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(54) **Air movement apparatus.**

(57) The invention relates to cooling fans which are disclosed in the context of fan assisted heat exchanger systems such as for use in vehicles. Shrouding is provided to match the active area of a rectangular radiator with an area swept by a cooling fan and in the preferred embodiments utilises two small diameter side-by-side fans in order to effect a better match between the cross-sectional area of the radiator and the area swept by the fans. Preferably,the fans are rotated in a synchronised manner in counter-rotation and the means for providing this drive may comprise gearing connected with a prime mover or a pulley and drive belt system. In the latter case, the drive belt is preferably a toothed belt and may be provided with teeth on both sides to secure the desired counter-rotation of the two fans.

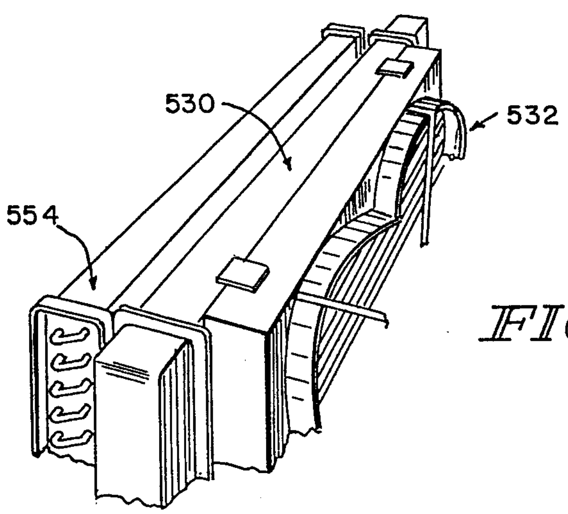

FIG. 11

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Description

AIR MOVEMENT APPARATUS

Background of the Invention

This invention relates to cooling fans. The invention is disclosed in the context of cooling fan-assisted heat exchanger systems, such as vehicle engine coolant and lubricant cooling systems and vehicle air conditioner systems. However, it is believed to be useful in other types of cooling fan systems, such as box-type window fans, etc.

Recent trends in automobile styling have resulted in cars with lower hood lines. The height of the cooling system radiator has therefore been reduced, necessitating an increase in the width of the radiator to maintain the same surface area. Axial flow cooling fans used with automobile radiators sweep round areas of the radiators. This results in a significant mismatch in the active area of the rectangular radiator and the area swept by a single cooling fan. To improve the efficiency of the fan in drawing air across as great an area as possible of the rectangular radiator at low vehicle speeds, funnel-like shrouds have been employed. Such shrouds typically have rectangular openings at the forward end matched generally to the rearward facing area of the radiator, and round openings at their rear ends matched to the area swept by the fan blades. One disadvantage of this arrangement is that the presence of the shroud inhibits cooling efficiency at highway speeds by impeding the free flow of air through the radiator.

One approach that has been utilized to alleviate the above-mentioned problems has been to employ two smaller diameter side by side fans rather than a single fan, thereby effecting a better match between the cross sectional area of the rectangular radiator and the areas swept by the cooling fans. An example which is not intended as an exhaustive analysis of the prior art is U.S. Patent 3,601,100. Also of interest, but not intended as exhaustive, is U.S. Patent 4,186,693. However, dual side by side fans can cause undesirable effects, such as increased noise. A particular type of noise associated with such fans occurs when the fans rotate at similar, but not precisely the same, speeds. This type of noise occurs at a beat frequency which is the difference between the speeds of rotation of the two fans multiplied by the number of blades on each fan. Also, dual fans with non-intersecting swept areas, while an improvement over single fans, are not optimally arranged for the best possible area match between fan and radiator.

Summary of the Invention

According to one aspect of the invention, an air movement mechanism comprises a first axial flow fan, a second axial flow fan, a prime mover, means for coupling the first and second fans to the prime mover for rotation about their respective axes of rotation, a shroud having first and second generally circular cross section openings, and means for mounting the first fan in the first generally circular cross section opening and the second fan in the second generally circular cross-section opening. Rotation of the first and second fans about their respective axes by actuation of the prime mover causes the first and second fans to sweep respective first and second areas corresponding generally to the first and second generally circular cross section openings, respectively.

According to another aspect of the invention, an air movement mechanism comprises an axial flow fan, a prime mover, means for coupling the prime mover to the fan, a shroud having a generally circular cross section opening, and means for mounting the fan in the generally circular cross-section opening. Rotation of the fan by actuation of the prime mover causes the fan to sweep an area corresponding generally to the generally circular cross-section opening. Rotation of the fan by the prime mover deflects air through the generally circular cross-section opening in a first direction around the axis of rotation of the fan. The air movement mechanism further comprises one or more vanes oriented and configured to deflect air flowing through the generally circular cross section opening in a second direction opposite the first direction around the axis of rotation of the fan.

According to yet another aspect of the invention, an air movement mechanism for moving air through a heat exchanger comprises a first axial flow fan, a second axial flow fan, means for mounting the first fan so that rotation of the first fan causes it to sweep a first generally circular area, means for mounting the second fan so that rotation of the second fan causes it to sweep a second generally circular area, first means for rotating the first fan, means for coupling the first fan to the first rotating means, second means for rotating the second fan, and means for coupling the second fan to the second rotating means. The heat exchanger includes an active surface through which air moves to effect heat exchange. The means for mounting the first and second fans mounts them so that they sweep first and second overlapping, generally circular areas of the active surface.

According to illustrative embodiments of the present invention, a cooling fan-assisted heat exchanger or radiator is provided wherein there is an improved match between the area swept by multiple cooling fans and the area of the radiator through which cooling air flows.

Additionally, according to embodiments of the present invention, a cooling fan-assisted heat exchanger or radiator is provided with multiple cooling fans synchronized to reduce noise.

Further according to illustrative embodiments of the present invention, a cooling fan-assisted heat exchanger or radiator is provided with multiple counter-rotating synchronized cooling fans.

Brief Description of the Drawings

The invention may best be understood by referring to the following description and accompanying drawings which illustrate the invention. In the drawings:

Fig. 1 illustrates a rear elevational view of part of an engine cooling system radiator with multiple overlapping synchronized fans in accordance with the present invention;

Fig. 2 illustrates a fragmentary top plan view of the part of an engine cooling system of Fig. 1;

Fig. 3 illustrates a sectional view of a detail of Fig. 2, taken along section lines 3 - 3 thereof;

Fig. 4 illustrates a rear elevational view of an engine cooling system radiator with multiple overlapping synchronous fans in accordance with the present invention;

Fig. 5 illustrates a rear elevational view of part of another engine cooling system made in accordance with the present invention;

Fig. 6 illustrates a rear elevational view of part of another engine cooling system made in accordance with the present invention;

Fig. 7 illustrates a rear elevational view of part of another engine cooling system made in accordance with the present invention;

Fig. 8 schematically illustrates a top plan view of part of another embodiment of an engine cooling system made in accordance with the present invention;

Fig. 9 illustrates a schematic rear elevational view of part of another engine cooling system made in accordance with the present invention;

Fig. 10 illustrates a rear elevational view of part of another engine cooling system made in accordance with the present invention;

Fig. 11 fragmentarily illustrates a perspective view of the top and part of one end of a vehicle air conditioner condenser, a radiator and a full box shroud according to an embodiment of the invention;

Fig. 12 illustrates a rear elevational view of part of another engine cooling system made in accordance with the present invention;

Fig. 13 illustrates a rear elevational view of part of another engine cooling system made in accordance with the present invention;

Fig. 14 illustrates a rear elevational view of part of another engine cooling system made in accordance with the present invention;

Fig. 15 illustrates a sectional view, taken generally along section lines 15-15 of Fig. 14;

Fig. 16 illustrates a sectional view, taken generally along section lines 16-16 of Fig. 14;

Fig. 17 illustrates a rear elevational view of part of another engine cooling system made in accordance with the present invention;

Figs. 18 a-m illustrate rear elevational views of parts of engine cooling systems made in accordance with a number of different embodiments of the present invention;

Figs. 19a-b illustrate top plan views of parts of two engine cooling systems made in accordance with two embodiments of the present invention;

Figs. 20a-b illustrate top plan views of parts of two engine cooling systems made in accordance with two embodiments of the present invention;

Fig. 21 illustrates a transverse sectional view of part of an engine cooling system made in accordance with another embodiment of the present invention; and

Figs. 22a-b illustrate rear elevational views of parts of two engine cooling systems made in accordance with two embodiments of the present invention.

Description of the Preferred Embodiments

For the purposes of promoting an understanding of the present invention, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It is nevertheless to be understood that no limitation of the scope of the invention is thereby intended, the proper scope of the invention being indicated by the claims appended below and the equivalents thereof.

Referring in particular to Figs. 1 and 2, a vehicle cooling system radiator 11 is configured for use in association with a liquid-cooled internal combustion engine. Radiator 11 is of greater width than height.

Axial flow fans 12 and 13 are mounted behind radiator 11 in spaced relationship thereto. Fan 12 includes three radially extending blades 14, 15 and 16 extending from a hub 20 which is mounted on a drive shaft 21. Drive shaft 21 is the output shaft of an electric drive motor 22. A pulley 23 is mounted on drive shaft 21 in driven engagement therewith. Fan 13 includes three radially extending blades 24, 25 and 26 extending from a fan hub 29 mounted on a shaft 30 in driven engagement therewith. Shaft 30 is rotatably supported in a bearing assembly 31. A pulley 32 is mounted on shaft 30 in driven engagement therewith. Drive motor 22 and bearing assembly 31 are maintained in fixed spaced relationship with respect to each other by a support member 33 to which each is fixed.

