H. C. EGERTON.

WAVE DISTRIBUTION.

APPLICATION FILED JULY 26, 1917.

1,365,470. **Patented Jan. 11, 1921.**

2 SHEETS—SHEET 1.

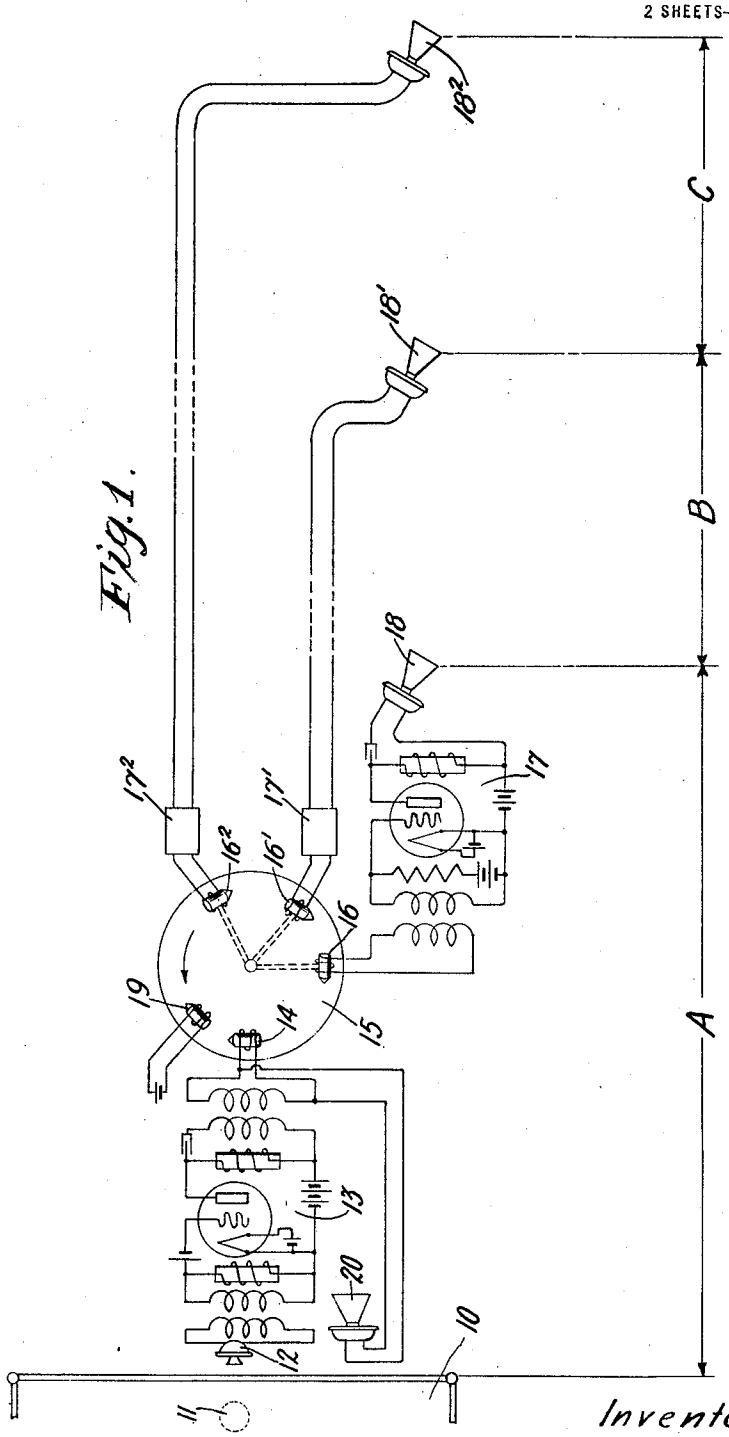


Fig. 1.

