July 19, 1932. A. D. GARDNER 1,868,008

FAN

Filed April 4, 1931 2 Sheets-Sheet 1

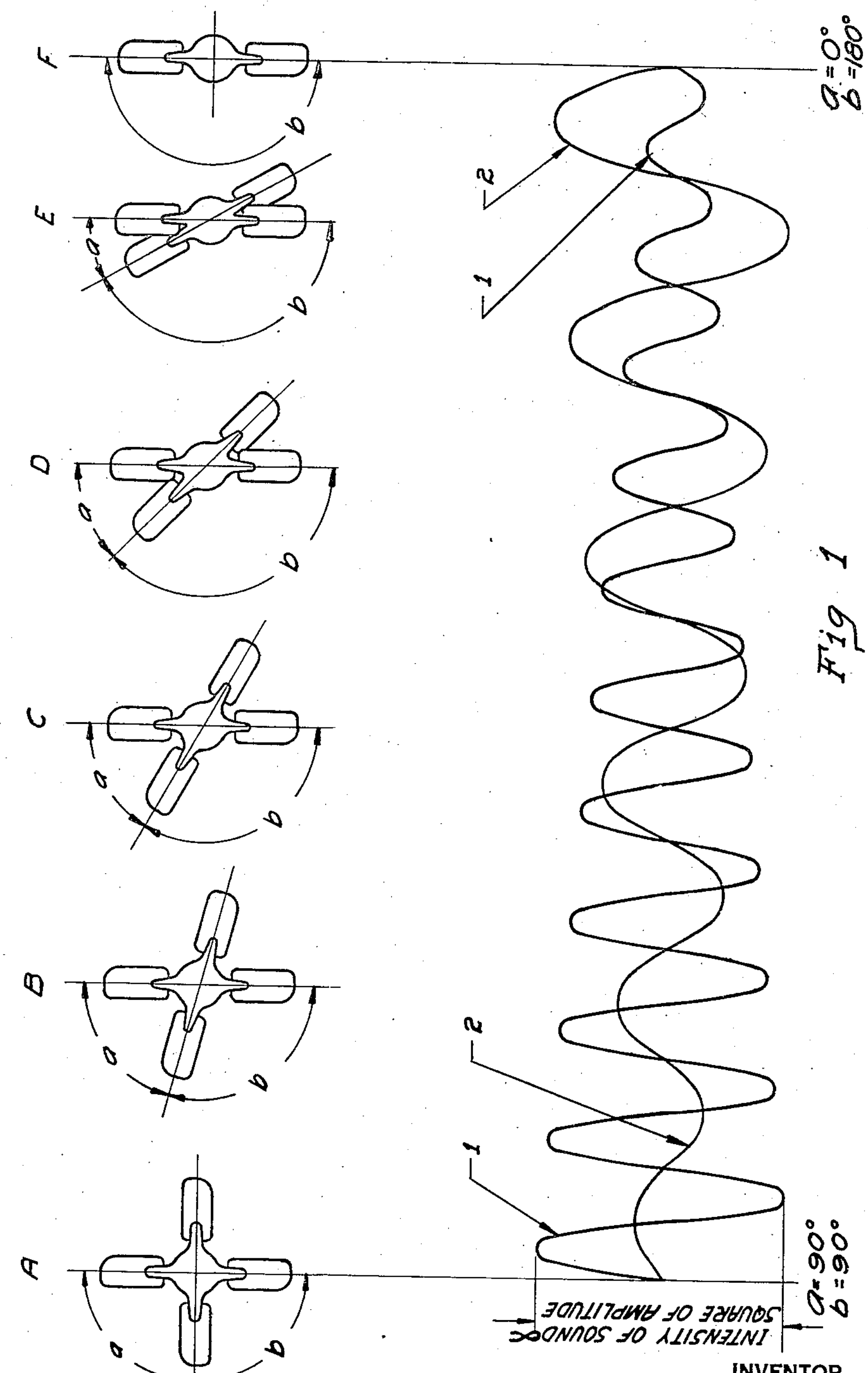

Fig 1

EFFECT OF ANGULAR SPACING ON RELATIVE INTENSITIES

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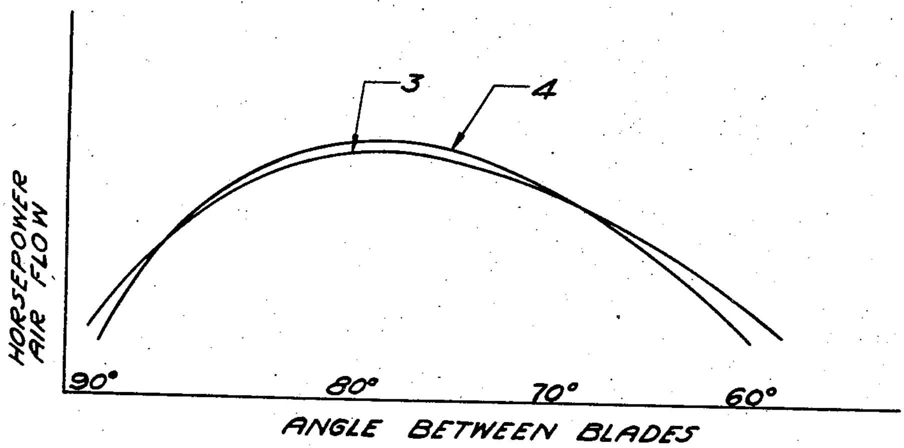

Fig 2

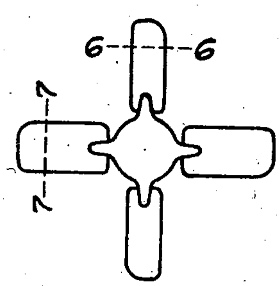

Fig 3

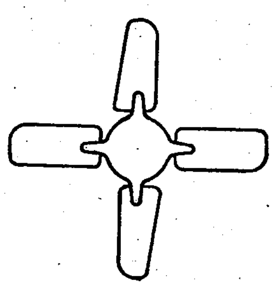

Fig 4

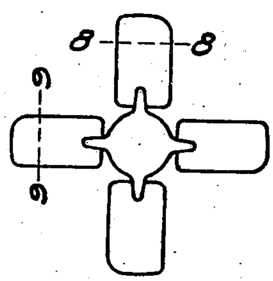

Fig 5

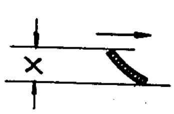

Fig 6

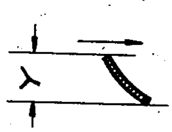

Fig 7

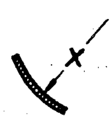

Fig 8

Fig 9

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Patented July 19, 1932

1,868,008

UNITED STATES PATENT OFFICE

ARCHIBALD D. GARDNER, OF JACKSON, MICHIGAN, ASSIGNOR TO AUTOMOTIVE FAN & BEARING CO., A CORPORATION OF MICHIGAN

FAN

Application filed April 4, 1931. Serial No. 527,679.

This invention relates to devices for producing a flow of air, such as fans for automotive devices and for other cooling purposes.

An object of the invention is to decrease apparent noise of fans used for the above mentioned purposes.

Another object is to increase the air flow produced by the fan.

Another object of the invention is to decrease the apparent noise by constructing a fan with blades having dissimilar spacing, projected width, shape, or curvature, or any combination of these features.

Still another object is to obtain an increase of air flow by employing fans with one, or any combination, of these features.

Other objects of the invention will appear in the following description, reference being had to the drawings in which:

Fig. 1 illustrates the dominant sounds of a four blade fan, illustrating the relation between the sound intensity and angle between blades.

Fig. 2 illustrates curves of air delivery and required power.

