June 22, 1965　　J. W. RYAN　　3,190,034

DEVICE FOR SIMULATING MOTOR SOUNDS

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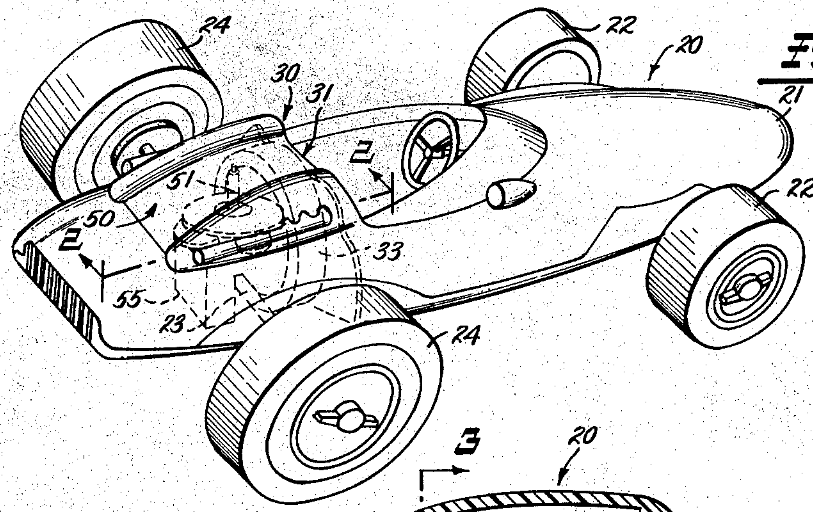

Fig. 1.

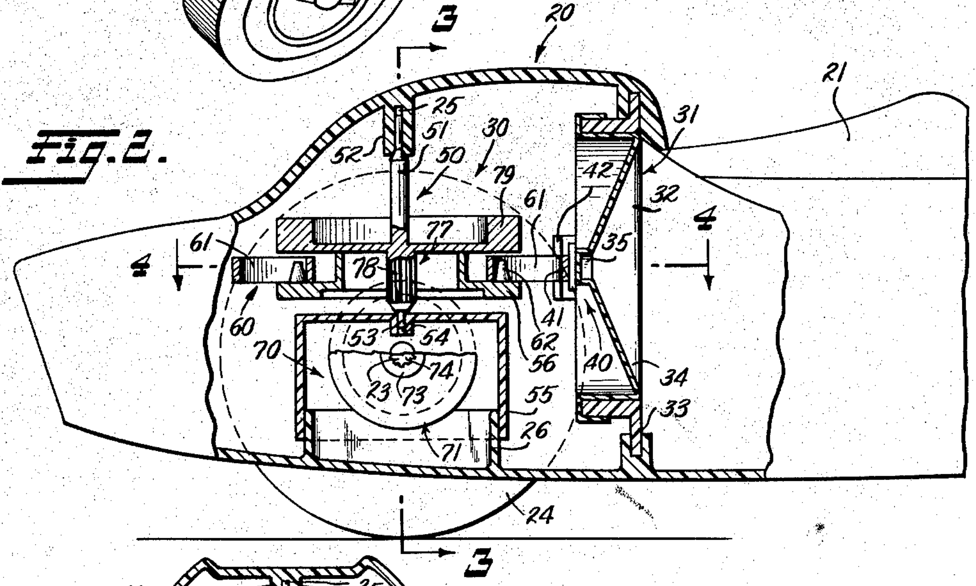

Fig. 2.

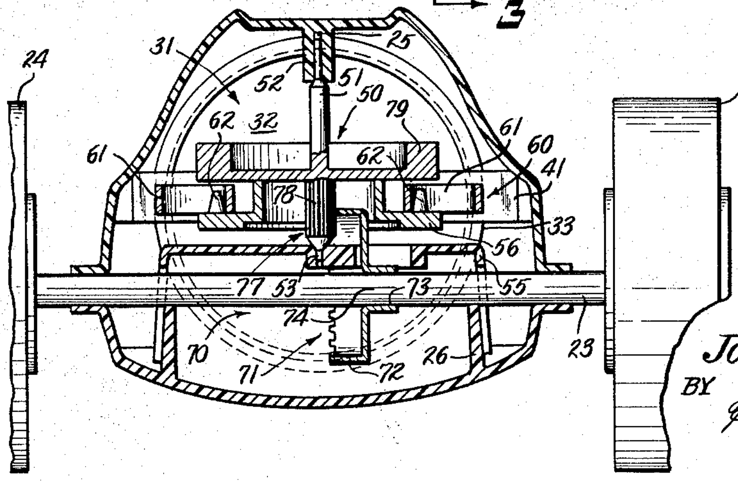

Fig. 3.

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Fig. 4.

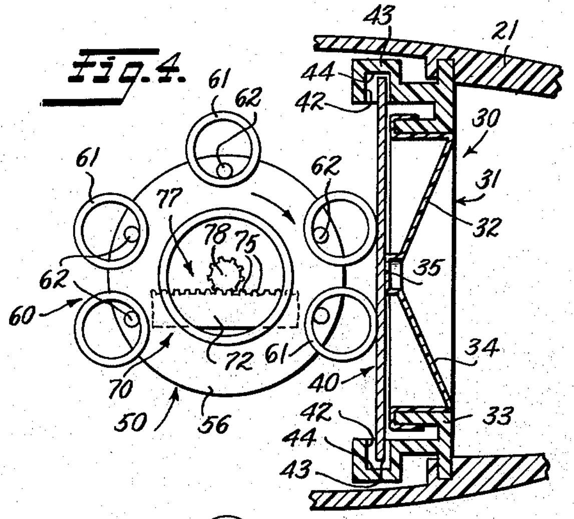


Fig. 5.

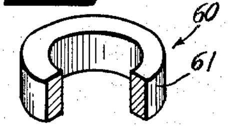


Fig. 7.

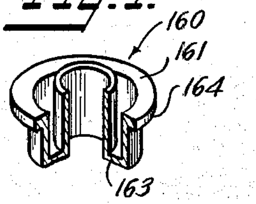
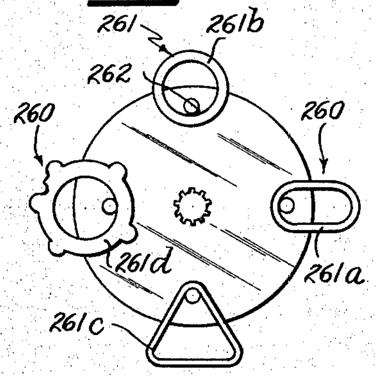


Fig. 8.



