Nov. 27, 1928. 1,692,868

W. RUDOLPH

ACOUSTICAL APPARATUS FOR TELEPHONIC COMMUNICATION

Filed Aug. 25, 1921

Fig. 1.

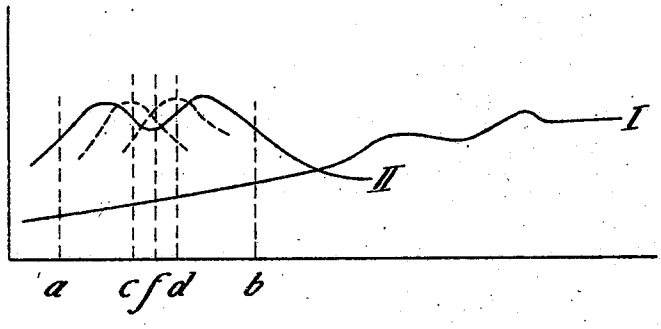


Fig. 2.

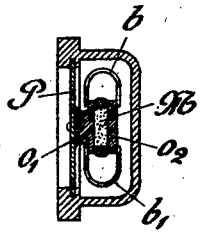
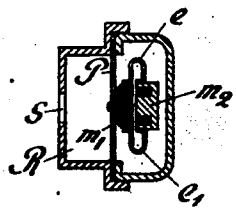


Fig. 3.



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UNITED STATES PATENT OFFICE.

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ACOUSTICAL APPARATUS FOR TELEPHONIC COMMUNICATION.

Application filed August 25, 1921, Serial No. 495,236, and in Germany September 27, 1920.

This invention relates in general to a novel construction of acoustical apparatus for telephonic communication and the like, and more particularly to a novel construction of microphonic transmitters and telephone receivers.

In constructing such devices it has hitherto been the general practice to strictly avoid any coincidence between their natural rates of vibration and the frequencies or groups of frequencies which they were designed to receive or reproduce. Above all things all possible care was taken to make such natural rates of vibration as might exist higher than the frequencies of the sound to be transmitted, e. g. in talking apparatus for telephonic communication these natural rates of vibration were made higher than the principal rates of vibration occurring in human speech.

In contradistinction to this practice the present invention contemplates the utilization of the natural rates of vibration of such apparatus for the purpose of improving the efficiency in the transmission of sound. The invention resides in constructing these sound apparatus of two or more intercoupled vibratory structures whose natural tuning is such that the coupling frequencies, i. e. the frequencies of resonance peculiar to the apparatus when its vibratory structures are coupled, form the limits between which the frequencies lie for which the apparatus is intended.

In the apparatus constructed hitherto the coupling frequencies were made to lie outside of the region of the rates of vibration to be transmitted, in order to thus obtain a good and undistorted reproduction of the sounds in question, particularly of human speech. Recent developments in the art of constructing acoustical apparatus now render it possible to damp the natural rates of vibration to such an extent that, in spite of their being utilized for sound transmission, no disturbing distortion of the voice vibrations occurs. On the other hand the invention enables a marked increase of the efficiency of this apparatus to be achieved.

The invention will now be explained with reference to the accompanying drawing in which

Fig. 1 illustrates by curves the fundamental principle on which the invention is based,

Figure 2 shows an application of the invention to microphone receiving transmitters, and Figure 3 shows an application of the invention to sound apparatus of the electromagnetic type of construction.

In Fig. 1 the curve I illustrates the acoustic properties of a modern telephone receiver of the kind now generally used. II is the resonance curve of a receiver according to the invention. For both curves the abscissæ represent rates of vibration and the ordinates represent the degrees of loudness obtained. The region a—b is that in which the principal frequencies of the sounds occuring in human speech lie.

Examples of the practical application of the invention are shown in Figs. 2 and 3. Fig. 2 is a sectional view of a capsular microphone in which there are two vibratory bodies, the one being the actual microphone or energy converter M and the other the diaphragm P. The latter has a certain natural rate of vibration; and the former has also since it is designed in such a way that the two electrodes o_1, o_2 form separate masses which are interconnected by elastic members, such as the bows b, b.

In Fig. 3, which is a sectional view of a telephone receiver, the diaphragm P also has, of course, a certain natural rate of vibration, and forms one of the vibratory bodies or structures of the apparatus. The second vibratory body or structure is the air space or chamber R, which is constructed in the form of an open Helmholtz resonator having a diaphragm at one end and the opening s at the other through which it acts upon the sound transmitting air (acoustic duct of the ear).