Fig. 3 illustrates fans with blades having different projected width.

Fig. 4 illustrates fans with blades having different blade shape or outline.

Fig. 5 illustrates fans with blades having different curvature.

Fig. 6 is a section taken on the line 6—6 of Fig. 3.

Fig. 7 is a section taken on the line 7—7 of Fig. 3.

Fig. 8 is a section taken on the line 8—8 of Fig. 5.

Fig. 9 is a section taken on the line 9—9 of Fig. 5.

In the automotive industry greater stress is being placed upon the elimination of noises in the automotive power plant, the cooling fan having been one source of such noises. In my researches I have discovered how to reduce these fan noises and to reduce the noise of the engine as a whole by harmonizing the fan noise with the dominant noise of the rest of the power plant.

Air requirements of automotive cooling fans are being constantly increased as performance requirements of the engine are increased. I have discovered how to deliver increasingly large amounts of air through the radiator core, and at the same time to reduce the noise of the fan to a volume comparable to, or even less than, other noises present in the power plant or other units.

On some cars I have found it practically impossible to eliminate noise with conventional types of fans; in fact, I have found in certain installations, practically no difference in volume or intensity of fan noise, between an extremely "noisy" fan (on some other installation) and a "quiet" fan, proven to be eminently satisfactory, on another installation. The fan and the parts surrounding it thus seemed to comprise a combination which was but little affected by changing from one fan to another of the same conventional type. Since an appreciable reduction in fan noise appears impossible under such conditions, I produce apparent quietness by altering the noise characteristics of the fan so that the fan noise blends, or merges, with the power plant noises at the speeds and under the operating conditions where it is outstanding. This is accomplished to varying extent in several ways:

1. Changing of the angular spacing of the fan blades about the axis of rotation.
2. Changing the projected width of some of the blades.
3. Changing the shape or outline of some of the blades.
4. Changing the curvature of some of the blades.

For a two-blade fan, the frequency of the sound given forth is

$$\frac{2\times \text{fan R.P.M.}}{60}$$

cycles per second; for a four-blade fan the fundamental frequency is twice as great, or

$$\frac{4\times \text{fan R.P.M.}}{60}$$

cycles per second, for a six-blade fan,

$$\frac{6\times \text{fan R.P.M.}}{60}$$

cycles per second.

For example, a two-blade fan gives forth the tone B of 120 cycles (in the bass clef) at about 3600 R. P. M.; a four-blade fan gives forth as a fundamental the tone *b* of 240 cycles (bass clef) at about 3600 R. P. M.; a six-blade fan the tone *c* (middle) at about 2560 R. P. M.

The four-blade fan is in reality two two-blade fans, and the fundamental sound given forth may be considered as made up of sound having frequency of (*a*)

$$\frac{4\times \text{R.P.M.}}{60}$$

cycles per second (four-blade whine) and (*b*)

$$\frac{2\times \text{R.P.M.}}{60}$$

cycles per second (two-blade roar). When the angle between adjacent blades is 90 degrees, then the intensity of the two-blade sound becomes a minimum, as shown by the curve 2 under fan adjustment A of Fig. 1, and intensity of the sound wave of four blade frequency is represented by the curve 1.

The four-blade sound thus strongly predominates when the blades are 90° apart. As the fan blades are shifted to gradually decrease the angle *a* at B, C, D and E, the intensity of the four-blade sound, decreases and the intensity of the two-blade sound, increases, until at F the two-blade sound is a maximum and the four-blade sound is a minimum. At this position the two pairs of blades may be considered as having merged into one. It will be seen that the so-called four-blade sound is in reality the octave of the two-blade sound similarly the corresponding component of a six-blade fan is the double octave.

For positions A, B, and C, the higher frequency four-blade sound is dominant while for positions D, E, and F, the lower pitched two-blade sound is dominant.

