Oct. 31, 1950 C. H. ALLEN ET AL 2,528,026

HIGH-FREQUENCY SIREN

Filed Aug. 18, 1948 3 Sheets-Sheet 1

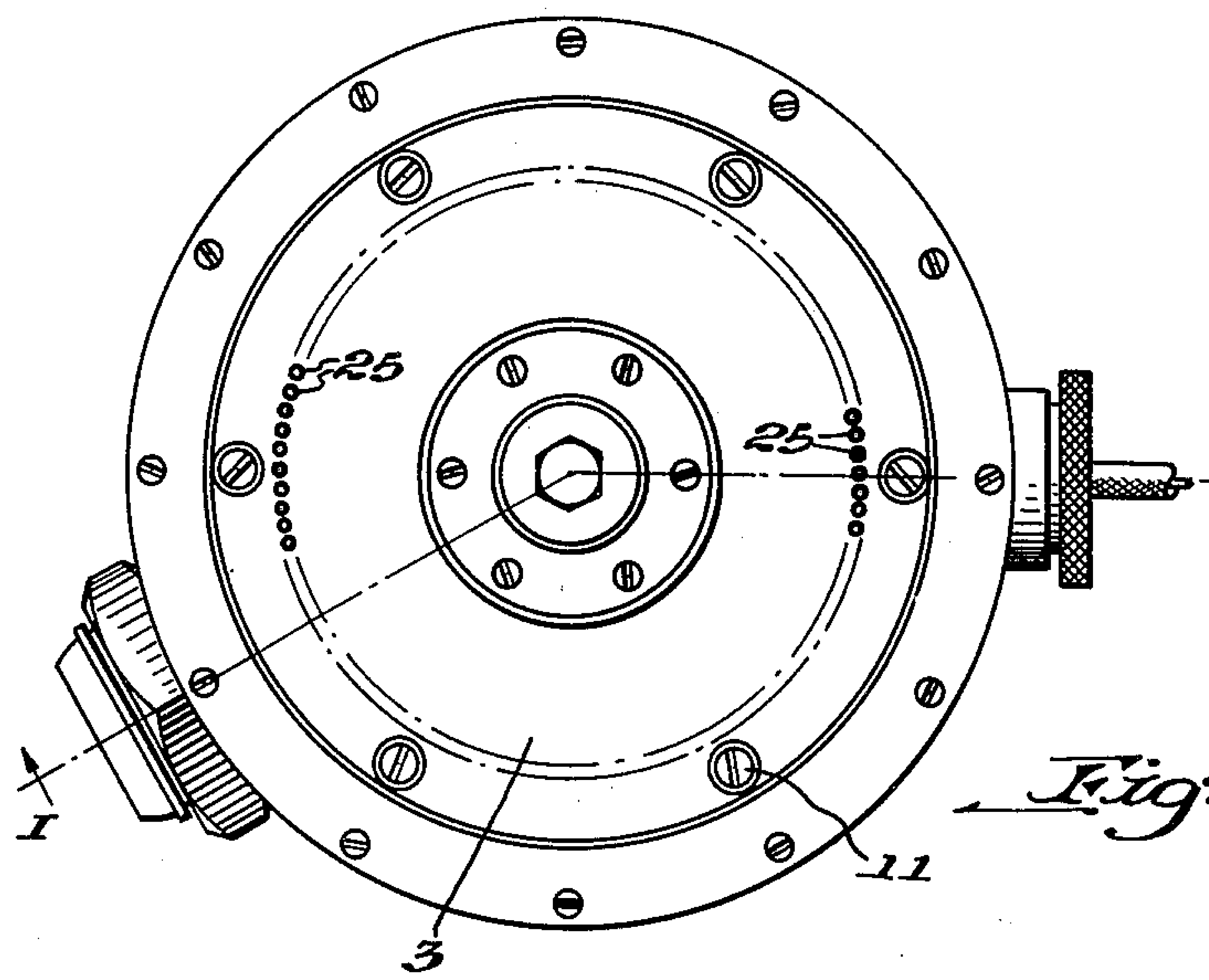

Fig. 2.