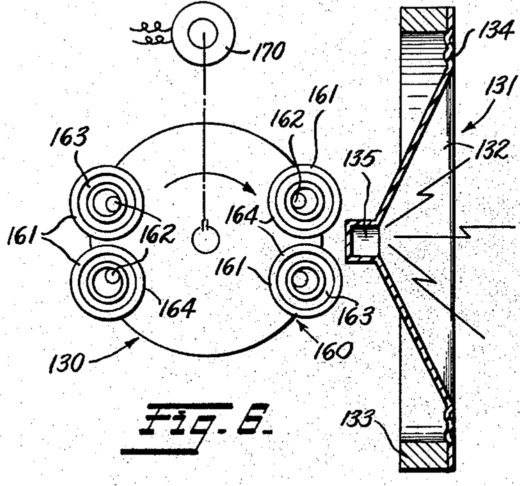


Fig. 6.

Fig. 9.

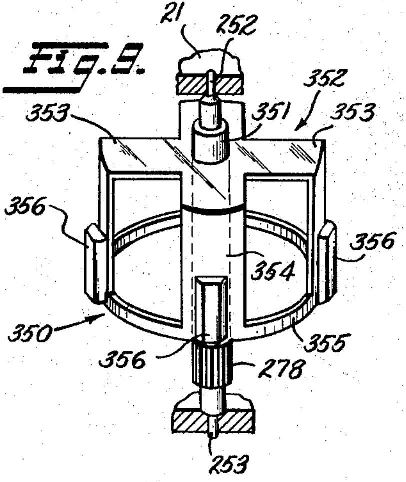
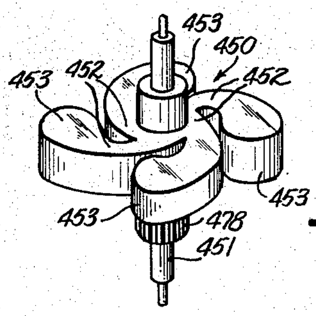


Fig. 10.



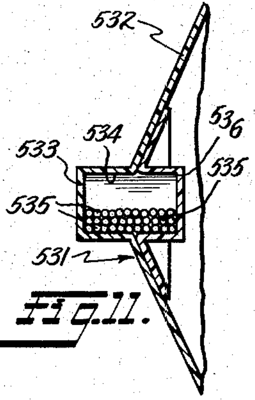


Fig. 11.

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Fig. 12.

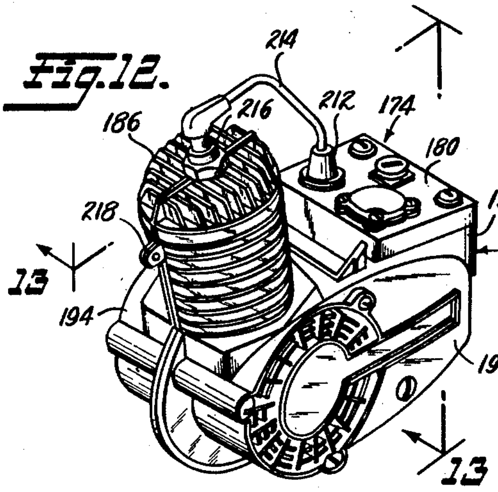


Fig. 14.

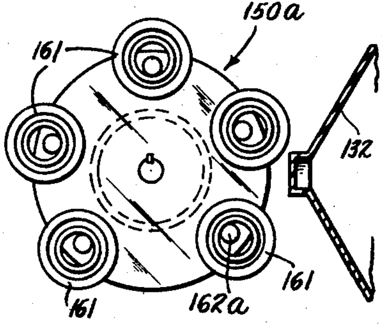
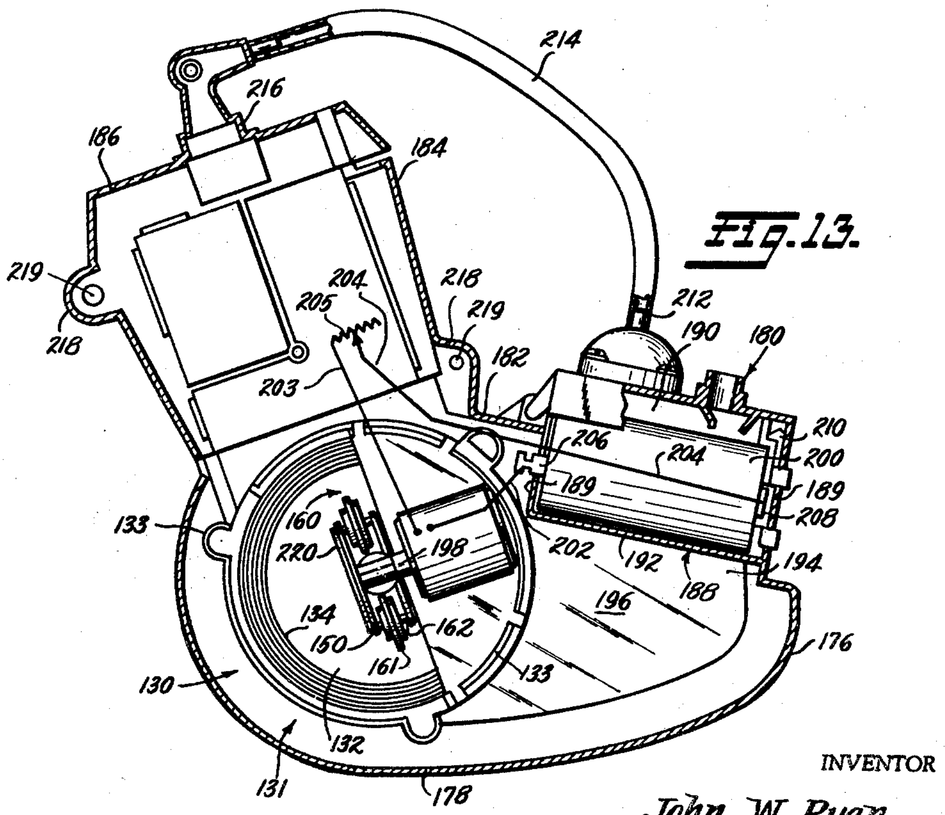


Fig. 13.



