A modular liquid cooling spray unit includes a longitudinally and upwardly extending trough wall portion having a rear surface adapted to serve as at least part of a boundary wall for one edge of a liquid reservoir or conduit and to maintain a desired liquid level in such reservoir. The unit includes a spray member support portion on which a plurality of rotary spray members are mounted for rotation on a horizontal axis spaced in front of and parallel to the front of the trough wall portion. Each unit includes conduit means for feeding liquid through the trough wall to the spray members for projection of drops of liquid from the unit in a plurality of trajectories substantially all of which have horizontal components extending generally crosswise of the trough wall. In one form the unit includes both front and rear trough wall portions extending upwardly from a horizontal base portion to provide an open-topped trough or channel for the liquid to be cooled. The unit is preferably constructed of preformed reinforced concrete, which may also be prestressed at selected portions, and the spray members are preferably constructed as circular flat discs mounted on the support portion for rotation on said axis, with at least a portion of each spray member spaced vertically below an expected heated liquid level in the trough. Liquid is fed by gravity through an appropriate conduit and the wall of the trough to a limited area on the surface of each spray member for projection of the liquid in the form of drops in response to rotation of the discs.

The trough wall serves as part of a reservoir or conduit which maintains heated liquid at a high enough level for gravity feed to the spray members. Improved features include special bearing and coupling details by which a plurality of spray member subgroups can be axially spaced along the unit and removable connected to supporting shaft portions at each bearing, with minimal problems resulting from possible flexing or misalignment of parts of the unit, and with convenient removal of individual sections or subgroups. Improved lubricating systems for such shaft portions and features for convenient lifting and moving of the unit and for its drainage, as well as for convenient assembly of a plurality of such units in longitudinal alignment to provide desired liquid projection and cooling over a relatively long path at the edge of a suitable receiving area are also included.

28 Claims, 17 Drawing Figures
MODULAR LIQUID COOLING SPRAY UNITS

CROSS-REFERENCES TO OTHER APPLICATIONS

Certain features disclosed and described in the present application, and additional assemblies incorporating such features, are claimed in other co-pending U.S. Pat. applications filed on the same date as the present application, identified by Ser. Nos. 296,777, and 296,779, respectively entitled "Liquid Cooling Apparatus" and "Liquid Cooling Assemblies," and assigned to the same assignee as this application.

BACKGROUND OF THE INVENTION

In many commercial applications, particularly where large quantities of water or other liquid are used for the cooling of apparatus in an operating plant, there is a need for improved methods and apparatus by which the somewhat heated liquid which is received from heat exchangers in such a plant, after performing its cooling function, can again be cooled to a desired degree, either for recirculation and further use within the plant, or for restoration of the liquid to a natural source such as a lake or river from which it may have been drawn in the first place. The return or discharge of such liquids into natural waters at a higher temperature than the ambient temperature of the natural water itself, has been thought to give rise to problems generally referred to by the term "thermal pollution." There have been a number of different devices, such as large cooling towers, cooling ponds extending over substantial areas of land, and various aerating devices, all of which have been used or suggested for use in the cooling of desired quantities of liquid to avoid such thermal pollution. In an earlier co-pending application Ser. No. 47,078 filed June 17, 1970, now U.S. Pat. No. 3,719,353, and assigned to the same assignee as the present application, the use of one or more rotary spray members to which liquid is fed for projection of liquid drops upwardly from the surface of a liquid reservoir or conduit has been more fully described and claimed. In the above-identified co-pending applications filed concurrently with the present application, apparatus features and assemblies are described which can be utilized to provide a desired directional wind effect by projection of liquid drops in such a manner that they move in various paths, all of which have some horizontal components extending in the desired direction.

SUMMARY OF THE INVENTION

The present invention provides a modular liquid cooling spray unit for controlled projection of liquid drops in desired trajectories, particle sizes, velocities, and volume rates. Such a modular unit includes at least one longitudinally and upwardly extending trough wall portion having a base portion adapted for supporting the trough wall portion at one edge of a reservoir or channel of heated liquid to be cooled, and with the trough wall portion having a rear surface adapted to provide at least part of a boundary wall for maintaining a desired liquid level in such reservoir or channel. The unit includes a spray member support portion on one of said trough wall and base portions, a plurality of rotary spray members mounted on the spray support portion for rotation on a horizontal axis spaced in front of and parallel to the front of the wall portion, with at least a portion of each spray member spaced vertically below the desired level of heated liquid in the reservoir.

The unit also includes conduit means for feeding liquid through the trough wall portion and metering it to at least one surface of each spray member at a limited area which is below the heated liquid level and from which the rotation of the spray members carries the liquid and projects liquid drops in a plurality of trajectories, all of which have horizontal components extending generally crosswise of the trough wall.

In one form the unit includes both front and rear trough wall portions extending upwardly from a horizontal trough wall base portion to provide an open-topped trough or channel for the liquid to be cooled. A support portion on the trough supports a driving motor adapted for rotation of the spray members in a desired angular direction around their common axis.

In a preferred form of the invention, the base and trough wall portions are formed as a single preformed reinforced concrete unit of substantial length, which may also be prestressed at selected portions. Such a modular unit is suitable for shipment from a place of manufacture to a desired operational location, at which such a unit can be assembled in combination with a plurality of similar units which are aligned with each other on a supporting area along the edge of a suitable receiving area for the liquid to be sprayed. The unit must be sufficiently strong to be adaptable to rough ground or poor soil conditions without damage to the trough wall and base portions and without undue misalignment of the bearings.

In the preferred form of the invention, the spray member support portion extends forwardly from the front trough wall portion and includes a plurality of bearing units spaced along said axis with an axial supporting shaft portion rotatably supported in each bearing unit. The spray members are preferably arranged in a plurality of subgroups each having a plurality of spray members secured to an axial spray shaft portion extending between the supporting shaft portions of adjacent bearing units. Shaft connections between the axial spray shaft portions, axial supporting shaft portions, and the driving shaft of a driving motor insure common angular rotation of all such portions on said axis as a unit. The shaft connections include at least one resilient coupling or universal joint member to accommodate any slight axial misalignment or flexing of the various spray member subassemblies and prevent unusual wear on the individual bearings.

The shaft connections are further constructed with removable joint members at each end of a spray member subgroup for convenient installation, removal and replacement of the spray member subgroup and its axial spray shaft portions as a separate subassembly. Shaft connections which combine the universal joint and removable joint members as parts of a common assembly are constructed to facilitate radial removal of spray unit subgroups without removal of the bearing units.

