April 28, 1936. C. A. BULKELEY 2,038,536

SPRAY COOLER

Filed Aug. 28, 1933 3 Sheets-Sheet 1

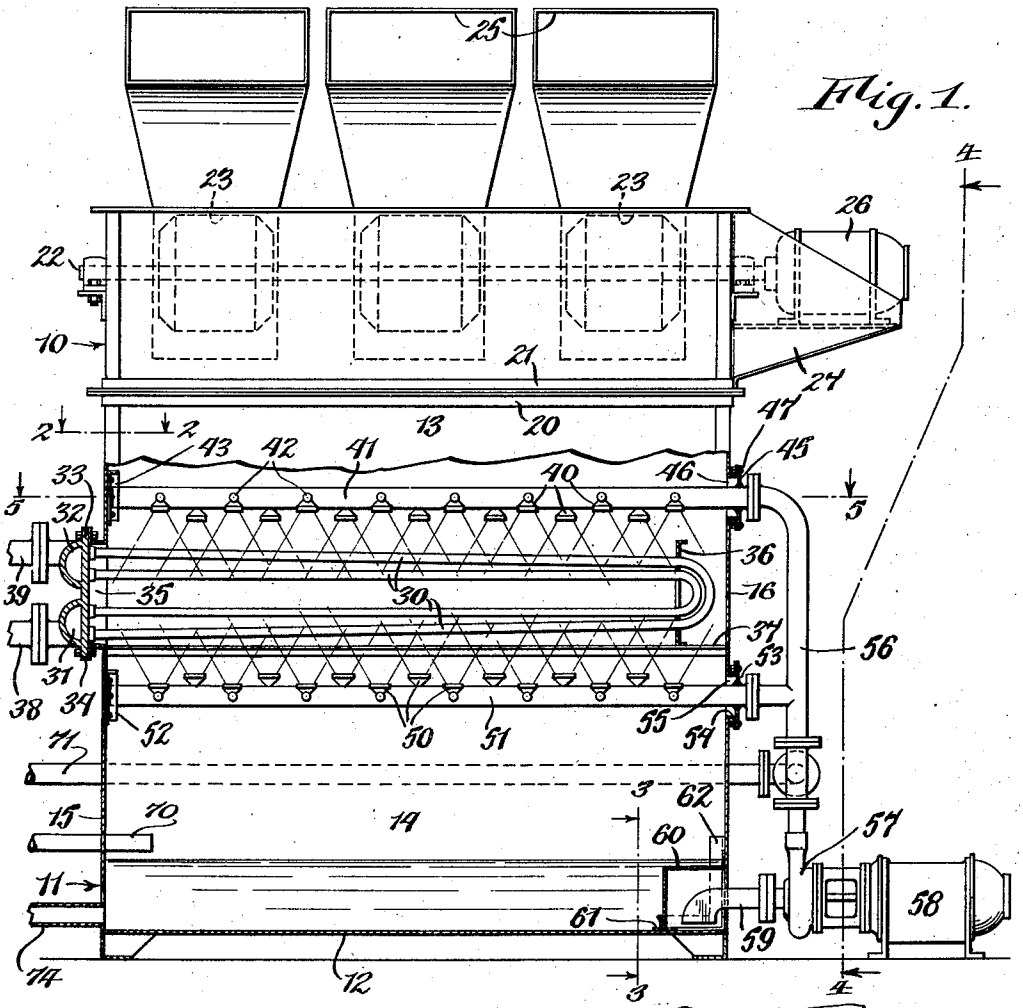


Fig. 1.

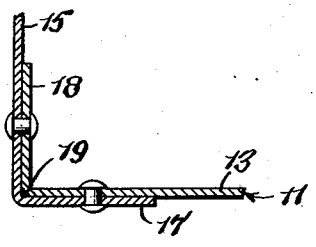


Fig. 2.

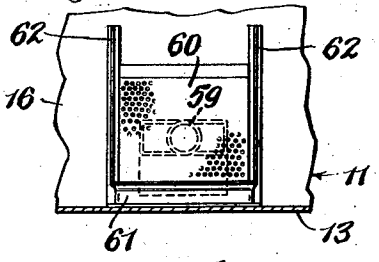


Fig. 3.

