

May 4, 1948.

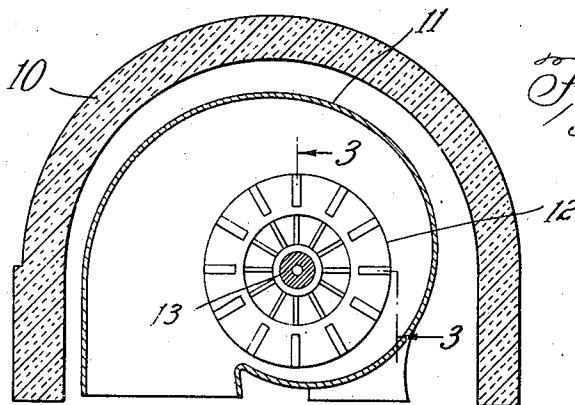
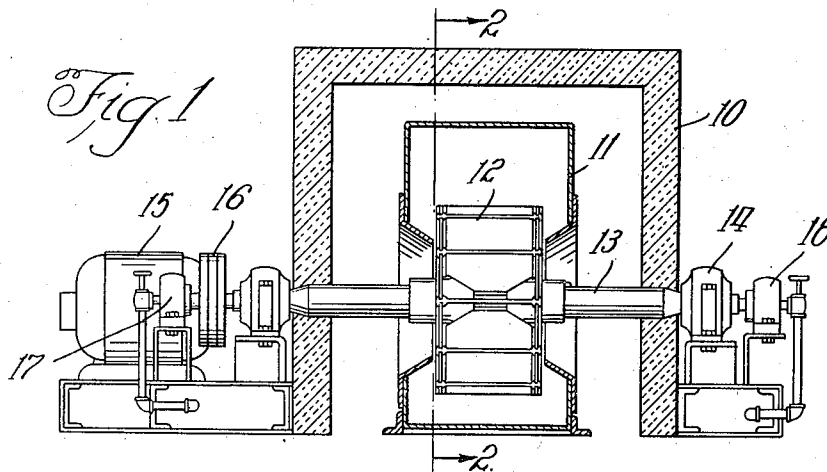
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2,441,121

HIGH-TEMPERATURE FAN

Filed Aug. 31, 1945

7 Sheets-Sheet 1



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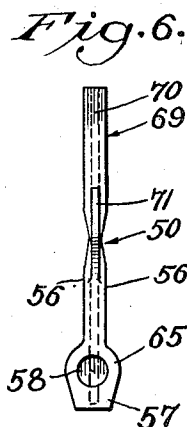
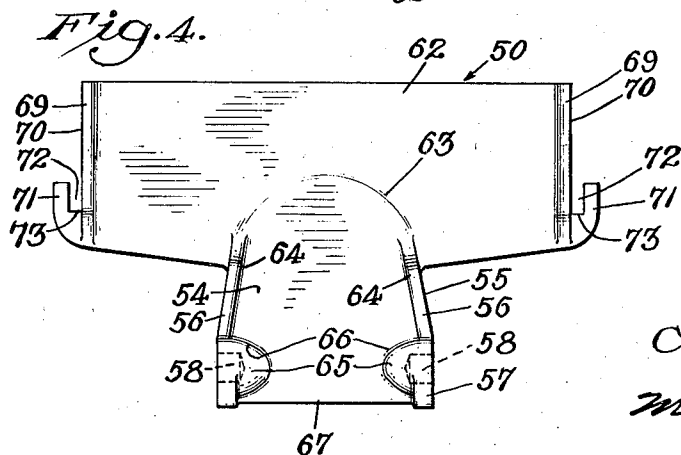
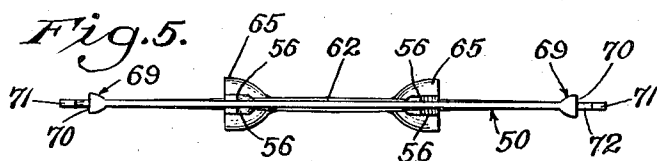
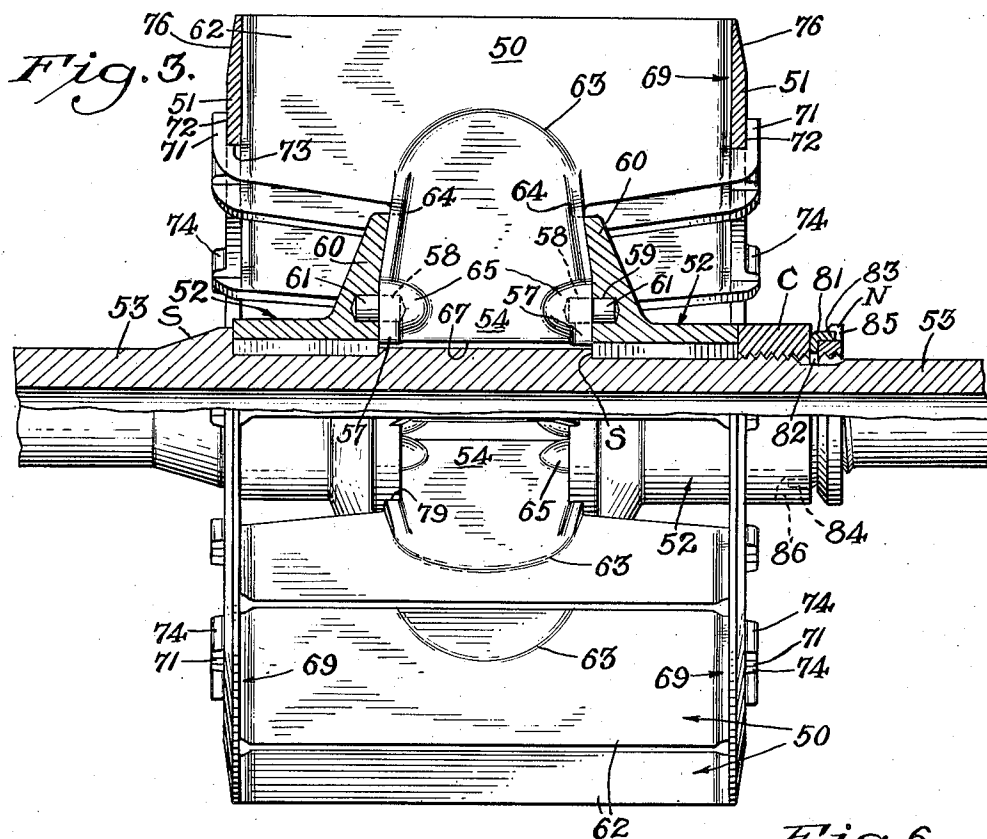
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7 Sheets-Sheet 2



