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(54) DUCTWORK IMPROVES EFFICIENCY OF COUNTERFLOW TWO PASS ACTIVE HEAT SINK

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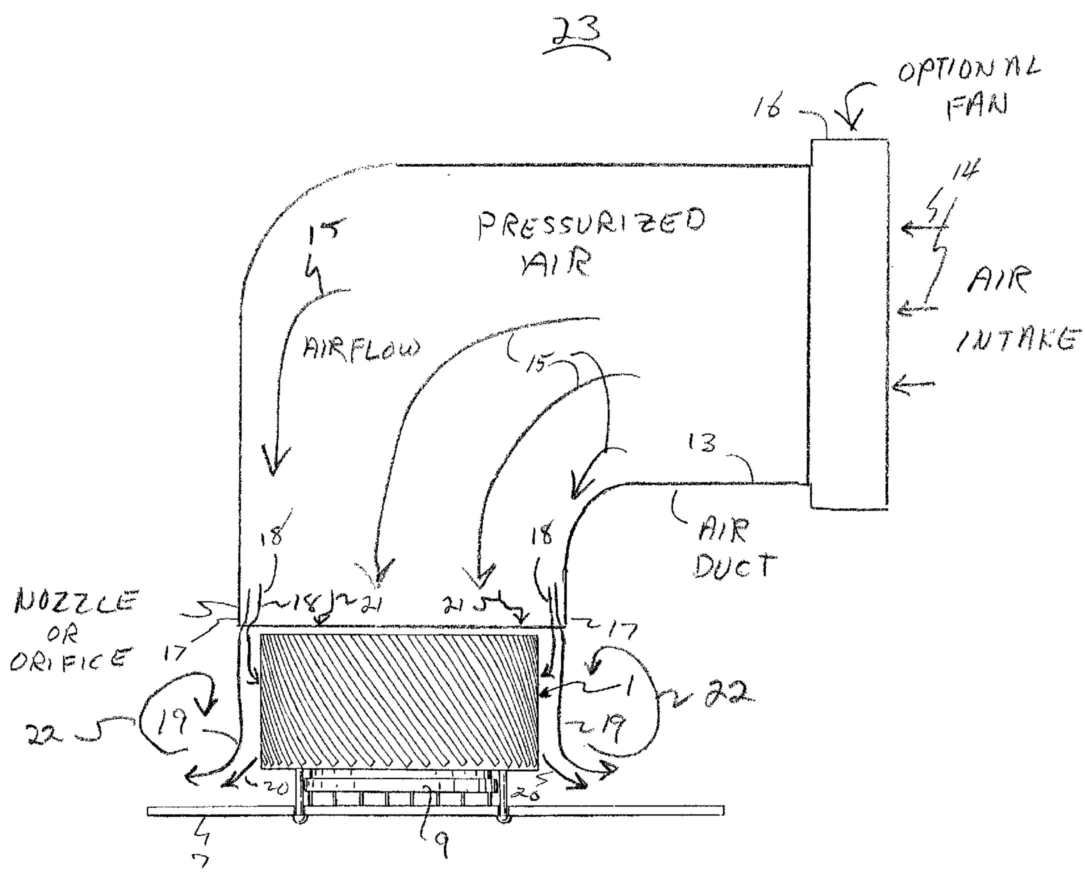
(57) ABSTRACT

The heat removal ability of a spiral finned counterflow two pass active heat sink ("Wagner" active heat sink) is increased by eliminating a slight recirculation of heated discharge air back into the cool intake air by conducting intake air to the Wagner active heat sink with a ductworks having an orifice proximate the intake end of the heat sink. The diameter of the orifice is larger than that of the Wagner active heat sink, and if the heat sink does not extend into the orifice, then a pusher fan may be located somewhere near the entrance of the duct to fill it with pressurized air that then exits from the orifice to form a curtain of cool air around the outside of the Wagner active heat sink. This curtain of cool air replaces the certain amount of heated discharge air that otherwise recirculates back into the input of the heat sink. If the ductwork can be extended toward the Wagner active heat sink, or the heat sink moved toward the orifice, such that heat sink penetrates the orifice and is partly inside the ductwork by an amount related to the geometry of the fan within the Wagner active heat sink, then the pusher fan can be eliminated in favor of the suction provided by the Wagner active heat sink itself.