The invention further provides a relatively simple and economical form of construction, in which individual units can be readily positioned in longitudinal alignment with each other along a supporting surface at one edge of a liquid receiving reservoir or conduit, and in which the units can also serve as at least part of a supply reservoir wall or conduit for maintaining the liquid
to be cooled at a high enough level for direct gravity feeding to the spray members on the unit and for projection from such spray members to a receiving area at a somewhat lower level. The preferred form of preformed modular unit also includes appropriate value features for draining the trough portion of the unit, for feeding heated liquid from an adjacent reservoir into the trough portion of the unit, and for gravity feeding of liquid from the trough portion to a plurality of the spray members through a single liquid feeding manifold which serves a plurality of such spray members. By providing a trough portion at one edge of the modular unit, which can be used as an upper edge of a heated liquid reservoir, the invention further provides an arrangement by which the pressure of the liquid in such a higher level heated liquid reservoir can hold the unit in position against undesired movement toward such reservoir, so that the unit needs to be secured only against relative movement in the opposite direction, i.e., away from the trough and the higher liquid level at one edge of the trough. The term "reservoir" as used herein included a longitudinally extending conduit, and such a conduit may even be formed by longitudinal alignment of a plurality of modular units having longitudinally extending front, rear and bottom trough wall portions with no crosswise end wall portions. The modular units of this invention are particularly adapted for construction and operation to provide desired directional wind effects as described in an above-identified, concurrently filed co-pending application entitled "Liquid Cooling Apparatus," and also to provide modular units suitable for use as individual elements to be combined and arranged as described in the other concurrently filed application entitled "Liquid Cooling Assemblies." Other features and advantages of the invention will be apparent from the following description, in which the preferred embodiments of the invention are shown and described in greater detail.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings which form a part of this application, and in which like reference characters indicate like parts,

FIG. 1 is a plan view of a modular liquid cooling spray unit according to the invention;

FIG. 2 is a sectional view on the line 2—2 of FIG. 1 showing details of the lifting mechanism for the unit;

FIG. 3 is a partial sectional view on the line 3—3 of FIG. 1 showing details of the supply valve for controlling the admission of heated liquid to the trough of the unit;

FIG. 4 is a partial sectional view on the line 4—4 of FIG. 1 showing details of the drain valve for the unit;

FIG. 5 is a schematic sectional view showing a preferred arrangement of the unit on a supporting surface between a heated liquid supply area and a cooled liquid receiving area and in which the unit according to the present invention can maintain a difference in liquid level between such areas;

FIG. 6 is an enlarged partial sectional view at one edge of the spray unit of FIG. 5 showing details of the mechanism by which the unit is held in position on its supporting surface;

FIG. 7 is an enlarged partial sectional view on the line 7—7 of FIG. 1;

FIG. 8 is an enlarged partial sectional view on the line 8—8 of FIG. 7, rotated 90° and showing details of the liquid supply manifold for the spray members of the unit;

FIG. 9 is an enlarged sectional view on the line 9—9 of FIG. 7 showing details of a pressurized lubrication system for the bearings of the unit;

FIG. 10 is an enlarged partial front elevation of the device of FIG. 1, with certain parts broken away and certain parts shown in section for greater clarity;

FIG. 11 is an enlarged sectional view of one of the flexible couplings shown in FIGS. 1 and 10;

FIG. 12 is an enlarged view of a clamping ring constituting part of a flexible coupling between spray member subassemblies;

FIG. 13 is a partial plan view of a modified modular unit according to the invention illustrating the provision of a water lubricated bearing;

FIG. 14 is a partial front elevation of the device of FIG. 13, with certain portions shown in section on the line 14—14 of FIG. 13;

FIG. 15 is a sectional view on the line 15—15 of FIG. 14;

FIG. 16 is a sectional view on the line 16—16 of FIG. 14 showing details of a preferred connection for convenient disassembly and removal or replacement of individual rotor units; and

FIG. 17 is a partial sectional view, generally similar to FIG. 7 of a modular unit having only one upwardly extending trough wall portion.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A modular liquid cooling spray unit according to the invention is shown in plan view in FIG. 1 and is indicated generally at 21. The unit includes a longitudinally extending trough having a base portion 22, a front trough wall portion 23 and a parallel rear trough wall portion 24 extending upwardly from the base portion. Thus an open-topped trough is provided for receiving heated liquid to be cooled. Unit 21 may include first and second end wall portions 26 and 27, which also extend upwardly from the base portion at each end of the trough for closing the respective right and left hand ends of the longitudinally extending trough, as viewed in FIG. 1. The spray unit also includes a spray member support portion on the trough. In this embodiment, the spray member support portion extends forwardly from the front trough wall portion 23 as shown at 29. Support portion 29 is preferably formed as an extension of the base portion 22 of trough 28, so that portions 22 and 29 are essentially in a common plane, with their common bottom surface providing a substantially continuous flat base for supporting the spray unit at the edge of a suitable liquid reservoir, as shown in FIG. 5.

Spray member support portion 29 carries a plurality of bearing units spaced longitudinally along the base portion. Thus bearing support 31 is located at the left end of the unit in FIG. 1, intermediate bearing units 32 are located in the central portions of the spray unit, and an end bearing 33 is supported at the right end of support portion 29. These bearing units are adapted to support a plurality of rotary spray members on the support portion 29 in such a manner that these spray mem-
bers rotate on a horizontal axis spaced in front of and parallel to the front trough wall portion, with at least a portion of each spray member spaced vertically below an expected level of heated liquid in trough 28. The preferred spray members are shown as circular, substantially flat, disc-like members, all of which are perpendicular to the common axis of rotation along which they are spaced as shown. In the preferred form of modular spray unit, these spray members 36 are arranged in a plurality of subgroups as part of the column supporting platform including the spray member support portion 29 and the base portion 22 of trough 28. Thus all these parts provide a substantially continuous flat base extending throughout the total area of the modular spray unit.

In the device of FIG. 1, it is contemplated that there may be as many as six subgroups of rotary spray members, e.g., the two end groups 37 and 39 and four intermediate groups 38. Because of the substantial length of such a unit, which may extend as much as 60 feet along the common axis of rotation, the invention further provides at least one universal joint member adapted to accommodate limited axial misalignment of the axial supporting shaft portions of different spray member subgroups. Preferably, each bearing unit 31, 32 and 33 includes its own relatively short supporting shaft portion which is rotatably supported within that bearing unit and which has longitudinally projecting ends to which other elements of the assembly can be connected. Thus the axial spray shaft portion 42 of spray member subgroup 37 may have flexible or universal joint connections, as described below, with each of the supporting shaft portions 41 of bearings 31 and 32. Moreover the shaft portions are preferably provided with shaft connections which include removable joint members at each end of a spray member subgroup, in order that the spray members in that group, with their spray member shaft portion 42 may be initially installed or later removed and replaced as a unit, without disturbing the remainder of the assembly and without disassembly of the actual bearings at 31, 32 or 33. Examples of such removable joint members are described elsewhere in this application. Moreover, the connection 46 between motor 44 and the supporting shaft portion of bearing 31 also provides some flexibility, and thus constitutes a limited universal joint to accommodate possible misalignment of the various shafts.