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Fig. 7.

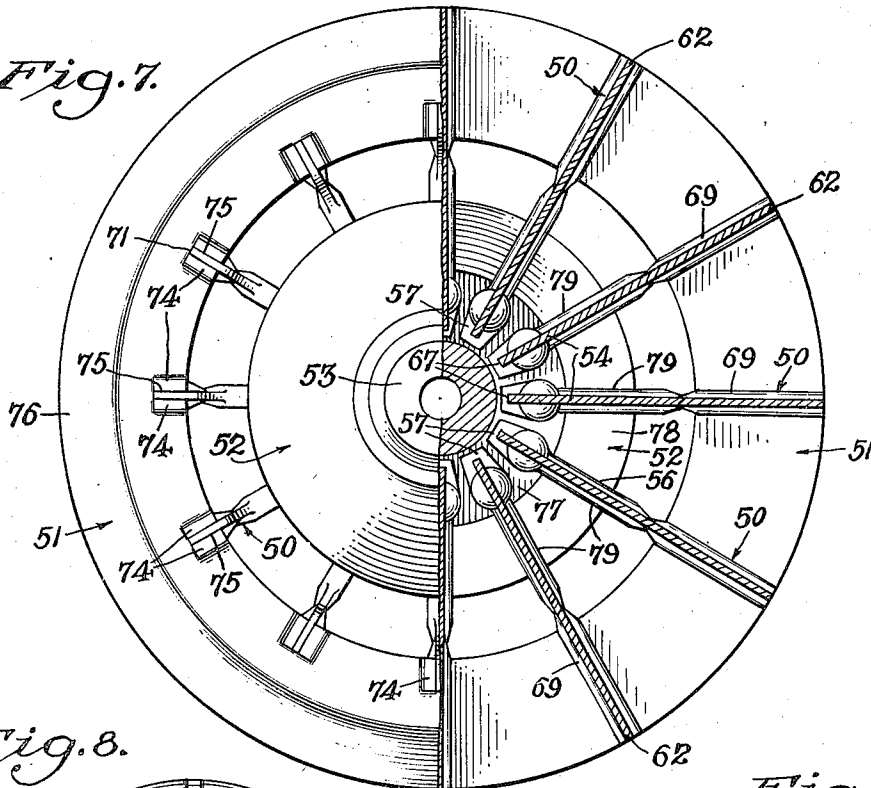


Fig. 8.

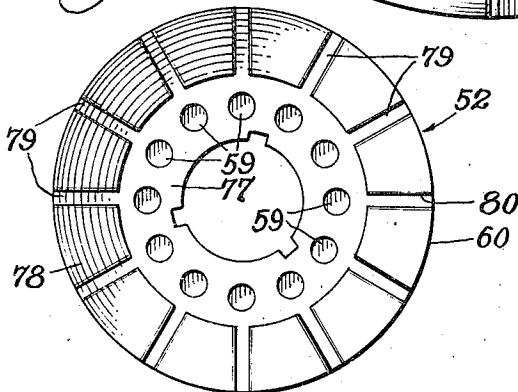


Fig. 9.

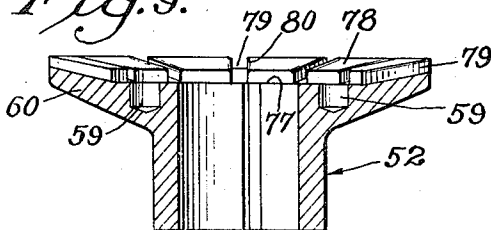


Fig. 10.