As is readily apparent from Fig. 1, fans 12 and 13 are spaced with respect to each other and are generally coplanar, such that the circular areas swept by fans 12 and 13 overlap. In order that fans 12 and 13 be able to rotate without colliding they are counter-rotating and synchronized. In the embodiment illustrated in Fig. 1, the means by which counter-rotation and synchronization is achieved includes pulleys 23 and 32 and drive belt 36. Drive belt 36 is trained around pulleys 23 and 32 and twisted as it passes from one pulley to the other. Consequently, fans 12 and 13 are driven in opposite directions by movement of belt 36. Belt 36 and pulleys 23 and 32 are toothed (as shown in Fig. 3) to avoid slippage of belt 36 with respect to pulleys 23 and 32, so that the illustrated timing between fan 12 and fan 13 will remain constant.

Fans 12 and 13 and their associated drive elements can be mounted with respect to radiator 11 by any suitable mounting means. The particular mounting means illustrated in Fig. 1 includes mounting members 37-42 which serve to maintain axial clearance space between fans 12 and 13 and radiator 11, and to maintain the axes of rotation of the fans fixed with respect to the area of the radiator 11 through which air flows for heat transfer purposes.

The efficiency of radiator 10 with its associated cooling fans 12, 13 is enhanced by ring shrouds 46 and 47. Each ring shroud 46 and 47 is an arc of a circle slightly greater in diameter than the diameter of the circular area swept by fans 12 and 13, respectively. Ring shroud 46 is mounted concentrically with fan 12 and ring shroud 47 is mounted concentrically with fan 13. As illustrated, the ring shrouds are not complete rings, but rather are arcs. Each ring shroud 46, 47 terminates at the points 48 and 49 of intersection of the two ring shrouds. The ring shrouds 46 and 47 enhance the efficiency of the fans by reducing the amount of air that slips around the tips of the fan blades.

The efficiency of radiator 10 is further enhanced by radial pre-rotating vanes 50 which are fixed within ring shrouds 46 and 47 between fans 12 and 13 and radiator 11. Pre-rotating vanes 50 are oriented such that air drawn through radiator 11 deflected, or "pre-rotated" in the direction opposite the direction of rotation of the fan. Since fans 12 and 13 are counter-rotating, pre-rotating vanes 50 within ring shrouds 46 and 47 are correspondingly oriented to deflect air flowing into ring shrouds 46 and 47 in opposite directions.

To reduce the likelihood of belt 36 rubbing against itself where it crosses itself, means, such as a PTFE pad or plate or an idler wheel (not shown), supported by the support means 33 which supports the motor 22 and fans 12, 13, is interposed between the crossing runs of the belt 36. This tends to increase belt 36 life and reduce the likelihood of noise which might otherwise result from the belt 36 rubbing against itself.

The engine cooling radiator 110 of Fig. 4 is similar to the embodiment of Figs. 1-3, including fans 112 and 113, and a twisted belt 136. This embodiment utilizes two blade fans rather than three blade fans. Fan 112 includes blades 114 and 115, and fan 113 includes blades 124 and 125. This embodiment does not include pre-rotating vanes or ring shrouds.

The embodiment of Fig. 4 has an advantage when installed in automobiles employing transversely mounted "V" engines. In such automobiles, the front exhaust manifold is usually very close to the top of the radiator. There is plenty of room available for the electric fan drive motor below the exhaust manifold once the fan assembly is installed, but installation into the automobile from above is difficult because of the lack of clearance between the manifold and the radiator. The fans of the engine cooling assembly of Fig. 4 can be easily installed despite the limited clearance by orienting the fans 112, 113 so that their blades 114, 115, 124, 125 are vertical, then lowering the fans into the engine compartment at a point to one side or the other of their installed positions below the exhaust manifold. The drive motor 122 to which fan 112 is mounted drops down to one side or the other of the exhaust manifold. Once motor 122 is below the exhaust manifold, fan 112 can be moved into its installed position.

The embodiment illustrated in Fig. 5 is similar to the embodiment illustrated in Figs. 1 - 3, with the principal difference being that one-bladed fans 212 and 213 are used instead of multiple-bladed fans. Balance is maintained by suitable counterweights 217 and 218. It is not necessary that fans 212 and 213 be counter-rotating. Consequently, the drive belt 236 is not twisted. Drive belt 236 and the corresponding pulleys are notched as in the other embodiments to maintain the synchronization between the fans 212 and 213.

Fans 212 and 213 travel in opposite directions in the area between the axes of the two fans, so it is not necessary to employ pre-rotating vanes in that area. The fans serve as mutual pre-rotators for each other in the overlapped swept areas. Thus, pre-rotating vanes 250 extend only along those radii which intersect ring shroud 246 and ring shroud 247.

A modification of Fig. 5 is illustrated in Fig. 6. Fans can be operated without ring shrouds or pre-rotating vanes without significant loss in efficiency by mounting a tip shroud 251 on the end of each fan blade. Tip shrouds 251 are short, somewhat cylindrical sections which extend generally perpendicular to fan radii. These tip shrouds 251 serve the same function as ring shrouds in controlling the flow of air around the blade tips, namely, to prevent air from slipping around the ends of the blade tips.

In the embodiment of the invention illustrated in Fig. 7, the fan blades 314 and 324 are counter-rotating, do not have overlapping swept areas, and are synchronized by means of twisted belt 336. Important noise reduction advantages can be gained by synchronization of the fan blades even though they are not overlapping, due to the elimination of beat frequency noise.

In another variation, illustrated schematically in Fig. 8, the swept areas of the counter-rotating fans can be overlapping in the plane through which cooling air flows, even though the fans themselves do not operate in the same plane; that is, one fan is located forward of the other.

In Fig. 9, the drive motor 522 for fans 524, 526 is remotely located. This arrangement has the advantage of permitting the motor to be mounted where there is plenty of room for it and where it is away from sources of high heat. In order to provide synchronization and counter rotation of fans 524, 526 a single side toothed belt 527 is provided. Belt 527 is twisted at points 523, 525 to place the teeth on the outside at idler pulley 529, and on the pulley side at the drive pulleys associated with both of fans 524, 526.

Of course, any of the previous embodiments could be modified by locating the fans forward of the radiator rather than behind it.

In the embodiment of the invention illustrated in Fig. 10, the rearward (engine) side 528 of a radiator 530 is covered by a full box shroud 532 providing an opening 534 surrounded by a rearwardly projecting wall 536. The opening 534 is in the shape of two intersecting circles 538, 540. A fan motor 542 mounted from a support 544 attached to the wall 536 of the shroud drives a fan 546 mounted on the motor 542 shaft and a second fan 548 by means of a twisted belt 550. Belt 550 is toothed so that fans 546, 548 are synchronized and counter-rotate. Fan 546 sweeps an area covering essentially all of the projection of circle 538 on the rearward side 528 of radiator 530 out of which cooling air flows. Fan 548 sweeps an area covering essentially all of the projection of circle 540 on the rearward side 528 of radiator 530. All of the air flowing through the rearward side 528 of radiator 530 is channelled through the opening 534 provided by the box shroud 532.

Fig. 11 illustrates a typical construction of the vehicle engine coolant radiator 530, a vehicle air conditioning condenser 554 and the box shroud 532 with mounted fans and fan motor 542 in assembled configuration. It should be understood that this is the current conventional order in which the components 530, 546, 548 and 554 are arranged, but that the invention can be employed whether they are arranged in this, or some other, order.

Fig. 12 illustrates a system employing two three-bladed fans 554, 556 in a ring-type shroud 558 as opposed to the box-type shroud 532 of Fig. 11. The difference between shroud 558 and shroud 532 is that all of the air that flows through the rear surface 560 defined by radiator 562 of Fig. 11 need not flow through the opening 562 defined by the intersecting rings 564, 566 which form the ring shroud 558. Some air is permitted to flow through rear surface 560 and rearward at the corners 568 of the radiator and outside the shroud 558 at the intersection of the rings 564, 566 at 570. Fans 554, 556 counter-rotate and are synchronized by a toothed belt 571 which extends between the motor 572 upon which fan 554 is mounted and a toothed pulley 574 to the axle of which fan 556 is mounted.

In Fig. 13, a system employs two three-bladed fans 576, 578 that do not sweep overlapping or intersecting areas of the rear surface 580 of a radiator 582. Rather the circles 584, 586 swept by fans 576, 578, respectively, are separated as illustrated at 588. The fans 576, 578 are synchronized and counter-rotate, owing to the twisted belt 590 extending between the motor 592 to which fan 576 is mounted and the pulley 594 associated with fan 578. The fans 576, 578 need not be counterrotating since they do not overlap.

In Figs. 14-16 a full box shroud 600 has been employed in an installation including a vehicle air conditioning condenser 602 mounted in front of (toward the grille of the vehicle from) the vehicle engine coolant radiator 604. The box shroud 600 incorporates pre-rotating vanes 606 associated with a fan 608. The pre-rotating vanes 606 are integrally formed or mounted in the interior of the box shroud 600. In the system of Figs. 14-16 the vanes 606 are angled inwardly along chords of the circle 612 swept by fan 608, rather than along radii of this circle, as illustrated in Fig. 14. Fig. 16 illustrates the angling of the prerotating vanes 606 downwardly from the front of the vehicle toward the rear of the vehicle to counter the upward deflection imparted to the air flowing through rear surface 616 of the radiator 604 by the upward concave curve of blade 618 of fan 608.

