet 6

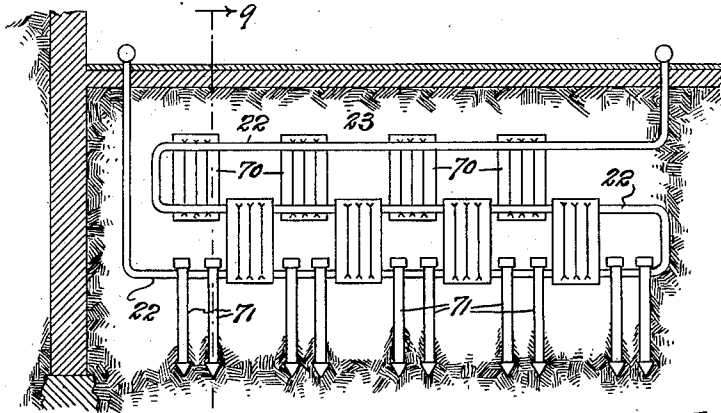


Fig. 8

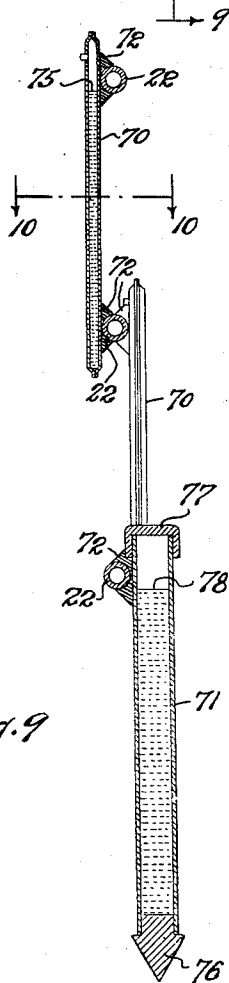


Fig. 9



Fig. 10

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HEAT PUMP OPERATED SYSTEM FOR HOUSE HEATING

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7 Sheets-Sheet 7

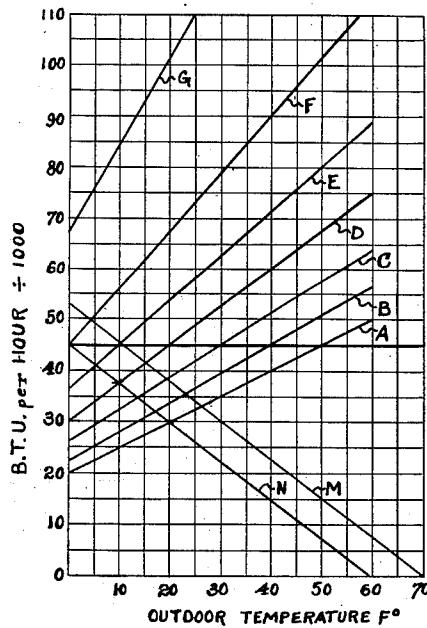


Fig. 11

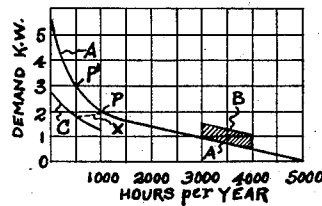


Fig. 13

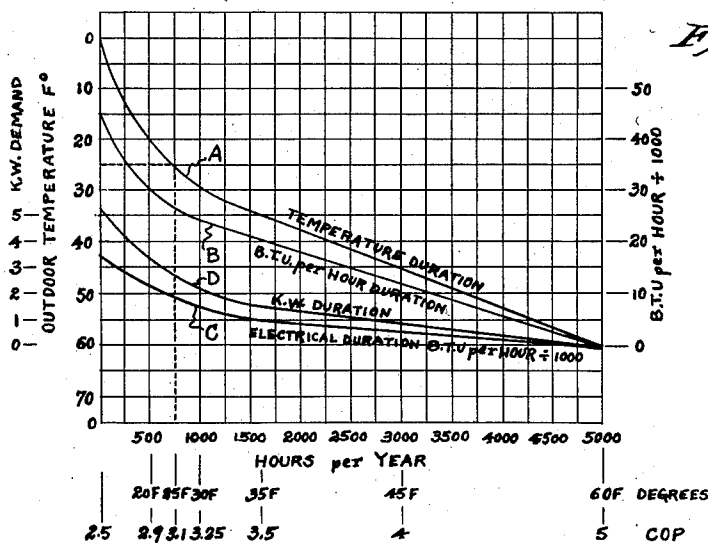


Fig. 12

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1

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HEAT PUMP OPERATED SYSTEM FOR HOUSE HEATING

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Application February 23, 1952, Serial No. 273,124

8 Claims. (Cl. 237—2)

This invention relates to a heat pump operated system for house heating, and the invention has reference, more particularly, to a heat pump operated heating system wherein a heat pump of minimum capacity in combination with means to provide a relatively high temperature heat source in cold weather can operate with a coefficient of performance of approximately 5, and thus supply the heat requirements of the house at zero degree F., which would otherwise require two heat pumps of like capacity pumping from zero F. at a coefficient of performance of approximately 2.5 each.

To provide heat pump means which will operate over a wide range of temperature to which an ordinary heat source (e. g. outdoor atmosphere) is subject involves the following problems:

(a) The adjustment of expansion valves for operation over a wide temperature range is difficult.

(b) To pump a desired amount of heat, the heat pump must possess a vapor displacement which will increase rapidly as the temperature of the heat source is reduced. For example, the size (displacement) of the heat pump operative to deliver a given quantity of heat from a zero degree source must be approximately double that required to pump the same quantity of heat from a forty degree source.

(c) The principal advantage of heat pump for space heating is that the energy delivered to the space is much greater than the energy required to drive the pump. This ratio, known as coefficient of performance, increases with rise of temperature of the heat source, and the system must be designed accordingly. In such system, the coefficient of performance with a heat source temperature of approximately sixty degrees F. is about 5 and with a heat source temperature of zero degrees is about 2.5. It follows therefore that a heat pump of about one-half the size of that necessary to pump required heat from a zero degree source, when pumping from a sixty degree source, will consume only about one-half the electrical energy consumed by the full size pump when pumping from a zero degree source, and the half-size pump when pumping from said sixty degree source will deliver the larger quantity of heat.

In some systems as heretofore designed, two approximately half-size heat pumps are used, and both are run, when the heat source temperature is zero F., at a coefficient of performance of only about 2.5, but only one of these heat pumps is run when the heat source temperature is high. The system of the present invention avoids necessity for using two such heat pumps, and by providing means to provide a relatively high temperature heat source available for use in cold weather, permits the use of a single half size heat pump and thus effects great economy of electrical energy consumption in operation of the system.

Having the above in view, it is an object of this present invention to provide a warm earth heat storage area and means to supply heat thereto, whereby to provide a high temperature heat source available to be

2

drawn upon by the heat pump in cold winter weather, so that a heat pump of minimum capacity, pumping from said high temperature heat source, will have a high coefficient of performance, and thus reduce the power demand upon a utility system for space heating in the coldest winter weather.

