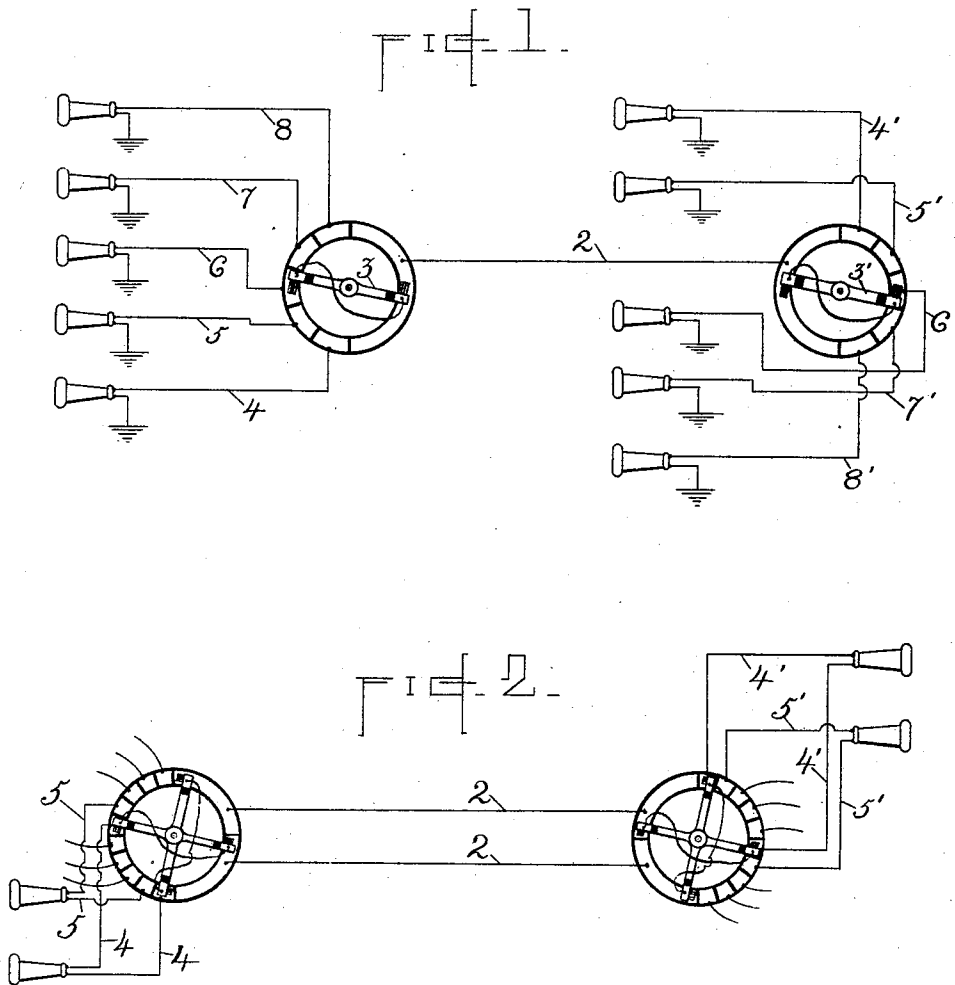


No. 745,734.

PATENTED DEC. 1, 1903.

W. M. MINER.
MULTIPLEX TELEPHONY.
APPLICATION FILED FEB. 26, 1903.

NO MODEL.



WITNESSES:

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WILLARD M. MINER, OF PLAINFIELD, NEW JERSEY.

MULTIPLEX TELEPHONY.

SPECIFICATION forming part of Letters Patent No. 745,734, dated December 1, 1903.

Application filed February 26, 1903. Serial No. 145,182. (No model.)

To all whom it may concern:

Be it known that I, WILLARD M. MINER, a citizen of the United States, and a resident of Plainfield, in the county of Union and State of New Jersey, have invented certain new and useful Improvements in Multiplex Telephony, of which the following is a specification.

My invention relates to an improved art of multiplex telephony, the object of which is to permit a number of telephone conversations to be carried on over one line-wire or circuit without interference with one another.

