

June 16, 1942.

W. A. LEA ET AL

2,286,366

ORCHARD HEATER

Filed Nov. 26, 1937

2 Sheets-Sheet 1

Fig. 1.

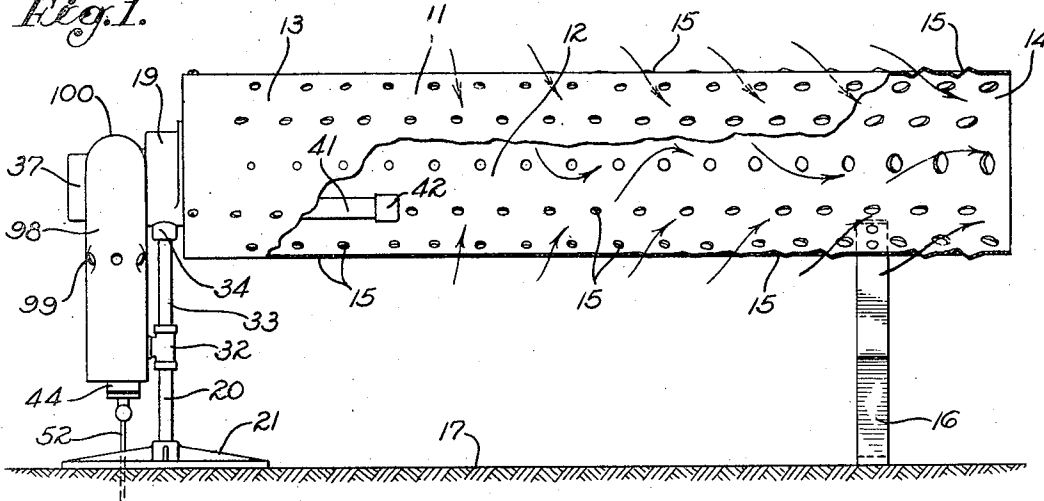


Fig. 2.

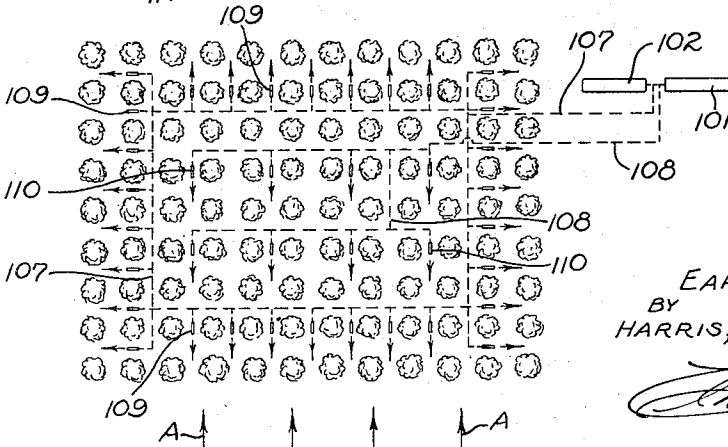
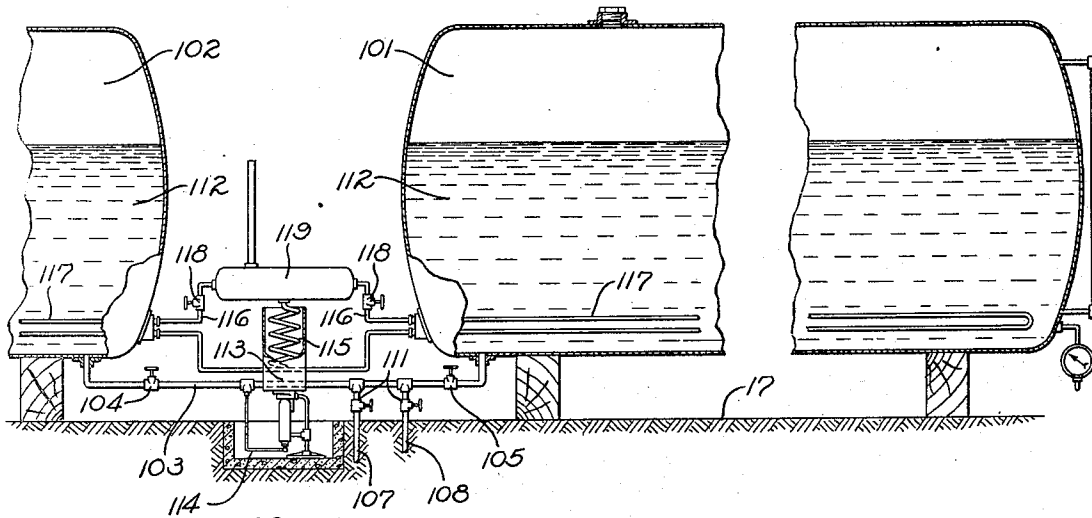


Fig. 3.

