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W. C. JONES

1,863,308

RECEIVER

Filed June 12, 1928

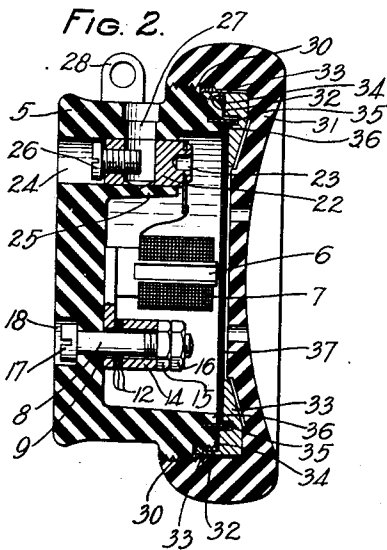
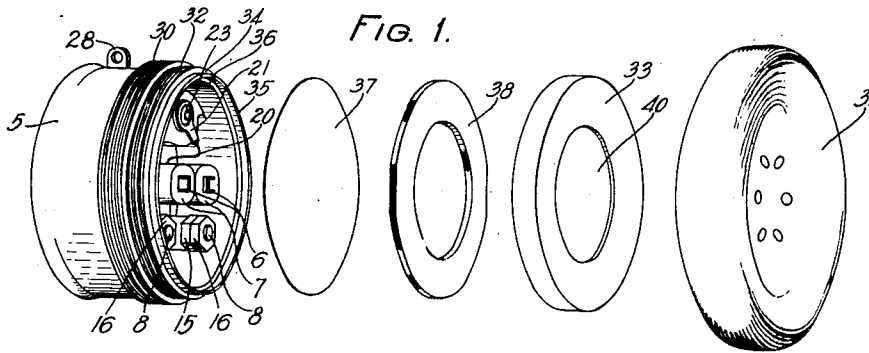


FIG. 3.

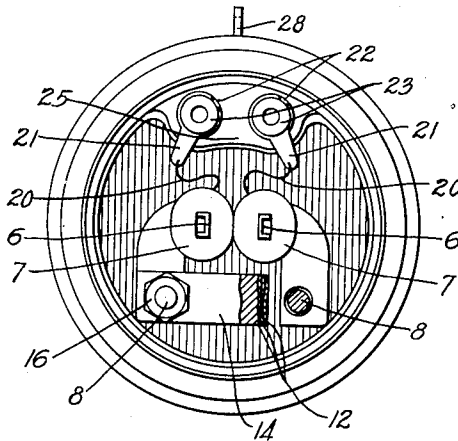


FIG. 4.

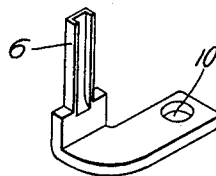


FIG. 7.

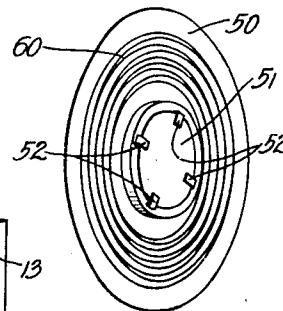


FIG. 6.

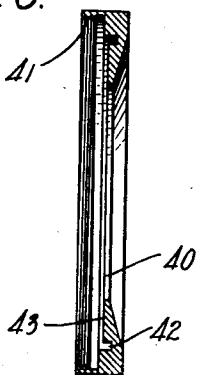
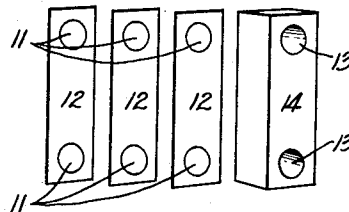


FIG. 5.



INVENTOR
WARREN C. JONES
BY

Walter C. Kiesel
ATTORNEY

UNITED STATES PATENT OFFICE

WARREN C. JONES, OF FLUSHING, NEW YORK, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

RECEIVER

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This invention relates to telephone receivers and particularly to receivers which employ permanent magnets for supplying polarizing flux.

5 An object of this invention is to reduce the acoustic shock effect of receivers which are acoustically coupled to the ear.

Another object of this invention is to obtain substantially uniform magnetic action in a telephone receiver from magnets which may vary considerably in strength.

When a click occurs while a telephone receiver is held to the ear an oscillatory pressure wave is developed at the ear drum. 15 Three characteristics of this wave are of interest from the standpoint of the design of a click reduction receiver, namely, the maximum pressure change, the frequency of the oscillation and its rate of decay.