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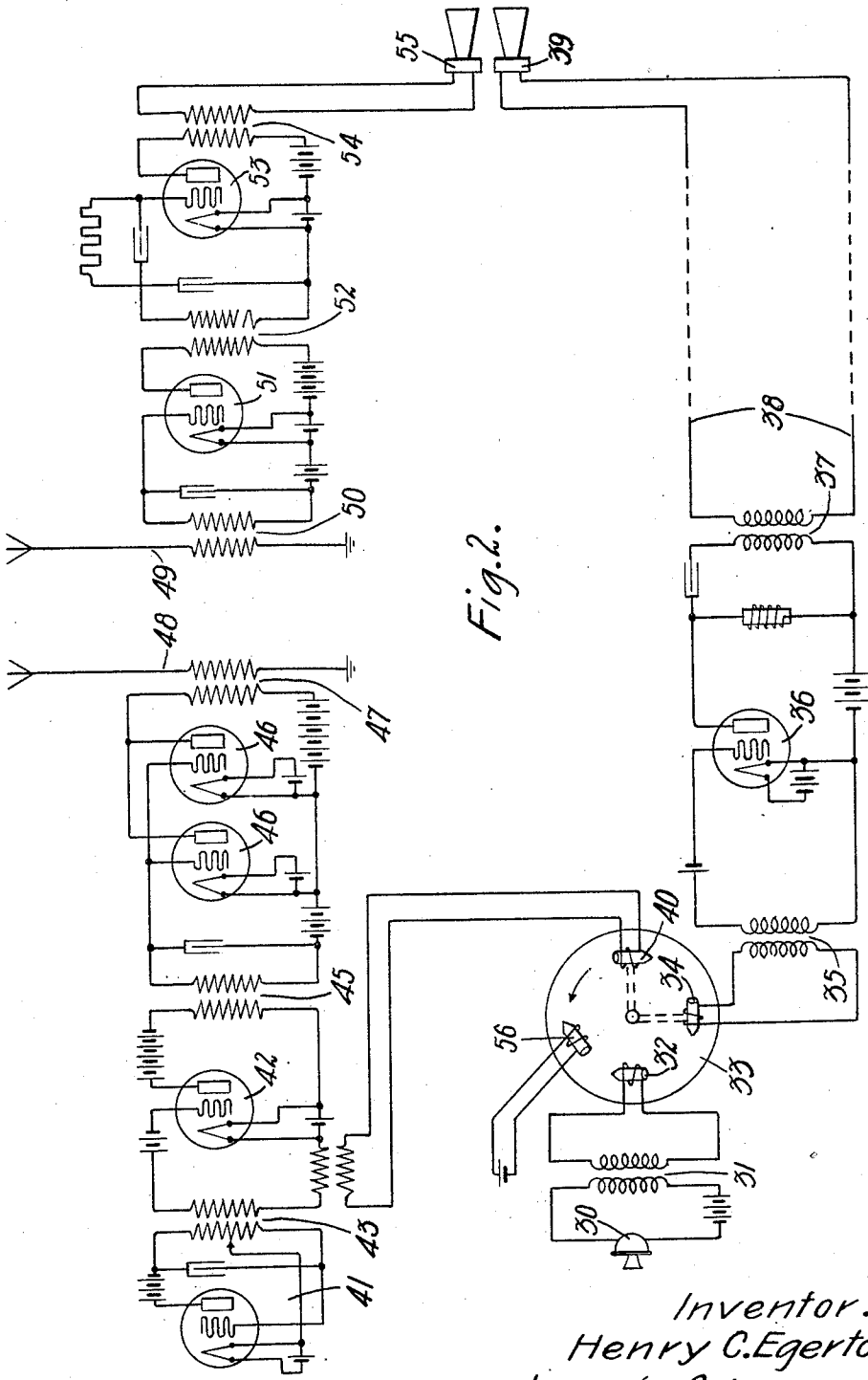


Fig. 2.

Inventor:
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by J. E. Roberts Atty.

UNITED STATES PATENT OFFICE.

HENRY C. EGERTON, OF PASSAIC, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

WAVE DISTRIBUTION.

1,365,470. Specification of Letters Patent. Patented Jan. 11, 1921.

Application filed July 26, 1917. Serial No. 182,964.

To all whom it may concern:

Be it known that I, HENRY C. EGERTON, a citizen of the United States, residing at Passaic, in the county of Passaic and State of New Jersey, have invented certain new and useful Improvements in Wave Distribution, of which the following is a full, clear, concise, and exact description.

This invention relates to wave distribution and more particularly to a method and apparatus for transmitting identical messages through a plurality of media having different rates of wave propagation so as to produce consonant effects at a distant station.

One application of the invention is found in solving the problems of addressing an audience in a large auditorium, or open air assembly, where it is often impossible for the speaker's voice to carry satisfactorily to the more remote portions of the audience. To overcome this to a certain extent, telephone receivers connected to a microphone in proximity to the speaker have heretofore been distributed to the more remote parts of the audience to reproduce the speaker's words simultaneously with their utterance by the speaker. While this has improved conditions somewhat where the speaker's voice was completely inaudible it, in some cases, results in interference between the sound waves produced by the speaker's voice and the sound waves produced by the auxiliary receivers within the limits in which the speaker's voice had been but faintly audible previously.