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SPRAY COOLER

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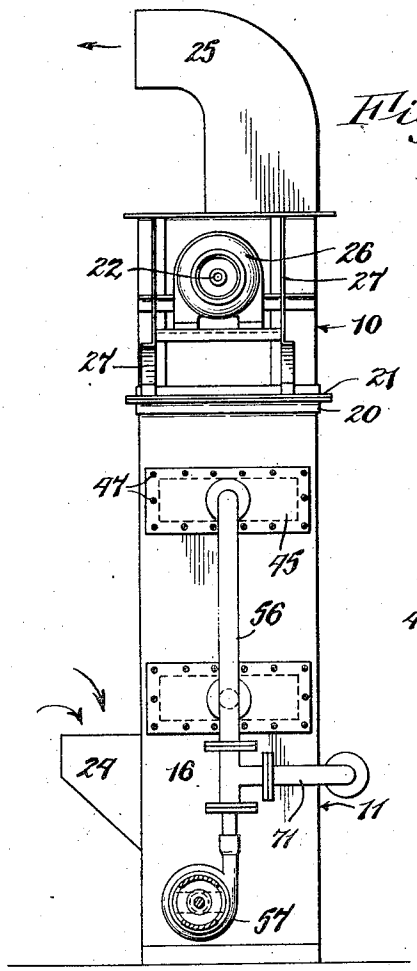


Fig. 4.

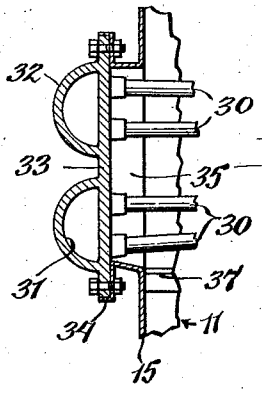


Fig. 6.

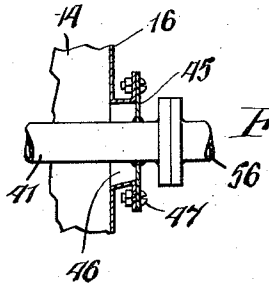


Fig. 7.

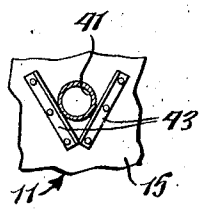


Fig. 8.

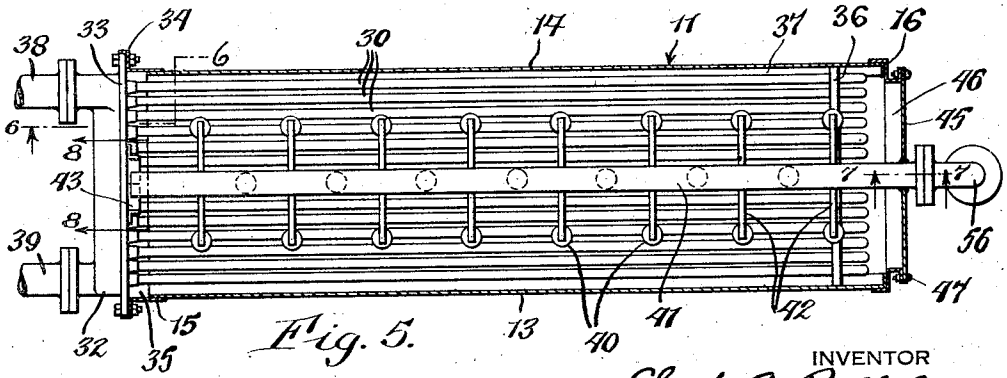


Fig. 5.

