

[54] SOUND AMPLITUDE LIMITERS

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3,527,901 9/1970 Geib..... 179/107 E

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FOREIGN PATENTS OR APPLICATIONS

598,919 10/1959 Italy 179/107 E

[22] Filed: **Dec. 26, 1973**

[21] Appl. No.: **427,911**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 253,935, May 17, 1972, abandoned.

Primary Examiner—Ralph D. Blakeslee

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[51] Int. Cl. **H04p 25/02**

[58] Field of Search 179/107 R, 107 E

[57] **ABSTRACT**

This invention pertains to improvements in sound-amplitude limiters, and in particular, incorporates the principle of sound-amplitude limiting into a novel device which is self-contained in the ear canal of the user.

[56] **References Cited**

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10 Claims, 12 Drawing Figures

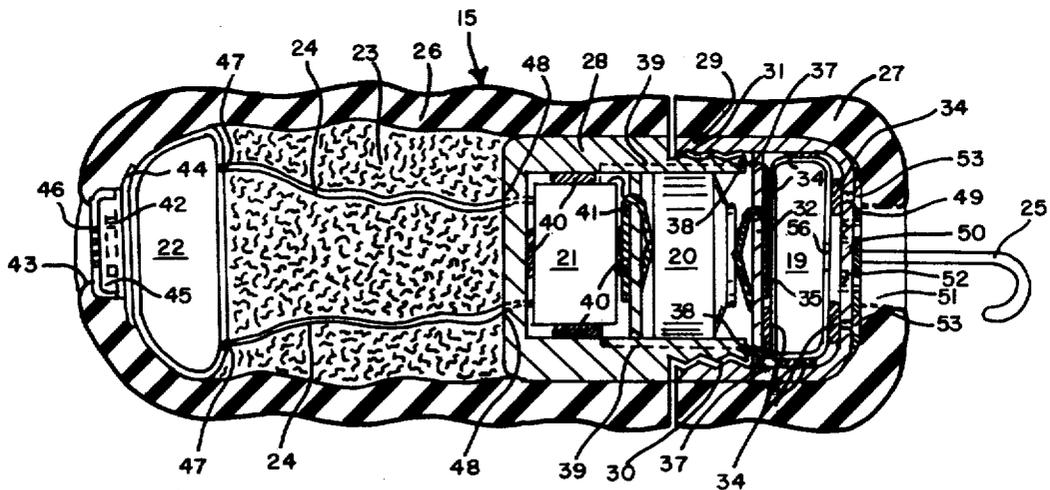


FIG. 1

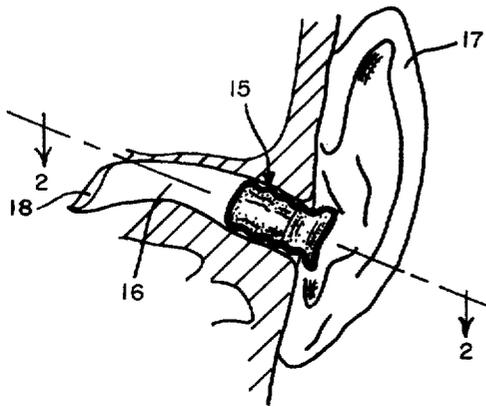


FIG. 2

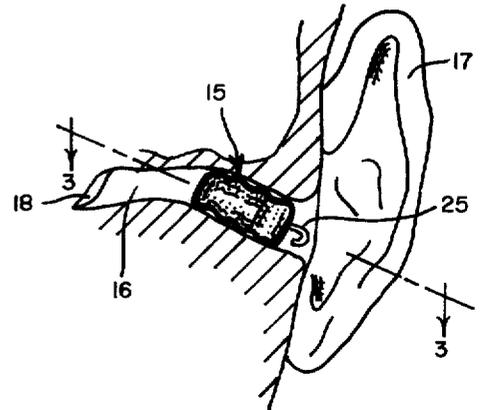


FIG. 3

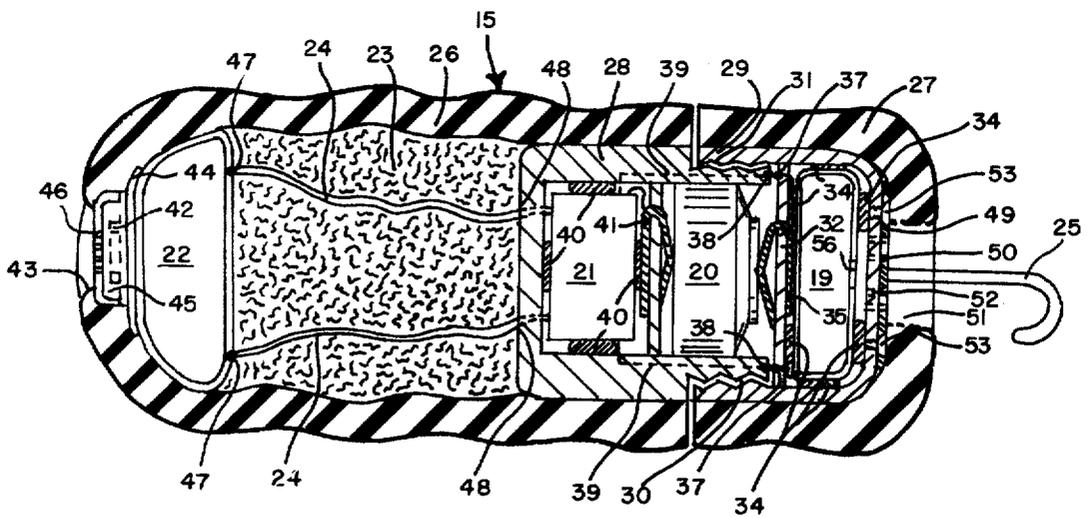


Fig. 4

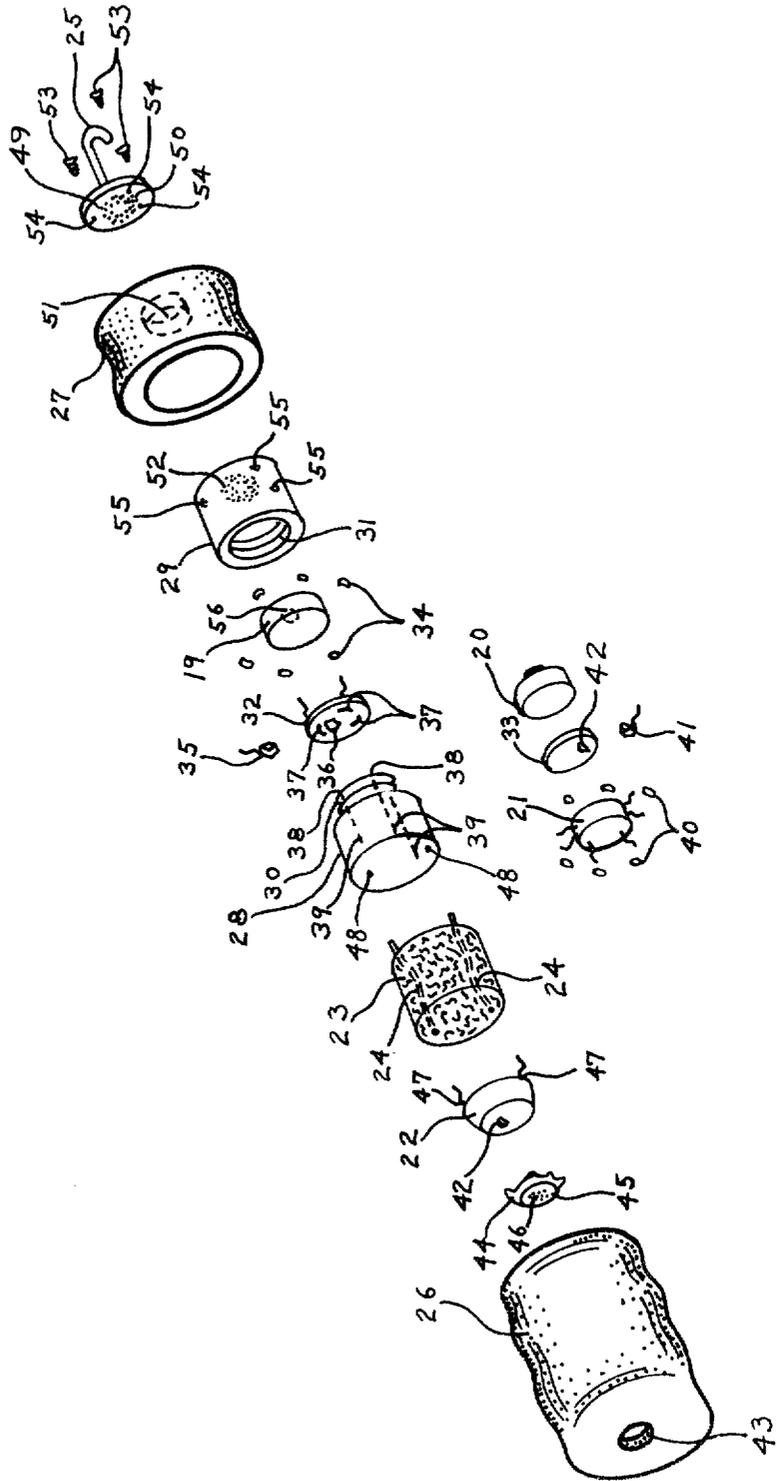


Fig. 5

ACOUSTICAL CHARACTERISTICS FOR SOUND-AMPLITUDE LIMITERS, EARPLUGS, AND HEARING-AIDS.

