

April 13, 1937.

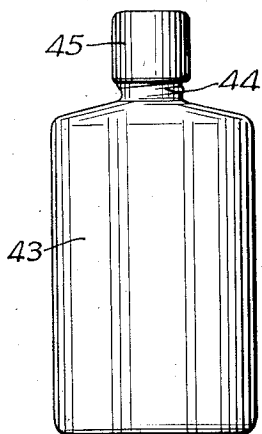
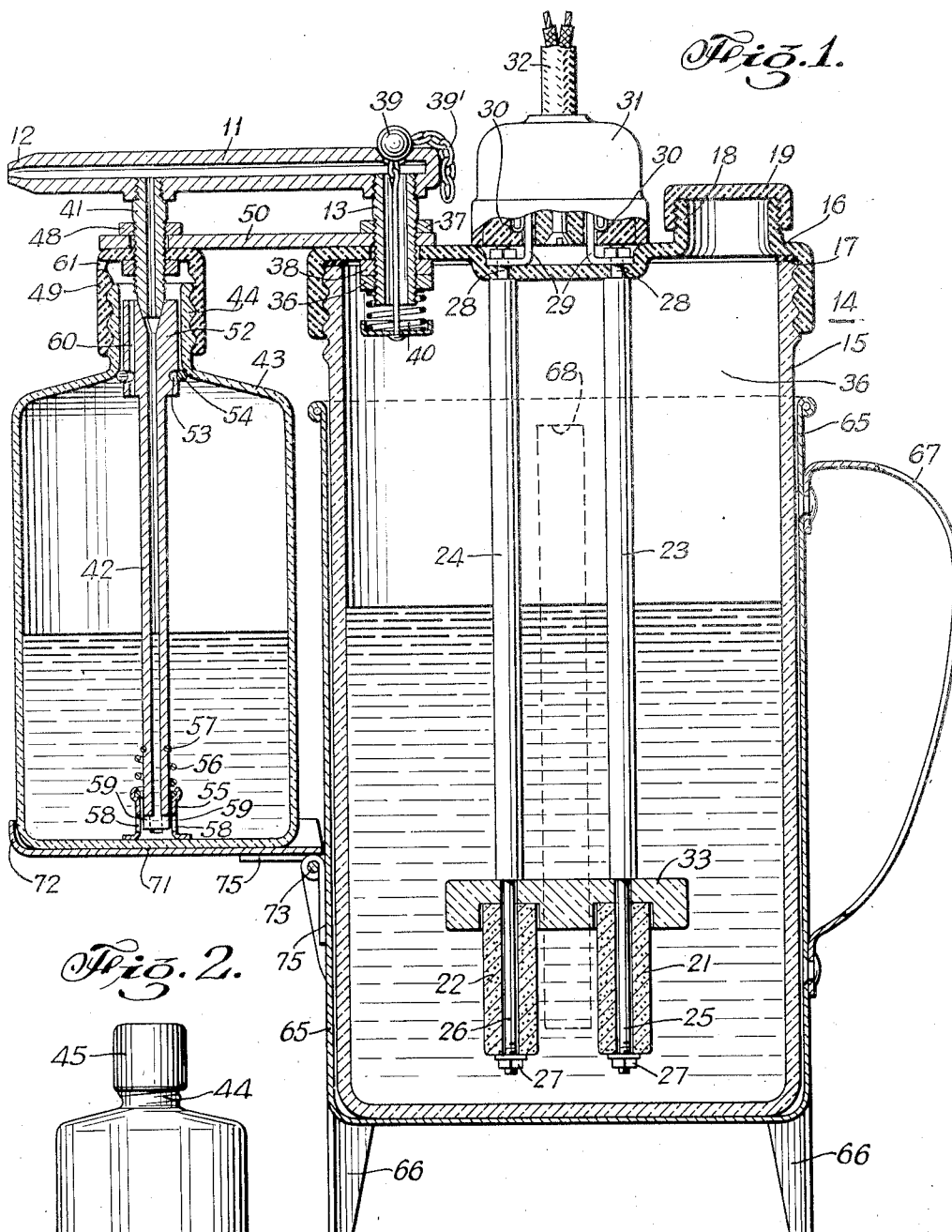
S. DEUTSCH

2,076,709

SPRAYING DEVICE

Filed Jan. 30, 1933

3 Sheets-Sheet 1



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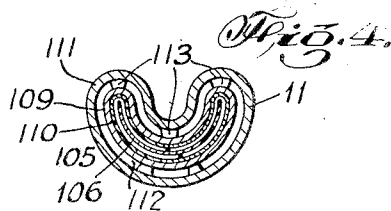
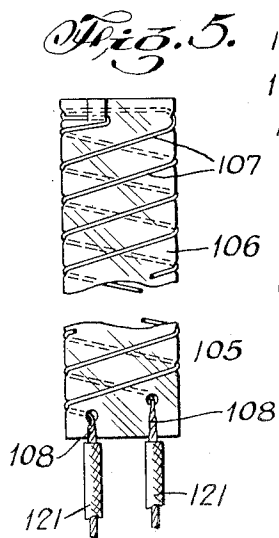
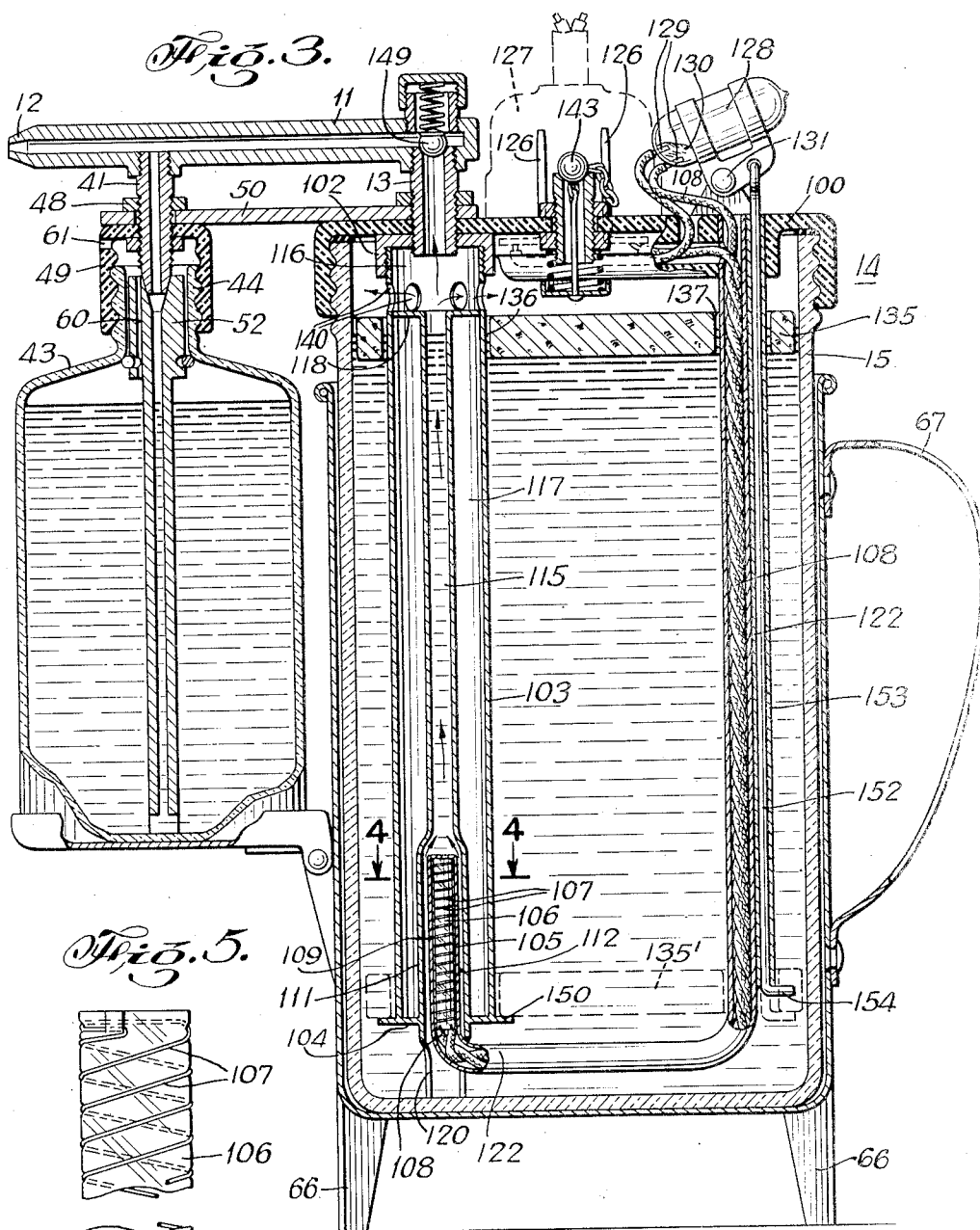
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SPRAYING DEVICE