Another object of the invention is to provide the house to be heated by a heat pump with a roof adapted to pass solar energy into the attic, and to adapt a heat pump to take heat automatically from either outdoors or the attic, whichever is warmest, in moderate winter weather, and to take heat from an earth heat storage area in very cold winter weather.

It is a further object of this invention to arrange the heat pump condenser to supply heat to the house in warmer winter weather as needed, and, when such heat is not needed by the house, to cause the heat pump to operate to receive heat from attic air or outdoor air, whichever is warmest, and pump this heat into an earth heat storage area to maintain this area at a temperature well above normal earth temperature, so that all of the heat taken by the heat pump from this earth heat storage area in extremely cold winter weather is replaced by a greater amount of heat pumped into this area either from the attic or outdoors during the warmer winter weather, whereby a heat pump about one-half the normal size, receiving heat from this warm earth heat storage area, will be able to heat the house in the coldest winter weather.

A further object of this invention is to take heat from an earth heat storage area in very cold winter weather to supply the evaporator of a heat pump with heat to heat a house, and to replace this heat in part by solar heat pumped from the attic in sunny weather, and in part by sensible heat continuously extracted from the hot condensed refrigerant.

It is a further object of this invention to store heat in an earth heat storage area in such a manner that the upper zone of the earth heat storage area is at a maximum temperature while the lower zone of the earth heat storage area is at a temperature relatively little above that of the deep earth, and to supply one way heat conductors adapted to readily conduct heat upwards to charge heat into the upper zones of the earth heat storage area during charging periods and to readily conduct heat upwards from the lower zones of the earth storage area during the storage heat discharging periods.

It is a further object of this invention to provide means to cause moisture to collect around earth heat transfer fluid conducting coils in an earth heat storage area, whereby the heat conductivity from and to the coils is improved, and to maintain the moisture around the coils by electrical osmosis.

It is a further object of this invention to wall in an earth heat storage area whereby the migration of cold moisture in the earth following storms is prevented and heat is not carried away by such migrating moisture.

It is a further object of this invention to establish an attic solar energy heat trap by providing a metal roof protected from outdoor air currents by a material both convective heat insulating and radiant heat conducting and to provide novel automatic means of shunting attic air through an attic heat receiving heat exchanger during relatively high attic air temperatures, and shunting outdoor air through said heat exchanger at other times.

It is a further object of this invention to provide a house with an attic roof highly conducting to solar energy and thermally resistant to frigid outdoor air whereby said attic will maintain a relatively high air temperature during sunny periods and to install in said attic a heat exchanger to supply heat to a heat pump whereby during sunny periods the coefficient of performance of

3

said heat pump will be high and the electrical energy consumption will be low.

It is a further object of this invention to partially bury a house in the earth and provide means to use solar energy to raise the temperature of the surrounding earth whereby the living spaces adjacent said warm earth are kept in a dry and livable condition.

Other objects of this invention, not at this time more particularly enumerated, will be understood from the following detailed description.

Illustrative embodiments of this invention are shown in the accompanying drawings, in which:

Fig. 1 is a schematic cross-sectional elevation of a house adapted to be heated by a heat pump operated heating system according to this invention, this view showing locations of the heat pump, attic heat exchanger, house heat dispensing heat exchanger, and earth heat storage area, the latter being located beneath the house, and Fig. 1A is a fragmentary view, showing the earth heat storage area located exteriorly of the house.

Fig. 2 is a schematic view of one embodiment of a heat pump operated house heating system according to this invention such as shown in Fig. 1.

Fig. 3 is a schematic view of modified embodiment of a heat pump operated house heating system according to this invention; and Fig. 4 is a schematic view of another modified embodiment of a heat pump operated house heating system according to this invention.

Fig. 5 is a detail vertical sectional view of an attic heat recovery apparatus, taken on line 5—5 in Fig. 1, but drawn on an enlarged scale; Fig. 6 is a vertical sectional view of the same, taken in line 6—6 in Fig. 5; and Fig. 7 is a vertical sectional view of the same, taken on line 7—7 in Fig. 6.

Fig. 8 is a fragmentary vertical sectional view through an earth heat storage area of the system, showing the heat transfer fluid conducting coils therein provided with one way heat conductor connected therewith and leading thereto from deep earth beneath said storage area; Fig. 9 is a vertical longitudinal section, taken on line 9—9 in Fig. 8, but drawn on an enlarged scale; and Fig. 10 is a detail transverse sectional view, taken on line 10—10 in Fig. 9.

Fig. 11 is a graph illustrating the adaptation of a heat pump to a house heating system according to this invention; Fig. 12 is a graph indicating duration curves in hours per year at various temperatures in a temperate area, such e. g. as the New York metropolitan district, from which curves heating requirements can be ascertained; and Fig. 13 is a graph showing a curve indicating power requirement when the heat pump receives heat from the earth heat storage area when outdoor temperature is very low, i. e. approximately at zero F.

Similar characters of reference are employed in the hereinabove described views, to indicate corresponding parts.

Referring first to Fig. 1 which illustrates a house structure having an attic space above its living rooms. The house roof 151, which extends over the attic space, is constructed of heat conductive material, preferably comprising aluminum painted black, although it may comprise thin wood shingles or other heat conductive material. Said roof 151 is covered with a convective heat insulating but radiant heat conducting material 152, such as glass, corrugated transparent plastic material or the like. The end gables of the house are preferably heat insulated, and louvers are provided in the attic walls, whereby to be adapted to stand open in the summer, but to be closed in the winter. A heat pump or compressor 3, preferably located in the lower region of the house, pumps heat from an evaporator 1 to a condenser 5 in the usual manner. As shown more in detail in Fig. 2, a pump 17P pumps a cold heat transfer fluid from an evaporator coil 10 to an attic heat recovery apparatus 107 in warm winter weather. This cold heat transfer fluid is warmed

4

by attic air as it passes through the attic heat recovery apparatus 107, and carries the heat so received to said evaporator coil 10. The warmed heat transfer fluid gives up its received heat to the liquid refrigerant in the evaporator 1, causing said refrigerant to boil. In very cold winter weather pump 17P is shut down and pump 20P is operated. The cold heat transfer fluid is thereupon pumped through the conducting coils 22, which are buried in the heat storage area 23 beneath the house, and back to the evaporator coil 10, thus transferring heat from the earth heat storage area to the liquid refrigerant in evaporator 1, causing said refrigerant to boil. When pump 26P is operated, it pumps hot heat transfer fluid from the coil 12 in condenser 5 to a house heat dispensing heat exchanger 106, from which heat is emitted to warm the house air, whereupon the somewhat cooled heat transfer fluid passes back to the condenser coil 12 and is again warmed as it condenses the hot compressed refrigerant gas delivered to the condenser by the compressor 3. When the demand for house heat is satisfied, pump 26P is stopped, and pump 30P is put in operation. Said pump 30P operates to circulate the hot heat transfer fluid through the coils 22 in the earth heat storage area 23 and back to the coil 12 in condenser 5, so that heat delivered to the condenser 5 by operation of compressor 3 is conducted to and stored in the earth heat storage area 23.