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United States Patent Office

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3,190,034

DEVICE FOR SIMULATING MOTOR SOUNDS

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Filed Dec. 9, 1964, Ser. No. 419,270
10 Claims. (Cl. 46—111)

This application is a continuation-in-part of a copending application filed October 2, 1963 under Serial No. 313,285 by the applicant herein. In general, the present invention relates to a device for simulating motor sounds. More specifically, the present invention relates to a device adapted to emit when operated sounds closely corresponding to the sounds of an internal combustion motor.

In said co-pending application it was noted that, in the past, there have been many toy vehicles having devices mounted thereon to simulate a motor sound. The conventional device which has been employed involves a reed fixed at one end and extending free at another end but engaged with a rotating gear wheel so that the reed is vibrated to emit sounds. However, such prior art motor sound devices customarily emitted very high-pitched uniform sounds which were far removed from the ordinary internal combustion motor sound of vehicles such as trucks and cars whose motor sound is customarily low-pitched and usually includes a cyclic variation of sound.

Furthermore, the usual prior art motor sound device involved a substantial period of contact between the portion of the device emitting the sound and the portion of the device actuating the sound emitter. Thus, a considerable portion of the vibrational energy was lost and the resulting sound device was relatively inefficient. Also, prior art motor sound devices usually utilized direct contact between the sound emitter and the actuator for the sound emitter, so that stresses and strains were put on the sound emitter which did not contribute to the volume of the sound being emitted. Consequently, the usual prior art device had a relatively short life because of the intense strains and stresses being put on the sound emitter apart from the function of emitting sound.

Many of these prior art motor sound devices include resonator means which is coupled to a driving means in such a manner that the resonator means is excited for a fixed period.

The spectral analysis of the sound produced by a typical automobile engine indicates that, for optimum reproduction, the maximum energy contained in the spectrum should be below approximately 2500 c.p.s. However, in an automobile engine and in a system for simulating motor sounds, the frequency of the sound alone is insufficient to define a reasonable simulation of a motor sound. The spectrum should be one in which a broad sweep of frequencies is indiscriminately produced without sharply defined and well-separated peaks. Sharply defined and well separated peaks produce a musical sound like a low-pitched horn or bell. When such peaks do not exist, a "noise" results and, if the noise is in a relatively low frequency range, it simulates a motor sound.

The devices for simulating motor sounds of the present invention include systems which are shock-excited with a lot of resonance. This shock-exciting is done repetitively, without necessarily having a fixed period. The exciting of the system is done in a "free mode." This means the system is simply hit; it is not rigidly coupled to a driving means. Thus, the present invention relates only to vibratile systems in which there is not a rigid coupling and direct drive of the resonator.

Vibratile systems which are capable of producing sound within the frequency ranges which characterize the noise produced by internal combustion engines may, within broad limits, be made of many different types of materials whether a single compound, such as polyethylene, or an extremely complex mixture of compounds, such as cardboard. The material may be homogeneous, laminate, or randomly discontinuous, such as chipboard. Also, the material may be solid, porous or of varying density and cross section, such as a woven or pressed fiber structure like fiberboard.

Such vibratile systems may also be made with almost any geometry. For example, a cone, a plane disc and a cup with nearly cylindrical side walls may be employed. These changes in geometry have a marked effect on the resonance characteristics of the system. The same mass of the same material reacts differently acoustically if it is shaped as a cone or cup rather than as a flat disc.

Similarly, the same object will react quite differently acoustically if it is mounted differently. A compliant mounting, in which the object is held loosely and flexibly, will cause it to have different resonance characteristics fro ma mounting in which it is held rigidly at some one point.

The natural or resonant frequency of a vibratile system is the basic frequency at which it resonates in response to a shock excitation. Although it is difficult to measure this with great precision, it is a characteristic of the system and usually can be discerned on a spectral analysis of the sound produced by the system at the lowest-frequency substantial peak produced by the system. For example, the spectral analyses of certain toy motor unit cones show a number of peaks, with the last major peak in the vicinity of 2,500 c.p.s. Thus the "bulk" of the acoustic energy produced in simulation of a motor sound should be below 2,500 c.p.s. The natural or resonant frequency of that same cone, however, is about 250 or 350 cycles. Repeated shock excitation of a vibratile system thus may produce the bulk of the energy at frequencies well above the natural or resonant frequency of the particular resonator employed.

The characteristics of vibratile systems which are capable of producing motor sounds may be defined in terms of the "stiffness" of the system. The natural or resonant frequency of the system is defined by the equation

$$f_r = \frac{1}{2\pi}\sqrt{\frac{\text{stiffness}}{\text{mass}}}$$

Stiffness is measured in dynes per centimeter.

This equation reflects the obvious fact that the same material with the same geometry produces different resonances, as its mass is varied. A small brass bell has a high pitch; a heavy brass bell may have an extremely low pitch. This formula makes it possible to define a physical characteristic of the vibratile systems—their stiffness—which is a necessary condition for any system within a range of weights that is practical for toy use (e.g., ⅒ gram to 100 grams) which is capable of producing a reasonable simulation of a motor sound. However, this necessary condition is not in and of itself a sufficient condition; it still must be qualified—i.e., the system must be of a size and nature normal and practical for a toy. With such a limitation, the more extreme combinations of characteristics are eliminated (e.g., an extremely tiny disc of very small mass and very high stiffness, which will produce sounds within the proper frequencies, but which will be inaudible or nearly inaudible and may have a more nearly musical distribution of peaks rather than the noise-like distribution which is necessary to simulate a motor sound).

A second limiting factor is that the impedance of the vibratile system is defined by the equation:

$$Z_0 = \sqrt{(\text{mass})\ (\text{stiffness})}$$

The impedance is a measure of the efficiency of the system; i.e., the effort required to produce sound from it. If the impedance is very high, the system is impractically inefficient. This equation supports the fact that the use of an extremely stiff system (e.g., an ordinary metal bell) which is so heavy that its natural frequency is within the desired range, is impractical for a toy because of the great weight required to attain this and the energy required to excite the system. It is also eliminated because of the necessary condition that the spectrum produced by such a system be one in which there are not clearly defined and well-separated peaks, producing a musical sound rather than a noise.