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3 Sheets-Sheet 2



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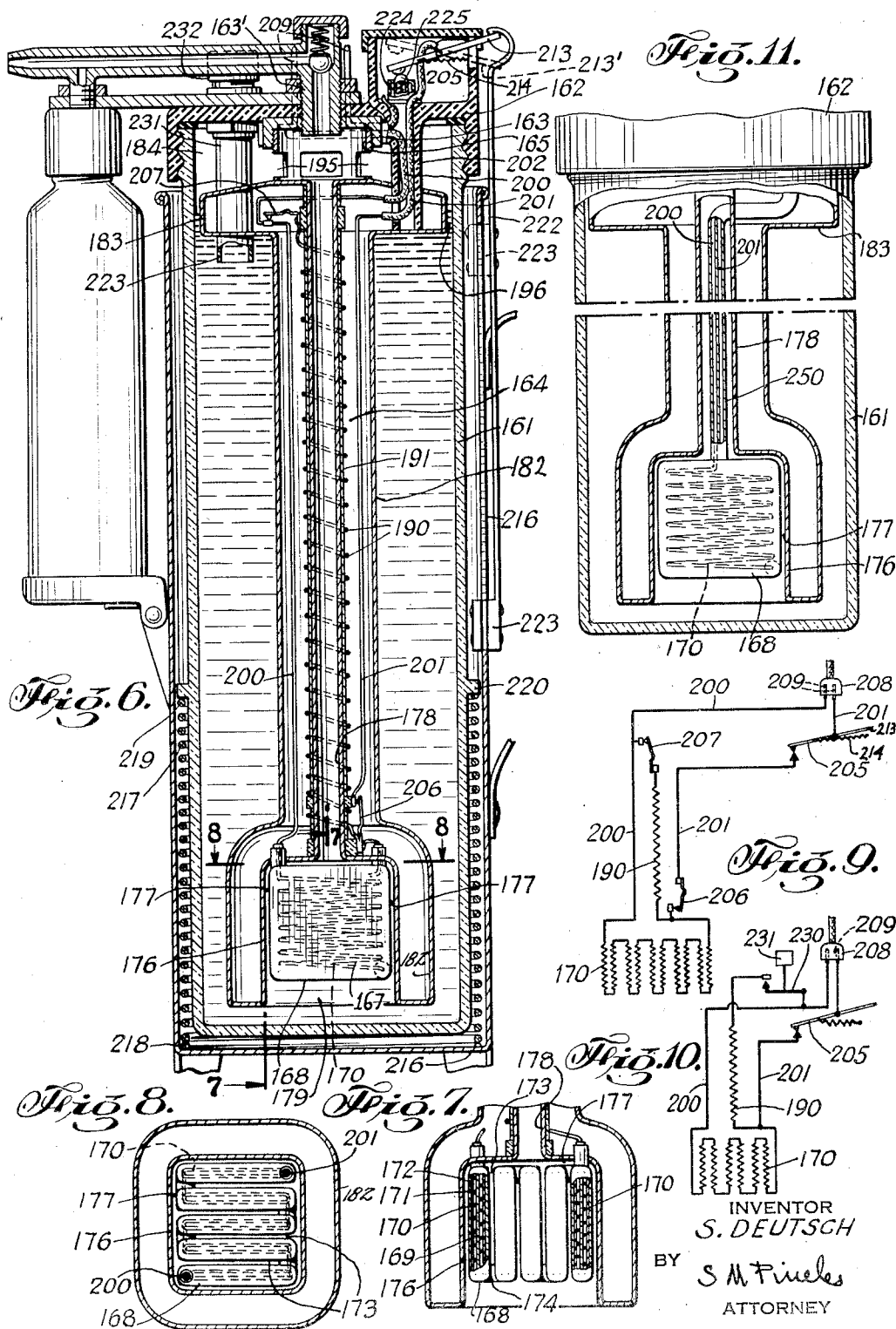
S. DEUTSCH

2,076,709

SPRAYING DEVICE

Filed Jan. 30, 1933

3 Sheets-Sheet 3



UNITED STATES PATENT OFFICE

2,076,709

SPRAYING DEVICE

Simon Deutsch, South Bend, Ind.

Application January 30, 1933, Serial No. 654,268

11 Claims. (Cl. 219—38)

This invention relates to spraying devices, and it has particular relation to devices utilizing a compressed fluid stream through a nozzle for impelling a concentrated liquid into the stream, and to discharge said liquid in dispersed atomized form in front of the nozzle.

Among the objects of the invention is an improved sprayer construction eliminating the necessity for handling and pouring the concentrated liquid that is to be sprayed and producing efficient spraying action in a small size unit by an instantaneously acting electrically-heated vaporizer.

The foregoing and other objects of the invention will be best understood from the following description of exemplifications thereof, reference being had to the accompanying drawings, in which

Fig. 1 is a vertical sectional view of a spraying unit embodying one form of the invention;

Fig. 2 is a view of the liquid holding container detached from the spraying unit;

Fig. 3 is a view similar to Fig. 1 showing a modified form of the invention;

Fig. 4 is a cross sectional view through the flash boiler unit along line 4—4 of Fig. 2;

Fig. 5 is an enlarged simplified view of the heating unit of the flash boiler of Fig. 3;

Fig. 6 is a view similar to Fig. 1 of another form of flash boiler sprayer;

Fig. 7 is a vertical sectional view of the flash boiler unit of Fig. 6 along line 7—7;

Fig. 8 is a horizontal sectional view through the flash boiler unit along line 8—8 of Fig. 6;

Fig. 9 is a circuit diagram of the electrical heater arrangement of the flash boiler of Fig. 6;

Fig. 10 is a circuit diagram similar to Fig. 9, illustrating a modified arrangement; and

Fig. 11 is a vertical sectional view of a portion of a flash boiler sprayer showing a further modification.

Steam-operated atomizers in which steam generated in a small boiler is released through a nozzle, producing a steam blast sucking through a suction tube a liquid into the blast, dispersing and atomizing the liquid, and discharging it in heated and vaporized condition in front of the nozzle, have long been known in the art. Such sprayers are particularly effective in atomizing concentrated liquid fumigants, insecticides, medicines, perfumes, and like concentrates. The hot vapor produces finer and more uniform dispersion and atomization of the concentrated liquid than possible otherwise. The so produced mist of vapor and heated, vaporized liquid particles

fills the space receiving the spray, and under the influence of the expanding vapor the particles of the liquid penetrate uniformly into all surfaces, nooks and crevices into which they would otherwise not be carried.

Heretofore, the practical use of such sprayers has remained very limited and never reached a stage of development commensurate with the effectiveness of disinfecting and purifying action, and the thoroughness of distribution and penetrability made possible by the intimate atomization of the highly concentrated liquids suitable for use in such sprayers. One of the difficulties lies in the heretofore existing necessity of manually handling the concentrated liquids employed in such sprayers. The filling of the liquid container of the sprayer, involving the pouring and handling of the concentrated disinfecting, purifying, and like liquids, by the user, is objectionable, because the concentrate, though harmless in atomized condition, is in many cases unpleasant, and dangerous during pouring and direct handling in liquid form when it is liable to be inadvertently poured out in large quantities in a single spot.