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2 Sheets-Sheet 2

Fig. 5.

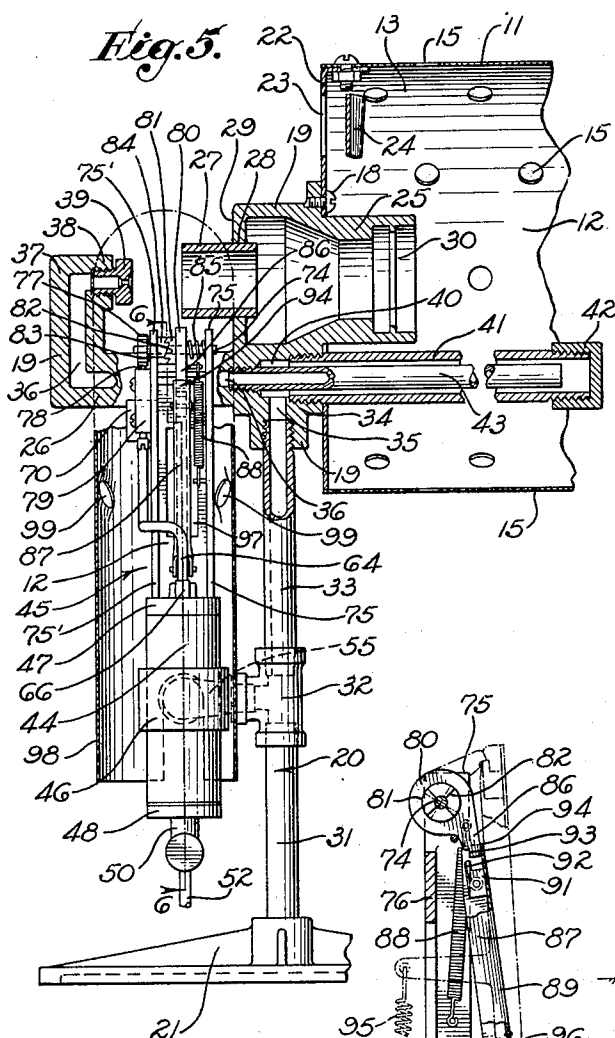


Fig. 4.

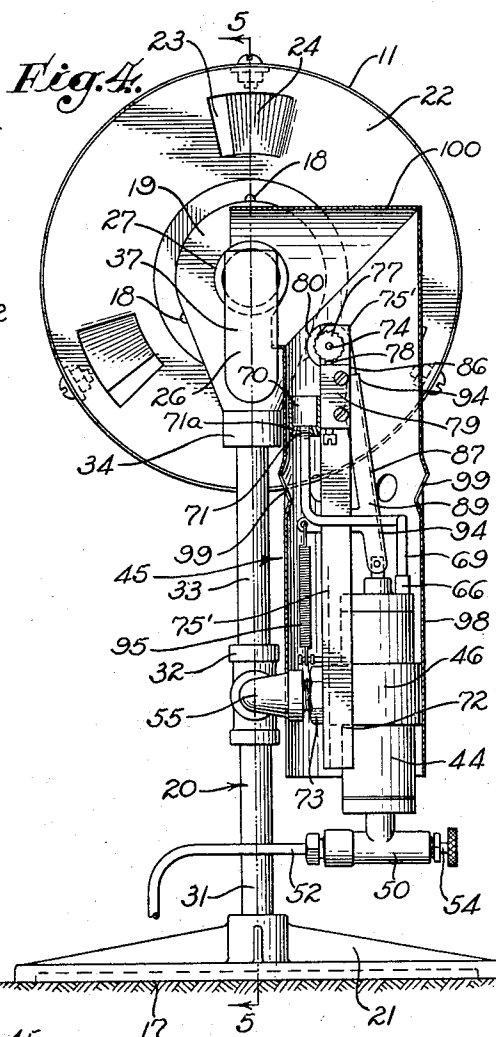
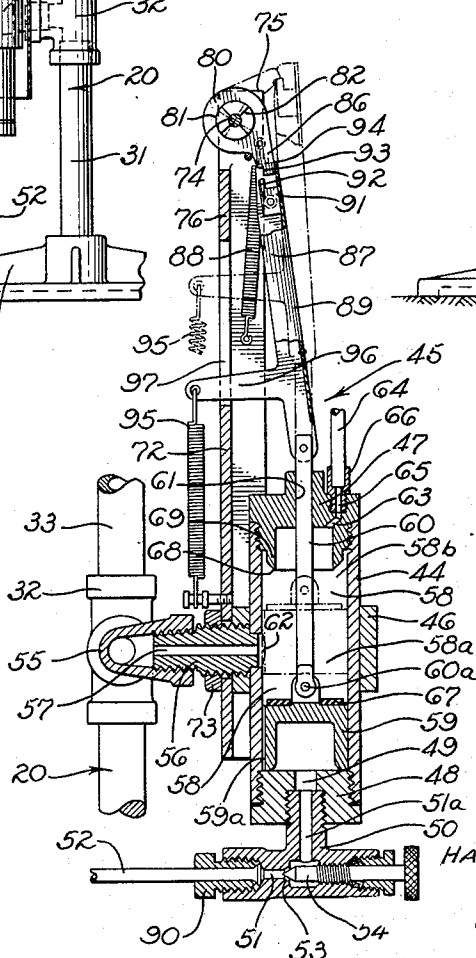