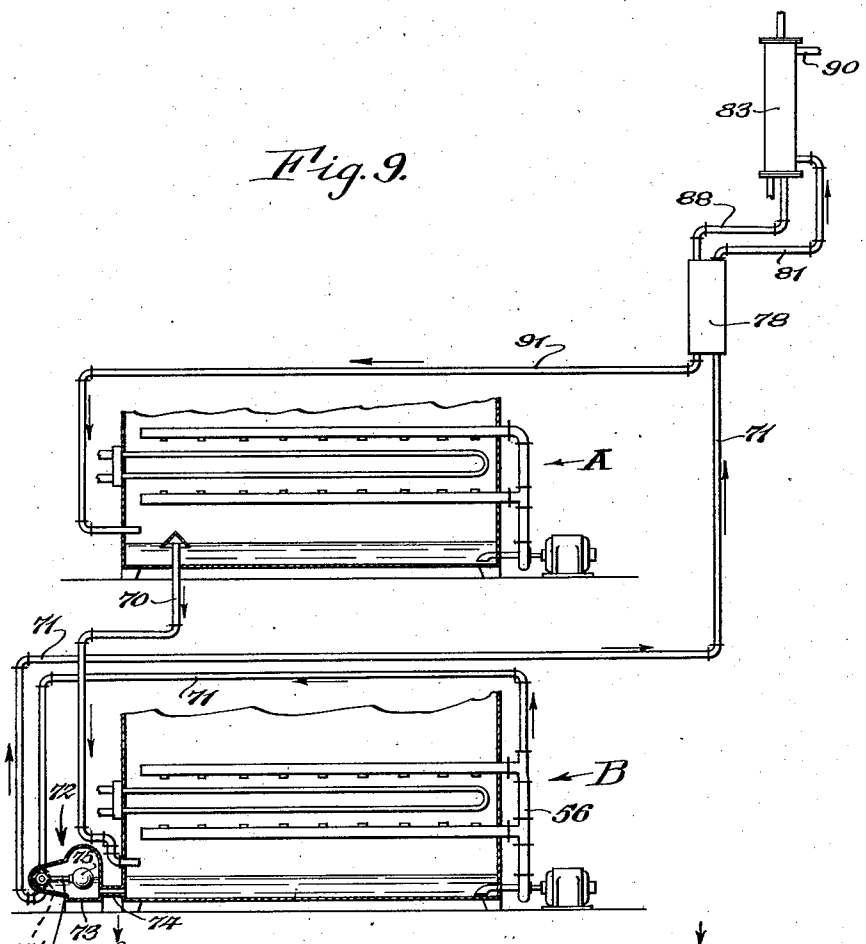
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SPRAY COOLER

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Fig. 9.



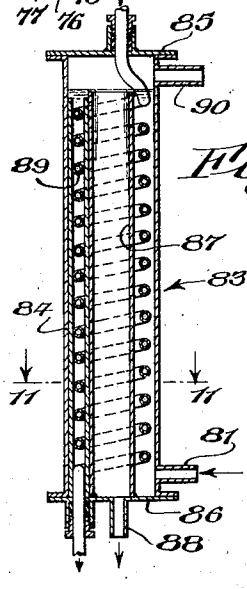


Fig. 10.

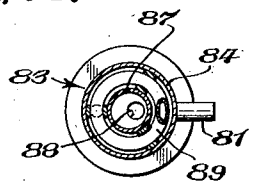


Fig. 11.

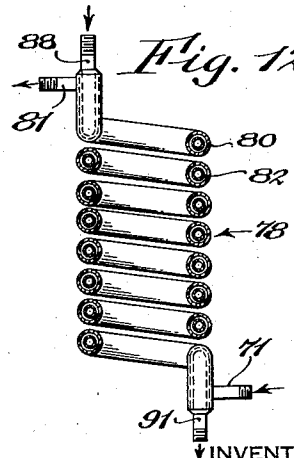


Fig. 12.

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UNITED STATES PATENT OFFICE

2,038,536

SPRAY COOLER

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Application August 28, 1933, Serial No. 687,032

11 Claims. (Cl. 261—11)

This invention relates to a brine spray cooler and more particularly to an air cooler in which the stream of air is drawn over cooling coils through which a refrigerating medium is passed and upon which brine is sprayed so that the air leaving the coils is cooled and leaves saturated with moisture. Such brine spray coolers can be used in either a humidifying or dehumidifying capacity and can therefore be used in conditioning the air of small stores, although the principal use of such brine spray coolers is for cooling and humidifying rooms where food is stored or where factory processes require a cool humid air.

The principal object of the present invention is to provide a forced air cooler which is so designed as to provide an exceptionally efficient heat transfer between the air stream and the cooling medium.

A further object of the present invention is to provide such a cooler in which any desired condition of temperature and humidity can be maintained and in which particularly a very high relative humidity in the enclosure can be obtained for the storage of food products or the like which are subject to loss of weight, discoloration or deterioration when stored in a dry place.