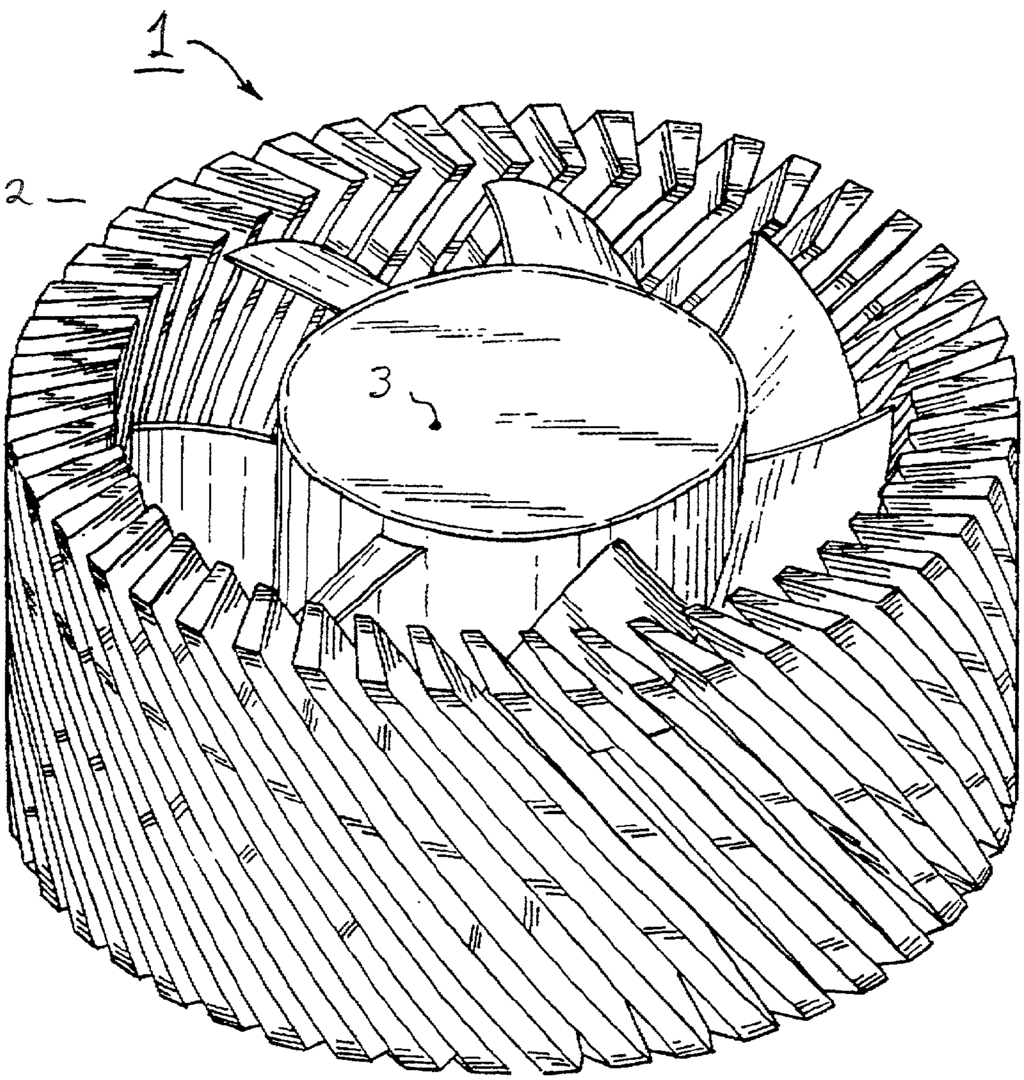


FIG. 1
(PRIOR ART)