In Fig. 17, a system employing two, two-bladed, synchronized, counter-rotating fans 620, 622 is employed. The fans 620, 622 are mounted behind the rear surface 624 of the radiator 626 by a support assembly 628. Synchronization and rotation directions are determined by a twisted toothed belt 630 extending between a toothed pulley 632 associated with the drive motor 634 on which fan 620 is mounted and a toothed pulley 636 coupled to fan 622. A ring shroud 638 formed from two intersecting rings 640, 642 is also supported from support assembly 628 and encloses the areas 644, 646 of the rear surface 624 of radiator 626 swept by fans 620, 622, respectively.

One problem presented by the assembly or servicing of fan cooling systems in vehicles with transverse mounted V-engines is the proximity of an exhaust manifold to the cooling system radiator, fan(s) and fan motor(s). This is particularly the case when the fan(s) and fan motor(s) is (are) mounted on the rear (engine) side of the radiator. This problem was mentioned in the discussion of Fig. 4. In many cases there is plenty of room for the fan motor below the interfering exhaust manifold, once the fan motor is installed. The use of a belt drive permits the fan motor to be positioned where clearance between the fan motor and the exhaust manifold can be optimized.

Several arrangements are illustrated in Figs. 18a-m which permit fan drive motor M placement where clearance between the fan motor M and exhaust manifold (not shown) can be maintained, even though the drive pulleys F associated with the fans and one or more idler pulleys I are behind the rear surface S of the radiator R. The drive belt(s) B may be toothed on one side and twisted or toothed on both sides to provide synchronization, and, where necessary or desirable, counter-rotation, of the fans F.

In situations in which belt drives are difficult to implement to synchronize multiple fans and to provide counter-rotation where desirable, other synchronous drives are available. In Figs. 19a-b, two types of gear and shaft drives are illustrated. In the first, synchronization and counter-rotation of two fans 650, 652 is provided by bevel gears 654, 656 coupled to respective fans 650, 652 and bevel gears 658, 660 provided on opposite ends of a shaft 662 connecting bevel gears 658, 660 and supported above bevel gears 654, 656 so that bevel gears 654, 656 engage bevel gears 658, 660, respectively.

In Fig. 19b synchronization is provided by bevel gears 664, 666 coupled to respective fans 668, 670 and bevel gears 672, 674 provided on opposite ends of a shaft 676 supported above bevel gears 664, 666 so that bevel gears 664, 666 engage bevel gears 672, 674, respectively. In this embodiment, fans 668, 670 are synchronized and rotate in the same direction.

In Fig. 20a, two fans 678, 680 are driven through a flexible shaft, such as the center shaft 682 of a Bowden cable or sheathed cable 684. Worms 686, 688 are mounted in spaced relation adjacent one end of shaft 682. Worm gears 690, 692 are coupled to fans 678, 680 respectively. A drive unit 694, which may be an engine driven viscous clutch or other suitable drive mechanism, powers the shaft 682 which in turn rotates fans 678, 680 synchronously in the same direction.

In Fig. 20b, two fans 696, 698 are driven through a flexible shaft 700 from a drive unit 702. Drive is provided by two worms 704, 706 mounted in spaced relation adjacent the end 708 of shaft 700 which is not engaged by drive unit 702. The fans are synchronized by the engagement of worms 704, 706 with worm gears 708, 710 mounted on the fans 696, 698 respectively. Counter-rotation of fans 696, 698 is achieved because the worms 704, 706 are positioned on relatively opposite sides (i.e., top and bottom or rights and left-hand sides) of their respective worm gears 708, 710.

Fig. 21 illustrates another configuration different than that illustrated in Figs. 14-16. In Fig. 21 a full box shroud 712 incorporates integral support for two side-by-side fans 714, 716 and a motor 718 for driving them. The shroud 712 includes a venturi 720, 722 surrounding each fan 714, 716, respectively. The shroud 712 is positioned between a vehicle air conditioning condenser 724 and an engine coolant radiator 726.

Figs. 22a illustrates an embodiment of the invention in which a single belt 754 with teeth on one side only can be used to synchronize two fans 756, 758, and provide counter-rotation to the two fans 756, 758 without requiring the belt to be twisted across itself. This eliminates the PTFE pad or plate or idler wheel mentioned in the discussion of Figs. 1-3 to separate the two oppositely moving runs of the belt where it crosses itself. This arrangement is achieved by providing an idler or drive pulley 760 adjacent the pulley 762 associated with fan 758. The belt 754 is twisted at 764, 766 to present the teeth of the belt against the toothed or notched surfaces of both of the pulleys 762, 768 associated with fans 758, 756, respectively.

Fig. 22b shows a somewhat mirror-image or inversion of the arrangement of Fig. 22a. The twists in the belt 770 of the embodiment of Fig. 22b are at 772, 774. Belt 770 is toothed on one side only.

While certain embodiments of the invention have been illustrated and described in some detail in the drawings and foregoing description, it is to be understood that this description is not intended as a limitation on the scope of the invention claimed in the claims below.

Claims

1. An air movement mechanism comprising a first axial flow fan, a second axial flow fan, a prime mover, means for coupling the first and second fans to the prime mover for rotation about their respective axes of rotation, a shroud having first and second generally circular cross-section openings, and means for mounting the first fan in the first generally circular cross-section opening and the second fan in the second generally circular cross-section opening, rotation of the first and second fans about their respective axes by actuation of the prime mover causing the first and second fans to sweep respective first and second areas corresponding generally to the first and second generally circular cross-section openings, respectively.

2. A mechanism according to claim 1, characterised in that the first and second generally circular cross-section openings intersect, their combined form being somewhat figure-eight shaped.

3. A mechanism according to claim 2, characterised in that the prime mover comprises means for synchronising the rotation of the first and second fans about their respective axes of rotation.

4. A mechanism according to claim 3, characterised in that the prime mover comprises means for rotating the first and second fans in relatively opposite directions.

5. A mechanism according to any preceding claim, characterised in that the shroud further comprises a generally rectangular cross-section opening and a transition region between the generally rectangular cross-section opening and the first and second generally circular cross-section openings.

6. A mechanism according to claim 5, characterised in that the shroud is proportioned and designed for attachment adjacent a surface of a liquid-cooled heat engine coolant radiator, through which surface air moves to effect heat exchange, the shroud mountable against the surface with the generally rectangular cross-section opening facing the surface.

7. An air movement mechanism comprising an axial flow fan, a prime mover, means for coupling the prime mover to the fan, a shroud having a generally circular cross-section opening, means for mounting the fan in the generally circular cross-section opening, rotation of the fan by actuation of the prime mover causing the fan to sweep an area corresponding generally to the generally circular cross-section opening, rotation of the fan by the prime mover deflecting air through the generally circular cross-section opening in a first direction around the axis of rotation of the fan, and one or more vanes oriented and configured to deflect air flowing through the generally circular cross-section opening in a second and opposite direction around the axis of rotation of the fan.

8. A mechanism according to claim 7 and further characterised by a second axial flow fan, means for coupling the prime mover to the second fan, the shroud having a second generally circular cross-section opening, means for mounting the second fan in the second generally circular cross-section opening, rotation of the second fan by the prime mover deflecting air through the second generally circular cross-section opening in a first direction around the axis of rotation of the second fan, and one or more vanes oriented and configured to deflect air flowing through the second generally circular cross-section opening in a second and opposite direction

around the axis of rotation of the second fan.

9. The mechanism of claim 8, characterised in that the first-mentioned and second generally circular cross-section openings intersect, their combined form being somewhat figure-eight shaped.

10. A mechanism according to claim 7, 8 or 9, characterised by means for supporting the vanes in the shroud adjacent the or each generally circular cross-section opening.

11. A mechanism according to any one of claims 7 to 10, characterised in that the shroud is constructed from resinous material.

12. A mechanism according to claim 11, characterised in that the vanes are constructed from resinous material and the means for supporting the vanes adjacent the or each generally circular cross-section opening comprises means for providing the vanes integrally with the shroud, the vanes extending internally of the shroud into the region adjacent the generally circular cross-section opening or openings.

13. A mechanism according to any one of claims 7 to 12, characterised in that the shroud further comprises a generally rectangular cross-section opening and a transition region between the generally rectangular cross-section opening and the generally circular cross-section opening, or openings, and the means for supporting the vanes in the shroud comprises means for supporting the vanes in the transition region.

14. The mechanism of any one of claims 7 to 13, characterised in that the shroud is proportioned and designed for attachment adjacent a surface of a liquid-cooled heat engine coolant radiator, through which surface air moves to effect heat exchange, the shroud mountable against the surface with the generally rectangular cross-section opening facing the surface.

15. A mechanism according to claim 8 or any preceding claim appendant thereto, characterised in that the means mounting the first and second fans mounts them so that they rotate generally in the same plane, means being provided for synchronising the rotation of the first and second fans.

16. A mechanism according to claim 8, or any preceding claim appendant thereto, characterised in that the means mounting the first and second fans mounts them so that they rotate generally in different planes.

17. A mechanism according to claim 16, characterised in that means are provided for synchronising the rotation of the first and second fans.