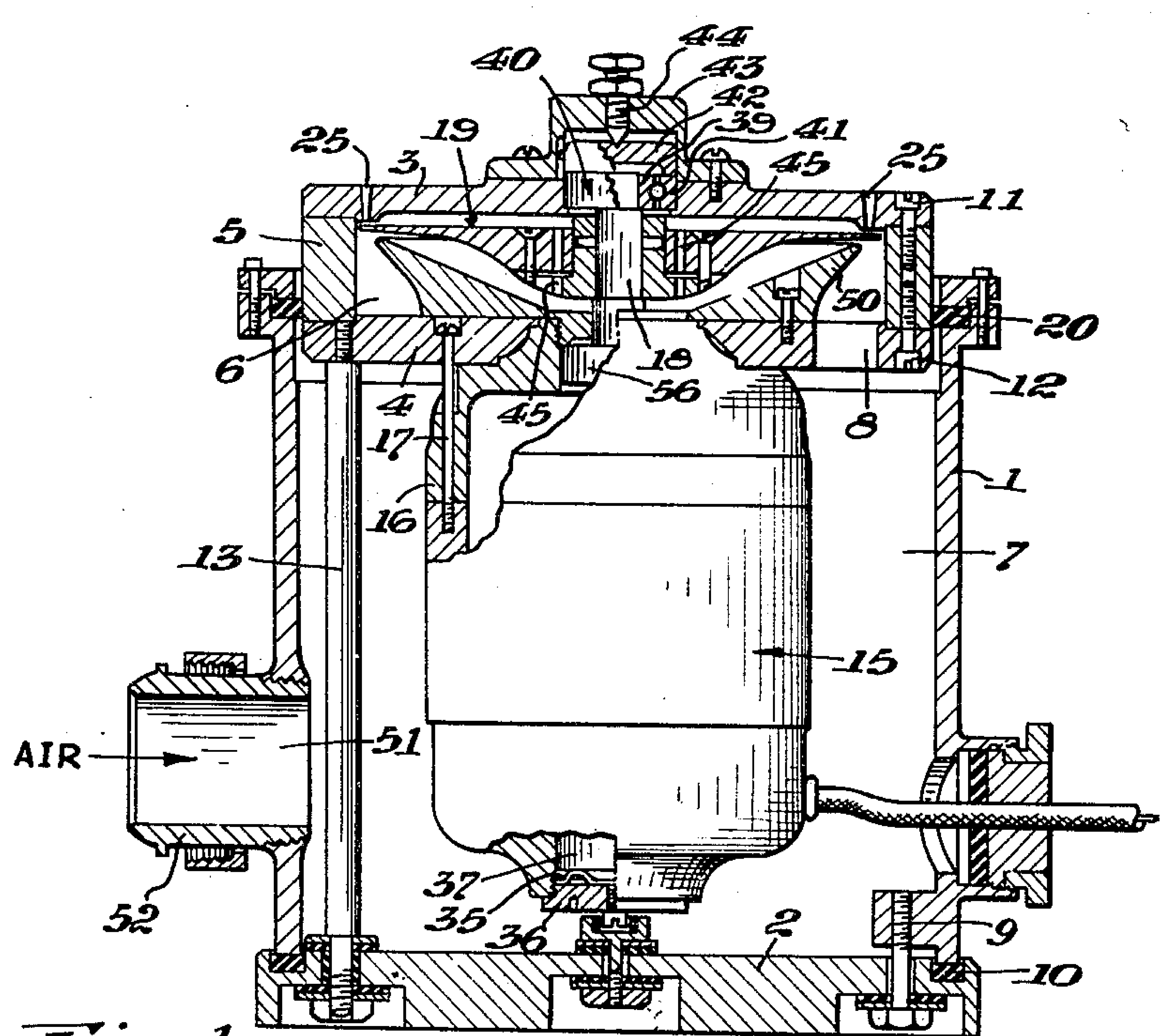

Fig. 1.

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HIGH-FREQUENCY SIREN

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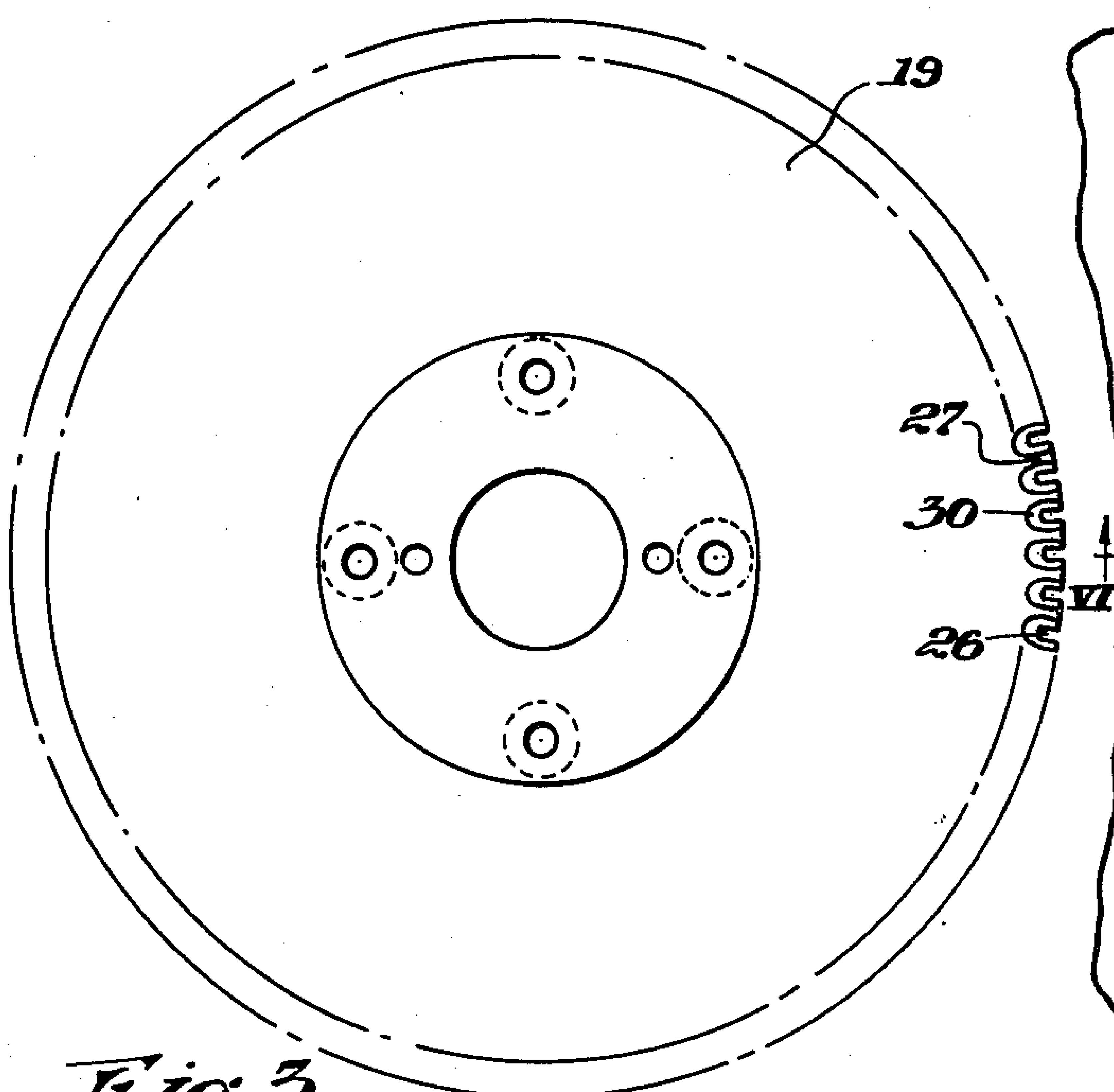

Fig. 3.