Another object is to provide such a cooler which, by reason of its superior heat transfer efficiency, can operate at a higher back pressure than coolers heretofore used. This often enables a smaller sized compressor to be installed and decreases the operating cost.

Another purpose of the present invention is to provide such a cooler which will operate at constant maximum capacity without interruption. With the present cooler the cooling coils are constantly sprayed with fine brine sprays at high velocity, these sprays keeping the coils clear of frost at all times so that there can be no diminution of capacity, due to frost collection as in a dry cooler.

Another object of the present invention is to provide such a brine spray cooler made of a butt welded aluminum casing, aluminum coils, eliminator plates, fan housings, fan blades, spray nozzles, air outlets and drip pan.

Another purpose of the invention is to so arrange the brine circulating pump that the pump is below the brine level and is thus always primed and to so construct the casing that it is completely sealed and is of strong and durable construction. Those parts which may require removal for the purpose of cleaning are also so mounted as to be readily removable.

Another object of the present invention is to provide means for avoiding a waste of salt when, during dehumidification, a dilution of the brine occurs and the excess water must be removed.

Other objects are to provide such a cooler which is compact and is entirely self-contained; which is extremely simple in construction and not liable to get out of order and can be produced and operated at low cost.

In the accompanying drawings:

Fig. 1 is a front elevation, partly in section, of the brine spray cooler made in accordance with my invention.

Figs. 2, 3, 4 and 5 are sections taken on the correspondingly numbered lines on Fig. 1.

Figs. 6, 7 and 8 are vertical sections taken on the correspondingly numbered lines on Fig. 5.

Fig. 9 is a diagrammatic elevation of a battery of the brine spray coolers shown in Figs. 1–8 and showing automatic means for withdrawing the brine from the brine spray coolers as it becomes diluted by the moisture withdrawn from the air during dehumidification, and also showing the manner in which this withdrawn diluted brine is passed through a concentrator and after concentration returned to the brine spray coolers.

Fig. 10 is a vertical central section through the brine solution concentrator shown in Fig. 9.

Fig. 11 is a horizontal section taken on line 11—11 Fig. 10.

Fig. 12 is a vertical central section through the heat interchanger which is employed in connection with the concentrating system to cool the concentrated solution from the concentrator by means of the dilute solution delivered to the concentrator.

The brine spray cooler is shown as having a casing composed of two sections 10 and 11, the lower section 11 housing the cooling coils and brine sprays and the upper section 10 housing the discharge fans. The lower section 11 consists of a bottom 12, a front wall 13, a rear wall 14 and end walls 15 and 16. As best shown in Fig. 2 the end walls 15 and 16 are flanged inwardly at their vertical edges, as indicated at 17 and the front and rear walls 13 and 14 are similarly flanged inwardly, as indicated at 18. These flanged edges 17 and 18 are interfitted, as shown in Fig. 2 and are riveted with aluminum rivets. Before being so riveted a packing strip 19 is inserted at the corners of the flanges 17 and 18 between the walls. This packing strip provides a tight seal for the casing. The casing is built up of aluminum sheets or of sheets of suitable aluminum alloy.

To the upper edge of each of the walls of the

casing section 11 are welded angle bars 20, also made of aluminum, these angle bars forming a frame around the upper open end of the casing section 11 on which similar angle bars 21 of the upper casing section 10 are mounted. The upper casing section 10 is of box form and is made in the same manner as the lower casing section 11. In the end walls of the upper casing section 10 is journalled a fan shaft 22 which is shown as carrying three fan rotors 23 which draw air up through an inlet box 24 of the lower casing section and discharge it through outlets 25, these outlets being preferably directed to discharge the air horizontally. The fan shaft 22 is driven by a motor 26 which is suitably supported by a bracket 27.