20 The major portion of the research effort relative to the reaction of the ear to pressures in the region of the threshold of feeling has been confined to sustained pressures usually of sine wave form. For example, it is known 25 that in the region of 500 to 1000 cycles a root mean square pressure of approximately 2800 dynes per square centimeter (peak pressure 4000 dynes per square centimeter) is required to produce a sensation of feeling. At frequencies above and below 1000 cycles the pressure at threshold is somewhat lower. Measurements, which have been made, have shown that the maximum permissible pressure during a click is somewhat lower than 35 the threshold values defined above. The results of these measurements may be summarized as follows:

1. Some observers considered pressures less than 100 dynes per square centimeter, i. e., 40 pressures which fall within the range utilized in speech, objectionable. Quite obviously it would be impossible to eliminate clicks of this intensity without affecting transmission. The receiver, however, can be so designed that 45 the click is rendered less objectionable, for ex-

ample, by eliminating the sense of pitch by increased damping.

2. There appears to be closer correlation between the maximum change in pressure and the undesirability of the click than between peak pressure and undesirability. In other words, for a constant peak pressure an increase in damping will improve the performance of the receiver from the standpoint of click intensity. 55

3. In order to prove satisfactory to the majority of the telephone subscribers it would appear that a receiver should be so designed that a change in pressure in excess of 1500 dynes per square centimeter will never be produced. 60

In addition to the relation between damping, peak pressure, and change in pressure brought out in the previous paragraphs, damping has also been found to have a bearing on the reaction of the ear to the pitch of a click. In this connection experiments have shown that if a damping constant defined as the mechanical resistance divided by twice the effective mass, is in excess of 400 c. g. s. units (numeric seconds) the pitch of the free vibration of the diaphragm is no longer discernible and one of the most disturbing features of many clicks is removed. 65

It would seem, therefore, that a receiver to be entirely satisfactory from a standpoint of clicks should be so designed that it would never produce a change in pressure in excess of 1500 dynes per square centimeter and should have a damping constant in excess of 400. 75

In general there are a number of methods by which change in pressure can be limited. For example, means can be provided for limiting the maximum potential across the terminals of the receiver, the force developed at the air-gaps, the displacement of the diaphragm, etc. In designing the receiver according to this invention the second method has been chosen and the magnetic circuit has 80 85 90

been so proportioned that saturation occurs before the force exerted on the diaphragm produces a displacement sufficient to cause an excessive pressure change at the ear drum.

When a receiver is held tightly to the ear the pressure developed at the ear drum bears the following relation to the displacement of the diaphragm

$$p = \frac{EAd}{V}$$

where

d = Displacement of the diaphragm (cm.)

V = Volume of the air enclosed between the diaphragm and ear drum (cm.³)

p = Pressure at ear drum (dynes/sq. cm.)

A = Effective area of the diaphragm (cm.²)

E = Bulk modulus of elasticity for air. (1.41 x 10⁶)

In the ordinary receiver of this type approximately 5 cc. of air is enclosed between the diaphragm and the ear drum.

It is evident therefore that the pressure developed at the ear drum can be decreased by either decreasing the maximum displacement or the effective area of the diaphragm or both and that if the change in pressure is to be limited to 1500 dynes/sq. cm. the fractional change in the volume of the enclosed air must not exceed 10⁻³. It is also evident that for a given effective area of the diaphragm very definite limitations are placed upon maximum permissible displacement of the diaphragm and hence upon the cross sectional areas of the portions of the magnetic circuit which saturate and limit the force, on the diaphragm. In the receiver according to this invention the area of cores is approximately .0036 sq. in. and the material is a magnetic alloy having a very low saturation density. Since that variety of permalloy composed of 78.5% nickel, 2.86% chromium and the balance iron is a material in which saturation sets in abruptly it is preferred to use this material for the core material. Permalloy may be defined as an alloy containing nickel to the extent of 30% or more, balance chiefly iron and having the characteristic property of high initial permeability.

The diaphragm of the receiver may contain substantially the same materials as the magnet cores in order that a very efficient magnetic circuit may be obtained. In one embodiment of the invention the diaphragm was made of duralumin with a small insert of permalloy of such dimensions that the permalloy insert would saturate simultaneously with the core thus adding to the abruptness of the saturation.

According to another feature of this invention the diaphragm is loosely supported against the clamping seat by means of a plurality of paper rings which act to dampen the diaphragm to such an extent that the pitch of the free vibrations, which has been

found to be one of the most disturbing features of clicks, if not discernible. This paper damping has been added to insure a damping constant in excess of 400 when the receiver is not held to the ear. This method of support also eliminates the undersirable temperature effects which result from unequal radial expansion in the case of tightly clamped diaphragms and permits the use of minimum length air gaps. The paper rings exert sufficient pressure to prevent rattling but the pressure is not, however, high enough to prevent the diaphragm and the supporting surface moving relative to each other.