The attic heat recovery apparatus 107 can be arranged to receive attic air regardless of its location, i. e. although it is preferable to locate said attic heat recovery apparatus within the attic, this is not essential so long as its intake communicates with the attic air. It has been found that in sunny winter weather the attic air will receive enough heat to remain warm enough to efficiently serve the heat recovery device 107 for delivery of a full quota of heat to the heat pump notwithstanding the outdoor air may be at freezing temperature.

As shown in Fig. 1, above the earth heat storage area 23 and its contained heat transfer fluid conducting coils 22, there shown beneath the house, it is desirable to provide a series of trenches T which are traversed by a perforate water pipe P imbedded in coarse gravel G with which said trenches are filled, so that water in desired quantity may flood these trenches when needed. A battery B is connected between this water pipe P and the earth heat storage area coils 22 so as to cause water to flow from the former to the latter. When the earth is found to have low thermal conductivity, water is caused to flow to the coils 22 by electric osmosis, thus tending to hold moisture around said coils for a long period.

As shown in Fig. 1A, the earth heat storage area 23 and its contained heat transfer fluid conducting coils 22 can optionally be located exteriorly of but adjacent to the house. In such case the area should be walled in by walls W to prevent entrance into said area of cold moisture which may saturate the outer earth after a storm. Said walls prevent both inward and outward migration of moisture to and from the earth heat storage area, and thus prevents dissipation of stored heat by carrying away thereof by migrating moisture. The means above described for holding moisture by electric osmosis around the coils 22 may be used with the exterior earth heat storage area, if desired.

Referring now to Fig. 2 in which one embodiment of the system is schematically shown in detail, cold liquid refrigerant gas is delivered by conduit 2 from the evaporator 1 to the compressor 3, which is driven by electric motor 14, and is compressed and heated by operation of the compressor. The hot refrigerant is delivered by conduit 4 from the compressor 3 to the condenser 5, and is condensed in the latter so as to fill the same to a level 13. The condensed liquid refrigerant is discharged from the condenser 5 through pipe 6 for flow through coils 7, and thence, by way of return pipe 8, through a float valve 9 back to evaporator 1, whereby to flood the in-

5

terior of the latter to a level 11. The coils 7 are buried in the earth heat storage area 23, so as to be adjacent to and across the heat transfer fluid conducting coils 22. The arrangement being such that said coils 7 first pass through the hot upper levels of said earth heat storage area, and lastly through the cooler lower levels of the latter, so that the refrigerant gives up its sensible heat to the earth around the coils 7 and 22. The evaporator coil 10 carries heat transfer fluid. The liquid refrigerant in evaporator 1, by boiling, extracts heat from the heat transfer fluid flowing in said evaporator coil, thus cooling said heat transfer fluid. Heat transfer fluid flows in the condenser coil 12. The hot compressed refrigerant gas discharged from the compressor through pipe 4 into condenser 5 is condensed by the heat transfer fluid flowing through said condenser coil 12, so that the temperature of said heat transfer fluid is raised.

Consider now the heat sources which serve the heat pump. In average winter weather (above approximately 25° F.) relatively cold heat transfer fluid will be drawn through pipe 16 and check valve 17C by pump 17P from the evaporator coil 10. Pump 17P will force this relatively cold heat transfer fluid through pipe 18 to the attic heat recovery device 107, detailed description of which will be herein later set forth. The heat transfer fluid is passing through the attic heat exchanger 107E extracts heat from relatively warm air blown through said heat exchanger 107E by a fan 107F which is driven by a motor 107M. The cold heat transfer fluid is thus warmed and flows on through pipe 19 and pipe 15 back to and through the evaporator coil 10, and the heat received thereby in the heat exchanger 107E is extracted from the coil 10 by the colder boiling liquid refrigerant in the evaporator 1. When the temperature of the air delivered through the attic heat recovery device 107 reaches a low value, e. g. 25° F. and under, and a control means (later herein described) is set to sound an indicative alarm when such temperature drop occurs, the householder will stop pump 17P and fan 107F, and will start pump 20P. Cold heat transfer fluid will thereupon be drawn through pipe 16 and check valve 20C by said pump 20P, and will be forced by the latter through pipes 21 and 22C to the bottom section of coils 22 which are buried in the earth heat storage area 23, thus keeping the bottom sections of said coils 22 and the contiguous lower levels of the earth storage area 23 cooler than the upper levels of said area, whereby to avoid losses of stored heat by dissipation thereof to the deep earth underlying said storage area 23. The cold heat transfer fluid will be warmed by heat contained in the earth heat storage area 23 as said fluid flows upwardly through successively higher sections of the coils 22, and finally leaves the latter through pipe 22H leading from the highest and hottest section of said coils. From pipe 22H, the warm heat transfer fluid passes through pipe 24 and pipe 15 to and through the coil 10 of evaporator 1, and in traversing said coil 10 gives up its heat at a relatively high temperature to the boiling refrigerant in evaporator 1. In this manner, heat is withdrawn from the earth storage area 23 as a source of heat for operation of the heat pump.

The circulation of hot heat transfer fluid is next considered, such circulation is effected by stopping pump 20P and starting operation of pump 26P which is driven by motor 26M. Pump 26P draws hot heat transfer fluid from coil 12 of condenser 5 through check valve 26C, and forces the same through pipe 27 to and through the house heat exchanger 106E of a house heating device 106. Fan 106F which is driven by motor 106M drives house air through said heat exchanger 106E, and this air is thereby warmed by heat transferred thereto from the hot heat transfer fluid and then returned to the house space. The cooled heat transfer fluid discharges from the heat exchanger 106E through pipe 28 and pipe 29

6

back to the condenser coil 12, where it is again heated by condensation of the refrigerant gas delivered from the compressor 3 to the condenser 5. In warm winter weather, when the heat pump is not needed for direct heating of the house space in the manner above set forth, pump 26P is stopped and pump 30P driven by motor 30M is started. The circulation of hot heat transfer fluid through the house heating device 106 being stopped, fan 106F is also stopped. By its operation, pump 30P now draws hot heat transfer fluid from condenser coil 12 through pipe 25 and check valve 30C, and forces the hot fluid through pipe 31 and pipe 22H to the earth heat storage coils 22 of the earth heat storage area 23. In flowing through said coils 22, the hot heat transfer fluid first gives up a large amount of its heat to the top levels of the earth heat storage area, and as it progresses gives up in diminishing amounts and at lower temperature heat to the lower levels of said earth heat storage area. The cooled transfer fluid leaves the coldest sections of the coils 22 through pipe 22C, and thence flows through pipe 32 and pipe 29 back to condenser coil 12 where it is again heated.