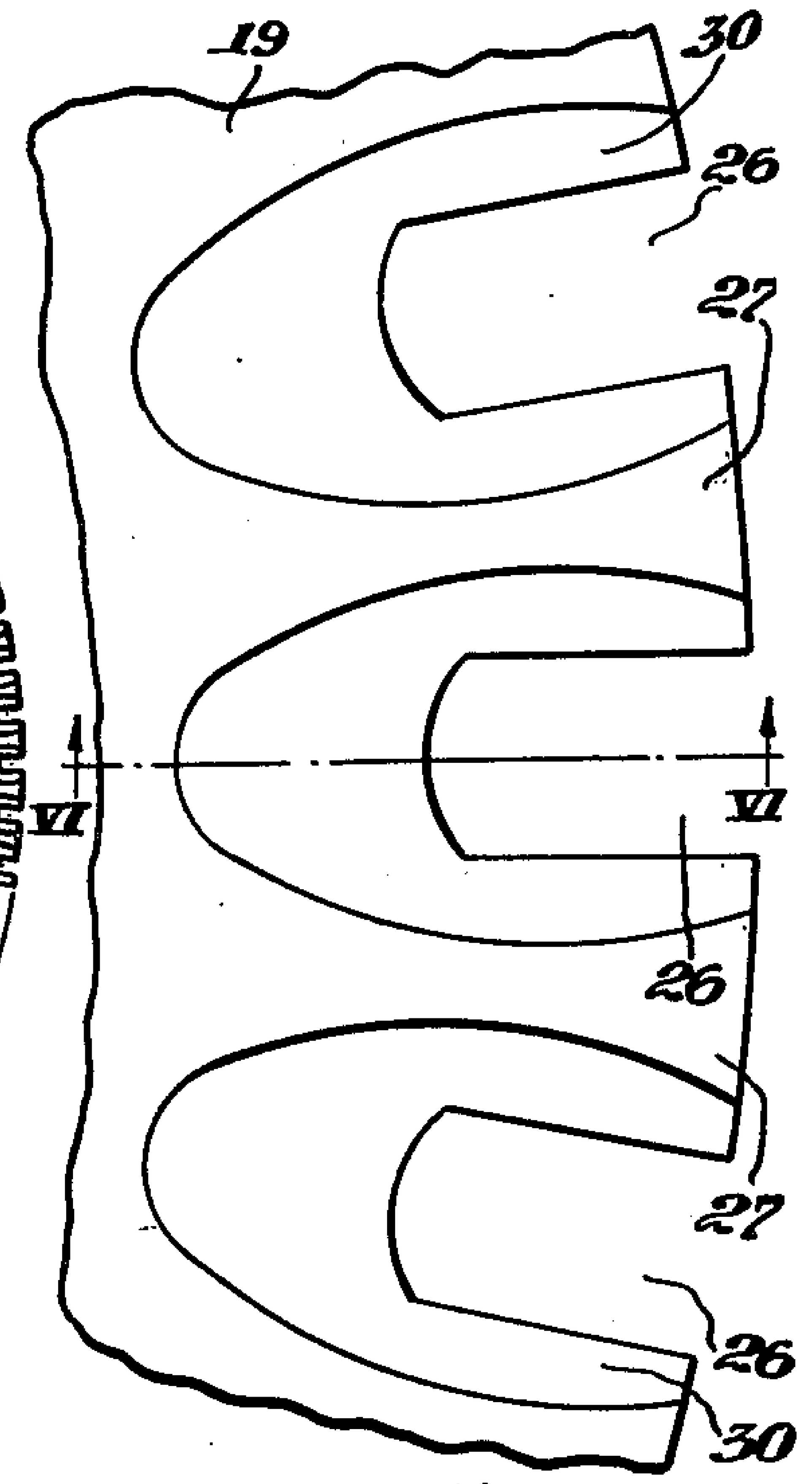

Fig. 4.

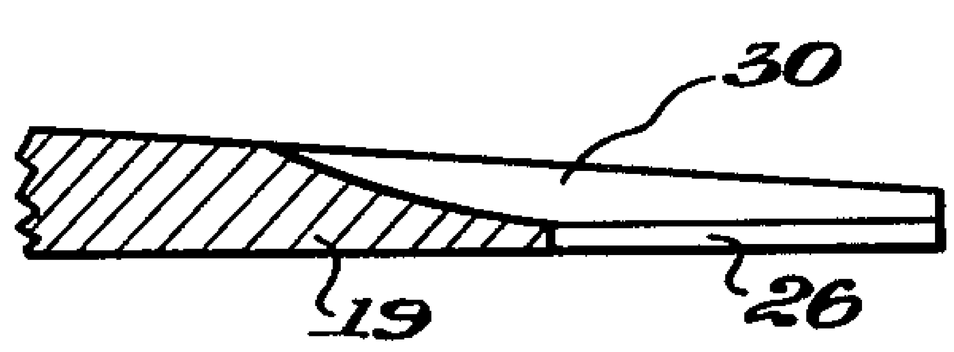

Fig. 6.

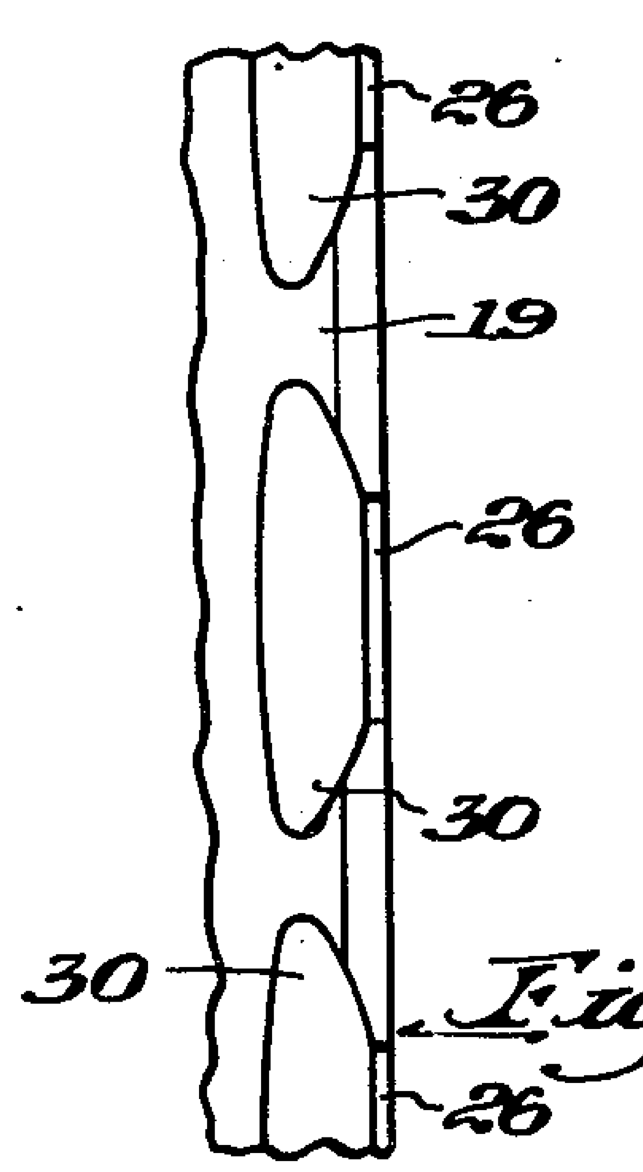

Fig. 5.