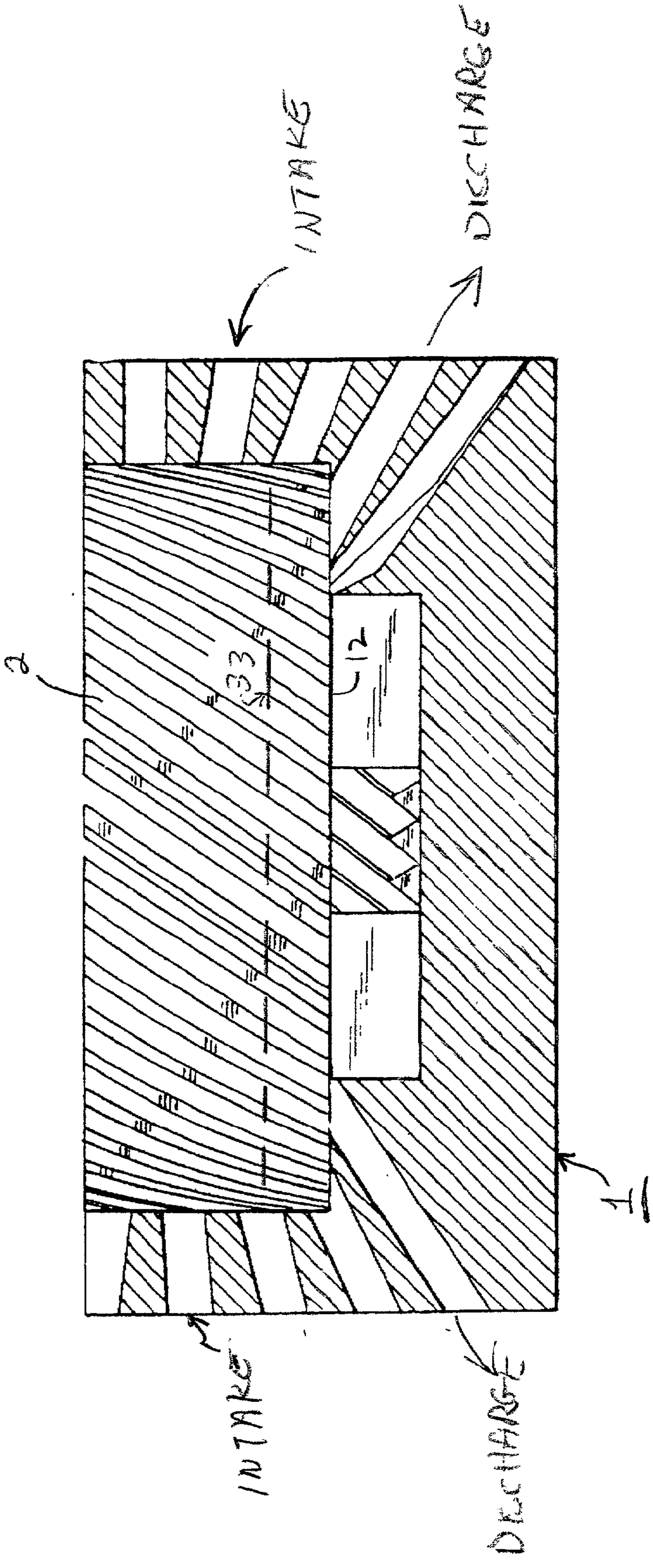


FIG. 2
(PRIOR ART)

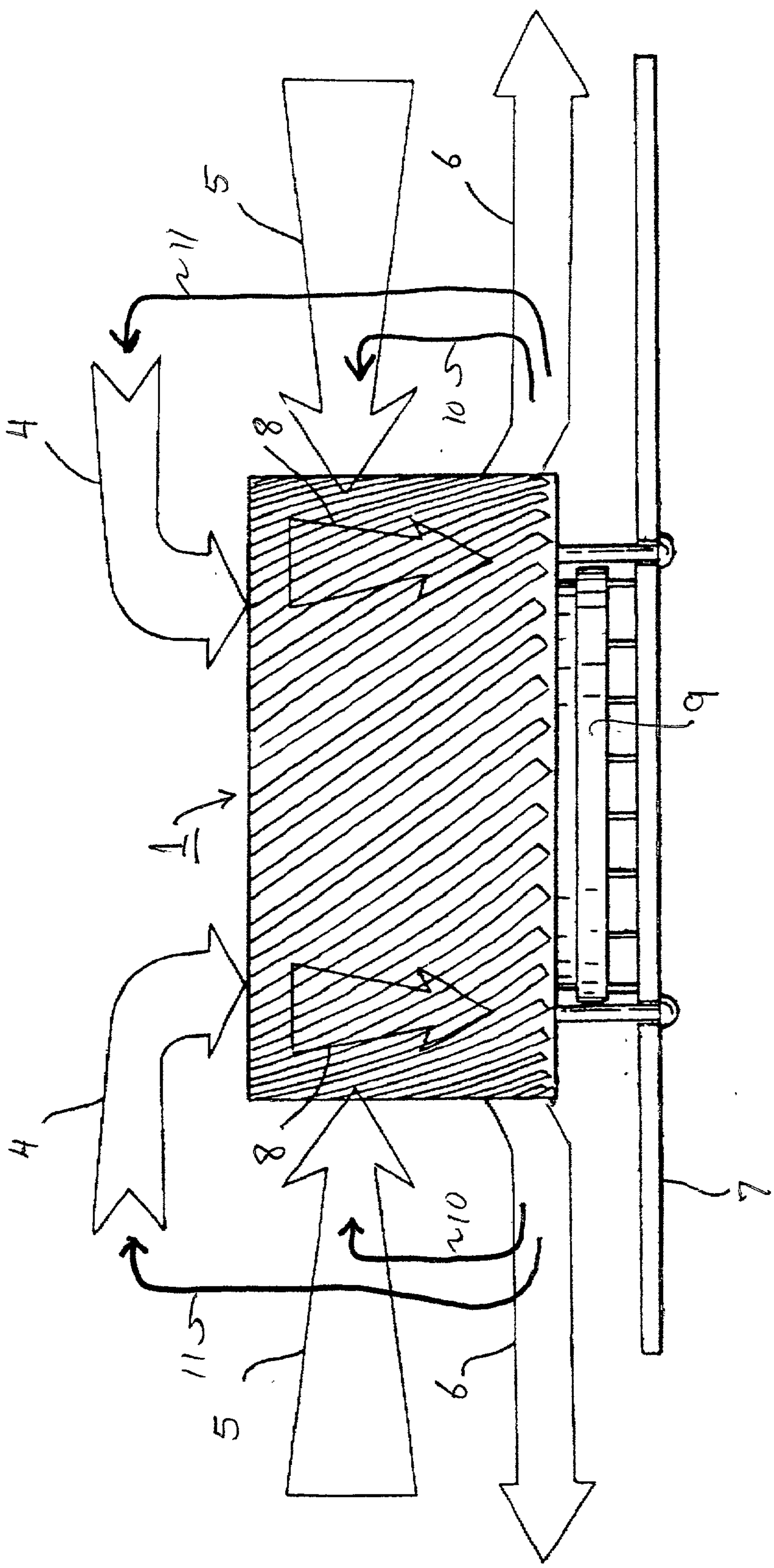


FIG. 3
(PRIOR ART)