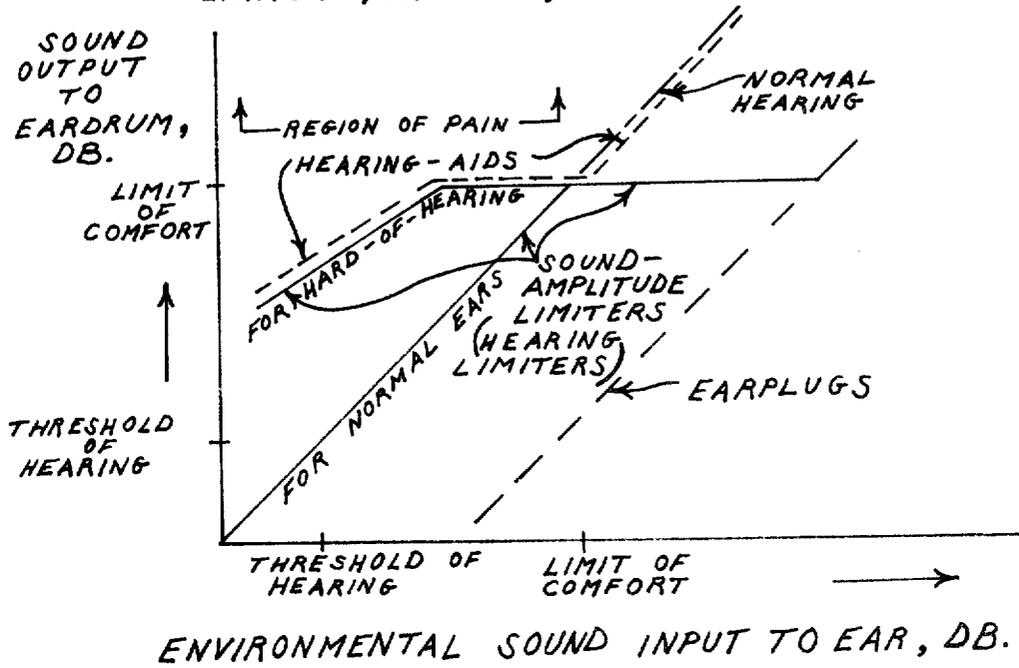


Fig. 6

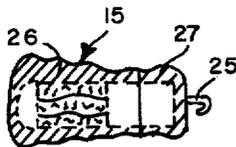


Fig. 7

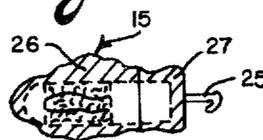


Fig. 8

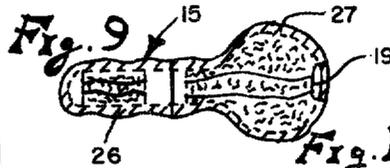
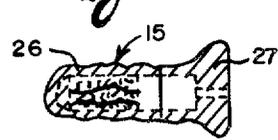


Fig. 12

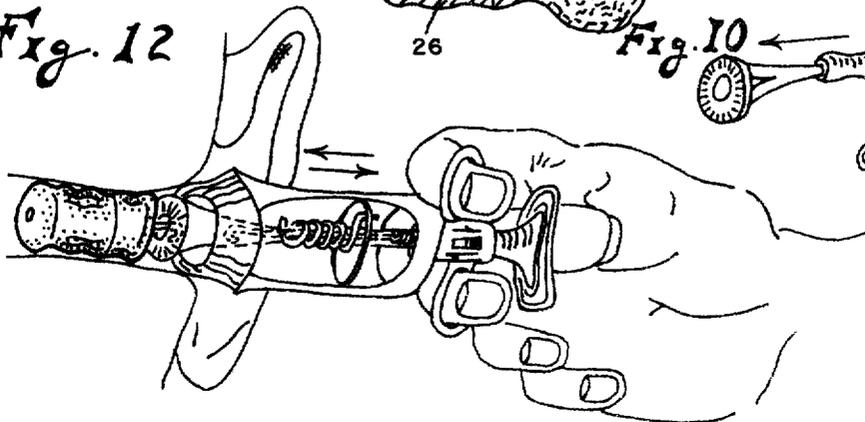


Fig. 10

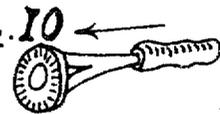
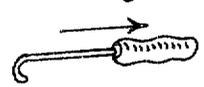


Fig. 11



SOUND AMPLITUDE LIMITERS

The invention herein described is a continuation-in-part of the now-abandoned application filed May 17, 1972, Ser. No. 253,935.

Sound-amplitude limiters are devices which limit the intensity of sound reaching the ear drum to a comfortable level while simultaneously allowing sounds of lesser intensity to reach the ear drum undiminished, intended for use basically by persons with normal hearing. It is the basic object of this invention to illustrate how the acoustical principle of sound-amplitude limiting can be utilized with ease and practicality of great numbers of persons who now suffer from the well-publicized problem of noise pollution. The invention accomplishes this by adapting the basic acoustical principle of sound-amplitude limiting into a device which is contained within the ear cannal (aural orifice) of the ear, thus rendering the device to be of small size, light in weight, convenient to use, practically or totally unapparent to observation, and of widespread applicability to the general ambient noise conditions experienced daily by a vast segment of the population.

SUMMARY OF THE INVENTION

A federal government-sponsored panel has recently asserted that noise pollution in the United States was "on the verge of reaching a serious level" and has called for new federal and state standards to protect Americans against hearing damage and annoyance. The panel recommended steps to help eliminate some of the din of modern living and said the United States should establish a national goal to "work toward an environment for all Americans free of noise that jeopardizes their health and welfare or unnecessarily detracts from the quality of life."

"Millions of workers are now exposed to noise levels that have been shown conclusively to produce hearing damage," the panel named by the Commerce Department said. "Most of these workers are unaware of the hazard and do not act to protect themselves."

The Department of Health, Education and Welfare should establish "interim criteria and guidelines for use in setting standards to human exposure to noise," the panel said. One of the recommendations of the panel, to establish an Office of Noise Abatement in the Environmental Protection Agency, has been proposed by President Nixon in a bill now before the Senate.

The panel further stated that almost all Americans were responsible for what it called a "widespread pollutant which can have many adverse effects on man." The panel said that 150 million Americans living in cities and suburbs were exposed to annoying noise that "constitutes a degradation of health."

Urban and suburban noise levels are rising with advanced technology and increased population, exposing the populace to the din of traffic, trucks, sirens, pneumatic drills, machinery, construction and demolition equipment, horn blasts, squeeling tires, screeching brakes, trains, motorcycles, and riveting guns.