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HIGH-FREQUENCY SIREN

Filed Aug. 18, 1948 3 Sheets-Sheet 3

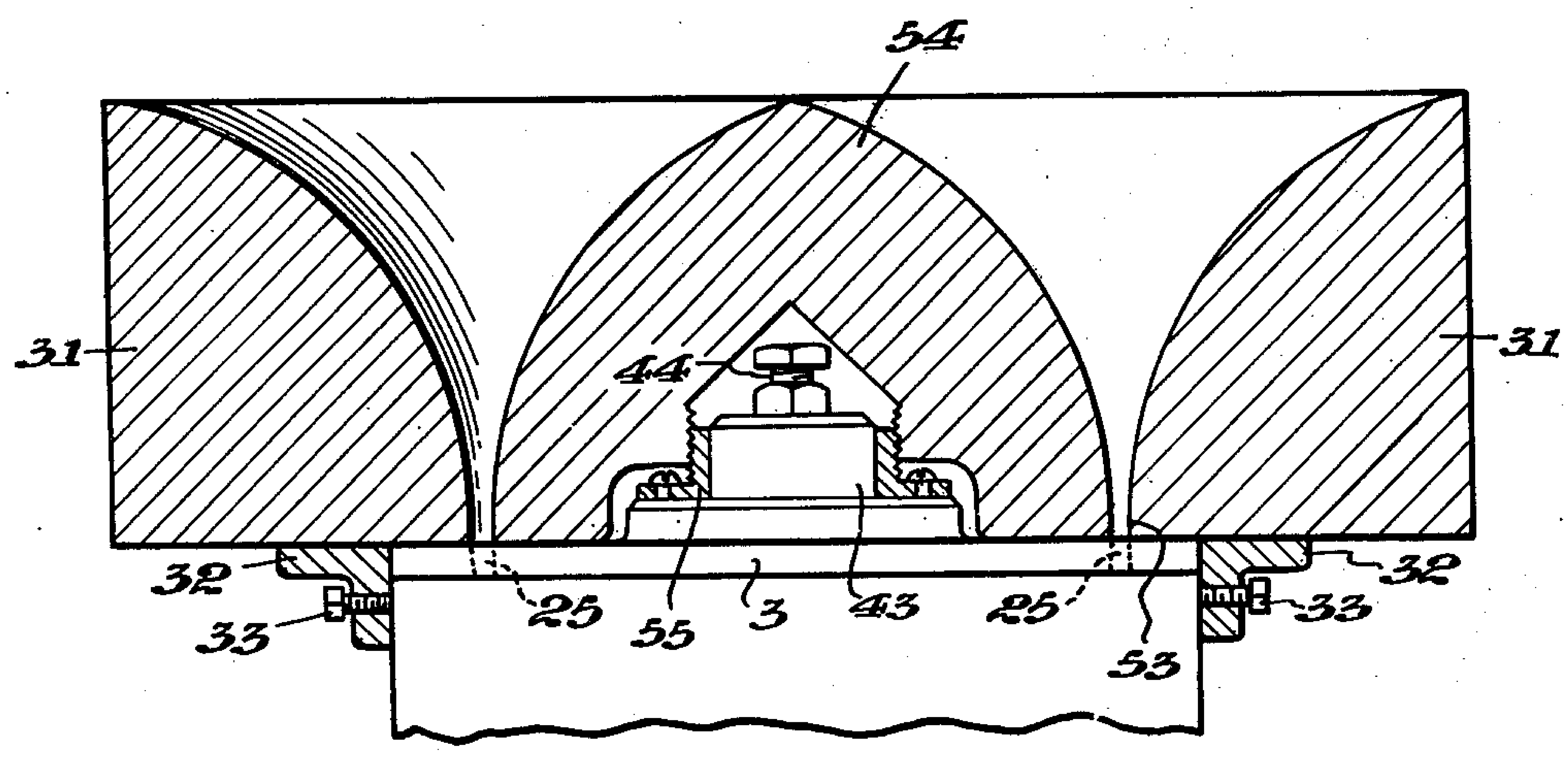

Fig. 7.

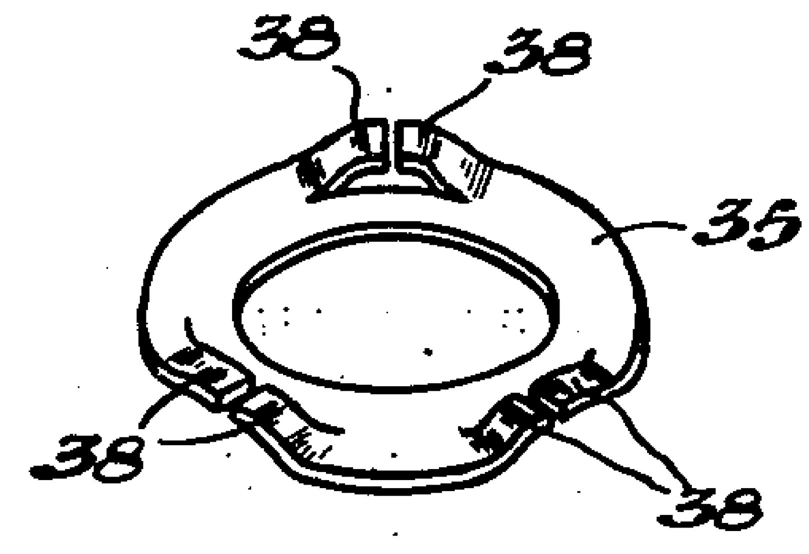

Fig. 8.