Fig. 6.



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2,286,366

ORCHARD HEATER

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Application November 26, 1937, Serial No. 176,614

3 Claims. (Cl. 126—59.5)

This invention relates to air heaters and particularly to heaters adapted for use in batteries of units for heating extended areas at a plurality of points of heat generation. In the description and drawings, orchard heating has been selected as an illustration of a type of installation of heaters of our invention, but we do not wish our invention to be considered as limited to this adaptation, since it is also capable of employment to heat shop rooms, buildings, and other extensive volumes of air.

It is one of our objects to provide a heater which shall completely and efficiently burn a gaseous fuel supplied to it without the production of smoke, soot, or other products of incomplete combustion.

It is another object to provide a heater which shall be automatically ignited by the flow of fuel to the heater, or by the pressure of the fuel in the supply conductor.

It is another object to provide a heater which shall be adapted to receive a fuel of the type which is liquid within the range of atmospheric temperatures above freezing at pressures above atmospheric normal, but which is gaseous at temperatures above freezing at normal atmospheric pressure, and shall be further adapted by lowering its pressure to convert a liquid fuel of this type into a gas and then burn it.

It is another object of our invention to provide a heater which shall be constructed to mix and heat air with the heated products of combustion and thereby increase the quantity and velocity and lower the temperature of the resulting mixture of gases discharged from the heater.

It is still another object of our invention to provide a heater having both a pilot burner and main burner and consuming fuel supplied under pressure in which either the pilot or the main burner shall operate according to the degree of pressure in the supply conductor.

It is still another object of our invention to provide a heater which shall discharge its heated products in a desired horizontal direction and more particularly in a focused horizontal stream, to more gradually and uniformly warm the ground air, than is otherwise possible, to the end that the layer of warm air at higher levels which is above the safety temperature may not be penetrated by localized currents of vertically moving columns of hot air. This feature, by which we are able to propel the heated products in any desired horizontal direction, makes it possible to oppose, halt, and turn back horizontally moving currents of cold air that may be moving toward

or into the orchard or other area which it is desired to warm.

It is a further object of our invention to provide a heater which shall be so constructed as to secure its heating effect principally from convection, and which shall have a minimum of radiation to the end that the ground and surrounding objects may not be unduly heated with destructive effect.

Our invention, also, has as one of its objects the provision of a heater which shall be adjustable in rate of output of thermal units from a relatively very small quantity to a quantity of heat units much above prior practice in orchard heating, to the end that fewer heater units may be required in a given area, and at the same time no disadvantages flow from the corresponding greater concentration of heat emitted from each unit, such as scorching the ground or foliage or piercing the ceiling of warm upper air stratum.

It is a further object of our invention to make provision for the use of our heaters in batteries which shall be subject to a unitary remote control of the ignition, for the selection of either pilot or main burner, and of the rate of production of thermal units of the individual heaters.