18. A mechanism according to claim 16 or 17, characterised in that the first and second fans are rotatable in relatively opposite directions.

19. A mechanism according to claim 15, 16, 17 or 18, characterised in that the means coupling the first fan to the prime mover comprises a first shaft and a first pulley rotatable with the first shaft and the second fan is driven by means that comprises a second shaft, a second pulley rotatable with the second shaft, an endless flexible belt engaging the first and second pulleys to synchronise the rotation of the first and second fans.

20. A mechanism according to claim 19, characterised in that the first and second pulleys comprise radially extending teeth and the endless flexible belt comprises teeth, the teeth on the belt engaging the teeth on the first and second pulleys.

21. A mechanism according to claim 20, characterised in that the endless flexible belt comprises two oppositely facing sides, each side of the endless flexible belt comprising teeth, the teeth on one side of the belt engaging the teeth on the first pulley and the teeth on the other side of the belt engaging the teeth on the second pulley.

22. A mechanism according to claim 21, characterised in that the endless flexible belt contacts the first and second pulleys on two relatively oppositely facing regions of the first and second pulleys to effect counterrotation of the first and second pulleys in response to endless belt movement.

23. A mechanism according to claim 20, characterised in that the endless flexible belt is twisted to cause rotation of the first and second pulleys in relatively opposite directions.

24. A mechanism according to any one of claims 19 to 23, characterised in that the prime mover has an output shaft which comprises one of said first and second shafts.

25. A mechanism according to any one of claims 15 to 18, characterised by a first gear, means for coupling the first fan to the first gear, a second gear, and means for coupling the second fan to the second gear, the means for synchronising the rotation of the first and second fans comprising means for engaging the first and second gears and means for coupling the first gear-engaging means to the second gear-engaging means.

26. A mechanism according to claim 25, characterised in that the means for engaging the first gear comprises a third gear, the means for engaging the second gear comprises a fourth gear, and the means for coupling the first gear-engaging means to the second gear-engaging means comprises a shaft joining the first gear and the fourth gear.

27. A mechanism according to claim 26, characterised in that the first and second gears are coupled to the output shaft of the prime mover.

28. A mechanism according to claim 27, characterised in that the output shaft comprises first and second worms engaging the first and second gears.

29. A mechanism according to claim 28, characterised in that the first and second worms contact the first and second gears, respectively, on relatively oppositely facing surfaces of the first and second gears to effect

counter-rotation of the first and second gears in response to output shaft movement.

30. An air movement mechanism for moving air through a heat exchanger, the mechanism comprising a first axial flow fan, a second axial flow fan, means for mounting the first fan so that rotation of the first fan causes it to sweep a first generally circular area, means for mounting the second fan so that rotation of the second fan causes it to sweep a second generally circular area, first means for rotating the first fan, means for coupling the first fan to the first rotating means, second means for rotating the second fan, and means for coupling the second fan to the second rotating means, the heat exchanger including an active surface through which air moves to effect heat exchange, and the means for mounting the first and second fans mounting them so that they sweep first and second generally circular areas of the active surface, the first and second areas overlapping.

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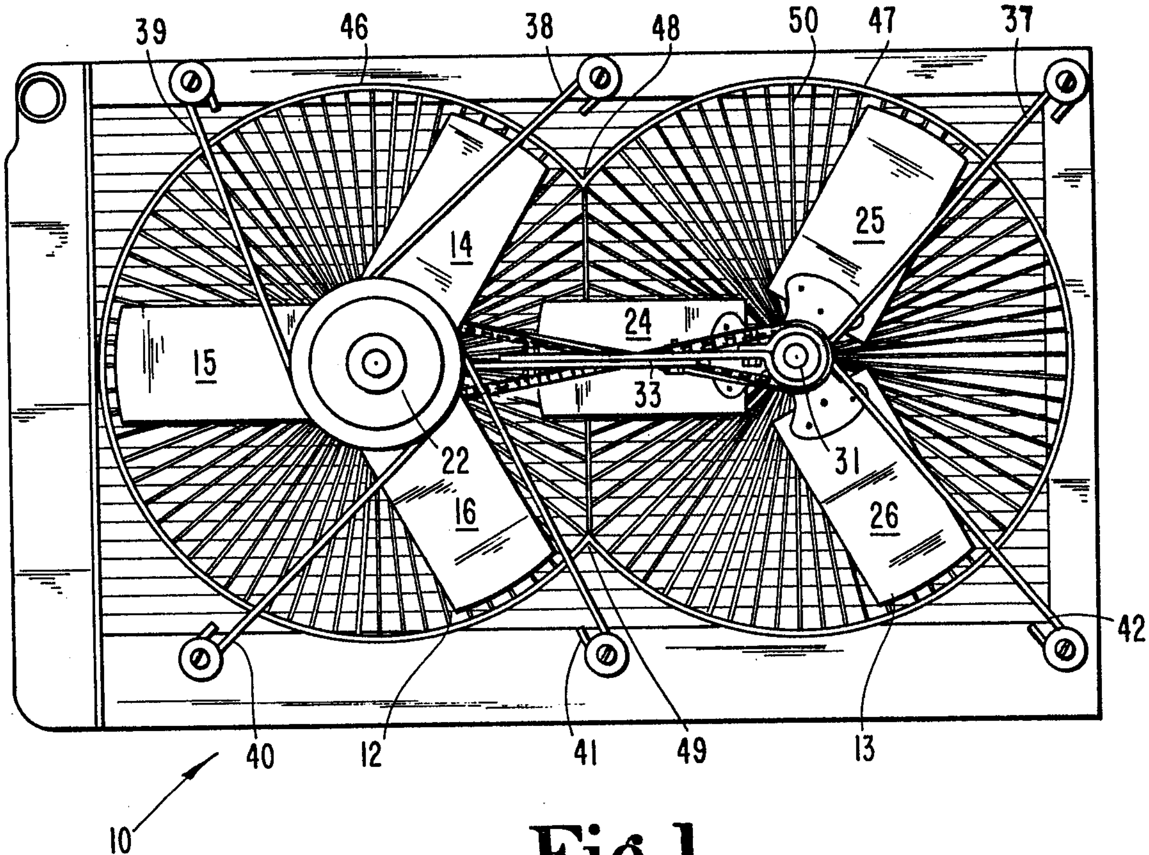

Fig.1

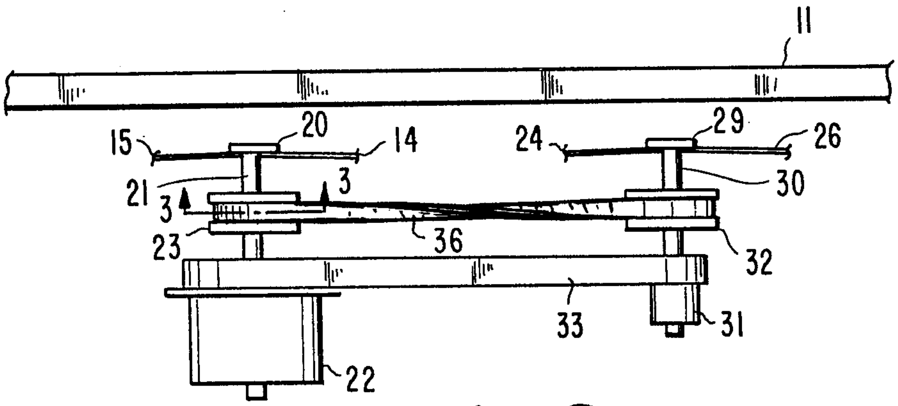

Fig.2

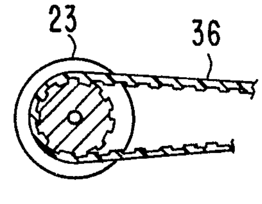

Fig.3

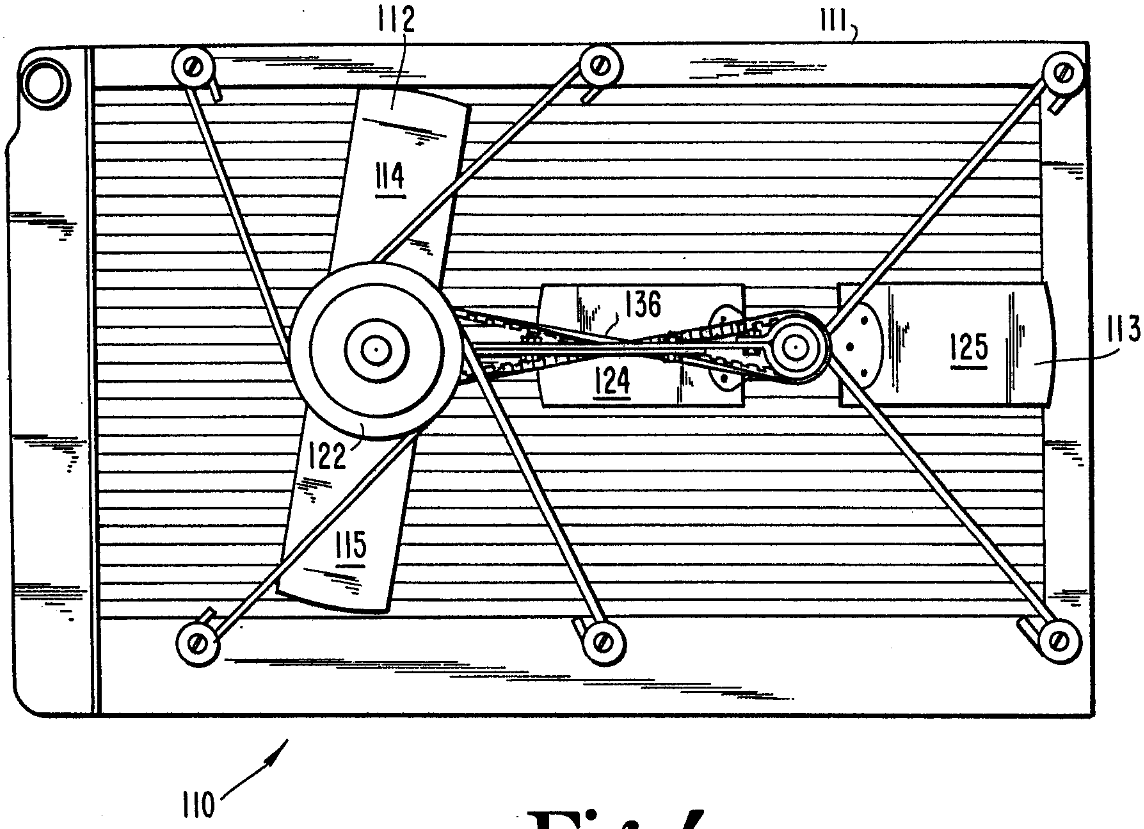
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Fig.4