An illustrative arrangement of control means by which the householder can selectively put in and out of operation the several pump and fan motors at proper times, whereby to operate the system in the manner above described, is shown in connection with the system embodiment of Fig. 2, and the same also includes signaling devices. Said illustrative control means includes a pressure gauge 107P, calibrated in degrees F. and equipped with the usual adjustable high and low alarm contacts 107PH and 107PL. A liquid pressure thermostat 107T is located in the air stream blown through the attic heat recovery device 107, and is operatively connected by a conduit 107C with and in actuating relation to said pressure gauge 107P. The control means also includes another pressure gauge 23P, calibrated in degrees F., and equipped with the usual adjustable high and low alarm contacts 23PH and 23PL. A liquid pressure thermostat 23T is located in the earth heat storage area 23, and is operatively connected by a conduit 23C with and in actuating relation to said pressure gauge 23P.

The control means is mounted on a panel 100 suitably located within the house. Power is served to the panel over conductors 101 and 102 through a power switch 121, conductor 102 being the neutral or grounded wire. Mounted on the panel is a three pole, double throw switch 103 and a two pole, double throw switch 104, the hinge contacts of which are all connected to power wire 101. One terminal of each motor 106M, 26M, 30M, 14, 20M, 17M and 107M and an alarm bell 117 is connected to the ground wire 102. The power switch 21 being closed, the householder will close the three pole switch 103 to the up position and also the two pole switch 104 to up position. Under these conditions the three pole switch 103 will close circuits so that motor 14 will drive the heat pump compressor 3, motor 26M will operate pump 26P to circulate hot heat transfer fluid through the house heating device 106, and motor 106M will operate fan 106F to blow house air through said heating device 106, while the two pole switch will close circuits so that motor 17M will operate pump 17P to circulate cold heat transfer fluid through the attic heat recovery device 107, and motor 107M will operate fan 107F to blow attic or outdoor air, as the case may be, through the heat exchanger 107E of the heat recovery device 107. When the controls are thus conditioned, the heat pump will be in standard operation, receiving heat from the attic heat recovery device 107, and delivering heat plus losses to the house heating device 106.

In average winter weather, a single pole, double throw switch 120 will be thrown to up position so as to connect alarm bell 117 to the high temperature alarm contact 23PH of pressure gauge 23P, so that operation of this gauge 23P by the earth heat storage area thermostat 23T,

will ring the alarm bell 117, to warn the householder that enough heat is stored in the earth heat storage area. A single pole, double throw switch 119 will be thrown to down position which will condition the pressure gauge 107P for operation by the thermostat 107T associated with the attic heat recovery device 107, whereby to sound the alarm bell 117 when the temperature of the air circulated through the attic heat recovery device drops too low to supply enough heat for economical operation of the heat pump, that is when air temperature drops e. g. to 25° F.

If attic or outdoor air serving the attic heat recovery device 107 rises in temperature, e. g. to 50° F., as shown by the pressure gauge 107P, householder will throw control switch 103 to down position, thus stopping motor 106M and fan 106F of the house heating device 106, and also stopping motor 26M and pump 26P to interrupt circulation of hot heat transfer fluid through house heating device 106, while at the same time continuing operation of heat pump compressor operating motor 14, and starting motor 30M to operate pump 30P, whereby to circulate hot heat transfer fluid through the earth heat storage area coils 22, thus to supply heat to the earth heat storage area 23 for storage therein. This operation is continued until pressure gauge 23P indicates high temperature, e. g. 65° F., and closes on high alarm contact 23PH, so that alarm bell signal is given. Under this condition, householder can open switch 103 and stop the heating system, at the same time throwing switch 120 close on low temperature contact 23PL of gauge 23P, so that alarm 117 will sound when temperature of earth heat storage area drops to a predetermined low value, e. g. 60° F. If this occurs switch 103 can be thrown down to resume heat storage operation or up to resume house heat dispensing operation.

If alarm is sounded to indicate temperature drop of attic or outdoor air serving the attic heat recovery device 107, the householder will throw switch 104 to down position, whereby to stop operation of motor 107M and fan 107F, and also motor 17M which operates pump 17P for circulating cold heat transfer fluid through the attic heat recovery device 107, while at the same time starting operation of motor 20M to drive pump 20P, whereby to circulate heat transfer fluid in such manner as to carry heat from the earth heat storage area 23 to the heat pump evaporator coil 10. Under these circumstances, switch 119 will be thrown up to close on contact 107Ph of gauge 107P, said gauge when reaching its high temperature indicating condition will close the alarm circuit and ring alarm bell 117, to warn the householder that switch 104 may then be returned to its normal up position for standard operation of the heat pump and the system.

In Fig. 3 is shown a modified arrangement of the heat pump operated house heating system of this invention. This modified arrangement differs from that above described and shown in Fig. 2 principally in that the refrigerant rather than the heat transfer fluid is circulated to and from the heat pump through the attic heat recovery device 107 and the house heating device 106, while the heat transfer fluid circulates only to and from the coils 22 of the earth heat storage area 23. In this modified arrangement of the system, the circulation of heat transfer fluid to conduct heat from the earth heat storage area 23 to the evaporator coil 10 of evaporator 1 is substantially similar to the arrangement in the system shown in Fig. 2, and the circulation of hot heat transfer fluid, whereby to conduct heat to the storage area in average winter weather, and through a condenser coil 12, is also substantially similar to the arrangement in the system shown in Fig. 2. However, in this embodiment of Fig. 3, the attic heat recovery device 107 is connected in the liquid refrigerant circulating line, and whenever the heat pump is operated to receive heat from the attic heat recovery device 107, said device 107 serves as an evapo-

rator, and condensed liquid refrigerant, delivered through pipe 33 is evaporated in the heat exchanger 107E, and the cold refrigerant gas then passes by way of pipe 34 directly through an evaporator 1 to the heat pump compressor 3.

The house heating device 106, in this modified system, is connected directly to heat pump compressor 3 by pipe 4A which leads to the heat exchanger 106E, so that the latter can serve as a condenser for delivered hot refrigerant gas, and thus transfer the heat of condensation to the air blown through the heat exchanger 106E by fan 106F for house space heating effect. The condensed liquid refrigerant discharges from the heat exchanger 106E through pipe 4B, and passes directly to condenser 5, and thence by pipe 35 into a float valve 36 by which its flow to a liquid refrigerant cooler 77 is governed, being discharged from the latter through float valve 78 to pipe 33 through which it passes to the attic heat recovery device 107 for recirculation to the heat pump compressor 3. The liquid refrigerant cooler 77 performs a function similar to that performed by the pipes 7 in the system of Fig. 2, in that sensible heat is given up by refrigerant liquid for transfer by heat transfer fluid to the earth heat storage area 23. In the cooler 77, the liquid refrigerant flows from right to left in counterflow relation to cold heat transfer fluid flowing in the cooler contained coil 38 from left to right, said heat transfer fluid being delivered to coil 38 by pipes 22C and 37 from the relatively cool deep section of the coils 22 of the earth heat storage area 23. In so passing through the cooler coil 38, the heat transfer fluid is warmed.

