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Boler

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[54] **LIQUID COOLING APPARATUS**

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[52] **U.S. Cl.** **261/90,** 239/224

[51] **Int. Cl.** **B01f 3/04**

[58] **Field of Search** ..... 239/550, 219–221, 239/224, 16–23; 261/116, 119 R, 120, 90, 89, 92; 62/304, 305

[56] **References Cited**

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[57] **ABSTRACT**

An improved liquid cooling apparatus for a projection of liquid drops in trajectories, particle size, velocities and volume rates effective for improved cooling of the liquid includes a plurality of parallel disc-like spray members of improved construction. Such spray members are spaced from each other along a common axis of rotation and have preferably circular peripheries from which liquid is to be sprayed. The axis is generally horizontal and is also perpendicular to the individual spray members. The apparatus further includes means for feeding liquid to be cooled to at least one surface of each spray member at a limited area spaced inwardly from the periphery of the spray member, so that rotation of the spray member on its axis moves the liquid centrifugally outwardly along the surface and frictionally in the direction of rotation of the surface. The surface of the spray member to which liquid is fed is provided with a plurality of circumferentially spaced liquid guide vanes projecting axially from the surface of the spray member and extending in a generally radial direction at only the outer portions of the spray member surface, i.e., starting at a point outside the limited area to which liquid is fed to the member and extending radially toward the periphery of the spray member. The invention further provides a splash shield which extends parallel to the spray member surface immediately adjacent the projecting vanes, so that the shield minimizes or substantially prevents the splashing of liquid in an axial direction and insures retention of the liquid on the spray surface and along the guide vanes for maximum effectiveness in projecting the desired particles of liquid from the periphery of the rotating member. In some embodiments, the splash shield member is secured to and rotates with the spray member. In other cases it may be secured to a stationary portion of the apparatus. The apparatus also includes features by which the spray members can be removed and replaced, without disturbing the position of the means for feeding liquid to the surface or surfaces of the spray members.

