

Sept. 3, 1940.

T. W. CARRAWAY

2,213,622

COOLING UNIT

Filed Oct. 20, 1937

4 Sheets-Sheet 1

Fig. 1.

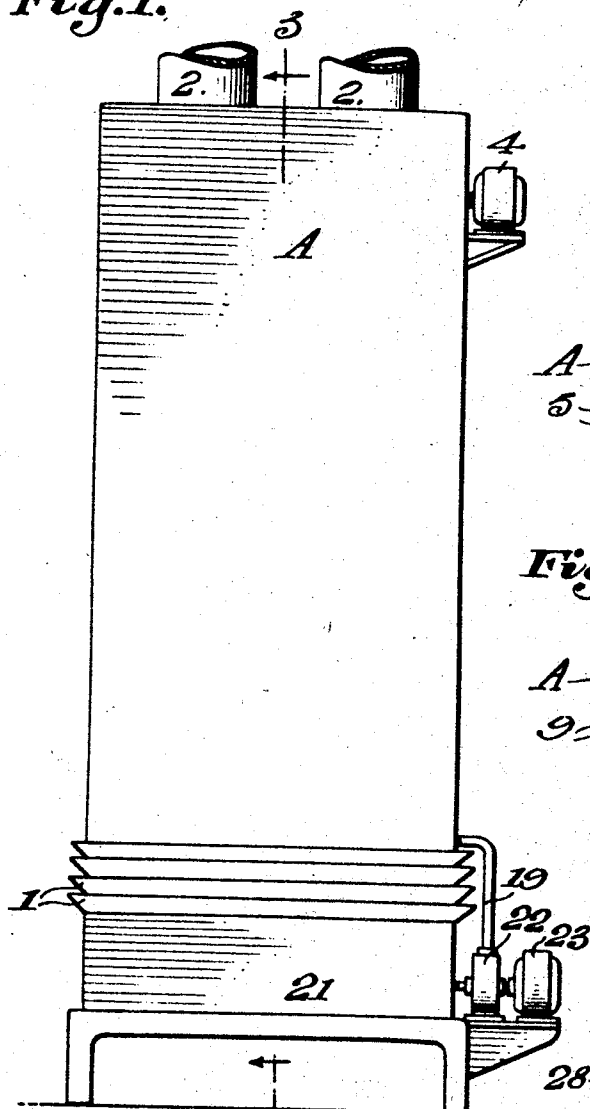


Fig. 4.

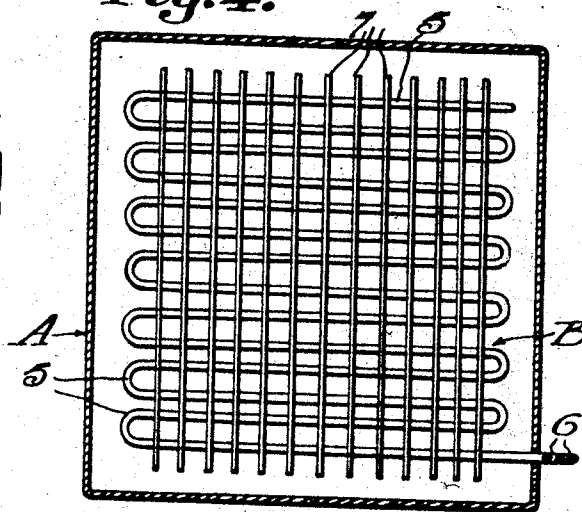


Fig. 5.

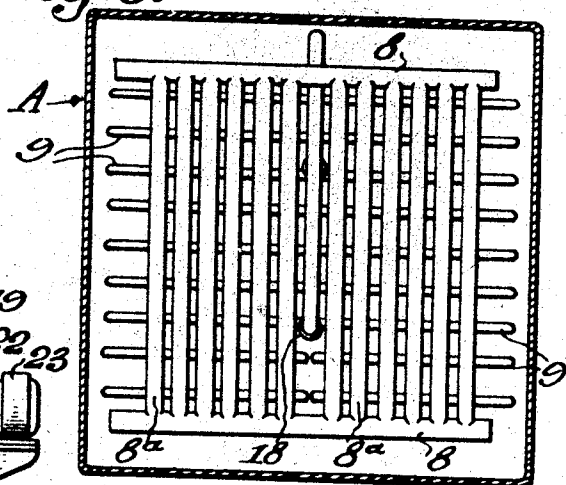
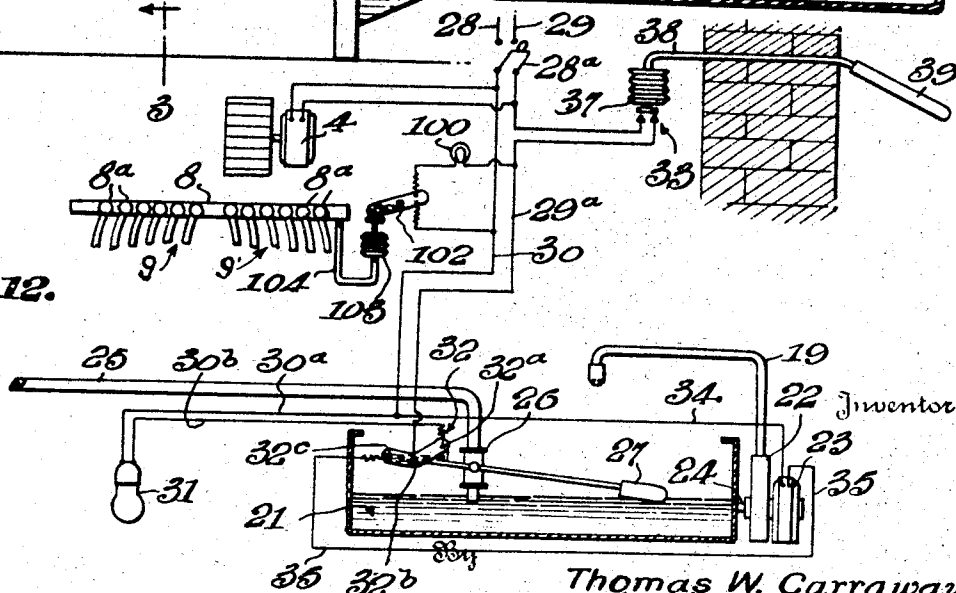


Fig. 12.