In order to feed liquid through wall 23 to the individual spray members 36, the invention provides conduit means which include at least one manifold for each spray member subgroup. Such a manifold is shown at 47 in FIG. 1 and in further detail in FIG. 8. The manifold is secured to the front trough wall portion 23 and receives liquid from trough 28 through openings 48 in the wall 23. In turn, the manifold 47 delivers liquid through appropriate extensions 49 provided with liquid delivery openings which discharge limited amounts of liquid to at least one surface of each spray member at a limited area which is below the expected liquid level in trough 28. From this limited area the rotation of the spray members carries the liquid and projects liquid drops in a plurality of trajectories substantially all of which have horizontal components extending generally crosswise from trough 28, i.e., perpendicular to the axis of rotation of the spray members 36. At least part of the manifold is preferably made of rubber or other elastomeric material for convenient flexing to dislodge undesired objects deposited by the liquid.

As shown in FIGS. 1 and 2, the modular liquid spray unit of the present invention is provided with appropriate lifting connections 51 which are adapted to receive a plurality of lifting hooks on a lifting crane cable, for lifting and positioning the spray unit on a prepared supporting area along one edge of the liquid reservoir. These lifting connections are illustrated as lifting eyes 51 at the upper end of lifting bolt members 53 which may be threaded to provide inward force on both the front and rear wall portions 23 and 24. Two of these lifting connections are shown at 51 in FIG. 1, one in each of the front and rear wall portions. It will be understood that a further similar pair of lifting connections 51 will be provided at a symmetrical or balanced location at the right hand end of the unit of FIG. 1, although these additional lifting connections 51 do not appear in the FIG. 1 view, wherein substantial portions of the entire unit have been omitted, as indicated at 52.

In the preferred embodiment of the invention, the main portions of the unit, and particularly the base portion 22 and at least the trough walls 23 and 24, are constructed as a preformed unit made of precast concrete. In such a case, the internally threaded anchor member 54 (FIG. 2) can be positioned within walls 23 and 24 as part of the casting operation. These members 54 have irregular outer surfaces and are adapted to engage the surrounding concrete in such a way that the lifting forces on connections 51 will be distributed within the wall portions in a manner adequate to carry the weight of the unit during lifting, transportation and installation or removal.

In order to admit heated liquid to be cooled into trough 28, the rear trough wall portion is provided with one or more liquid inlet openings 56. Thus liquid to be cooled can be admitted to the trough from a supply of such liquid located close to the trough. Inlets 56 are provided by appropriate tubular members 57 extending through the rear wall portion 24. A movable inlet valve member for each such liquid inlet opening is provided at 58. This valve is pivoted at 59 to the wall portion 24 for swinging movement between a normal open position, as shown in heavy lines in FIG. 3, and a closed position shown in dotted outline in FIG. 3. The valve is closed when further admission of liquid to trough 28 is to be prevented, in order to drain remaining liquid from the trough.

In the modular unit 21 of FIG. 1, the rear wall portion 24 of trough 28 has at least one end 61 which extends longitudinally beyond the corresponding end wall 27 at that end of the unit. Thus the extended rear wall portion is adapted for engagement along a vertical line 62.
with the opposite end of the rear wall portion 24a of a similar adjacent unit 21a, when a plurality of these modular units are aligned in a row along one edge of a liquid reservoir. Thus, as shown in FIG. 5, the rear trough wall portions 24, 61, 24a, etc., all have a height providing at least part of one side wall for an adjacent reservoir and for maintaining the level of heated liquid to be cooled in such reservoir at a desired higher level than the supporting area on which the modular units are aligned.

As shown in FIG. 1, the base portion 22 is also extended as shown at 63 to provide a continuation of the common supporting platform of the modular unit to an end line 64 which is adapted to fit closely against the end wall 26a of an adjacent unit (FIG. 1), when the units are to be in exact longitudinal alignment. If the units are to be placed in a row at a slight angle to each other, for example to follow a curved reservoir or conduit edge, the extension 63 of the base portion may be initially formed with an inclined edge as shown by the dotted line 66 of FIG. 1, or a portion of the extension 63 may be removed at the installation site to permit the desired angular arrangement. In any such case, however, the rear wall portions of adjacent units will still meet as shown at 62, in order to provide a continuous rear wall portion serving as at least part of a boundary wall for the adjacent heated liquid reservoir. Similarly, the edge line 64 could be initially formed at an angle in the opposite direction to the angular line 66, where the desired angular orientation of the adjacent units so requires.

The extension of the base at 63, not only provides for convenient flexibility in the angular installation of adjacent units in a row, but also provides a convenient drainage space 67 between the end wall 27 of one unit and the opposite end wall 26a of an adjacent unit. While suitable drainage openings can be provided at other points, if desired, it is advantageous to provide such a drainage opening in one of the end walls 26 or 27 of each unit. As illustrated, such a drainage opening is provided at 68 and 68a in the respective right end walls 26 and 26a of adjacent units. Thus liquid to be drained from troughs 28 can be conveniently discharged at the end of each trough, and where there is an adjacent trough immediately next to such a unit, the drainage will take place in a drainage space such as 67, where it can be conveniently discharged between the end walls of the adjacent units and across the front edge of the unit toward an appropriate receiving reservoir or conduit for cooled liquid. Such a drainage opening is provided by a pipe section 69 in the end wall 26. A movable valve member 71 is pivoted at 72 to a support 73 in end wall portion 26 for movement between a normally closed position (shown in heavy lines in FIG. 4) and an open or drain position (shown in dotted outline in FIG. 4). Thus, when it is desired to drain trough 28 for any reason, the valves 58 for inlets 56 in the rear trough wall portion will be closed, and the drain valve 71 in end wall 26 of each trough will be opened. Such drainage may be desirable, for example, when the unit is installed in a climate where the liquid could freeze within trough 28 if the supply of heated liquid through inlets 56 should be interrupted for one reason or another.