12 Claims, 6 Drawing Figures

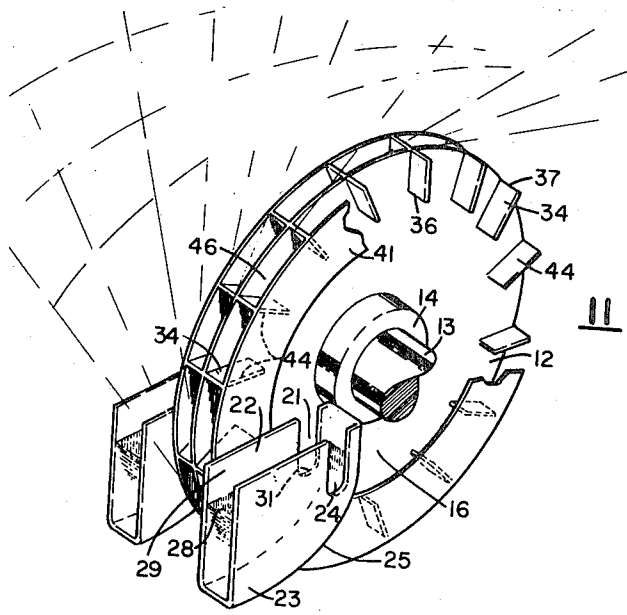


Fig. 1

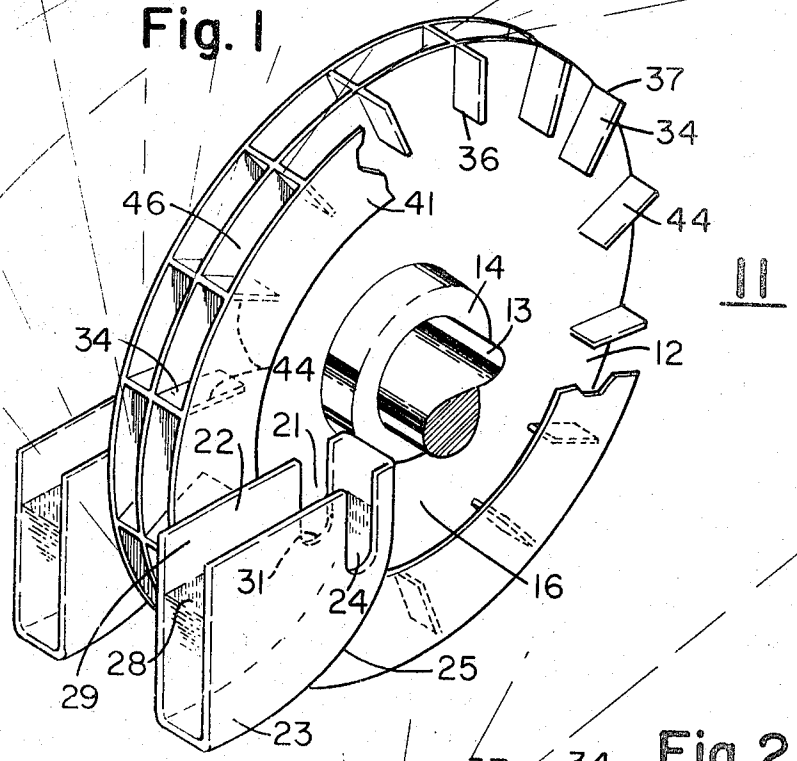


Fig. 2

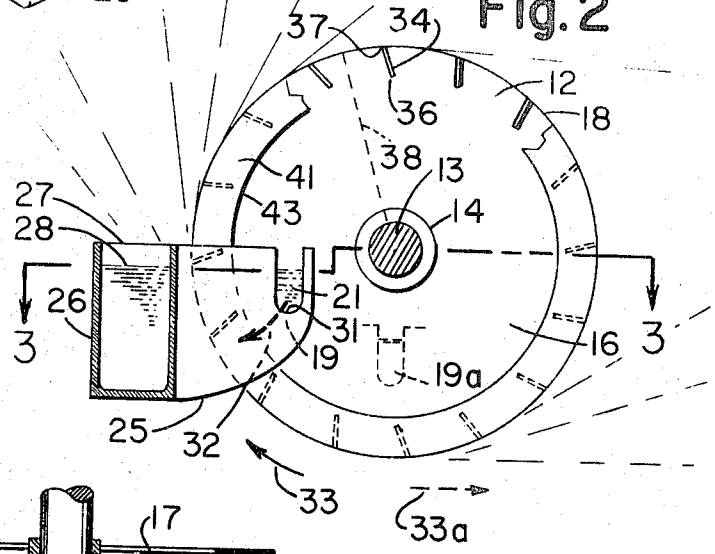


Fig. 3

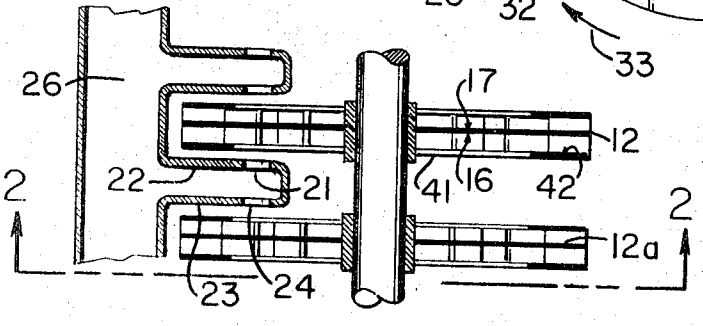


Fig. 4

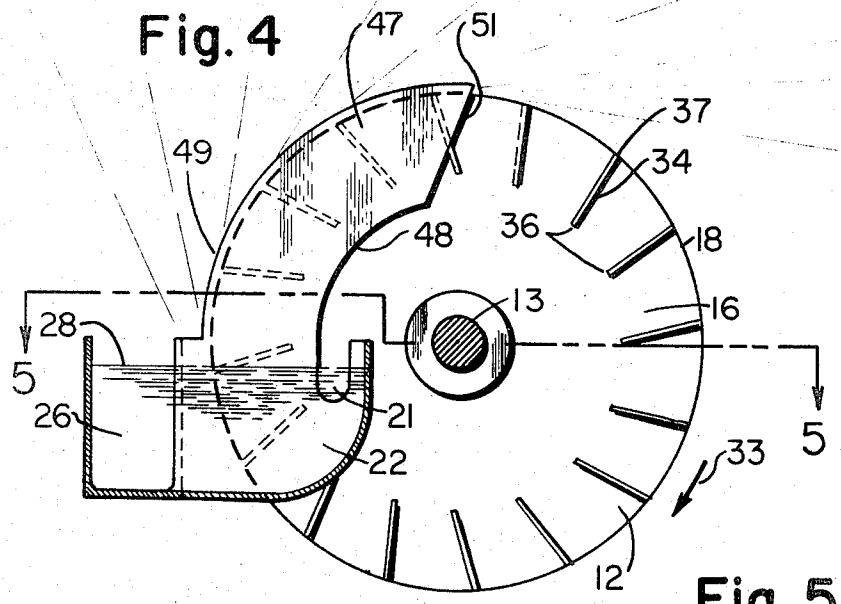


Fig. 5

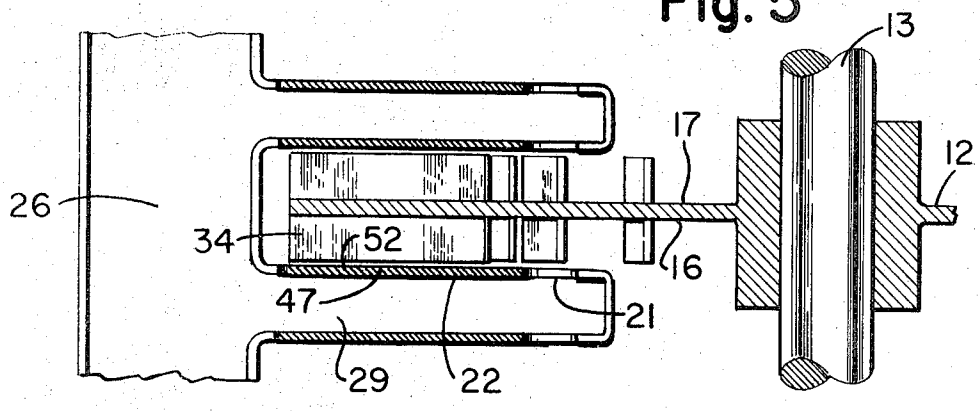
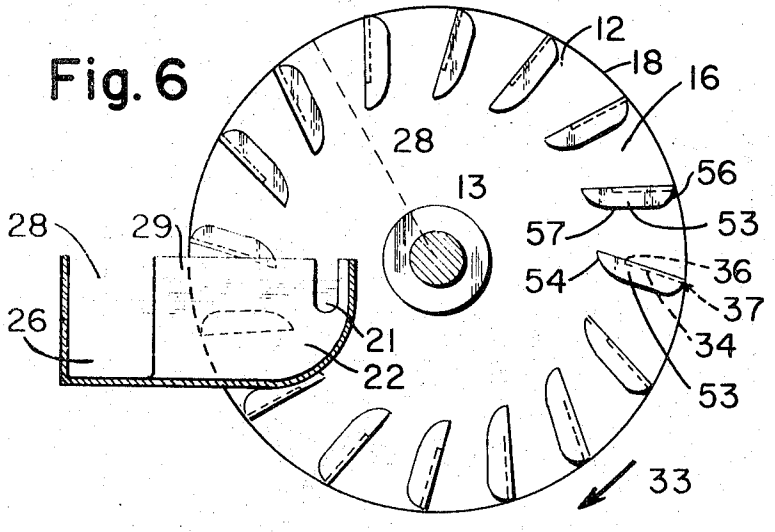


Fig. 6



LIQUID COOLING APPARATUS

CROSS REFERENCES TO OTHER APPLICATIONS

Certain features described and claimed in the present application may be considered as improvements suitable for use in combination with, or for incorporation in, the liquid cooling devices shown and claimed in the following co-pending applications, which have been assigned to the same assignee as the present application, i.e.:

U.S. Ser. No.	Filing Date	Inventor(s)	Title
47,078	June 17, 1970	Lloyd Cherne Leonard J. Boler Ernest E. Matthews, Sr.	Liquid Cooling System Application and Method
296,777	October 10, 1972	Leonard J. Boler	Liquid Cooling Apparatus

(the above-identified application U.S. Ser. No. 47,078 has issued as U.S. Pat. No. 3,719,353 dated Mar. 6, 1973).

BACKGROUND OF THE INVENTION

A variety of forms of liquid cooling devices have been previously developed, which are designed to provide desired cooling of heated liquids at substantial volume rates of flow. As one example, it has been customary in many cases to obtain cooling liquids for electric power generating plants by drawing such liquids from a nearby stream, lake or other natural water source. In some cases the liquid is returned to the natural source after the desired cooling operation is complete. Since the liquid has been used for cooling purposes, its temperature at the point of discharge from such a plant is higher than the temperature of the original source. Thus there is a possibility of so-called "thermal pollution" of the natural waters by reintroduction of liquid at a higher temperature.