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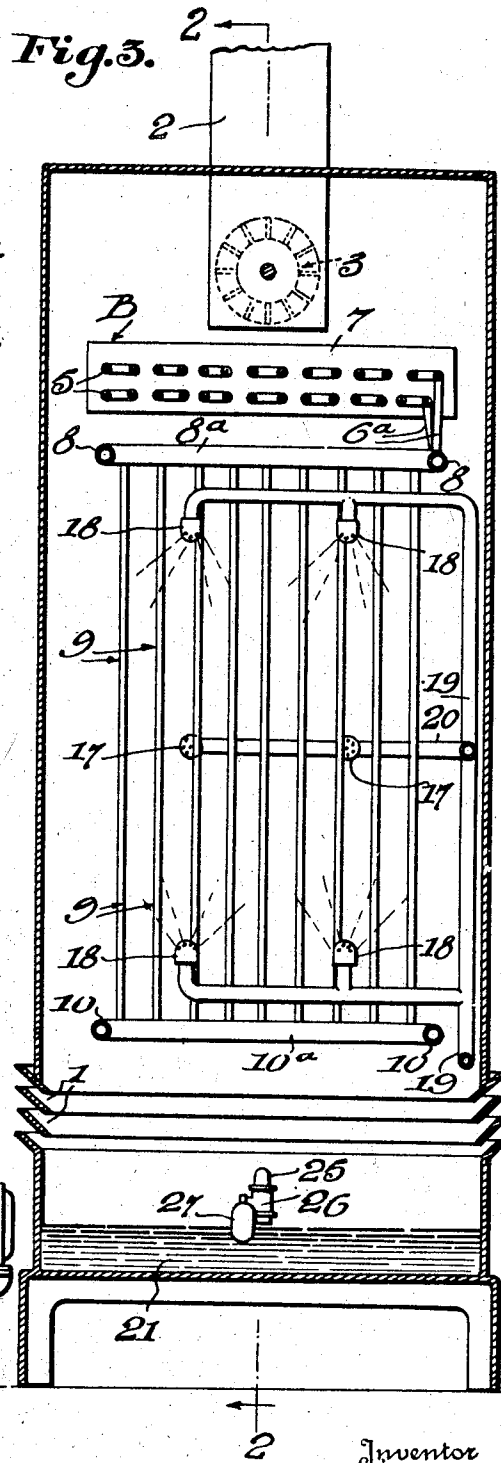
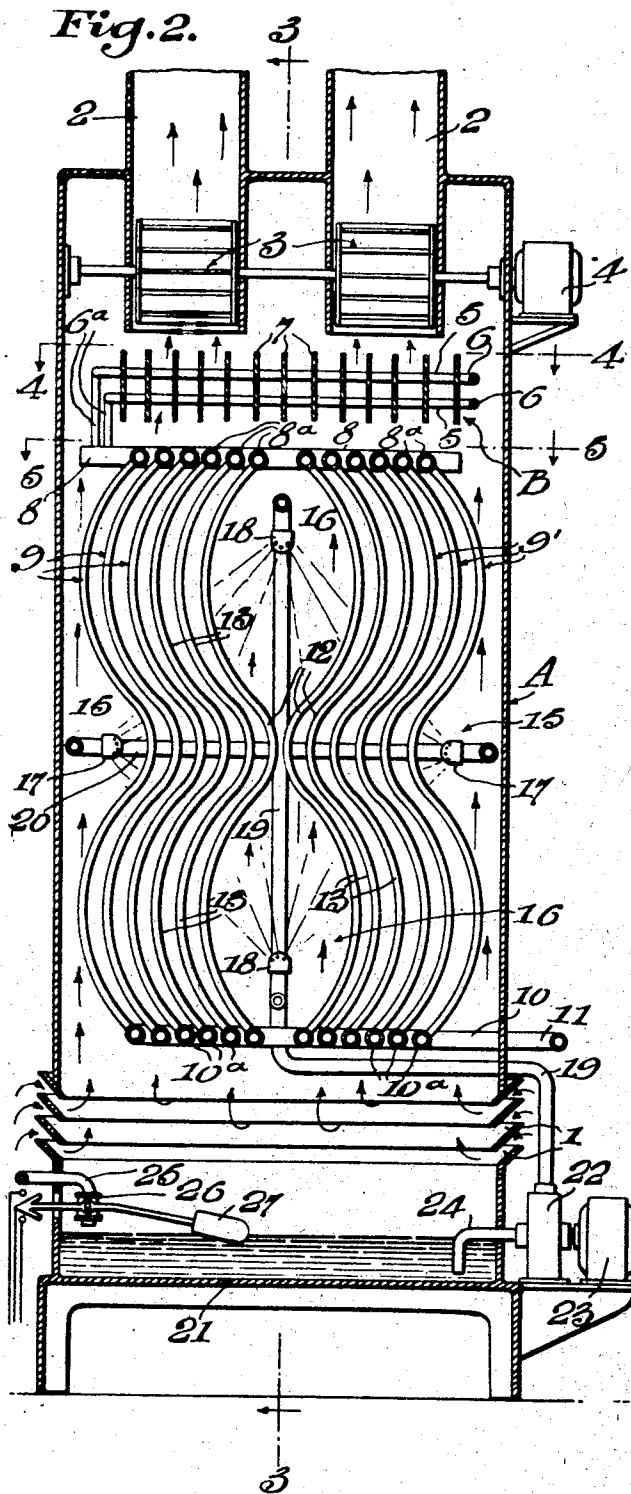
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4 Sheets-Sheet 2



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Sept. 3, 1940.