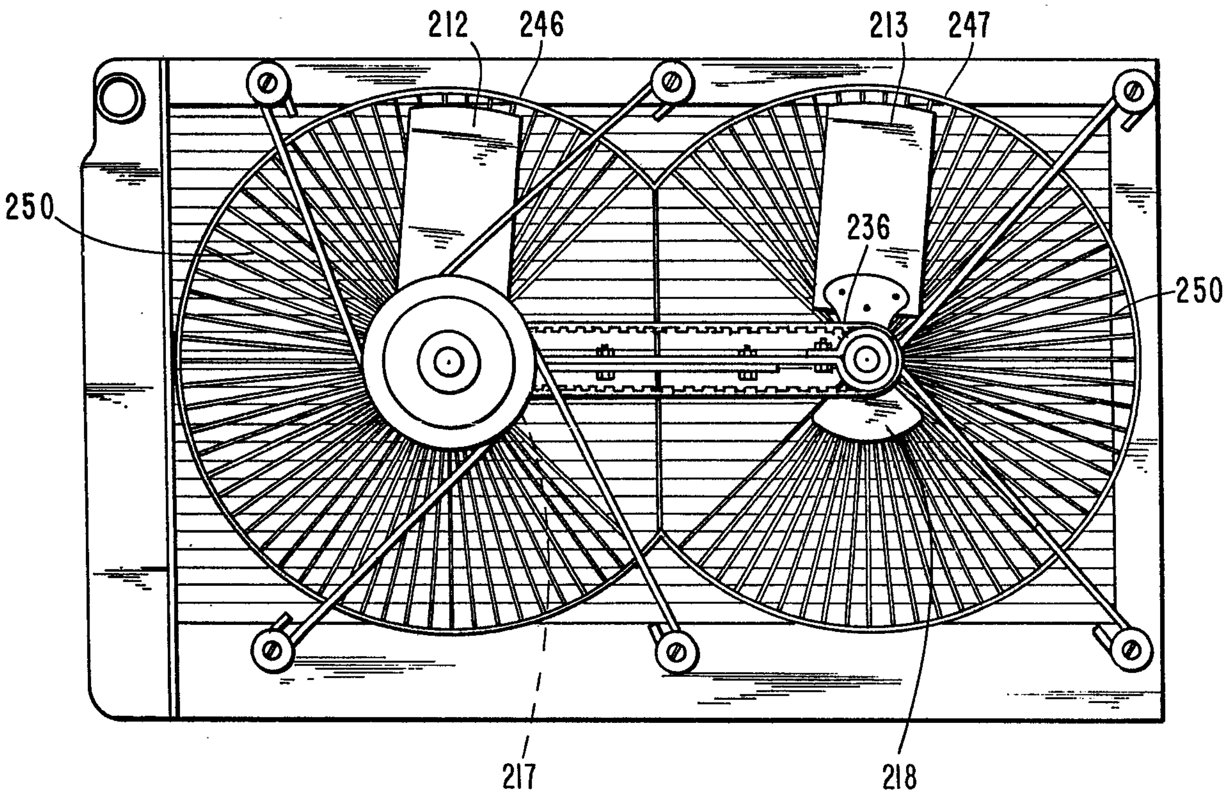
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Fig.5