Investigation of these matters has resulted in the conclusion that a stiffness between 10^4 and 10^8 dynes per centimeter is the range within which a practical toy device to simulate motor sounds can be made. These limits of stiffness, applied to systems weighing between $1/10$ gram and 100 grams, produce natural frequencies (within the limits of practicality discussed above) which are in the range necessary to produce a motor sound. The more extreme combinations of high mass and low stiffness, and low mass with high stiffness, have to be omitted. For example, a 100 gram system with a stiffness of 10^1 (which would be something like a very heavy, floppy, loose piece of rubber) is quite impractical, producing a natural frequency of about 1½ cycles per second. The extreme combination of a stiffness of 10^8 and a weight of $1/10$ gram, which would be something like a very tiny disc of hard plastic or soft metal, produces a frequency which is far too high—well above 5,000 cycles per second. Taking the more reasonable combinations, even at the outer limits of the ranges, such as a stiffness of 10^4 and a weight of $1/10$ gram (producing a natural resonance of 50 cycles per second), or a stiffness of 10^8 and a weight of 100 grams (producing a natural frequency of 155 cycles) the range of 10^4 to 10^8 stiffness demonstrates that by using the more stiff systems with greater masses or the less stiff systems with lesser masses within the ranges of mass and stiffness, that 10^4 to 10^8 dynes per centimeter are the outer limits of stiffness which may be utilized effectively in toys to simulate motor sounds.

The following chart is a listing of 21 different sorts of vibratile systems, ranging from bicycle bells to toy motor sound cones and flat plates of polyethylene, paper, cardboard, styrene, brass, steel and rubber:

Type of resonator	Dia., in.	Material	Fr. (c.p.s.)	Mass (gm.)	Stiffness (dynes/cm.)
Bell #1		Steel	1,850	47	6.4×10^9
Bell #2		do	2,050	55	9.1×10^9
Bell #3		do	1,700	23	2.6×10^9
Bell #4		do	1,400	64	5.0×10^9
Engine cone		Styrene	250	1.6	4.0×10^6
Racer cone		do	555	1.1	1.4×10^7
Voice unit cone		do	230	0.9	1.9×10^6
.5 mil flat plate, free.	3	P.E.*	25	0.1	2.5×10^3
.5 mil flat plate, tight.	3	P.E	200	.1	1.6×10^5
9 mil flat plate, free.	3	Paper	145	1.0	8.3×10^5
24 mil flat plate, free.	3	Cardboard	360	2.8	1.4×10^7
6 mil flat plate, tight.	3	P.E	150	0.8	7.1×10^5
6 mil flat plate, tight.	8	P.E	41	4.2	2.8×10^5
24 mil flat plate, free.	8	Cardboard	60	13.8	1.9×10^6
15 mil flat plate, free.	3	Styrene	180	2.5	3.2×10^6
5 mil flat plate, free.	3	Brass	500	6.7	6.6×10^7
2 mil flat plate, free.	3	Steel	130	2.5	1.7×10^6
1 mil flat plate, free.	3	do	160	1.2	1.2×10^6
8 mil flat plate, tight.	3	Rubber	120	1.5	8.5×10^5
60 mil flat plate, free.	3	Styrene	480	10.2	9.3×10^7
60 mil flat plate, free.	8	do	120	53.8	3.1×10^7

*Polyethylene.

For each of the above systems, some of which were mounted freely and others of which were mounted rather tightly, the mass was determined and the natural frequency was determined. The stiffnesses were then computed and, as can be seen, all the practical simulations of a motor sound fell within the stiffnesses between approximately 10^4 and 10^8. The measurements of the frequencies recorded in the table are approximations which are accurate to the first digit. The list shows that practical weights of very stiff metals (such as bicycle bells with stiffnesses in the range of 10^9), produced natural resonances above 1,000 cycles per second. In order to obtain a system where repetitive shock-excitation produces a noise wherein the bulk of the noise is below 2500 c.p.s., the natural frequency of the resonator should be below 1,000 c.p.s. Thus, steel bells were not satisfactory. An extremely light and thin disc of polyethylene, with a stiffness below 10^4 did produce a natural frequency of 25 cycles per second (which might conceivably simulate a motor sound), but such a tiny disc is much too fragile to be practical for a toy.

In view of the foregoing, an object of the present invention is a toy motor sound device adapted to emit sounds closely corresponding to sounds of an internal combustion engine.

Another object of the present invention is a toy motor sound device having a vibratile system which is shock-excited with a lot of resonance.

Still another object of the present invention is a motor sound device wherein the sound emitter may be protected from direct contact with the actuator for the sound emitter and thus relieved of unusual stresses and strains.

A further object of the present invention is to provide a resonator for a toy motor sound device having (1) a low resonant frequency, (2) a body which is sufficiently stiff to reproduce high frequencies, and (3) amplitude capabilities within the material stress limits which will permit production of a high level of low frequency energy.

A still further object of the present invention is to provide a striker means for a toy motor sound device which will excite a resonator with a long impulse and which will produce an output from the resonator having a spectrum containing a maximum of energy in frequencies below about 2500 c.p.s.

Another object of the present invention is to provide a toy motor sound device which simulates an internal combustion engine in both appearance and sound.

Yet another object of the present invention is to provide a vibratile system for a motor sound device which has a stiffness within the range of approximately 10^4 to 10^8 dynes per centimeter.

Another object of the present invention is to provide a striker means for a motor sound device having an impeller on which individual strikers are loosely mounted at random angles which are no less than 60 degrees apart.

Other objects and advantages of the present invention will be readily apparent from the following description and drawings, which illustrate a preferred exemplary embodiment of the present invention as well as alternative embodiments of the present invention.

