

March 10, 1964

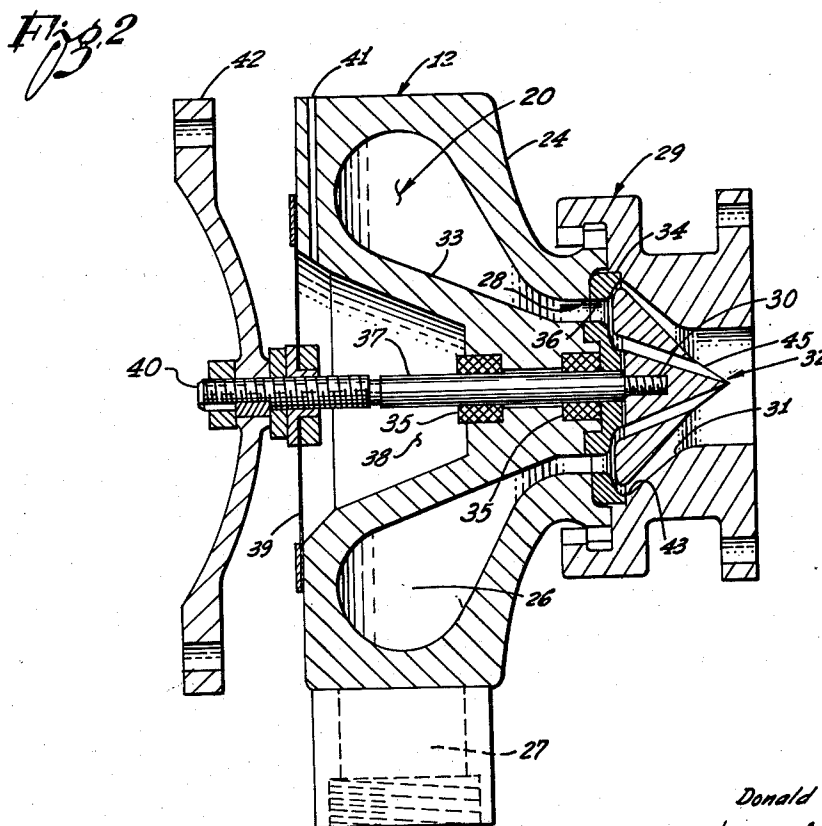
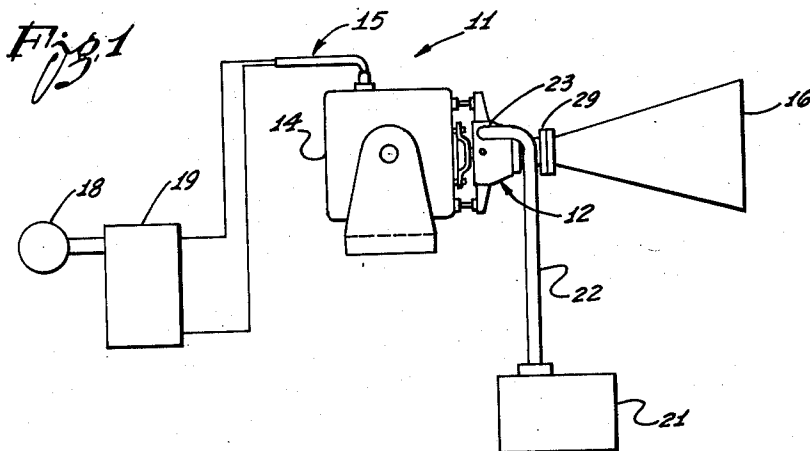
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3,124,099