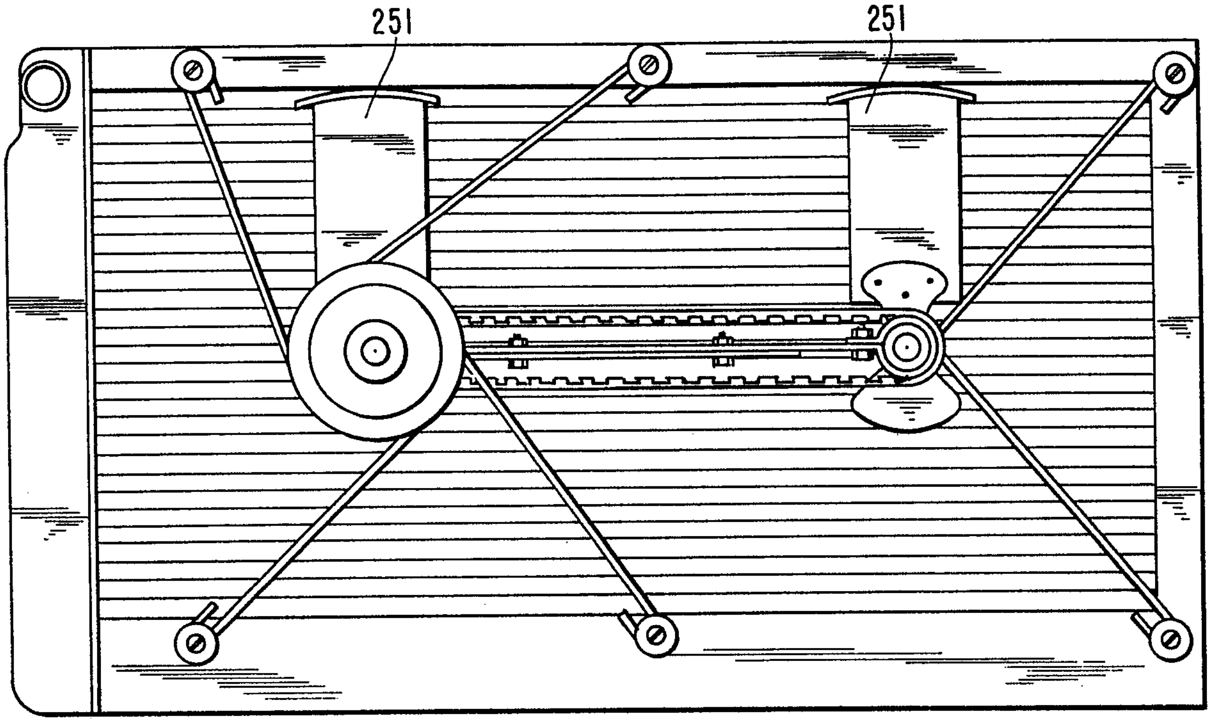


Fig.6

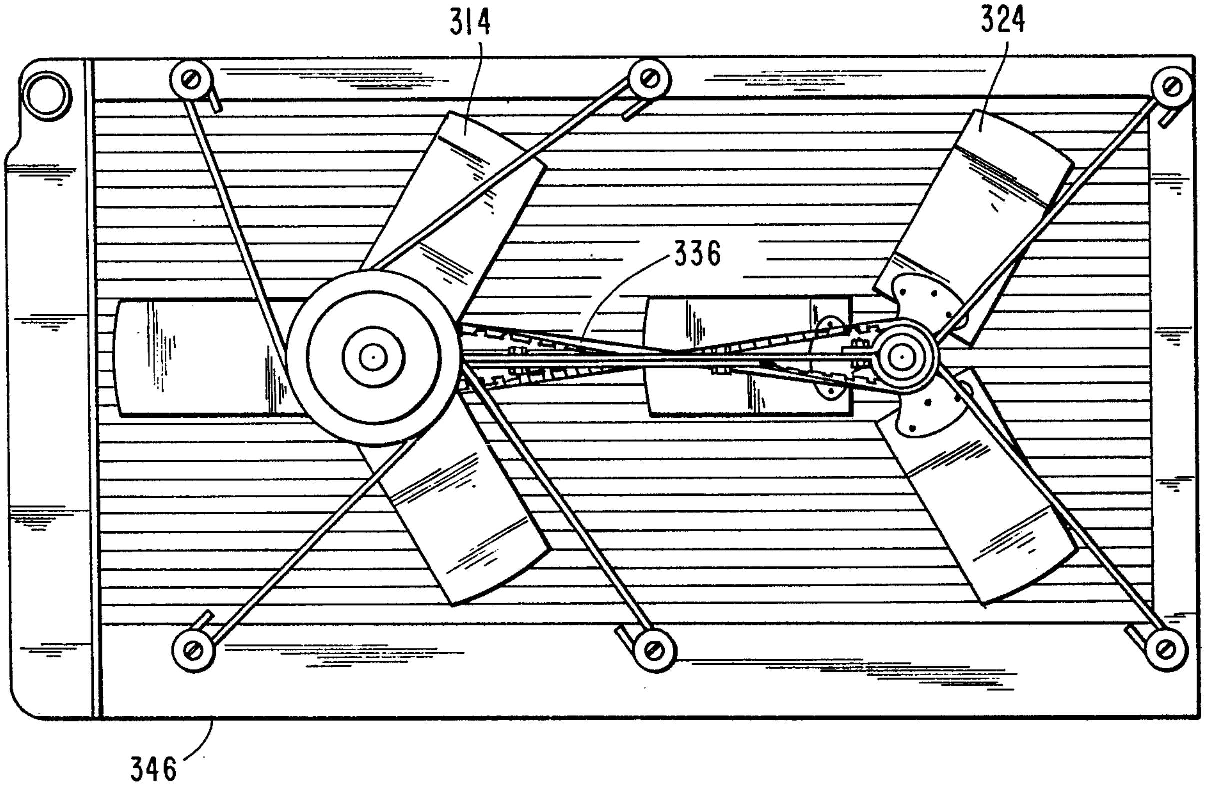


Fig.7

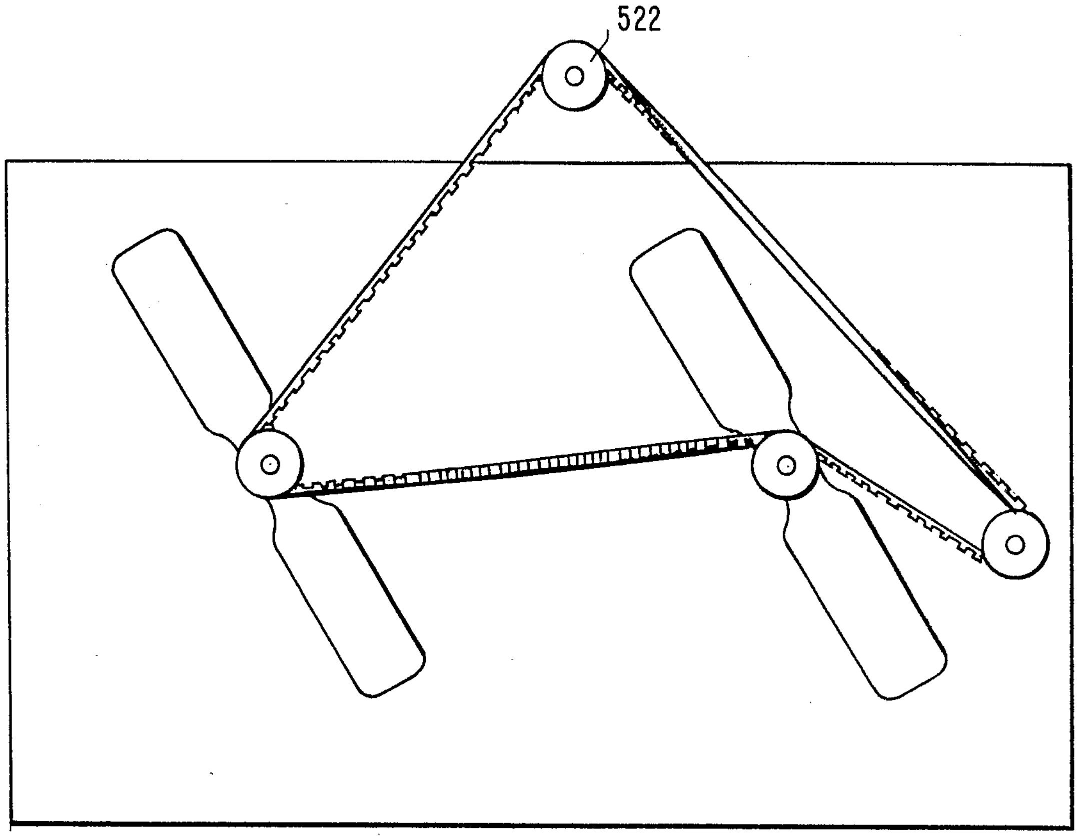


Fig.9

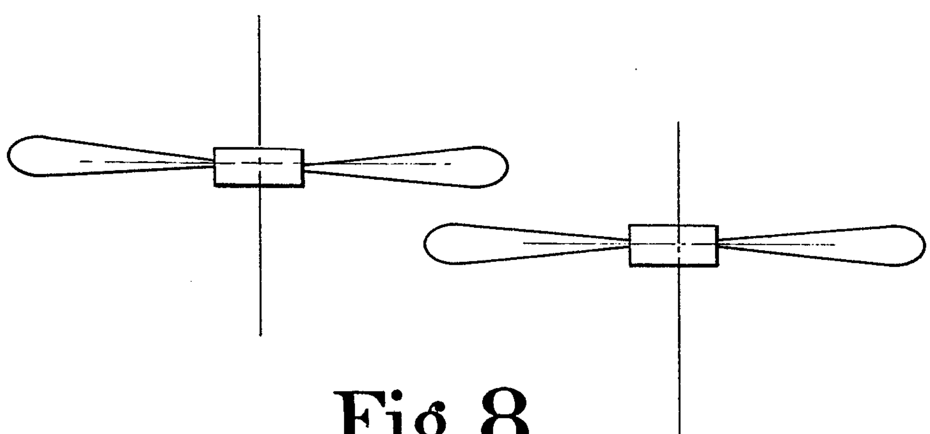


Fig.8

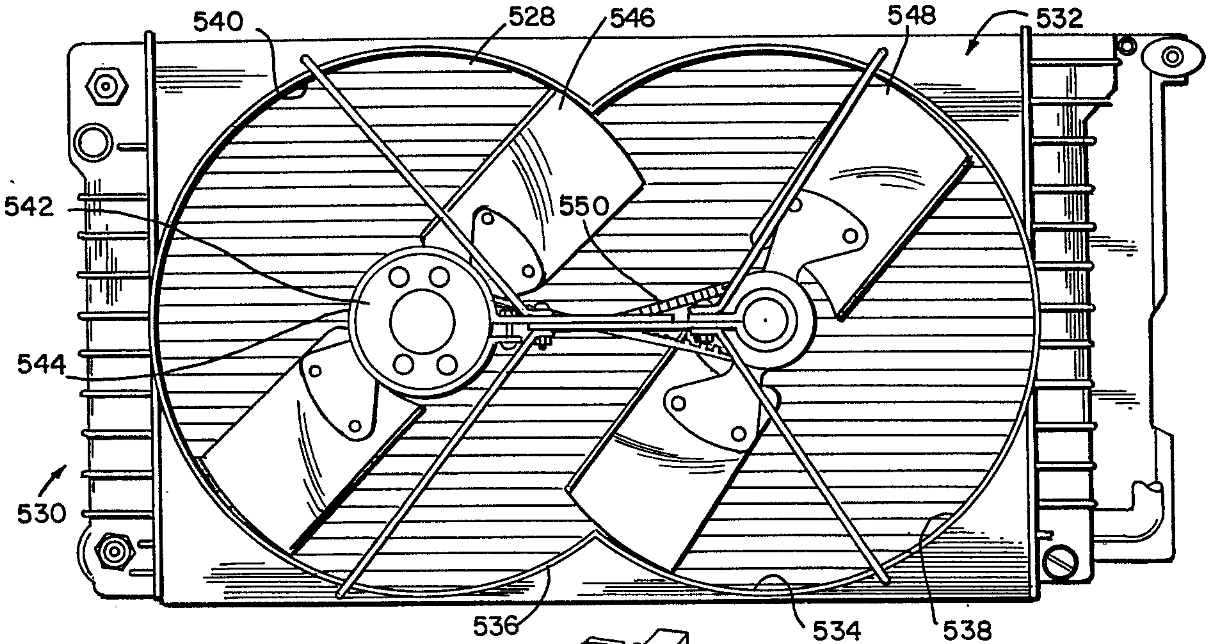


FIG. 10

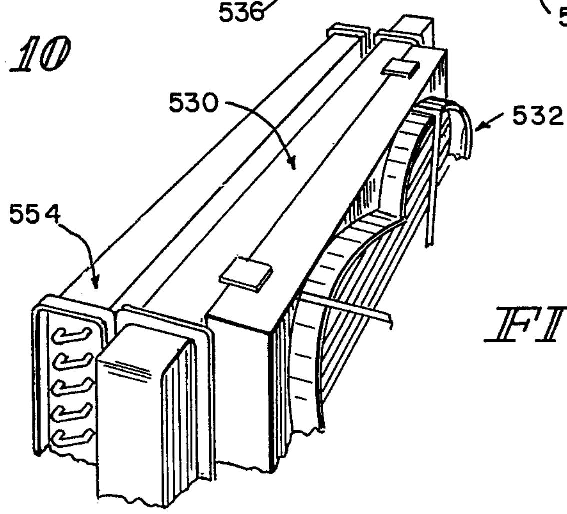


FIG. 11

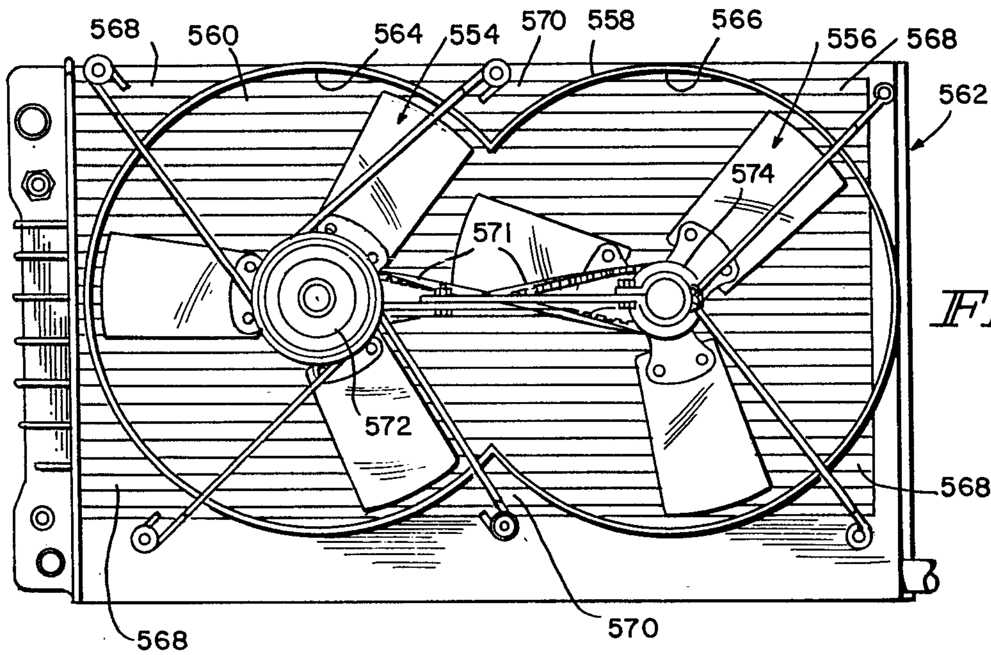


FIG. 12

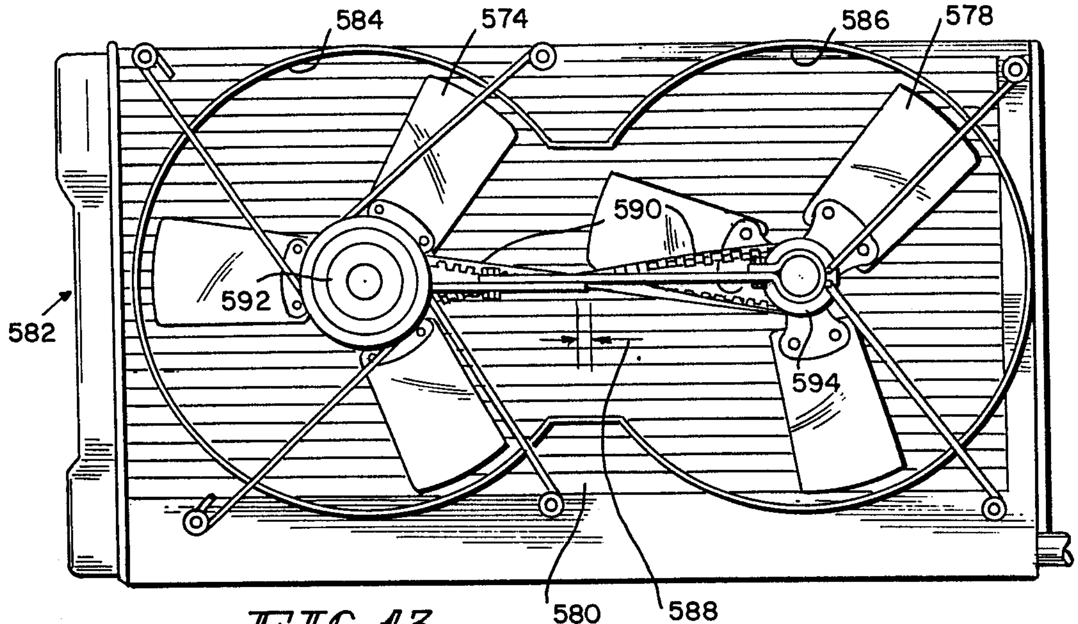


FIG. 13

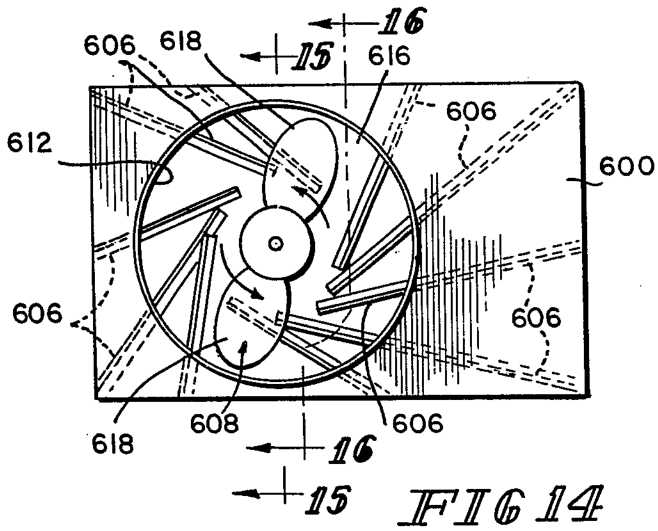


FIG 14

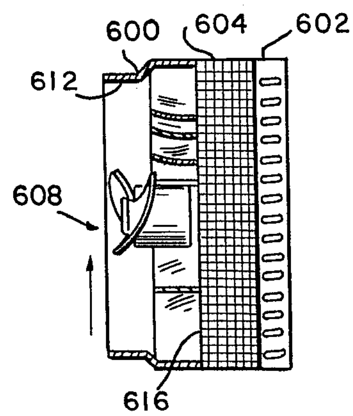


FIG. 15

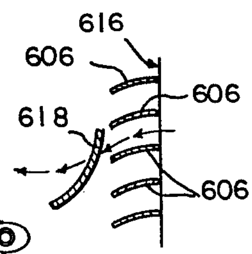