In general, the present invention involves a motor sound device having a vibratile system including a resonator adapted to emit an internal combustion motor sound when struck. Rotatably mounted adjacent said resonator is an impeller having at least one lug mounted on its periphery adapted to strike said resonator during the rotation of the impeller. Also, the motor sound device has drive means for rotating said impeller. Preferably, mounted between the impeller and resonator is a bridge which is adapted to move solely substantially perpendicular to the resonator and to translate blows thereon to said resonator. Also, preferably, the impeller includes a plurality of lugs spaced around its periphery with each of said lugs being retractably mounted on the impeller and adapted to be extended to strike the resonator or bridge by the centrifugal force exerted thereon by the rotation of the impeller and to be retracted by its impact with the bridge or resonator. The lugs may be spaced at random angles of no less than 60 degrees apart and may be made of materials such as wood, plastic and metal having sufficient mass and velocity to shock-excite the resonator with a lot of resonance.

The resonator may have a conical shape and may have a stiffness between approximately 10^4 to 10^8 dynes per centimeter for a mass of from $\frac{1}{10}$ to 100 grams. The cone is suspended in such a manner as to produce its desired low frequency resonance with the mass of the cone used. The cone has an amplitude capability within the stress limits of the material used, thereby permitting production of a high level of low frequency energy.

The mass of and the types of material employed in both the lugs and the resonator is such that undamped resonances are minimized, and so that the output from the resonator has a spectrum containing a maximum of energy in frequencies below approximately 2500 c.p.s.

In order to facilitate understanding of the present invention, reference will now be made to the appended drawings of a preferred specific embodiment of the present invention as well as alternative embodiments of the present invention. Such drawings should not be construed as limiting the invention which is properly set forth in the appended claims.

In the drawings:

FIGURE 1 is a perspective view of a toy auto containing the motor sound device of the present invention.

FIGURE 2 is a cross-sectional view of a portion of FIGURE 1, taken along the lines 2—2 of FIGURE 1.

FIGURE 3 is a cross-sectional view of FIGURE 2, taken along the lines 3—3 of FIGURE 2.

FIGURE 4 is a cross-sectional view of FIGURE 2, taken along the lines 4—4 of FIGURE 2.

FIGURE 5 is a partially broken-away perspective view of a portion of FIGURE 4.

FIGURE 6 is a plan view corresponding to FIGURE 4 illustrating an alternate embodiment of the present invention.

FIGURE 7 is a partially broken-away perspective view of a portion of FIGURE 6.

FIGURE 8 is a plan view of the impeller portion of FIGURE 4 showing an alternate embodiment of the impeller with a variety of lugs mounted thereon.

FIGURE 9 is a perspective view of an alternate embodiment of the impeller portion of the motor sound device.

FIGURE 10 is a perspective view of still another alternate embodiment of the impeller portion of the present invention.

FIGURE 11 is a cross-sectional view of an alternate embodiment of the resonator of the present invention.

FIGURE 12 is a perspective view of simulated internal combustion engine and motor sound device of the present invention.

FIGURE 13 is a cross-sectional view, on an enlarged scale, taken along line 13—13 of FIGURE 12.

FIGURE 14 is a plan view of the impeller portion of FIGURE 5 showing an alternate embodiment thereof.

As illustrated in FIGURES 1–5, the motor sound device **30** of the present invention may be mounted in a vehicle **20** such as an automobile. The motor sound device includes a resonator **31** adapted to emit an internal combustion motor sound when struck. Mounted adjacent the resonator **31** is a bridge **40** adapted to move solely substantially perpendicular to the resonator and to translate blows thereon to said resonator. Also, the motor sound device **30** includes a rotatably mounted impeller **50** having at least one lug **60** mounted on its periphery adapted to strike said bridge **40** during the rotation of said impeller **50** and drive means **70** for rotating said impeller.

The vehicle **20** includes a body **21** with the motor sound device mounted therein. The body **21** is carried by the front axle (not shown) having wheels **22** mounted on its ends and a rear axle **23** having wheels **24** mounted on its ends. The body **21** is preferably made of a synthetic resin or plastic, as indicated by the cross-hatching employed in the drawings. Such materials have a comparatively low resonance frequency so that the body **21** serves as a resonance chamber when employed in conjunction with a motor sound device of the present invention to enhance the sound produced thereby.

Mounted within the body **20** is the motor sound device **30** having a resonator **31** adapted to emit an internal combustion motor sound when struck. The resonator **31** includes a flexible cone **32** mounted on a frame **33** which is attached to the vehicle body **21**. The cone **32** has a somewhat thinner cross-section **34** adjacent to the frame **33** to increase its flexibility and has an apex plug **35** adjacent to the remaining portion of the motor sound device **30**.

Although a number of different types and sizes of cones **32** will manifest themselves, a cone approximately $2\frac{1}{4}$ inches in diameter and $\frac{1}{2}$ inch deep, which has a sidewall thickness of approximately 15 millimeters and which is made from a cellulose acetate butyral having a mass of 1.6 grams and a stiffness of 4.0×10^6 dynes has been found to be satisfactory. Such a cone has a natural frequency of approximately 250 c.p.s. which is low enough to permit it to respond with a lot of resonance to shock-excitation. The edge support of the cone **32** in frame **33** is such that low frequency resonance is obtainable with the mass of the cone used. In addition, the cone **32** has satisfactory amplitude capabilities with material stress limits which permit production of a high level of low frequency energy. When struck with a striker means of the present invention, the output from the cone **32** has an acoustical spectrum containing a maximum of energy in the lower frequencies i.e., below approximately 2500 c.p.s. The thinner cross-section **34** of the cone **32** not only serves as a damper for the cone, but also extends the life of the cone by permiting it to roll on the reduced cross-section thereby reducing fatigue.

Mounted adjacent to the resonator **31** and perpendicularly to the apex plug **35** is a bridge **40** which is adapted to move solely substantially perpendicular to the resonator **31** and to translate blows thereon to the resonator **31**. The bridge **40** includes a rigid strip **41** of tough material such as plastic which is slidably mounted in grooves **42** in the frame **33** of the resonator **31** with the ends **43** of the strip **21** near the bottoms **44** of the grooves **42**. Thus, strip **41** is adapted to slide perpendicular to the resonator **31** and is substantially restrained from sliding parallel to the resonator **31** so that the strip **41** will minimize side loads exerted on the cone **32**, by the lugs **60**. When the vehicle **20** is pushed along a floor or the like, by a child, the drive means **70** rotates the impeller **50** with sufficient force so that the lugs **60** would rapidly erode the plug **35** away if the lugs **60** were to contact it directly.