The principal object of the present invention is to provide a method and apparatus whereby waves may be transmitted to a certain position by two or more different media having unequal rates of wave transmission, so that the same or substantially identical waves will arrive at such position in substantial synchronism, and this end is accomplished by propagating certain waves in the medium having the lower rate of wave transmission and timing the transmission of the same or substantially identical waves over the medium of higher rate so that the waves reaching such position by both of such different media arrive thereat in substantial synchronism.

A further object of the invention is to provide a suitable method and apparatus whereby sound waves are produced in one medium at one of a plurality of sound producing sources, and similar sound waves transmitted by another medium having a different rate of sound wave transmission to other of said sources to reproduce similar sound waves in the first-mentioned medium in synchronism or consonance with the arrival of similar sound waves in this medium from the first-mentioned source to intensify such sound waves and overcome, to a great extent, the interference heretofore experienced.

To accomplish this object, the method contemplates the provision of two or more sources of sound waves located at different positions to operate in the same medium, and the use of suitable apparatus coöperating with the first of said sources to reproduce substantially identical sound waves to those produced at the first source and in the same medium therewith at the second and succeeding sources in synchronism with the arrival of substantially identical sound waves from the preceding sources through the medium in which the sounds are reproduced at the second and succeeding sources.

The method which constitutes the invention is capable of being carried out with a great variety of apparatus and is not limited to reinforcing the voice of a speaker, since it can obviously be used in a number of other ways as, for example, in reproducing phonographic or other records at a number of different places in a common auditorium or the like, or in sending a message from one station to another at the same time by both wire and wireless methods and synchronizing the waves from both at the receiving station.

In the accompanying drawings Figure 1 illustrates one embodiment of the invention suitable for sound transmission in large auditoriums; while Fig. 2 illustrates an arrangement suitable for transmission and synchronization of a message transmitted to a distant station by both wire and wireless telephone circuits.

Referring to Fig. 1 showing one arrangement of apparatus suitable for use in large auditoriums to enable the words of a speaker to be readily heard at any point therein a speaker's platform 10 is shown and the normal position of the speaker indicated by a dotted circle 11. Any suitable sound record-

ing device is arranged in a position to be actuated by the sound vibrations of the speaker's voice in air to record the same on any suitable record. The drawing shows a telephonic transmitter 12 operating inductively through an audion amplifier 13 and electromagnetic recorder 14 to record the speaker's words upon a telegraphone record disk 14; the record being rotated at a definite rate of speed by any desired means (not shown). The induction coils, associated with the amplifier, serve to step up the voltage with little distortion, while the audion amplifier serves to amplify the current with no distortion whatsoever; while the retardation coils shown are placed in the circuit to prevent the passage of alternating current between the two sides of the line and yet permit the supply of direct current from the battery to the line. The operation of these devices is well known, however, and no further description thereof is believed necessary to the understanding of the present invention.

Assume that the speaker's voice can be easily and clearly understood over the area A, shown on the drawing, whereas the speaker's voice is faint within the area B; unintelligible for the most part throughout the area C, and inaudible beyond the area C.

It is well known that sound waves have the definite velocity of 1,090 feet per second in still air at 32° Fahrenheit, which results in an appreciable difference in the time it takes the speaker's voice to reach different parts of a large auditorium or the like. This time interval should be compensated for in intensifying or producing substantially identical sound waves at two or more places in the same auditorium. The present method accomplishes this by producing sound waves in air at one position and reproducing identical sound waves in air at the second and succeeding positions at the instant the particular sound waves from the first position reach the second and succeeding positions through the air medium. The succeeding positions are preferably arranged so that the successive reproduction in air thereat will also coincide with the arrival of the identical sound waves through the air from all the preceding positions at the position being considered.

Therefore, to enable those within the area B to hear the speaker's words easily it is necessary to locate a sound reproducer at the forward limit of B and arrange it to reproduce the identical words of the speaker at the moment the original sound waves from the speaker reach the reproducer, whereby the words reproduced reinforce and intensify the actual words of the speaker and render them loud enough to be easily heard throughout the area B. To accomplish this with the apparatus illustrated, an electromagnetic reproducer 16 is adjustably mounted with respect to the record 15 and inductively associated with an audion amplifier 17 which operates a loud speaking receiver 18. The reproducer 16 would be adjusted to reproduce the recorded sound waves at the receiver 18 at the same instant as the original sound waves from the speaker reach the receiver and as the rate of electrical transmission is much more rapid over the circuit between the reproducer 16 and the receiver 18, than the travel of sound waves in air, the reproducer 16 is positioned to delay the reproduction at the receiver 18 sufficiently to compensate for the different rates of wave transmission over the two different media. If desired, a number of loud speaking receivers can be arranged in parallel with the receiver 18 and located at the same distance from the speaker. The horns of the receivers 18 would preferably be directed in the same direction as the sound waves from the speaker's voice to minimize interference between sound waves in air from the different sources traveling in an opposite direction to those from the primary source. This principle should also be applied, as far as possible, in positioning the secondary sound producers.