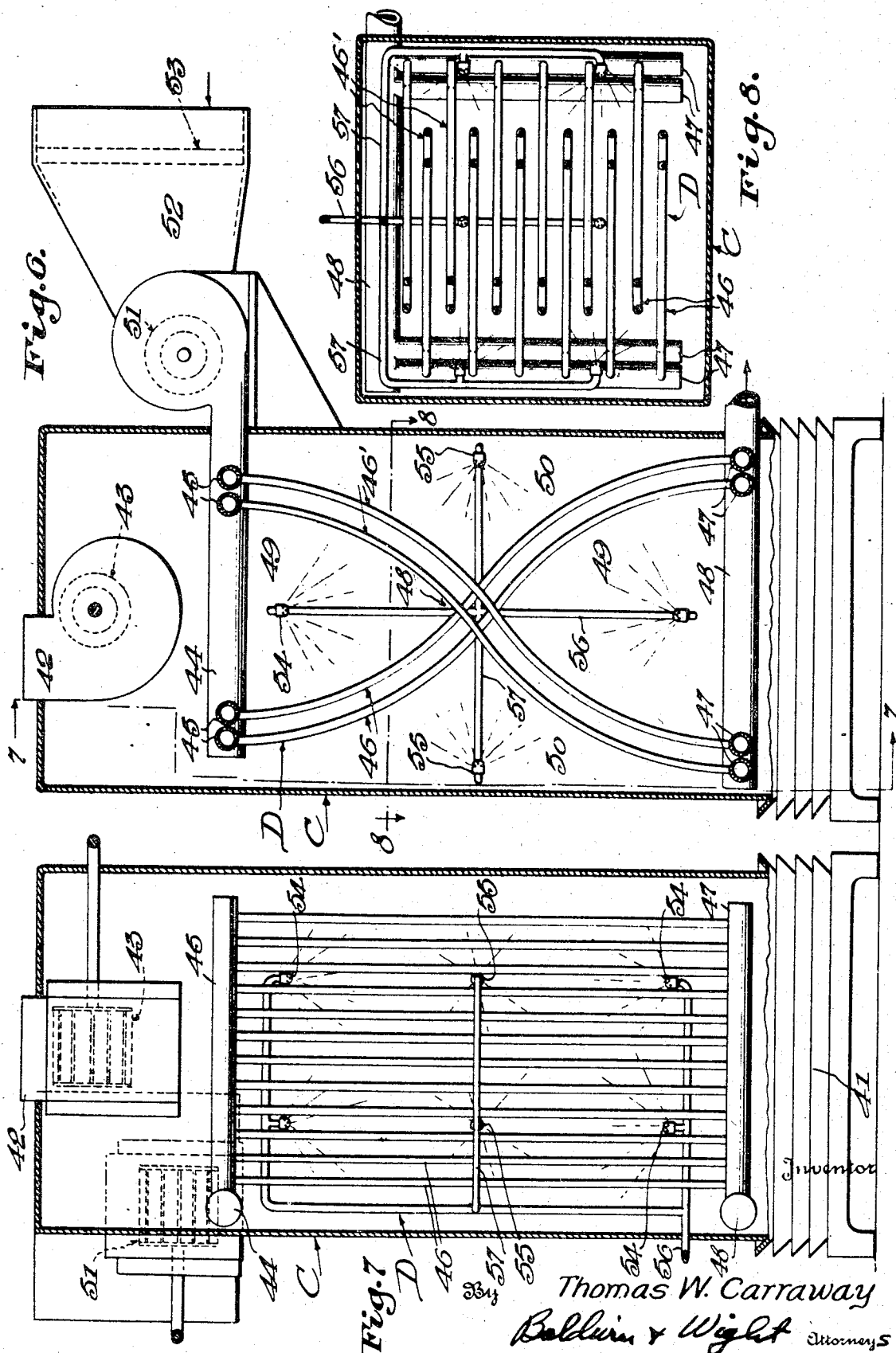
T. W. CARRAWAY

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COOLING UNIT

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4 Sheets-Sheet 3



Sept. 3, 1940.