FIG. 16

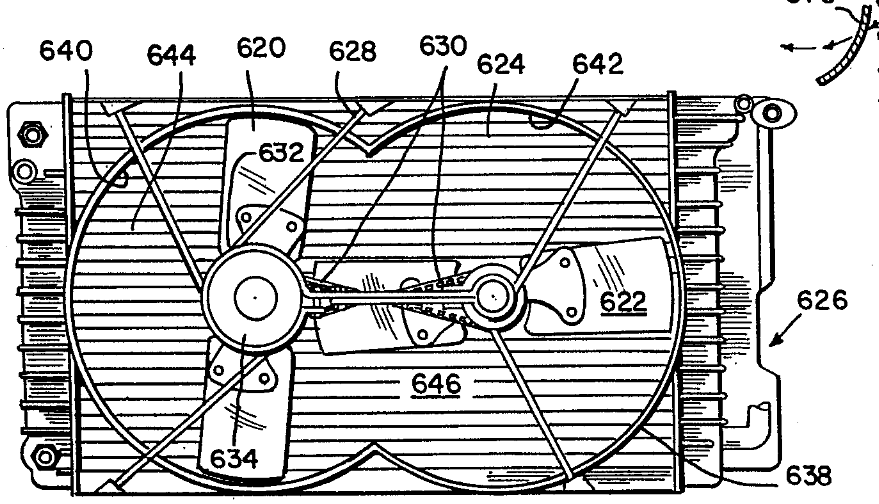


FIG. 17

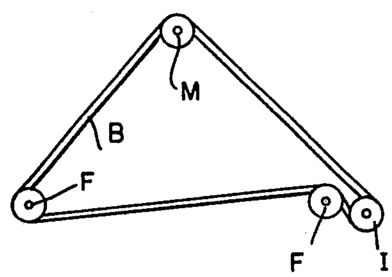


FIG. 18a

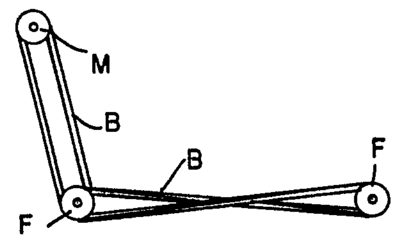


FIG. 18b

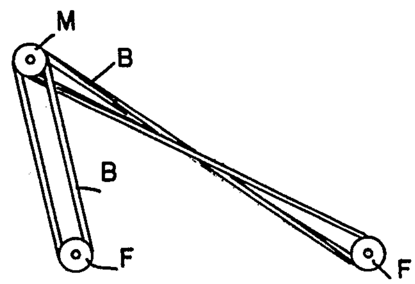


FIG. 18c

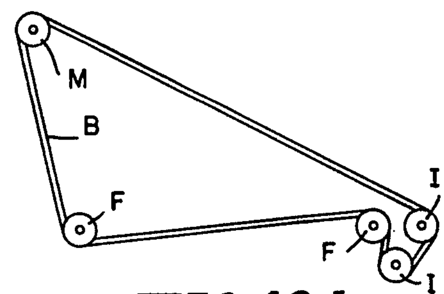


FIG. 18d

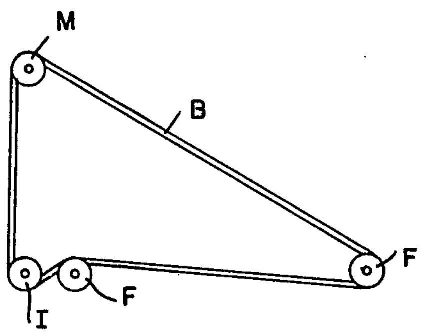


FIG. 18e

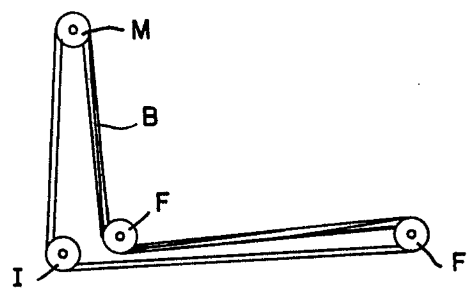


FIG. 18f

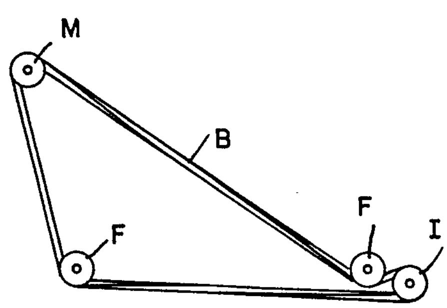


FIG. 18g

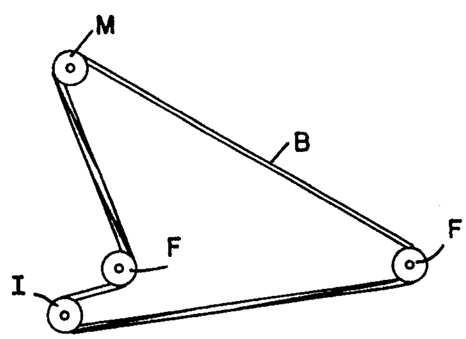


FIG. 18h

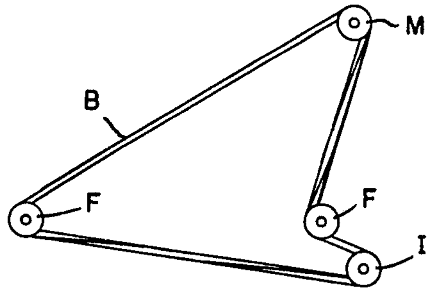


FIG. 18i

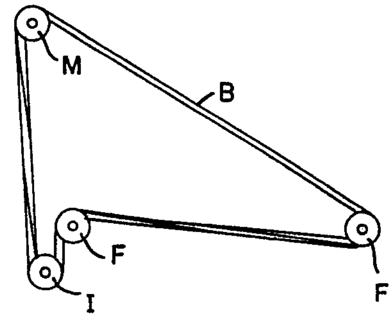