The cooling surface is shown as composed of a plurality of smooth surfaced aluminum hairpin tubes 30 having upper and lower legs, the lower legs being connected to an inlet header 31 and the upper legs being connected to an outlet header 32. These headers 31 and 32 are preferably connected by a single integral tube sheet 33 and the edges of this tube sheet are removably bolted to the flanges 34 surrounding an opening 35 in the side wall 15. In forming the attaching flanges 34 the sheet material of the end wall 15 at the opening 35 is bent outwardly to form a neck and then laterally to form the flanges 34. At the ends of these flanges L-shaped pieces of sheet aluminum are welded to complete the structure. The hairpin tubes and the headers are insertable and removable as a unit and for this purpose the bent ends of the hairpin tubes are inserted in a slotted plate 36 which is of channel form in cross section, as best shown in Fig. 1. This channel plate slides upon horizontal angles 37 which are welded to the front and rear walls of the casing.

Any suitable cooling medium can be employed but where low temperatures are desired ammonia or other gaseous refrigerant can be directly expanded in the hairpin tubes 30, the refrigerant being supplied from an inlet line 38 and the expanded gas being removed from an outlet line 39.

The high heat transfer efficiency of the present brine spray cooler is obtained by spraying brine through a multiplicity of jets directly on the hairpin tubes 30, these jets being arranged above and below the hairpin tubes so that the spray water impinging on the tubes forms a thin film around each tube and is rapidly whirled around each tube. It has been found that this effect is obtained by arranging the jets so that the downward and upward sprays work in direct opposition to one another, the sprays being arranged sufficiently close to the tubes so that the brine impinges directly thereon and the film formed thereon is whirled by the high velocity of the spray water.

For this purpose the upper nozzles 40 are arranged in three longitudinal rows, the central row being mounted directly in the underside of a pipe 41 and the outer rows of nozzles 40 being carried by lateral branch pipes 42 which are connected to the central longitudinal pipe 41. One end of the central pipe 41 is supported in a V-shaped saddle 43 which is riveted to the corresponding end wall 15 of the lower casing section 11, as best shown in Figs. 1 and 8. This saddle is preferably composed of two pieces of angle bars and is so designed that the pipe 41 after being inserted in the casing can be readily seated in the saddle 43. To the other end of the pipe 41 is welded a rectangular plate 45 which closes an opening 46 through which the main longitudinal pipe 41 and its associated branch pipes and nozzles can be readily removed. The edges of the opening 46 are flanged in the same manner as the opening 35 and the plate 45 is removably bolted to these flanges by aluminum bolts 47.

The upwardly directed spray nozzles 50 below the coils are mounted on a longitudinal pipe 51 in the same manner as the upper nozzles and this pipe is similarly supported at one end in a V-shaped saddle 52. The other end of this pipe 51 is similarly supported by a plate 53 which is bolted to flanges 54 around an opening 55 in the same manner as the closure plate 45 of the upper set of spray nozzles. Both pipes 41 and 51 are connected by a common brine supply pipe 56 to the outlet of a circulating pump 57, this pump being driven by a motor 58. This pump withdraws brine from the bottom of the lower casing section 11 through a pump inlet 59. The inlet opening of the pump inlet 59 is preferably disposed against the bottom 12 of the lower casing section and the pump 57 is preferably arranged below the level of the brine in the bottom of the lower casing section 11 so that the pump is at all times primed.

In order to prevent clogging of the pump a screen is placed around the pump inlet 59. This screen consists of a box 60 of perforated sheet aluminum having a top wall and three side walls. This box-like screen fits into guides provided on the bottom and end walls 12 and 16 of the casing and composed of angles 61 which are welded to the bottom wall 12 of the casing and angles 62 which are welded to the side wall 16 of the casing. A screen of this form has been found to be entirely effective in preventing clogging of the nozzles and at the same time the screen is readily removable for the purpose of cleaning when this becomes necessary. Further, by making the screen box out of perforated aluminum the screen is far more durable than woven wire screening and at the same time it is self-supporting, requiring no frame as would be the case if woven wire screening were employed.

