M. C. A. LATOUR.

MULTIPLEX TELEPHONY.

APPLICATION FILED MAY 27, 1905.

913,521.

Patented Feb. 23, 1909.

3 SHEETS—SHEET 1.

Fig. 1.

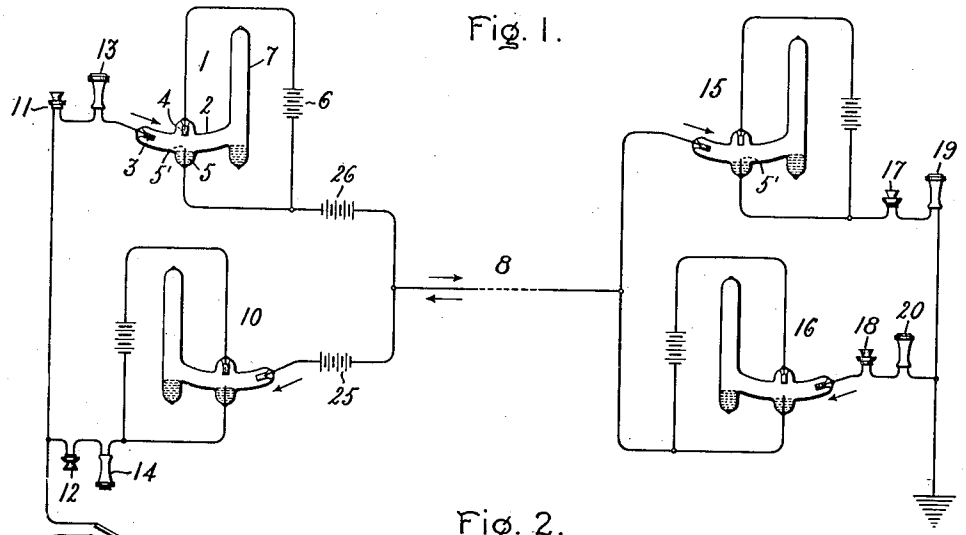


Fig. 2.

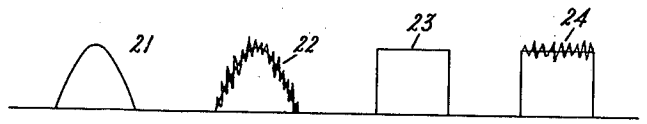
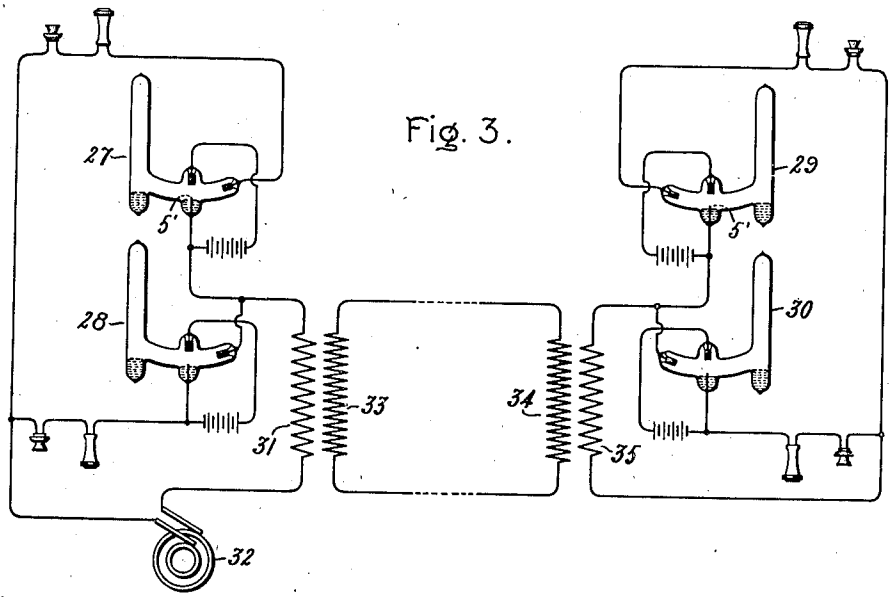


Fig. 3.



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3 SHEETS—SHEET 2.