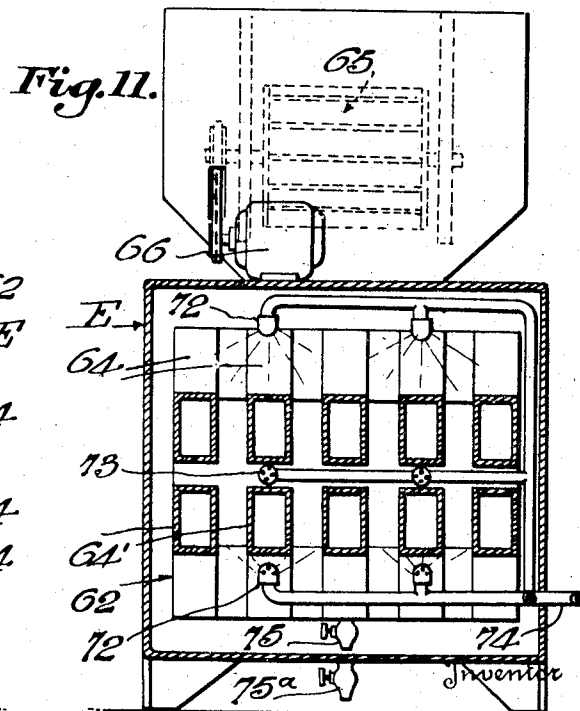
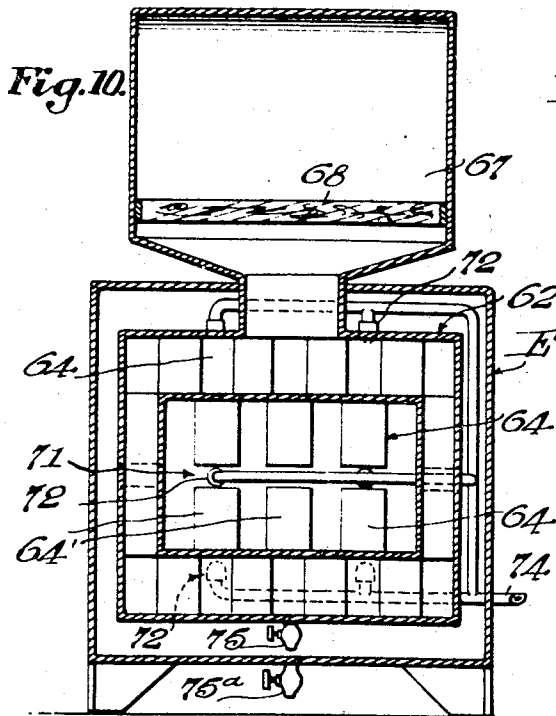
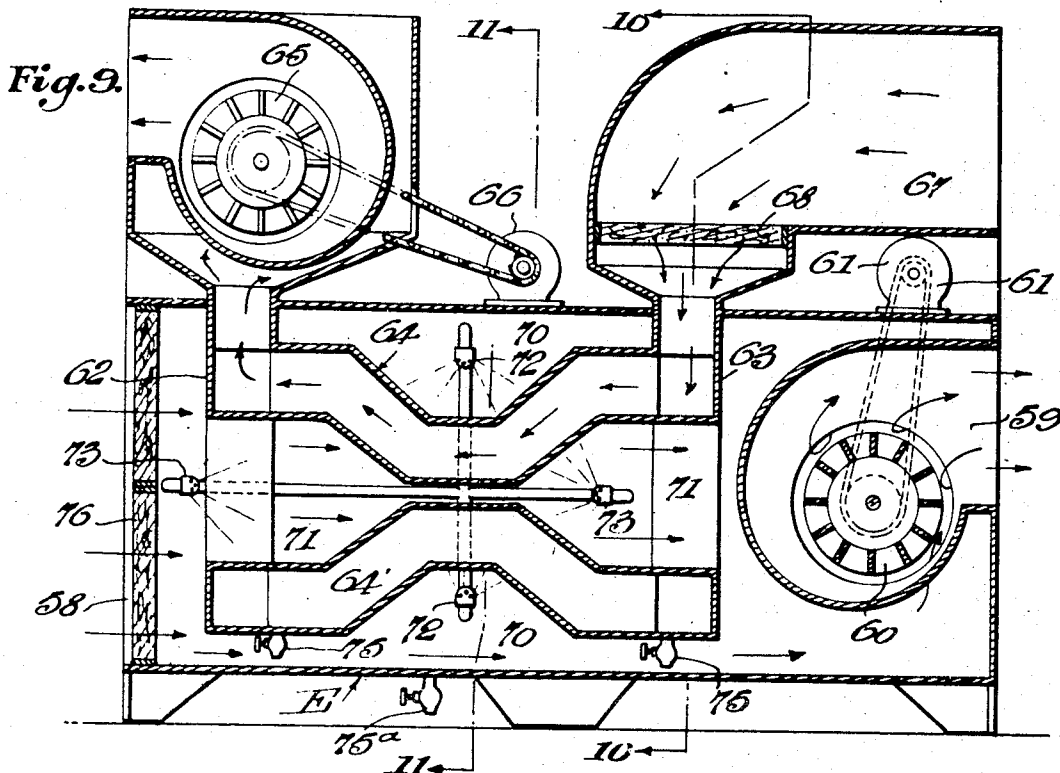
T. W. CARRAWAY

2,213,622

COOLING UNIT

Filed Oct. 20, 1937

4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,213,622

COOLING UNIT

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Application October 20, 1937, Serial No. 170,117

8 Claims. (Cl. 257—70)

This invention relates to cooling units, and more particularly to cooling units of the kind in which a fluid to be cooled is passed through a heat-transfer element such as a duct or the like, the heat-transfer element being subjected to the cooling effect of a stream of air passing in contact with the element, the air stream itself and the element being cooled by evaporating moisture in the air stream.

Cooling units of this kind have been used heretofore principally because they can be operated somewhat more cheaply than cooling units of the more generally used types in which the cooling is effected with the aid of compression-expansion machinery or by the use of large quantities of water sprayed into the air being cooled or conditioned. Generally stated, units of the class to which my invention relates and which heretofore were known in the art comprised one or more pipes, ducts, or the like through which air or other fluid to be cooled was passed, means for spraying water on the ducts or pipes, and means for moving air around the pipes wet by the spray, the water thus sprayed on the pipes or ducts evaporating and being carried away by the air stream as water vapor. The heat for evaporating the water was drawn directly from the pipes or ducts through which the fluid to be cooled was passed.

I have found that the efficiency of such units may be increased greatly by arranging the ducts or pipes and the means for introducing the water in such a way that, instead of spraying water almost directly upon the ducts or pipes, the water is atomized and diffused into the stream of air well removed from the pipes or ducts. I have found that this eliminates, to a greater extent than heretofore has been considered possible, the carrying away of unevaporated particles of water, and results in maximum evaporation whereby for a given quantity of water supplied to the unit a maximum cooling load can be carried.

An object of my invention, therefore, is to provide a cooling unit of the class referred to in which the relative arrangement of the ducts or pipes and the water-supplying means is such as to promote maximum evaporation of the water supplied to the air stream, and hence to produce a maximum cooling effect.