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UNITED STATES PATENT OFFICE

2,528,026

HIGH-FREQUENCY SIREN

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Application August 18, 1948, Serial No. 44,888

12 Claims. (Cl. 116—137)

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The invention relates to sirens of the type in which a fluid under pressure, usually air, intermittently escapes through spaced ports in a stator which are alternately opened and closed by a rotating rotor provided with spaced apertures and port closures.

The general object of the invention is to improve the construction, and the consequent performance, of such sirens to the end that they may produce very high intensities at high frequency ranges up to and above 30 kilocycles per second.

A specific object is to provide a siren of the type described which is a small, light, and portable, but intense and highly directional, high frequency sound source.

Another object is to provide a siren of the type described with means to produce intense sound with high efficiency over a wide frequency range, the upper limit of frequency range being up to and in excess of ten times the lower frequency limit.

Another object is to provide a siren of the type described with means to easily vary the frequency of the sound produced over the above-mentioned frequency range and to maintain this frequency fixed within close limits at any desired frequency within said range.

Another object is to provide a siren of the type described with means for so adjusting the rotor with relation to the stator that the face of the rotor may be maintained so close to the stator that the flow of air through the stator ports is effectively interrupted even at the highest frequencies of operation, and consequently high efficiencies maintained at such frequencies.

Another object is to provide a siren of the type described with a strong disc-like rotor having a thin peripheral portion provided with a plurality of apertures and port closures, the peripheral portion being sufficiently stiff to prevent substantial deflection by the pressure of air in the siren casing, but being thin compared with the distance the air can go through the ports during the short time interval that the ports are open at the highest operating frequency.

Another object is to provide a siren of the type described with a casing forming an air supply chamber in which the motor is mounted and is cooled by air passing through the chamber.

Another object is to provide a siren of the type described with a casing forming an air supply chamber having therein a deflection plate adjacent to the rotor to reduce turbulence of air in the casing and to distribute such air substantially uniformly to a plurality of stator ports.

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The preferred embodiment of our invention is illustrated in the accompanying drawings, of which Fig. 1 is a vertical sectional view through the siren when positioned to discharge air impulses vertically, the plane of view being indicated by the line I—I, Fig. 2; Fig. 2 a plan view of the siren; Fig. 3 a plan view of the rotor of the siren; Fig. 4 a plan view to materially enlarged scale of air escape apertures and port closures at the periphery of the rotor; Fig. 5 an end view of the portion of the rotor shown in Fig. 4; Fig. 6 a sectional view taken on the line VI—VI, Fig. 4; Fig. 7 a central transverse sectional view of an exponential horn associated with the top of a siren as seen in Fig. 1; and Fig. 8 a plan view of an armature biasing spring.

The general construction of the siren will first be explained, and then the special features of its construction that make it possible to operate the siren effectively and efficiently to produce high intensity sound waves at high frequency ranges. In the description of the siren it is assumed to be in the position shown in Fig. 1 for discharging vertically, although the siren may be positioned to discharge in any direction.

The siren includes a casing which forms a chamber for air under pressure, the chamber preferably being large enough to contain an electric motor for driving the siren rotor. As illustrated in Fig. 1, the casing comprises an outer cylindrical shell 1, a bottom plate 2, and a top plate 3 which is constructed to form the ported stator of the siren. Adjacent to the top of the siren there is a transverse plate 4 which, with top 3 and an annular ring 5 forms a rotor compartment 6 that communicates with main air chamber 7 within the casing by openings 8 formed in plate 4.

Bottom 2 and transverse plate 4 are connected to each other in their spaced relationship by a plurality of supports or rods 13, and bottom 2 is connected to the lower end of the shell or side wall 1 by bolts 9, there being an annular packing ring 10 between the lower edge of shell 1 and bottom 2 to isolate vibrations and prevent noise resulting from them. Stator plate 3 is connected to the top of ring 5 by bolts 11, and transverse plate 4 is attached to the bottom of the ring by bolts 12. An annular sealing ring 20 between casing ring 5 and shell 1 provides a flexible sliding connection which isolates vibrations, provides for such relative motion of casing ring 5 with respect to shell 1 as may accompany changes in temperature or chamber pressure, and maintains a tight pressure seal between the two parts. Within air chamber 7 there is a variable high speed (e. g. 300 revolutions per second or higher) electric motor 15 having a divided housing 16 that is rigidly connected to and supported by transverse plate 4 by bolts 17. The rotatable armature of motor 15 is provided at its upper end with a shaft 18 that extends through rotor compartment 6, and to which a disc-like rotor 19 is directly and rigidly attached.

The stator 3 is provided with a plurality of like ports 25, the axes of which are parallel to the axis of rotor 19 and intersect a circle having its center on such axis. For high intensity it is desirable to space the ports very close to each other, as shown in Fig. 2. Preferably they are spaced from each other not more than twice the diameter of their outlets nor less than twice the diameter of their inlets. As shown particularly in Fig. 3, the peripheral portion of rotor 19 is provided with a plurality of apertures 26 which may be openings through the rotor but are preferably spaces between teeth 27 that form closures for port inlets. In a siren such as this, the frequency of the sound produced is equal to the number of apertures in the rotor multiplied by the revolutions per second of the rotor. Accordingly, to obtain high frequency the rotor must be rotated at a high rate of speed and its periphery must be provided with a large number of alternately arranged apertures 26 and port-closing teeth 27. By providing the stator 3 with a corresponding number of uniformly spaced ports 25, a high intensity sound source is produced.

We have constructed a siren the same as that shown in the drawings having its stator provided with 100 ports and its rotor provided with 100 apertures, both lying in circles having three inch radii, and in its operation have produced frequencies from 2.5 to 37 kilocycles per second, and have obtained intensities greater than 175 decibels when using air that was continuously supplied under a pressure of about 30 pounds per square inch above atmospheric.

For producing such high frequencies, the peripheral portion of the rotor should be as thin as possible to facilitate the flow of air through its apertures when they register with the inlets of the ports in the stator, but the rotor must be of such strength that it will withstand the stresses of its high rotating speeds, and be of such rigidity that its peripheral portion will not be deflected against the plane of the inlets of the stator ports under the pressure of air on the lower face of the rotor. Such peripheral thinness combined with structural strength and stiffness cannot be attained by a rotor having uniform thickness throughout, or by one that is tapered uniformly throughout.