For years now, and in growing numbers daily, residents near jet airports have been complaining of noise problems, and even attempting legal action. In another few years, noise problems may be compounded with the advent of the SST (supersonic transport). This aircraft may not only be as noisy as current aircraft, but may create sonic booms, which, while of short duration, may be of high intensity. Moreover, the sonic

boom gives no warning of its approaching imminence, materializing seemingly at random to persons on the ground at unpredictable times and with unpredictable intensities. In a few years, then, persons with no protection from random, high-intensity sound may well suffer in ways difficult to predict.

Sixty years ago, Robert Koch, Nobel laureate, predicted: "A day will come when man will have to fight merciless noise as the worst enemy of health." Dr. Vern O. Knudsen, chancellor emeritus of the University of California, has said: "Noise, like smog, is a slow agent of death. If it continues for the next 30 years as it has for the past 30, it could become lethal."

From the above discussion, and an awareness of the general scope and broad, widespread nature of the problem of noise pollution, it becomes apparent that it has been virtually impossible, within the context of our present technology, to sufficiently silence our machines, appliances, and all other sources of noise, to an appreciable extent. While it is true that, in some instances, there has been some success in reducing noise levels, the general level of noise continues to increase, due to the incompatibility of the operation of present machines with the non-production of noise. In other words, if the attention of noise-abatement endeavors is predominantly focused, as it currently is, upon the present sources of noise, there is relatively little of practical value that can be accomplished, as proven by the current growing magnitude of the problem. But, on the other hand, if attention is transferred from the source or transmitter of the noise to the receiver, the ear, then it becomes possible, using non-linear electronic and acoustic techniques, to provide a device which not only subdues and effectively impedes loud sounds and noises to a level sufficiently low as to be within the comfort level of the human ear drum, but also, during lapses of the intense noise, permits the user of the device to hear sounds of normal intensity so that they are unsubdued, thereby enabling ordinary conversation, communication, and listening to be unimpaired. It is for these basic reasons that the device herein described was conceived, offering to the populace a reasonable, workable, and practical solution to many of their noise problems, by means of the filtering, dampening, and discriminating of sound energy, allowing only that sound intensity to be heard which is unpainful to the human ear.

In addition, it has simultaneously become possible, by utilizing modern microminiaturized electronic techniques, to package the device so that it is situated comfortably, unnoticed, and untroublesome in Nature's own little secret hiding place, the ear canal. Thus, with such tiny, unapparent packaging, and yet retaining a high degree of efficiency, the device described herein can be an effective soldier in the battle against noise, at last offering the general populace the first practical means for relief against noise pollution.

Other, more specialized applications of this device, and modifications thereof, mainly for persons who work in high-intermittant-noise environments, but who wish to retain the capacity for conversing normally with others, such as certain types of industrial workers and soldiers, for example, may prove to be quite numerous.

Thus, it is a principle object of the present invention to provide a device which subdues the intensity of ambient sound so that it reaches the ear drum within the limit of comfort, and simultaneously permits ambient

sound which is below the limit of comfort to reach the ear drum undiminished.

It is another principle object of the present invention to provide a novel sound-amplitude limiter, in accordance with the above paragraph, which is worn by the user as a self-contained unit in the outer end of the ear canal; and which, for most persons with normal hearing, is worn as an identical pair, one device in each ear canal.

It is another object of the invention to provide a novel sound-amplitude limiter for limiting the intensity of sound reaching the human ear drum to be below the threshold of discomfort while simultaneously allowing sound below that threshold to reach the ear drum electronically reproduced, by means of an earpiece which is worn in the ear canal and which contains a sound-deadening substance located between either: (a) the speaker and microphone of a microminiaturized electronic sound-reproducing circuit with output-limiter and power source, or (b) the speaker and sound-powered microphone of a microminiaturized electronic sound-reproducing circuit with output-limiter.

It is another object of the invention to provide a novel sound-amplitude limiter as described above which is self-contained in the ear canal and which is of the approximate size, shape, and fitness within the ear canal as an ear plug.

It is another object of the invention to provide a novel sound-amplitude limiter as described above which is self-contained in the ear canal, and which is of the approximate size, shape, and fitness within the ear canal as an earplug; such fitness being without soreness or irritation of the ear canal lining membranes by means of an undulating-surfaced, soft, resilient, and flexible earpiece casing which prevents localized pressure spots from arising between casing and ear canal lining, and which said earpiece casings may be manufactured in various shapes and sized, in the case of "ready-made" limiters; or such fitness being provided by custom-molding said earpiece casing to the shape of the ear canal of the particular user, in the case of "tailor-made" limiters.

It is another object of the invention to provide a novel sound-amplitude limiter as described above which is of the approximate size, shape, and fitness within the ear canal as an earplug, which has a soft, flexible earpiece casing, and which said earpiece is of two attachable and unattachable parts; an inner part towards the inner ear, and an outer part towards the outer ear.

It is a further object of this invention to provide a novel sound-amplitude limiter as described above, the inner and outer casings of which are fitted over, contain, and are bonded to, or are molded over, an inner and outer housing.

It is a further object of this invention to provide a novel sound-amplitude limiter as described above, which said inner and outer housings typically screw or otherwise attach together, as with a jar and its cover, facilitating an easy change of batteries or repair of the unit, and which said inner and outer housings contain the amplifier with output-limiter, the battery or power source, and the microphone, said microphone being positioned at the outermost end of the outer housing, nearest the external ear.