It is a further object of our invention to provide a heater which either singly or in batteries may be supplied with a fuel in liquid form in conductors of small size and cost, which fuel shall be converted to gaseous form at the heater units. To accomplish this advantageous result, we prefer to employ as fuels butane, propane, pentane, hexane, or other hydrocarbon of this type, which are liquid at all ordinary atmospheric temperatures above freezing in combination with super-atmospheric pressures ranging upward from about ten pounds per square inch, depending upon the temperature and the particular type of fuel, but which fuels at the same temperatures are gaseous at normal atmospheric pressure. We accordingly store the fuel in tanks under pressure, and pipe it under pressure and in liquid form to the heater units, where the pressure is released and the fuel is gasified and burned.

It is a further object of our invention to provide means for maintaining the pressure in the supply system sufficiently high to ensure the fuel being in liquid form until it reaches the heater units, and also to ensure a constant rate of supply to the heaters, with a resultant constant rate of liberation of thermal units.

Still other objects and advantages of our in-

vention will appear from the description and drawings, of which:

Fig. 1 is a view in side elevation of the heater with a part of the flue broken away.

Fig. 2 is a sectional elevation of two associated fuel supply tanks and tank heater.

Fig. 3 is a schematic plan view of an orchard showing one possible arrangement of heaters therein.

Fig. 4 is an enlarged elevational view of the heater shown in Fig. 1, with the pilot hood shown in section.

Fig. 5 is a side elevational view in section of the burner end of the heater taken along the line 5—5 of Fig. 4, the pilot assembly being shown in side elevation in front of the section plane.

Fig. 6 is a vertical sectional view of the pilot assembly taken along the line 6—6 of Fig. 5.

A horizontally disposed cylindrical heater flue 11 receives the jet of burning gas at its one end 13, and conducts and directs it longitudinally within its interior chamber 12, the heated products of combustion being discharged horizontally from the other and open end 14 of the flue 11. As the jet of flame travels through the flue, air is drawn in through louvered apertures 15. These apertures 15 are designed to supply an excess of air, this excess is mixed with and heated by the hot gases of combustion, and both increases the volume and velocity and correspondingly lowers the temperature of the resulting gaseous discharge from the flue. The cold air entering through the apertures 15 also lowers the temperature of the flue walls and reduces radiation therefrom.

The injector action which tends to draw air into the stack is greatest at the burner end 13 of the stack and least at the discharge end 14. Accordingly the apertures 15 may be of variable size, increasing progressively from the burner end 13 to the discharge end 14, being so formed that the planes of the louvered apertures are progressively changed in angular relationship to the plane tangential to the adjacent portion of the flue wall, the planes of the bounding edges of the apertures at the burner end lying flat in the flue wall, and the planes of the bounding edges of the apertures at the discharge end being tilted at a substantial angle to the longitudinal lines of the flue wall. This design of the louvered apertures provides for an intake of air into the flue in substantially equal amounts through the several apertures, irrespective of their position longitudinally of the flue, since the apertures of greater diameter and greater angular set at the discharge end offer less resistance to the flow of air therethrough, a feature which compensates for the lesser degree of injector action at the discharge end. The angular set of the apertures also prevents discharge of the gaseous contents of the flue through the louvered apertures, which would dissipate the heat laterally of the flue, instead of discharging it in a horizontal jet as it is contemplated by our invention.

The flue 11 is rigidly mounted at its discharge end upon a supporting standard 16 which is movable with respect to the ground 17 upon which it rests. At the burner end, the flue 11 is provided with an end wall 22 which may be integral with the side walls of the flue 11 or secured thereto by welding, by bolts, or in any well known manner. The end wall 22 is secured by screws 10 to a burner casting 19, which is in turn supported upon a standard 20. This standard 20 is provided at its lower end with a pedestal 21 which

is movable upon the ground 17. The vertical cylindrical end wall 22 of the flue 11 is formed with intake openings 23 to admit air to the interior chamber 12 of the flue. In stamping the end wall to make these openings 23, the metal is cut on three sides of the opening and the flap thus formed is bent inwardly to provide a deflector 24 to impart a spiral movement to the air rushing in through the openings, which movement gives the air and burner flame a thorough mix resulting in more complete incorporation of the excess air in the heater discharge.

The burner casting 19 comprises a horizontally disposed hollow mixing cylinder 25 and a goose neck projection 26 extending rearwardly from the under side of the cylinder 25. The fuel gas and injected air enter the cylinder 25 through a rearwardly extending cylindrical intake hood 27 secured in an opening 28 in the rear wall 29 of the cylinder 25 and in axial alignment with the cylinder. The air and gas are thoroughly mixed in the cylinder 25, combustion takes place therein, and they leave it through a circular opening 30 at its forward end, entering the flue as an extended flame therein.