Leaving the cooler coil 38, the warmed heat transfer fluid passes through pipe 39, valve 40 and through a restricted orifice fitting O to pipe 41, and thence to pump 30P which is driven by motor 30M. Pump 30P forces the warm heat transfer fluid by way of pipes 42 and 22H into the hot end of the earth heat storage area coil 22. The restricted orifice fitting O limits the flow of heat transfer fluid through the coil 38 of cooler 77 to a quantity sufficiently small so that the limited amount of condensed liquid refrigerant available in cooler 77 is able to warm the heat transfer fluid to a temperature substantially higher than the temperature of the top level of the earth heat storage area 23. Since the hot liquid refrigerant passes through the cooler 77 in counterflow relation to the heat transfer fluid, said refrigerant liquid is cooled nearly to the temperature of the relatively cool bottom level of the earth heat storage area 23.

In normal operation of the modified system of Fig. 3, when temperature of air blown through the attic heat recovery device 107 is e. g. above 25° F., pump 20P is idle, so that refrigerant evaporator 1 serves merely as a conduit to deliver cold refrigerant gas from the attic heat recovery device 107 to the heat pump compressor 3.

In very cold winter weather, if temperature of air serving the attic recovery device 107 drops to e. g. 25° F. or below, the fan 107F of heat exchanger 107E is stopped and said heat exchanger 107E fills up with condensed liquid refrigerant which overflows therefrom through pipe 34 into evaporator 1, while it fills to a normally maintained level 11. Pump 20P is started and operates to draw cold heat transfer fluid from coil 10 in evaporator 1 through check valve 20C, and forces this cold heat transfer fluid through pipe 21 into the deep end of the coils 22 of the earth heat storage area 23, and thence upwardly through said coils 22, whereby the heat transfer fluid is warmed by the heat in said storage area 23, and thereupon is returned for recirculation through the coil 10 of evaporator 1. Heat from the warm heat transfer fluid in coil 10 causes the liquid refrigerant in evaporator to boil, and the resultant refrigerant gas to pass to the heat pump compressor 3.

A solenoid coil 84 is connected in parallel with the motor 106M for fan 106F of the house heating device, so that when the fan motor 106 is running said solenoid coil

84 is energized to cause its armature 85 to be drawn up and thereby to close valve 45 and open valve 40 so that hot heat transfer fluid can be delivered by pump 30P to the coils 22 of the earth heat storage area 23 for delivery to the latter of heat for storage as above described.

In warm winter weather, when the temperature of air circulating in the attic heat recovery device 107 reaches a predetermined high value, and heat is not needed to heat the house, the fan motor 106M of the house heating device 106 is stopped, but the compressor motor 14 is continued in operation to drive the heat pump compressor 3, and motor 30M is also continued in operation. When the fan motor 106M is stopped, the solenoid 84 is deenergized and its armature 85 drops to thereby close valve 40 and open valve 45. Under these conditions, pump 30P draws a maximum quantity of hot heat transfer fluid through coil 12 of condenser 5, and pumps the same through pipe 22H to the top section of the coils 22 of the earth heat storage area 23, and thence through said coils 22 back to coil 12 of condenser 5 by way of pipes 22C and 43. While passing through coils 22, the hot heat transfer fluid gives up heat to the earth heat storage area for storage therein, being thereby cooled for return to condenser coil 12. When the fan motor 106M is shut down, very little heat is extracted from the hot refrigerant gas circulating through the house heating device 106, and said hot refrigerant gas flows through the house heating device 106, and said hot refrigerant gas flows through the latter to condenser 5 where it is condensed so as to give up its heat to the heat transfer fluid circulated from coil 12 by pump 30P. The liquid refrigerant is returned from condenser 5 to the attic heat exchanger 107E, and thence back to heat pump compressor 3 through the circuit already above described.

In Fig. 4 is shown another modified arrangement of the heat pump operated house heating system of this invention. The modified system of Fig. 4 differs from those of Figs. 2 and 3 mainly in the inclusion in the earth heat storage area 23 of a water tank type of auxiliary heat storage means located beneath the house, and wherein the refrigerant serves both as a heat pump treated medium and as a heat transfer fluid. In this arrangement, a water tank 55 of comparatively narrow width and of suitable depth is installed to extend lengthwise of the house through the earth beneath or adjacent to the house. The walls and floor of the tank are provided with suitable waterproofing 55A. The water in the tank 55 is maintained at the level 56. In normal operation, e. g. when the temperature of the air moving through the attic heat recovery device 107 approximates 45F, cold liquid refrigerant passes through pipe 33 to heat exchanger 107E of the attic heat recovery device, wherein it is evaporated, absorbing heat from the warm air blown through said heat exchanger 107E by fan 107F. The relatively cool refrigerant gas passes from heat exchanger 107E through pipe 34 and pipe 2 into the heat pump compressor 3, being thereupon compressed and superheated to pass thence through pipe 4A to heat exchanger 106E of the house heating device 106. The refrigerant gas is condensed in heat exchanger 106E, and thus gives up its heat to the house air which is blown through the latter by fan 106F. Leaving the heat exchanger 106E, the condensed refrigerant passes down pipe 4B into condenser receiver 5, rising therein to a level above normal level 47, thereby raising the float valve 46, and allowing hot liquid refrigerant to flow down through pipe 48 and through pipe 22H into the hot end of the coils 22 of the heat storage which are submerged in the water content of tank 55. The hot liquid refrigerant flows through said coils 22 thus giving up heat to the water in the tank and to the earth surrounding the tank for storage. The cool liquid refrigerant flows from coils 22 through pipe 22C to a receiver 49, and thence through pipe 50, expansion valve 51, branch pipe 61 to and through a two-way valve 52, which is set to deliver said refrigerant to pipe 33 for return to heat

exchanger 107E of the attic heat recovery device 107, to repeat the cycle of evaporation, compression and condensation.

In warm sunny winter weather, when e. g. the temperature of air moving through the attic heat recovery device 107 is 55° F. or higher, and the heat pump is not needed for house heating, fan motor 106F of the house heating device 106 is stopped, and consequently condensation of refrigerant gas delivered to heat exchanger 106E by heat pump compressor 3 practically ceases. Under these conditions, motor 130M is started to drive pump 130P, whereby said pump draws cold liquid refrigerant from receiver 49 through pipes 50 and 64, and delivers same through pipe 65 to a spray head 63 within the condenser receiver 5. The cold liquid refrigerant thus sprayed into the condenser receiver 5 condenses the hot refrigerant gas delivered by compressor 3 through heat exchanger 106E, so that the thus condensed refrigerant raises its level in condenser receiver 5 above the normal level 47, whereby to open float valve 46. Through the thus opened float valve 46, the condensed refrigerant, having been raised in temperature e. g. approximately 10° F., passes through pipes 48 and 22H to the coils 22 of the heat storage area, passing thence back to receiver 49 to be again returned to the condenser receiver spray head 63 to repeat the cycle. In this manner heat is delivered to the storage area for storage, and the temperature of the water in tank 55 is gradually raised until liquid pressure thermostat 23T induces operation of alarm sounding means to indicate to the householder that stored heat is ample, whereupon the householder can shut down the heat pump until need of its operation for house heating effect arises.