The sound reaching the area C would be similarly intensified and rendered intelligible through a similar adjustable reproducer 16′ operating through an amplifier 17′ and receiver 18′ adjusted so as to reproduce certain sound waves in air at the same instant that substantially identical sound waves traveling in air reach the receiver 18′ from the speaker and the next preceding receiver 18. A similar arrangement of electromagnetic reproducer 16^2, amplifier 17^2 and receiver 18^2 operates in a similar manner to render the words of the speaker clearly audible to those in the rear of the area C. Individual hand or head receivers may be used in place of the loud speaking receivers, or both loud speaking and individual receivers used together, if desired.

An electromagnetic eraser 19 may be operated to obliterate the magnetic record on the disk 15 as soon as it has been reproduced, or the eraser may be omitted and a wire or wire disk record used which admits of keeping the record for further reproduction in the same way as ordinary phonographic records, if desired. A wire disk record suitable for use in this way is shown in a patent to Lieb 907,383, dated December 22, 1908, and with such records the recorder and reproducer would be arranged to move radially toward the disk to accommodate them to the changing diameter of the wire spiral during rotation of the disk. In reproducing a telegraphone record in a large auditorium there would be no speaker, but it

would be desirable to reproduce the same at a number of different places in the auditorium to render it audible throughout. In this case the receiver 18 would be the first to reproduce the record in the air while the reproducers 16′ and 16² would be adjusted so as to reproduce the same part of the record in air at the same instant such particular sound waves from the receiver 18 traveling through the air would reach the receivers 18′ and 18² respectively.

In some cases it may also be found desirable to augment the speaker's voice at substantially the same position at which he is speaking, either in connection with or independently of reproduction of his words in other parts of an auditorium or the like, as previously described. To accomplish this result with the apparatus shown, it is only necessary to connect a loud speaking receiver 20 to receive fluctuating current proportional to the fluctuations produced by the speaker's voice in the transmitter 12. This may be done in a variety of ways as, for example, by connecting the receiver across the secondary of the induction coil connected to the recorder 14 and in parallel therewith, as shown. Owing to the high speed of electrical transformation and amplification, as compared with the velocity of sound in air, the sound waves produced in the air by the receiver 20 would coincide with those of the speaker to such an extent as to render any theoretical interference of sound waves impossible of detection. To prevent "singing" occurring by locating the transmitter 12 and the receiver 20 in close proximity it is preferable that the transmitter 12, in such a case, be a chest or throat transmitter which will be unaffected by the sound produced by the adjacent receiver 20.

It is not necessary in the carrying out of the method by a telegraphone that the current be amplified either before or after being recorded on the recorder 15, but more satisfactory results are obtained thereby.

In telephonically transmitting a message from one station to another over a loaded wire telephone circuit the rate of transmission through the medium of the wire circuit is low as compared to the rate of transmission of messages by wireless telephone waves through the medium of the ether; the rate in the latter case being about three times that in the former. Under this situation, if a message is to be sent from one station to another both by wire and wireless telephony, the present invention may be readily applied thereto, as, for example, by recording the sound waves sent out over the line wire at the calling station and delaying the reproduction of such waves as wireless waves sufficiently so that the waves reaching the other stations through the wireless waves in the ether arrive at the receiving station in synchronism with the substantially identical sound waves transmitted thereto over the wire circuit.

One simple arrangement suitable for this purpose is shown in Fig. 2. In this construction a microphone 30, serves to vary the current flow through the primary winding of an induction coil 31; the secondary winding of which is connected to an electromagnetic recorder 32. A record corresponding to the variations received by the recorder 32 is transferred thereby to a telegraphone record or disk 33, driven at a definite rate of speed by any suitable means (not shown). An electromagnetic reproducer 34 is arranged in operative relation to the record 33 and inductively associated through an induction coil 35 with an audion amplifier 36. This amplifier is in turn inductively connected through another induction coil 37 with a line circuit 38, with which the telephone receiver 39 at the distant receiving station is operatively associated in any suitable manner. Inasmuch as the receiver 39 would be located at a considerable distance from the sending station, under the conditions assumed, a considerable amount of apparatus would intervene in the wire circuit between the sending and receiving station but as such apparatus is well known and forms no part of the present invention no detailed showing thereof is considered necessary.