According to another feature of this invention substantially uniform magnetic action is obtained from magnets which vary in strength. Under ideal conditions saturation should take place abruptly and no additional flux should thread the air gap after the maximum permissible force on the diaphragm has been developed. Under these conditions the shape of the magnetization curve is such that the efficiency of the receiver decreases to a very low value at polarizing flux densities in excess of the optimum value. Although the ideal conditions are not actually met in practice the drop of efficiency in a receiver constructed according to this invention is sufficiently marked as to necessitate rather rigid requirements for the strength of the magnet in order that the efficiency may not drop too low. It has been found possible to employ magnets of varying strength by introducing reluctance, both series and shunt between the magnet and the pole pieces in the form of insulated shims of permalloy. The flux limiting effect is increased due to the fact that the shims are insulated from each other, the separations due to the insulation forming air gaps. These members act as a magnetic choke and give substantially uniform magnetic action from magnets varying considerably in strength.

In the drawing illustrating this invention, Fig. 1 is a partially exploded view in perspective of a watch case receiver embodying the features of the invention.

Fig. 2 is a sectional view of the assembled receiver.

Fig. 3 is a plan view of the receiver with the receiver cap removed.

Fig. 4 is an enlarged view in perspective of one of the magnet cores of the receiver.

Fig. 5 is an enlarged view in perspective of the magnet and magnetic shunt employed in the receiver.

Fig. 6 is a sectional view of the paper damping ring (retaining shell) used in the receiver.

Fig. 7 is a perspective view of a diaphragm which may be used in place of the diaphragm 37 shown in Fig. 1.

As shown in the drawing, 5 designates a receiver case within which are located mag-

net cores 6 and around which are placed operating coils 7. The magnet cores 6 are bolted to the base of case 5 by means of screws 8 which extend through openings 9 in base 5, through openings 10 in magnet cores 6, through holes 11 in permalloy shims 12 and through holes 13 in magnet 14. The nuts 15 are screwed down on the threaded portion of screws 8 against magnet 14. Lock nuts 16 are screwed down against nuts 15. The head portions 17 of screw 8 fit in the recessed portion 18 of the base 5. The conductors 20 from coils 7 are attached to terminals 21 which are attached to the inner ends of terminal sockets 22 by means of rivets 23. The terminal sockets 22 are wedged in openings 24 through shoulder portion 25 which serves as a terminal block in base 5. Terminal screws 26 screw into the outer end of terminal bushing 22 and serve to secure the tips of the receiver connecting cord (not shown) which are placed in cord tip openings 27 in base 5. Cord tie post 28 is wedged in the case 5 and serves to hold the tie portion of the receiver cord to remove the strain exerted on the cord, from the cord tips.

The base 5 has a threaded flange portion 30 of slightly greater diameter than the remainder of the base extending around its circumference. This flange portion 30 serves to hold the receiver cap 31 which screws thereon. Adjacent flange portion 30 is another threaded flange portion 32 which has a lesser diameter than the flange portion 30. This flange portion 32 serves to secure the metal shell 33 which screws thereon. In the wall portion 34 of the base 5 between the threaded flange portion 32 and the inside of the wall portion 34 is the damping ring retaining cylinder 35. The retaining cylinder 35 cooperates with the wall portion 34 to form a shelf 36 between the cylinder 35 and the inner edge of the wall portion 34. On the shelf portion 34 the diaphragm 37 is supported and against the upper surface of the diaphragm 37 the paper damping rings 38 are held by the metal shell 33 which screws on the threaded flange portion 32. The shell 33 has a circular opening 40 formed therein, the diameter of which is approximately the same as the inner diameter of the damping rings 38. The outer diameter of the damping ring 38 is approximately the same as the diameter of the diaphragm 37. The shell 33 has a threaded portion 41 which is adapted to screw on the threaded flange 32 of the case 5. Between the threaded portion 41 and the opening 40 is arranged a concentric circular groove 42 which is adapted to receive the upper rim of cylinder 35 when the shell 33 is screwed down on the threaded flange 32. The circular groove 42 has a diameter slightly greater than that of the diaphragm 37 and of the outer diameter of the damping rings 38 and between the groove 42 and the opening 40

is formed a smooth face portion 43 which has approximately the same width as and which contacts against the upper surface of the paper damping rings 38 when the shell 33 is screwed down on the flange 32. The diaphragm 37 is thus held against the shelf portion 34 by pressure on the paper damping rings 38. The pressure of the paper damping rings on the diaphragm, as has been previously explained, dampens the movement of the diaphragm to such an extent that the pitch of the free vibrations is not discernible to the ear. The pressure of the rings when the shell 33 is properly adjusted is sufficient to prevent rattling of the diaphragm but insufficient to prevent the diaphragm moving relative to its supporting surface.