To avoid these problems, the heated liquid effluent from a cooling operation is customarily subjected to various types of cooling. It may even be recirculated to the particular plant and used repeatedly for the desired cooling effect within the plant, after the discharged heated liquid has been cooled in some manner.

As shown in the above co-pending U.S. Pat. application, Ser. No. 47,078, filed June 17, 1970, and assigned to the same assignee as the present application, a system has been designed to provide the desired cooling effect by the use of apparatus which projects substantial quantities of liquid up into the atmosphere, so that the drops of liquid are subjected to evaporative cooling as they move up in their projected paths or trajectories and then drop back into an appropriate section of a liquid receiving reservoir or conduit. The other identified co-pending U.S. Pat. application, Ser. No. 296,777, filed Oct. 10, 1972 shows a number of cooling apparatus arrangements in which rotary spray members provide for controlled projection of liquid drops in trajectories, particle sizes, velocities and volume rates which provide a substantial directional wind effect in essentially one horizontal direction for improved cooling of the liquid on a continuous basis above an open-air receiving reservoir or conduit. The rotary spray members shown in these prior applications are provided with relatively flat liquid receiving and spraying surfaces, on which there is a certain amount of slippage between the liquid which is fed to one part of the rotating surface and the surface itself.

In the earlier of the above identified co-pending applications, there is also a disclosure of spiral guide portions on some of the rotary spray surfaces, with such guide portions following a particular forwardly directed curvature and extending radially all the way from an inner point near the axis of rotation of such a member to an outer end at the periphery of such a spray member. As a practical matter, however, it has now been found that the use of the spiral guide members shown in that application is less efficient than the use of the flat surfaces without guide vanes, and in any event, the guide vanes as previously described and claimed have not enhanced the efficiency of the unit in terms of quantities of liquids sprayed per unit of power input, as compared to the flat surfaces previously shown.

SUMMARY OF THE INVENTION

The present invention provides an improved liquid cooling apparatus for projection of liquid drops in trajectories, particle sizes, velocities and volume rates effective for improved cooling of the liquid, on the type in which the apparatus includes a plurality of parallel disc-like spray members spaced from each other along a common axis of rotation and having peripheries from which liquid drops are to be projected, and in which the axis of rotation is generally horizontal and perpendicular to the spray members, and the device includes means for feeding liquid to be cooled to at least one surface of each spray member at a limited area spaced inwardly from its periphery and from which the rotation of the spray member causes the liquid to move centrifugally outwardly along said surface and frictionally in the direction of rotation of the surface. According to the invention, the surface of the spray member to which such liquid is fed is provided with a plurality of circumferentially-spaced liquid guide vanes projecting axially from the surface and extending generally radially at only the outer portions of said surface outside the limited area at which liquid is fed to this surface, i.e., between such limited area and the periphery of the spray member. The outward spacing of the guide vanes provides for their engagement with the liquid after the liquid has been fed to said limited area and has started to move outwardly along the spray member surface. The invention further provides a shield portion having a splash shield surface extending parallel to the spray member surface and spaced axially therefrom at a location immediately adjacent the projecting edges of the guide vanes. The splash shield surface covers an area extending outwardly from the limited area at which liquid is fed to the spray member surface to that portion of the spray member periphery at which the liquid is projected from the spray member.

Preferred embodiments of the invention are shown in which the shield portion is secured to the spray member for rotation of the spray member, vanes and shield

portion as a unit. In one such case, the shield portion is a flat annular member having an inner circular edge coaxial with the axis of rotation of the spray members and having a radial location spaced outwardly from the limited area to which the liquid is fed and inwardly from the innermost edges of the radial vanes. In another such embodiment, each guide vane on the spray member surface has its own individual shield member consisting of a liquid retaining lip extending radially along the vane parallel to the spray member surface and forwardly in the direction of rotation of the spray member to provide a guide channel defined by the spray member, vane and lip, with the open side of such channel on the side of the vane toward which rotation of the spray member is intended to project the liquid.

