R. A. FESSENDEN.

SOUND PRODUCER.

APPLICATION FILED FEB. 28, 1917.

1,277,562. Patented Sept. 3, 1918.

Fig. 1.

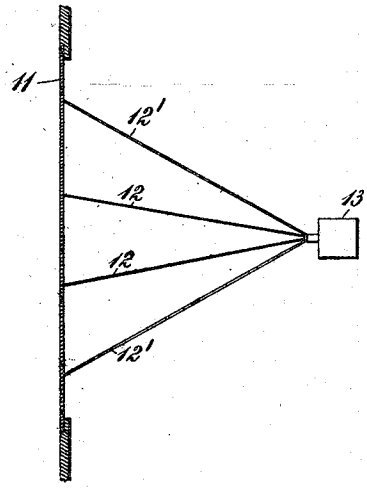


Fig. 2.

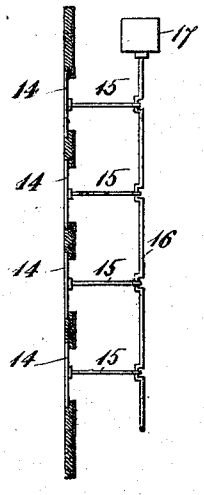
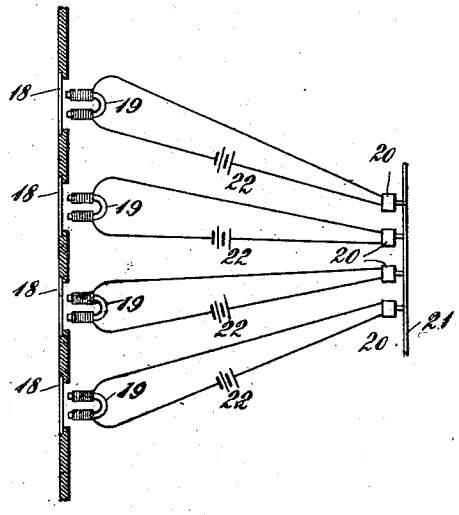


Fig. 3.



INVENTOR:
Reginald A. Fessenden

By Cox & Adams
HIS ATTORNEYS:

UNITED STATES PATENT OFFICE.

REGINALD A. FESSENDEN, OF BROOKLINE, MASSACHUSETTS, ASSIGNOR TO SUBMARINE SIGNAL COMPANY, OF PORTLAND, MAINE, A CORPORATION OF MAINE.

SOUND-PRODUCER.

1,277,562. Specification of Letters Patent. Patented Sept. 3, 1918.

Application filed February 28, 1917. Serial No. 151,611.

To all whom it may concern:

Be it known that I, REGINALD A. FESSENDEN, of Brookline, in the county of Norfolk and State of Massachusetts, a citizen of the United States, have invented a new and useful Improvement in Sound-Producers, of which the following is a specification.

My improvement has for its object the increase in the efficiency of sound production, and more particularly of diaphragm sources of sound, though not limited to this type of source.

In 1905 applicant overcame the difficulties which had hitherto prevented the measurement of the comparative sensitiveness of the ear to sounds of different frequencies by splitting up the ultra-audible impulses produced by his high frequency generator by means of a commutator, and using the groups of wave trains of different frequencies so produced to generate sounds.

The curve so obtained, by plotting the sound frequencies against aural sensibility showed a marked increase at 500 frequency and a maximum at approximately 920 frequency. A patent for the application of this discovery was granted to applicant, *i. e.*, U. S. Patent No. 918,306, dated April 13, 1909.

As the result of experiments of locating direction by sound shadows, applicant has now found that the frequency for which the ear is most sensitive, that is, 920, is that which is most efficient in giving good all-around reception of sound, combined with good efficiency of sound source location of sound waves impinging on round bodies of the size of the human head.

The maximum efficiency of the ear to sounds of approximately 920 frequency is consequently probably an evolutional development analogous to the maximum sensibility of the eye to the wave length of maximum radiation in the solar spectrum.

In the production of sound by diaphragms and other means, whether of the most audible or other frequencies, difficulties have been met with. For example, it has been proposed to produce sound for submarine signaling and other purposes by means of small diaphragms moving through large amplitudes instead of large diaphragms moving through small amplitudes.

Applicant, by developing the mathematical theory of sound along new lines, and confirming the mathematical results by experiments, has discovered that the product of area and amplitude is no criterion of sound production efficiency, but that to produce sound efficiently, the radius of the diaphragm must be of approximately the same length as or longer than the quarter wave length of sounds of the frequency generated, in the medium in which the diaphragm is immersed.