The impeller **50** is rotatably mounted adjacent to the bridge **40** and has a plurality of lugs **60** spaced around its periphery adapted to strike the bridge **40** during the rotation of the impeller **50**. The impeller **50** includes a spindle **51** having an upper reduced end **52** which is rotatably received in a socket **25** of the body **21**. Similarly, the spindle **51** has a lower reduced end **53** which is rotatably received in a socket **54** of a case **55** which is mounted on a bridge **26** of the body **21**. Mounted around the spindle **51** is a disc **56**.

The lugs **60** are retractably mounted on the impeller **50** and adapted to be extended to strike the bridge **40** by the centrifugal force exerted thereon by the rotation of the impeller **50** and to be retracted by their impact with said bridge. The lugs **60** include rings **61** loosely mounted on pivot pins **62** attached to the disc **56** of the impeller **50**.

The pivot pins **62** are preferably spaced about the disc **56** at random angles which are no less than 60 degrees apart, as shown for the pins **162*a*** in FIGURE 14.

The rings **61** have a carefully developed radial compliance designed to excite the cone **32** with a long impulse so that the output from the cone will have a spectrum containing a maximum amount of energy in the lower frequencies. The mass and stiffness of the rings **61** are such that they will shock-excite the cone **32** with a lot of resonance and with sufficient higher frequencies to maintain acoustical balance simultaneously with a high acoustical level. It has been found that rings having a $\frac{9}{16}$ O.D. by $\frac{7}{16}$ I.D. by $\frac{1}{4}$ inch thickness and which are made of an acetal resin possesses a satisfactory mass and stiffness for the velocity imparted to them by the impeller **50**.

The impeller **50** is rotated by a drive means **70** which includes a first gear means **71** mounted on the rear axle **23** of the vehicle **20** and a second gear means **77** mounted on the spindle **51** of the impeller **50**. The second gear means **77** is engaged with the first gear means **71**. The first gear means **71** includes a cup gear **72** which is mounted on the rear axle by engaging its central sleeve **73** with a knurled portion **74** of the rear axle **23**. The second gear means **77** is produced by forming a gear **78** out of the lower portion of the spindle **51** adjacent its lower end **53**. The gear **78** is engaged with the teeth **75** of the cup gear **72**. The drive means **70** also includes a fly wheel **79** which is coaxially mounted on the disc **56** of the impeller **50** and forms the connection between the disc **56** and the spindle **51** of the impeller **50**.

The operation of the motor sound device **30** of the toy vehicle **20** of FIGURES 1–5 is very simple but yet achieves sounds closely corresponding to the sounds of an internal combustion motor. When the toy vehicle **20** is moved along a surface with its wheels **22** and **24** engaged therewith, the wheels **24** rotate the axle **23**. The axle **23** in turn rotates the cup gear **72**, the gear **78** and thereby rotates the disc **56** of the impeller **50**. The rotation of the impeller **50** extends the rings **61** of the lugs **60** so that they strike the bridge **40**. However, when striking the bridge **40**, because the rings **61** are loosely mounted on pivot pins **62**, they immediately retract after striking the bridge **40** so that the impact of contact therewith is essentially instantaneous. Also, since the bridge is substantially restrained from sliding parallel to the resonator **31** because the ends **43** of a strip **41** are near the bottoms **44** of the grooves **42**, the bridge **40** is moved by the impact of the lugs **60** solely substantially perpendicular to the resonator and thereby strikes the apex plug **35** of the cone **32**. The cone **32** in turn emits when struck by the bridge **40** a low-pitched sound in a regular cycle depending on the placement and configuration of the lugs **60** on the impeller **50** so that the sounds produced closely correspond to the sounds of an internal combustion motor. Alternatively, the strip **41** can be bowed inwardly against plug **35** so that it is in permanent engagement therewith. In either event, the sound produced is substantially the same since the cone **32** is excited with a long pulse by virtue of the radial compliance of the rings **61**.

Many other specific embodiments of the present invention will be obvious to one skilled in the art in view of this disclosure. For example, as illustrated in FIGURES 6, 7, 12 and 13, the motor sound device **130** may include simply a resonator **131** adapted to emit an internal combustion motor sound when struck, a rotatably mounted impeller **150** having at least one lug **160** mounted on its periphery adapted to strike the resonator **131** during the rotation of the impeller **150** and drive means, including an electric motor **170**, for rotating said impeller. Also, the resonator **131** may include a cone **132** mounted on a frame **133** with the portion **134** of the cone **132** adjacent the frame **133** being corrugated. In addition, the impeller **150** may include lugs **160** wherein rings **161** are loosely mounted on pivot pins **162** attached to the impeller **160**. However, the rings **161** may have a U-shaped cross-section **163** with an outwardly extending flange **164** adapted to strike the resonator **131**. Alternatively, the rings **161** can be mounted on an impeller **150a** having pins **162a** mounted thereon at random angles of at least 60 degrees with respect to each other. With this arrangement, the rings **161** strike the cone **132** on an irregular cycle producing a rumble to enhance the motor sound produced thereby.

The cone **132** may advantageously correspond in size and shape with, and may be made from the same material as, the cone **32** previously described. The bridge **40** described in connection with the FIGURES 1–4 embodiment may be eliminated from the resonator **131** so that the rings **161** strike the apex plug **135** directly. This is feasible because the motor **170** drives the impeller **150** with less acceleration than is imparted to the impeller **50** of the previous embodiment when the vehicle **20** is pushed along a suitable surface. Thus, the problem of frictional wear on the plug **135** is not as great as it is in connection with the FIGURES 1–4 embodiment. Also, the rings **161** may advantageously have a different radial compliance than the rings **61** and are preferably made of a softer material than the rings **60**. For example, the rings **161** may be advantageously made of polyethylene having a modulus of elasticity of approximately 100,000 p.s.i. in lieu of the rings used in the previous embodiment. The FIGURE 7 configuration of the rings **161** is an important feature of the device **130**. It has been found in actual practice that such a configuration in combination with an electrically driven rotor or impeller **150** and the particular cone **132** disclosed herein produces a sound corresponding more nearly to the sound produced by a typical automobile engine than is produced when other shaped rings are employed in the same system.