Another object is to provide a unit of the kind referred to in which the arrangement is such as to produce a soft, even flow of air around the pipes or ducts, such flow having been found to be most conducive to maximum evaporation.

A further object is to provide a novel associa-

tion of heat-transfer means and water-supplying means.

Other objects will become apparent from a reading of the following description, the appended claims, and the accompanying drawings, in which:

Figure 1 is a view in front elevation showing one embodiment of my invention;

Figure 2 is a vertical section taken on the line 3—3 of Figure 3;

Figure 3 is a vertical section taken on the line 3—3 of Figures 1 and 2;

Figure 4 is a cross section taken on the line 4—4 of Figure 2;

Figure 5 is a cross section taken on the line 5—5 of Figure 2;

Figure 6 is a view in vertical section corresponding to Figure 2 but showing a modification;

Figure 7 is a section taken on the line 7—7 of Figure 6;

Figure 8 is a section taken on the line 8—8 of Figure 6;

Figure 9 is a longitudinal vertical sectional view of a further modification;

Figure 10 is a vertical cross section taken on the line 10—10 of Figure 9;

Figure 11 is a vertical cross section taken on the line 11—11 of Figure 9; and

Figure 12 is a diagrammatic view showing control apparatus.

The cooling units shown in the drawings are illustrative of practical embodiments of the invention, but it will be understood that the invention may be embodied in other forms.

Referring first to the form shown in Figures 1 to 5 inclusive and 12, the cooling unit is shown as comprising an upright or vertical casing A having inlet openings or louvers 1 at the bottom end and discharge or outlet openings 2 at its upper end. A pair of blowers 3 is associated with the outlet openings, and is driven by means such as a motor 4 for causing air to enter the casing through the louvers 1 to flow upwardly therethrough and to be discharged through the openings 2 to any convenient point outside of the space to which cooled air or other fluid is to be delivered.

Mounted within the casing is a heat-transfer unit B which in the form shown includes two horizontal coils 5—5 having inlets 6—6 and extending back and forth through fins or radiator plates 7. The outlet ends of the coils 5—5 are connected respectively as at 6^a—6^a to headers 8—8 disposed under and closely contiguous to the coils 5. The headers 8—8 are connected by 55

cross headers 8^a. Connected to the several cross headers 8^a are two sets of ducts 9 and 9' symmetrically disposed on opposite sides of a plane central and longitudinal or vertical with respect to the casing, such plane being perpendicular to the paper in Figure 2 and along the section line 3—3. The ducts 9 are all relatively close to each other, as are the ducts 9', so as to provide relatively small spaces therebetween. The bottom ends of the ducts are connected to cross headers 10^a which in turn communicate with headers 10 communicating with a discharge pipe or conduit 11.

Near their central points the ducts 9 are curved inwardly as at 12 towards the ducts 9', and, conversely, the ducts 9' are curved inwardly at their central portions as at 12 toward the ducts 9. On opposite sides of their central portions, i. e., both above and below their central portions, the ducts are curved outwardly as at 13, so that the ducts 9 become disposed relatively far from the ducts 9', and the ducts 9' become disposed relatively far from the ducts 9. As a result of this curvature of the ducts, there are provided two relatively large uninterrupted spaces 15—15 between the central portions of the ducts and the walls of the casing, and two relatively large uninterrupted spaces 16—16 between the ducts 9 and the ducts 9'. The provision of these spaces around and between the ducts is of particular importance, as will now be explained.

Positioned within and arranged to discharge directly into the spaces 15—15 are atomizers 17—17, and, similarly, atomizers 18—18 are positioned within and arranged to discharge directly into the spaces 16—16. Water is conveyed to the atomizers by means of a pipe 19 leading to the atomizers 18—18 and having a branch 20 leading to the atomizers 17—17. The water may be supplied by any suitable source of water under pressure, but preferably, and in accordance with a further feature of the invention, the water is supplied from a sump or reservoir 21 in the bottom of the casing, from which water may be drawn by a pump 22 operated by a motor 23, the inlet side 24 of the pump communicating with the reservoir and the discharge side being connected directly to the pipe 19.

In operation, the blowers 3 are run continuously in order to maintain a steady flow of air upwardly through the casing A around and in contact with the ducts 9 and 9'. The fluid to be cooled is delivered to the inlet ends 6 of the coils 5, and, after passing through the coils, it flows downwardly into the headers 8 and 8^a, thence downwardly through the ducts 9 and 9', and thence outwardly through the bottom headers and the discharge connection 11. Water is delivered under pressure to the atomizers 17 and 18, the latter spraying finely atomized water into the spaces 15 and 16 respectively. Because of the relatively large spaces 15 and 16 in which the atomizers are located and into which they discharge, the water will be thoroughly atomized, spread out, and diffused in the stream of air flowing upwardly through the casing. The atomization thereby effected is much more thorough and efficient than would be the case if the water were sprayed more directly upon the ducts. I have found that, when the ducts are wet with a rather thick layer of unatomized water because of the atomizers being located too close to the ducts, there is a tendency for the air stream to pick up small drops or globules of unatomized water and to carry it entrained in

the air stream out through the casing. Water which is removed from the casing without first being converted into water vapor results in a substantial increase in the cost of operation, since it is chiefly the evaporation of the water which extracts heat from the ducts 9 and consequently from the fluid flowing through the ducts. Furthermore, a relatively thick coating or layer of water on the ducts has a substantial insulating effect, interfering with and retarding the heat transfer. In accordance with my invention a very thin film of water or moisture is maintained on the duct surfaces, the film being so thin as to evaporate readily and moreover is not thick enough to have any appreciable insulating effect. It is apparent that, although my novel and improved arrangement of the ducts and atomizers provides for particularly efficient atomization and heat transfer, this desirable result is accomplished without spreading the entire heat-transfer unit, and therefore without increasing the size of and rendering bulky the unit considered as a whole. It should be noted that air entering the bottom of the casing is directed downwardly at first by the louvers 1, so that, by the time the air reaches the ducts, there will be no substantial localized concentrations of air velocity, and instead there is a soft substantially uniform flow of air throughout the entire cross section of the casing. Such an even flow of air has been found to cooperate most efficiently with the novel arrangement of the atomizers within the enlarged atomization spaces. As is apparent, the air, after entering the louvers 1, flows substantially straightway through the casing in a direction opposite the general direction of flow of the fluid to be cooled through the ducts 9 and 9'. The counter flow of the air and the fluid to be cooled produces the maximum cooling effect with the use of a given quantity of water and cooling air.