In another embodiment, the shield portion constitute a stationary portion of the apparatus. An improved means for feeding liquid to the spray member surface includes a stationary conduit member projecting inwardly alongside the spray member from a location radially outside its periphery, said conduit member having a side wall parallel to the spray member surface, and the side wall having a discharge opening through which the liquid is projected axially onto a flat inner portion of the spray member surface at the desired limited area thereof, all portions of the conduit member, its side wall and discharge opening being spaced axially from the spray member surface a distance providing clearance for said guide vanes for relative radial assembly or disassembly of the spray member and vanes with respect to the conduit member.

Other details of construction of the preferred embodiments will be apparent from the following detailed description and claims.

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 partial perspective view of an improved liquid cooling apparatus according to the invention, with certain parts broken away to show details of one arrangement of guide vanes, splash shield portion, and liquid feeding conduits;

FIG. **2** is an end view of the device of FIG. **1**, with certain portions broken away for clearness;

FIG. **3** is a top view of the device of FIG. **1**, with certain parts shown in section along the line **3—3** of FIG. **2**;

FIG. **4** is a view similar to FIG. **2** of another embodiment of the invention in which a stationary splash shield portion is carried by the liquid feeding conduit of the device;

FIG. **5** is a view similar to FIG. **3** of the device of FIG. **4**, taken on the section line **5—5** of FIG. **4**.

FIG. **6** is a view similar to FIG. **4** of still another embodiment of the invention in which each guide vane of a rotary spray member is provided with an individual splash shield portion.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIGS. **1–3**, a preferred embodiment of the invention includes a liquid cooling apparatus indicated generally at **11** and provided with a plurality of parallel disc-like spray members **12, 12***a* etc., which are spaced from each other along a common axis of rotation as defined, for example, by the central longitudinal axis of a rotary shaft **13**. Each flat disc-like spray member **12, 12***a* is fixed to the shaft by a suitable hub portion or retaining ring **14**, so that the spray members may be rotated on their common axis by rotation of such a shaft in a desired direction.

Each spray member **12, 12***a* has at least one flat liquid spraying surface **16**, and preferably two such surfaces **16** and **17** at opposite faces of the disc **12**. Each spray member or disc **12** also has a periphery **18** from which liquid is to be projected. The periphery is prferably circular and concentric with the axis of rotation, as shown.

As described in the above identified applications, liquid to be cooled is fed to a selected limited area of surface **16**, for example, as shown at **19** (FIG. **2**). A preferred liquid feeding means according to the present invention includes a discharge opening **21** in one wall **22** of an open topped trough or liquid feeding conduit, which has a second parallel wall **23**. A combination bottom and end wall **25** completes the construction of a stationary liquid conduit member projecting inwardly along the spray member, i.e., between adjacent spray members, from a location radially outside their peripheries.

Liquid to be cooled is supplied to these inwardly projecting conduit members by an outer supply reservoir **26** which is illustrated as an axially extending trough having an open top **27** and in which the liquid is supplied at a normal liquid level shown at **28**. The liquid in the supply trough flows into the radial conduit members adjacent each spray member, and these in turn are also open at their top as shown at **29**. Similarly, the discharge openings **21** and **24** are illustrated in the form of open-topped notches in the respective side walls, and these discharge openings have lower edges **31**, over which the liquid within the supply conduits is adapted to flow and be projected axially against the flat inner surface portions of the spray members **12, 12***a* etc. at the desired limited areas **19** spaced inwardly from the peripheries of the spray members.

As shown in FIG. **2**, for example, the limited area **19** which receives the liquid from discharge opening **21** is located approximately half way between the periphery of spray member **12** and its axis of rotation, and somewhat below the level of the axis itself. As the spray member rotates in the direction of arrow **33**, the liquid which engages the surface **16** will be urged along a path indicated schematically by arrow **32**, in which the liquid is moved centrifugally outwardly along the surface **16** and frictionally in the direction of rotation of that surface as shown by arrow **33**.