In the preferred form of modular spray unit 21, as shown in FIG. 1, the major wall portions are desirably constructed as a unit of precast concrete, and the various wall sections are so shaped and arranged as to facilitate the preforming operation and the convenient removal of the unit from the necessary forms. In some cases, where the relative length of the unit, and the forces to which it may be subjected during lifting, transportation, installation or removal so require, at least a portion of the trough is preferably formed of longitudinally prestressed concrete. In one embodiment, the front and rear trough wall portions may include a plurality of longitudinally extending tension members 76 which are initially positioned longitudinally in the appropriate mold sections in known manner and are placed under tension during the casting operation. Such tensioning members could also be placed in the base portions 22 and 29. In the form shown, however, the longitudinally extending tension members are located only in the front and rear trough wall portions, and the base portion may include untensioned reinforcing material 79. When the unit is removed from the mold, the removal of the initial tension on the longitudinally extending members causes these members to compress and to hold the front and rear trough wall portions in longitudinal compression. This longitudinal compression of the front and rear trough walls also holds the base portion in sufficient longitudinal compression for the desired strength and resistance to damage. In any event, whether prestressed concrete wall portions are used in any given case or not, the present invention provides a construction in which the base portion and trough wall portions of the modular spray unit can be formed as an integral, precast concrete unit, on which the necessary additional mechanical elements of a complete liquid cooling spray unit can be readily assembled and transported.

As described, such a unit may be conveniently transported and positioned on a supporting area 77 (FIG. 5) at one edge of a suitable heated liquid reservoir. In this case, the supporting area 77 is shown as a flat concrete section on top of a longitudinally extending mound or barrier between two reservoir or conduit areas. The adjacent edges of these reservoir areas may be surfaced with concrete or other reinforcing material as shown at 79 in connection with the body of heated liquid 81 adjacent the rear wall portions 24 of the spray cooling units. Similarly, the edge of a receiving reservoir or conduit for cooled liquid may be surfaced as shown at 82 to prevent erosion of the main barrier mound 78 by the cooled liquid 83 at the left of FIG. 5. The arrangement of a row of generally aligned modular units 21 along the supporting surface 77, and the abutting engagement of the ends of rear trough wall portions 24 of adjacent aligned units, combine to provide a vertical extension of the heated liquid reservoir wall 79 which maintains the liquid in such reservoir at a higher level 84 than the level 86 of cooled liquid 83 at the front edges of the spray units 21. Thus the spray units provide their own vertical head for gravity flow of heated liquid to the individual spray members 36, from which the liquid is projected in appropriately sized drops along the desired trajectories to insure cooling of the liquid, before the drops finally are received at 83 in the reservoir of cooled liquid. In this arrangement, the forces exerted on the spray units 21 will be primarily from right to left as viewed in FIG. 5, in view of the pressure of the heated liquid reservoir against the rear sides of the respective trough wall portions. Thus the spray units can conveniently be held in desired position.
on the supporting surfaces 77 by a relatively simple and economical arrangement of securing members 87 which are driven or otherwise positioned within appropriate recesses 88 in the supporting surface 77 along the lower front edge of each spray unit. In this case the lower front edge is provided by the front edge of the spray unit supporting portion 29, which is part of the common supporting platform of each unit 21.

Further details of the spray member supports and of the conduit means for feeding liquid from the trough 28 to the surfaces of spray members 36 are shown in FIGS. 7-12. Thus, as shown in FIGS. 7 and 8, the manifolds 47 which are designed to provide appropriate conduits for feeding liquid from trough 28 to a limited area of the surface of each rotary spray member 36, are preferably formed with a horizontal main body portion having upper, lower and end wall portions which provide an open rear edge for abutting engagement with the front trough wall portion of the unit. Such manifolds 47 receive liquid from the trough 28 through the openings 48 in the front wall, and the projecting extensions 49 of manifolds 47 carry the liquid to a point adjacent the desired limited surface area of each spray member in the particular spray member subgroup served by a given manifold. A delivery opening 94 in each such extension 49 is oriented to deliver the liquid from the manifold to the appropriate surface area. The manifold 47 in FIG. 7 is constructed of two individually preformed units, i.e., upper and lower units 89 and 91 which have flat mating surfaces adapted to engage each other along a horizontal plane at 92. Thus each manifold member 89 and 91 provides essentially one-half of the total manifold construction for the area which it serves. The main body portion 93 of each such section is completely open along the rear edge of the manifold so that it can be placed in abutting engagement with the front surface of front trough wall portion 23 opposite openings 48. The extension portion of each manifold 49 is of lesser depth than the main body portion 93, so that when the two manifold sections 89 and 91 are assembled as shown in FIG. 7, each extension will project inwardly toward the axis of rotation of the rotary spray members 36 to a point where the delivery openings 94 will supply a limited volume rate of liquid to only that portion of each spray member 36 which will insure the desired trajectory for the liquid drops projected by the disc. In this case the limited area is shown at essentially the same horizontal level as the axis of rotation of members 36 and at a radial location closer to the periphery of the spray member than to the axis of rotation.

As shown in FIG. 8, each of the manifold sections 89 and 91 provides essentially half of the desired ultimate body portion 93 extending longitudinally along a plurality of spray members 36. Thus liquid is carried from an individual opening 48 in the front trough wall portion 23 and distributed longitudinally to each of the discs served by the particular manifold assembly, and the liquid is then fed individually to the discs through extensions 49 and delivery openings 94. It will be clear from FIG. 8 that each unit 89 and 91 is designed for convenient precasting or molding in such a manner that the manifold sections can be readily separated from the particular mold. In those cases where the extension 49 is adjacent the outer surface of the endmost spray member 36 in a given subgroup, the outwardly directed delivery opening may be suitably closed by a plug 95. Thus the unit of FIG. 8 can be used either as an end unit, or as an intermediate unit constituting part of a longer manifold section. These upper and lower manifold units are preferably made of molded plastic material, such as a suitable thermal-setting resin composition. The use of rubber or other elastomeric material for at least extensions 49 facilitates the manual flexing of these extensions to dislodge undesired objects deposited by the liquid. Manifolds 47 could also be made as a one-piece element. In any case the interior passages of the manifold are shaped to provide a streamlined liquid flow with minimal turbulence, at a fast enough flow rate to avoid sediment deposits.

