COMMERCIAL AIR COOLED APPARATUSES INCORPORATING AXIAL FLOW FANS COMPRISING SUPER LOW NOISE FAN BLADES

BACKGROUND OF THE INVENTION

[0001] Large Super Low Noise commercial fans which are used in commercial air cooled apparatuses such as cooling towers, air cooled heat exchangers, including large radiator air coolers and air cooled steam condensers, have a diameter greater than four feet and have blades with forward swept concavely curved leading edges. The forward swept concave leading edges reduce the noise generated by such fan blades. A forward swept leading edge is a leading edge that in inclined at an angle in the direction of fan rotation. A typical fan 1 having blades 2 having a curved forward swept leading edge 3 is shown in FIG. 1. As can be seen the leading edges have a concave forward sweep 4. The forward swept concave leading edge fan blades provide for the quietest fans. Fans with such blades are referred commonly referred to as "Super Low Noise fans" or alternatively as "Ultra Low Noise fans". A description of such fan blades is provided in the article entitled "Blade Sweep of Low-Speed Axial Fans" by T. Wright and W. E. Simmons published in the January 1990 Journal of Turbomachinery, pages 151 to 158, and the paper entitled "Reduction of Noise Generation By Cooling Fans" by Ir. Henk F. Van der Spek, presented at the 1993 Cooling Tower Institute Annual meeting. These articles are fully incorporated herein by reference. These blades are typically fabricated from fiberglass with a polyester resin to allow easier molding into their complex shape. Moreover these blades are rigidly mounted to a fan hub. Consequently these Super Low Noise fans, which are currently the quietest available, are heavy and expensive to fabricate. Because of their weight, they are cumbersome to install, requiring cranes or heavy equipment, and unbalances can generate substantial loads on the supporting structure and bearings which can lead to structural failure and/or reduced fan bearing life.

SUMMARY OF THE INVENTION

[0002] According to an aspect of the present invention, there is provided an commercial air cooled apparatus and a large diameter axial flow fan combination comprising: said commercial air cooled apparatus generating an air flow for cooling; and said large diameter axial flow fan mounted on said air cooled apparatus for generating said air flow in said air cooled apparatus for said cooling, characterized in that: said fan has a diameter of at least

four feet (1.2 meters), said fan comprising a plurality of blades, wherein each of said blades comprises a leading edge opposite a trailing edge, wherein the entire of said leading edge of each of said blades is linear and forward swept, and wherein each blade comprises a metallic outer surface, a forward spar and a rear spar interconnected to the forward spar by a connecting spar, wherein said fan is a Super Low Noise fan. ~~In an exemplary embodiment large diameter axial flow fans and commercial air cooled apparatuses incorporating such fans are provided. In an exemplary embodiment, a large diameter axial flow fan is mounted on an air cooled apparatus for generating an axial air~~

~~flow in the air cooled apparatus for accomplishing the cooling. The fan has a diameter of at least four feet. The fan has plurality of blades. Each blade includes a leading edge opposite a trailing edge. The entire of the leading edge of each of the blades is linear and forward swept, and each blade includes a metallic outer surface. The fan is a Super Low Noise fan.~~

[0002a] In a further exemplary embodiment, the commercial air cooled apparatus is selected from the group of air cooled apparatuses consisting of air cooled heat exchangers, radiator coolers, air cooled steam condensers, and cooling towers. In one exemplary embodiment, each blade leading edge is forward swept at an angle of 25° as measured from a radius of rotation of the blade. In another exemplary embodiment, the each of the blades is made from sheet metal stressed skin. In a further exemplary embodiment, the sheet metal is aluminum. In yet another exemplary embodiment, the fan has a diameter of at least 9, 10, 11, 12, 13, or 14 feet. In yet a further exemplary embodiment, the fan has at least three blades and in another exemplary embodiment the fan has at least four blades. In a further exemplary embodiment, the fan includes a hub and the blades are resiliently mounted to the hub. In another exemplary embodiment, each blade is filled with foam. In yet another exemplary embodiment, the entire trailing edge of each blade is linear. In yet a further exemplary embodiment, each blade has a length of 42 inches. In another exemplary embodiment each blade has a length of 48 inches. In yet another exemplary embodiment, each blade has an average chord length of 48 inches. ~~In yet a further exemplary embodiment, t~~The fan generates a sound power level in dBA. Such power lever may be determined by the following equation:

$$\mathbf{PWL = C + 30^* \log_{10}(TS/1000) + 10^* \log_{10}(HP) + Add}$$

Where:

PWL = Fan Sound Power Level in dBA

C = Fan baseline noise level in dBA which is a function of blade design

TS = Fan tip speed in ft/minute which is equal to π * Fan RPM * Fan Diameter

HP = Fan Shaft Horsepower

Add = Additional noise due to entry and installation effects.

[0003] As disclosed, the value of~~In one exemplary embodiment~~ **C** for the fan is not greater than 45 dBA, in particular, the value of~~ In another exemplary embodiment~~ **C** for the fan is in the range of 43 to 45 dBA. It is also disclosed that the value of~~In yet another exemplary embodiment~~ **C** for the fan is ~~in~~ not greater than 43 dBA.

8. The combination of any of claims 1 to 4, wherein the fan has a diameter of at least 12 feet (3.65 meters).

9. The combination of any of claims 1 to 4, wherein the fan has a diameter of at least 13 feet (3.96 meters).

10. The combination of any of claims 1 to 4, wherein the fan has a diameter of at least 14 feet (4.26 meters).

11. The combination of any of claims 1 to 10, wherein the fan has at least 3 blades.

12. The combination of any of claims 1 to 10, wherein the fan has at least four blades.

13. The combination of any of the preceding claims, wherein the fan comprises a hub, and wherein the blades are resiliency mounted to the hub.

14. The combination of any of the preceding claims, wherein each blade is filled with foam.

15. The combination of any of the preceding claims, wherein the entire trailing edge of each blade is linear.

16. The combination of any of claims 1 to 15, wherein each blade has a length of about 42 inches (1.067 meters).

17. The combination of any of claims 1 to 15, wherein each blade has a length of about 48 inches (1.219 meters).

18. The combination of any of the preceding claims, wherein each blade has an average chord length of about 48 inches (1.219 meters).

~~19. The combination of claim 1, wherein the fan sound power level in dBA is determined as follows:~~

~~$PWL = C + 30 * \log_{10}(TS/1000) + 10 * \log_{10}(HP) + Add$~~

~~where:~~

~~PWL = Fan Sound Power Level in dBA~~

~~C = Fan baseline noise level in dBA which is a function of blade design~~

~~TS = Fan tip speed in ft/minute which is equal to π * Fan RPM * Fan Diameter~~

~~HP = Fan Shaft Horsepower~~

~~Add = Additional noise due to entry and installation effects~~

~~wherein C for the fan is not greater than 45 dBA.~~

~~20. The combination of claim 19, wherein C for the fan is in the range of 43 to 45 dBA.~~

~~21. The combination of claim 19, wherein C for the fan is in not greater than 43 dBA.~~

~~22~~19. The combination of any of the preceding claims, wherein each blade leading edge is forward swept at an angle of 25° as measured from a radius of rotation of such blade.

~~23~~20. The combination of any of claims 1 to 4, wherein the fan has a diameter of at least 5 feet (1.52 meters).

~~24~~21. The combination of any of the preceding claims, wherein the forward spar is forward swept.

~~25~~22. The combination of any of the preceding claims, wherein the metallic outer surface comprises a first surface portion extending between said spars opposite as a second surface portion extending between said spars, wherein the first surface portion is concave and the second surface portion is convex.

~~26~~23. The combination of any of the preceding claims, wherein the trailing edge is linear.