In accordance with my invention, this difficulty is eliminated by having the concentrated liquid for the sprayer filled in special tightly sealed containers at filling stations and left in this condition until used up in the sprayer. The filled container made, for instance, in the form of a bottle with a narrow neck, is provided with an internal suction tube extending from the bottom of the bottle to the lower part of the opening in the neck thereof, where the upper end of the suction tube has a head which closes the bottle opening and prevents the liquid from being poured out. The opening at the upper end of the neck is sealed by a suitable cap, for instance, by providing a thread on the outer surface of the neck and a corresponding thread on the rim of the cap which is screwed to the neck and tightly seals with its upper surface the upper edge of the bottle neck.

The nozzle unit through which the vapor stream for sucking and atomizing the liquid is discharged, differs in construction from the sprayers as heretofore made by having, instead of the usual long suction tube extending from the nozzle duct to the bottom of the liquid container, only a short nozzle suction tube section sufficiently long to reach into the neck of the bottle and engage the upper opening of the bottle suction tube in the head portion thereof to form therewith a continuous suction duct between the space near the bottom of the bottle and the nozzle

duct and thus operate like the continuous duct of the prior art sprayers.

There is also provided at the lower end of the nozzle suction tube a mechanical junction member for mechanically clamping the bottle to the nozzle, holding the bottle, and pressing the head at the upper end of the bottle suction tube against the lower end of the nozzle suction tube to provide a tight seal between the two ends and secure the effect of a continuous suction duct. The junction member may be in the form of the outer part of a screw cap, like that used for sealing up the top of the bottle, and is tightly joined to the upper suction tube so that by screwing the bottle in from below, the bottle neck is threaded into the cap member carried by the upper suction tube portion, the bottle is pulled up and firmly clamped by the cap junction, sealing the lower end of the upper suction tube against the upper end of the bottle suction tube. The sealing surfaces are preferably of interfitted conical shape to secure a tight joint.

By this arrangement, the supply of the concentrate for the sprayer may be accomplished without requiring any pouring of the concentrated liquids, and preventing spilling of the liquid, by the user. All that the user has to do, if the liquid in the bottle connected to the nozzle unit is exhausted, is to unscrew the old bottle from the cap junction of the nozzle suction tube, unseal the cap of a filled concentrate bottle, and then screw the neck of the unsealed bottle into the threaded cap junction of the nozzle suction tube, thereby re-establishing a unitary suction duct for sucking the concentrated liquid of the new bottle into the atomizing stream of the nozzle duct. Thus the troubles and discomfort caused by sprayers with a continuous suction tube leading from the nozzle to the bottom of the liquid container, requiring pouring of the concentrated liquid into the container each time it is exhausted, is eliminated.

Another disadvantage of sprayers as heretofore available is the fact that the entire, relatively large body of vaporizable fluid in the boiler vessel must be heated to vaporizing temperature in order to produce the compressed vapor for atomization and spraying of the concentrated liquid. This delays the starting of the sprayer and also results in an unnecessary loss of heat, and undesirable prolongation of the spraying action when it is to be stopped.

In accordance with my invention, I supply the actuating vapor for sprayers of the type described by means of a small electrically-heated flash boiler constructed to gradually admit small quantities of preheated water to a flash evaporator having electrically-heated narrow conduits which cause practically instantaneous evaporation of the water as it enters in a thin layer into the conduits. This enables instantaneous generation of the steam and production of a sufficient quantity of steam to set the sprayer into action quickly after the electrical heater is energized, and avoids the necessity of first heating the entire body of water in the boiler to vaporizing temperature and then develop the steam pressure required for the spraying action. By the use of this electrically-heated flash boiler, the entire spraying unit is thus reduced in volume and its action is made practically instantaneous and subject to quick control.

In Figs. 1 and 2 is shown a spraying device embodying one form of the invention. It comprises a rigid nozzle unit having a tubular nozzle

duct 11 terminating at its front end in a spray nozzle 12 and connected at its rear end through a vapor supply tube 13 to the top space of a vaporizer 14. The vaporizer 14 comprises a jar 15, preferably of transparent tight material, such as glass, and has its upper open end provided with a threaded outer edge portion tightly closed by a threaded edge cover 16, which is preferably of rigid insulating material, such as a phenolic condensation product. A packing ring 17 may be provided along the edge of the jar 15 to secure a tight enclosure. The jar is arranged to be filled through the water inlet opening 18 on the top 16 up to about half of the height of the jar with a suitable vaporizable liquid having a small amount of electrolytic conduction, such as water, the opening being tightly closed by a detachable screw cap 19. To evaporize the water, there are mounted near the bottom of the vessel a pair of rectangular electrodes 21 and 22. The electrodes are supported on two rods 23 and 24 having at their lower ends conducting terminal extensions 25 and 26 fitting into suitable openings within the electrodes 21 and 22 and holding the electrodes in place by means of screw nuts 27, and also making good electrical contact with the electrodes 21 and 22 through the contact with their interior walls surrounding the rod extensions.

The upper ends of the rods are tightly secured by threaded extensions 28 in a depressed portion of the jar top 16, the exterior ends of the extensions 28 carrying terminal prongs 29 for engaging socket terminals 30 of a socket 31 connected through a flexible cable 32 to a domestic electric current source of 110 volts, for instance. To render the suspension of the two electrodes 21 and 22 rigid, an additional insulating spacer 33 is held clamped by the rod extensions 25 and 26 to the two electrodes 21 and 22 making the electrode assembly firm.

The lead rods 23 and 24 are preferably made of a material, such as Monel metal, stainless steel, or ordinary steel, which does not react with the water or the vaporizable fluid in the vessel during operation. The electrodes 21 and 22 may likewise be of Monel metal, stainless steel, ordinary steel, carbon, or a similar conducting body which will permit current flow between the electrodes through the liquid in which they are immersed without undesirable reactions.

The vapor supply tube 13 between the nozzle duct 11 and the vapor space 35 in the top portion of jar 15 has its upper end threaded into a suitable opening on the lower side of the duct nozzle, and its lower end likewise threaded and clamped tightly within an opening in the top 15 by means of nuts 36, 37 and washer 38. A safety valve in the form of a ball 39 is held pressed against a valve seat on the upper side of the nozzle duct 11 opposite the end of vapor supply tube 13, the ball 39 being held against its seat by means of a suitable spring mounting 40. To permit ready release of the steam, the valve ball 39 is provided on its exterior with a little pull chain 39' so that it may be lifted from its seat, if the steam is to be released and the operation stopped.

To a portion in the nozzle duct lying back of the nozzle 12 are joined a pair of suction duct sections 41 and 42 extending to near the bottom of a liquid container 43. A distinct feature of the invention is the special combination of the liquid container 43 and two suction duct sections 41 and 42 and their cooperation with the nozzle unit and vapor source. As seen in Fig. 2, the liquid container 43 is preferably made in the form of a

bottle, of transparent material, such as glass, for instance, and has a small upwardly projecting neck portion 44 which is closed at the top by a cap 45, by a threaded joint between the exterior of the neck portion and the cap, for instance.

The suction duct is made of two sections, the upper section 41 being in the form of a nozzle suction tube extending from the nozzle duct 11 until the neck portion of the liquid container 43, and the lower section 42 being in the form of a separate suction tube extending from the neck portion of the bottle 43 till the bottom thereof. The upper end of the nozzle suction tube 41 is threaded into a corresponding hole on the underside of the nozzle duct 11, its interior opening into the nozzle duct. An intermediate portion of the upper suction tube 41 is threaded on its exterior and has attached thereto, by means of a pair of nuts 48, a cap-shaped junction member 49 similar to the bottle cap 45, and a supporting strip 50, the other end of which is clamped, by means of nut 37 and the vapor supply tube 13, to the jar top 16. In this way, the nozzle duct 11 with the suction duct section 41, supporting strip 50 and vapor supply tube 13 form a rigid structure firmly supported on the cover 16 of the vaporizer jar.