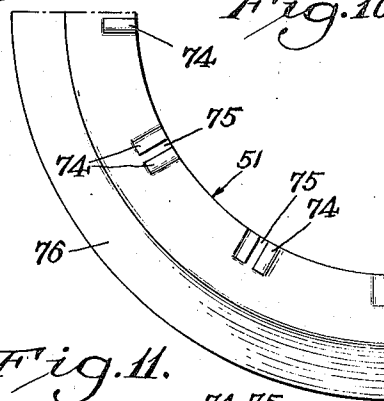
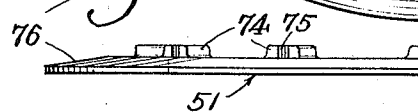


Fig. 11.



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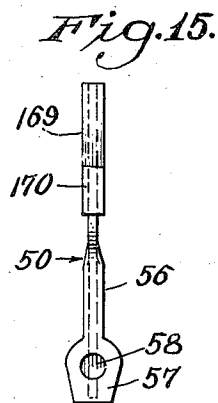
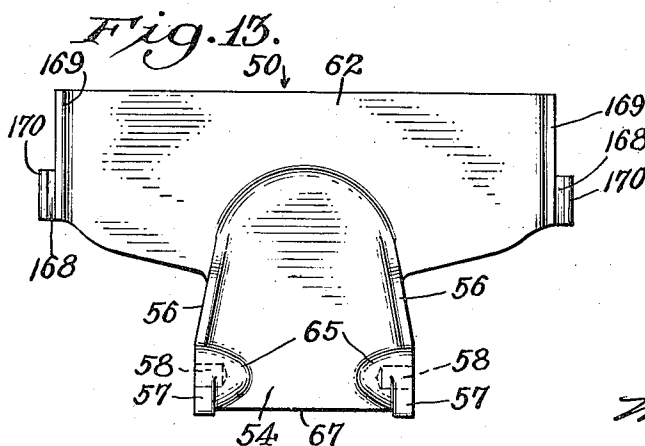
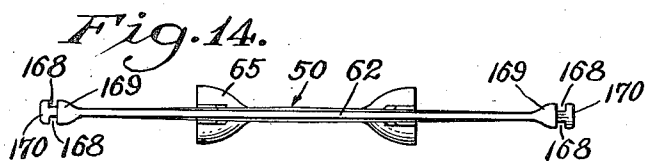
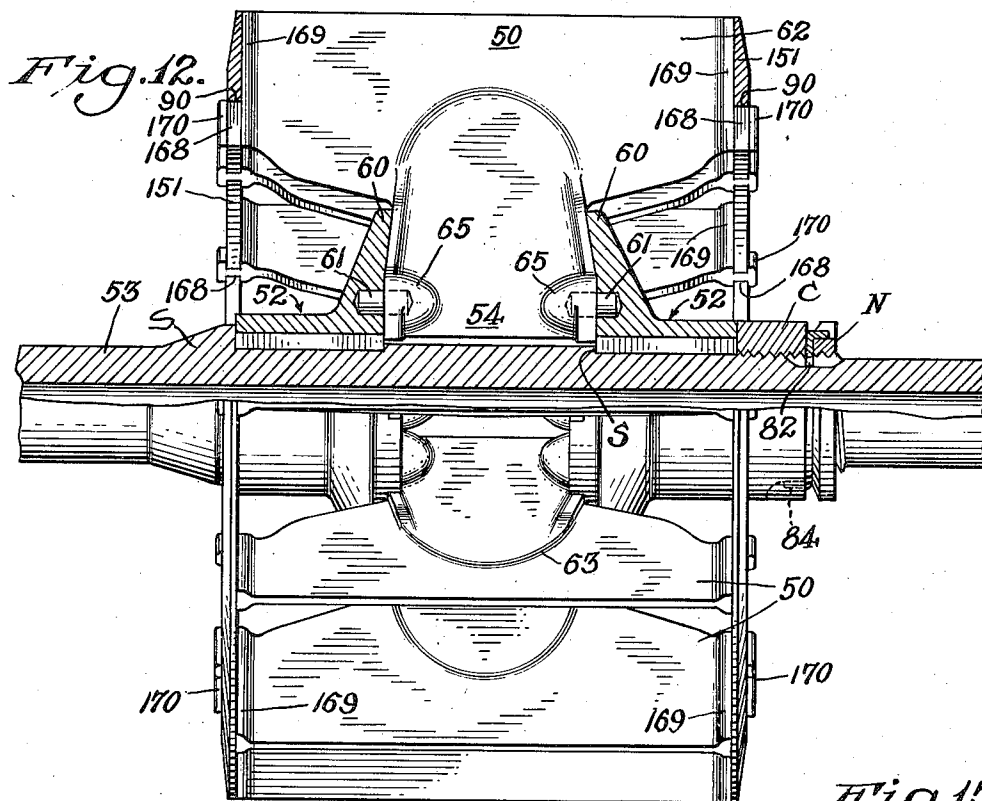
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Fig. 16.

