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Payne

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[54] **ACOUSTICAL IMPEDANCE MATCHING DEVICE FOR A HIGH IMPEDANCE TRANSDUCER**

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[21] Appl. No.: **266,855**

[52] **U.S. Cl.** ..... **181/0.5 R,** 325/361

[51] **Int. Cl.** **G01v 1/00**

[58] **Field of Search** ..... 325/352, 353, 361; 333/32, 333/34; 340/8 MM, 15; 181/27 A, 27 C, 27 D, 31 A, 0.5 R

[56] **References Cited**

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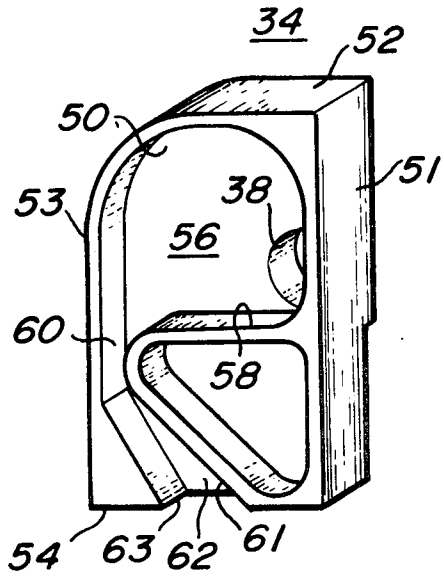
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Assistant Examiner—Marc E. Bookbinder
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[57] **ABSTRACT**

A miniature acoustical impedance matching device for use with a high acoustical impedance transducer which converts electrical waves to sound waves and must be acoustically impedance matched to prevent distortion. The device includes a housing with an acoustical chamber formed therein. A first aperture is formed in the housing for allowing exit of the sound waves from the chamber, and a second aperture is formed for allowing entry of the sound waves from the transducer. The first aperture acts to inhibit exit of the sound waves for developing a predetermined sound wave pressure in the chamber. The predetermined sound wave pressure acts to provide an acoustical impedance match for the transducer to reduce or prevent distortion. A passage is coupled to the first aperture for allowing emission of the sound waves.

The matching device can be mounted in a portable radio receiver, thus allowing a transducer normally operable only with a hyperbolic or exponential horn, to be used without a horn.