It is a further object of this invention to provide a novel sound-amplitude limiter as described above,

which said amplifier with output-limiter and said microphone are separated within the inner and outer housings by the battery, such separation minimizing any feedback effects.

It is a further object of this invention to provide a novel sound-amplitude limiter as described above, which has a quantity of sound-deadening material, such as milkweed floss, kapok, glass fibers, or silicone rubber, positioned as a plug anywhere between the microphone and speaker of said earpiece, but typically and as illustrated said plug of sound-deadening material being located between the housing and the speaker, said speaker being electrically connected to the output of the amplifier by two wires which run through said sound-deadening material.

It is a further object of this invention to provide a novel sound-amplitude limiter as described above whose outer casing is either of three basic types: (a) the first type having a broadened outer end which blocks any further inward travel of the earpiece within the ear canal, and which said broadened outer end can be used to facilitate the easy insertion and removal of said earpiece by the fingers of the user; (b) the second type of outer casing not having a broadened end, which permits the earpiece to be inserted further within the ear canal so as to be completely unnoticeable from observation, said earpiece in this instance having a hook on the outermost end with which a similar but longer hook can be inserted by the fingers of the user for removal; and (c) the third, or "industrial" type of outer casing, especially useful for extreme noise conditions, having a spherical outer end protruding beyond the ear canal which is filled with additional sound-deadening material and in which the microphone has been repositioned to the outermost tip of the outer casing, with the connecting wires of said microphone running through the additional sound-deadening material to terminals in the microphone compartment of the outer housing, which said microphone compartment has also been filled with additional sound-absorptive material.

It is a further object of this invention to provide a novel sound-amplitude limiter as described above, which said battery of said sound-amplitude limiter may be removed with the resultant device becoming an effective ear plug, especially useful to the user during sleep which might otherwise be interrupted by annoying sounds.

In the drawings:

FIG. 1 is an elevational view of the first form of sound-amplitude limiter, showing the device inserted in the ear canal.

FIG. 2 is an elevational view of the most inconspicuous form of sound-amplitude limiter, showing the device inserted in the ear canal.

FIG. 3 is a longitudinal sectional view taken along line 3 — 3 of FIG. 2.

FIG. 4 is an exploded view of the device of FIGS. 2 and 3 in perspective.

FIG. 5 is a graph illustrating the acoustical characteristics of sound-amplitude limiters, earplugs, and hearing-aids.

FIGS. 6 to 9 illustrate various typical modifications of inner and outer casings.

FIGS. 10 to 12 are perspective views of special and alternative tools which can be used for the insertion and removal of the device of FIG. 2.

TECHNICAL DESCRIPTION

Referring first to FIGS. 1 and 2, the invention described herein is typically an earpiece, indicated as a whole by the reference character 15, which utilizes the most modern in microminiaturized electronic circuitry and acoustical components, thereby rendering the device not only effective functionally but small enough to be perhaps completely self-contained within the ear canal 16 of the human ear 17, external of the ear drum 18, and practically invisible from human observation, as illustrated in FIG. 2.

Referring to FIG. 3, in essence the device contains some of the components of modern microminiaturized electronic hearing aids, in that it contains a miniature PA (public address) system, with microphone 19, battery 20, amplifier-type circuitry with output-limiter 21, and speaker 22; and, in addition, contains the sound-absorptive material 23 of modern ear-plugs. It is assumed that for most persons, a pair of sound-amplitude limiters would be worn, one in each ear.

Referring to FIG. 5, sound-amplitude limiters provide their operational characteristics by what might be called discrimination, in that sound inputs above a certain maximum-intensity limit, typically taken as the limit of comfort, are restricted in their output intensity reaching the ear drum to an acceptable level for the human ear, while those sound inputs below the maximum-intensity limit result in an output intensity which is equivalent to the input. This type of operational characteristic is in contrast to hearing aids, which amplify sounds for hard-of-hearing persons up to a maximum-intensity limit, but which provide no protection against high-intensity sounds; and is also in contrast to ear plugs or ear protectors, which diminish and provide protection against high-intensity sound, but which simultaneously and proportionally diminish desirable, low and medium-intensity sound such as conversation, in a linear manner, at each discreet frequency. Sound-amplitude limiters, therefore, have unique functional characteristics which render them different from both hearing-aids and ear-plugs, and which said unique functional characteristics enable sound-amplitude limiters to be utilized for different purposes, by different persons, and for different situations than either hearing aids or ear-plugs.

Referring again to FIG. 3, a sound-amplitude limiter 15 is designed so that most un-transduced sound, that is, sound which is directly transmitted through the material of the device and not converted to electrical signals and then re-converted back to sound at the speaker 22, is blocked-out from reaching the middle ear by a highly effective sound-absorbing material 23 which is located within the earpiece 15 which is situated in the ear canal, with the exception of acceptable, transduced sound which is converted to electrical signals, output-limited, and transmitted through the sound-absorbing material 23 by two wires 24 connecting to the speaker 22 or sound-transducer at the inner tip of the device, nearest the ear drum. Said sound-absorbing material 23 is typically composed of milkweed floss, kapok, glass fibers, or silicone rubber which is capable of attenuating the sound volume by a factor of approximately 8 times, or 30 decibels, or even more. The microphone 19, battery 20, and amplifier-type circuitry (with output-limiter and suitable frequency-response characteristics) 21 can typically be located, as