The standard 20 consists of a lower solid vertical rod 31, a T fitting 32, threadedly mounted at the upper end of rod 31, and an upper pipe section 33 having threaded engagement with the T 32 at its lower end and at its upper end with a boss 34 formed on the under side of the projection 26. This boss 34 has a central vertical bore 35 communicating with the interior of the pipe section 33 at the point of threaded engagement. The bore 35 also communicates at its upper end with a bore 36 in the gooseneck projection 26, which bore extends horizontally from the front end of the projection 26, rearwardly to a vertical leg 37 thereof, thence upwardly to a horizontally disposed end portion 38, and thence horizontally to the end of projection 26. The bore 35 at the end portion 38 is threaded and into it is screwed the burner tip or nozzle 39 in axial alignment with the intake hood 27.

The forward end of the bore 36 has an enlarged portion 40 which is threaded at its front end to receive the rear end of the cylindrical pre-heater 41, which projects horizontally into the flue chamber 12 between the axis and lower wall thereof for a relatively short distance, and is closed at its outer end with a cap 42. A horizontal pipe section 43, open at both ends, is threadedly mounted at its rear end in the front end of that portion of the bore 36 which is of smaller diameter. This pipe section projects into the pre-heater 41 and its forward end is disposed a short distance from the cap 42.

A cylinder 44 of a pilot assembly 45 is closed by cylinder heads 47 and 48 at its upper and lower ends respectively. The head 48 is provided with a central vertical bore 49, of which the lower end is threaded to receive the vertical leg of a T-shaped fitting 50. The horizontal portion of fitting 50 is provided with an axial bore 51, of which one end is enlarged and threaded to receive a compression joint 52 at the end of a fuel supply pipe 52 which conducts fuel from the source of supply to the heater. The other end of the bore 51 is formed with a valve seat 53 and has mounted therein an adjustable needle valve 54 of standard construction. Bore 51 communicates with bore 49 through a vertical bore 51a in the vertical leg of the fitting 50. When butane or similar liquid fuel is employed, it is conducted as a liquid under pressure to the heater and as it

passes through the needle valve in fitting 50 its pressure is removed and it is converted into a gas. The cylinder 44 is supported vertically by a connection to the T 32 consisting of an elbow fitting 55, which is threaded into the horizontal leg of the T 32, and a horizontal short nipple 56, which has a threaded connection at one end with the fitting 55, and a threaded connection at the other end with a band 46 which encircles and is rigidly secured to the cylinder 44 about midway of the ends of the cylinder. The interior 57 of the nipple 56 communicates at one end with the lower portion 58a of the interior chamber 58 of the cylinder 44, and at the other end with the interior of the elbow 55, which in turn communicates with the interior chamber of the T 32 and the pipe 32.

Within the cylinder 44 is slidably mounted a piston 59 which is adapted to impart a reciprocatory motion to a piston rod 60. This rod is suitably secured by a wrist pin connection 60a to the upper face of the piston and is slidably mounted within an axial bore 61 extending vertically through the cylinder head 47. As the piston 59 is moved upwardly by the pressure of the fuel entering the cylinder 44 from the pipe 52, it uncovers a main fuel outlet port 62 as its lower end passes above the level of the bore 57. At the same time a small fractional part of the fuel leaks by the piston between it and the walls of the piston 44 into the upper chamber 58b. This leakage then passes through a duct 63 in the cylinder head 47, and through a bore 65 of a fitting 66 and issues from the cylinder into a pilot tubing 64, which is secured to the cylinder head 47 by means of this fitting 66. While not usually necessary, the piston wall may be provided with a longitudinal groove 59a to ensure passage of this small quantity of fuel by the piston to chamber 58b. When the piston reaches the upper limit of its movement, a valve disk 67, made of synthetic rubber or other suitable material and fastened to the upper face of the piston, contacts an annular valve seat 68 formed on an annular projection 69 extending downwardly from the cylinder head 47, and halts the passage of fuel from the cylinder chamber 58 to the pilot tubing 64.

The pilot tubing 64 terminates at a point such that when the fuel issuing from it is ignited, the pilot flame will be projected into the neighborhood of the fuel jet issuing from the nozzle 39 of the main burner. The upper end of the pilot tubing 64 is provided with a mixing cup 70 formed with a central tapped opening 71 in its bottom wall into which the upper end of the tubing is threaded, and having two air intake openings 71a also in its bottom wall which admit air for combustion of the pilot flame.