In very cold winter weather, when e. g. temperature of air moving through the attic heat recovery device 107 is e. g. below 25° F., liquid pressure thermostat 107T induces operation of alarm sounding means to indicate need for increased heat in service of the heat pump, so that householder may thereupon stop fan motor 107M and adjust the two-way valve 52 so as to divert condensed liquid refrigerant delivered through expansion valve 51 for flow to an under water evaporator 54 through pipe 53, said evaporator 54 being submerged in the water contained in the tank 55. In the evaporator 54 the delivered condensed liquid refrigerant boils and is thus evaporated, and the resultant refrigerant gas passes from said evaporator 54 through pipes 62 and 2 to the heat pump compressor 3 where it is compressed and superheated, and thence delivered to the house heating device 106 so as to be condensed in heat exchanger 106E, whereby to give up its heat of condensation to house heating air blown through heat exchanger 106E by fan 106F. The refrigerant condensed in the heat exchanger 106E passes thence to the condenser receiver 5, and through open float valve 46 to pipes 48 and 22H back to the storage area coils 22.

It will be obvious that, in normal operation, e. g. when pumping from 30° F. and higher, the hot condensed refrigerant gives up a large part of its sensible heat to the tank water and to the surrounding earth, so that this heat is stored.

Thermal check valves 71 are desirably connected between the earth underlying the tank 55 and the water content of said tank. These thermal check valves 71 are later herein described. Said thermal check valves function to conduct heat from deep earth underlying tank 55 to the water content of the tank, in the event that, during protracted spells of cold winter weather, the temperature of the water in the tank drops to 50° F. or below.

In a preferred arrangement, the coils 22 submerged in the water content of tank 55 are located between one side of the tank and baffle means extending through the tank. Cold water flows under the bottom 60 of the baffle, is heated and rises to flow over the top 59 of the baffle, thereby pushing cold water down so that warm water is

located at upper levels of the tank and cold water at lower levels thereof.

Referring to Figs. 5, 6 and 7, these views show an illustrative structural arrangement of the attic heat recovery device 107, whereby the air delivered therethrough will be automatically drawn either from indoor attic air or outdoor air, whichever is of higher temperature. The attic heat recovery device 107 comprises a duct structure having an upstanding intake section 107I at one end, which is open adjacent to the peak of the attic interior, and an upstanding discharge section 107D at its opposite end. Within and across the duct, between the intake and discharge sections, is located the heat exchanger 107E, fan 107F and motor 107M for driving the latter. The discharge section 107D of the duct is provided at its end with an outlet port 98, which opens into the attic interior, and in an adjacent side wall with a second outlet port 97, which opens through a branch duct 107B extending through the house wall W to outdoors. A damper 86, located within the discharge section 107D of the duct between the ports 98 and 97, is fixed on a shaft 87, so as to be movable to selectively close one of said ports and open the other. Temperature responsive means is provided for automatically moving said damper 86 to close either port 98 or port 97 accordingly as outdoor temperature is higher than indoor temperature, and vice versa. This temperature responsive means comprises an indoor Sylphon bellows 96, supported from the interior side of the house wall W by bracket 96A, and an outdoor Sylphon bellows 95 supported from the exterior side of the house wall W by a bracket 95A. These Sylphon bellows contain a volatile substance, such as butane, and the opposed ends of said Sylphon bellows are interconnected by a slide bar 94. Rotatably supported in connection with the attic heat recovery device 107, adjacent to said slide bar 94, is a pulley 89 upon the shaft of which is fixed a forked lever arm 93, the fork of which engages a laterally projecting coupler pin 94A affixed to the slide bar 94. To the pulley 89 is anchored a pull cable 92. This pull cable engages around a pulley 88 fixed on a shaft 87 by which damper 86 is actuated. The free end portion 91 of pull cable 92 is attached to an anchored pull spring 90. Pull spring 90 normally exerts pull on cable 92, whereby to rotate the pulley 88 and shaft 87 in direction to swing damper 86 into closed relation to the outlet port 98 which communicates with the attic interior.

In operation, the attic heat recovery device performs as follows: When attic air is at higher temperature than outdoor air, the butane in indoor Sylphon bellows 96 expands and that in outdoor Sylphon bellows 95 contracts. This results in sliding the slide bar 94 outwardly, to thereby move the forked lever arm 93 to the right, thus rotating the pulleys 89 and 88 counterclockwise, and thereby swinging damper 86 to closed relation to outdoor communicating port 97 and opening port 98. Under these conditions air is taken from the attic interior and passed through the heat exchanger 106E and back into attic. The heat pump is thus served by heat taken from warm attic air.

On the other hand, when outdoor air is at a higher temperature than attic air, the butane in outdoor Sylphon bellows 95 expands and that in indoor Sylphon bellows contracts. This results in sliding the slide bar 94 inwardly, to thereby move the forked lever arm 93 to the left, thus rotating the pulleys 89 and 88 clockwise, and thereby swinging damper 86 to closed relation to attic interior communicating port 98 and opening outdoor communicating port 97. Air will now enter the attic space through an intake passage means 153 (see Fig. 1), and will be passed through the heat exchanger 107E and thence back outdoors through port 97 and branch duct 107B. The heat pump is thus served by heat taken from outside air.

In the operation of the illustrative embodiments of the heat pump operated house heating system according to

this invention, when spring weather arrives, and prolonged cold weather spells are not likely to occur, charging of heat into the earth heat storage area 23 may be discontinued, and heat may be extracted from the earth heat storage area 23 whenever the temperature of said area is higher than that of outdoor air passed through the attic heat exchanger 107E.

In systems according to this invention in illustrative embodiments such as shown in Figs. 2 and 3, wherein an earth heat storage area 23 has imbedded therein heat transfer coils 22, it is desirable to provide in connection with said coils 22, between the same and the underlying earth mass, a thermal check valve structure which functions to transmit heat from deep earth to the coils 22 and the earth heat storage area 23 surrounding the latter, but which operates to prevent dissipation of heat to deep earth from said coils 22 and the surrounding earth heat storage area 23. One practical form of such thermal check valve structure is shown in Figs. 8 to 10 inclusive, and includes a series of one way heat conductive devices 70. Each said device 70 comprises a hollow, substantially flat thin metal envelope, preferably of the perpendicularly ribbed formation shown in Fig. 10 whereby to strengthen and reenforce the same against collapse or distortion. Each said envelope is filled to a level 75, spaced a substantial distance below its upper end, with a low boiling point liquid, such as butane. These one-way heat conductive devices extend between adjacent courses of the coils 22, i. e. from a lower course to a next course above, and are fastened thereto by thermally conductive concrete 72 composed of cement containing, as aggregate, a highly heat conducted material such as iron filings, steel chips or the like. To the lowest courses of the coils 22 are fastened a type of one-way heat conductive devices 71 which can be driven into the deep earth underlying the earth heat storage area 23. These latter devices are preferably in the form of metallic tubular members, closed at their upper ends by caps 77, and at their bottom ends by sharpened driving members 76. Each tubular member is filled to a level 78, spaced a substantial distance below its closed upper end, with a low boiling point liquid, such as butane. Each device is driven downward into the earth underlying the earth heat storage area 23, whereupon its upper end is fastened to a lowest level course of coils 22, by a thermally conductive concrete 72 such as already above described.