shown, towards the outer end of said sound-absorbing material 23. The detailed electronic circuitry actually to be utilized is fully described in the literature. At the outermost extremity of the device may be a tiny hook 25, allowing a person to reach in the ear with a similar but longer hooking device, such as that shown in FIG. 11, and remove his or her pair of sound-amplitude limiters whenever desired. For the easy insertion of hook-type sound-amplitude limiters into the ear canal, a tool such as that shown in FIG. 10 may be used. For both insertion and removal of hook-type sound-amplitude limiters, a convenient combination tool such as that shown in FIG. 12 might be used. It is possible that certain persons at times may wish to remove the batteries of their pair of sound-amplitude limiters, whereupon the devices become an effective pair of earplugs useful for sleepers who are bothered by annoying sounds. Because sound-amplitude limiters can be left in the ears continuously, with only occasional removal, and because they offer no impairment to normal hearing, they can provide continuous protection against unpredictable, high-intensity sound energy.

Referring to the longitudinal sectional view of FIG. 3, and the exploded perspective view of FIG. 4, a more complete description of a typical physical embodiment of a sound-amplitude limiter can be given.

The earpiece 15 is constructed so as to facilitate the easy change of batteries, which is the only maintenance procedure occasionally required of the user, besides periodically removing the earpiece from the ear canal for the cleaning of the casing surface. The casing of the earpiece 15 is thus composed of two parts, an inner casing 26 nearest the inner ear and an outer casing 27 nearest the external ear. Both the inner and outer casings are made of a soft, resilient, and pliable material, typically silicone rubber or latex; and, in the case of ready-made limiters, having slightly-undulating surfaces so that they may readily conform to the shape of the ear canal upon insertion without creating localized pressure points between casing and ear canal lining membranes which can cause soreness and irritation. In addition, such said undulating surfaces permit an airtight seal between casing and ear canal lining, thus enhancing the sound-blocking feature of ready-made devices.

The inner casing 26 and outer casing 27 are fitted over, contain, and are bonded to, or molded over, the inner housing 28 and outer housing 29, respectively, which said housings together contain the microphone 19, battery 20, and amplifier-type circuitry with output-limiter 21. The wafer-type battery 20 is situated between the microphone 19 and the amplifier 21 to separate the two and minimize any feedback effects. The inner housing 28 and outer housing 29 typically screw or otherwise attach together, as with a jar and its cover, by means of male threads 30 on the outermost extremity of inner housing 28, and female threads 31 on the innermost extremity of outer housing 29. The inside volumes of both the inner housing 28 and outer housing 29 are cylindrical, and when the two housings, along with their bonded casings, are unscrewed or otherwise unattached, the battery 20 easily slips out of the cylinder of the inner housing 28, whereupon a new battery easily slips in.

The microphone 19, battery 20, and amplifier 21 are positioned within their own separate compartments within the housings by means of the outer housing plate

32, and the inner housing plate 33. The outer housing plate 32 and inner housing plate 33 are each rigidly affixed in their proper position within the inner cylindrical volumes of the outer housing 29 and inner housing 28 respectively, but each plate is easily unfixed and removed, if desired, for maintenance or repair of the microphone 19 or amplifier 21.

The microphone 19 is positioned within the outer end of the outer housing 29 and covered by the outer housing plate 32. Said microphone 19 is positioned with the microphone aperture 56 at the outer end and is held in place within its compartment by means of rubber spacers 34.

An outer housing plate battery clip 35 clips onto the outer housing plate 32 by means of an arc-shaped notch 36 through said outer housing plate 32. The outer housing plate battery clip 35 lies flat against the outer side of the outer housing plate 32, but protrudes slightly inward from the inner side of said outer housing plate 32, so as to provide a slight spring compression against the battery 20 and tension against the male threads 30 and female threads 31 as the inner housing 28 and outer housing 29 are screwed together.

The two electrical connections from the microphone 19 and the electrical connection from the outer housing plate battery clip 35 are made through three hair-spring-loaded arc-shaped contacts 37 which are evenly spaced about the outer circular periphery on the inner face of outer housing plate 32. These arc-shaped contacts 37 subtend small arcs which make connection with three appropriately mating semi-spherical contacts 38 evenly spaced about the outer circular periphery of the outermost face of the inner housing 28, as the inner housing 28 and the outer housing 29 are screwed together and tightened.

The electrical wires connecting from the three semi-spherical contacts 38 to the amplifier 21 run along three grooves 39 on the inner cylindrical wall of inner housing 28.

The amplifier 21 is positioned within the inner end of the inner housing 28 and covered by the inner housing plate 33. Said amplifier 21 is held in place within its compartment by means of epoxy or rubber spacers 40.

An inner housing plate battery clip 41 clips onto the inner housing plate 33 by means of an arc-shaped notch 42 through said inner housing plate 33. The inner housing plate battery clip 41 lies flat against the inner side of the inner housing plate 33, but protrudes slightly outward from the outer side of said inner housing plate 33, so as to help provide a slight additional spring compression against the battery 20 and tension against the male threads 30 and female threads 31 as the inner housing 28 and outer housing 29 are screwed together and tightened.

An electrical wire connects the inner housing plate battery clip 41 to the amplifier 21 within the amplifier compartment.

The speaker 22 is fitted and bonded within the innermost tip of inner casing 26, so that the acoustic output aperture 42 of speaker 22 is adjacent to the aperture 43 of inner casing 26, which in turn is adjacent to the user's ear drum. The flanged edges 44 of inner end plate 45 are sandwiched between the tip of inner casing 26 and the tip of speaker 22. Inner end plate 45 has tiny apertures 46, the axes of which are perpendicular to and offset from the acoustic output aperture 42 of speaker 22.