In determining the most suitable angle to be used for any given installation, the first step is to observe the noise characteristics of the power plant under various conditions of speed and throttle opening without the fan. This can be done by comparing the pitches of the various noises with a tuning fork, or by actually measuring the noises with one of the more elaborate recording instruments, of which there are a number available.

The second step is to install the fan and take the same observations on the fan.

A comparison of the frequencies of the sounds as determined above will enable the observer to specify rather closely the most suitable angle, after which the exact angle can be determined by check runs, the object being to adjust the fan so that its dominant sound or noise will be the same as the dominant noise of the engine or an overtone that harmonizes therewith.

Making the above observations and comparisons is sometimes somewhat involved so that for general use it is best to employ the cut-and-try method of making observations for a given blade position, then repeating for a slightly different angular spacing of blades until the whole field of angularity is covered, noting the combined engine-fan noise effect for each setting. One may then re-test two or three positions of best noise results to determine the exact angular setting.

In some cases changing angular spacing of blades as little as one degree makes a noticeable difference in the extent to which the fan sound stands out above the other noises, while on other installations a change of five degrees is necessary to show a change in noise characteristics.

As regards the effect of angular spacing of blades on the quantity of air delivered by the fan, it has been found on a certain four-blade fan, for instance, that the air flow does not drop off, in fact actually increases, as the angle is changed from 90 degrees to about 75 degrees. For angles below 75 degrees the air flow drops rather rapidly. This is shown in Fig. 2 where 3 indicates the curve of air flow and 4 the curve of horse power. The horse power requirements follow the air flow curve rather closely over a rather wide range of values of angle between blades.

Instead of varying the angle between the blades, one may secure similar results by designing one pair of blades with one value of projected width and the other pair (in a four-blade fan) with a different value of projected width; also, one may make one pair of blades with a certain shape, say with parallel sides, and another pair with a different shape, say, with converging or diverging sides; likewise, one may construct one pair of blades with one particular curvature and the other pair with still another curvature.

In Figs. 3, 6 and 7 I have shown a fan with equal angular spacings. The blades of each opposed pair have the same projected width but the projected width of one pair *x* is different from the projected width *y* of the other pair.

In Fig. 4 I have shown a four-blade fan

in which the blades of each pair have the same shape but each pair has a different shape than the other.

In Figs. 5, 8 and 9 I have shown a four-blade fan in which one pair of similarly curved blades has a different curvature than the other pair.

In harmonizing the noises with fans having blades of different projected width, shape or curvature one may follow the method already outlined in connection with fan blades having different spacing.

It will be apparent that one could vary still other features of the fan blades to produce a variation of tone. The various features I designate as characteristics of the blades.

When a particular type fan has been fitted to a particular type engine it can be used as standard equipment for all engines of the same construction.

While I have illustrated fans with variation of only one feature or characteristics in each of the figures, similar results can be obtained by varying two or more of the features of the blade.

I have illustrated fans with opposite blades so as to have static balance but the same result can be obtained by using an uneven number of blades where the blades will not be directly opposite. In such cases the characteristics can be varied while still obtaining static balance by the inherent position of the blades.

While I have described this invention with particular reference to cooling fans, it will be apparent that the same principle applies to propellers in airplanes and the claims are not to be limited to any particular device.

The fan construction per se is not claimed herein. It is made the subject of a divisional application filed June 7, 1932, Serial No. 615,813.

Having described my invention, what I claim is:

1. In combination, an engine having certain dominant sounds, a member rotated thereby and a plurality of fan blades attached to said member and positioned to produce dominant sounds combining with the first mentioned dominant sounds to produce minimum resultant noise.

2. In combination, an engine having certain dominant sounds, a member rotated thereby and a plurality of blades attached to said member to rotate in substantially the same circular path and unequally spaced to produce dominant sounds combining with the first mentioned dominant sounds to produce minimum resultant noise.

In testimony whereof, I have signed my name to this specification this first day of April, 1931.

ARCHIBALD D. GARDNER.