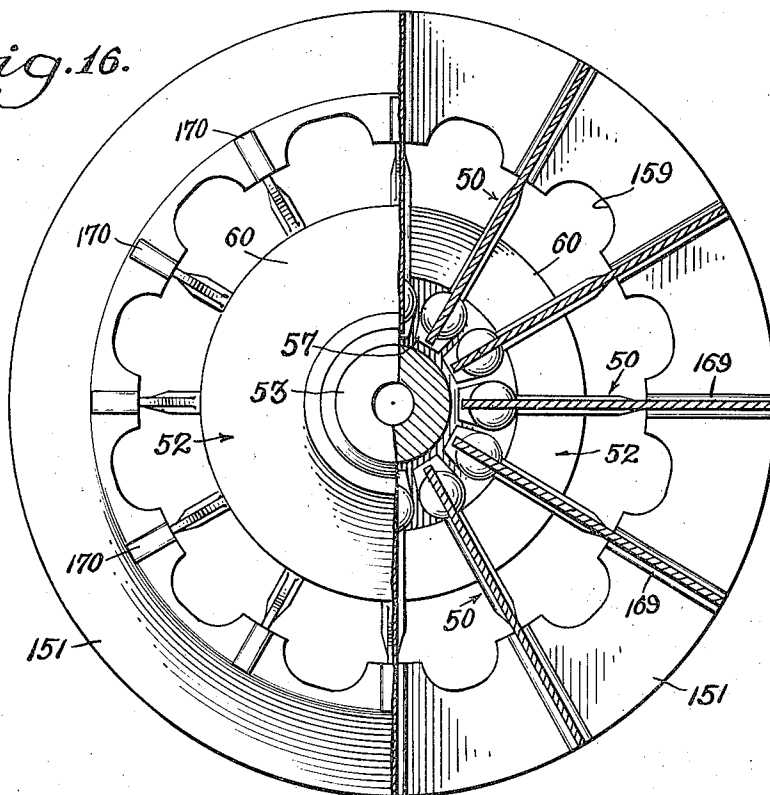
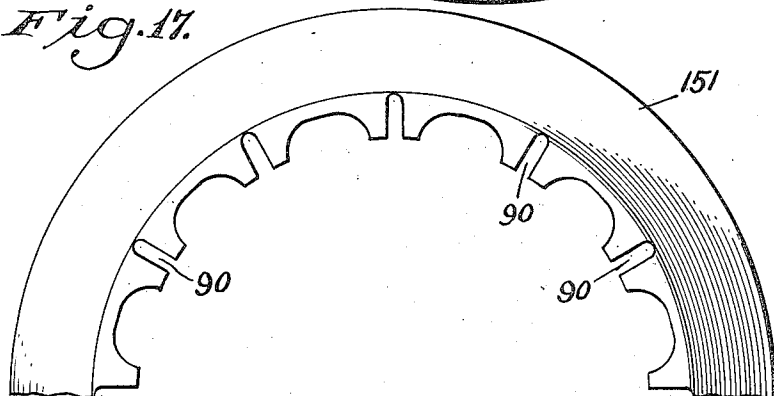


Fig. 17.



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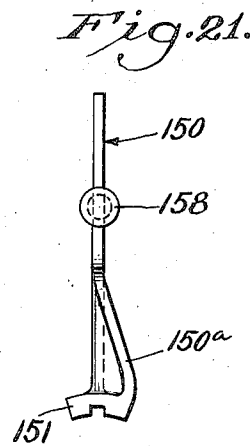
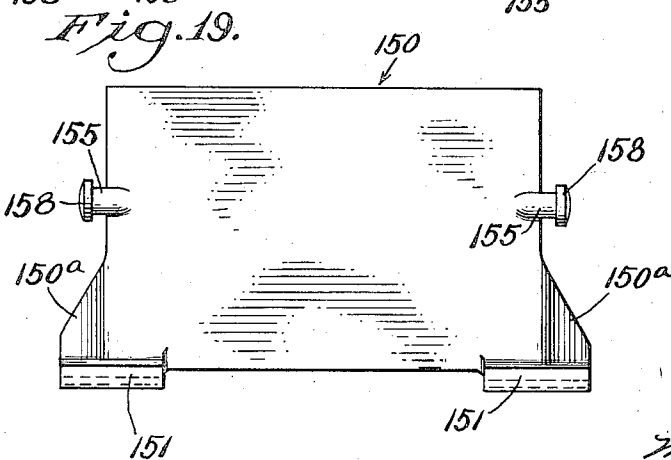
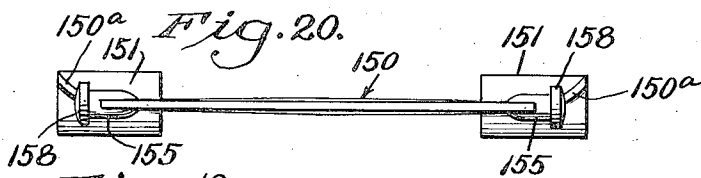
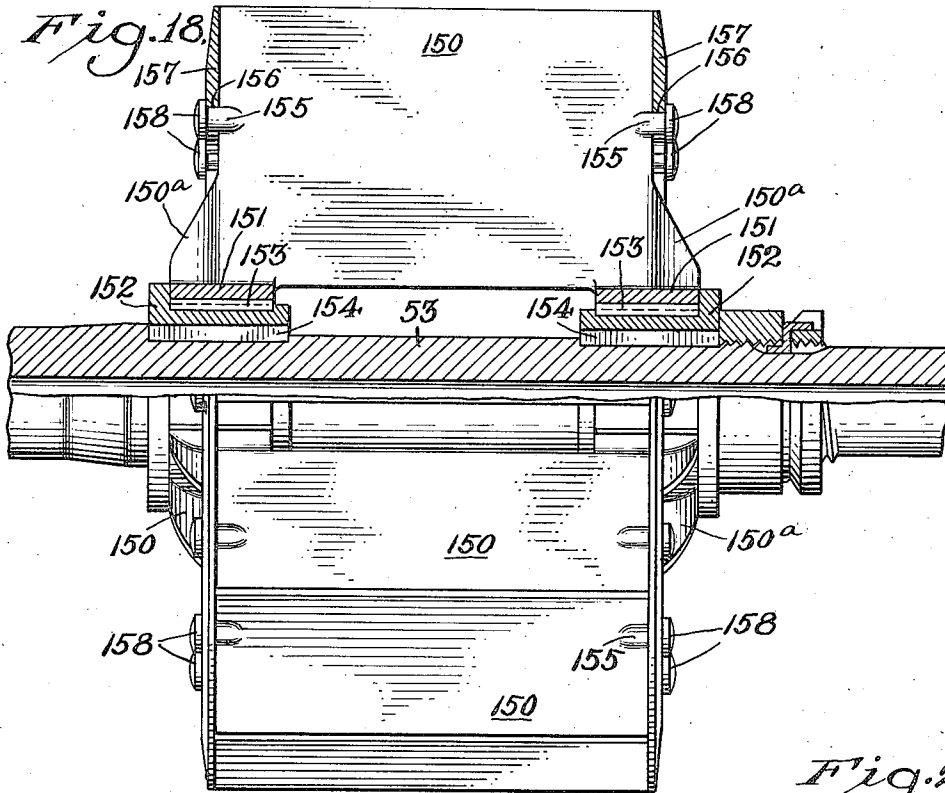
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Fig. 22.