Details of one embodiment of the bearing units 31, 32 and 33 are shown in FIGS. 9 and 10. Each of these bearing units is supported on a suitable bracket 97 secured to the spray member support portion 29. Each bearing includes a housing 98, provided with appropriate bearing races which carry mechanical antifriction bearing elements 99 of known construction for rotatably supporting the axial shaft portions 41. Such mechanical antifriction bearing elements ordinarily require lubrication by a suitable petroleum lubricant. The unit shown in FIG. 9 provides a supply of such lubricant under a slightly higher-than-ambient pressure, so that the interior of bearing housing 98 will be adequately lubricated, while moisture from the surrounding atmosphere or from adjacent spray members 36 is effectively excluded from the interior of these bearing elements. The lubricating means 101 for this purpose includes a vertically extending tube 102 projecting upwardly from bearing housing 98 and having communication with appropriate openings 103 in the top of the bearing housing. An open bottomed lubricant container 104 is telescopingly supported on said tube with the aid of a piston-like section 106 at the top of tube 102. Container 104 includes a supply of lubricating grease at 107, and container 104 may be provided with an auxiliary annular weight member 108 resting on a flange 109 projecting externally at the bottom of container 104. The total weight of members 104 and 108 thus tends to urge the open bottomed lubricant container downwardly on piston portion 106 and thereby force lubricant from the container through the opening 111 of tube 102 into the bearing housing 98. Appropriate grease seals 114 at the ends of the bearing housing 98 assist in retaining the lubricant within the housing and help to maintain somewhat higher than ambient temperature therein. Gradually, however, grease may be forced out of the housing 98 by the gravity pressure from container 104. A convenient indicating member 112 may be supported on the bearing housing 98 and carries a suitable scale or index 113 to give a visual indication when the supply of lubricant at 107 in a given container has approached the point where the container should be replaced with a fresh one. The arrangement of such a vertically movable lubricant container thus provides a means for maintaining a slightly higher pressure within the bearing housing and excluding moisture, without substantial consumption of lubricating material. Such a unit may require replacement only after a substantial time interval such as several months to a year. An adjustable metering valve 105 in tube 102 provides for manual adjustment of the lubricant feed rate.
As shown in FIGS. 10, 11 and 12, the modular unit includes shaft connections between the axial spray shaft portions 42 and the axial supporting shaft portions 41 which preferably serve a multiple purpose. These connections must in any event insure common angular rotation of the different shaft portions on their common longitudinal axis as a unit, so that the rotary driving force from motor 44 is transmitted to each of the subgroups of rotary spray members. The shaft connections, as described, also include at least one universal joint member to accommodate limited axial misalignment of the supporting shaft portions. Such a joint member is shown at 46 between the driving shaft of motor 44 and the shaft portion 41 of bearing 31. Here the shaft portion 41 has a driven disc 116 secured to it to rotate with the shaft, while the motor carries a similar driving disc 117. These discs are connected by a flexible annular connection 118 of known construction to insure simultaneous rotation of driven disc 116 and its shaft 41 in response to rotation of the motor shaft and its driving disc 117. At the same time, the flexible annular connection 118 does tolerate some misalignment of the two shaft portions.

Similarly, a universal joint member is provided at the connection between each axial supporting shaft 41 and the adjacent end of the corresponding spray shaft portion 42. Such a universal joint is indicated generally at 119 in FIG. 10 and includes a connecting sleeve 121 shown in further detail in FIG. 11. Sleeve 121 at its left end in FIG. 11 has an internal diameter at 122 adapted to fit over the end of the spray member shaft 42. A key slot 123 in the end of member 121 is engaged by a key (not shown) on shaft 42. A plurality of such key slots and keys may be located around the shaft, and a circumferential retaining recess 124 is also provided at the left end of sleeve 121 for retaining ring 131 (FIG. 12). When sleeve 121 is in assembled position on shaft 42, the two portions 132 and 133 of clamping ring 131 are secured together in recess 124 by retaining bolts 134. When the bolts are tightened the ring 131 holds the sleeve 121 against axial displacement on shaft 42. The right end of sleeve connection 121, as viewed in FIG. 11, carries an inner bearing sleeve 126 which has a circumferential inner surface 127 adapted to fit closely on the end of supporting shaft 41. A longitudinal slot or key way 128 in the inner surface 127 of this interconnecting sleeve 126 is adapted to be engaged by an appropriate key (not shown) on shaft 41.

The outer and inner sleeve portions 121 and 126 are secured to each other by an intermediate annular member 129 of rubber or other resilient material. Such material is suitably bonded to each of the sleeve portions 121 and 126 to insure their rotation essentially as a unit. The resilient material of member 129, however, does permit some resilient flexing and thus provides a limited universal joint connection to accommodate limited axial misalignment between the supporting shaft portion of the bearing and the axial spray member shaft portion. The provision of similar universal joint connections at each end of each spray member subgroup insures accommodation of any misalignment which might occur through inadvertent errors or inaccuracies in initial assembly of the unit as well as through unintended bending or flexing of the modular unit. Thus, this arrangement permits the construction of a relatively long modular spray unit with a plurality of spray member subgroups, all driven effectively by a single driving motor 44.

The shaft connections are also designed to serve as removable joint members at each end of the respective spray member subgroups, in order to provide for convenient initial assembly of one subgroup at a time, as well as for convenient removal and replacement of any one spray member subgroup and its axial shaft portion as a separate subassembly. The construction shown in FIGS. 10–12 provides such a removable joint arrangement. Thus, if it is desired to remove the left hand spray member subgroup in FIG. 10, the clamping ring 131 would first be loosened or removed. The sleeve member 121 at its internal sleeve connection 126 would then be slid axially along supporting shaft portion 41 toward bearing 32 until sleeve 121 is clear of the end of spray member shaft portion 42. During this movement, the spray member subassembly and its shaft 42 would of course be independently supported in appropriate manner. Once the sleeve portion 121 is clear of the shaft 42, the complete subassembly of rotary spray members and spray shaft portions 42 can then be removed or replaced as a unit with the aid of suitable lifting mechanism.

As shown in FIG. 10, the right-hand bearing unit 33 supports the end of the last spray member subgroup 39. Thus, it is not necessary to provide a resilient or universal joint type of connection at this point. In fact, it is desirable to provide a radially rigid connection between shaft 41 and the end of the spray member shaft 42 so that there will be a firm and accurate support for this end of the series of rotary spray members. Thus a modified removable joint connection 136 may be provided at this point, if desired, in lieu of the specific axially movable sleeve connection 121 used at the other joints. The details of such a modified removable connections, as well as other types of removable and flexible or universal joint connections suitable for use in place of the shaft connections 119 will be apparent to those skilled in the art based on the teachings of the present invention.

Another embodiment of the invention is shown in FIGS. 13 through 16, in which a preferred from of bearing unit is described in connection with a modified modular unit 138 which is particularly adapted for use in combination with such a bearing. Thus, spray unit 138 includes a plurality of modified bearing units indicated generally at 139. Such a unit includes a liquid lubricated bearing in which the water or other heated liquid in trough 28 is used as the liquid lubricant.

