

Sept. 23, 1947.

J. Y. DUNBAR ET AL

2,427,664

HEARING GUARD AND EAR PROTECTOR

Filed Sept. 17, 1945

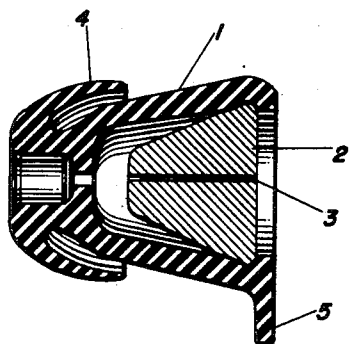


Fig. 1

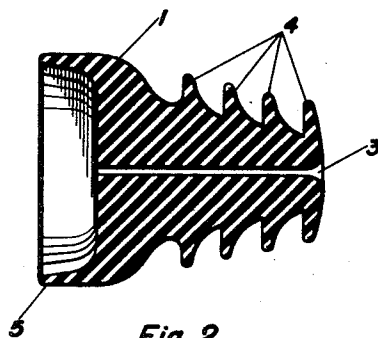


Fig. 2

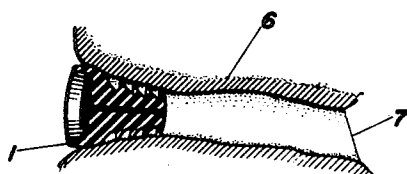


Fig. 3

Inventor

James Y. Dunbar

John S. Knight

By *Joseph L. Chappel*

Attorney

UNITED STATES PATENT OFFICE

2,427,664

HEARING GUARD AND EAR PROTECTOR

James Y. Dunbar and John S. Knight,
United States Navy

Application September 17, 1945, Serial No. 616,942

3 Claims. (Cl. 128—151)

(Granted under the act of March 3, 1883, as
amended April 30, 1928; 370 O. G. 757)

1

This invention pertains to improvements in hearing guards and especially to a plug for protecting the inner ear and contiguous brain sections from damage due to blast and shock waves, and from excessive sound levels.

The use of hearing guards of rubber, composition, wax, and cotton has long been customary in an effort to protect the ear mechanism. The use of modern explosives has rendered these inadequate. Attempts have also been made to filter out certain intense sounds and to seal the ears against high pressures without satisfactory result.

Present records and data show that damage does not coincide with excess pressures or duration of pressure alone. Injury in some cases is greater even with the use of ear plugs as the rate of pressure change is increased, even when low maximum pressures are encountered. It, therefore, appears that damage is caused by the rate of rise of pressure which is a shock function.

An object of this invention is to provide an ear plug capable of offering sufficient mass impedance to resist sudden pressure changes with a minimum of exposed area and provided with means for hearing conversation, and equalizing air pressure in the outer ear canal.

Details of the invention will become apparent from a description of the following figures in which:

Fig. 1 is a cross section of a hearing guard and ear protector provided with a heavy mass impedance member;

Fig. 2 is a cross section of an ear protector of heavy mass in which the mass of the protector performs the required impedance function;

Fig. 3 shows the ear protector of Fig. 2 inserted in the outer ear canal.

In Fig. 1 an ear protector 1 of any well known design is provided with a heavy mass impedance member 2, as shown. It will be noted that the heavy mass inertia plug is perforated at 3 for a purpose later described.

Without any protection the air in the external passage of the ear canal is compressed when acted on by a blast force resulting in acceleration of the ear drum. A heavy mass plug in the outer ear will offer high impedance to rapid changes of pressure. The resistance offered by the mass to wave fronts of high intensity will prevent injurious blast shock on the ear drum and increase the efficiency of the ear protector.

It has been found that a lead plug weighing .005 pound will accelerate approximately $1/1000$ as much as would the ear drum without pro-

2

tection when acted on by a force of 10 pounds per square inch. It has also been found that an increase in weight of a lead plug from .005 pound to .020 pound or an increase in weight by 4 times will decrease the shock only about half. Therefore, the weight should be selected for wearing comfort.