We have found that adequate strength and rigidity is attained in a rotor having a thin peripheral portion if its shape from its center to its periphery is such that the thickness of the rotor varies with the distance from its center according to the following relation:

$$Z=Ae^{-Bx^2}$$

In this relation, Z is the thickness of the rotor at any distance x from its center, A is the thickness of the rotor at its center, e is the base of natural logarithms, and B is a constant that determines the rate at which the thickness decreases with the distance from the center. The value of B may be determined from the following expression:

$$B=s\frac{W}{g}\frac{(2\pi n)^2}{2T}$$

In this expression s is the desired safety factor, W the weight per unit volume of the material of which the rotor is made, g the acceleration due to gravity, n the maximum desired rotor speeds in number of revolutions per second, and T the yield point of the material of which the rotor is made. In applying the foregoing to a determination of the shape of the rotor, there is chosen a thickness at the periphery of the rotor such that it will be small compared with the distance air can travel through the ports during the time interval that the ports are open, and such that for the metal used it will be sufficiently stiff to resist substantial deflection under the maximum air pressure to be used in the siren. Having chosen such thickness, the shape of the rotor to provide it with adequate strength may be determined from the foregoing data.

While the efficiency of the siren is increased by decreasing the thickness of the rotor adjacent to its apertures, there is little further increase in siren efficiency if such thickness is decreased to less than one-fifth of the distance the air can travel through the ports in the time interval during which the ports are open. By way of example, and not of limitation, good efficiency is obtained in a siren of the type herein disclosed, when operating at 30 kilocycles per second, if the thickness of the rotor at its periphery lies between about .030 and .010 of an inch. The lower limit is determined principally by the stiffness of the metal used or by the inability to machine it thinner, while the upper limit is determined by the maximum operating frequency and pressure. The upper limit increases (although not linearly) with the value of operating pressure chosen, and decreases reciprocally with increase in desired maximum operating frequency. If the rotor is made too thin it is liable to vibrate or deflect seriously under the pressure of the air in the chamber.

The preferred shape of the rotor teeth 27 to form apertures 26 is shown in Figs. 4, 5 and 6. To reduce air turbulence, the lower face of the rotor adjacent to each aperture is provided with a bevel 30 in shallow arc shape at each side and the inner end of each aperture, the bevel at the inner end being longer than those at the side. By way of example, and not of limitation, the bevel is such that the edges of the teeth at the margins of the apertures are about one-quarter as thick as the teeth at the inner ends of the apertures. To obtain high efficiency, theory indicates that the width of the teeth and apertures in the rotor should be equal, and equal to each other, and should be several times as wide as the diameter of the inlets of the ports in the stator so that the time interval during which the ports are fully opened or fully closed should be long compared with the time intervals during which the ports are being opened or closed. In actual practice, due to limitations on rotor speed imposed by material strength and by speeds of commercially available motors, for high frequency operation the smallness of the stator openings required by such a design greatly reduces the possible power output because of the high flow resistance and small total area of opening through which air may discharge. It has been found that reasonably high efficiency, 20 to 40 per cent, has been obtained using teeth and apertures approximately equal to each other, the apertures being slightly greater in width than the diameter of the port inlets. The teeth should be slightly wider than the diameter of the port inlets, and may be as much as twice such diameter, to assure positive closure of all ports simultaneously. The apertures between the teeth are preferably the same width as the teeth, but may be slightly narrower with good results.

When the siren is operated at high frequencies, in the neighborhood of 35 kilocycles per second and higher, the wave length of the sound that is radiated from the stator ports is less than one-half inch, which is the approximate thickness of stator plate 3 necessary to give it sufficient mechanical strength. Accordingly, as shown in Fig. 1, each port 25 is flared outwardly from its inlet to its outlet in conical shape to form a complete horn in itself. This flare is approximately 5.1 degrees to the axis of each port. The diameter of the outer end of each port is about one-half of a wave length at the higher frequencies, and the inner end is about one-quarter of such wave length, in view of which the outer end is a good and the inner end a poor radiator. Accordingly, sound is radiated from the siren much more readily than back into it.

When operating the siren at lower frequencies, which result in wave lengths materially greater than the diameter of the outlets of the stator ports, acoustic output and efficiency is increased by detachably connecting a two-piece, concentric, exponential horn having an undivided inlet annulus, or throat, 53 (Fig. 7) which lies directly above the circular ring of ports 25 in the stator, and has an area approximately equal to the combined outlet area of those ports. Such a horn consisting of outer and central parts 31 and 54 is shown in Fig. 7. As shown, these parts are separate blocks, the central part 54 being shaped in all transverse axial planes thereof the same as shown in Fig. 7. The outer part 31 is a ring within which the central part 54 is positioned to form, with part 54, throat 53 and the remainder of the exponential horn space. Ring 31 is shaped in all transverse axial planes thereof the same as shown by the section line on Fig. 7. The bottom of outer part 31 is provided with a flanged ring 32 having an inner face that fits neatly on the peripheral face of stator plate 3, the depending flange of the ring being provided with setscrews 33 for detachably clamping the horn to the siren. The central part 54 of the horn is connected to the siren independently from the outer part 31 by means of a threaded hub 55 which fits around or may be made part of the flanged cap 43. For high frequency operation it has been found that the use of the outer section 31 of the horn alone as an exponential baffle without the inner section advantageously deflects the discharged direct air stream from the ports outwardly along the surface of such baffle, and thus leaves the central region above the siren substantially free from the direct air current discharged from the ports.

The high frequency of the siren attained by the large number of alternately disposed rotor apertures 26 and teeth 27 makes it necessary to form relatively small ports 25 in the stator, which results in a substantial resistance to the flow of air through the ports when they are open. Also, the smallness of the teeth materially decreases the resistance to air leakage when the ports are closed. For high efficiency the leakage resistance must be kept high compared with the flow resistance. To accomplish this, means are provided for maintaining the top surface of the rotor accurately positioned close to the surface of the stator adjacent to its port inlets and for adjustably positioning the rotor to effect the desired spacing of it from the stator while the siren is either stopped or in operation.