Instead of the said resonator, or in addition to it, the parts of the electromagnet energy-converter may be made to act as the second (or the third) vibratory structure, in which case the electromagnet would preferably be made to consist of two parts m_1 and m_2 as shown, which operate as vibrating masses interconnected by elastic members e and e_1. The elastic members may also consist of diaphragms, springs or any other suitable elastic bodies.

The individual tuning of the bodies or structures (where, for example, the vibratory system consists of a diaphragm and a microphone or an electro-magnet) may be made such that the natural rate of vibration of the

diaphragm lies somewhat below, and that of the microphone or electromagnet somewhat above (but is not very different from) the average frequency that is to be transmitted. This tuning is indicated by the crest at *c* and *d* of the dotted lines (Fig. 1). The average frequency of the acoustic range to be transmitted lies at *f*. When the two vibratory bodies, whose individual or independent frequencies of resonance are at *c* and *d* respectively, are coupled together, a system with coupling frequencies of resonance results, these coupling frequencies being further apart than the frequencies of resonance at *c* and *d* of the uncoupled individual vibratory structures. Hence the region in which the complete apparatus operates with a high efficiency is that extending between *a* and *b*, as indicated by the curve II in Fig. 1.

In the preferred form of my invention, the damping of the coupled vibratory structures is made so great relatively to the coupling that the depressions between the peaks or crests of the resonance curve of the coupled system are at a height greater than 40 per cent of the maximum amplitude (highest crest); or, in other words, by suitable damping of the vibratory structures the highest resonance peak of the coupled system is prevented from going beyond the point where it would destroy the aforesaid ratio.

The invention may also be accomplished by making the individual tunings of the vibratory bodies or structures equal, and coupling them suitably; or by making the tuning of the energy-converting device lower than that of the diaphragm, and coupling them suitably. As to this latter method, however, it may be said that as a rule, particulalry where a microphone is the energy-converter, the arrangement does not give as satisfactory results as where if anything the tuning of the energy-converter is higher than that of the diaphragm.

The term "body" or "bodies" as used in the claims is intended to include a body or bodies of air, such for example as that in chamber R (Figure 3). The reference, in the claims, to the upper and lower frequencies of resonance of the coupled system, is intended to mean the frequencies on the resonance curve of the system such as *b* and *a* respectively of Figure 1.

I claim:

1. A telephone apparatus including a plurality of oscillatory structures having definitely proportioned masses and elastic members to provide definite resonant frequencies and damping factors, means for mechanically coupling said structures together, said coupled structures, by virtue of the relation of the masses and elastic members, having resonant peaks between which the speech frequency lies and a coefficient of acoustic coupling less than the damping factor, whereby the result is obtained that the depressions in the resonance curve are above 40% of the highest peak of said curve.

2. A telephone apparatus having a plurality of oscillatory structures, one structure including a sound detector, a second structure comprising a microphone, means for mechanically coupling said structures together, each structure having a definite resonant frequency before coupling obtained by the adjustment of masses and elastic members, and said coupled structures having a definite coupling coefficient obtained by adjustment of the masses of the oscillatory structures such that the speech frequencies lie within the two resonant peaks of the coupled structure.

3. A telephone apparatus having a plurality of oscillatory structures, one structure including a sound detector having a definite resonant frequency, a second structure comprising a transmitter having a second definite resonant frequency, means for mechanically coupling said structures together, each structure having its masses and elastic members so proportioned that the two resonant frequencies of the acoustically coupled system lie just outside, on either side respectively, of the speech range of frequencies.

4. A telephone apparatus having a plurality of oscillatory structures, one structure including a sound detector having a definite resonant frequency, a second structure comprising a transmitter having a second definite resonant frequency, means for mechanically coupling said structures together, each structure having its masses and elastic members so proportioned that the two resonant frequencies of the acoustically coupled system lie just outside, on either side respectively, of the speech range of frequencies, the resonant peak corresponding to the detector lying below the speech range and the resonant peak corresponding to the transmitter lying above the speech range.

5. An electrical acoustical transmitter having a plurality of oscillatory structures, one structure including in combination a sound detector and a tuned resonating chamber having a definite resonating frequency, a second structure comprising a transmitter having a second definite resonant frequency means for mechanically coupling said structures together, each structure having its masses and elastic members so proportioned that the two resonant frequencies of the acoustically coupled system lie just outside, on either side respectively, of the speech range of frequencies.

In testimony whereof I affix my signature.

WILHELM RUDOLPH.