2 Claims, 8 Drawing Figures



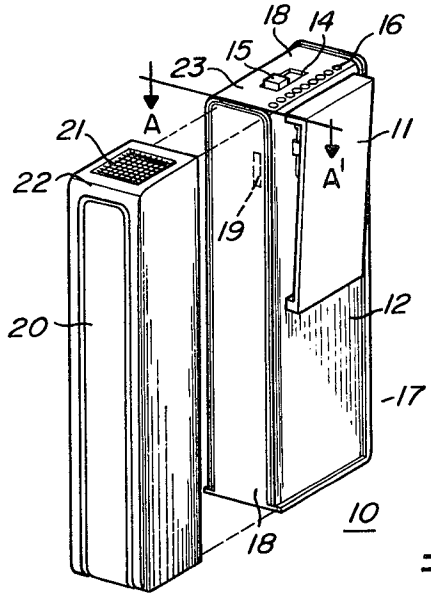


Fig. 1

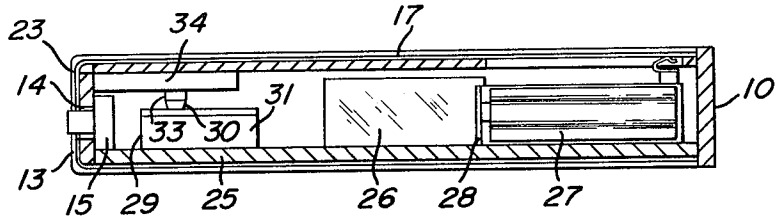


Fig. 2

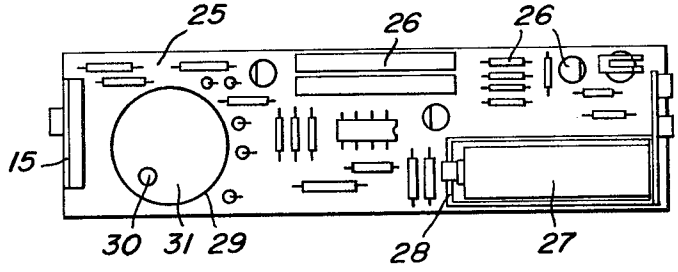


Fig. 3

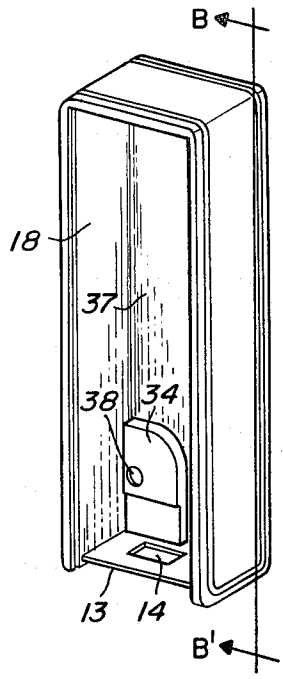


Fig. 4

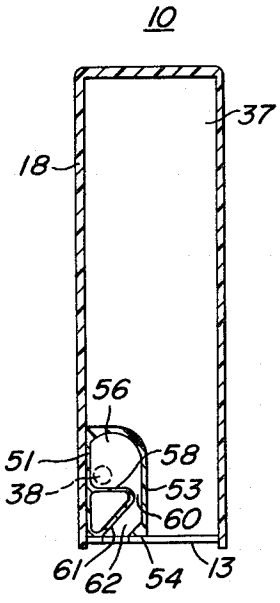


Fig. 5

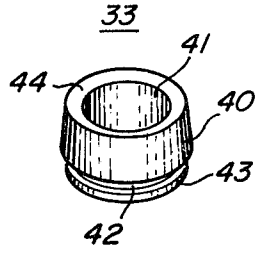


Fig. 7

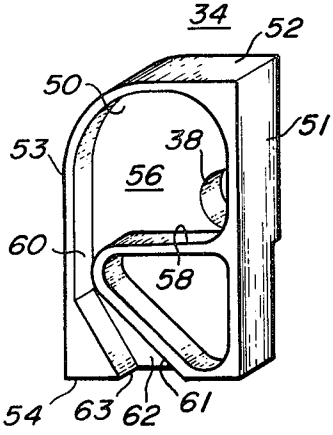


Fig. 6

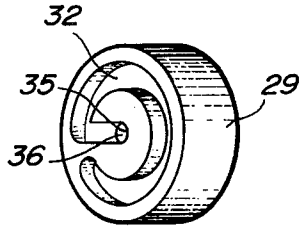


Fig. 8

ACOUSTICAL IMPEDANCE MATCHING DEVICE FOR A HIGH IMPEDANCE TRANSDUCER

BACKGROUND

In small, portable radio apparatus such as a receiver or a pager, to be carried by a user, it has become desirable to employ transducers operating with hyperbolic or acoustical horns for reproducing the audio signals. One such system is described in co-pending U.S. Pat. application Ser. No. 216,674, now U.S. Pat. No. 3,748,583 filed Jan. 20, 1972, and assigned to the same assignee as this application. In that application, the acoustical horn described provides between 10 and 15 (db) of acoustical, or sound level gain for the sound waves developed by the transducer.

In many instances the higher level audio output provided by an exponential or hyperbolic horn is not necessary. In these instances, the transducer output level itself is sufficient. As the radio apparatus housing is normally made from a plastic material which is injection molded, it becomes a relatively simple matter, to modify the housing mold for eliminating that part of the housing which forms the acoustical horn. In fact, both housings may be made with an adjustable mold. Of course it would be most desirable to use the same receiver chassis and transducer in all varieties, both low and high audio level of the radio apparatus. The transducer and acoustical horn are, however, matched to one another in order to provide the high level audio output without substantial audio distortion. That is, the length of the acoustical horn causes a build-up of sound pressure waves. This build-up of sound pressure waves acts to load the transducer and provide a proper acoustical impedance match, thus preventing distortion of the audio signal as a result of improper acoustical matching of the transducer. If the transducer output is coupled directly to a point external of the housing, the absence of a proper sound pressure level loading on the transducer will result in an improper acoustical impedance match for the transducer. The improper acoustical impedance match will cause the transducer to produce severely distorted audio signals.

SUMMARY

It is an object of this invention to provide a miniature acoustical impedance matching device for use with a high acoustical impedance transducer which properly matches the transducer and prevents distortion.

Another object of this invention is to provide a miniature acoustical impedance matching device which allows one transducer to be used with and without a matched acoustical horn in accordance with the audio power level desired.

Yet another object of this invention is to provide an improved radio receiver apparatus which includes an acoustical impedance matching device for properly matching and loading a high acoustical impedance transducer.

In practicing this invention, a miniature acoustical impedance matching device is provided for use with a high acoustical impedance transducer that converts electrical waves to sound waves and must be acoustically impedance matched. The transducer is normally coupled to an acoustical horn which acts to provide the necessary acoustical loading and impedance matching for the transducer. Proper matching and loading of the transducer by the horn prevents distortion of the audio signals by the transducer. The horn also acts as an amplifier for amplifying the audio signals. The miniature acoustical impedance matching device includes a housing which has an acoustical chamber defined therein that has a first cross-sectional area. An aperture is formed in the housing for allowing exit of the sound waves from the chamber. The aperture has a second smaller cross-sectional area than the area of the chamber, thus inhibiting exit of the sound waves. This results in the development of a predetermined sound wave pressure in the chamber. The sound wave pressure acts to load and provide an acoustical impedance match for the transducer, thus preventing distortion of the reproduced audio signals.