Two electrical wires 24 run from two terminals 47 on speaker 22, through the sound-deadening material 23 and two holes 48 in the innermost face of inner housing 28, to the output terminals of amplifier 21.

The soft, resilient inner casing 26, the flexible sound-deadening material 23, and the pliable, loosely run wires 24 permit approximately the innermost half of the device 15 to follow the twist and turn of the ear canal, thus insuring proper fitness therein, and preventing any undue stress on the device itself.

At the outermost end of a "hook-type" device 15 is a hook 25 which is part of outer end plate 49. Outer end plate 49 has tiny apertures 50 which are mounted adjacent to aperture 51 of outer casing 27 and tiny apertures 52 of the outermost end of outer housing 29. Outer end plate 49 is sandwiched between outer casing 27 and the outermost end of outer housing 29, said outer end plate 49 being attached to the outermost end of outer housing 29 by means of screws 53 through countersunk holes 54 in outer end plate 49 and holes 55 in the outermost end of outer housing 29.

FIGS. 6 and 7 illustrate two variations in shape of inner casing 26 as used with hook-type devices.

FIG. 8 illustrates a variation in shape of outer casing 27 as used with a "finger-type" device.

FIG. 9 illustrates a typical "industrial-type" device which is especially useful for extreme noise conditions. The outer casing 27 has a spherical outer end protruding beyond the ear canal which is filled with additional sound-deadening material and in which the microphone 19 has been re-positioned to the outermost tip of the outer casing, with the conducting wires of said microphone 19 running through the additional sound-deadening material to terminals in the microphone compartment of the outer housing, which said microphone compartment has also been filled with additional sound-absorptive material. It is possible that ladies would find this type of device especially attractive to wear if the outside surface of the sphere were covered with some type of decoration.

Various modifications may of course be made from the illustrative embodiment hereinbefore described and any part may be omitted and replaced by a substitute which performs the same function or the same function plus one or more additional functions, and changes or reversals of position may be made without departing from the broad spirit of the invention as succinctly set forth in the appended claims.

The inventor claims:

1. A sound-amplitude limiter which is self-contained in the ear canal of the user, and which is used by persons with normal hearing as an indential pair, comprising:
 - a. a casing which is adapted to be fitted into the ear canal;
 - b. a microphone within the outer tip of said casing adjacent the external ear;
 - c. a speaker within the inner tip of said casing adjacent the ear drum;
 - d. an amplifier-type circuit of nominal gain of one with output-limiter and a battery located within said casing between said microphone and said speaker;
 - e. a plug of sound-deadening material located within said casing between said microphone and said speaker, said plug of sound-deadening material

having two electrical connecting wires passing through it;

- f. the above mentioned electronic components hooked-up in operable relationship as a miniature public address system so that sound inputs above the limit of comfort for the human ear are reduced to that limit at the ear drum, while sound inputs below said limit are electronically reproduced at the ear drum.

2. The sound-amplitude limiter of claim 1 wherein said casing which is adapted to be fitted into the ear canal is comprised of:

- a. an inner casing towards the inner ear made of a soft, resilient, pliable material such as rubber or latex, which said inner casing has undulating surfaces enabling tight fitness within the ear canal without irritation.

- b. an outer casing towards the outer ear made of the same of similar material and with the same or similar undulating surfaces as said inner casing.

3. The sound-amplitude limiter of claim 2 wherein:

- a. said inner casing is fitted over, contains, and is bonded to an inner cylindrical housing having male threads at its protruding outer end;

- b. said outer casing is fitted over, contains, and is bonded to an outer cylindrical housing having female threads at its inner end;

- c. said inner and outer housings, which are contained by said inner and outer casings, respectively, screw together and form a compartment for said microphone, said battery, and said amplifier-type circuitry with output-limiter;

- d. said compartment is further divided into a microphone compartment at the outer end by an outer housing plate which is rigidly affixed to said outer housing, an amplifier compartment at the inner end by an inner housing plate which is rigidly affixed to said inner housing, and a battery compartment between said inner and outer housing plates; said microphone and said amplifier being separated by said battery to minimize any feedback effects.

4. The sound-amplitude limiter of claim 3, wherein:

- a. said inner and outer housing plates have battery clips attached thereto which provide a slight compression force against the battery terminals and a slight tension force against said male and female threads as said inner and outer housing are screwed together;

- b. the inner face of said outer housing plate contains three hairspring-loaded arc-shaped contacts which are evenly spaced about the outer circular periphery, which said arc-shaped contacts subtend small arcs and make connection with three appropriately-mating semi-spherical contacts evenly spaced about the outer circular periphery of the outermost face of the inner housing, as the inner and outer housings are screwed together and tightened;

- c. said arc-shaped contacts and said semi-spherical contacts provide electrical connection for the two microphone leads and the outer housing plate battery clip lead to said amplifier.

5. The sound-amplitude limiter of claim 4 wherein:

- a. an inner end plate is affixed adjacent to the inner end of said speaker, the flanges of said inner end plate being sandwiched between said speaker and said inner casing, and the axes of the tiny apertures in said inner end plate being perpendicular to and

offset from the acoustic output aperture of said speaker;

- b. an outer end plate with a hook is affixed adjacent to the outer end of said outer housing, said outer end plate being sandwiched between said outer casing and said outer housing and secured by screws onto said outer housing, and the tiny apertures in said outer end plate being aligned with the tiny apertures in said outer housing.