According to the present invention, surface **16** is further provided with a plurality of circumferentially spaced liquid guide vanes **34** which project axially perpendicular to the surface **16** and which extend generally radially at only the outer portions of surface **16**. Thus the inner ends **36** of guide vanes **34** are positioned around the circumference of surface **16** at a location which is spaced outwardly from the limited area **19** at which liquid is fed to the surface, i.e., at a radial distance from the axis of rotation which is somewhat greater than the radial distance from the axis to the area where the liquid first reaches the surface. Vanes **34** extend outwardly so that their outer ends **37** are substantially at the periphery **18** of the surface. As fur-

ther illustrated in FIG. 2, the vanes 34 extend along the spray member surface in a generally radial direction. In the embodiment of FIGS. 1–3, these vanes 34 are extended along the spray member surface at an acute angle to the actual radius 38 of the spray member (FIG. 2). In this case the acute angle is such that the vanes extend outwardly and rearwardly from such actual radius, as viewed with reference to the direction of rotation shown by arrow 33. In this case, as shown by the heavy lined portions of FIG. 2, the device is arranged to project liquid particles upwardly from the left side of spray members 12. For some applications, however, particularly as described in the above identified copending application Ser. No. 47,078, it may be desirable to project particles of liquid to the right, from the lower portions of spray memeber 12. In this case, the limited area at which liquid should be fed to spray surface 16 is indicated in dotted outline at 19*a*, and the spray surface would be rotated in the opposite direction as shown by dotted arrow 33*a*. When operated in this manner, the vanes 34 would extend at an acute angle outwardly and forwardly from the actual radius 28, as viewed with respect to the direction of rotation shown by arrow 33*a*.

Thus some variation in the exact orientation of the guide vanes 34 may be desirable, depending on the particular projection effects desired. In general, however, these guide vanes will extend either in essentially a radial direction or at a relatively acute angle one way or the other with repect to the actual radial direction 38.

According to a further feature of the present invention, a shield portion or member 41 has a splash shield surface 42 extending parallel to the spray member surface 16 immediately adjacent the vanes 34. This splash shield surface is further located over an area which extends outwardly from the limited area at which liquid is fed to the spray member surface to that portion of the spray member periphery 18 at which the liquid is projected from the spray member. In the embodiment shown in FIGS. 1–3, the shield portion 41 is in the form of a flat annular member having an inner circular edge 43 coaxial with the axis of rotation. The radial location of this inner edge 43, as will be particularly seen in FIG. 2, is spaced outwardly from the limited area 19 or 19*a* to which the liquid is originally fed, and inwardly from the innermost edges 36 of the radial vanes 34. In this particular embodiment the shield portion 41 is secured rigidly to the spray member for rotation of the spray member, vanes and shield portion as a unit. Specifically, shield portion 41 is secured to the outer or projecting radial edges 44 of the vane members 34 and thus provides a somewhat enclosed channel 46 through which the liquid reaches the periphery 18 of the spray surface 16, this channel being defined by the disc surface 16, the vanes 34 and the splash shield surface 42 of the spray member portion 41. Member 41 is particularly designed to maintain the desired effective projection of the liquid particles by means of vanes 34 to enhance the projecting effect which would otherwise be obtained essentially by frictional engagement of the liquid particles with the surface 16. In the embodiment shown in FIGS. 1–3, liquid supply conduit members are provided at both surfaces of at least some of the spray members 12, 12*a*, and these spray members have guide vanes projecting axially in opposite directions from their respective spray surfaces, with a corresponding shield member and splash shield surface extending parallel to each respective spray surface immediately and axially adjacent the vanes at each opposite surface of such spray members. The combination of the guide vanes 34 at only the outer portions of the spray member surfaces, together with the splash shield portions 41 which extend radially inwardly beyond the inner edges of the guide vanes 34, and the relative location of all of these parts radially outwardly beyond the limited area to which liquid is fed at a flat and uninterrupted portion of the spray member surface 16, has been found to provide more efficient projection of liquid for more effective cooling, as compared to the previously known devices having rotary spray surfaces. Thus, for example, a greater quantity of liquid can be projected over greater distances for greater cooling effects, with the same power input, or the device may be operated at a lower power input to achieve substantially the same projection and cooling effects of prior devices which do not incorporate the features of this invention.