Each bearing unit 139 includes a modified supporting shaft portion 141 mounted for rotation within a supporting bearing assembly 140. The bearing assembly includes a cylindrical outer housing 142 which supports an internal liquid lubricated journal member 143 of generally annular construction. Such a journal member is constructed in known manner of an appropriate rubber or other material which provides a suitable anti-friction support for the shaft portion 141 when the inner surface of the journal member 143 is continually wetted by suitable liquid, such as water. Thus, the outer bearing housing 142 has several inlets 144 through which liquid is fed to a circumferential supply groove 146 in the inner surface of journal member 143. The journal member is also provided with a plurality of axially extending grooves 147 (FIGS. 14 and 15) which conduct liquid from the centrally located circumferen-
3,856,280

3,856,280

13
tial groove 146 outwardly toward each end of shaft portion 141. Thus, grooves 147 divide the inner surface of journal member 143 into a plurality of bearing seg-

14
ments 148 which effectively define a cylindrical inner bearing surface for shaft portion 141. During rotation of shaft 141, liquid enters at inlets 144 and is carried around circumferential groove 146 and axially out along grooves 147. Thus, each bearing segment 148 is continually lubricated by the liquid, and the wet rubber or equivalent surface provides a low coefficient of friction for rotatably supporting shaft portion 141. In such bearings, a constant flow of the lubricating liquid during operation is essential, and the liquid which flows along the axial grooves is discharged at each end of the journal member 143 as indicated, for example, at 149 in FIG. 14. Liquid would be similarly discharged at the opposite end of journal member 143 in this view.

According to an important feature of this modifi-

cation of the invention, liquid from the trough 28 of the modular spray unit is fed to the inlet 144 of the liquid lubricated bearing unit by special arrangement de-

signed to insure proper operation of the bearing under different climatic conditions, including the freezing temperatures encountered in a winter environment.

Thus, the bearing assembly 140 is supported in a liquid containing housing defined by walls 151 and 152 at each end of the bearing, a forwardly and upwardly incl-

lined bottom wall 155 and a front wall 153 extending upwardly from wall 155 and the spray member support section 29 and closing the front end of the space be-

between walls 151 and 152, and the front surface of the front trough wall portion 23 of the unit. Thus, a liquid containing chamber 154 is supplied by wall portions which may, if desired, be constructed as integral extensions of the trough portions 23 and 29. This bearing-

enclosing chamber is effectively connected to the trough 28 by an opening 156 in front trough wall portion 23 at the extreme bottom of the trough. Thus, the liquid level in chamber 154 will at all times be the same as that in trough 28. When the trough is drained, the bearing-enclosing chamber 154 will be filled with liquid.

Conversely, when the trough 28 is filled with heated liquid to be cooled, the bearing-enclosing chamber 154 will be similarly filled with heated liquid. Thus, if the unit has been drained during freezing weather, and if any particles of liquid might have been left within the bearing assembly 140, so that particles of ice could have been formed which would interfere with free operation of the bearing, the complete enclosure of bear-

ing assembly 140 with heated liquid, when such liquid is again fed to the previously drained trough and bearing chambers, will insure complete thawing of all of such frozen particles by the time the liquid in trough 28 has reached a level at which operation of the spray members would be started.

Another feature of this modified bearing arrange-

ment is the provision of a filter member in the liquid supply conduit which is provided between the trough 28 and the liquid lubricated journal member. Such a filter member is shown in the form of a fine screen 157 in FIGS. 14 and 15. The screen is provided with an appropriate frame having an upper handle portion 158 for convenient removal and cleaning of the screen. The screen is retained between vertical guides 159 and 161 and extends entirely across the chamber 154 between the liquid supply opening 156 from trough 28 and the bearing assembly 140. Thus, any solids which might have been included in the liquid within trough 28 and which might be capable of damaging the liquid lubricated bearing assembly 140 will be intercepted so that their passage to the liquid inlet of the bearing unit will be prevented. A cover 160 may be added to exclude debris, and the inclined bottom 155 minimizes deposits within the housing.

As shown in FIGS. 14 and 16, a modified shaft con-

nection is provided between the supporting shaft por-

tion 141 of the bearing 139 and the end of the spray member shaft portion 162. This bearing construction is designed to facilitate radial removal of the spray unit subgroup, without the necessity of axial sliding of a shaft connection housing, as previously described in connection with housing 121 of FIGS. 10 and 11. Thus, a modified connection of FIGS. 14 and 16 requires less axial space between the nearest spray member 36 of the subgroup and the actual bearing assembly itself. Moreover, the shaft connections of FIGS. 14 and 16 fa-

cilitate the radial movement of the spray member sub-
group and make it somewhat easier to install or remove the subgroup, without the necessity of supporting the subgroup with its spray member shaft portion in almost exact alignment with the supporting shaft portion of the bearing unit, before an axially telescoping connection housing can be moved into locking position 165.

Thus, the shaft connections shown in FIGS. 14 and 16 provide a removable joint member at one end of a spray member subgroup which also incorporates the desired universal joint member to accommodate any limited misalignment of the shaft portions. This removable joint member includes a two-part outer housing in which the first part is secured to the end of one of the axial supporting shaft and axial spray shaft portions 141 and 162. As illustrated in FIGS. 14 and 16, the removable and universal joint member 163 has its first housing part 164 integrally connected to the end of the shaft portion 141 to rotate therewith. This first housing part 164 constitutes one-half of a complete annular outer housing which extends axially shaft portion 141 along the outside be spray member shaft portion 161. This first housing part has radially projecting flanges 167 at each side which are adapted to abut corresponding portions 168 of the second outer housing part 166 to complete the annular outer housing. These parts are secured to each other during operation by bolts 169 passing through flanges 167 and 168. When the parts are in the position shown in FIG. 14, with the first hous-
ing part 164 below the shaft portion 162, bolts 169 can be removed and the second housing part 166, with its associated parts, can be lifted from the top of the assembly so that there is no obstacle to direct axial lifting of shaft portion 162 in an upward direction out of the semicircular housing part 164.