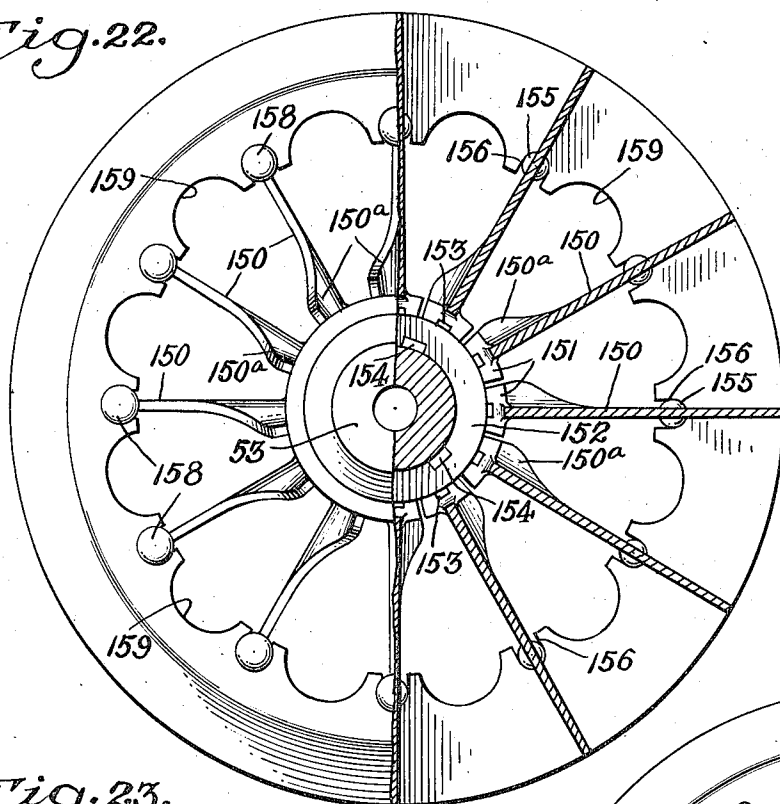


Fig. 23.

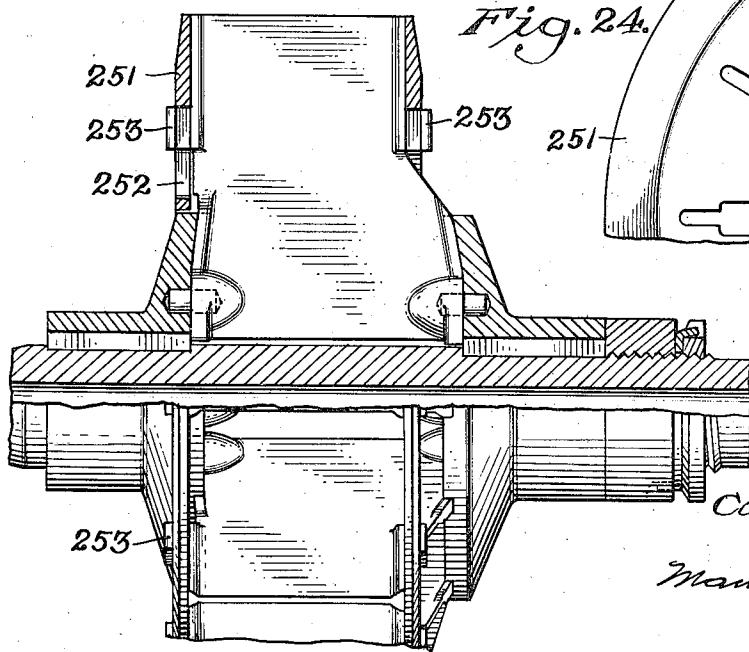
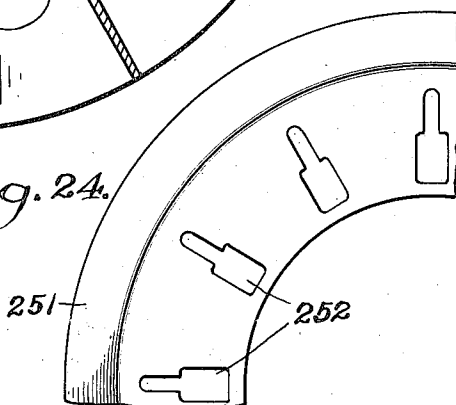