The unit is set in the storage chamber or room to be cooled and air from this room is drawn down through the inlet 24 into the lower part of the lower casing section 11. The air is then drawn upwardly past the lower nozzles 50, hairpin tubes 30 and upper nozzles 40. These nozzles spray brine at high velocity into the air stream, thereby humidifying the air and by reason of their opposed relationship, also spray brine against the hairpin tubes so as to create a whirling film of brine around each of the tubes, this whirling film greatly increasing the heat transfer efficiency so that as the air stream passes the tubes it is quickly lowered in temperature and the heat rapidly absorbed by the refrigerant passing through the tubes. At the same time by the employment of brine there is no danger of any ice formation on the tubes and frost cannot collect because the whirling films of brine keep the tubes entirely free from all frost. The brine is supplied to the nozzles 40 and 50 by the pump 57 which withdraws the brine from the bottom of the casing and through the rectangular filter box 60 and discharges it into the pipes 41 and 51 which carry the spray nozzles. The filter 60 is conveniently removable by simply lifting it from its guide rails 61 and 62.

The air leaving the cooling coils and the sprays is drawn upwardly past eliminator plates (not shown) and is discharged through the outlets 25

horizontally back into the room by the fans 23.

When the temperature of the refrigerating medium used in the hairpin tubes 30 is below the dewpoint of the air to be conditioned this air is chilled below its dewpoint on passing the tubes and consequently moisture is precipitated from the air and mixes with the brine solution in the bottom of the casing. It is apparent that this excess water must be discharged and if discharged by means of a simple overflow into a waste pipe a large amount of salt will be lost, this loss of salt amounting to from 50 to 200 pounds of salt per day in a single brine spray cooler. Moreover, it is, of course, necessary that the attendant keep track of the degree of concentration of this solution since otherwise freezing is apt to occur.

To avoid these difficulties the present invention proposes to provide an automatic system for withdrawing the brine from the bottom of the brine spray cooler when the dilution reaches a predetermined point, delivering the withdrawn brine to a concentrator where it is concentrated and returning the concentrated brine to the brine spray coolers for re-use. The system is also applicable to a battery of brine spray coolers only one control and concentrator being provided for the entire battery. Fig. 9 shows diagrammatically two brine spray coolers A and B which are constructed as previously described. The brine spray cooler A is arranged above the brine spray cooler B and is provided in its bottom with a suitable overflow pipe 70 which maintains a constant level of brine in the bottom of the casing. The overflow of brine through the pipe 70 is discharged directly into the bottom of the casing of the brine spray cooler B. The outlet line 56 from the pump of the brine spray cooler B connects with another pipe 71 in which a float valve control 72 is provided. This float valve control can be of any suitable form but preferably comprises a casing 73 which is connected by a pipe 74 with the bottom of the casing of the brine spray cooler B so that the level of brine in the float valve casing 73 is the same as in the bottom of the brine spray cooler itself. A ball float 75 is arranged within the float valve casing 73 and through an arm 76 actuates a valve 77 in the brine line 71. As the brine solution in the lowermost brine spray cooler B becomes more dilute through the addition of water during the dehumidifying operation of both the brine spray coolers A and B, the level of the brine in the brine spray cooler B rises, thereby raising the ball float 75 and permitting a discharge of brine through the pipe 71. This pipe connects with a heat exchanger 78. This heat exchanger can be of any suitable form but is preferably of the double coil type, the dilute brine being delivered from the pipe 71 into an outer helical coil 80 and passing out of the heat exchanger through an outlet pipe 81. Within the outer coil 80 is arranged an inner coil 82 through which the heating medium is passed, this being the concentrated brine after it has been heated in the concentrator.

The dilute brine from the pipe 81 passes into a concentrator 83. This concentrator can be of any suitable form, but as shown, comprises a cylindrical casing 84 having upper and lower end heads 85 and 86 and containing a tubular sleeve 87 which is welded to the bottom head 86 and is open at its upper end. The dilute brine inlet pipe 81 connects with the outer shell or wall 84 of the concentrator and the brine flows upwardly along the outside of the central sleeve 87 and flows over the top of this sleeve passing out from the concentrator through a line 88. Steam is used as the heating medium, the steam pipe passing through the end heads 85 and 86 of the concentrator and being formed into a helix 89 which surrounds the inner sleeve 87. In passing the convolutions of the steam pipe 89 the dilute brine is heated to a high temperature and water is driven off from the solution in the form of steam, this steam being discharged through a steam outlet pipe 90. The concentrated solution from the pipe 88 of the concentrator passes through the inner coil 82 of the heat exchanger 78, thereby being cooled before being returned to the brine spray cooler and also preheating the dilute brine delivered to the concentrator. From the heat exchanger 78 the concentrated brine flows by gravity through a pipe 91 which discharges directly into the bottom of the upper brine spray cooler A. Since the upper brine spray cooler A overflows into the lower brine spray cooler B it is apparent that the strength of the brine solution in both coolers will be substantially the same at all times.