FIG. 18j

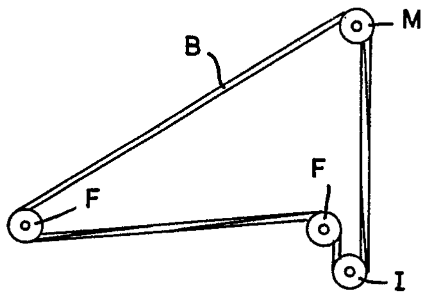


FIG. 18k

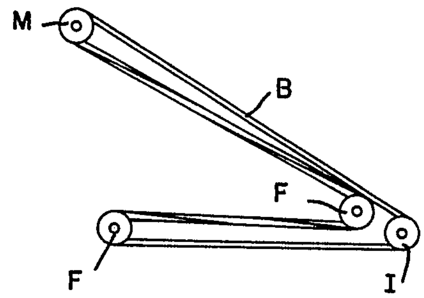


FIG. 18l

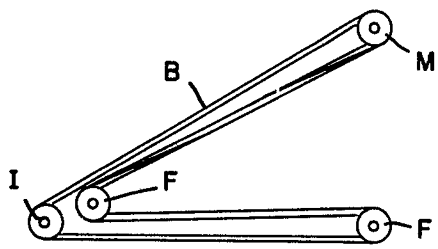
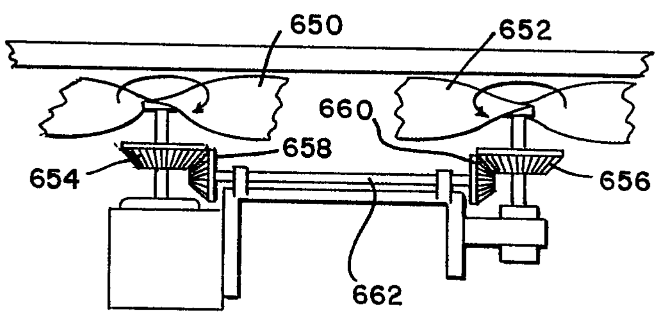


FIG. 18m

FIG. 19a



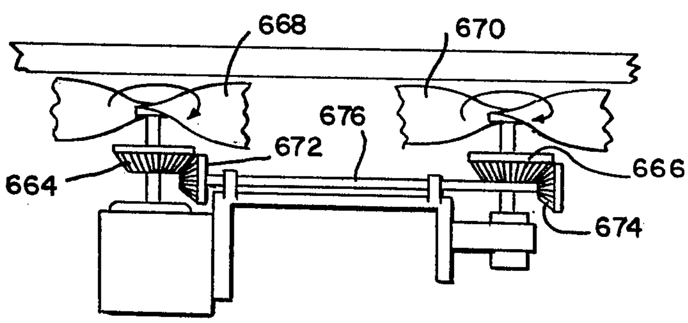


FIG. 19b

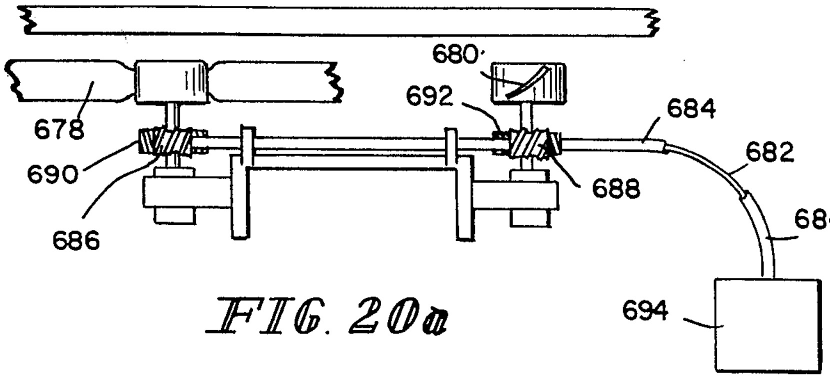


FIG. 20a

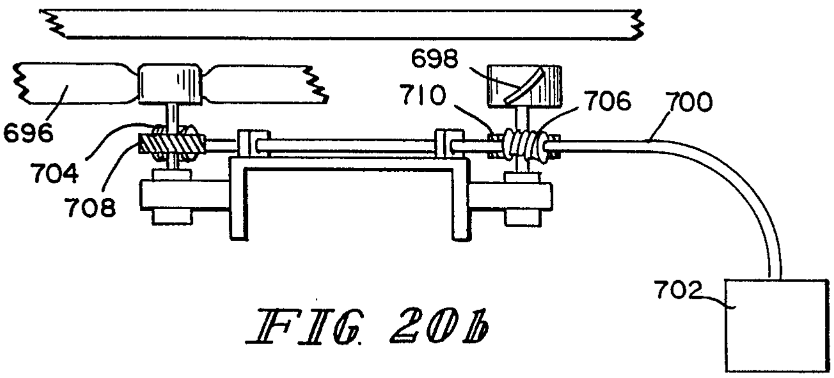


FIG. 20b

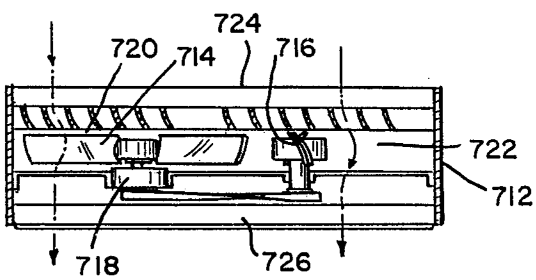


FIG. 21

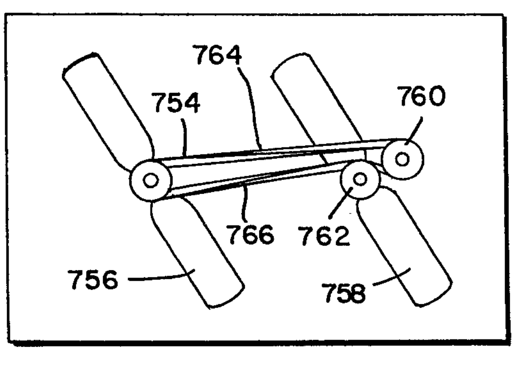


FIG. 22a

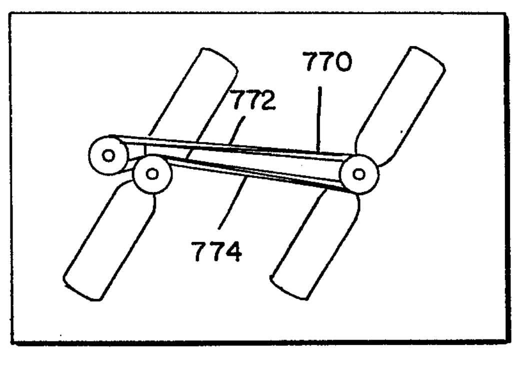


FIG. 22b