Fig. 24.



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UNITED STATES PATENT OFFICE

2,441,121

HIGH-TEMPERATURE FAN

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Application August 31, 1945, Serial No. 613,751

5 Claims. (Cl. 230-134)

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This invention relates to centrifugal fans or blowers and has for its principal object to give the several parts all the freedom of movement in expanding and contracting that may be necessary to prevent distortion and maintain dynamic balance while providing safe restraint against a broken blade's getting away and working destruction.

Generally speaking, this is accomplished by making the shroud rings or side plates ride or float on the blades with appropriate freedom to expand and contract individually while surrounding the edge portions of the blades and restraining outward movement beyond selected limits. The inner portions of the blades may be made fast to hub members leaving the shrouds to prevent the escape of an outer portion of a broken blade, or the shrouds may take all the stress due to centrifugal force acting on the blades.

In the accompanying drawings, several selected forms are shown by way of illustration.

Figs. 1 and 2 are diagrammatic views of a double inlet fan and its associated parts in one form of installation;

Fig. 3 is a part edge view and part vertical section along the axis of the fan embodying the invention;

Fig. 4 is an elevation of one of the blades;

Fig. 5 is an end view of one of the blades looking at Fig. 4 from the top;

Fig. 6 is a side view of one of the blades looking from the right in Fig. 4;

Fig. 7 is a part side elevation of the fan shown in Fig. 3 and part section through the middle at right angles to the axis;

Fig. 8 is a front view of one of the hubs;

Fig. 9 is a section through one of the hubs along the axis;

Fig. 10 is a side view of a quarter segment of one of the shrouds;

Fig. 11 is an edge view of Fig. 10;

Fig. 12 is in part an edge view of a different embodiment and part section along the axis;

Fig. 13 is an elevation of one of the blades in Fig. 12;

Fig. 14 is an end view of the blade looking from the top in Fig. 13;

Fig. 15 is a side view of the blade looking from the right in Fig. 13;

Fig. 16 is in part a side view of the fan shown in Fig. 12 and in part a vertical section through the middle at right angles to the axis;

Fig. 17 is a side view of a half segment of one of the shrouds;

Fig. 18 is in part an edge view and in part a sec-

tion along the axis of another embodiment of the invention;

Fig. 19 is an elevation of one of the blades shown in Fig. 18;

Fig. 20 is an end view of one of the blades looking from the top in Fig. 19;

Fig. 21 is a side view of one of the blades looking from the right in Fig. 19;

Fig. 22 is in part an end elevation and in part a section along the middle at right angles to the axis of the wheel shown in Fig. 18;

Fig. 23 is in part an edge view and in part an axial section of a single inlet fan corresponding to the form shown in Figs. 18-22; and

Fig. 24 is a side view of a quarter segment of the shroud at the closed side of the fan.

This application is a companion to my applications: Ser. Nos. 536,801, filed May 22, 1944, now Patent No. 2,385,837; 533,456, filed May 1, 1944, now Patent No. 2,415,033; 590,753, filed April 28, 1945; 594,750, filed May 19, 1945.

In Figs. 1 and 2, 10 indicates a conventional form of masonry installation for a fan or blower within which is a metal casing 11 for a double inlet fan 12 mounted on a hollow water cooled shaft 13 journaled in bearings 14 and driven by a motor 15 through a V-belt drive 16. The shaft is water cooled through connections indicated at 17 and 18.

The detail of a preferred form of double inlet fan is shown in Figs. 3-11 (Sheets 2 and 3). The fan is composed of twelve blades, generally indicated at 50, two circular shrouds 51, and two hub portions 52 assembled on a hollow shaft 53.

In Figs. 3 and 4, it will be seen that each blade is composed of a generally flat plate having an inner portion or foot 54 with outwardly converging side edges 55 by virtue of which it becomes somewhat wedge shaped or delta shaped. Each side edge 55 is provided with flanges or machining pads 56, which join sector-shaped flanges 57, the twelve of them forming a circular group between the hub portions 52, as shown in Fig. 7. Each sector-shaped flange 57 is provided with an opening 58 aligned with an opening 59 in the adjacent flange 60 of the hub portions 52, and these aligned openings receive fastening dowel pins 61, 24 of them positively fastening and holding the blades against outward movement under centrifugal force. Those pins are in circular arrangement about the axis of rotation and in themselves, like the blades which they fasten, they tend to establish and maintain dynamic balance.