From the foregoing it is apparent that the present invention provides a brine spray cooler which is extremely compact and simple in construction and will stand up for a long period of time under conditions of constant service without getting out of order or requiring replacement or repair of any of the parts. The use of brine sprays in the manner shown also makes the brine spray cooler particularly adaptable for cold storage work where humid air conditions are desirable for the preservation of the product being stored. Moreover, the brine spray cooler positively circulates the air in the room or storage chamber so that all of the stored product is quickly lowered to the desired temperature. Moreover, by reason of the opposed relation of the brine sprays and the impinging of these opposed sprays upon the cooling surface, the cooler is extremely efficient in heat transfer efficiency so that a small amount of cooling surface can be used with a cooler of relatively high capacity and which is capable of quickly absorbing sudden live loads imposed upon it. With the present invention also, provision is made for automatically withdrawing the brine solution from the brine spray coolers and concentrating it to not only maintain the strength of the brine solution but also to avoid the waste of salt which would otherwise be required to be added to the solution.

I claim as my invention:

1. In a spray cooler of the character described, a casing, a tube cooling coil across said casing, a series of fixed spray nozzles on one side of said coil and arranged to direct sprays of liquid to impinge against said cooling coil, a series of fixed spray nozzles on the other side of said cooling coil and arranged to direct sprays of liquid in direct opposition to the other series of spray nozzles so as to contact with one another and to also impinge against said cooling coil, means for supplying liquid to said two series of nozzles to provide sprays of high velocity whereby a whirling film of liquid around the tubes of said coil is continuously maintained by the opposing action and velocity of said sprays and means for passing a low temperature cooling medium through said coil.

2. In a spray cooler of the character described, a casing, a tube cooling coil disposed horizontally across said casing, a series of fixed spray nozzles arranged above said coil and arranged to direct sprays of liquid downwardly to impinge against

said cooling coil, a second series of fixed spray nozzles arranged below said cooling coil and arranged to direct sprays of liquid upwardly and in direct opposition to the first named series of sprays and to impinge against said cooling coil, means for supplying liquid to said two series of nozzles to provide sprays of high velocity whereby whirling films of liquid are formed on the tubes of the coil by the opposing action and velocity of said sprays and means for passing a cooling medium through said coil.

3. In a spray conditioner of the character described, a casing, a tube cooling coil arranged across said casing, a pipe arranged to one side of said coil, means inside of the casing for loosely and removably supporting one end of said pipe against the inside of one wall of said casing, the opposite wall being provided with an opening through which the other end of said pipe extends and through which the pipe assembly can be withdrawn, a plate secured to said other end of said pipe and removably secured to said opposite wall of said casing to form a closure for said opening, spray nozzles carried by said pipe and directing sprays of liquid to impinge against said coil, means for connecting said pipe to a liquid supply source and means for passing a medium through said coil having a temperature different from the sprays.

4. In a cooler conditioner of the character described, a casing, a tube cooling coil arranged across said casing, a pipe arranged to one side of said coil, a V-shaped bracket secured to the inside of one wall of said casing and forming a saddle for supporting one end of said pipe, the opposite wall of said casing being provided with an opening through which the other end of said pipe extends, a plate secured to the other end of said pipe and removably secured to said opposite wall of said casing to form a closure for said opening, spray nozzles carried by said pipe and directing sprays of liquid to impinge against said coil, means for connecting said pipe to a liquid supply source and means for passing a medium through said coil having a temperature different from the spray.

5. In a cooler conditioner of the character described, a sheet metal casing, a tube cooling coil arranged across said casing, a pipe arranged to one side of said coil, means for removably supporting one end of said pipe against the inside of one wall of said casing, the opposite wall being provided with an opening through which the other end of said pipe extends, said opposite wall of said casing being flanged outwardly around said opening, a plate secured to the other end of said pipe, bolts securing said plate to said flange to form a removable closure for said opening, spray nozzles carried by said pipe and directing sprays of liquid to impinge against said coil, means for connecting said pipe to a liquid supply source and means for passing a medium through said coil having a temperature different from the sprays.