Units of the kind described are adapted for cooling the refrigerating medium used in a compression-expansion apparatus, in which case the refrigerating medium is conducted through the ducts 9 and 9'. However, units of the same general nature are well adapted for cooling of other fluids, such as water or oil as well as the direct cooling of air, in which case the air to be cooled is conducted through the ducts 9 and 9' and delivered to the room or other space to be conditioned or cooled. When used for cooling air, it may be desirable to increase somewhat the cross-sectional size of the ducts to permit the free and easy flow of relatively large volumes of air.

Control means are provided for maintaining a proper quantity of water in the sump or reservoir 21, and for giving a signal in case the water in the sump or reservoir should drop below a predetermined level. As shown in Figures 2 and 12, the sump 21 is fed by a main water supply pipe 25, flow from which is controlled by a valve 26 which is in turn controlled by a float 27. The arrangement is such that, when the water in the sump falls below a predetermined level, the float will descend, opening the valve 26, whereas, when the water reaches or is above a predetermined level, the float will rise to close the valve 26.

Control means is provided for the water supplying means and for actuating a signal if the water supply fails. When the water is supplied to the atomizers by means of a pump, the control means may comprise a float operated switch

means adapted to stop the pump motor and to actuate the signal when the water in the reservoir drops below a predetermined level which should be somewhat below the level at which the valve 26 opens to introduce more water into the reservoir. One form of such control means is shown diagrammatically in Fig. 12 as being in circuit with electrical supply conductors 28 and 29 controlled by a master switch 28^a. A conductor 30 leads from the conductor 28 to a branch conductor 30^a, connected to one terminal of a signal 31 of any suitable kind such as a lamp or a bell. The other terminal of the signal is connected to a conductor 30^b which leads to one end terminal 32^a of a single pole double-throw switch 32. The central pole 32^b of the switch 32 is connected to a conductor 29^a which has interposed therein a temperature responsive switch 33, the purpose of which will be described later. The conductor 29^a leads from the switch 33 through the master switch 28^a to the supply conductor 29. The parts thus far described constitute the circuit for operating the signal 31.

The circuit for controlling the operation of the pump in dependence upon the level of water in the reservoir includes the supply conductor 28 leading through the switch 28^a to the conductor 30, which has a branch 34 connected to one side of the pump motor 23. The other side of the pump motor is connected to a conductor 35 which leads to an end terminal 32^c of the switch 32. Included also in this circuit is the conductor 29^a which leads from the central terminal 32^b of the switch 32 through the temperature responsive switch 33 and the master switch 28^a to the main supply conductor 29.

The operation of the control means as influenced by the level of the water in the reservoir will be described, first assuming that the switch 33 is closed. Assuming also that the pump is running to deliver water from the reservoir to the atomizers, the switch 32 will be in the position shown in Figure 12. In this position, the motor circuit will be closed from the conductors 28, 30, 34, 35, the switch terminals 32^c and 32^b, the conductor 29^a and the switch 33 to the conductor 29. The water level will descend until the float has dropped sufficiently to open the valve 26 to admit more water to the tank. If the supply of water through the pipe 25 is unfailing the level of water in the tank will rise until the float cuts off the valve 26. If, however, the water supply should fail, the float will continue to descend below the level at which it opens the valve 26 until the switch 32 has been tipped clockwise, as viewed in Figure 12, causing the mercury to bridge across the terminals 32^a and 32^b. This will complete a circuit through the conductors 28, 30, 30^a, the signal 31, the conductor 30^b, the switch 32, the conductor 29^a and the switch 33 so as to actuate the signal indicating that the water supply has failed and giving the necessary warning. At the same time, tipping of the switch 32 will break the circuit between the switch terminals 32^b and 32^c, thereby opening the motor circuit and stopping the pump. It is of particular importance that the switch 32 be so mounted and positioned that bridging of the contacts 32^b and 32^c will be maintained for some time after the float has descended to a position to open the valve 26. In normal operation the float will descend to a position opening the valve 26 frequently so as to replenish the water supply, but the signal 31 should not be actuated and the pump should

not be stopped unless the float descends to a considerably lower position.