The main body of the inner portion or foot 54

of the blade is thickened relative to the outer portion 62, the inner portion being on the order of $\frac{3}{8}$ " thick and the outer portion on the order of $\frac{1}{4}$ " thick. The change in thickness is very gradual to avoid any abruptness, and avoiding abruptness is the rule throughout this fan construction. While no distinct line can be indicated for the change from one thickness to another, the thinner portion of the blade is roughly bounded by the line 63 in Figs. 3 and 4.

The machining pads 56 of the sector-shaped flanges 57 are joined to the inner portions 54 by gently curving fillets 64, generally indicated by shading. In order to provide metal and strength about the inner ends of the openings 58, bosses 65 are provided adjacent to the sector-shaped flanges 57, and they are joined to the thinner inner portions 54 by other gently curving fillets 66. The extreme inner edges 67 of the blades are comparatively straight, and, together, the twelve of them form a sort of polygon around the shaft 53 but spaced from it, as appears in Figs. 3 and 7. The flanges 57 are slightly longer than the intervening portions 54.

At or adjacent to each side edge, each blade is thickened to provide ribs 69 with flat faces 70 to bear against the inner walls of the shrouds 51. At the inner portions of the ribs 69, the blades are provided with hooks 71 providing openings 72 to receive the shrouds 51 and having shoulders 73 adapted to be opposite the inner peripheries of the shrouds.

Each shroud 51 adjacent to its inner periphery on the outside is provided with lugs 74, the adjacent faces of which define a passage 75 to receive one of the hooks 71 as the blades are assembled with the shrouds.

Each shroud is of uniform thickness except adjacent to the outer edge, where it is tapered, preferably by inclining from the outer side toward the inner side, as indicated at 76. This tapering reduces weight and places the mass of the metal in a position of advantage to resist the bursting tendencies of centrifugal force on the shroud. In one theory of design, they are considered like a flywheel, and it is assumed that one-half the centrifugal force is resisted by the metal lying along a diameter. Theoretically, therefore, the most effective distribution would be great thickness at the inner periphery and extreme thinness from there to the outer edge. The form shown is a compromise between theoretical perfection and practical necessity.

It will be apparent that the shrouds merely float on the twelve blades with freedom to expand and contract independently, the interlock between the hooks 71 and the lugs 74 serving to prevent slippage in accelerating and decelerating.

The flange 60 of each hub portion 52 has an inner flat face 77 for contacting with and bearing against the grouped flanges 57 of the blades. Outwardly of this face 77, which is at right angles to the axis, each flange 60 has an inclined face 78 provided with twelve slots 79 to receive and hold the machined faces 56 of the converging edges 55 of the inner portions 54 of the blades. While the slots are backed by a considerable thickness of flange metal, the inner portions are rounded at the corners 80 to avoid any abrupt change in surface that might foster cracks. The fit between the sides of the slots and the machined faces 56 is close and, together with the dowel pins 61, provides a strong driving and holding joint between the hubs and the blades. The adjacent

surfaces of the slots 79 and the machined faces 56 being remote from the axis of rotation, minor accumulations of tolerances will have less effect than they would have if those surfaces were close to the axis. Thus, the construction insures accurate and positive placing and holding of the blades in their relatively diverging positions with respect to the hubs in accelerating, driving, and decelerating. This accuracy also contributes to the smooth support of the shrouds on the twelve blades, both in operation and in expanding and contracting.

Each hub portion 52 has a bore to receive the shaft 53 to which it is keyed. The left hub portion 52, as shown in Fig. 3, rests against a shoulder S on the shaft, and the right hub portion is held against the blades by a large locking collar C, made fast by a lock nut N and a lock washer 81 having one tab 82 fitting in one of the key slots in the shaft 53 and other tabs 83 and 84 bent into the respective notches 85 and 86 in the lock nut N and the locking collar C. In initial assembly, the collar C is set up wrenchtight and then backed off enough to provide for expansion, which can be initially determined by calculations and corrected by empirical data.

The fan shaft is water cooled and is made of carbon steel. The hub portions 52 are of suitable alloy. The shaft and hub portions, therefore, have different coefficients of expansion. The tendency thus created to increase the clearance between the hub portions and the shaft as the fan is heated up is greatly augmented by the fact that the shaft is water cooled and the hubs are not. Bearing in mind that all of the fan is carried by the hubs on the shaft and that a 30-inch fan, substantially as shown in Figs. 3-11, will weigh on the order of 650 pounds, it is apparent that a slight eccentricity between the hub portions and the shaft results in enormous forces due to lack of dynamic balance. To prevent this condition and to obtain and maintain dynamic balance, three or more keys or splines are used to effect a driving connection between the shaft and the hub portions.

In Fig. 8, three keyways are shown at 120 degrees on centers, and that number will probably be most used, though four keys at 90 degrees are contemplated. The detail and advantages of this are discussed in my copending application Ser. No. 533,456, filed May 1, 1944.

In this embodiment of the invention, it is contemplated that the pins 61 will establish a circular datum line on which the blades are fastened to the hub members and by which centrifugal force is resisted. The blades are also held by the intimate relation between the inclined portions 79 of the flanges 60 and the grip on the machined faces 56 of the flanges 55. Hence, even if there should be a break through a blade in the general area of the pins 61, the blade would still be held by the flanges 60. If a break should occur beyond the grip of the flanges 60, the outer portion of the blade would be held against centrifugal force by the two shrouds, and thus be prevented from flying off tangentially to the probable destruction of the fan.