It has heretofore been proposed in the art of telegraphy to utilize one line-wire for a number of simultaneous Morse or other telegraph transmissions by establishing at the opposite ends of said line, respectively, suitable synchronously-operating circuit-changers or switches sometimes termed "distributers" or "sunflowers," said distributers operating to establish a connection between the line and a series of branches or subcircuits in succession and at rapidly-repeated instants of time, so as to produce, in effect, the condition of a continuous connection between corresponding branches or subcircuits at opposite ends of the wire, said corresponding branches containing the transmitters and receivers that are used in conjunction for the purpose of transmitting intelligence. The suggestion has been made heretofore that by means of the same apparatus it would be possible to use one line for a number of simultaneous telephonic communications, and previous experimenters have laid down as the controlling factor in such telephonic multiplex transmission that conversation may be carried on successfully over a large number of subcircuits provided that the intervals of time elapsing between the successive connections of any one branch or sub circuit with the line are not greater than about one one-hundredth of a second, the theory being that, as expressed by one experimenter, "the ear will utterly fail to detect an interruption of a continuous sound for an interval of as much as one one-hundredth of a second." In an apparatus organized to operate upon this principle there is of necessity, owing to the exceedingly complex nature of the sounds of the voice or of articulate speech and the exceedingly great number of

waves necessary to produce even a single word, a loss in each interval between the successive closures of circuit of many of the finer or more complex sonorous vibrations upon which depends the quality of sound that characterizes the human voice. This will be evident when we consider that the number of waves producing a single word may be many hundreds in number. In fact, it has been demonstrated by means of a phonograph-record that the number of vibrations involved in the words "Royal Society of Edinburgh" spoken with the slowness of ordinary speech would be over three thousand; but as is well known the diaphragm of the phonograph does not respond with perfect accuracy to all the vibrations of the voice, and hence the record produced would not contain all of the partial vibration or overtones which give to speech its timbre and individuality. It is further well known as a fundamental law of acoustics that each vowel sound is simply the result of the reinforcement by the air in the cavity of the mouth of one, or, in some cases, two overtones of determinate pitch contained in the sound which proceeds from the vocal cords. The notes or tones characteristic of such vowel sounds as it has been determined vary from about two hundred and twenty-five vibrations per second through a range proceeding by octaves for the various vowels to a note of three thousand six hundred vibrations per second, which is the characteristic note for the vowel "i." Without regard to the exactness of the figures given by various physicists, it is undoubtedly the fact that the characteristic vibrations of human speech are of very great frequency and for many sounds are of a number of thousands per second. It is therefore obvious that any system of multiple telephony which permits an interruption of the telephonic circuit for as much as one one-hundredth of a second or even for an interval very many times less necessarily must be imperfect, owing to the loss of many characteristic notes or vibrations belonging to the voice in talking.

Experiment demonstrates the unsuitability of such previous systems even when the duration of the interval between successive closures of any one subcircuit is reduced to a much smaller interval than that indicated

by previous experimenters as within practical limits, and even when the exact interval previously indicated as permissible—namely, one one-hundredth of a second is employed—
 5 it will be found that a choppy or irregular effect or sensation is produced in the ear of the listener.

My present invention proceeds upon the theory that for the successful transmission
 10 of speech over any one of the branch or sub circuits successively connected to the line the closures of connection for that branch must be repeated with a frequency or rapidity approximating the frequency or average
 15 frequency of the finer or more complex vibrations which are characteristic of the voice or of articulate speech, and this I have demonstrated to be the true and necessary principle of operation by actually operating the
 20 circuit-closing switches or distributors, so as to produce closures of each of a number of branches or subcircuits at a frequency of as high as four thousand three hundred and twenty closures per second, at which rate I
 25 find that the voice with all its original timbre and individuality may be successfully reproduced in the receiving instrument. At this rate of contact or closure a connection is furnished for every one of the various vibrations or waves which are required to produce
 30 speech or the human voice, and while I have obtained the best results from such rate of closure I have also succeeded in getting what might be considered as commercial results
 35 by using rates of closure that, comparatively speaking, are as low as three thousand five hundred closures per second, this being practically the rate of the highest note which characterizes vowel sounds. As the rate increases, however, and up to that named—
 40 namely, four thousand three hundred and twenty closures per second—I find that the accuracy and clearness of the speech transmission increases, but that beyond said highest
 45 rate no beneficial effects are obtained, but there is rather a loss of effect, from which it is to be inferred that the higher rate is that of the highest rate of the overtones or partial tones that belong to the human voice.
 50 I do not, however, in my claim of invention limit myself to the special rate named, but claim as the principle of my improved method the provision of a contact or closure with such frequency as to provide a circuit or
 55 connection in readiness for approximately all the waves or vibrations that characterize spoken words. It will be understood, of course, that with the lowering of the rate there is a necessary tendency to loss of some
 60 of the characteristic vibrations, although a rate of three thousand six hundred closures per second will provide for all of the overtones characterizing the vowels and will therefore permit the several simultaneous
 65 transmissions to be carried on with some degree of distinctness. By proper observance of the rule that I have herein laid down—