In the illustrative embodiment of this feature of the invention, the armature of the motor is yieldingly urged upward by a spring 35 which acts between a plug 36 at the lower end of the motor housing and a thrust ball bearing 37 that surrounds and engages the lower end of the armature shaft. As shown in Fig. 8, spring 35 may be formed of a ring of spring metal that is provided with slits midway between its inner and outer edges to form tongues 38 that are bowed upwardly to engage the outer race of thrust bearing 37. Under the action of such spring, the armature shaft, which is located laterally by lower bearing 37 and upper bearing 40 in the motor housing, and to the upper portion 18 of which rotor 19 is directly and rigidly connected, may be moved upwardly to press the peripheral portion of the upper face of the rotor 19 firmly against the portion of the stator adjacent to the inlets of its ports 25 which lie in the continuous face of a smooth annular boss, as shown.

At its upper end, armature shaft 18 is provided with a shoulder which is engaged by the inner race 39 of a thrust bearing 40, the outer race 41 of which is completely free from the wall of the central opening of stator 3. Above bearing 40, there is an inverted cup 42 the edge of which bears upon the top of race 41. This cup is inclosed by a flanged cap 43 which is attached to the top of stators 3, and is provided at its top with an adjusting setscrew 44, the lower end of which bears centrally upon the top of cup 42. The cap and setscrew are provided with interengaging threads of such small pitch that by turning the setscrew a micrometer adjustment of cup 42, and consequently of armature shaft 18, may be effected to variably position the top of the rotor with relation to the bottom of the stator as desired, and such adjustment may be effected while the siren is in operation.

To substantially equalize the pressure of the air on the upper and lower faces of the rotor, and consequently to preclude material upward deflection of the thin periphery of the rotor or substantial overloading of the thrust bearing 40 by the pressure of the air, the rotor is provided with one or more transverse openings 45.

In the operation of the siren, it has been found possible, and highly efficient for high speed operation, to so withdraw adjusting screw 44 that the rotor is pressed against the stator by the action of spring 35. The rotor and stator then remain separated by a thin film of air which acts as an effective lubricant as long as the rotor is driven at high speed, but the rotor cannot be stopped without damaging it unless setscrew 44 is so moved inwardly that there is some positive clearance between the rotor and stator. By adjusting setscrew 44 so that the rotor presses against the stator, air leakage through stator ports 25 between impulses is eliminated, and by adjusting so that there is positively maintained a very small space between rotor and stator such air leakage is negligible. In both cases the result is that the efficiency of the siren is reduced little, if any, by such leakage.

Within rotor compartment 6, and attached to the top of transverse plate 4, there is a deflection plate 50, the outer edge of which terminates just short of the inner ends of rotor apertures 26. This plate serves the double function of materially reducing turbulence of the air in the air chamber of the siren, thus advantageously reducing the drag on the rotor and of effecting a substantially even distribution of the air in rotor compartment 6 so that it flows substantially uniformly through stator ports 25.

Air is supplied to the main air chamber 7 of the siren through an opening 51 in the lower portion casing shell 1, a pipe coupling 52 being attached to the shell at such opening. This air forms a motor cooling medium, part of the air flowing through the motor and part of it flowing around the motor housing. This air so cools the motor that it can be safely operated much above its rated full load power and speed, thus enabling generation of desired high frequencies with a relatively small light-weight motor.

A siren embodying this invention has been constructed the same as shown in the drawings, has been used extensively in laboratory studies of high acoustic intensities in frequency ranges as high as 37 kilocycles per second. In such use of the siren some striking phenomena have been observed. The high acoustic power of the siren when operated at high intensities has been demonstrated by setting fire in six seconds to a wad of cotton held a few inches above the siren, and by similarly burning steel wool in about a minute. The acoustic power was found to exceed 2 kilowatts. Its power has been further demonstrated by floating articles in antinode surfaces between the siren and a sound reflector a few inches from the stator. For example, it was found that as many as seven marbles, ¾ of an inch in diameter, floated simultaneously in a single antinode surface. They clung together and spun as a group with increasing angular velocity, about the central one in a horizontal plane, until they flew apart. If the spinning was inhibited by touching the group with a stiff wire probe, the marbles stayed in the field indefinitely. Mice and insects have been subjected to the intense sound generated by the siren and have been injured or killed by the effects of such sound in a matter of a few seconds or a few minutes depending upon the type of animal exposed.

Because of its very high frequency and intensity, the siren may advantageously be used commercially for vibrating liquids and gases. For example, clothing may be effectively cleaned or washed by placing it in a body of water that is vibrated by the action of the siren, and various chemical reactions in liquid chemical mixtures may be activated by similarly vibrating the liquids. As to the action of the siren on gases, it may be used to precipitate smoke and other solid particles from products of combustion, and the like. Experiments with mice and insects indicate that this siren might be very useful in biological research and in pest control.

In the operation of the siren, air is supplied to air chamber 7 through opening 51 in the casing and under pressures which have varied from 5 to 30 pounds per square inch above atmospheric. Motor 15 has been operated at variable speeds to produce air impulses at frequencies of 37 kilocycles per second and higher, the wave lengths being less than a half inch at the higher frequencies.

By using suitable motor controls, the higher siren frequency limit may be more than ten times the lower frequency limit, and any given frequency may be maintained within close limits.

Before starting the siren, setscrew 44 is adjusted positively to position against the resistance of spring 35, the upper face of rotor 19 a very small distance below the plane of the inlets of stator ports 25, but when the rotor is operating at a high speed the setscrew may be turned outwardly so that it does not positively space the rotor from the stator. When that is done a thin film of air between the rotor and stator acts as a lubricant to prevent the rotor from rubbing on the stator, but when the frequencies are reduced and before the operation of siren is stopped it is necessary again to adjust the setscrew positively to position the rotor below the stator.

According to the provisions of the patent statutes, we have explained the principle and mode of operation of our invention, and have illustrated and described what we now consider to be its best embodiment. However, we desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

We claim:

1. A high frequency siren comprising a casing forming a chamber for air under pressure and having an end wall provided with a plurality of equally spaced ports having their axes lying in a circle and having their inlets lying in a plane, a motor within said casing having its armature shaft perpendicular to the plane of said port inlets, a disc-like rotor rigidly connected directly to said shaft and having a thin peripheral portion provided with equally spaced apertures positioned to register simultaneously with the inlets of said ports, means yieldingly urging said shaft towards the plane of said port inlets, and adjustable means for moving said shaft in the opposite direction positively to space the face of said rotor variably from the plane of said port inlets.