The frame for the igniter mechanism is a channel-shaped upright 72, which is mounted in position by means of a nut 73 threaded upon the nipple 56, by which it is drawn into fixed position against the band 46. A pin 74 is revolvably mounted between flanges 75 and 75' of the upright 72. These flanges extend upwardly a short distance above the upper end of a channel web 76. The pin 74 projects beyond the flange 75' and has fixedly mounted upon the projecting portion a steel disk 77, the rim of which is serrated and frictionally contacts a piece of flint 78. This flint is held resiliently against the rim of disk 77 by means of a spring (not shown) within a housing 79 mounted upon the outer face of the channel flange 75'. The peripheral rim of the disk 77 and the flint 78 are so constructed and

their contact relationship is of such a character that when the disk is given a rapid movement of rotation through a small arc, sparks are generated sufficient to ignite the jet of fuel gas issuing from the adjacent pilot cup 70. This rapid rotational movement is imparted to the disk by means of a mechanism described as follows.

An impulse wheel 80 is loosely mounted upon the pin 74 between the channel flanges 75 and 75'. It is formed with an axial projection 81 extending toward the channel flange 75', having jaws 82 which engage in mating relationship jaws 83 formed on a disk 84 which is keyed or otherwise fixedly secured to the pin 74. The impulse wheel 80 is resiliently held axially against the disk 84 by means of a spiral spring 85 interposed between the flange 75 and the impulse wheel. The impulse wheel is provided with an integral dog 86 which is resiliently held in a vertically depending position against the upper end of an arm 87 by means of a spring 88 secured at its upper end to the dog 86 and at its lower end to the flange 75'. The arm 87 is channel-shaped in cross section and is arranged with its flanges 89 extending toward the upright 72. A block 91 is rigidly secured between the flanges 89 and the arm 87 and is formed with an upwardly extending lip 92 which mates with a notch 93 formed on the lower end of the dog 86. The arm 87 is hinged at its lower end to the upper end of the piston rod 60, and at its upper end its web 94 engages in vertically slidable contacting relationship the outer face of the dog 86, and is resiliently held in such relationship by means of a spring 95 secured at its lower end to the outer face of the web 76 of the channel standard 72, and at its upper end to a cross arm 96 which is integrally formed upon and projects from the arm 87 near its lower end, and which extends through, and is free to move vertically in, a slot 97 formed in the standard web 76.

A cylindrical hood 98 formed with a ring of louver openings 99 and supported loosely upon the elbow 55 serves to enclose all parts of the pilot assembly 45, protecting it from rain when the heater is used in exposed locations, and shielding the pilot flame from wind. An upper horizontal portion 100 of the hood 98 serves to direct the pilot flame toward the fuel jet of the main burner and insures a quick positive ignition thereof.

The igniter mechanism is so constructed and arranged that when the piston 59 is at its lowermost position, the block 91 and the dog 86 are slightly separated, and the upper end of the web 94 rests upon the back of the dog. As the piston moves upwardly, the block 91 engages the dog 86 and rotates the wheel 80 until, as shown in dotted lines in Fig. 6, the dog 86 disengages the lip 92 and the impulse wheel 80 is given a sudden rotational movement by the action of the spring 88. The jaws 82 which latch idly by jaws 83 during the upward movement of the dog 86, engage these jaws 83 on the downward impulse, and the steel disk 77 rubs against the flint 78 and generates igniting sparks.

While heaters equipped with our igniting mechanism will operate on natural gas, we prefer to use a liquid fuel of the character above described. When liquid fuel such as butane is used, it is centrally stored in a common reservoir. We prefer to use two tanks, which are given exemplary illustration in Fig. 2 and are designated with the numerals 101 and 102. The

use of two tanks instead of one affords an advantage in that when one tank is emptied in the operation of the heating system, it can be shut off from the heaters and refilled while the other tank is furnishing the fuel supply. The fuel outlet pipe 103 is equipped with shut-off valves 104 and 105 by which the supply network of pipes shown in Fig. 3 can be connected to either or both of the supply tanks. We prefer to divide this supply system of pipes into two or more sub-systems, 107 and 108, each sub-system being provided with a shut-off operating valve 111 so that either can be operated without the other, or both can be operated simultaneously, as may be desired.

It will be understood that the heaters may be grouped in one or more systems for group operation as indicated by the size and other conditions of the orchard. We have illustrated in Fig. 3 a sample installation. In this installation the sub-system of pipes 107 is connected to heaters 109 disposed about the four edges of a rectangular orchard. The heater units, as will be understood by reference to the above description of an individual heater unit, are capable of being placed with their flues pointing in any desired direction. Heaters 109 are shown in Fig. 3 as directed outwardly toward the boundaries of the orchard, and, in an installation such as shown in Fig. 3, can be fired in advance of the firing of the remaining heaters 110 supplied by pipe system 108, which heaters are located in the central portions of the orchard. Heaters 110 are shown with their flues pointing toward the prevailing movement of cold air as indicated by the arrows A.