The removable joint member 163 further includes a two-part annular inner housing, each part of which is removably keyed to the end of the remaining shaft por-
tion which, in this case, is shaft portion 162. Thus the lower half of the assembly shown in these figures in-
cludes one part 173 which constitutes one-half of the annular inner housing and which is removably keyed at 174 to the shaft portion 162. During initial assembly, with the upper bearing parts removed, the key 174 can be placed in its slot in the annular inner housing 173 and the shaft 162 can then be rotated so that its keyway is in position to be lowered vertically on to key 174 and housing portion 173. The second inner housing part
176 similarly has a removable key connection 177 to the opposite portion of shaft 162. Each of these inner housing parts in connected to its corresponding outer housing part by one portion of a two-part annular resilient intermediate universal joint member. Thus, the first part 171 of such a resilient annular section is secured between the first outer housing part 164 and the first inner housing part 173 to provide for simultaneous rotation of these parts as a unit. Similarly, the remaining annular resilient intermediate universal joint part 172 is secured between the second outer housing part 166 and inner housing part 176, so that all these parts can be removed as a unit when the bearing is disassembled. Such disassembly at 169 and removal of the parts 166, 172 and 176 thus permits removal of key 177 and radial upward lifting of shaft 162 from the shaft connection and bearing unit 139. Thus, the construction of this removable joint member provides both the desired universal joint action to accommodate limited misalignment of the shaft and the desired ready removability of the member to simplify assembly and installation of the unit and with minimal problems in disconnecting the shaft connection for later removal or replacement of such a sprayer member subgroup.

As illustrated in FIG. 17, the present invention, in its broadest aspects, provides a single longitudinally and vertically extending trough wall portion 23 essentially similar to the trough wall portion 23 previously described. In this case, however, the trough wall portion has a modified base portion 181, in lieu of the horizontal trough base portion 22 of the previously described embodiments. This modified base portion 181 comprises a downwardly projecting lower extension of the trough wall portions 23 which is adapted to project downwardly below the surface of the supporting barrier portion 78 between a heated liquid reservoir 81 and a cooled liquid reservoir 83. Thus the trough wall portion 23 of this modular unit is adapted to be mounted along an edge of the heated liquid reservoir and to provide at least part of a reservoir wall portion at said edge to maintain the desired liquid level 84 at a substantially higher level than the supporting area 78 and cooled liquid reservoir 83.

This single trough wall portion 23 includes a sprayer member support portion 29, essentially similar to that previously described in connection with the devices of FIGS. 1 through 16. This sprayer member support portion carries spray members 36 with the aid of suitable bearings, as previously described. Moreover trough wall portion 23 includes a feed opening 48 which provides a conduit means from reservoir 81 through the trough wall portion 23 and a conduit or manifold 47 to the liquid delivery openings 94 from which liquid is fed to the surfaces of spray members 36 at the desired volume rates.

Trough wall portion 23 may be anchored by the projection of its supporting base portion 181 below the surface of supporting area 78, as described, and the spray member support portion 29 may even engage the upper reinforced surface area 77 of the supporting area to help resist tilting of the trough wall portion 23 under the pressure of the liquid in reservoir 81.

As shown in FIG. 17, the respective reservoirs may have special surface materials as shown at 77, 79, and 82. In this case, the rigid surface portions are interrupted along the top of the supporting area by a longitudinally extending slot 182 which has sufficient width to permit convenient relative vertical movement of the unit to insert or remove its supporting base portion 181 from the space provided by slot 182.

According to the foregoing specification, the nature and background of this invention have been set forth, and some of the ways of practicing the invention have been described, including the preferred embodiments presently contemplated as the best mode of carrying out the invention.

We claim:

1. A modular liquid cooling spray unit for controlled projection of liquid drops in desired trajectories, particle sizes, velocities, and volume rates providing cooling of the liquid, said modular unit comprising a longitudinally and upwardly extending trough wall portion having a base portion adapted for supporting the trough wall portion at one edge of a reservoir of heated liquid to be cooled, with the trough wall portion having a rear surface adapted to provide at least part of a reservoir boundary wall for maintaining a desired liquid level in such reservoir, a sprayer member support portion on one of said trough wall and base portions, a plurality of rotary sprayer members mounted on said sprayer member support portion for rotation on a horizontal axis spaced in front of and parallel to the trough wall portion, with at least a portion of each sprayer member spaced vertically below the desired level of heated liquid in each reservoir, and conduit means in said trough wall portion for feeding liquid from said reservoir through said trough wall portion to at least one surface of each sprayer member at a limited area which is below said desired liquid level and from which the rotation of the spray members carries liquid and projects liquid drops in a plurality of trajectories substantially all of which have horizontal components extending generally crosswise of said trough wall portion.

2. A modular liquid cooling spray unit for controlled projection of liquid drops in desired trajectories, particle sizes, velocities, and volume rates providing cooling of the liquid, said modular unit comprising a longitudinally and upwardly extending trough wall portion having a base portion and said trough wall portions extending upwardly from said base portion and providing an open-topped trough for receiving heated liquid to be cooled a sprayer member support portion on said trough, a plurality of rotary sprayer members mounted on said support portion for rotation on a horizontal axis spaced in front of and parallel to the front trough wall portion, with at least a portion of each spray member spaced vertically below an expected level of heated liquid in said trough, a motor support portion on said trough for supporting a driving motor adapted for rotation of such spray members in a desired angular direction around said axis, and conduit means for feeding liquid from said trough to at least one surface of each sprayer member at a limited area which is below said expected liquid level and from which the rotation of the spray members carries the liquid and projects liquid drops in a plurality of trajectories substantially all of which have horizontal components extending generally crosswise of the trough.

3. A liquid cooling spray unit according to claim 2 adapted for assembly in an aligned row of similar units, said unit having first and second end wall portions extending upwardly from the base portion at each end of
the trough for closing the ends of the trough, said rear trough wall portion having at least one end extending longitudinally beyond the front trough wall and end wall portions at said one end and thereby providing a drainage space between the front and end wall portions of said unit and the opposite front and end wall portions of a similar unit when such a similar unit is assembled with the rear trough wall portions of adjacent units abutting each other.

4. A liquid cooling spray unit according to claim 3 in which both the rear trough wall and base portions extend beyond the front wall at said one end, and one of the end wall portions of the spray unit has a drain opening therein at the bottom of the trough for emptying liquid from the trough, and a control valve mounted on said end wall portion for selectively opening and closing said drain opening.

5. A liquid cooling spray unit according to claim 2 in which said base portion and trough wall portions are formed as an integral, precast concrete unit.

6. A liquid cooling spray unit according to claim 5 in which at least a portion of said trough is formed of longitudinally prestressed concrete.

7. A liquid cooling spray unit according to claim 6 in which said front and rear trough wall portions include a plurality of longitudinally extending tension members prestressing said trough wall portions in longitudinal compression, and in which said base portion includes untensioned reinforcing material and is held in longitudinal compression by the prestressing of the trough walls.