The neck of a bottle 43 filled with concentrated liquid, as shown in Fig. 2, may, after unscrewing its closure cap 45, be screwed into the cup-shaped junction member 49, firmly clamping the bottle neck within the junction member 49. Within the interior of the bottle is mounted the lower section 42 of the suction duct, in the form of an upstanding longitudinal tube having an enlarged head 52 fitting the opening of the bottle neck 44 to hold the suction tube 42 in upstanding position within the bottle. The suction tube head 52 extends downwardly beyond the junction of neck 44 with the top of bottle 43, and is provided at the portion of its periphery immediately below the junction with an annular groove 53 in which is mounted a resilient split ring 54 of a diameter slightly larger than the diameter which it has in the position shown in Fig. 1. The gap of the resilient ring 54 is made sufficiently large so that when it is pressed into the slot 53, it will conform to the diameter of the head 52 and make it possible to insert the tube 42 with the head 52 with ring 54 through the neck 44 of the bottle, the ring 54 being pressed into the slot 53 while the head travels inwardly through the bottle neck. On reaching the lower end of the bottle neck 44, the ring 54 expands within the groove 53 and locks the head of the suction tube 42 inside the bottle so that it cannot be readily removed therefrom.

To secure a good fit between the clamping ring 54, the suction tube head 52, and the junction of the bottle neck with the bottle top, the lower end of the suction tube 42 has slidably mounted thereon a tube extension 55 pressed downwardly by a helical spring 56 held on the tube 42 to exert a longitudinal upward pressure on the suction tube 42. Slots 58 in extension tube 55 and slots 59 in the lower end of tube 42 provide passages for the liquid into the lower end of the suction tube 42. A good hold for the suction tube 42 within the barrel may be obtained without the extension tube 55, by making suction tube 42 sufficiently long to rest against the bottom of the bottle 43 when the spring ring 54 engages the head 52 and the neck junction in the way shown in Fig. 1.

The bottle suction tube head 52 has a narrow

longitudinal channel 60 and the cap 49 holding it clamped to the nozzle unit has a small opening 61 to permit entry of air into the upper space within the bottle 43 when the level of the liquid goes down on withdrawal of liquid through the suction tube 42 by the vapor stream through the nozzle duct 11. These openings are so small that leakage of the liquid is effectively prevented even if the bottle is tilted.

By supplying the users of the sprayer with 10 filled bottles as shown in Fig. 2, arranged for attachment to a short suction tube depending from the nozzle duct, as shown in Fig. 1, spilling and pouring out of the concentrated liquid by the user in connection with the operation of the 15 sprayer is positively eliminated.

In accordance with the invention, the consumer acquires the liquid for the sprayer, in the form of completely filled and sealed bottles, as shown in Fig. 2. These bottles are filled with the concentrated liquid at a filling station where proper 20 safeguards are taken to have the filling go on without undesirable spilling of the liquid concentrate. Into each filled bottle, there is inserted at the filling station a suction tube extension 25 42 as shown in Fig. 1, the tube being locked by the lock ring 54 as shown in Fig. 1, to close up the opening in bottle neck 44 and prevent outpouring of the concentrated liquid in case the bottle is tilted in handling. The bottle is then 30 sealed with the cap 45 so that it is positively closed and no liquid can escape therefrom, and in this condition the bottle is distributed to consumers who use the sprayer.

These sealed bottles are received by consumers, 35 and are sealed till the contents of the bottle in use on the sprayer is exhausted. When a fresh supply of concentrated liquid is needed, the user unscrews the empty bottle 43, takes off the cap 45 of a new filled bottle, and screws in the full 40 bottle into the clamping junction cap 49, as shown in Fig. 1, until the lower end of the upper nozzle suction tube 41 engages the opening in head 52 at the top of the bottle suction tube 42 mounted within the bottle. The direct handling and pouring 45 of the concentrated liquid by the user is thus completely eliminated and a new supply for the sprayer may be provided simply by unscrewing the empty bottle and screwing in instead a filled bottle, with its interiorly mounted suction tube 50 and neck-opening closure preventing spilling or pouring out of the concentrated liquid from the bottle.

For convenience in use, the vaporizer jar 15 is mounted in a metallic cylindrical casing 65 having 55 legs 66 and a handle 67 for carrying the whole apparatus, the casing having longitudinal slots 68 to permit watching the level of the water in the vessel. To aid in supporting the liquid containing bottle 43, there is provided on the side 60 of the casing 65 facing the bottle a supporting plate 71, with a flange 72 surrounding the bottom of the bottle, the plate 71 being hinged on a pivot pin 73 held by the casing wall 65, and a spring 75 holding the plate 71 yieldably in horizontal 65 position to support the bottle. This permits ready unscrewing of the used up bottle and screwing in of a bottle filled with the liquid by merely pulling down the hinged supporting plate 71 during these operations. 70

In Figs. 3 to 5 is shown a modified form of spraying device which, in addition to the invention described in connection with the invention shown in Figs. 1 and 2, embodies also an improved 75 flash boiler for producing the operating steam

in a greatly improved and simplified manner. The nozzle unit with the concentrated liquid supply container, the vaporizer jar and the supporting casing are constructed like the corresponding parts described in connection with Figs. 1 and 2. New is the combination of internal construction of the electrical vaporizer equipment with such sprayer.

As shown in Fig. 3, there is secured to the underside of the jar top 100, at the point of connection of the vapor supply tube 13 with the jar top 100, a supporting collar 102 which in turn supports a downwardly extending cylindrical vaporizer 103 reaching to near the bottom of the jar 15 where it is partially enclosed by a bottom wall 104. Mounted within an opening in the bottom wall 104 of the vaporizer 103 is an electrically-heated duct vaporizer 105 shown in detail in Figs. 4 and 5. The vaporizer comprises one or more units, each having a heater made, for instance, of an insulating sheet 106 around which is wound a resistance wire 107, as indicated diagrammatically in Fig. 5, which is heated to high temperature by current supplied through terminals thereof. The insulating sheet 106 with the windings 107 thereon are enclosed by a waterproof casing 109, of metal, for instance, an insulating layer 110 interposed between the winding surface and the outer casing 109 maintaining the winding completely insulated from the casing walls.

The heating casing is in turn surrounded by an outer casing 111 spaced by a very small gap from the wall of the interior casing 109 to provide a flat narrow duct 112 between the opposite walls. This duct 112 extends throughout the full height of the heater element 105, and is very flat, having almost capillary width, although satisfactory operation will be obtained with ducts of a width of about $\frac{1}{8}$ of an inch. Small spacers 113 provided between the opposite walls of the duct maintain the spacings of the walls at the proper short distance. The heated duct unit so formed may be made of flat shape, or of semi-circular shape as shown in Fig. 4, and constitutes thus a body having a central sheet-like electrical heater surrounded by a duct of very small thickness. The walls of said duct are heated by the heater, and a vaporizable substance, such as water, impelled into said duct, will enter it in the form of a thin sheet, and will be by flash-like action instantaneously converted into steam.

One or more of such vaporizer duct units may be arranged side by side within the opening of the lower wall 104 of the vaporizer. As indicated in Fig. 3, the upper end of the flat duct 112 leads into a duct extension 115 disposed longitudinally within the interior of the vaporizer 103, the upper end of the duct extension terminating in a steam chamber 116. Where several such duct units are used together, their ducts may lead either through a common or separate duct extensions to the chamber 116. The space 117 around duct extension 115 is segregated from the steam chamber 116 by a wall 118, this space being left empty or being filled with a heat insulating material, to oppose loss of heat by the outer duct casing 111 and duct casing extension 115 to the surroundings thereof. The casing duct 111 of the vaporizer unit has a downward extension 120 below the bottom wall 104 of the vaporizer, the extension being provided with slots to permit water from the vessel to enter into the duct 112 surrounding the heater coil 107.