Since the rate of wave transmission through the medium of the ether is about three times that through the medium of a wire circuit, it is necessary to compensate for this difference if sound waves transmitted by both wire and wireless circuits are to be reproduced in synchronism at the receiving station. This may be accomplished either by delivering the high frequency waves to the ether a definite period after the delivery of similar waves to the wire circuit or by delivering the waves to both the wire and radio circuits at the sending station, then recording the waves transmitted by the ether at the receiving station and reproducing the recorded waves thereat a definite period thereafter so as to synchronize with the arrival thereof of similar waves transmitted by the wire circuit.

In the particular system illustrated, the radio transmission of the high frequency waves is delayed by positioning a second electromagnetic reproducer 40 so as to reproduce the same portion of the record 33 at such an interval after the reproducer 34 as to compensate for the difference in rate between wire and radio transmission. To facilitate obtaining the proper relationship between the reproducers 34 and 40, the two are preferably arranged so that they can be adjusted relatively to each other to vary the interval between them according to the

difference in time of transmission by wire and radio circuits between the sending station and any one of a number of different receiving stations with which communication might be had.

Any suitable wireless sending and receiving apparatus may be employed for radio transmission, but the particular apparatus illustrated corresponds with that shown in a copending patent application, Serial No. 50150, of Harold W. Nichols, filed September 11, 1915, issued as Patent No. 1,325,574, Dec. 23, 1919. This comprises an oscillation generator 41, the oscillations of which are impressed upon the input circuit of a vacuum tube or other suitable modulator 42, through the medium of an induction coil 43. Another induction coil 44 having its primary winding in circuit with the reproducer 46 and its secondary winding included in the input circuit of the modulator 42, serves to impress the oscillations developed in the reproducer 40 by the record 33 upon this input circuit. Under the influence of these different oscillations the modulator 42 develops modulated high frequency oscillations in its output circuit which, through the medium of an induction coil 45, are impressed upon the input circuit of a group of vacuum tube amplifiers 46, arranged in parallel. These amplifiers produce augmented high frequency oscillations in their output circuit and an induction coil 47 transfers such oscillations to the sending antenna 48, through which electromagnetic waves are originated in the ether for transmission to the receiving station.

These waves impinge upon the antenna 49 of the receiving station and are transferred by means of an induction coil 50 to the input circuit of an amplifier 51 by which the energy of oscillations in the output circuit is increased over that received in the input circuit. An induction coil 52 acts to transfer this increased energy to the input circuit of a thermionic element 53 which operates to detect the incoming high frequency modulated oscillations and to transmit only low frequency oscillations corresponding to the waves developed by the telegraphone record 33 to the output circuit. This output circuit includes the primary winding of an induction coil 54, and a loud speaking telephone receiver 55 in circuit with the secondary winding of this coil, serves to reproduce these low frequency oscillations as articulate sound waves.

The receivers 39 and 55 at the receiving station are preferably arranged adjacent to each other, and from the foregoing description it will be apparent that identical messages transmitted to the receiving station by wire and radio circuits can be reproduced in consonance thereat; the message reproduced by the receiver 39 reinforcing that reproduced by the receiver 55 and vice versa. If desired to erase the matter recorded on the record 33 after reproduction thereof, an electromagnetic eraser 56 may be provided for this purpose.

What is claimed is:

1. The method of transmitting intelligence from one station to another station by a plurality of media having different rates of wave propagation which consists in producing impulses in one medium at one station for transmission thereby to said other station, in utilizing such impulses to produce impulses corresponding thereto, in recording said corresponding impulses upon a record capable of immediate reproduction, in subsequently reproducing said recorded impulses at said other station coincident with the arrival thereat of and in consonance with the original impulses transmitted by said first medium, and in utilizing a second medium having a higher rate of wave propagation than the first medium in the transmission of impulses between said record and one of said stations.