The miniature acoustical impedance matching device may be employed in a portable radio receiver for properly matching the transducer employed therein. This allows the same radio chassis, including the same transducer device, to be used, in applications where a high audio output level is required, and where a lower audio output level is required.

THE DRAWINGS

FIG. 1 is a perspective view of a portable radio pager including the acoustical impedance matching device of this invention; and also of the acoustical horn portion of a housing which may be provided when higher audio levels are desired and for which this invention has been substituted.

FIG. 2 is a section view of the pager of FIG. 1 along the section lines AA', showing the circuit board and components of the removable radio receiver mounted in the pager housing;

FIG. 3 is a view of the portable radio receiver chassis, including the transducer adapted to be mounted in the pager housing shown in FIG. 1;

FIG. 4 is a perspective view of the housing shown in FIG. 1 with the U-shaped front and rear cover and removable radio receiver chassis removed;

FIG. 5 is a cross-sectional view of the housing in FIG. 4 along the section lines BB';

FIG. 6 is a perspective view of the acoustical impedance matching device of this invention showing the interior construction;

FIG. 7 is a perspective view of the coupling device shown in FIG. 2;

FIG. 8 is a perspective view of the transducer device shown in FIG. 3 with its cover removed.

DETAILED DESCRIPTION

Referring to FIG. 1, a rectangular elongated housing 10 contains a self-contained removable radio receiver chassis. Clip 11 secured to back wall 12 of U-shaped housing cover 17, allows the radio pager to be secured in a user's shirt pocket or on the user's belt. Top wall 23 of U-shaped housing cover 17, and inside top wall 13 of housing 10 each have an aperture 14 therein, through which extends switch 15 on the radio receiver chassis. Apertures 16 allows exit of the audio sound waves from housing 10.

In many applications it is desirable to provide an acoustical horn for amplification of the audio signals developed by the transducer in the pager. In FIG. 1, an acoustical horn 20 such as disclosed in the above-noted co-pending patent application is shown. When such an acoustical horn is used, side wall 18 becomes an interior partition wall. Aperture 19 in side wall 18 couples

the sound waves from the transducer to acoustical horn **20.** Sound waves coupled to acoustical horn **20** from aperture **19** are amplified and exit from aperture **21** in top wall **22.**

If a radio pager is desired which does not have an amplified audio output, the radio pager housing **10** will not include acoustical horn section **20.** Side wall **18** will be an outer wall and aperture **19** will not be provided. The audio output will be coupled from the transducer through an acoustical impedance matching device, to be further described in a subsequent portion of this application, and will exit at apertures **16** in housing **10** as noted above.

Referring to FIGS. **2** and **3,** the portable radio receiver chassis for the pager is shown. Printed circuit board **25** seats in housing **10.** Switch **15** is mounted thereon and extends through aperture **14** in top wall **13.** A number of components **26** representative of the entire radio circuitry for the radio receiver chassis are shown on printed circuit board **25.** A battery **27** is secured in battery holder **28** on printed circuit board **25.** Battery **27** provides the power necessary for operating the radio receiver. Transducer device **29** is also secured to printed circuit board **25** and converts the received demodulated signals to audio signals, thus providing an entirely self-contained, operable, portable radio receiver chassis.

Referring to FIG. **8,** there is shown transducer device **29** with housing cover **31** removed. The transducer **35** is located beneath the structure shown and directly below aperture **36.** The audio signals developed by transducer **35** are coupled through the spiral passage shown at **32** and emitted at aperture **30** in transducer housing cover **31** as sound waves. These sound waves are coupled via a coupling device **33,** (shown in FIGS. **2** and **7**) to the acoustical impedance matching device **34** secured to housing **10.**

Referring to FIG. **4,** the acoustical impedance matching device **34** is more clearly shown. Device **34** is secured to top wall **13,** rear wall **37,** and side wall **18.** Device **34** has a first aperture **38** in the top surface thereof. Coupling device **33** is seated in aperture **38,** and held in place by the aperture **38** side walls.

Coupling device **33** is a resilient cylindrical member, which has an outer wall **40,** and an aperture **41,** axially extending through the cylinder. Circumferential groove **42** is cut in outer wall **40** of coupling device **33,** adjacent end **43.** The side walls of aperture **38** on matching device **34** are inserted into groove **42** for securing coupling device **33** to matching device **34.** Coupling device **33** may be manufactured from rubber or a synthetic equivalent of rubber.