namely, the provision of a contact or a frequency of connection determined by the frequency of the overtones or partial tones of
 70 the human voice which it is desired to reproduce in the instrument in each subcircuit—a great many simultaneous conversations may be carried on over one line or circuit. So far
 75 as observable, if this rule be observed the duration of the intervals between successive closures as compared with the duration of each closure is comparatively unimportant. In fact, if the frequency of the closures be
 80 such as hereinbefore set forth—that is to say, be adjusted to the frequency of the characteristic overtones of speech—so that there shall be a closure provided at some instant or other in the time of each vibration, the
 85 duration of each said closure is comparatively unimportant, and hence it becomes obviously possible to use a larger number of simultaneous transmissions than has ever before been
 90 proposed. I have in practice obtained perfectly commercial results with four simultaneous transmissions. As will be seen, therefore, my method involves a practical departure from previous practice in so far
 95 as I proceed not with reference to the duration of the intervals permissible between successive closures of any one branch or sub circuit, but organize and operate the apparatus with reference to the production of
 100 closures of determinate frequency irrespective of duration of each closure or duration of each intermediate interval during which circuit is broken upon said branch or sub circuit.

Having described the general principle of my invention, it will be obvious that the apparatus for carrying the same into effect
 105 would in its general form be the same as that heretofore used for multiplex telephony or telegraphy, excepting that the apparatus would be run at an enormously greater speed
 110 so as to bring the frequency of the closures of connections upon the several branches or subcircuits up to a rate approximating in greater or less degree the rate of the vibrations of the overtones characterizing speech.
 115 A rate of closure of one or two thousand per second will not answer the purpose of my invention; but as the rate increases and passes beyond three thousand improved results will become apparent and markedly so when a
 120 rate of three thousand five hundred or three thousand six hundred per second is reached, the best results being obtained, however, when the rate reaches about four thousand three hundred per second.
 125

The accompanying drawings illustrate in diagrammatic fashion a pair of rotating circuit closers or distributors in a typical form, sometimes employed for multiplex transmission over a single-line circuit.
 130

The rotary arms at opposite ends of the line 2 are marked 3 3', respectively. They are kept in synchronism by any means known in the art, and each is shown as rotating over five

contacts, to which are connected, respectively, the five branch or sub circuits 44', 55', 66', 77', 88'. The correspondingly-numbered branches include the telephonic apparatus or sets of apparatus that are used in conjunction for conversation. The circuit shown is a ground-circuit; but, as will be obvious, the apparatus might be organized in the well-known manner as is shown in Fig. 2 to provide a metallic circuit for each telephonic transmission. Since my invention, however, does not depend upon any special construction of apparatus, but involves rather the novel principle of use of the same, it is not necessary to describe the apparatus in detail, it being obvious to electricians and mechanics that any desired means may be used for securing the necessary speed of rotation of the arms of the distributors to accord with the principles hereinbefore laid down. Thus, for instance, the shafts carrying the rotary arms may be operated by synchronized electric motors geared or belted to said shafts to give them the necessary speed of rotation. The motor may be synchronized by the means described in my prior patent, No. 702,452, dated June 17, 1902, or by any other synchronizing expedients employed in telegraphy or telephony where it is desired to maintain rotating circuit-changers at opposite ends of the line in synchronous rotation. While the desired frequency of closure may be secured by proper gearing, as described, an additional expedient to secure such desired frequency would be, as well understood in the art, to repeat the contacts connected to each said circuit a number of times in the circumference of rotation of the circuit-closing brush or brushes, so that for each whole revolution of the shaft carrying the arms there would be a number of closures of the circuit. The arrangement

and size of the contacts are unimportant, the only requirements being that good contact should be made. The duration of each contact, as hereinbefore set forth, is not a controlling factor in the principle of my invention.

I claim as my invention—

1. The herein-described improved art of multiplex telephony consisting in synchronously closing the connection between the line and corresponding branches or subcircuits with a frequency corresponding to the frequency of the tones and overtones characterizing speech.

2. The herein-described improvement in multiplex telephony consisting in synchronously closing the connection between the line and corresponding branches or subcircuits with a frequency corresponding to the frequency of the vibrations belonging to the notes characterizing the vowel sounds.

3. The herein-described improvement of multiplex telephony consisting in closing the connection between corresponding branches or subcircuits and the line at a rate of approximately four thousand three hundred and twenty closures per second more or less as described.

4. The herein-described improvement in multiplex telephony consisting in closing the connection between the line and corresponding branches or subcircuits with a frequency corresponding to the frequency of the vibrations produced by spoken words.

Signed at New York city, in the county of New York and State of New York, this 24th day of February, A. D. 1903.

WILLARD M. MINER.

Witnesses:

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E. L. LAWLER.