The electric terminals 108 of the heater coil 107 are connected to two lead-in wires 121 and are

protected by a waterproof enclosure 122, preferably of metal, joined to the lower end of the inner heater casing 109 to keep water out from the interior of casings 109 and 122, the two lead-in wires 121 in the enclosing casing 122 being led out through the top of jar 100, where the upper end of the casing 122 is tightly sealed to prevent escape of steam from the jar.

One of the conductors 108 extending from the interior of the jar has connected in series therewith a mercury switch 128, the two switch contacts 129 being immersed in a body of mercury 130 when the switch is tipped to the left, as shown in Fig. 3. The two ends of the wires 108 are connected to two terminal plugs 126 mounted on the top 100 of the vaporizer jar, the two plugs 107 being arranged for detachable engagement with a socket 127, leading from a domestic electric supply line, of 110 volts, for instance. The electric switch 128 is pivoted on a supporting member 131 mounted on the jar top 100. By tipping it to the left, the line connection is closed by the switch contacts 129 and the heater 107 will be energized. If the switch 128 is tipped to the right, the mercury 130 flows to the opposite end of the switch 128, interrupting the circuit and breaking the supply of current to the heater 107.

The jar top 100 has also an opening for pouring in water or another vaporizable liquid into the jar with a suitable closure cap, like the opening 18 and closure cap 19 in Fig. 1, these parts not being seen in the view of Fig. 3.

A floating baffle member 135 with a pair of openings 136 and 137 fitting around the vaporizer tube 103 and outlet conductor enclosure 122 is provided within the jar to rise and fall with the level of the liquid in the jar 15. Assuming the jar has been filled for operation to the level indicated in the drawings, the float 135 will occupy the position indicated and will move down as the water level goes down. The steam chamber 116 provided in the upper end of the cylindrical vaporizer wall 103 is provided with an opening 140 to permit steam coming up through duct extension 115 to spread over the upper space of the jar 15 lying above the water, a safety valve 143, similar to valve 39 of Fig. 1, serving to prevent development of excessive steam pressure in the steam space within the jar, and to release excess steam from the jar.

On the upper end of the vapor supply tube 13, there is provided an auxiliary outlet valve 149 for automatically opening the outlet of the supply tube 13 when the pressure within the chamber 116 rises to a value at which enough steam flow will be produced in the nozzle duct 11 to effect efficient spraying action. However, the dimensions of the supply tube 13 and of the nozzle duct and the nozzle may be so arranged to make it unnecessary to use such valve, as in the arrangement shown in Fig. 1.

The downward movement of the water level is limited by a stop member 150 at the lower end of the vaporizer 103 so that, as the water descends to near the bottom of the jar, the float is finally retained in the position indicated by the dotted line 135'. There is also provided a tripping rod 152 slidably mounted in a tube 153 extending, for instance, along the electrical conductor casing 122 and tightly sealed in an opening within the top jar 100, the rod 152 being arranged to pull the mercury switch 128 to the right hand position where it opens the heater circuit when the lower downwardly bent end 154 of the rod becomes engaged with the downwardly moving float member

135. This opens switch 128 and stops operation of the sprayer.

The floating baffle member 135 serves, however, not only for tripping the mercury switch 128, but also as a barrier between the body of the water in the lower part of the jar 15 and the steam space in the upper part of the jar. The floating member is made of effective heat insulating material, such as cork, to reduce to a small value the condensation of the steam produced by the vaporizer units while the main body of water is still relatively cold. Once the upper surface of the floating member 135 has assumed the temperature of the steam, very little condensation of steam will occur notwithstanding the fact that the water below the float is still at a low temperature, and would cause a great deal of condensation if it were directly exposed to the steam space.

The vaporizer can be quickly started and give instantaneously steam generation sufficient to operate the sprayer without waiting for the whole body of water in the vaporizer jar 15 to be brought to evaporation temperature. Before starting the jar 15 is filled with water up to the level indicated in Fig. 3. The electric power is then turned on by pivoting the mercury switch 128 to the left, as shown in Fig. 3. This starts the current flow through the heating coil 107, bringing up the surfaces of the heated vaporizer duct 112 to a high temperature and converting the water therein into steam which moves upwardly through duct extension 115 into steam chamber 116. The force of the rising steam expels the water from the duct extension 115 which overflows through openings 140 into the liquid within the jar. The thin layer of water entering from the space near the bottom of the jar into the narrow duct 112 is then instantaneously evaporated in flash-like manner as it enters the narrow duct. This instantaneous steam generation continues, and produces in a very short time enough compressed steam in the chamber 116 of a pressure sufficient to operate the sprayer. At the proper pressure value, the valve 149 in the supply tube 13 will open and steam will be discharged at high velocity through the nozzle duct 11 operating the vaporizer, as in the arrangement in Fig. 1, but avoiding the delays inherent in a vaporizer arrangement which requires the bringing up of the entire body of the water in the vessel to the evaporation temperature.

In Figs. 6 to 9 is shown a modified construction of a flash boiler spraying device embodying a number of important features for securing efficient steam generation within small boiler structures. The nozzle unit with the concentrated liquid container are constructed like the corresponding parts described in connection with Figs. 3 to 5. The jar 161 for holding the vaporizable liquid, such as water, with the covering top 162 for tightly enclosing the jar, form an elongated vessel which, when filled, holds a relatively high column of water. To the underside of the cover 162 is secured a supporting collar 163, for instance, by a threaded connection to the lower end of the steam supply tube 163' tightly seated within the jar top 162. Within this collar 163 is supported the electrical vaporizer 164 by means of a tubular extension 165 projecting from the top thereof and engaging the interior of said collar 163.

The vaporizer 164 has in its lower end formed an electrically-heated duct vaporizer 167 comprising one or more heating units 168 forming one or more narrow ducts extending in vertical di-

rection around the outer surfaces of the heater units. As shown in Fig. 8, the individual heater units 168 may each comprise an insulating sheet 169 around which is wound a resistance wire 170 which is heated by electrical current to high temperature. The insulating sheet 169 with the windings 170 are enclosed by a water-tight casing 171, of metal or similar material, an interposed insulating layer 172 maintaining the winding insulated from the casing.

The individual heater units 168 are assembled side by side to form between their opposite flat surfaces a plurality of flat water ducts 173, the individual units being held apart by suitable small tubular spacers 174 occupying only a negligible space so as to permit free flow of water through the ducts 173. The heating resistors 170 of the several heater units are interconnected in series, as shown in Fig. 9, the interconnecting conductors passing between the individual units through the tubular spacers 174 so that the entire resistance winding of the units is insulated and protected against entrance of water into the interior.

The several heater units 168 are in turn enclosed by an outer common casing 176, of metal, for instance, which forms an outer duct 177 around the heating units 168 into which the individual ducts 173 merge. A common outlet duct 178 from an opening on the upper side of casing 176 extends toward the top of jar 161 so that fluid from the open bottom 179 of casing 176 may flow through the ducts 173 and 177 upwardly into the duct 178 toward the top opening 180 thereof and discharge there. A heat insulating protecting cover is provided around the heater casing 176 and the outlet duct 178 by an outer enclosure casing 182, preferably made of metal. The space within the enclosure 182 may be either left empty, or a suitable heat flow insulating material may be placed in the hollow interior thereof to oppose flow of heat from the interior duct walls 176 and 178 to the space around the exterior enclosure 182.

At the top of the heat insulating enclosure 182 is formed a baffle member 183 extending transversely across the jar 161 and separating the small upper space 184 within the jar from the lower water space thereof. This baffle member 183 may be made in the form of a hollow metal member, and may be filled with a poor heat conducting material to limit heat conduction there-through, or may be made hollow only in the center portion around the outlet duct 178, the outer portion of the baffle 183 being, for instance, of a solid heat insulating substance.