AIR MODULATOR ACOUSTIC GENERATOR

Filed Sept. 18, 1961

2 Sheets-Sheet 1



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Fig. 3

Acoustic Output

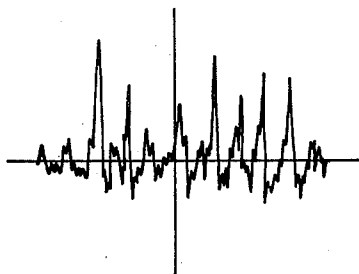


Fig. 6

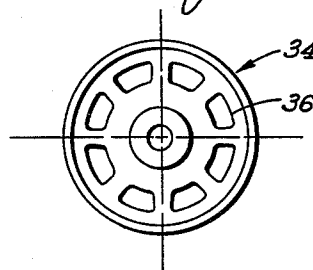


Fig. 4

Electrical Input

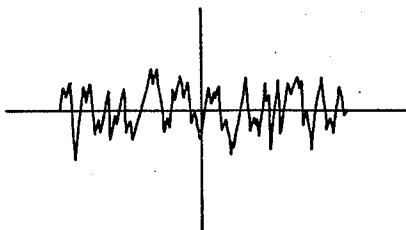
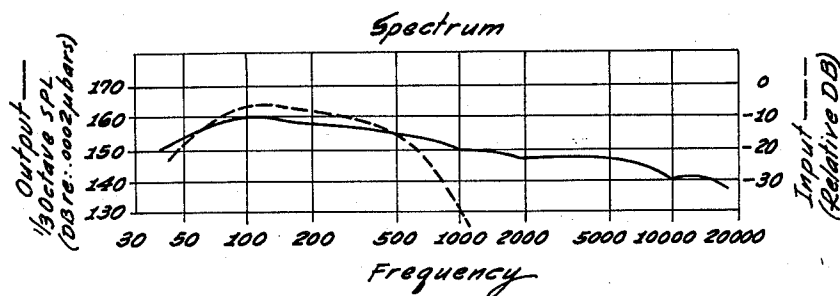


Fig. 5



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AIR MODULATOR ACOUSTIC GENERATOR
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6 Claims. (Cl. 116—137)

This invention pertains generally to sound generating apparatus and more particularly to sound generators capable of simulating acoustic environments encountered during the operation of reaction type propulsion systems and the like.

Accordingly it is an object of this invention to provide a sound generator adapted to produce random acoustic energy at intensity levels equivalent to that produced by reaction type propulsion systems currently used in aircraft and missiles.

Another object is to provide a sound generator adapted to generate random acoustic energy which is audible over the full audio frequency range.

Another object is to provide a sound generator having valve and throat portions of novel configurations cooperating with each other in a manner enabling the generator to produce a sound energy field that exhibits a smooth continuous spectrum over the full audio frequency range with simultaneous random amplitudes at all frequencies within the range.

Another object is to provide a sound generator having a wide frequency band output with a restricted (narrow frequency band) displacement input to the generator.

Although the characteristic features of the present invention are particularly pointed out in the appended claims, the invention itself, also the manner in which it may be carried out, will be better understood by referring to the following description taken in connection with the accompanying drawings forming a part of this application and in which:

FIGURE 1 illustrates diagrammatically a complete sound producing system utilizing the sound generator as disclosed herein.

FIGURE 2 is an enlarged sectional view of the sound generator utilized in the sound producing system shown in FIGURE 1, the section being taken on the center line of the sound generator.

FIGURES 3 and 4 graphically illustrate the electrical input and acoustic output of the sound producing system of FIGURE 1.

FIGURE 5 graphically illustrates typical frequency spectrums of the input electrical signal and the acoustical output.

FIGURE 6 is a plan view of the stator as viewed along the line 6—6 of FIGURE 2.

Referring to the drawings for a description of the sound generator as disclosed herein, FIGURE 1 shows a pneumatic sound producing system indicated in its entirety by the numeral 11. The system 11 includes a sound generator 12, vibration apparatus 15, horn 16, signal source 18, power horn 16 and source of air 21 at super-atmospheric pressure.

The vibration apparatus 15 includes a vibration exciter 14, a power amplifier 19 and a signal source 18. The vibration apparatus 15 may be any one of a number of types, suitable vibration apparatus being disclosed in U.S. Patent No. 2,955,460, dated October 11, 1960.

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Specific structure mounting the generator 12 on the exciter 14 is optional, however, as mounted the generator has a fixed relation with respect to the exciter housing throughout the operation of the system 11. A narrow frequency band (70–500 c.p.s.) of random electrical power is supplied to the exciter 14 from the signal source 18, otherwise the vibration apparatus is operated substantially as the apparatus disclosed in the referenced patent.

Air to be modulated is supplied to the generator 12 at approximately 200 p.s.i.g. from the air source 21. This air is transmitted to the generator 12 via a conduit 22 entering the generator at a location as indicated by the numeral 23 in FIGURE 1.

Referring now to FIGURE 2, it will be seen that the generator 12 comprises a housing 24 having a fluid passageway 20 formed therein. The passageway 20 includes an intermediate portion 26 of toroidal configuration, a tangentially positioned inlet portion 27 and a central annular outlet portion 28.