Another embodiment of the invention is shown in FIGS. 4 and 5, in which the shield member which forms one element of the invention constitutes a stationary portion of the apparatus. In this case, the rotary spray member 12 is again provided with spray surfaces 16 and 17 to which liquid is fed from a supply line or trough 26 by conduits 29. Thus liquid is fed through discharge opening 21 in side wall 22 onto the desired limited area of surface 16 of the spray member. Vanes 34 are similarly provided only at the outer circumferential portions of this spray member, just as in the embodiment of FIGS. 1–3. In this case, however, the splash shield portion or member 47 is a stationary member which is specifically constructed as an upwardly projecting extension of the side wall 22 of the liquid feed conduit member. This stationary shield portion 47 has an inner peripheral edge 48 which is essentially concentric with the axis of rotation of the spray member, just as in the case of the inner edge 43 of the device of FIGS. 1–3. The radial location of this inner edge 48 is spaced inwardly from the inner edges 36 of the guide vanes 34 on the spray member, just as in the previous case. The outer edge 49 of shield portion 47 is generally circular and has a radial spacing from the axis of rotation which is essentially the same as or slightly greater than the radius of the periphery 18 of the spray member. In this case, it is not necessary for the shield portion 47 to extend circumferentially all around the shaft 13, since the member 47 is at a fixed location. Thus it has an upper edge or end 51 which is just far enough around the periphery 18 in the direction of rotation 33 to insure that it can perform its splash shielding function throughout that portion of the movement of spray surface 16 which is necessary to project substantially all of the liquid from the periphery 18.

As shown particularly in FIG. 5, the portion 47 has an inner splash shield surface 52 which is spaced axially a very slight distance from the vanes 34 and is as close as reasonably possible, subject to provision of the necessary clearance for rotation of the spray member 12 and its vanes 34. Thus the desired effective projection of particles with the aid of the limited guide vanes 34 located at only the outer peripheral portions of the spray surface 16 can again be achieved, while the liquid is essentially retained and carried by the combination of the spray surface 16 and the guide vanes 34 between

that spray surface **16** and the splash shield surface **52.**

Still another embodiment of the invention is shown in FIG. **6,** in which an identical rotary spray member **12** has at least one spray surface **16** which is essentially flat and uninterrupted throughout the central areas of member **12** at which liquid is to be fed through a discharge opening **21** in the side wall **22** of an open topped supply conduit **29** identical to that previously described. In this case, the spray member surface **16** has guide vanes **34** identical to those of the previous embodiments, with the exception that they extend at an acute angle outwardly and forwardly in the direction of rotation shown by arrow **33,** as viewed with respect to the actual radius **38** from the axis of rotation. In this embodiment of FIG. **6,** the desired splash shield surface is provided by the inner face of an individual shield member **53** secured to the projecting radial edge of each vane **34.** Each individual shield member **53** has its inner end **54** located radially inwardly from the inner end **36** of the vane member. Thus the liquid carried by the spray surface **16** passes within the space between spray surface **16** and the inner end **54** of shield members **53,** before the liquid is engaged by any portion of vanes **34,** just as in the previous embodiments. The outer ends **56** of the individual shield portions **53** are again located close to the periphery **18** of spray member **12.**

As further shown in FIG. **6,** these shield portions **53** have radially extending forward edges **57,** which in effect provide a liquid retaining lip extending radially along the vane parallel to the spray member surface and forwardly in the direction of rotation of the spray member. The operation of this modified construction of FIG. **6** will be essentially similar to that of the previously described embodimentss.

As one specific example of the embodiment shown in FIGS. **1** to **3,** a rotor disc was used which had a circular periphery with a radius of 9 inches from the axis of rotation of shaft **13.** Guide vanes **34** extended inwardly 2 inches from the periphery, thus leaving a flat, uninterrupted central area of 7-inch radius for selection of the limited area to which liquid is to be fed. Annular shield **41** extended inwardly 1 inch beyond the inner edges **36** of vanes **34,** i.e., approximately 3 inches in from the periphery **18.** Thus the radius of inner edge **43** was 6 inches. Such an embodiment was rotated at 450 revolutions per minute (r.p.m.), and liquid was fed to the two opposite surfaces of spray member **12** at a total volume rate in the range from 5 to 25 gallons per minute, half of which was fed to each of surfaces **16** and **17.**

As far as the flat inner or central area is concerned, flat spokes or other interrupted portions could conceivably be used for the innermost area around shaft **13.** However, at least the outer annular portion which passes by the liquid feeding sput, i.e., which includes the selected limited intermediate area to which liquid is fed to the spray member, as well as the remaining outer portion, should be essentially flat or smooth to receive the liquid and feed it smoothly to the guide vanes and to the outer periphery.

As noted, the periphery of each spray member is preferably circular and concentric with the axis of rotation, but other effective liquid-spraying configurations may be possible. The term "disc-like," as used herein, is not intended to require a strictly circular periphery.