The thermal check valve structure functions as follows: Heat from deep earth contacting the tubular members 71 will cause the liquid contained therein to boil, and the resultant vapor at the cooler top of said members will condense, so that the heat of condensation will be transferred to the low courses of the coils 22. Heat from the low courses of the coils 22 will cause the liquid contained in the envelopes 70 to boil, and the resultant vapor will be condensed, so that the heat of condensation will be transferred to the earth of the earth heat storage area. In this manner heat may be recovered from deep earth in very cold winter weather. Since flow of heat downwardly through the thermal check valve structure cannot take place, said structures inhibit escape of any substantial amount of heat from the coils 22 and the surrounding earth heat storage area 23 to deep underlying earth.

In the system embodiment of Fig. 4, use of the thermal check valve envelopes 70 between courses of the coils 22 submerged in the water of the tank 55 is not necessary, and the thermal check valve structure may be limited to the inclusion of the tubular members 71 arranged to extend between bottommost courses of the coils 22, through the tank bottom, into deep earth, so that heat conducted from the deep earth is transferred substantially directly to the water content of tank 55.

The efficiency of the heat pump operated house heating system of this invention will be enhanced, when used in a house structure a substantial part of the living space

thereof extends below ground surface level and into the earth adjacent the earth heat storage area, since the living space contiguous to the earth will be maintained in a dry and livable condition.

The operation and advantages of the heat pump operated house heating system of this invention is indicated by the graphs of Figs. 11, 12 and 13.

In Fig. 11, the curve G indicates B. t. u. per hour plotted vertically against outdoor temperature plotted horizontally, and represents a heat pump having sufficient capacity to heat a house requiring a net heat input of 67,500 B. t. u. per hour at zero F. outdoor temperature; said house being erected above ground level.

Curve F represents the output in B. t. u. per hour, plotted as ordinate against outdoor temperature in deg. F. as abscissa, required to heat a house of the same size as in curve G but partially buried in the earth and having the attic built in the form of a solar heat trap, and having the earth under the house heated.

Curve E represents a heat pump able to supply 36,000 B. t. u. per hour at zero deg. F. and able to supply the 41,000 B. t. u. per hour required by the house at about 6 deg. F. (curve N). This heat pump taking heat from a minimum earth temperature of 10 deg. F. would be able to supply the 45,000 B. t. u. per hour required by this house at zero F.

Curve D represents the output of a heat pump having an output of 30,000 B. t. u. per hour at zero deg. F. and able to supply all heat requirements of the houses as shown (curve N) for temperatures above 10° F. and able to supply the heat requirements of a house at zero deg. when taking heat from the earth at 20° F.

Curve C represents the output of a heat pump able to supply about 26,000 B. t. u. per hour from air at zero deg. F. and able to supply the entire requirements of a house when taking heat from the earth at a temperature of 30 deg.

Curve B represents the output of a heat pump having exactly one-half the size of heat pump G and able to supply the house requirements when receiving heat from air at 17° F. (curve N) and able to supply the entire heat requirements of the house at zero deg. when taking heat from the earth at a temperature of 40° F.

Curve A represents the output of a heat pump having capacity of 20,000 B. t. u. per hour when receiving its heat from air at zero deg. F.; i. e. having a capacity of about 45 percent of the capacity of heat pump G and able to supply all requirements of the house from an outdoor air temperature of 20 deg. F. and above (curve N). This heat pump will be able to supply the entire heat requirements of a house at a temperature of zero deg. when taking heat from the earth at a temperature of 50 deg. F. Since it is proposed in this design to maintain an earth temperature seldom less than 60° F., heat pump A will be able to supply the heat requirements of the house. However, in order to have a substantial safety factor even after an unusually long cold spell the heat pump having an output in accordance with curve B might be used; i. e., having exactly one-half the capacity of heat pump (curve G).

In Fig. 12 curve A represents an approximate duration curve of outdoor temperature deg. F. against hours per year in the metropolitan district around New York.

Curve B is obtained from curve A by plotting directly under any temperature on curve A the heat requirement of the house as shown on curve N, Fig. 11, for that temperature; it therefore gives the B. t. u. per hour plotted at the extreme right against hours duration as abscissa.

The curve C electrical input in B. T. U. per hour as ordinate against hours duration as abscissa is obtained by dividing the requirements as shown on curve B by the coefficient of performance at that temperature as shown on page 555 of the July 1951 magazine of Mechanical Engineering. These coefficients are plotted as the lower

abscissa in Fig. 12. If the electrical B. t. u. per hour at any duration is divided by 3,413 (the B. t. u. in one kilowatt hour), the curve D is plotted against kilowatt demand as ordinate on the extreme left and duration in hours per year as abscissa.

In Fig. 13 curve A is the same as curve D in Fig. 12. By referring, however, to curve B in Fig. 11 it is seen that if the heat pump D accepts its heat from the ground at the expected ground temperature of 60° F. with a coefficient of 5 as shown in Fig. 12, then instead of having a power requirement as shown by curve A, the power requirement will be as shown by curve C; i. e., at zero deg. F. outdoors but with ground heat received at 60° F. the coefficient of performance will be 5 instead of 2.5 and the maximum demand will be reduced to one-half by reason of the fact that the heat pump is receiving heat from the earth at 60° F. at a coefficient of performance of 5, while the heat pump G (Fig. 11) received heat from outdoor air at zero F. at a coefficient of performance of only 2.5.

Curve X illustrates the variable demand which will be obtained if the heat pump in the range between 25° F. and 30° F. is sometimes run on outdoor air and sometimes run on ground storage; i. e., in this range it will be run on ground storage whenever the ground temperature is, say, above the desired 60° F. and it will be run on outdoor air in this range when the ground temperature is under the desired 60° F.

The cross hatched area between curves A and B illustrates the amount of energy that will be required to pump heat from a warm attic into the warm earth.

I am aware that many embodiments of my invention differing from those shown could be made without departing from the scope thereof as defined in the following claims. It is therefore intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a house heating system employing a heat pump, an earth heat storage area under the house to receive and store heat from said pump in the warmest winter weather when the house space does not require heat and to serve as a relatively high temperature heat source for said pump in the coldest winter weather when the house space needs heat, conduit means between the heat pump and storage area for conducting heat transfer fluid from one to the other, said conduit means including coils imbedded in the earth of said storage area, said coils having courses thereof perpendicularly spaced within said earth, said conduit means being so connected with the heat pump that warm heat transfer fluid moving from the pump to the storage area enters the high level courses of the conduit coils and back to the pump from the low level courses of said conduit coils but when heat transfer fluid is circulated to supply heat to the pump the same is drawn from the high level courses of the conduit coils and returned to the low level courses thereof, and one-way thermally conductive devices connected between low level and high level courses of said conduit coils operative to induce upward flow of heat therebetween, said devices operating to transfer heat to the storage area earth during delivery of the heat output of the heat pump thereto, said devices being adapted, on the other hand, to receive heat from the storage area earth and conduct it to heat transfer fluid circulated in said conduit coils when supplying heat from storage to the heat pump, whereby dissipation of stored heat to deep earth underlying the storage area is reduced to a minimum.