Secured to the housing 24, at a position surrounding the outlet 28, is a throat section 29. The section 29 has a passageway formed therein defining the throat 31 of the generator 12. The horn 16 is secured to the section 29 as shown in FIGURE 1. The configuration of the throat 31 formed in the section 29 and the manner in which it cooperates with the valve head 32 will be further discussed as the specification progresses.

A central portion 33 of the housing 24 cooperates with its shell portion to define the aforementioned annular outlet 28 and also to support a stator plate 34 having ports 36 formed therein. The central portion 33 also provides suitable structure having bushings 35 mounted therein in which a valve stem 37 is slideably mounted. The stem 37 has a centered or neutral position in which the forward end 30 thereof (right hand end as viewed in FIGURE 2) is located in the throat 31 while its other end 40 projects a short distance aft of the housing 24.

The aforementioned valve head 32 is secured to the forward end of the stem 37 and functions to close the ports 36 at such time as the head 32 contacts or seats on the stator plate 34. This latter position of the head 32 is referred to as its bottomed position and corresponds to the centered position of the stem 37.

The central portion 33 also has a recess formed therein constituting a fluid reaction chamber 38. The chamber 38 is rendered fluid tight by a flexible diaphragm 39 and, accordingly, is adapted to receive and retain air at super-atmospheric pressure. This pressurized air, entering through the passageway or bore 41, is supplied from a separate source (not shown).

The pressure within the reaction chamber 38 acts on the flexible diaphragm 39 to produce a force which is transmitted to the stem 37. This force tends to move the stem in the aft direction causing the valve head to seat on the stator plate 34 and arrest fluid flow through the generator. This reaction force is countered by a similar but opposite force produced on the stem by action of pressure within the plenum chamber 26 acting on the valve head 32. This latter force results in a mechanical balance of forces acting on the valve member 32 and reduces the power required by the vibration exciter for a given acoustical power output.

The outer ends of a spring-like driving beam 42 is secured to the exciter 14, the stem 37 is also secured to

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the beam 42 at its mid-section. The exciter 14 originates reciprocating movement which is transmitted to the stem 37 and valve head 32 by the beam 42. Linear motion of the head 32 and stem 37—in an aft direction—is arrested at such time as the head seats on the plate 34. At this time driving portions of the exciter 14 have only traveled—in aft direction—through a portion of their stroke, the resilient properties of the beam allows the driving portions of the exciter 14 to complete the remaining portion of their stroke in an aft direction. This position of the driving portions of the exciter, that is their positions at such time as the head 32 is caused to seat on the plate 34, is hereafter referred to as their centered position.

The relationship of the intermediate portion 26 of the passageway 20, throat 31 and head 32 is such that, at such times as the head 32 is slightly spaced from its bottomed position on the stator plate 34, a smooth continuous flow of pressurized air occurs through the generator 12.

By referring to FIGURE 2 it will be seen that the head 32 is generally of conical configuration. Auxiliary ports or passages 45, extending from the base to a position near the apex, are provided in the head 32. The base of the head 32 is positioned in an enlarged portion of the throat 31 and cooperates with the walls of the section 29 to define an annular passage 43. Accordingly with the head 32 spaced from its seat, air is free to flow through the annular passage 43 and the passages 45. This design and relationship of the head 32, intermediate portion of the passageway 20 and throat 31 presents, to air flowing through the generator 12, an area decreasing and then increasing at an exponential rate.

In other words the design is such that the area presented to the air flow is exponentially reduced as it approaches the plate 34, and the flow area down-stream of the plate 34 expands smoothly at another exponential rate. There are no area discontinuities throughout the air flow path of the generator 12 at such time as the valve is in its open position. This control over the area optimizes the flow characteristics of the generator and minimizes the acoustical losses of the generator.