Instead of making the heater units 168 of flat shape, they may be of curved shape and assembled side by side to form curved ducts as described in connection with the flash boiler heater of Figs. 3 to 5. Where the vaporizer is small and a single large duct surface is sufficient, only a single heater unit with an enclosing casing, like casing 176, may form the main heating duct in the lower portion of the water jar, this duct having connected thereto the outlet tube 178 and being provided with an enclosure 182, as shown in Fig. 6.

The outlet duct 178 is arranged to be heated by an outlet heater 190 in the form of a coil wound on an electric insulating layer 191 surrounding the duct to direct a flow of heat into the interior of the duct. The heating resistors 170 of the heating units 168 and the outlet heater resistor 190 are supplied with electrical current

in the way shown in the circuit diagram of Fig. 9. The heater resistors 170 are connected in one or more series circuits to provide a total resistance suitable to develop, at the applied voltage, an amount of heat sufficient to cause a vaporizable substance, such as water, entering in form of thin sheets into the ducts 173 and 177, to be substantially instantaneously brought up to vaporization temperature and be instantaneously converted by flash-like action into steam. The outlet heater resistor 190 is proportioned to develop, at the applied voltage, in cooperation with the main heater units 168, sufficient additional heat to convert the water initially filling the outlet duct 178 into steam, so that as the water in the heater unit ducts 173 begins to vaporize, also the water in the outlet duct 178 is made to vaporize, the vapor rising upwardly through outlet duct 178 into the steam space 184 on the top of the vessel between the upper surface of the baffle 183 and the bottom of the jar cover 162. The supporting member 165 projecting upwardly from the top of baffle 183 has large holes 185 near its lower end to permit free outflow of vapor and water into the surrounding space and to lead water particles ejected by the steam flow toward the periphery of the vessel where it is returned through the surrounding gap 196 to the body of water in the lower part of the jar. The gap 196 around the outer surface of the baffle 183 is sufficiently large to permit flow of water and steam from the steam space 194 to the water space below the baffle, the path of flow being sufficiently long to prevent excessive condensation of the steam admitted to the steam space 194, operating in this respect, like the floating member 135 in the modification shown in Fig. 3.

Two lead-in wires 200 and 201 are brought through a lead-in tube 202 sealed in the top 162 of the jar into the interior of the baffle 183. Lead-in wire 200 is directly connected to one end terminal of the serially connected heating resistors 170, the other lead-in wire 201 being connected through main cutout switch 205 and thermostatically actuated cutout switch 206 to the other end terminal of the heating resistors 170. The outlet heating resistor 190 has one end connected to the lead-in wire 201 and the other end through a thermostatic cutout switch 207 to lead-in wire 200. When the main cutout switch 205 is closed, and thermostatic switches 206 and 207 are likewise closed, current from the domestic line socket 208 flows through plugs 209 on the jar cover 162 to the main heater coils 170 and the outlet heater coil 190 heating ducts 173 of the heater units and the outlet duct 178.

The cutout switches 206 and 207 are of the thermostatic cutout type, which normally hold their switch contacts closed as long as their temperature lies below a certain value, and open the switch contacts with a snap action when the temperature of the actuating element rises above a certain value, operating in reverse order if the temperature changes in reverse direction. Such thermostatic switches are described in the Spencer patents, Nos. 1,448,240, 1,812,722 and 1,813,776, and many other types are well known in the art.

As shown in Figs. 6 and 9, the thermostatic switch 206 is mounted inside the enclosure 182 disposed near the junction of the duct 177 with the outlet duct 178. One end terminal of the series resistors 170 and one end of the outlet heater resistor 190 are connected to one terminal of the thermostatic switch 206, supply line

lead 201 being connected to the other terminal of the switch. The other thermostatic switch 207 has its contacts connected to the other end of the outlet heater resistors 190 and to the supply lead 200, respectively, the latter being also directly connected to the other end terminal of the heating resistors 170.

If both switches 206 and 207 are closed, heater coils 170 as well as heater coil 190 are energized in parallel from the leads 200 and 201. If thermostatic switch 207 opens while thermostatic switch 206 is still closed, the outlet heater coil 190 is cut off, discontinuing the heating of the outlet duct 178. The main heating resistors 170 continue to carry current and generate heat, the switch 206 being closed. If switch 206 is opened, it interrupts the circuits to resistors 170 as well as to the resistor 190, stopping the flow of electrical current to both sets of resistors, and cutting off the heating.

The thermostat switch 206 serves as the main thermostatic cutout and is adjusted to open when the temperature in the adjacent portion of the heater duct 176 rises to a predetermined high value which it assumes when the water in the vessel has been evaporized to a low height at which the vapor generation is stopped. The thermostatic switch 207 is adjusted to disconnect the outlet duct heater coil 190 when the water initially present in the outlet duct 178 has been evaporized and the outlet duct 178 assumes a temperature corresponding to the condition in which it is substantially free from water and permits unobstructed flow of steam from the ducts 173 between the main heater units 168 in the bottom of the vessel.

As an additional safety measure, the evaporator is provided with an automatic cutout snap switch 205 mounted on the top of the jar cover 162. Switch 205 is connected in series with one of the leads, for instance, lead 201, from the current supply plugs 209 on the top of the cover 162 to the heater units inside the vaporizer 164. The switch may have a toggle lever 213 held either in closed position as shown in full lines, or in the open position as indicated by dotted lines 213', by means of a spring 214. When in operation, the switch is moved by the outwardly projecting end of lever 213 to the position shown in the drawings, where it closes the circuit. By pushing the outward switch lever end 213 downwardly, the left end of the switch arm reaches a point where it moves over its pivot center and trips to open position, instantaneously interrupting the circuit.

The tripping of lever 213 is actuated in accordance with the weight of the vaporizer jar 161 to permit the switch 213 to stay in closed position as long as the amount of water in the vessel is of a quantity at which the vaporization can continue, and to trip open the supply circuit and positively stop the energization of the heating coils if the water has fallen to a level at which further energization of the heaters becomes dangerous. This may, for instance, be effected by suspending the jar 161 in a metallic supporting casing 216 on a helical compression spring 217 mounted around the lower portion of the jar 161, the spring resting with its lower turn 218 on the bottom of casing 216, and engaging with its upper turn 219 an outward flange 220 of the jar 161. On the side of the periphery of the supporting casing 216, below the point where the lever 213 of cutout switch 212 projects out of the casing, a tripping rod 222 is mounted, the

upper end of the rod being bent to engage the outwardly projecting end of the switch lever 213. The height of the tripping point at the end of rod 222 may be adjusted by its slidable mounting member 223 with which it is secured to the supporting casing 216.

The helical supporting springs 217 and its supports with the tripping rod 222 are so adjusted that when the vaporizer vessel 161 is filled with water, it occupies the position shown in Fig. 6, the switch lever 213 making contact with the opposite contact member 224 which is pressed to an outward position by a spring 225.

As the water in the vessel is vaporized and the water level falls down, the jar 161 rises and the switch 213 has its end pushed downwardly, in accordance with the rate at which the water is used up and the weight of the vessel is reduced. The length of the downward movement of the end of the contact member 213 of the switch is so adjusted that when the water level has fallen to a value at which further steam generation would be dangerous, the lever 213 is just in the dead center over its pivot point and slight further rise of the vessel causes the lever 213 to move with a snap to its open position, opening the circuit to the heater resistors 170 and 190 and stopping further heat generation. This cutout switch provides additional safety against flow of heating current in case the thermostatic cutout switches 206 and 207 fail to respond.

To easily fill the vessel with water or another suitable vaporizable fluid, a filling tube 231 extends through the jar top 162 and is tightly sealed therein, being closed on the top with a cap 232 and having its lower end passing through the baffle member 183 and opening at 233 into the water space of the jar.