The liquid fuel, indicated in Fig. 2 by the numeral 112, is held under pressure in the tanks. As the tank is gradually emptied of its supply the pressure therein tends to drop. Since the pressure of fuel at the heaters determines the rate of flow of fuel thereto, and consequently the rate of liberation of thermal units, it is desirable to maintain a fairly constant pressure in the supply tanks. We accomplish this by providing a tank heater 113, which heater may be similar to those used in the orchard. Such a heater may be fed from the fuel outlet pipe 103 through a pipe 114, and the feed controlled by a needle valve such as shown at 54, in Fig. 6. Water in a closed system, which is provided with an expansion tank 119, is warmed in a coil 115 and conducted through a pipe 116 to a heating loop 117 mounted within the fuel tank and adjacent its bottom, and thence back to the heater 113. By regulation of the flow of fuel to heater 113, and by regulation of the flow of water by means of a valve 118, the liquid fuel within either tank can be raised to any desired temperature, and the pressure thereby increased to any desired degree, maintaining a constant pressure at the heaters or varying it as desired, according to the varying heating needs of the orchard. It will also be apparent that by selective regulation of the needle valves 54, the quantity of fuel consumed in any individual heater unit and the resultant liberated thermal units can be varied at will. By means of the valves 54 those heaters at greatest distances from the supply tank can be regulated to compensate for the greater pressure drop due to hydraulic friction in the supply pipes.

In operating our heaters, butane or liquid fuel of similar properties is stored under pressure, for example a pressure of seventy pounds at

100° F., in the storage tanks 101 and 102. The corresponding valve 105 or 104 is fully opened and either one or both of the operating valves 107 and 108 are fully opened, subjecting the network or networks of supply pipes to the full tank pressure less the loss in pressure head due to hydraulic friction of the fuel liquid within the distributing pipe system. When the liquid fuel under pressure reaches one of the needle valves 54 and passes therethrough, its pressure is reduced. In accordance with the physical properties of this type of liquid fuel, it is gasified as it leaves the needle valve, and as a gas enters the cylinder chamber 58. Here it exerts pressure upon the piston 59 which begins to move upwardly. Gas leaks by the piston or passes through the groove 59a into the upper cylinder chamber 58b and thence by the pilot tubing 64 to the pilot cup 70, where it is mixed with air and is jetted upwardly. As the piston 59 moves upward, it operates the arm 89 which, by the train of devices heretofore described, generates igniting sparks adjacent the pilot jet of gas. In the meantime the piston 59 has uncovered the port 62, and fuel gas passes from the chamber 58 through the bore 57, elbow 55, fitting 32, pipe section 33, bore 35, bore 40, preheater 41, pipe section 43, bore 36, to the nozzle 39, from which it issues in a jet of high velocity. This fuel jet is ignited by the pilot flame issuing upwardly from the pilot tubing 64 and then enters the intake hood 27.

As it streams rapidly into the hood 27 and mixing cylinder 19, air is drawn in through the annular gap between the nozzle 39 and hood 27, and is carried along with the fuel jet into the mixing chamber within the mixing cylinder 19. This air is sufficient for complete combustion. No soot, smoke, or other unburned products are blown from the heater, but we provide the flue 11 with louvers 15 to supply a substantial excess of air as has been heretofore described. The principal purpose, fulfilled by these louvers and the openings 23 in the end wall 22 of the flue, is that of mixing a substantial excess of air with the products of combustion so as to increase the quantity and velocity and lower the temperature of the resulting heater discharge. This cold air entering the sides of the tubular member in and around the flame produces a very decided Venturi effect and thereby increases the velocity of the issuing volume of heated air. This is due to the fact that a column of fluid in motion has a reduced pressure along its side. This can be determined by the aid of an equation from Torricelli's theorem, wherein

$$P = \frac{1}{2} V^2 D$$

wherein V equals the velocity, D the density of the fluid and P the amount of reduced pressure, so that, $\frac{1}{2}$ the velocity squared times the density gives P, the amount of reduced pressure.