At such times as an electrical signal is fed to the exciter 14 it will now be apparent that (due to the resilient character of the beam member 42) the motion of the valve head 32 will be positively and abruptly arrested as the head 32 contacts the plate 34. The valve head 32 will be displaced and returned to its seat in accordance with electrical signals fed to the exciter 14. The type of valve head motion produced can be represented as the halfwave rectification of the exciter head motion. The valve has been designed to exhibit large flow differences with very small displacements. If a sine wave electrical signal is supplied to the exciter, the combination of the halfwave valve motion and the large initial and final flow variations will produce output pressure pulses substantially of square-wave configuration. An analysis of this shape of pulse exhibits a strong harmonic train extending eight or more octaves above the fundamental frequency. The pressure pulse, being of large amplitude, is subjected to distortions that tend to increase the slope of the pulse front and thus produce further increases in the harmonic content of the pulse. If the exciter is supplied a random electrical signal of the typical wave form illustrated in FIGURE 4, the ensuing valve motion will produce a series of output pressure pulses displaying random amplitudes, random pulse widths, and random intervals between consecutive pulses as illustrated in FIGURE 3. A spectrum analysis of the output wave will show a continuous spectrum covering the full audio frequency range. A typical output spectrum analysis is shown in FIGURE 5 along with a spectrum of the electrical input. This full frequency range output is achieved with a narrow frequency range input by the aforementioned harmonic distortions of the input signal induced by the units unique valve motion. The input signal is limited to the upper

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frequency at which the exciter is capable of providing the minimum displacement necessary for effective modulation.

Thus it will be seen that an acoustic generator capable of producing the many objects of the invention is provided. While in order to comply with the statute, the invention has been described in language more or less specific as to structural features, it is to be understood that the invention is not limited to the specific features shown, but that the means and construction herein disclosed comprise a preferred form of putting the invention into effect, and the invention is therefore claimed in any of its forms or modifications within the legitimate and valid scope of the appended claims.

What is claimed is:

1. In sound producing apparatus, the combination comprising: an exciter including a housing and a driving member adapted to be actuated through a predetermined linear range; a sound producing member including a housing having a fluid passageway formed therein; means securing said sound producing housing in fixed relation with respect to said exciter housing; a disc-like valve seat mounted in said passageway; a valve member having head and stem portions, said valve member being slideably mounted in said passageway for movement between open and closed positions in which said head portion is spaced from said valve seat and is seated on said valve seat, respectively; the linear range through which said valve member moves when actuated between its open and closed positions being less than said predetermined range; resilient means connecting said valve stem and the driving member of said exciter; said fluid passageway including an intermediate portion of toroidal configuration, an inlet portion having a tangential relation with respect to said toroidal portion, and an annular outlet portion having a concentric relation with respect to said toroidal portion; and said passageway, at such times as said valve member is in its open position, cooperating with said head portion to define an unobstructed passageway increasing exponentially in cross-section up-stream and down-stream of said valve seat.

2. In sound producing apparatus, the combination comprising: an exciter including a housing and a driving member adapted to be actuated through a predetermined linear range; a sound producing member including a housing having a fluid passageway formed therein; means securing said sound producing housing in fixed relation with respect to said exciter housing; a disc-like valve seat mounted in said passageway; a valve member having head and stem portions, said valve member being slideably mounted in said passageway for movement between open and closed positions in which said head portion is spaced from said valve seat and is seated on said valve seat, respectively; the linear range through which said valve member moves when actuated between its open and closed positions being less than said predetermined range; resilient means connecting said valve stem and the driving member of said exciter; said valve seat mounted in an enlarged portion of said passageway and including a plurality of ports therein, and said head portion of said valve member being of conical configuration.

3. The combination of claim 2 in which said head portion includes a plurality of passages extending between the base and apex thereof.

4. In sound producing apparatus, the combination comprising: a housing having a fluid passageway formed therein; a disc-like valve seat mounted in said passageway; a valve member including a stem having a plain end and a valve head mounted on the other end; said valve member being slideably mounted in said passageway for movement through a linear range between an open position in which said head is spaced from said valve seat allowing fluid flow through said passageway and a closed position in which said valve head is bottomed on said valve seat precluding fluid flow through said passageway; resilient means secured to the free end of said valve stem;

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said passageway including an intermediate portion of toroidal configuration, an inlet portion having a tangential relation with respect to said toroidal portion, and an annular outlet portion having a concentric relation with respect to said toroidal portion; and said passageway at such times as said valve member is in its open position, cooperating with said head to define an obstructed passageway increasing exponentially in cross-section upstream and down-stream of said valve seat.

5. The combination of claim 4 in which said valve seat is mounted in an enlarged portion of said annular portion of said passageway and includes a plurality of ports, and the head portion of said valve member is of conical configuration.

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6. The combination of claim 5 in which said head portion includes a plurality of passages extending between the base and apex thereof.

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