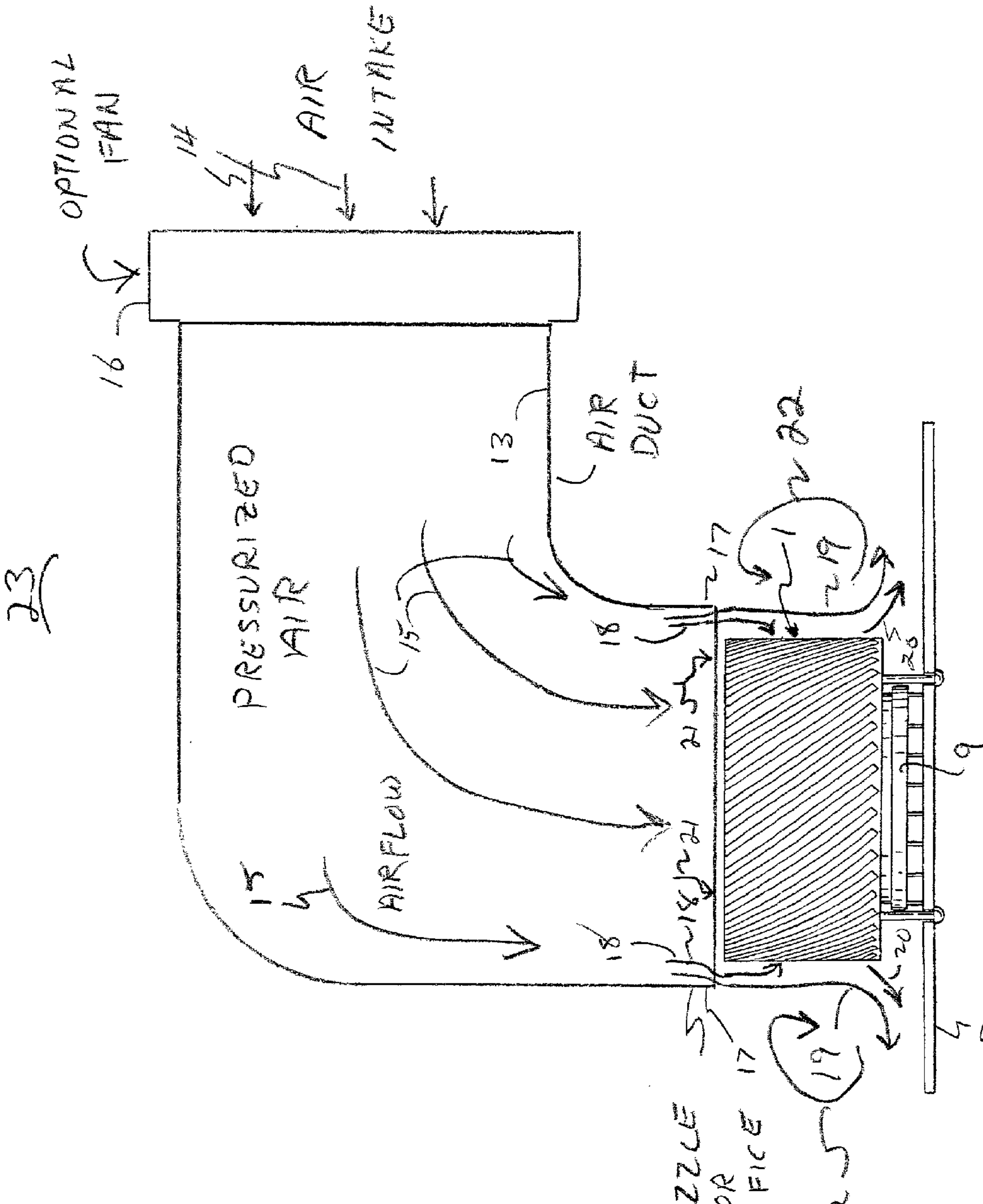

23
OPTIONAL FAN
14
AIR INTAKE
16
PRESSURIZED AIR
AIRFLOW
15
13
AIR DUCT
18
21
17
19
22
20
9
7
NOZZLE OR ORIFICE

FIGURE 4

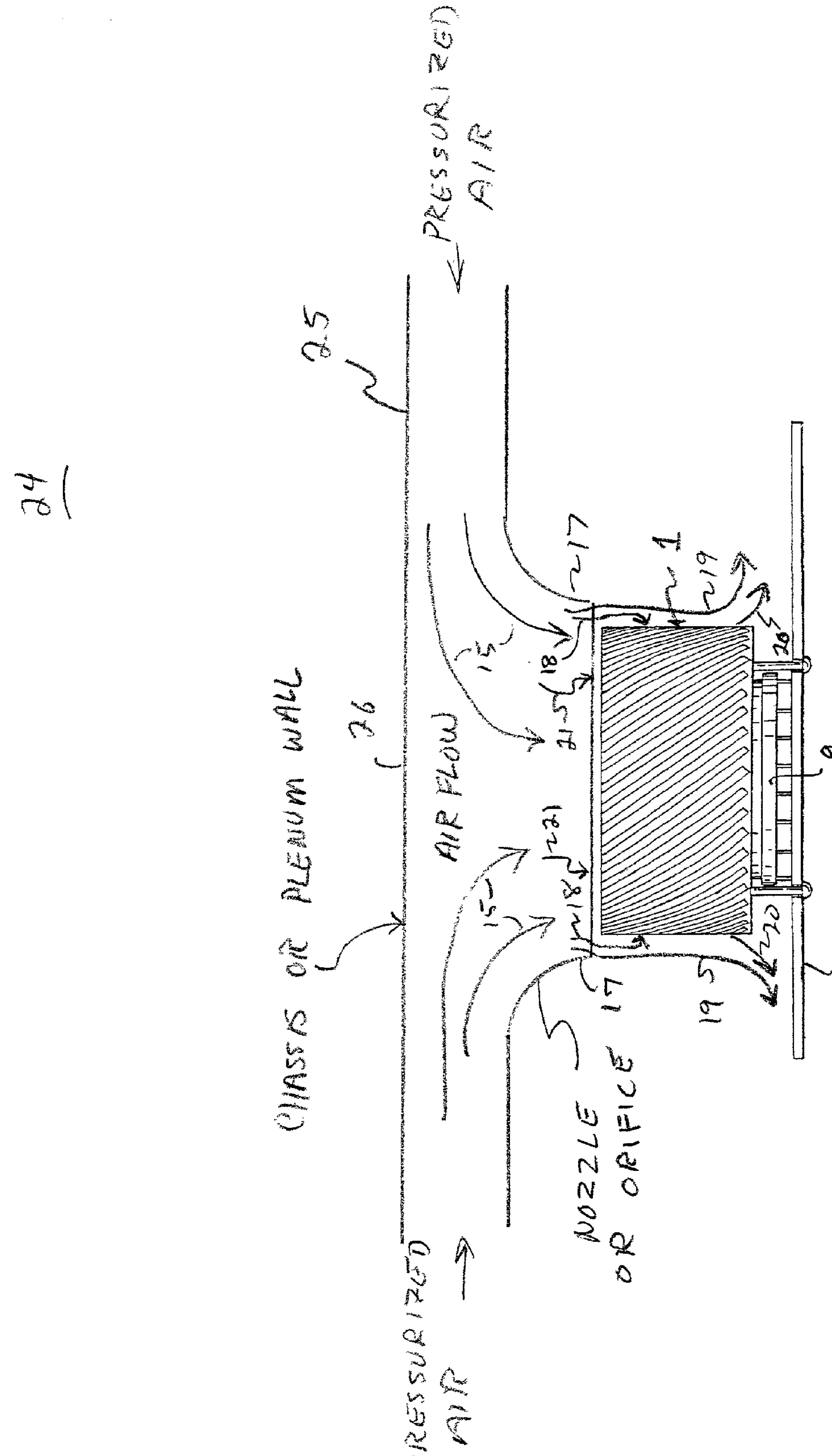

24
25
PRESSURIZED AIR
CHASSIS OR PLENUM WALL
26
AIR FLOW
NOZZLE OR ORIFICE
15
17
18
19
20
21
1
9
7
PRESSURIZED AIR

FIGURE 5

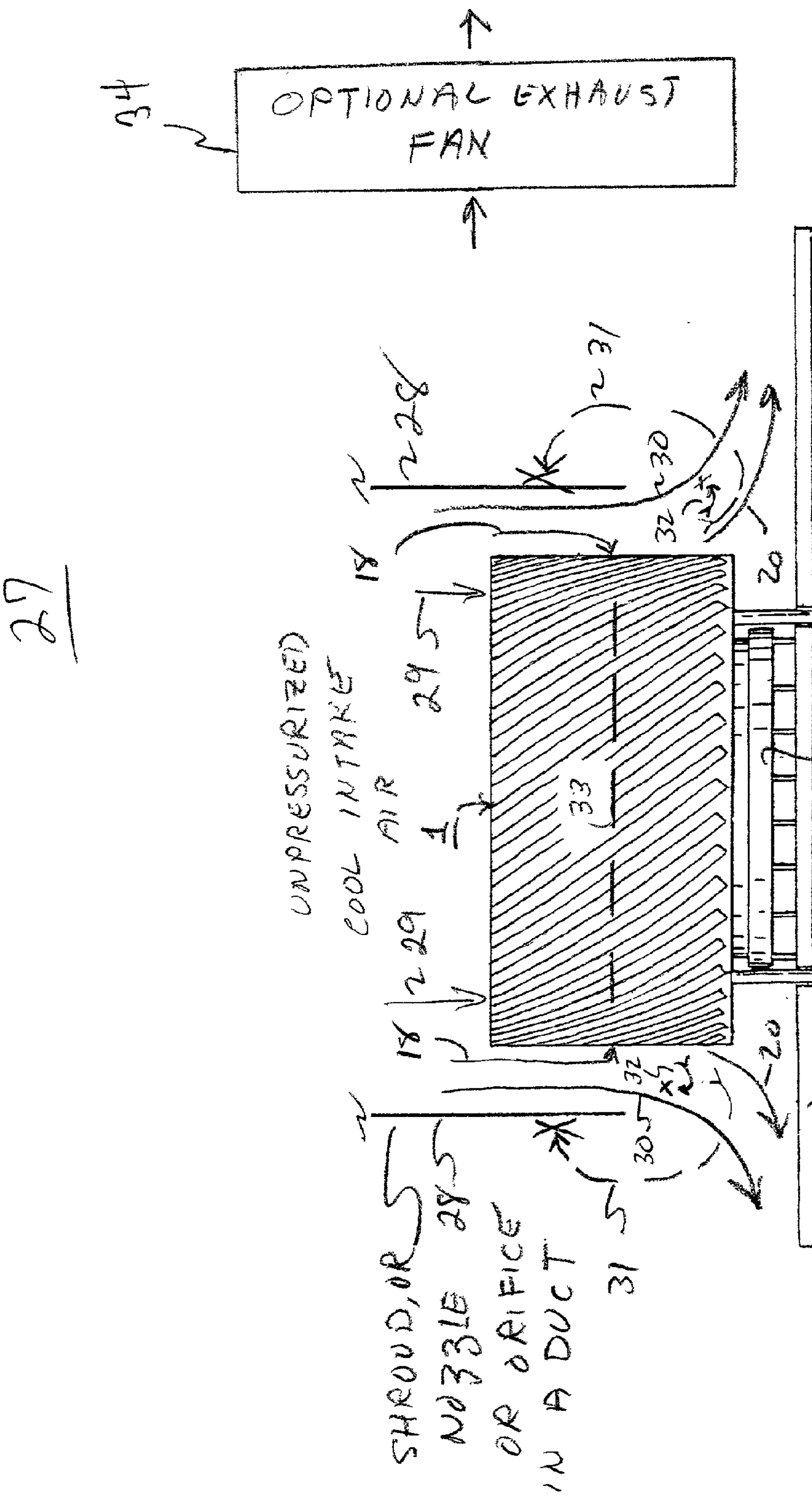

OPTIONAL EXHAUST FAN
34
27
UNPRESSURIZED COOL INTAKE AIR
SHROUD, OR NOZZLE OR ORIFICE IN A DUCT
28
29
18
1
33
30
31
32
20
9
7

FIGURE 6

DUCTWORK IMPROVES EFFICIENCY OF COUNTERFLOW TWO PASS ACTIVE HEAT SINK

REFERENCE TO RELATED APPLICATION

[0001] The subject matter of this Application is related to that disclosed in U.S. Pat. No. 5,785,116 entitled FAN ASSISTED HEAT SINK, filed by Wagner on Feb. 1, 1996 and issued on Jul. 28, 1998. That Patent describes a particular type of internal fan heat sink for microprocessors, large power VLSI devices and the like, that dissipate a sufficient amount of power to require a substantial heat sink. The instant invention pertains to a manner of using that same type of internal fan heat sink, which heat sink has a number of unique properties that do not readily lend themselves to summary description: it is not a garden variety heat sink with a fan grafted onto it. For this reason U.S. Pat. No. 5,785,116 is hereby expressly incorporated herein by reference, so that all the unique properties of that active heat sink, including its manner of operation and manufacture, will be fully available for the understanding of this Disclosure.

BACKGROUND OF THE INVENTION