The motor sound device **130** may be advantageously mounted in a simulated combustion engine, generally indicated at **174**, which is adapted to be mounted on a frame, such as a bicycle or tricycle frame. The simulated engine **174** includes a casing **176** having a rounded lower wall **178**, a removable cap **180**, a top wall **182**, a cylinder wall **184** and a cylinder-head wall **186**. A simulated distributor housing or compartment **188** is formed within the casing **176** by a pair of end walls **189**, a pair of side walls **190** and a bottom wall **192**.

The curved lower wall **178** is joined to a pair of spaced-apart side walls **194** in such a manner that a simulated crankcase or chamber **196** is provided within the casing **176** for accommodation of the motor sound device **130**.

The motor **170** for the sound device **130** is preferably a D.C. motor so that the rate of rotation of its associated spindle **198** is proportional to the input voltage to the motor **170**. Consequently, the intensity and rapidity of repetition of the sounds produced by the motor sound device **130** is proportional to the input voltage to the electric motor **170**. The electric motor **170** is connected to a battery **200** directly by a first lead wire **202** and indirectly by a second lead wire **203** which may be connected to a suitable regulator means which is shown schematically at **205** and which may comprise the regulator means shown and described in applicant's co-pending application, Serial No. 361,653, filed April 22, 1964, now Patent No. 3,160,984 entitled Toy Motor Sound Control Means. A third lead wire **204** may be employed to connect the regulator means described in said co-pending application Serial No. 361,653 to the battery **200**. The battery **200** contacts a metal lug **206** which is attached to the lead wire **202**. The battery **200** also contacts a metal clip **208** which is attached to the third lead wire **204**. The battery **200** can be replaced periodically as required by removing the cap **180** which is secured to the wall **189** by a latching means **210**.

A simulated electrical distributor **212** is mounted on the cap **180** and is connected by a simulated spark plug wire **214** to a simulated spark plug **216** which, in turn, is mounted on the cylinder-head wall **186**.

A plurality of ears or bosses **218** are mounted on the casing **176** and each boss **218** is provided with an aperture **219** provided therein which is adapted to mount the casing **176** on a frame (not shown).

A cover plate **220** retains the lugs **161** in position on their associated pins **162**.

Still other specific embodiments of the present invention are illustrated in FIGURES 8–11. In FIGURE 8, the impeller **250** includes a plurality of lugs **260** spaced around its periphery. Each lug includes a ring **261** having a variety of shapes such as substantially ellipsoidal **261***a*, circular **261***b*, triangular **261***c*, and irregular **261***d*. Similarly, the pivot pins **262** on which the rings **261** are mounted may be spaced varying distances from the center of the impeller **250**.

The impeller **250** may be used in place of the impeller **50** in the sound device **30** or alternatively, it may be used in place of the impeller **150** in the motor sound device **130**. When used in the sound device **30** the rings **261***a*, and **261***b*, **261***c* and **261***d* are preferably made from a material having a modulus of elasticity of approximately 400,000 p.s.i. On the other hand, when employed in conjunction with the sound device **130**, these rings are preferably made from a polyethylene material having a modulus of elasticity of approximately 100,000 p.s.i. Also, when used in the motor sound device **30**, the rings **261***a*–**261***d* preferably have a mass equivalent to the mass of the rings **61** and when used in the motor sound device **130**, the rings preferably have a mass comparable to that of the rings **161**. The random shape of the rings **261***a*–**261***d* enhances the motor sound produced by the device in which the rings are employed by imparting a rumble to the sound produced by the motor sound device.

In FIGURE 9, the impeller **350** includes a spindle **351** having a bracket **352** mounted thereon with arms **353** extending outwardly. Dependent from the arms **353** are flexible struts **354** supported at the bottom by a flexible brace ring **355**. Mounted on the struts **354** are knobs **356** which are adapted to strike the bridge or resonator.

The impeller **350** may be mounted in the body **21** of the vehicle **20** by pivot pins **252** and **253** provided on the upper and lower ends thereof, respectively. A gear **278** may be provided on the lower end of the impeller **350** for actuation by the gear **72** in vehicle **20** so that the impeller **350** will be driven thereby.

The knobs **356** preferably have a modulus of elasticity within the range of about 100,000–400,000 p.s.i.

In FIGURE 10, the impeller **450** has a spindle **451** on which are mounted a plurality of outwardly extending arms **452** with each of said arms having a knob **453** mounted on the end thereof.

The impeller **450** may be mounted in the vehicle **20** in such a manner that a gear **478** provided on the impeller **450** engages the driving gear **72** provided in the vehicle **20**. The arms **452** and their associated knobs **453** are preferably made from a non-metallic material having a modulus of elasticity within the range of about 100,000 p.s.i.–400,000 p.s.i.

In FIGURE 11, the resonator **531** includes a cone **532** with an apex plug **533** having a chamber **534** therein. Contained within the chamber **534** are a plurality of freely movable weights **535**. The chamber **534** of the plug **533** may be simply formed by capping the chamber **534** in the cone **532** with a cover **536** mounted on the interior surface of the cone **532**.

The cone **532** is preferably made from the same material as the cones **32** and **132** and the weights **535** preferably comprise spherical balls made of a suitable plastic or the like. The weights **535** not only enhance the random nature of the sound produced by the cone **532** when it is struck by any of the impellers previously shown and described herein, but also serves as a damper for the cone **532**.

In addition to the foregoing alternate embodiments of the present invention, it should be noted that there are many other specific embodiments possible. Thus, the motor sound device **30** may be driven by an electric motor powered by batteries, rather than the mechanical energy stored in a fly wheel **79** or merely a gear drive connected to the wheels of a car being rolled along a surface. Also, the motor sound device **130** may be mounted in a suitable vehicle, such as the vehicle **20**, instead of in the simulated engine **174**.

It should also be noted that resonators having various geometric shapes, masses and stiffnesses may be employed, as listed hereinbefore.