2. A high frequency siren comprising a casing forming a chamber for air under pressure and having an end wall provided with a plurality of equally spaced ports having their axes lying in a circle and having their inlets lying in a plane, a motor within said casing having its armature shaft perpendicular to the plane of said port inlets, a disc-like rotor rigidly connected directly to said shaft and having a thin peripheral portion provided with equally spaced apertures positioned to register simultaneously with the inlets of said ports, a spring yieldingly urging said shaft towards the plane of said port inlets, and adjustable means for moving said shaft counter to the action of said spring to space the face of said rotor variably from the plane of said port inlets.

3. A high frequency siren comprising a casing forming a chamber for air under pressure and having a wall provided with a plurality of equally spaced ports having their axes lying in a circle and having their inlets lying in a plane, a motor within said casing having its armature shaft perpendicular to and one end of it passing through the plane of said port inlets, a disc-like rotor rigidly connected directly to said end of said shaft and having a thin peripheral portion provided with equally spaced openings positioned to register simultaneously with said inlet apertures, a spring acting on the other end of said shaft yieldingly urging the shaft towards the plane of said port openings, and a setscrew having an end acting on the other end of said shaft to space the face of said rotor variably from the plane of said

port openings counter to the action of said spring.

4. A high frequency siren comprising a casing forming a chamber for air under pressure, the chamber having a stator wall provided with a plurality of equally spaced ports having their inlets lying in a plane, a disc-like rotor in said chamber adjacent to said wall having a thin peripheral portion provided with a plurality of equally spaced apertures positioned to register simultaneously with said inlets of said ports, and a stationary deflection plate adjacent to said rotor and having its outer edge extending substantially to the inner edges of said rotor apertures to reduce air turbulence on the air inlet side of the rotor.

5. A high frequency siren comprising a casing forming a chamber for air under pressure, the chamber having a stator wall provided with a plurality of equally spaced ports having their inlets lying in a plane, a disc-like rotor in said chamber adjacent to said wall having a thin peripheral portion provided with a plurality of equally spaced apertures positioned to register simultaneously with said inlets of said ports, and a deflection plate adjacent to said rotor having its outer edge extending substantially to the inner edges of said rotor apertures to reduce air turbulence, said rotor being provided with one or more transverse pressure-equalizing openings between its center and the inner edges of its said peripheral openings.

6. A high frequency siren comprising a casing forming a chamber for air under pressure and provided with an air inlet opening adjacent to one end thereof, the casing having a wall at the other end thereof forming a stator, provided with a plurality of equally spaced air escape ports having their axes lying in a circle and having their inlets lying in a plane, a motor mounted in said casing chamber and spaced from the walls thereof, and a disc-like rotor attached to the armature of said motor and having a thin peripheral portion provided with a plurality of equally spaced apertures positioned to register simultaneously with said inlet ports, the air supplied through said casing inlet to said escape ports flowing through said motor and around it in said space between the motor and casing to cool the motor.

7. A high frequency siren comprising a casing forming a casing forming a chamber for a fluid under pressure, the chamber having a disc-like wall provided with a plurality of equally spaced fluid escape ports having their inlets lying in a plane, and a disc-like rotor having a thin peripheral portion provided with a plurality of port-closing teeth separated by port-opening apertures that are equal in width to the width of said teeth, said apertures being slightly greater in width than the inlets of said ports.

8. A high frequency siren comprising a casing forming a chamber for a fluid under pressure, the chamber having a disc-like wall provided with a plurality of equally spaced fluid escape ports of like size having their inlets lying in a plane, and a disc-like rotor having a thin peripheral portion provided with a plurality of teeth of like size separated by apertures of like size and equal in number to said ports, the width of said apertures being slightly less than the diameter of the inlets of said ports, and the width of said teeth being slightly larger than the diameter of the inlets of said ports.

9. A high frequency siren comprising a casing forming a chamber for a fluid under pressure, the chamber having a disc-like stator wall provided with a plurality of fluid escape ports having their inlets lying in a plane, and a disc-like rotor having a thin peripheral portion provided with a plurality of spaced port closures, the cross sectional shape of said rotor in a plane passing through its axis being such that the thickness varies with the distance from its center according to the relation

$$Z=Ae^{-Bx^2}$$

where Z is the thickness of the rotor at a distance x from its axis, A is the thickness of the rotor at its axis, and B is a constant which determines the rate at which the thickness of said rotor decreases.

10. A high frequency siren as defined in claim 11, in which the constant B is determined by the relation

$$B=s\frac{w}{g}\frac{(2\pi n)^2}{2T}$$

in which W is the weight per unit volume of the rotor material, g is the acceleration due to gravity, n is the rotor speed in number of revolutions per second, T is the yield strength of the rotor material, and s is a safety factor.

11. A high frequency siren comprising a casing forming a chamber for a fluid under pressure, the chamber having a disc-like stator wall provided with a plurality of fluid escape ports having their inlets lying in a smooth plane surface of an annular boss on said wall, a disc-like rotor having a thin peripheral portion provided with a plurality of spaced port closures adjacent to said boss, means for yieldingly urging said rotor towards said stator, and adjustable means acting upon said rotor positively to control the spacing of its peripheral portion from said plane surface of said annular boss.

12. A high frequency siren comprising a casing forming a chamber for a gas under pressure, the chamber having a disc-like stator wall provided with a plurality of gas escape ports having their inlets lying in a smooth plane surface of an annular boss on said wall, a disc-like rotor having a thin peripheral portion provided with a plurality of spaced port closures adjacent to said boss, and means for yieldingly urging said rotor towards said stator whereby the periphery of the rotor bears upon said boss, the gas in said chamber serving as the sole lubricant betwen the stator and rotor at high rotational speeds of the rotor.

CLAYTON H. ALLEN.
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Certificate of Correction

Patent No. 2,528,026 October 31, 1950

CLAYTON H. ALLEN ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 9, line 49, strike out the words "forming a casing"; column 10, line 17, for the claim reference numeral "11" read *9*;

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 26th day of December, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.