Referring again to FIG. **2,** output aperture **30** of transducer device **29** is positioned adjacent aperture **41** in coupling device **33.** When circuit board **25** is inserted into housing **10,** coupling device **33** is compressed, with end **44** bearing against transducer housing cover **31** and surrounding aperture **30.** Coupling device **33** acts to couple the sound waves from output aperture **30** of transducer device **29** to acoustical impedance matching device **34.** Because coupling device **33** only resiliently bears against transducer housing **31,** the portable radio receiver may be removed and reinserted in housing **10,** and when reinserted will make a good acoustical connection with impedance matching device **34.** This allows printed circuit board **25,** and the entire self-contained radio receiver chassis mounted thereon, to be removed, tested and easily reinserted; or to be inserted in a number of housings for use with different types of acoustical horns or impedance matching devices.

As previously mentioned, transducer device **29** is designed to normally work through a coupling chamber into an acoustical horn shown at **20** in FIG. **1.** If the audio sound wave amplification produced by acoustical horn **20** is not desired, a device must be used which will properly load transducer **29** so as to prevent it from causing a distortion of the reproduced audio signals. Acoustical impedance matching device **34** provides this necessary loading and acoustical impedance matching function.

Referring to FIG. **6,** sound waves developed by transducer **29** are coupled through coupling device **33** to aperture **38** in impedance matching device **34.** Impedance matching device **34** includes a top wall **50,** side walls **51, 52, 53** and **54,** and may include a bottom wall. In the embodiment shown, the bottom wall for impedance matching device **34** is supplied by bottom wall **37** of housing **10.**

An acoustical chamber **56** is defined by the walls of device **34,** bottom wall **37** of housing **10,** and an inner partition wall **58** of matching device **34.** Sound waves coupled through aperture **38** enter acoustical chamber **56.** Acoustical chamber **56** has a cross-sectional area which is substantially greater than aperture **38.** Side wall **53,** inner partition wall **58,** top wall **50** and bottom wall **37** of housing **10** also define an output aperture **60.** The cross-sectional area of output aperture **60** is substantially smaller than the cross-sectional area of acoustical chamber **56.** Sound waves entering acoustical chamber **56** via aperture **38** will attempt to exit via aperture **60.** Because the cross-sectional area **60** is substantially less than the cross-sectional area of chamber **56,** aperture **60** will act as a restriction that will inhibit exit of the sound waves. This will result in a predetermined sound wave pressure developing in chamber **56.** The sound wave pressure will be reflected back to transducer **29** where it will act to load transducer **29** and provide an acoustical impedance match which will prevent the transducer from distorting the reproduced audio signals.

A second, inner partition wall **61,** along with side wall **53,** top wall **50,** and bottom wall **37** of housing **10** acts to provide a passage **62** for coupling the sound waves from aperture **60** to a point external of housing **10** via aperture **16.** Passage **62** has at the junction of first inner partition wall **58** and second inner partition wall **61,** the same cross-sectional area as aperture **60.** The cross-sectional area of this passage increases in an exponential fashion until it reaches output aperture **63** and side wall **54.**

As can be seen, a miniature acoustical impedance matching device has been provided for use with a high acoustical impedance transducer which properly matches the transducer and prevents distortion. This allows one transducer to be used with and without a matched acoustical horn in accordance with the audio power level desired thus allowing variations in the housings of radio pagers while using the same radio receiver chassis and audio transducer.

I claim:

1. A miniature acoustical impedance matching device for use with a high acoustical impedance transducer means which converts electrical waves to sound

waves and which must be impedance matched to prevent distortion, said device including in combination;

a. a housing having top, bottom and side walls defining an acoustical chamber therein having a first cross-sectional area;

b. a first sound wave restricting aperture in said housing defined by said housing walls for allowing exit of said sound waves from said chamber, said first aperture having a second cross-sectional area smaller than said first cross-sectional area for restricting free exit of said sound waves, said acoustical chamber developing a predetermined sound wave pressure therein in responses to said first aperture restricting free exit of said sound waves, and said sound pressure providing an acoustical impedance match for said transducer means;

c. passage means coupled to said first aperture for allowing emission of said sound waves, said passage means being defined by said housing walls and having a first end coupled to said first aperture and having substantially the same cross-sectional area as said first aperture and said passage means further having an exponentially expanding cross-sectional area; and

d. means for coupling said sound waves from said transducer means to said chamber including a second aperture formed in said housing.

2. A miniature acoustical impedance matching device as claimed in claim **1** wherein said coupling means includes compressible coupling means mounted to the walls of the second aperture in the matching device, said coupling means being compressed by said transducer means between said transducer means output opening and the acoustical chamber for coupling the sound waves to said acoustical chamber.

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