6. A sound-amplitude limiter which is self-contained in the ear canal of the user, and which is used by persons with normal hearing as an identical pair, comprising:

- a. an inner part nearest the inner ear and an outer part nearest the outer ear which parts can be unscrewed or otherwise unattached from each other when the device is removed from the ear canal for maintenance or battery change;

- b. said inner part containing a speaker at the inner tip; a plug of sound-deadening material such as milkweed floss, kapok, glass fiber, or silicone rubber; and an inner cylindrical housing having a cylindrical compartment, closed at the inner end and open at the outer end, containing an amplifier of nominal gain of one with output-limiter at the inner end and having male threads on the protruding outer end;

- c. said outer part containing an outer cylindrical housing having a cylindrical compartment, open at the inner end and closed at the outer end, containing a microphone at the outer end and having female threads on the inner end;

- d. said inner cylindrical housing and said outer cylindrical housing when screwed together forming a compartment for said battery;

- e. the above mentioned electronic components hooked-up in operable relationship as a miniature public address system so that sound inputs above the limit of comfort for the human ear are reduced to that limit at the ear drum, while sound inputs below said limit are electronically reproduced at the ear drum.

7. The sound-amplitude limiter of claim 6 wherein:

- a. said inner part nearest the inner ear is fitted within, contained by, and bonded to a cylindrical-shaped inner casing having an aperture at the inner tip for the transmission of sound from said speaker to the ear drum, said inner casing also having an aperture at the outer end of sufficient size to fit over and contain said inner cylindrical housing;

- b. said inner casing is made of a soft, resilient, pliable material such as rubber or latex, which said inner casing has undulating surfaces enabling tight fitness and conformity within the ear canal without irritation;

- c. said outer part nearest the outer ear is fitted within, contained by, and bonded to a cylindrical-shaped outer casing having an aperture at the outer tip for the transmission of sound from the ambient environment to said microphone, said outer casing also having an aperture at the inner end of sufficient size to fit over and contain said outer cylindrical housing;

- d. said outer casing is made of a soft, resilient, pliable material such as rubber or latex, which said outer casing has undulating surfaces enabling tight fitness

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and conformity within the ear canal without irritation.

- 8. The sound-amplitude limiter of claim 7 wherein:
 - a. said inner and outer casings can be made in various shapes and sizes or custom-molded for the particular user; 5
 - b. said outer part does not have a hook, but said outer casing has a broadened outer tip which limits the inward travel of the device within the ear canal and is suitable for finger insertion and removal; 10
 - c. said outer part does not have a hook, but said outer casing has an enlarged, spherical outer end protruding beyond the ear canal which is filled with additional sound-deadening material and in which the microphone has been re-positioned to the outermost tip of said outer casing, with the connecting wires of said microphone running through the additional sound-deadening material to terminals in the microphone compartment of the outer housing, which said microphone compartment has also been filled with additional sound-deadening material, rendering the device especially useful for extreme noise conditions. 20
- 9. The sound-amplitude limiter of claim 8 wherein:
 - a. an outer housing plate is rigidly affixed within said outer cylindrical housing, which said outer housing plate separates said microphone on the outer side from said battery on the inner side; 25
 - b. an inner housing plate is rigidly affixed within said inner cylindrical housing, which said inner housing plate separates said amplifier with output-limiter on the inner side from said battery on the outer side; 30
 - c. said microphone and said amplifier with output-limiter are separated by said battery to minimize any feedback effects; 35
 - d. said inner and outer housing plates have battery clips attached thereto which provide a slight compression force against the battery terminals and a slight tension force against said male and female threads as said inner and outer cylindrical housing are screwed together and tightened; 40
 - e. the inner face of said outer housing plate contains 45

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- three hairspring-loaded contacts which are evenly spaced about the outer circular periphery, which said contacts subtend small arcs and make connection with three appropriately mating semi-spherical contacts evenly spaced about the outer circular periphery of the outermost face of the inner housing, as the inner and outer housings are screwed together and tightened;
- f. said contacts provide electrical connection for the two microphone leads and the outer housing plate battery clip lead to said amplifier;
- g. an inner end plate is affixed adjacent to the inner end of said speaker, the flanges of said inner end plate being sandwiched between said speaker and said inner casing, and the axes of the tiny apertures in said inner end plate being perpendicular to and offset from the acoustic output aperture of said speaker;
- h. an outer end plate with a hook is affixed adjacent to the outer end of said outer housing, said outer end plate being sandwiched between said outer casing and said outer housing and secured by screws onto said outer housing, and the tiny apertures in said outer end plate being aligned with the tiny apertures in said outer housing.

10. A sound-amplitude limiting device which is self-contained in the ear canal of the user, which is used by persons with normal hearing as an identical pair, and which is of the approximate size, shape, and fitness within said ear canal as an ear-plug; which said device limits the intensity of environmental sound reaching the ear drum to be below the limit of comfort while simultaneously allowing environmental sound below said limit of comfort to reach the ear drum undiminished, by means of a highly-effective sound-deadening substance located between the speaker and microphone of a microminiaturized electronic sound-reproducing system including battery and amplifier-type circuitry of nominal gain of one with output-limiter, said speaker being located at the inner tip of the device nearest the ear drum, and said microphone being located at the outer tip of the device nearest the external ear.

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