[0002] Integrated circuits are becoming more and more powerful all the time. Not only is this true in the sense that they do more, and do it faster (e.g., in the field of microprocessors and FPGA's—Field Programable Gate Arrays), but these newer parts dissipate amounts of power that were unimaginable just a few years ago. For example, there are parts under development that will dissipate one hundred and thirty watts and will need to get rid of the attendant heat through a surface area of about one square inch. There are exotic methods of heat removal that are possible, including heat pipes, chilled water cooling and even actual refrigeration. In the main, these techniques are cumbersome or expensive, and are not suitable for high volume commercial applications in modestly priced retail equipment, such as personal computers and workstations.

[0003] The active (meaning fan assisted) heat sink described in above incorporated Patent to Wagner was developed to deal with this situation. It is a heat sink having a spiral of fins that surround a fan around its circumferential periphery and are in its discharge path. This makes Wagner's active heat sink a two pass device, since the design draws a portion of its air in through the periphery (one pass) and then discharges it through more fins (second pass). It is a counter flow device, since the path of heat flow is generally opposite to the direction of air flow, so that as air is heated through contact with the fins it encounters still warmer fins as it continues along its path. This ensures greater heat transfer by maintaining temperature differential between the cooling air and the fins that are to give up their heat to the air. In addition, Wagner's active heat sink has a number of other desirable properties, such as low noise and an absence of extra mating surfaces that interfere with heat flow.

[0004] The preceding several sentences are a brief description of Wagner's active heat sink, but it is probable that, unless the reader has actually seen one, he or she will not have a completely satisfactory mental image of just what such a fine active heat sink really looks like. We can cure that by including certain of the figures from the Wagner Patent, which we have done. However, that still leaves us with the problem of a nice tidy way to refer to it: "spiral finned counterflow two pass active heat sink" is accurate as far as it goes, but is also pretty cumbersome. Various heat sinks of this design are on the market, offered by Agilent Technologies, Inc. under the trade name "ArctiCooler", but it would be a risky business to rely on that, since we can't be sure what that term will eventually come to encompass. So, we will do as we have already begun to do above: we shall call the kind of fan-assisted heat sink described in the Specification of the Wagner Patent a "Wagner active heat sink", or depending upon the grammatical needs at the time, "Wagner's active heat sink". By availing ourselves of this coined phrase, we shall avoid much inconvenience. On the principle that whatever makes for shorter sentences is good, when it is entirely clear that we are indeed referring to a Wagner active heat sink, we shall fell free to call it a "heat sink" as a further simplification.