As the liquid fuel expands and vaporizes upon entering the cylinder chamber 58, heat of vaporization is supplied from surrounding bodies and atmosphere, greatly reducing their temperature and that of the gas itself. This refrigerating effect is partly overcome after the heater is in normal operation by the radiation and conduction of heat from the burner flame. To assist in offsetting this refrigerating effect, and to ensure complete gasification of any liquid droplets, we provide the pre-heater 41 which is interposed in the path of the fuel to the nozzle

75 39.

It will be observed that the heaters create a focused movement of hot air in any desired horizontal direction. These horizontal streams of hot air mingle with and raise the temperature of the lowermost stratum of air in the orchard, which, because of its resultant decrease in density, begins a gentle upward movement. Gradually the entire layer of air below the ceiling of the upper layer of warmer air, which is above the danger point, is itself brought up to a safe temperature. Not until all areas of this cold lower layer are warmed to the ceiling temperature can any of the air streaming from the heaters pierce the ceiling with resultant loss of unused thermal units. Were the heaters to discharge their hot gases vertically upward, instead of horizontally as practiced by our invention, the lower stratum below the ceiling would have spotted areas of hot air over the heaters, and relatively cooler areas therebetween, with the result that the air in the heated areas would penetrate the ceiling and be ineffective in warming the air around the trees, and this penetration of the ceiling would occur before the entire ground layer was brought up to the safety temperature. We consequently conserve all the heat units potentially present in the fuel, first by completely burning it, and then by mixing it with cool air in the flue and discharging it horizontally at a high velocity in focused fashion in large streams of relatively low temperature.

While we have described one method of igniting the burner in our heater, we do not limit ourselves to this one method of practicing our invention. Lighting of the burner may be effected by a remotely controlled electric spark, or by making provision for the generation of flame temperatures adjacent the burner jet by chemical means such as the adsorption of the fuel gas by metals or other materials when the fuel gas reaches the heater.

We desire not to limit the scope of our invention to any particular form or embodiment thereof which may have been described above, but have defined it in the following claims.

We claim as our invention:

1. An orchard heater for heating and moving large volumes of heated air horizontally along the ground to intermingle with the cool atmosphere around the trees and warm the same, comprising an elongated circular tubular member substantially completely closed at one end and open at the other, openings in the wall of said tubular member in somewhat spaced relation and extending from one end to the other thereof, means for storing a supply of fuel under pressure and conveying said fuel to orchard heaters distributed about an orchard, means in said tubular member for burning said fuel movement of the products of combustion thereof drawing atmospheric air inside said tubular member to support combustion and excess air to cool the heat of combustion and to cool the wall of said tubular member so that an injector

effect is produced inside said tubular member which has the property of increasing the axial velocity flow of heated air from the open end of said tubular member, said large volume of heated air spreading out near the ground and warming the atmospheric air around and in the trees of the orchard.

2. An orchard heater for heating and moving large volumes of heated air horizontally along the ground around and adjacent the trees to intermingle with the cool ground air and warm the same comprising a round straight elongated tubular member located in a horizontal position near the ground with one end substantially completely closed and the other end open, louvres in the wall of said tubular member in somewhat spaced relation and extending from one end to the other of said tubular member, a source of fuel supply and means for leading fuel to said tubular member, burner means at the closed end of said tubular member to consume said fuel the burning thereof drawing atmospheric air much in excess of that needed to support combustion through the said louvres in the wall of said tubular member said air tending to support combustion and the excess thereof tending to cool said products of combustion and the wall of said tubular member which produces an injector effect inside of said tubular member which increases the velocity flow of heated air passing through and out of said tubular member which large volume of heated air intermingles with the cold air around the ground and the lower parts of the trees and quickly raises the temperature thereof to a safety point.

3. An orchard heater for heating and moving large volumes of heated air horizontally along the ground and adjacent the trees to intermingle with the cool ground air and warm the same, comprising an elongated tubular member located in a horizontal position near the ground one end of which is substantially completely closed and the other open, louvres in the wall of said tubular member, a source of fuel supply and means for conveying it to said tubular member, a means at the closed end of said tubular member for consuming said fuel, the size of said tubular member relative to the size of the flame produced in said tubular member being such that air much in excess of that needed for combustion is drawn inside said tubular member by the burning of said fuel which air acts to support combustion and the excess thereof tends to cool said products of combustion and to maintain the wall of said tubular member at a comparatively low temperature so that an injector effect is produced inside said tubular member which has the effect of greatly increasing the velocity flow of heated air from the open end of said tubular member, no flame of combustion appearing at the open end of said tubular member or popping out of said louvres.

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