6. In a cooler conditioner of the character described, a casing, a tube coil arranged across said casing, a pipe arranged to one side of said coil, a second parallel pipe arranged on the opposite side of said coil, means for removably supporting the corresponding ends of said pipes against the inside of one wall of said casing, the opposite wall being provided with a pair of openings through which the other ends of said pipes extend, a plate secured to said other end of each pipe and removably secured to said opposite wall of said casing to form a closure for the corresponding opening, spray nozzles carried by one of said pipes and arranged to direct sprays of liquid to impinge against said coil, spray nozzles carried by the other pipe and arranged to direct sprays of liquid to impinge against said coil, a pipe connecting the external ends of said pipes together and to a liquid source and means for passing a medium through said coil having a temperature different from the air spray.

7. In a cooler conditioner of the character described, a casing having an opening in one wall, a pair of headers removably secured to said wall and forming a closure for said opening, tubes arranged in said casing and connecting said headers, a pipe arranged to one side of said tubes, a second parallel pipe arranged on the opposite side of said tubes, means for removably supporting the corresponding ends of said pipes against the inside of the wall carrying said headers, the opposite wall of said casing being provided with a pair of openings through which the other ends of said pipes extend, a plate secured to said other end of each pipe and removably secured to the outside of the opposite wall of said casing to form a closure for the corresponding opening, spray nozzles carried by one of said pipes and arranged to direct sprays of liquid against one side of said tubes, spray nozzles carried by the other pipe and arranged to direct sprays of liquid against the other side of said tubes, means for passing a medium through said headers and tubes having a temperature different from said sprays and means connecting the external ends of said pipes with a spray liquid source.

8. In a cooler conditioner of the character described, a sheet metal casing, said casing having an opening in one wall and being flanged outwardly around said opening, a pair of headers, means for removably securing said headers to said flange to form a closure for said opening, tubes arranged in said casing and connecting said headers, a pipe arranged above said tubes, a second parallel pipe arranged below said tubes, brackets for removably supporting the corresponding ends of said pipes against the inside of the wall carrying said headers, the opposite wall of said casing being provided with a pair of openings through which the other ends of said pipes extend and said opposite wall being flanged outwardly around said openings, a plate secured to said other end of each pipe, means for removably securing each plate to the corresponding flange to form a closure for each opening, spray nozzles carried by one of said pipes and arranged to direct sprays of liquid to impinge against one side of said tubes, spray nozzles carried by the other pipe and arranged to direct sprays of liquid to impinge against the other side of said tubes, means for passing a medium through said headers and tubes having a temperature different from said sprays and a pipe connecting the external ends of said parallel pipes to one another and to a spray liquid supply source.

9. A spray cooler, comprising a casing having a bottom in which the spray water is collected and side walls rising from said bottom, spray means within said casing, a pump outside of said casing and having its inlet extending through the lower part of said casing to withdraw the collected spray water therein and having its outlet connected with said spray means, a removable screen around said inlet for filtering the water withdrawn by said inlet, two walls of the chamber formed by said screen being the bottom and a side wall of

said casing, and rails secured to the bottom of said casing around said screen and the side wall thereof and removably holding said screen in position.

10. In a brine spray cooler system of the character described, a pair of brine spray coolers each comprising a casing, spray nozzles in said casing, means for withdrawing brine from the bottom of each casing and means for cooling said brine, means for conducting the overflow from one of said brine spray coolers to the other and means for maintaining a predetermined concentration of the brine solution in both of said coolers, comprising a brine concentrator, means responsive to the level of the brine in the cooler receiving the overflow from the other for passing said brine through said concentrator and means for returning the concentrated brine to the brine spray cooler which overflows into the other.

11. In a brine spray cooler having brine discharge means, a tank for collecting the discharged brine, means for recirculating the brine from said tank to said discharge means and means for maintaining a predetermined concentration of the brine under conditions of operation where the brine is subject to dilution comprising a float valve responsive to the level of the brine in said tank for permitting discharge of brine in excess of a predetermined level, means for applying heat to said excess brine and evaporating a portion of the water therein and means for returning the concentrated brine to said tank.

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