Thus a versatile construction has been provided in which radial vane or guide members at only the outer peripheral portions of a rotary spray member surface can be combined with a variety of shield portions either of a stationary construction or which are designed to rotate as a unit with the rotary spray member, for use in a variety of applications, depending on the particular liquid projection and cooling effects which are desired. Variations in the details of construction and the shapes and dimensions of the various parts will be apparent to those skilled in the art, subject to the principles of the present invention as described herein. The present specification, however, sets forth some of the ways in which the invention may be put into practice, including the best mode presently contemplated for carrying it out.

I claim:

1. Liquid cooling apparatus for projection of liquid drops in trajectories, particle sizes, velocities and volume rates effective for improved cooling of the liquid, said apparatus comprising a plurality of parallel disc-like spray members spaced from each other along a common axis of rotation and having peripheries from which liquid is to be sprayed, said axis of rotation being generally horizontal and perpendicular to said spray members, means for feeding liquid to be cooled to at least one surface of each spray member at a limited area spaced inwardly from its periphery and from which the rotation of the spray member causes the liquid to move centrifugally outwardly along said surface and frictionally in the direction of rotation of the surface, said one surface of the spray member having a plurality of circumferentially-spaced liquid guide vanes projecting axially therefrom and extending generally radially at only the outer portions of said surface between the limited area at which liquid is fed to the surface and the periphery of the spray member for engaging the liquid after it has been fed to said limited area and started to move outwardly along said surface, and a shield member having a splash shield surface extending parallel to said one spray member surface immediately adjacent said vanes over an area extending outwardly from said limited area at which liquid is fed to the spray member surface to that portion of the spray member periphery at which the liquid is projected from the spray member.

2. Liquid cooling apparatus according to claim **1** in which the shield member is secured to the spray member for rotation of the spray member, vanes and shield member as a unit.

3. Liquid cooling apparatus according to claim **2** in which the shield member is a flat annular member having an inner circular edge coaxial with said axis of rotation and having a radial location spaced outwardly from the limited area to which the liquid is fed and inwardly from the innermost edges of said radial vanes.

4. Liquid cooling apparatus according to claim **2** in which each vane has its own individual shield member consisting of a liquid retaining lip extending radially along the vane parallel to the spray member surface and forwardly in the direction of rotation of the spray member.

5. Liquid cooling apparatus according to claim **1** in which the shield member constitutes a stationary portion of the apparatus.

6. Liquid cooling apparatus according to claim 5 in which the means for feeding liquid to the spray member surface includes a stationary conduit member projecting inwardly along the spray member from a location radially outside its periphery, and in which the shield member is carried by said conduit member.

7. Liquid cooling apparatus according to claim 1 in which the means for feeding liquid to the spray member surface includes a stationary conduit member projecting inwardly along the spray member from a location radially outside its periphery, said conduit member having a side wall parallel to the spray member surface, and said side wall having a discharge opening through which the liquid is projected axially onto the spray member surface, all portions of said conduit member, side wall and discharge opening being spaced axially from the spray member surface a distance providing clearance for said vanes for relative radial disassembly of at least the spray member and vanes from the conduit member.

8. Liquid cooling apparatus according to claim 7 in which the conduit member has axially spaced side walls and a bottom wall, thereby providing an open-topped trough projecting radially inwardly along the spray member surface, and said discharge opening being defined by a notch open at the top of the side wall and having a lower edge serving as the bottom of the discharge opening at a location adapted for overflow of liquid through said notch axially against the limited area of the spray member surface, said open-topped trough and notch facilitating removal of undesired foreign objects from the liquid reaching the conduit member.

9. Liquid cooling apparatus according to claim 1, having means for feeding liquid to both surfaces of at least some of the spray members, and such spray members having said guide vanes projecting axially in opposite directions from the respective spray member surfaces, with a corresponding shield member and splash shield surface extending parallel to each respective spray member surface immediately and axially adjacent said vanes at each opposite surface of such spray members.

10. Liquid cooling apparatus according to claim 1 in which the guide vanes extend along the spray member surface at an acute angle to an actual radius of the spray member.

11. Liquid cooling apparatus according to claim 10 in which the vanes extend at an acute angle outwardly and forwardly in the direction of rotation from such actual radius.

12. Liquid cooling apparatus according to claim 10 in which the vanes exttend at an acute angle outwardly and rearwardly from the direction of rotation from such actual radius.

* * * * *