I provide means for cutting off the supply of water to the atomizers when the temperature of the outside air or the air entering the casing falls below a predetermined point. For example, when air is drawn in from outside a building in the summer time it is necessary and highly important to provide the atomized water for extracting heat from the ducts 9 and 9'. On the contrary, when the air drawn from the outside is at a low temperature, say below freezing, it may not be necessary to employ atomized water for effecting the necessary heat abstraction, the low temperature of the outside air itself sufficing to effect the required heat transfer. For this reason I prefer to provide means responsive to the temperature of the outside air or the air entering the casing, for discontinuing the supply of water to the atomizers when the temperature of the outside air reaches a predetermined low point. In the form shown in Figure 12 the switch 33 is interposed in the pump and signal circuits and is adapted to be maintained closed during summer operation by means of any suitable device responsive to the temperature of the outside air, such, for example, as a siphon bellows 37 communicating by means of a tube 38 with a container 39 for a thermo-responsive fluid medium. When the outside air is above a predetermined temperature the fluid within the container 39 will expand causing the bellows 37 to close the switch 33 and thereby causing the motor 23 and the pump 22 to operate so as to supply water to the atomizers. When, however, the temperature of the outside air falls below a predetermined value the fluid within the container will contract, causing the switch 33 to be opened so as to stop the pump and motor and to discontinue supply of water to the atomizers. Furthermore, opening of the switch 33 will render the signal circuit inoperative. By virtue of this arrangement a substantial economy in the use of water is effected. Since the entire operating expense consists of the cost of the water and the cost of power for operating the blower and pump motors, dispensing when possible with one of these items of expense, namely the cost of the water, results in a material gain in operating economy. Moreover, it eliminates the danger of freezing which otherwise might occur if water were supplied into the casing when the air entering the casing is below the freezing temperature. It is apparent that control means such as those described above may also be used for controlling the supply of water when furnished directly from a city supply line without the use of a pump.

I provide means for giving a warning in the event the pressure in the heat exchange ducts should rise due, for example, to failure of the atomizers to deliver sufficient water vapor to effect the necessary abstraction of heat from the fluid flowing through the ducts. Preferably, this warning means is arranged to operate independently of the supply of water to the sump. Thus, if the pump fails, or if the atomizers become clogged the rate of heat abstraction from the ducts may be reduced to such an extent as to cause a rise of temperature and pressure in the ducts and such rise in pressure, however, will operate the warning signal even though the water may be at the desired level in the sump. In the form shown, this signalling means includes a signal device 100, such as a bell or light, and a

switch 102 connected in series across the conductors 29^a and 30. Normally, the switch is open but it is adapted to be closed in response to rising pressure in the ducts 9—9' and header 8 by means of a bellows 103 which communicates with the ducts and header 8 by means of a pipe 104.

The modification shown in Figures 6, 7 and 8 is constructed and arranged to operate in much the same basic manner as the form shown in Figures 1 to 5. In the modification, the unit includes a vertically extending casing C provided with an inlet opening constituted by louvers 41, and an outlet opening 42 arranged to receive and discharge air delivered by a blower 43 driven by a motor (not shown). The heat transfer unit D disposed within the casing differs specifically from the unit B shown in Figures 2 and 3. The unit D includes upper spaced headers 44 connected by cross headers 45. Sets of ducts 46 and 46' respectively are connected at their upper ends to the cross headers, and at their bottom ends are connected to cross headers 47 communicating at their opposite ends with headers 48. The ducts 46 are relatively close to each other so as to provide relatively small spaces therebetween, and the ducts 46' are relatively close to each other, providing relatively small spaces therebetween.

As shown in Figure 6, the upper ends of the ducts 46 are disposed at the left of the casing, and the ducts extend on an incline downwardly and to the right, being connected to the cross headers 47 adjacent the right hand side of the casing. Conversely, the ducts 46' are connected to the upper cross headers 45 adjacent the right hand side of the casing, and extend downwardly on an incline toward the left, and are connected to cross headers 47 adjacent the left hand side of the casing, the arrangement being such that the ducts 46 cross the ducts 46' as at 48 at about the middle of the casing. Preferably, the ducts are all curved as shown, in order to provide enlarged spaces 49—49 between the ducts 46 and the ducts 46', and enlarged spaces 50 between the ducts and the sides of the casing. A fan or blower 51 is arranged to draw fluid to be cooled in through an inlet duct 52, and to deliver it to the headers 44. Preferably a filter 53 is disposed in the path of the incoming air. The enlarged spaces serve a purpose analogous to that of the spaces 15 and 16 in Figure 2, that is to say, they provide spaces for complete atomization of water delivered by atomizers 54 and 55 located within and arranged to discharge directly into the spaces 49 and 50. The atomizers are supplied with water under pressure from a pipe 56 having a branch 57.

In operation, the blower 43 is run continuously so as to provide a steady uniform flow of air up through the casing around and in contact with the ducts 46 and 46'. The blower 51 draws in the air or other fluid to be cooled or conditioned, and forces it through the ducts, from whence it is discharged through the cross headers 47 and 48, being then delivered to the space to be cooled. As in the case of the form shown in Figures 1 to 5, the modification shown in Figures 6 to 8 may be used for cooling either air to be delivered to a room or the refrigerating medium of a compression-expansion refrigerating apparatus. If used for the latter purpose, the blower 51 would be replaced by the usual compressor, and the ducts would be connected in circuit with the compressor and expander. It is apparent that the modification shown in Figures 6 to 8 may be oper-

ated in connection with an automatic control of the kind shown in Figure 12 and previously described.

The modification shown in Figures 9 to 11, inclusive, is especially adapted for conditioning of air to be delivered to a room or other space to be cooled. This unit includes a horizontal casing E having an inlet end 58 and an outlet end 59, a blower 60 operated by a motor 61 being arranged at the outlet end for drawing air through the casing. Rectangular headers 62 and 63 are disposed respectively near the inlet and outlet ends of the casing, and interposed between the headers are two sets of ducts 64 and 64'. These ducts are large in cross section so as to permit the easy flow of air with as little friction as possible. Flow of air through the ducts is induced by means of a blower 65 driven by a motor 66 and communicating with the header 62. Air enters the ducts through a large intake 67 interposed in which is a filter 68. The ducts 64 and 64' are shown as being of rectangular cross section, but in accordance with the invention they may be of other shapes. It is of importance, however, that they be curved from end to end as shown in Figure 9 so as to provide relatively large atomizing spaces 70 and 71 in which are positioned atomizers 72 and 73. In this form also the relatively large spaces 70 and 71 provide for the substantially complete atomization of water delivered by the atomizers, and consequently result in the maximum cooling effect of the water supplied to the atomizers. The water may be supplied to the atomizers from any suitable source by means of a pipe 74. Drain cocks 75 are provided for draining off condensate which forms within the ducts 64 and 64' when the ducts are at a temperature lower than the dew point of air passing through the ducts. The casing may be provided with a drain connection 75^a for removing such slight amount of water as may collect unatomized at the bottom of the casing.