With the arrangement as described above, the sprayer shown in Figs. 6 to 9 will operate as follows: To start the vaporizer, the nozzle unit 11 has attached thereto the bottle with the concentrated liquid as in Fig. 3. The jar 161 is filled with water up to the level indicated, or to any convenient height, the electric terminals 209 on the jar cover 162 are plugged into a supply line socket, and the safety switch 213 moved to the closed position. Thereupon, a flow of heating current will start through the heater coils 170 of the heater units 168 in the bottom heater of the vessel and through the outlet heater coil 190, the thermostat switches 206 and 207 being closed and in closed position. The heater ducts 173 and 177, being very narrow and having almost capillary width, will be quickly heated up and will quickly vaporize the water within the ducts. Simultaneously the outlet heater will vaporize the water column within the outlet duct 178 and the combined conversion of the water within the ducts of the heater units and in the outlet duct will practically instantaneously convert the water in the ducts into steam and clear a path for entry of fresh water through the opening 179 in the bottom of the heater units into the heater ducts 173 between the heater units 168. The rising steam fills the steam space 184 in the top of the vessel. Under the action of the weight of the column of water in the vessel above the heating ducts 173 of the heater units 168, the water enters through the downward opening 179 of the heater casing 176 in thin flat layers between the hot walls of the ducts 173, becoming instantaneously vaporized by flash-like action into steam which flows toward the top of the vessel through the outlet duct 178 that is clear of water.

As soon as the temperature of the outflow duct 178 reaches a value corresponding to a condition in which it is free from water and provides a free outflow path for the steam, thermostatic switch 207 is actuated, cutting off the current flow through outlet heater resistor 190, and preventing its over-heating.

The rising steam quickly builds up pressure in the steam space 184 of the vessel because the surrounding walls thereof are quickly heated up and the baffle 183 prevents excessive flow of steam towards the still cool water body below the baffle and thus effectively prevents excessive condensation of steam. The steam generation is thus started almost instantaneously after energizing the heater coils and the heating of the coils is automatically adjusted to maintain the heating during operation at a value at which the required amount of steam for operating the sprayer is obtained. This is achieved without heating up of the entire body of water of the vessel to vaporization temperature as was required with prior-art vapor sprayers. Danger to the device due to excessive heating of the structure after the water has fallen to a level at which vaporization is cut off is prevented by automatic cutouts, assuring safety under all circumstances.

Internally mounted automatic cutouts, such as the thermostatic switches 206 and 207, may be avoided by using a simplified control circuit as shown in Fig. 10. In this arrangement the cutout thermostat switches 206 and 207 are eliminated. A main cutout switch 205 on the outside of the vessel, like that used in connection with the arrangement of Fig. 6, serves to cut off the current supply to the main heating resistors 170 and to the outlet tube heating resistor 190 in case the water in the jar has dropped to a low level at which no further water vaporization can take place. An automatic time cutout switch 230 controls the energization of the outlet heater coil 190. The switch 230 is preferably coupled with the main cutout switch 205 so that on moving the switch 205 to closed position for energizing the resistors 170, switch 230 is also closed. Switch 230 is further provided with a time-delay cutout device 231, such as a simple clockwork, which trips switch 230 a suitable time after the closure, say, a minute or two. This tripping is carried out without affecting the closed position of switch 205, and serves to cut off the heating resistor 190 of the outlet duct 178 a short time after the starting of the vaporizer, giving the resistor 190 time enough to evaporize and expel the water in the outlet duct and to provide a free outlet path for the steam generated by the heater ducts 173 in the bottom of the vessel.

The flash boiler described above is characterized by a number of important features especially adapted for use in connection with vapor sprayers and the like. It eliminates the necessity for heating the whole body of water to the vaporization temperature at the beginning of the spraying action. It permits quick generation of the amount of steam required to set the sprayer into action by admitting only a small part of the total quantity of water in the vessel to the heater unit. It keeps the heater unit insulated from the main body of water in the vessel, gives instantaneous generation of the required amount of operating steam, and cuts down the steam condensation accompanying operation of ordinary boilers.

By making the height of the vaporizing heater duct unit relatively small compared with the

height of the column of water in the vessel and mounting the heater unit below the water column, in a space containing only little water, there is provided a high pressure head for causing the water to flow into the heater ducts and to easily discharge the generated steam from the heater ducts into the steam space on the top of the vessel.

By subdividing the low heater duct unit into a plurality of narrow ducts, a large heating surface is obtained within a small space in the bottom part of the vessel, securing rapid vaporization of the water impelled by the high pressure head. While the heat flow is confined to a small body of water entering the narrow heater ducts, loss of heat to the outside water is prevented by a heat insulating enclosure enclosing the heater ducts.

To enable free inflow of water into the narrow heater ducts at the bottom of the vessel and free outflow of steam therefrom into the steam space on the top of the vessel, the steam outlet duct is made of a cross section and construction which quickly removes the water with which the duct is initially filled, the duct discharging freely the steam as it is generated. The special heating resistor of the outflow duct acts as an additional steam generator during the initial period of operation, and in conjunction with the main steam generation taking place in the heater ducts 173, quickly converts all the water in the steam outflow path into steam and provides a clear path for the steam flow into the upper steam space of the vessel.

By the provision of a heat insulating baffle member between the steam space on the top of the vessel and the space filled with water, the condensation of the initially generated steam by its exposure to a large body of relatively cold water is cut down, the solid surfaces exposed to the steam space being quickly heated up and being insulated against the water body. The baffle arrangement also enables maintaining of the full available pressure head of the water column effective for impelling the water from the bottom of the vessel into the main heater ducts 173.

In the modification of the vaporizer unit shown in the device of Fig. 11, the steam outlet duct 178 is not provided with an outer heating coil like the device of Fig. 6, but instead the two lead-in conductors 200 and 201 are connected directly to the heater coils 170 of the heating units, the two lead-in conductors being led through the interior of the outlet duct 178. These wires are imbedded in a casing 250, of metal, for instance, enclosing the conductors and protecting them against contact with water and steam. The resistance of the portion of the wire going through the outlet duct 250 is so adjusted and proportioned that it assists in initially heating the water in the outlet duct 178 when starting the sprayer to quickly remove the water therefrom and prevent free outflow of steam. The imbedded conductor portions 200 and 201 are preferably made of a material having a negative resistance coefficient so that their resistance becomes lower as their temperature rises, reducing the heat dissipation in the outlet duct 178 as soon as the outlet tube has been cleared from the water, and providing a free space for the flow of steam from the heating unit below it.

The invention is not limited to the details of construction and the particular materials referred to in the foregoing description of its exemplifications, but many other modifications

thereof will suggest themselves to those skilled in the art. It is accordingly desired that the appended claims be given a broad construction commensurate with the scope of the invention within the art.

I claim:

1. In a portable evaporator constituting a part of a sprayer for spraying a liquid by a discharge of compressed hot vapor supplied by said evaporator, encasing means having a space for holding a vaporizable liquid of varying level and a space above said liquid for collecting vapor generated from said liquid, evaporizing conduit means of narrow flow cross section having an inlet connected to the bottom level of said liquid holding space for guiding a flow of a thin layer of liquid from said liquid holding space, duct means of relatively small volume extending from the outlet end of said conduit means to the higher level of said vapor space for discharging fluid flowing through said conduit means into said vapor space, and heating means associated with said conduit means and said duct means confining the major flow of generated heat to the wall portions of said conduit means bordering said liquid layer, said conduit, duct and heating means being proportioned and constructed to convert liquid entering said conduit means into vapor discharging under pressure through said duct means into said vapor space.

2. In a portable evaporator constituting a part of a sprayer for spraying a liquid by a discharge of compressed hot vapor supplied by said evaporator, encasing means having a space for holding a vaporizable liquid of varying level and a space above said liquid for collecting vapor generated from said liquid, evaporizing conduit means of narrow flow cross section having an inlet connected to the bottom level of said liquid holding space for guiding a flow of a thin layer of liquid from said liquid holding space, duct means of relatively small volume extending from the outlet end of said conduit means to the higher level of said vapor space for discharging fluid flowing through said conduit means into said vapor space, heating means associated with said conduit means and said duct means confining the major flow of generated heat to the wall portions of said conduit means bordering said liquid layer, said conduit, duct and heating means being proportioned and constructed to convert liquid entering said conduit means into vapor discharging under pressure through said duct means into said vapor space, and heat insulating means interposed between said duct means and said liquid holding space for preventing flow of heat from the space in said duct to said liquid.