The embodiment shown in Figs. 12-17 (Sheets 4 and 5) corresponds to that just described except for a few differences in the connection between the shrouds and the edges of the blades. At or adjacent to each side edge, each blade in this latter construction is thickened and provided with grooves 168 whereby at each side of each groove there are ribs 169 and 170, the ribs

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170 being relatively short and the ribs 169 being relatively long. The latter are approximately as long as the shrouds are wide at their edges, and the former are about the depth of the slots in the shrouds.

Each shroud 151 is a ring provided with inwardly opening slots 90 adapted to receive the corresponding portions of the blades as the grooves 163 are slipped along the shrouds in assembling the blades by radially outward movement.

With this arrangement, as well as the form shown in Figs. 3-11 (Sheets 2 and 3) the shrouds that float on the blades are compelled to accelerate and decelerate with the blades, but can expand and contract independently of them and without putting any strain on them. They serve as a safety device to hold the outer portion of any blade beyond the hub flanges should the same break away from the inner portion.

Beyond the features described, the other parts in this embodiment shown in Figs. 12-17 (Sheets 4 and 5) correspond to those in the earlier embodiment, and they are indicated by the same reference characters.

In the construction shown in Figs. 18-22, the shrouds are given the duty of resisting centrifugal force in its entirety. This is somewhat extreme, and will probably find its chief usefulness in fans of light duty at relatively low temperatures among furnace fans.

Each blade 150, generally speaking, is a flat plate with inner extensions 150a curved, as best seen in Figs. 20, 21, and 22. Each blade has two feet 151 cylindrical on their inner surfaces to rest upon hub members 152 and secured to them by keys 153. The hub members are keyed to the shaft 53 by three keys 154 to maintain dynamic balance in spite of the differential of expansion, as heretofore explained.

Each blade at each side is provided with laterally extending pins 155 adapted to be received in slots 156 in the shrouds 157, which are held against lateral motion by heads 158 on the pins.

In order to lighten the shrouds, they are cut away between the slots 156, as indicated at 159.

This construction allows freedom of expansion and contraction between the several parts, and relatively outward movement of the blades is limited by the pins 155 in the slots 156 in the shrouds. They form the datum line and circular arrangement on which the blades necessarily come to rest in establishing dynamic balance.

In Figs. 23 and 24, there is shown a single inlet fan with the hubs and blades constructed and arranged after the fashion illustrated in Figs. 3-17, and the shrouds are interlocked with the blades somewhat after the fashion shown in Figs. 12-16, except that the inner shroud 251 is provided with keyhole slots 252 to receive the lugs 253 by which the blades and the inner shroud are interlocked.

I claim:

1. In a centrifugal fan, a plurality of blades in circular arrangement about a common axis of rotation with their inner portions converging inwardly toward said axis and their outer portions diverging outwardly from said axis, hub members in driving relation to the inner portions of

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the blades, a circular shroud at each side of the outer portions of the blades having its inner edge spaced radially outwardly from the hub members and provided with inwardly opening slots aligned with the blades, and projections on the blades engaged in said slots.

2. In a centrifugal fan, a plurality of blades in circular arrangement about a common axis of rotation with their inner portions converging inwardly toward said axis and their outer portions diverging outwardly from said axis, hub members in driving relation to the inner portions of the blades, a circular shroud at each side of the outer portions of the blades having its inner edge spaced radially outwardly from the hub members and provided with slots aligned with the blades and closed at their outer ends, and projections on the blades engaged in said slots.

3. In a centrifugal fan, a plurality of blades in circular arrangement about a common axis of rotation with their outer portions diverging outwardly from said axis and their inner portions converging inwardly toward the axis and having segmental flanges forming a circuit about said axis and having inner foot portions provided with outwardly converging side edges, a circular shroud at each side of the outer portions of the blades, projections on the blades engaged with the shrouds to hold them against individual outward movement, and hub members wedged within the circuit of the segmental flanges and having axially inclined opposed surfaces engaging the side edges of the inner foot portions of the blades.

4. In a centrifugal fan, a plurality of blades in circular arrangement about a common axis of rotation with their outer portions diverging outwardly from said axis and their inner portions converging inwardly toward the axis and having segmental flanges forming a circuit about said axis, an annular shroud at each side of the outer portions of the blades, projections on the blades engaged with the shrouds to hold them against individual outward movement, and hub members engaged with the circuit of segmental flanges on the inner portions of the blades and spaced radially inwardly from the inner edges of the shrouds.

5. In a centrifugal fan, a plurality of blades in circular arrangement about a common axis of rotation with their outer portions diverging outwardly from said axis and their inner portions converging inwardly toward the axis and each blade having symmetrically oppositely extending segmental flanges at each of its axial edges forming a circuit about said axis, an annular shroud at each side of the outer portions of the blades, projections on the blades engaged with the shrouds to hold them against individual outward movement, and a hub member keyed to each circuit of segmental flanges and spaced radially inwardly from the adjacent shroud.

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REFERENCES CITED

The following references are of record in the file of this patent:

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