2. The method of transmitting intelligence from one station to another station by a plurality of media having different rates of wave propagation which consists in producing impulses at one station in one of said media for transmission thereby to said other station, in utilizing said impulses to produce impulses corresponding thereto, in recording said corresponding impulses upon a record capable of immediate reproduction, in timing the reproduction of said recorded impulses in another medium having a relatively high rate of wave propagation to compensate for the difference in rates of propagation between said two media, and in translating said reproduced impulses into corresponding impulses in said first mentioned medium at said other station to coincide with the arrival thereat of the original impulses transmitted over said first mentioned medium.

3. The method of transmitting intelligence from one station to another station by two media having different rates of wave propagation which consists in producing impulses at one station in the medium having the lower rate of propagation for transmission thereby to said other station, recording said impulses upon a record capable of immediate reproduction, and delaying the reproduction of said recorded impulses in the medium having the higher rate of propagation so that the arrival of said reproduced impulses at said distant station will coincide with the arrival thereat of the original impulses transmitted over the medium having the lower rate of propagation.

4. The method of sound distribution which consists in producing sound waves at one position in one medium for transmission

thereby to another position, reproducing said sound waves at substantially the position of original production and in substantial consonance with the original sound waves, recording said sound waves upon a record capable of immediate reproduction, separately transmitting corresponding waves to said other position by another medium having a higher rate of wave production than said first medium, in timing the reproduction of said recorded waves in said second medium to compensate for the difference in rates of wave production between said medium, and in translating said reproduced waves into corresponding sound waves in said first mentioned medium at said other position to coincide with the arrival thereat of the original sound waves transmitted over said first mentioned medium.

5. The method of sound distribution which consists in producing sound waves at one position in air for transmission thereby to another position, reproducing said sound waves at substantially the position of original production and in substantial consonance with said sound waves recording said sound waves upon a record capable of immediate reproduction, separately transmitting waves corresponding to said recorded sound waves to said other position by another medium having a higher rate of wave propagation than air, in timing the reproduction of said recorded waves in said second medium to compensate for the difference in rates of wave propagation between air and said medium, and in translating said reproduced waves into corresponding sound waves in air at said other position to coincide with the arrival thereat of the original sound waves transmitted thereto by air.

6. A system of sound distribution comprising a transmitting station, means thereat to impress waves upon one medium for transmission thereby to another station, means to impress corresponding waves upon another medium having a different rate of wave propagation than said first medium, means responsive to waves transmitted thereto by one of said media to record such waves and including a record capable of immediate reproduction, means to reproduce corresponding waves from said record, and means to time the arrival at said other station of said reproduced waves to synchronize with the arrival thereat of consonant waves transmitted thereto by the other said media.

7. The method of sound distribution which consists in producing sound waves in air, recording said sound waves, separately transmitting waves derived from and corresponding to said recorded sound waves to a distant point by another medium having a higher rate of wave transmission than air, and timing the arrival of said separately transmitted waves at said distant point to coincide with the arrival of the original air transmitted sound waves at said point.

8. A system of sound distribution comprising a main transmitting station, means for recording sounds emitted at said station including a record capable of use to reproduce matter recorded thereon immediately subsequent to recording thereof, reproducing means responsive to said sound record and adapted to reproduce said record at a definite period of time after the recording thereof, and sound producing means at another station responsive to said reproducing means to reproduce said recorded sounds coincident with the arrival thereat of and in consonance with the sounds emitted by said main station; whereby said emitted sounds and those developed by said sound producing means reinforce each other without interference at such other station.

9. A system of sound distribution comprising a main transmitting station, a plurality of outlying reproducing stations, an intermediate means for recording sounds emitted at said main station and for transmitting waves corresponding thereto to said outlying stations in a definite order depending upon the respective distances of said outlying stations from said main transmitting station, said intermediate means including a record capable of use to reproduce matter recorded thereon immediately subsequent to recording thereof, and means at each of said outlying stations responsive to said transmitted waves to reproduce said recorded sounds at its respective station coincident with the arrival of and in consonance with the sounds emitted at said main station, whereby said emitted sounds and those developed at the respective outlying stations will reinforce each other without interference at the respective outlying stations.

10. In a system of sound distribution, a main transmitting station, a microphonic element thereat, means connected to said microphonic element to make an amplified record of sounds emitted at said transmitting station and including an amplifier to amplify the current changes produced by said microphonic element, an outlying reproducing station, and means coöperating with said sound record to reproduce said recorded sounds at said outlying station a predetermined time after the original production thereof at said main transmitting station and coincident with the arrival at said outlying station of and in consonance with the original sounds emitted at said main station.

In witness whereof, I hereunto subscribe my name this 24th day of July A. D., 1917.

HENRY C. EGERTON.