3. In a portable evaporator constituting a part of a sprayer for spraying a liquid by a discharge of compressed hot vapor supplied by said evaporator, encasing means having a space for holding a vaporizable liquid of varying level and a space above said liquid for collecting vapor generated from said liquid, evaporizing conduit means of narrow flow cross section having an inlet connected to the bottom level of said liquid holding space for guiding a flow of a thin layer of liquid from said liquid holding space, duct means of relatively small volume extending from the outlet end of said conduit means to the higher level of said vapor space for discharging fluid flowing through said conduit means into said vapor space, heating means associated with said conduit means and said duct means confining

the major flow of generated heat to the wall portions of said conduit means bordering said liquid layer, said conduit, duct and heating means being proportioned and constructed to convert liquid entering said conduit means into vapor discharging under pressure through said duct means into said vapor space, and heat insulating means interposed between said conduit and duct means and said liquid holding space for preventing flow of heat from the space in said conduit and duct to said liquid.

4. In a portable evaporator constituting a part of a sprayer for spraying a liquid by a discharge of compressed hot vapor supplied by said evaporator, encasing means having a space for holding a vaporizable liquid of varying level and a space above said liquid for collecting vapor generated from said liquid, evaporizing conduit means of narrow flow cross section having an inlet connected to the bottom level of said liquid holding space for guiding a flow of a thin layer of liquid from said liquid holding space, duct means of relatively small volume extending from the outlet end of said conduit means to the higher level of said vapor space for discharging fluid flowing through said conduit means into said vapor space, heating means associated with said conduit means and said duct means confining the major flow of generated heat to the wall portions of said conduit means bordering said liquid layer, said conduit, duct and heating means being proportioned and constructed to convert liquid entering said conduit means into vapor discharging under pressure through said duct means into said vapor space, and heat insulating baffle means separating the vapor space from said liquid.

5. In a portable evaporator constituting a part of a sprayer for spraying a liquid by a discharge of compressed hot vapor supplied by said evaporator, encasing means having a space for holding a vaporizable liquid of varying level and a space above said liquid for collecting vapor generated from said liquid, evaporizing conduit means of narrow flow cross section having an inlet connected to the bottom level of said liquid holding space for guiding a flow of a thin layer of liquid from said liquid holding space, duct means of relatively small volume extending from the outlet end of said conduit means to the higher level of said vapor space for discharging fluid flowing through said conduit means into said vapor space, heating means associated with said conduit means confining the major flow of generated heat to the wall portions of said conduit means bordering said liquid layer, said conduit, duct and heating means being proportioned and constructed to convert liquid entering said conduit means into vapor discharging under pressure through said duct means into said vapor space, and floating heat insulating baffle means separating the vapor space from said liquid.

6. In a portable evaporator constituting a part of a sprayer for spraying a liquid by a discharge of compressed hot vapor supplied by said evaporator, encasing means having a space for holding a vaporizable liquid of varying level and a space above said liquid for collecting vapor generated from said liquid, evaporizing conduit means of narrow flow cross section having an inlet connected to the bottom level of said liquid holding space for guiding a flow of a thin layer of liquid from said liquid holding space, duct means of relatively small volume extend-

ing from the outlet end of said conduit means to the higher level of said vapor space for discharging fluid flowing through said conduit means into said vapor space, heating means associated with said conduit means and said duct means confining the major flow of generated heat to the wall portions of said conduit means bordering said liquid layer, said conduit, duct and heating means being proportioned and constructed to convert liquid entering said conduit means into vapor discharging under pressure through said duct means into said vapor space, heat insulating means interposed between said conduit and duct means and said liquid holding space for preventing flow of heat from the space in said conduit and duct to said liquid, and heat insulating baffle means separating the vapor space from said liquid.

7. In a portable evaporator constituting a part of a sprayer for spraying a liquid by a discharge of compressed hot vapor supplied by said evaporator, encasing means having a space for holding a vaporizable liquid of varying level and a space above said liquid for collecting vapor generated from said liquid, evaporizing conduit means of narrow flow cross section having an inlet connected to the bottom level of said liquid holding space for guiding a flow of a thin layer of liquid from said liquid holding space, duct means of relatively small volume extending from the outlet end of said conduit means to the higher level of said vapor space for discharging fluid flowing through said conduit means into said vapor space, heating means associated with said conduit means and said duct means confining the major flow of generated heat to the wall portions of said conduit means bordering said liquid layer, said conduit, duct and heating means being proportioned and constructed to convert liquid entering said conduit means into vapor discharging under pressure through said duct means into said vapor space, and means responsive to a temperature condition of the fluid passing said conduit means for selectively controlling the energization of said heating means.

8. In a portable evaporator constituting a part of a sprayer for spraying a liquid by a discharge of compressed hot vapor supplied by said evaporator, encasing means having a space for holding a vaporizable liquid of varying level and a space above said liquid for collecting vapor generated from said liquid, evaporizing conduit means of narrow flow cross section having an inlet connected to the bottom level of said liquid holding space for guiding a flow of a thin layer of liquid from said liquid holding space, duct means of relatively small volume extending from the outlet end of said conduit means to the higher level of said vapor space for discharging fluid flowing through said conduit means into said vapor space, heating means associated with said conduit means confining the major flow of generated heat to the wall portions of said conduit means bordering said liquid layer, supplemental heating means for heating said duct means, said conduit, duct and heating means being proportioned and constructed to convert liquid entering said conduit means into vapor discharging under pressure through said duct means into said vapor space, and means responsive to a temperature condition of the fluid passing said conduit means for selectively controlling the energization of said supplemental heating means.

9. In a portable evaporator for evaporating a

liquid of variable pressure head and supplying vapor to a vapor space above the level of said liquid, evaporizing conduit means of narrow flow cross section for guiding a flow of a thin layer of said liquid, duct means of relatively small volume extending from the outlet end of said conduit means to the higher level of said vapor space for discharging fluid flowing through said conduit means into said vapor space, and heating means associated with said conduit means and said duct means confining the major flow of generated heat to the wall portions of said conduit means bordering said liquid layer, said conduit, duct and heating means being proportioned and constructed to convert liquid entering said conduit means into vapor discharging under pressure through said duct means into said vapor space.

10. In a portable evaporator for evaporating a liquid of variable pressure head and supplying vapor to a vapor space above the level of said liquid, evaporizing conduit means of narrow flow cross section for guiding a flow of a thin layer of said liquid, duct means of relatively small volume extending from the outlet end of said conduit means to the higher level of said vapor space for discharging fluid flowing through said conduit means into said vapor space, heating means associated with said conduit means confining the major flow of generated heat to the wall portions of said conduit means bordering said liquid layer, said conduit, duct and heating means being pro-

portioned and constructed to convert liquid entering said conduit means into vapor discharging under pressure through said duct means into said vapor space, and means responsive to a temperature condition of said duct for selectively controlling the energization of said heating means.

11. In a portable evaporator for evaporating a liquid of variable pressure head and supplying vapor to a vapor space above the level of said liquid, evaporizing conduit means of narrow flow cross section for guiding a flow of a thin layer of said liquid, duct means of relatively small volume extending from the outlet end of said conduit means to the higher level of said vapor space for discharging fluid flowing through said conduit means into said vapor space, heating means associated with said conduit means confining the major flow of generated heat to the wall portions of said conduit means bordering said liquid layer, supplemental heating means for heating said duct means, said conduit, duct and heating means being proportioned and constructed to convert liquid entering said conduit means into vapor discharging under pressure through said duct means into said vapor space, and means responsive to a temperature condition of the fluid passing said conduit means for selectively controlling the energization of said supplemental heating means.

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