There are many features of the present invention which clearly show the significant advance the present invention represents over the prior art. Consequently, only a few of the more outstanding features will be pointed out to illustrate the unexpected and unusual results obtained by the present invention. One feature of the present invention is the utilization of a cone for a resonator with the cone being freely flexible around its periphery. For example, as illustrated, the cone may be thinned out in cross-section adjacent its support means, or have a plurality of corrugations. In any event, such cone is adapted to emit low-pitched sounds similar to the sounds of an internal combustion motor. Another feature of the present invention is the utilization of a retractable lug which is extended by centrifugal force and then retracted by the force of the impact with the resonator device. With such arrangement, a sudden, sharp impact on the resonator is achieved and deadening of the resonator due to prolonged contact is substantially prevented. Still another feature of the present invention is the utilization of a bridge to translate the blows from the impeller to the resonator which is adapted to move substantially solely perpendicular to the resonator. At low impeller speeds and with specially designed resonator constructions, it is possible to achieve reasonable periods of use before the resonator is worn out by the impeller without the protection of the bridge. However, with high speed impellers or a simply designed resonator, the resonator is rapidly destroyed by the impeller without the protection of the bridge. Not only does the bridge protect the resonator from the direct impact of the impeller, but also removes the distorting forces imposed on the resonator by the impeller so that the resonator is actuated only in the direction to achieve maximum sound emission. Still another feature of the present invention is the utilization of various sizes and shapes of lugs as well as positions of lugs to achieve a desired cycle of sound. Also, suitable variation of sound may be achieved by loading the resonator with movable weights.

It will be understood that the foregoing description and examples are only illustrative of the present invention and it is not intended that the invention be limited thereto. All substitutions, alterations and modifications of the present invention which come within the scope of the following claims or to which the present invention is readily susceptible without departing from the spirit and scope of this disclosure are considered part of the present invention.

What is claimed is:

1. A toy vehicle comprising: a substantially hollow body member forming a resonance chamber; a resonator in the form of a cellulose-acetate-butyral cone having an apex plug mounted in said body member, said resonator having a low-pitched natural frequency below approximately 1,000 c.p.s.; wheel means rotatably mounted on said body member for facilitating travel of said vehicle along a surface; striker means rotatably mounted in said body member adjacent said resonator for cyclically impacting said resonator at its apex plug causing it to vibrate and produce a low-pitched sound simulating the sound of an internal combustion enigne; and gear means connecting said striker means to said wheel means for rotating said striker means when said vehicle is pushed along said surface, whereby said striker means will cyclically impact said resonator, said striker means comprising an impeller connected to said gear means; and a plurality of rings loosely mounted on pins attached to said impeller and positioned around the periphery of said impeller, said

lugs each being retractably mounted on said impeller for extension into engagement with said apex plug by the centrifugal force exerted thereon by the rotation of said impeller, said rings being made from an acetal resin having a modulus of elasticity of approximately 400,000 p.s.i.

2. A toy vehicle as defined in claim **1** wherein said rings are mounted on said impeller at random angles of at least 60 degrees with respect to each other.

3. A toy vehicle as defined in claim **2** wherein said rings each has approximately a $\frac{9}{16}$ inch outside diameter, a $\frac{7}{16}$ inch inside diameter and a $\frac{1}{4}$ inch thickness.

4. A toy vehicle as defined in claim **2** wherein at least one of said rings has a non-uniform peripheral surface.

5. A toy vehicle as defined in claim **2** wherein each of said rings has a different annular shape from the others.

6. A toy vehicle as defined in claim **1** wherein a portion of said body member comprises said resonator.

7. A device for producing sound simulating an internal combustion engine, comprising:

non-metallic resonator means having a low-pitched natural frequency substantially less than 2500 c.p.s., said resonator means being adapted to produce a noise when subjected to repetitive shock-excitation wherein the bulk of the noise has a frequency below approximately 2500 c.p.s.;

striker means movably mounted adjacent said resonator means for cyclical engagement therewith when said striker means is moved, and

means connected to said striker means for cyclically impinging it against said resonator means, whereby said resonator means produces noise the bulk of which is of indiscriminate frequencies below approximately 2500 c.p.s.,

said resonator means having a mass within a range of approximately .1 to approximately 100 grams and a stiffness within a range of approximately 10^4 to 10^8 dynes per centimeter.

8. A device for producing sound simulating an internal combustion engine, comprising:

non-metallic resonator means having a low-pitched natural frequency substantially less than 2500 c.p.s., said resonator means being adapted to produce a noise when subjected to repetitive shock-excitation wherein the bulk of the noise has a frequency below approximately 2500 c.p.s.;

striker means movably mounted adjacent said resonator means for cyclical engagement therewith when said striker means is moved, and

means connected to said striker means for cyclically impinging it against said resonator means, whereby said resonator means produces noise the bulk of which is of indiscriminate frequencies below approximately 2500 c.p.s.,

said resonator means having a mass within a range of approximately .1 to approximately 100 grams and a stiffness within a range of approximately 10^4 to 10^8 dynes per centimeter, said resonator being provided with means for dampening vibrations thereof.

9. A device for producing sound simulating an internal combustion engine, comprising:

non-metalic resonator means having a low-pitched natural frequency substantially less than 2500 c.p.s., said resonator means being adapted to produce a noise when subjected to repetitive shock-excitation wherein the bulk of the noise has a frequency below approximately 2500 c.p.s.;

striker means movably mounted adjacent said resonator means for cyclical engagement therewith when said striker means is moved, and

means connected to said striker means for cyclically impinging it against said resonator means, whereby said resonator means produces noise the bulk of which is of indiscriminate frequencies below approximately 2500 c.p.s.,

said resonator means having a mass within a range of approximately .1 to approximately 100 grams and a stiffness within a range of approximately 10^4 to 10^8 dynes per centimeter, said resonator means comprising a cellulose-acetate-butyral cone held securely around its circumference and having an apex portion adjacent said striker means to be struck thereby.

10. A device for producing sound simulating an internal combustion engine, comprising:

non-metallic resonator means having a low-pitched natural frequency substantially less than 2500 c.p.s., said resonator means being adapted to produce a noise when subjected to repetitive shock-excitation wherein the bulk of the noise has a frequency below approximately 2500 c.p.s.;

striker means movably mounted adjacent said resonator means for cyclical engagement therewith when said striker means is moved, and

means connected to said striker means for cyclically impinging it against said resonator means, whereby said resonator means produces noise the bulk of which is of indiscriminate frequencies below approximately 2500 c.p.s.,

said resonator means having a mass within a range of approximately .1 to approximately 100 grams and a stiffness within a range of approximately 10^4 to 10^8 dynes per centimeter, the natural frequency of said resonator means being in the range of about 250 c.p.s. to 500 c.p.s.

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