The magnet 14 through the pressure of nuts 15 on screws 8 presses firmly on the permalloy shims 12 which in turn press firmly on the bases of the magnet cores 6. The shims 12 are japped to separate the permalloy portions. This insulation separates the shims to a small degree, the separations effectively forming small air gaps between the shims. The shims being placed across the pole pieces form a magnetic shunt causing shunt reluctance. By having a plurality of shims insulated from each other series reluctance is introduced through the separation of the shims.

The magnet cores 6 are clearly shown in Fig. 4 to have a very small cross-sectional area. The magnet cores are constructed of permalloy with the portions which extend into the operating coils greatly reduced in size and channeled out to give a very small cross-sectional area.

The diaphragm shown in Fig. 7 consists of an outer portion 50 of duralumin in the center of which a permalloy insert 51 is held by means of the small metal brackets 52 which may be welded, cemented, or otherwise suitably secured to the duralumin portion 50. Corrugations such as 60 may be placed in the diaphragm between the outer and central portions. This type of diaphragm is used when very abrupt saturation of the magnetic circuit of the receiver is desired and the proportions of the permalloy insert 51 are so chosen that it becomes saturated simultaneously with the saturation of the magnet cores.

It has been shown that acoustic shock from a telephone receiver has been found to be due to:

1. The peak pressure at the ear.
2. Maximum changes in pressure.
3. The pitch of the free vibrations of the diaphragm.

By proportioning the magnetic circuit so that saturation occurs before the force exerted on the diaphragm is sufficient to cause an excessive pressure change at the ear the

peak pressure and, of course, the maximum changes in pressure have been sufficiently reduced. By damping the diaphragm, maximum changes in pressure have been reduced and the pitch effect of the diaphragm has been removed.

What is claimed is:

1. A telephone receiver comprising a diaphragm, a core and a coil surrounding a portion of said core for variably energizing said diaphragm, said core being of a material in which saturation sets in abruptly and dimensioned so as to become saturated before the pressure at the ear reaches the feeling point.
2. A telephone receiver comprising a diaphragm, a core and a coil surrounding a portion of said core for variably energizing said diaphragm, said core being of a material in which saturation sets in abruptly and dimensioned so as to become saturated upon abnormal energization of said diaphragm through said coil.
3. A telephone receiver comprising a diaphragm, a core and a coil surrounding a portion of said core for variably energizing said diaphragm, said core being of a material in which saturation sets in abruptly, and dimensioned so as to become saturated before said diaphragm produces a change in pressure at the ear in excess of 1500 dynes per square centimeter.
4. A telephone receiver comprising a diaphragm, a core and a coil surrounding a portion of said core for variably energizing said diaphragm, said core being of a material in which saturation sets in abruptly, and dimensioned so as to become saturated so that said diaphragm does not produce a fractional change in volume of the enclosed air in excess of 10^{-3} .
5. A telephone receiver comprising a diaphragm, a core and a coil surrounding a portion of said core for variably energizing said diaphragm, said core and said diaphragm proportioned to become substantially simultaneously saturated upon abnormal energization of said diaphragm through said coil.
6. In a telephone receiver, a vibrating diaphragm and a motor system therefor including permalloy magnet cores and windings thereon, said cores having a pole face area of substantially .0036 square inch.
7. In a telephone receiver, a vibrating diaphragm, electromagnets for operating said diaphragm, cores for said electromagnets, a permanent magnet to the opposite poles of which said cores are attached and permalloy shims in shunt to said magnet.
8. In a telephone receiver comprising a vibrating diaphragm, electromagnets for operating said diaphragm, cores for said electromagnets, a field magnet for producing a field between its poles, and means for limiting the magnetic flux to a predetermined

amount, said means including a permalloy member in shunt to said magnet.

9. In a telephone receiver comprising a vibrating diaphragm, electromagnets for operating said diaphragm, cores for said electromagnets, a field magnet for producing a field between its poles, and means for limiting the magnetic flux to a predetermined amount, said means comprising a plurality of permalloy shims in shunt to said magnet, said shims being spaced from each other.

10. In a telephone receiver, a vibrating diaphragm, electromagnets for operating said diaphragm, permalloy cores for said diaphragm, a permanent magnet to the opposite poles of which said cores are attached, and a plurality of permalloy shims in shunt to said magnet.

In witness whereof, I hereunto subscribe my name this 8th day of June, 1928.

WARREN C. JONES.