2. In a house heating system employing a heat pump according to claim 1, further including thermally conductive check valve means arranged to penetrate deep earth underlying said earth heat storage area and connected in heat transfer relation to the lowest courses of the coils of said heat transfer conducting conduits im-

bedded in said storage area, whereby, when heat stored in said storage area drops to a low temperature value, residual heat from said deep earth is transferred to said storage area.

3. In a house heating system, an electrically operated heat pump including an evaporator and a condenser, heat transfer fluid upon which the heat pump operates, a heat storage means provided by the earth beneath the house to be heated and comprising an upper level storage earth area and an underlying lower level storage earth area, heat transfer fluid conducting means comprising an upper section extending through the upper storage earth area and a lower section extending therefrom through the lower storage earth area, means operable during a heat storage period adapted to circulate hot transfer fluid through said conducting means in one direction, a second means operable during a stored heat withdrawal period to circulate cool transfer fluid through said conducting means in the opposite direction, said first mentioned circulating means comprising a means operative to move hot transfer fluid from the heat pump condenser first through the upper section of said conducting means which contacts the upper storage earth area, then on through the lower section of said conducting means which contacts the lower storage earth area and thence back to said condenser, and said second mentioned circulating means comprising means operative to circulate cool transfer fluid from the heat pump evaporator first through the lower section of said conducting means which contacts the lower storage earth area, then on through the upper section of said conducting means which contacts the upper storage earth area and thence back to said evaporator, all whereby said upper storage earth area is maintained at a relatively high temperature and said lower storage earth area is maintained at a relatively low temperature so that heat loss to deep earth is held to a minimum.

4. In a house heating system according to claim 3, one-way thermal check valve means cooperative with said conducting means and operative to transmit heat from underlying deep earth to the storage earth areas and to the sections of said conducting means extending through the latter, whereby dissipation of heat from the storage earth areas to deep earth is counteracted.

5. A house and heating system therefor including an electrically driven heat pump having an evaporator and a condenser normally operative to pump heat from outdoor air to heat the house space, said house including an attic space having a roof constructed to pass solar energy therethrough to raise the temperature of attic air during sunny winter days, an external cover for said roof adapted to insulate it from cold winter air without impeding transmission of solar energy, an attic heat recovery device connected by heat transfer fluid conduit means with the heat pump evaporator whereby to supply heat from the attic air to said evaporator, damper means operative to control movement of either attic air or outdoor air through the attic heat recovery device whichever is warmer, means responsive to both attic and outdoor air temperature for actuating said damper, a house space heating device connected by heat transfer fluid conduit means with the heat pump condenser to receive heat from said condenser, a heat storage area provided by the earth adjacently underlying the house space, heat transfer fluid conducting means imbedded in the storage earth area, means to circulate hot transfer fluid from the heat pump condenser through said conducting means, whereby to transfer heat to said storage earth area when heat is not required by the house space heating device, and means to circulate cool heat transfer fluid from the heat pump evaporator through said conducting means, whereby to transfer heat from said storage earth area to the transfer fluid and said heat pump evaporator during extreme cold weather.

6. A house and heating system therefor including an electrically driven heat pump having an evaporator and a condenser normally operative to pump heat from outdoor air to heat the house space, said house including an attic space having a roof constructed to pass solar energy therethrough to raise the temperature of attic air during sunny winter days, an external cover for said roof adapted to insulate it from cold winter air without impeding transmission of solar energy, an attic heat recovery device connected by heat transfer fluid conduit means with the heat pump evaporator whereby to supply heat from the attic air to said evaporator, damper means operative to control movement of either attic air or outdoor air through the attic heat recovery device whichever is warmer, means responsive to both attic and outdoor air temperature for actuating said damper, a house space heating device connected by heat transfer fluid conduit means with the heat pump condenser to receive heat from said condenser, a heat storage means provided by the earth beneath the house and comprising an upper level storage earth area and an underlying lower level storage earth area, heat transfer fluid conducting means comprising an upper section extending through the upper storage earth area and a lower section extending therefrom through the lower storage earth area, means operable during a heat storage period to circulate hot transfer fluid through said conducting means in one direction, a second means operable during a stored heat withdrawal period to circulate cool transfer fluid through said conducting means in the opposite direction, said first mentioned circulating means comprising a means operative to move hot transfer fluid from the heat pump condenser first through the upper section of said conducting means which contacts the upper storage earth area, then on through the lower section of said conducting means which contacts the lower storage earth area and thence back to the condenser, and said second circulating means comprising means operative to circulate cool transfer fluid from the heat pump evaporator first through the lower section of said conducting means which contacts the lower storage earth area, then on through the upper section of said conducting means which contacts the upper storage earth area and thence back to said evaporator, all whereby said upper storage earth area is maintained at a relatively high temperature and said lower storage earth area is maintained at a relatively low temperature so that heat loss to deep earth is held to a minimum.

7. A house and heating system therefor according to claim 6, including one-way thermal check valve means cooperative with the earth imbedded heat transfer fluid conducting means to transmit heat from underlying deep earth to the storage earth areas and to the sections of said conducting means extending through the latter, whereby dissipation of heat from the storage earth areas to deep earth is counteracted.

8. In a house heating system, an electrically driven heat pump comprising a refrigerant evaporator, a refrigerant compressor and a refrigerant condenser, a heat storage area in earth beneath the house, heat transfer fluid conducting means extending through said heat storage area, a heat transfer fluid conductive coil within the heat pump evaporator and connected in circuit with said heat transfer fluid conducting means traversing the heat storage area, another heat transfer fluid conductive coil within the heat pump condenser also connected in circuit with said heat transfer fluid conducting means traversing the heat storage area, the house containing an attic space, a metal roof over said attic space, a cover for said metal roof adapted to insulate it from cold blasts of winter air yet allowing solar energy to pass freely therethrough, whereby the attic air is heated during sunny winter days, an attic heat recovery device, means for circulating heat transfer fluid from the evaporator coil through said attic heat recovery device, whereby to supply heat from attic air to the heat pump, alternate means for circulating heat trans-

17

fer fluid from the heat transfer fluid conducting means of the storage area through said evaporator coil, whereby to supply heat from the heat storage area to the heat pump, a house heating device, means for circulating heat transfer fluid from the condenser coil through said house heating device, whereby to supply heat to the house space, 5 alternative means for circulating heat transfer fluid from said condenser coil through the heat transfer fluid conducting means traversing the heat storage area, whereby to charge heat into said storage area, and a damper means 10 operative in the attic heat recovery device to control movement therethrough of either attic or outdoor air, whichever is warmest, and means responsive to attic and outdoor air temperatures operative to automatically actuate said damper means.

15

18

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