A filter 76 is provided at the inlet end 58. Insofar as I am aware, filters have been used heretofore only in the stream of air which is to be delivered to the conditioned or cooled area. In accordance with this feature of my invention, I position the filter 76 in the path of the air which flows around the ducts and is later exhausted to the outside instead of being delivered to the conditioned space. Not only does the filter 76 act to prevent the ducts from becoming coated with solid foreign particles, but also it serves the even more important function of diffusing the air as it enters the casing and causing it to flow in a very uniform stream throughout the length of the casing. As previously stated, such even and uniform flow without any localized air velocities is highly conducive to atomization of a maximum part of the water delivered by the atomizers.

It will be observed that in all of the disclosed forms of the invention the atomization spaces not only are sufficiently large to give the water sprays an opportunity to "fan out" and thus become thoroughly atomized, but moreover they are not interrupted by baffles, fins, or the like, so that the steady even flow of air through the spaces is not interfered with.

The cooling units disclosed herein embody my invention in practical and the at present preferred forms, but it will be understood that changes may be made without departing from the invention as defined in the claims.

I claim:

1. In a cooling unit, the combination of a casing; a plurality of ducts therein for conducting fluid to be cooled; means for moving air through said casing in contact with said ducts, said ducts having portions lying relatively close together with relatively small spaces therebetween and having other portions intermediate their ends curved away from each other so that said other portions have relatively large spaces between them; atomizing means opening directly into said relatively large spaces and effective to bathe all said duct portions in a very thin film of water; and means for supplying water to said atomizing means.

2. In a cooling unit, the combination of a casing having an inlet end and an outlet end; a plurality of ducts therein for conducting fluid to be cooled; means for moving air substantially straightway through said casing from the inlet end to the outlet end, said ducts having portions lying relatively close together with small spaces therebetween and being shaped intermediate their ends to form other portions relatively far apart and providing resultant relatively large spaces therebetween and providing at least one such relatively large space at a location other than at or adjacent the inlet end of the casing; and atomizing means opening directly into said relatively large spaces and arranged to spray atomized liquid into said spaces and effective to bathe all said duct portions in a very thin film of water.

3. In a cooling unit, the combination of a casing; two sets of ducts symmetrically disposed therein respectively on opposite sides of a plane longitudinal and central with respect to the casing; means for moving air through said casing, the central portions of the ducts of each set being curved inwardly towards ducts of the other set and towards said plane providing resultant enlarged air spaces or pockets between the casing and said inwardly curved duct portions; and atomizing means opening into said spaces and arranged to spray atomized liquid into said spaces.

4. In a cooling unit, the combination of a casing; two sets of ducts symmetrically disposed therein respectively on opposite sides of a plane longitudinal and central with respect to the casing; means for moving air through said casing, the central portions of the ducts of each set being curved inwardly towards ducts of the other set and towards said plane providing resultant enlarged air spaces or pockets between the casing and said inwardly curved duct portions, the portions of the ducts intervening between said inwardly curved central portions and the ends of the ducts being curved outwardly away from said plane and thereby providing resultant air spaces or pockets between the respective sets of ducts at opposite ends thereof; and atomizing means opening into said spaces and arranged to spray atomized liquid into said spaces.

5. In a cooling unit, the combination of a cas-

ing; two sets of ducts symmetrically disposed therein respectively on opposite sides of a plane longitudinal and central with respect to the casing; means for moving air through said casing, the central portions of the ducts of each set being curved inwardly towards ducts of the other set and towards said plane providing resultant enlarged air spaces or pockets between the casing and said inwardly curved duct portions, the portions of the ducts intervening between said inwardly curved central portions and the ends of the ducts being curved outwardly away from said plane and curved back inwardly to provide additional resultant air spaces or pockets between the respective sets of ducts; and atomizing means opening into said spaces and arranged to spray atomized liquid into said spaces.

6. In a cooling unit, the combination of a casing; two sets of ducts disposed symmetrically therein, the ducts of one set extending diagonally from one side of the casing across the casing and to the opposite side thereof and the ducts of the other set extending diagonally from said other side of the casing across the casing and to the first named side of the casing, the ducts of the two sets crossing each other and the said arrangement of ducts and the casing providing a plurality of relatively open and uninterrupted spaces; means for moving air through said casing; and atomizing means opening into said spaces.

7. In a cooling unit, the combination of a casing; a duct therein for conducting fluid to be cooled; means for moving air through said casing in contact with said duct, said duct having spaced portions lying relatively close to a wall of the casing and providing relatively small spaces between said duct portions and said wall, and an intervening connecting portion extended away from said wall and then back toward said wall to provide a relatively large space between said intervening duct portion and said wall; atomizing means opening directly into said relatively large space and effective to bathe said duct portions with a very thin film of water; and means for supplying water to said atomizing means.

8. In a cooling unit, the combination of a casing; a plurality of ducts therein for conducting fluid to be cooled; means for moving air through said casing in contact with said ducts, said ducts respectively having spaced portions lying relatively close to a wall of the casing and providing relatively small spaces respectively between said duct portions and said wall, and intervening connecting portions extended away from said wall and then back toward said wall, said intervening duct portions collectively and the portion of said wall opposite said intervening portions being separated by a relatively large space; atomizing means opening directly into said relatively large space and effective to bathe said duct portions with a very thin film of water; and means for supplying water to said atomizing means.

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