For example, a telephone receiver diaphragm should have a diameter of approximately seven and a half inches or more, and a diaphragm for producing a fog signal of a frequency of 36 should, applicant has discovered, be 15 feet or more in diameter, for best efficiency.

In putting this discovery into practice, and in using these new types of diaphragms, with radii approximately equal or greater in size than quarter wave length, applicant has met with certain difficulties, means for overcoming which are also herein described and claimed.

For example, if a wooden diaphragm of say two inches thickness be used to produce a sound in water of frequency 440, and the diameter of the diaphragm be five feet and the vibrating force be applied at the center of the diaphragm, the elastic wave in the wood will travel out from the center to the edge of the diaphragm in the wood so much slower than it will through the water, owing to the flexural wave in a wooden structure of such dimensions being much slower than the compressional wave in water, that very little sound will be produced. And even if the diaphragm be made a foot thick still the result will be small.

Similarly, if a steel diaphragm one thirty-second of an inch thick and ten feet diameter be used to generate sound of frequency 1000, the result will be very inefficient for the same reasons.

In this latter case the difficulty may be overcome by using thicker steel, as has been the custom to date, or using a built-up girder. But I prefer to accomplish the result in another way, by driving the sound-emitting surface from a number of points, as shown in the figures.

In the drawings accompanying this specification, Figures 1, 2 and 3 show semi-diagrammatically, apparatus suitable for use in connection with this invention.

Fig. 1 shows the diaphragm 11, made of

1/32 steel, and 10 feet diameter. 12, 12, 12′, 12′, are piano wires, electrically welded at one end to the diaphragm, about six inches apart, the other ends being attached to the oscillator 13. The difference in length between the wires 12, 12, and 12′, 12′ being less than 2 feet, and the longitudinally elastic waves along the wires due to the vibration of the oscillator traveling at a velocity of 17,000 feet per second (velocity of sound in steel) the difference in time between the arrival of vibrations at the center and edge of the diaphragm will be only 1/10,000 of a second, and the diaphragm will work as a whole efficiently.

In place of using a continuous sheet of metal as a diaphragm, a number of diaphragms may be used, inserted in holes in a rigid surface. But here another element comes in, *i. e.*, whether the separate diaphragms are driven in phase or out of phase, and the distance between the diaphragms must be adjusted accordingly.

Applicant has determined mathematically, and confirmed it by experiment, that if the diaphragms are driven in phase, their centers should be of the order one half wave length or less apart. Fig. 2 shows such an arrangement, the diaphragms 14, 14, 14, 14, being driven in this case by small rods 15, 15, 15, 15, attached at one end to the diaphragms 14, 14, 14, 14, and at the other to the crank shaft 16, driven by the motor 17.

If the diaphragms are not driven in phase, however, their centers should be of the order of one half wave length or more apart, as shown in Fig. 3, where the diaphragms 18, 18, 18, 18, are driven by the telephone receiver magnets 19, 19, 19, 19, the electromagnet coil of each receiver being attached to an individual microphone button, as shown, and the buttons 20, 20, 20, 20, being mounted on the large wooden diaphragm 21. Batteries 22, 22, 22, 22, are used in the circuits of the receiver magnets and buttons, as shown.

On the wooden diaphragm 21 being talked against, the microphone buttons 20, 20, 20, 20, are vibrated and the diaphragms 18, 18, 18, 18, reproduce the speaking. But I have experimentally discovered that the currents in the circuits of the buttons 20, 20, 20, 20 are out of phase with each other, and that this is the reason why multiple button transmitters have always heretofore been found to be inoperative.

Consequently the motions of the diaphragms 18, 18, 18, 18, will also be out of phase, and if they are one half wave length or less between centers, the compressional wave will merely flow back and forth from one diaphragm to another, and not travel out.

But applicant has discovered that if the diaphragms be placed more than one half wave length between centers, this will not happen, and that the whole energy will be emitted. This leads to the peculiar result that while the sound will not be much louder close up to the diaphragms than a single diaphragm, at a distance the sound will be if anything louder than that due to the sum of the diaphragms. This has been verified by experiment.

What I claim as my invention is:—

1. In apparatus for producing sound, a diaphragm having its radius not substantially less than the quarter wave length of the sound which it is more especially desired to produce.

2. In an apparatus for producing sound, a diaphragm having its radius not substantially less than the quarter wave length of the sound which it is more especially desired to produce, and vibrated by a plurality of vibrating members attached to the diaphragm.

3. In an apparatus for producing sounds, a diaphragm having its radius not substantially less than the quarter wave length of the sound which it is especially desired to produce, and composed of a number of diaphragm elements, said elements having the distance between their centers adjusted in accordance with the degree of synchronism between the elements.

REGINALD A. FESSENDEN.