[0005] It will, of course, be appreciated that as the Wagner active heat sink gains further acceptance and additional needs and applications develop, the exact size, relative shape and so forth will evolve over time. Thus, there are already small ones, medium and large sizes, and extra heavy duty ones, etc. Thus, it will be understood that the specific examples shown in U.S. Pat. No. 5,785,116 (Wagner) are merely illustrative of a general class of active heat sinks (Wagner active heat sinks), and such specific details as the number of fins, whether they are straight or spiral, their thickness compared to their height, the number of blades on the fan, whether the thing is tall or squat, etc., are not determined by our meaning of the term "Wagner active heat sink".

[0006] To continue, then, as good as the Wagner active heat sink is, it is still the case that anything that can be done to enhance efficiency is desirable, since the wattages to be dissipated are increasing to such a large degree. One way to get an active heat sink that handles more heat is to make it bigger, but it would be better if there were a way to get an existing one to handle more heat without making it bigger. What to do?

SUMMARY OF THE INVENTION

[0007] A solution to the problem of increasing the heat removal ability of a Wagner active heat sink is to eliminate a slight recirculation of heated discharge air back into the cool intake air. This is accomplished by conducting intake air to the Wagner active heat sink with a ductworks having an orifice proximate the intake end of the heat sink. The diameter of the orifice is larger than that of the Wagner active heat sink, and if the heat sink does not extend into the orifice, then a pusher fan may be located somewhere near the entrance of the duct to fill it with pressurized air that then exits from the orifice to form a curtain of cool air around the outside of the Wagner active heat sink. This curtain of cool air replaces the certain amount of heated discharge air that otherwise recirculates back into the input of the heat sink. If the ductwork can be extended toward the Wagner active heat sink, or the heat sink moved toward the orifice, such that heat sink penetrates the orifice and is partly inside the ductwork by an amount related to the geometry of the fan within the Wagner active heat sink, then the pusher fan can be eliminated in favor of the suction provided by the Wagner active heat sink itself.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] **FIG. 1** is a top perspective view of a (prior art) Wagner active heat sink;

[0009] **FIG. 2** is a sectional view of the spiral finned portion of the heat sink of **FIG. 1**, with the fan removed for clarity;

[0010] **FIG. 3** is a side view of an installed Wagner active heat sink, showing the directions of airflow, and including the undesirable recirculation of heated discharge air into the intake;

[0011] **FIG. 4** is a simplified side view of the Wagner active heat sink of **FIG. 1** deployed in conjunction with a first pressurized ductwork that dispels the recirculation of **FIG. 3** with a curtain of cool air;

[0012] **FIG. 5** is a simplified side view of the Wagner active heat sink of **FIG. 1** deployed in conjunction with a second pressurized ductwork that dispels the recirculation of **FIG. 3** with a curtain of cool air; and

[0013] **FIG. 6** is a simplified side view of the Wagner active heat sink of **FIG. 1** deployed in conjunction with a shroud or an unpressurized ductwork that serves as a baffle to prevent the recirculation of **FIG. 3** while at the same time supplying by suction from the heat sink itself cool air to the input of the heat sink.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0014] Refer now to **FIG. 1**, wherein is shown a top perspective view of a prior art Wagner active heat sink **1**. There is an annular ring **2** of spiral cooling fins, preferable of aluminum, within the center of which is mounted a fan **3**. Not shown is the IC (Integrated Circuit) or other device that is to be cooled. It would be in contact with the underside of the heat sink, directly beneath the hub of the fan.

[0015] Now refer briefly to **FIG. 2**, which is a sectional view of the spiral finned portion of the heat sink of **FIG. 1**, with the fan **3** removed for clarity. Note the shelf **12**, which is somewhat below the bottom of the fan blades are. Somewhat above this shelf (at about one fourth of the way up the height of the fan blades) is a boundary (**33**) that separates where intake air is drawn into the heat sink and exhaust air is discharged.

[0016] The airflow situation for a Wagner active heat sink is shown in more detail in **FIG. 3**. In that figure a heat sink **1** and device **9** to be cooled are mated together, and the combination is mounted upon or carried by, for example, a printed circuit board **7**. Arrows **4** indicate intake air that enters the top of the heat sink **1**. Arrows **5** indicate additional intake air that enters the upper sides of the heat sink **1**. Arrows **8** indicate the paths the intake air from arrows **4** and **5** follow once inside the heat sink **1**. Arrows **6** indicate the path of heated air that is discharged from the heat sink. Now for the bad news. Some amount of heated discharge air can flow along paths indicated by arrows **10** and **11** to join the intake air. This is termed "recirculation", and is undesirable because it raises the temperature of the intake air entering the heat sink, and diminishes its efficiency. In general, the amount of recirculation is determined by the degree of obstruction in the path of the discharged air. In an ideal case the amount of recirculation is slight, and the efficiency reduction might be only 5% or 10%. If the discharge path is quite cluttered with large obstructions (e.g., other heat sinks, etc.) then the efficiency reduction might be as large as 50%. When the amount of power being dissipated is large, then even a small fraction of that can be significant amount of power.