8. A liquid cooling spray unit according to claim 2 in which the spray member support portion extends forwardly from the front trough wall portion and includes a plurality of bearing units spaced along said axis, said unit also having an axial supporting shaft portion rotatably supported in each bearing unit, a plurality of spray member sub-groups each having a plurality of said spray members secured to an axial spray shaft portion extending between the supporting shaft portions of a corresponding adjacent bearing unit.

9. A liquid cooling spray unit according to claim 8 which includes shaft connections between said axial spray shaft portions and axial supporting shaft portions insuring common angular rotation of said portions on said axis as a unit, said shaft connections including at least one universal joint member accommodating limited axial misalignment of the axial supporting shaft portions of different sub-groups of said spray members.

10. A liquid cooling spray unit according to claim 8 in which said shaft connections include removable joint members at each end of a spray member sub-group for removal and replacement of the spray member sub-group and its axial spray shaft portion as a separate subassembly.

11. A liquid cooling spray unit according to claim 10 in which the removable joint member at one end of a spray member sub-group includes said universal joint member, said removable joint member comprising a two-part outer housing having a first part secured to the end of one of the axial supporting shaft and axial spray shaft portions to rotate therewith and extending axially along the end of the other shaft portion, the outer housing also having a second part removably connected to the first part to hold the shaft portions in axial alignment when the two parts are secured together and to permit radial removal of the spray shaft portion when the second part is disconnected from the first part.

12. A liquid cooling spray unit according to claim 11 in which the removable joint member also includes a two-part annular inner housing, each part of which is removably keyed to the end of said other shaft portion, and a two-part annular resilient intermediate universal joint member, each part of which is secured to the corresponding part of its inner and outer housing thereby providing for simultaneous rotation of all the parts when the outer housing parts are assembled on the shaft portions, removal of the second outer housing part with its corresponding inner housing and resilient intermediate joint member parts thereby permitting said radial removal of the spray shaft portion.

13. A liquid cooling spray unit according to claim 8 having a bearing unit which includes mechanical anti-friction bearing elements for its axial supporting shaft portion, a bearing housing for said anti-friction bearing elements, and lubricating means for supplying lubricant to said bearing elements within said housing under a higher-than-ambient pressure, said bearing unit having sealing members around said shaft portion adapted to limit the escape of lubricant and maintain said pressure within the housing, thereby excluding moisture from said bearing elements.

14. A liquid cooling spray unit according to claim 13 in which said lubricating means includes a vertically extending tube projecting upwardly from the bearing housing and an open-bottomed lubricant container telescopingly supported on said tube and having a weight urging the container downwardly and thereby forcing lubricant from the container through the tube and into the bearing housing, said tube having a metering valve therein.

15. A liquid cooling spray unit according to claim 8 having a bearing unit which includes a liquid-lubricated journal member having an external liquid inlet, a cylindrical internal bearing surface, and connecting passages for limited liquid flow from said inlet across said bearing surface, and a liquid supply conduit between said trough and the liquid inlet of said journal member for supplying liquid from the trough to the journal member during operation of the spray unit.

16. A liquid cooling spray unit according to claim 15 in which the liquid supply conduit between the trough and journal member includes a bearing-enclosing chamber substantially circumferentially surrounding the liquid-lubricated journal member, said conduit connecting the chamber to the trough at a level below the journal member, and having a location and configuration automatically draining liquid from the bearing unit and chamber to the trough when the trough is emptied and automatically filling the chamber when the trough is filled, with heated liquid to be cooled, the heated liquid in said bearing-enclosing chamber thereby providing a temperature at said bearing which insures free flow of liquid through the liquid inlet and connecting passages of the bearing unit when the trough is filled.

17. A liquid cooling spray unit according to claim 16 in which the liquid supply conduit between the trough and journal member includes a filter member preventing passage of damaging solids from said trough to the liquid inlet of the bearing unit.

18. A liquid cooling spray unit according to claim 8 in which the spray member support portion and motor
19. A liquid cooling spray unit according to claim 2 in which the rear trough wall portion has a liquid inlet opening through which heated liquid to be cooled can be admitted to the trough from a supply of such liquid close to the trough.

20. A liquid cooling spray unit according to claim 19 having a movable inlet valve member for said liquid inlet opening for selectively admitting and excluding liquid to and from the trough.

21. A liquid cooling spray unit according to claim 20 in which said trough also has end wall portions closing the ends of said trough, one of the end wall and front trough wall portions having a drain opening therein at the bottom of the trough, and a movable drain valve member for said drain opening, whereby said trough may be selectively drained when said movable inlet valve is positioned to exclude further liquid from the trough.

22. A liquid cooling spray unit according to claim 19 in which the front and rear trough wall portions are provided with lifting connections adapted to receive a plurality of lifting hooks on a lifting crane cable, for lifting and positioning said spray unit on a prepared supporting area along one edge of a liquid reservoir.

23. A liquid cooling spray unit according to claim 19 in which the rear trough wall portion has a height providing at least part of one side wall of such a reservoir for maintaining a liquid level in such a reservoir at a desired higher level than said supporting area, said spray unit having a lower front edge adapted to engage the prepared supporting area, and securing means for engaging said lower front edge and said supporting area for preventing displacement of the spray unit away from the liquid reservoir in response to pressure against the rear trough wall portion.

24. A liquid cooling spray unit according to claim 8 in which the conduit means for feeding liquid from said trough to said spray members includes at least one manifold for each spray member subgroup, each such manifold having a horizontal main body portion with upper, lower and end wall portions providing an open rear edge for abutting the front trough wall portion of the unit and receiving liquid from the trough through an opening in the front trough wall portion, such manifold also having a front wall with a plurality of forwardly projecting extensions thereon spaced along the manifold for projection of each extension to a point adjacent the limited surface area of a corresponding spray member in said subgroup, and each such extension having at least one liquid delivery opening oriented to deliver liquid from the manifold to such limited surface area.

25. A liquid cooling spray unit according to claim 24 in which at least part of such manifold is made of elastomeric material for convenient flexing to remove undesired objects deposited by said liquid.

26. A liquid cooling spray unit according to claim 24 in which each of a plurality of said extensions has two oppositely directed liquid delivery openings for simultaneously feeding liquid to the limited surface areas of two adjacent spray members between which such an extension is adapted to project.

27. A liquid cooling spray unit according to claim 26 in which each such manifold comprises upper and lower individually performed units joined to each other along a plane of separation extending generally horizontally through the main body portion, forwardly projecting extensions and delivery openings of such manifold.

28. A liquid cooling spray unit according to claim 27 in which said upper and lower manifold units are made of molded plastic.