Although lead is preferred as the impedance mass, any heavy mass could be used without departing from the scope of the invention. The mass should be encased in a holder of rubber, neoprene, or any other resilient material formed to fit into the outer ear canal. It should be provided with resilient sealing flange or flanges 4 to prevent irritation and provide a snug fit, and should preferably be provided with a tab 5 to prevent too deep ear penetration as shown in Fig. 1. The mass may also be rubber mixed with a metallic salt of the type shown in Fig. 2. In other words any relatively high density material will suffice.

A small perforation or channel 3 is provided to extend through the mass designed to pass audible frequency and moderate intensity of speech and being small enough to prevent high pressure or energy sounds from passing. In so doing the perforated plug acts to dampen sounds or noises of high frequency and will filter sounds of high intensity and pressure.

The filtering protection of the perforation or tube 3 is a function of length and diameter of opening.

If the air confined in the outer ear canal 6 in front of the ear drum membrane or tympanum 7 and the tubular opening in the plug communicating therewith is considered as a resonator with a restricted neck as shown in Fig. 3, then,

$$\text{Natural frequency of the system } \omega = 2\pi f_n = \frac{l}{\sqrt{MC}}$$

$$M = \frac{\rho l}{\pi R^2} = \text{inertance}$$

$$C = \frac{V}{\rho c^2} = \text{capacitance}$$

$$\begin{aligned} \rho &= \text{density} \\ l &= \text{length of tube} \\ R &= \text{radius of tube} \\ V &= \text{chamber volume} \\ c &= \text{velocity of sound in air} \end{aligned}$$

$$f_n = \frac{Rc}{2\sqrt{Vl}} = K \frac{R}{\sqrt{l}}$$

in which K is a constant for all practical purposes.

It is, therefore, apparent that frequency of the

system varies directly as radius of the perforation and inversely as the $\sqrt{\text{length}}$. The size of opening to admit certain desired frequencies and intensities can, therefore, be determined.

It has been found that a perforation approximately .030 inch in diameter in a lead plug of approximately $\frac{1}{4}$ inch in length will permit sound of ordinary speech to pass and will filter out high frequency sounds and high pressure concussion noises. It is also of a size which may be easily cleaned with an ordinary straight pin.

The heavy mass plug may be added to the hearing guard and ear protector to obtain increased efficiency as in Fig. 1 or the mass may be integrally incorporated into the device as in Fig. 2. To obtain the most satisfactory results in filtering of high frequency sound and excessive concussion noises the perforation or channel should be of the order of approximately .030 inch in diameter and should be approximately $\frac{1}{4}$ inch or more in length.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

Having described our invention we claim:

1. A hearing guard comprising a resilient plug for the ear, a deformable resilient circumferential flange on one end of said plug, an open-ended chamber in the other end of said plug, a heavy mass secured in a portion of said chamber, said mass adapted to prevent passage of extreme sound intensities, a perforation in said plug and

in said mass connecting with said chamber and adapted to permit the passage of non-injurious sounds.

2. A hearing guard comprising a resilient plug for the ear, at least one deformable resilient circumferential flange on said plug for securing the said plug in the ear canal, open-ended chambers at each end of the plug, a heavy mass secured in one of said chambers, said mass adapted to prevent the passage of extreme sound intensities, a perforation in said plug and in said mass connecting said chambers adapted to permit the passage of non-injurious sounds.

3. A hearing guard comprising a resilient semi-metallic plug for the ear, a plurality of deformable flanges on said plug adapted to close the ear canal, a perforation in said plug, whereby the mass of the semi-metallic plug excludes extreme sound intensities and said perforation through said plug permits passage of non-injurious sounds.

JAMES T. DONBAIL,
JOHN S. KNIGHT.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

No	Number	Name	Date
	2,248,527	Krudgen	June 24, 1941
	383,732	King	July 29, 1884
	1,616,575	Emmett	Feb. 6, 1912
	2,352,953	Koop	Sept. 8, 1936