[0017] Refer now to **FIG. 4**, wherein is shown a simplified side view **23** of a Wagner active heat sink **1** deployed in conjunction with a pressurized ductwork **13** that dispels the recirculation of **FIG. 3** with a curtain of cool air **19**. In particular, an air duct **13** has a nozzle or orifice **17** that is slightly larger in diameter than the heat sink **1**, and which is disposed just above to top of the heat sink. The ductwork **13**, which may be of any suitable material (e.g., stamped, rolled or folded sheet metal, extruded plastic, etc.), is pressurized with air having a positive pressure relative to the discharge **20** from the heat sink **1**. One way to accomplish this is with a fan **16** located at a distal end of the duct **13**, and which draws in cool air **14** and creates the pressure inside the duct. Ducted air flows generally along the paths indicated by arrows **15** until it reaches the heat sink. Some of that air enters the top of the heat sink **1** as indicated by arrows **21**, some of it flows out of the nozzle **17** to travel along the top outer surface of the heat sink to be drawn in as intake air, as indicated by arrows **18**. Another portion of the ducted airflow **15** continues to travel downward along the outer surface of the heat sink **1**, following a path indicated by arrows **19**. This latter airflow along the path of arrows **19** is a curtain of cool air that blocks the detrimental recirculation of arrows **10** and **11** of **FIG. 3**. There may be some airflow in the direction of arrows **22**, but it does not penetrate the curtain **19** and is not drawn back into the heat sink.

[0018] The thickness of the air curtain **19** is essentially governed by the degree by which the nozzle **17** has larger diameter than the active heat sink **1**. A preferred range of thickness for the air curtain **19** is from about one quarter to one half an inch. In the figure the periphery of the nozzle **17** is shown as being slightly above the top of the heat sink **1**. It is shown this way for clarity. The preferred arrangement is that they be about even with each other.

[0019] **FIG. 5** shows a situation whose arrangement **24** is generally similar to that of **FIG. 4**, except that the shape of the duct **25** is different. It may be a plenum chamber, a back side of which may be an element of the chassis of the apparatus (e.g., a computer) whose IC **9** needs cooling. In the case shown, pressurized cool air arrives at the nozzle or orifice from two directions (a typical case would be that the plenum is as long and as wide as one side of the instrument chassis, so the air would enter radially from all directions). We have omitted the depiction of any auxiliary fans (e.g., **16** in **FIG. 4**) that would produce this pressurized air. Also, the figure suggests that airflow within the plenum is in both directions toward the heat sink. Suppose there were an extended plenum and more than one heat sink. Then airflow could be in one direction along the plenum, which air is then supplied to the different heat sinks in turn.

[0020] Now consider a slightly different case, where it is undesirable or otherwise impractical to provide a source of air that is at positive pressure with respect to the discharge of a Wagner active heat sink, yet it is still desirable to reduce or eliminate recirculation. An arrangement **27** for dealing with that situation is depicted in **FIG. 6**. A nozzle or orifice of a duct (similar to **25** or **13**, but not shown) or perhaps just shroud extending into a region of cool air suitable for use as intake air, any of which possibilities are indicated in the figure by reference character **28**, has a diameter larger than that of the heat sink, and encloses an upper portion of the heat sink **1** that is generally above location **33**. Recall that is at about this height that intake air is separated from discharge air. What happens is this. Airflow **29** is drawn into the top of the heat sink **1**, as one would expect. Arrows **18** indicate the extent of airflow that is drawn into the side of the heat sink **1**, which ends at location **33**. The proximity of flow along paths **18**, in conjunction with a low pressure region (according to Bernoulli's principle) created by discharge flow along arrows **20**, draws a curtain **30** of cooling air down along the outside of the heat sink. Arrows **31** and **32** indicate the paths recirculation would need to take if they were to occur. Arrows **32** indicate paths that air might take to re-enter the heat sink **1** above the level of line **33**. Such air is instead swept along by the curtain **30**. Even if some of that air **(32)** mixes with curtain **30** and then tries to re-enter above line **33** along path **31**, it is blocked by the shroud or nozzle **28**.

[**0021**] There is yet another way in which airflow for the cases of **FIGS. 4, 5** and **6** can be induced (with or without the fan **16** of **FIG. 4**). This other way is to locate an exhaust fan **34** within the chassis. (We show this in conjunction with **FIG. 6**, but it will be appreciated that it applies to **FIGS. 4 and 5**, as well.) If the air pressure at the top of the heat sink **1** is essentially at the same pressure as the exterior of the chassis, (especially possible if the ductwork that is there is for that purpose), then the exhaust fan creates a pressure differential that produces the air curtain **19**.

I claim:

1. In an active heat sink having fins surrounding a fan that draws intake air into an end of the fan as well as through intake portions of the fins surrounding the fan, and which discharges air through adjacent discharge portions of the fins, a method of preventing discharged air from recirculating as intake air, the method comprising the steps of:

ducting air to be used as intake air to a nozzle proximate the end of the fan;

pressurizing the ducted air above the pressure of the discharged air; and

directing a curtain of pressurized air from the nozzle over both the intake and the discharge portions of the fins.

2. In an active heat sink having fins surrounding a fan that draws intake air into an end of the fan as well as through intake portions of the fins surrounding the fan, and which discharges air through adjacent discharge portions of the fins, a method of preventing discharged air from recirculating as intake air, the method comprising the steps of:

ducting air to be used as intake air to a nozzle having an interior surface that surrounds the intake portions of the fins and that has a periphery proximate a boundary separating the intake portions of the fins from the discharge portions of the fins; and

inducing, with Bernoulli's principle and the reduced pressure of the discharged air, a curtain of air from the nozzle to flow over the discharge portions of the fins.

* * * * *