Fig. 4.

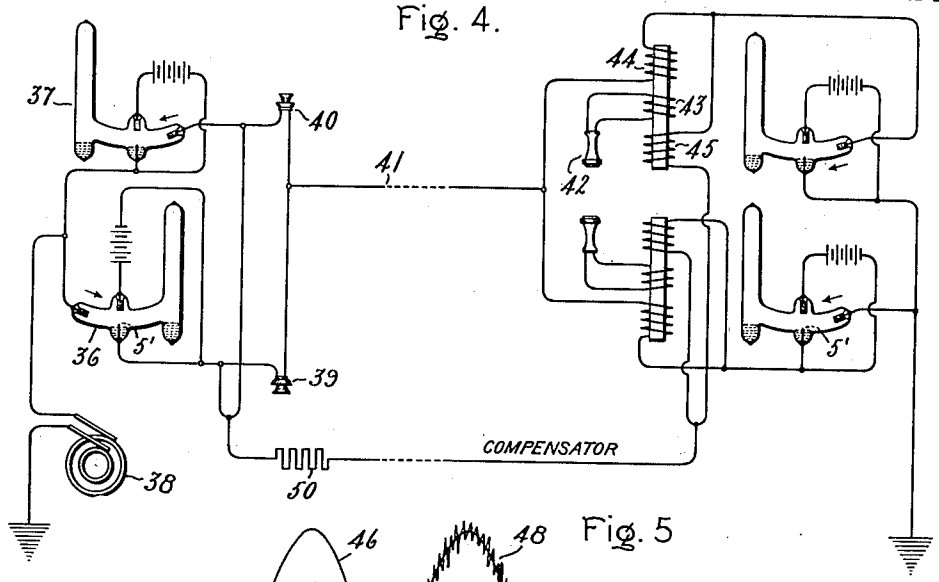


Fig. 5

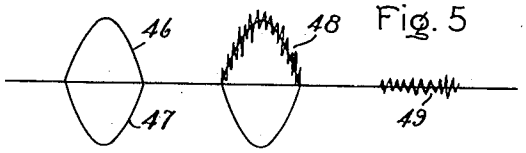


Fig. 6.

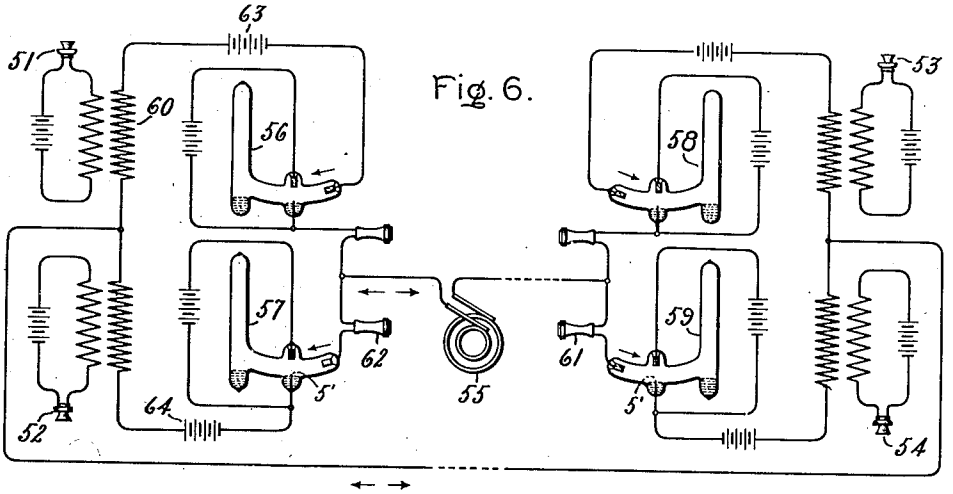
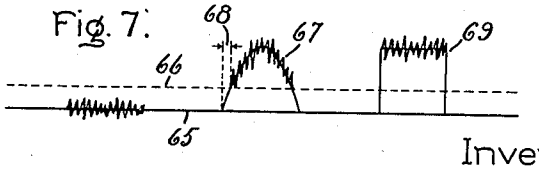


Fig. 7.



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3 SHEETS—SHEET 3.

Fig. 8

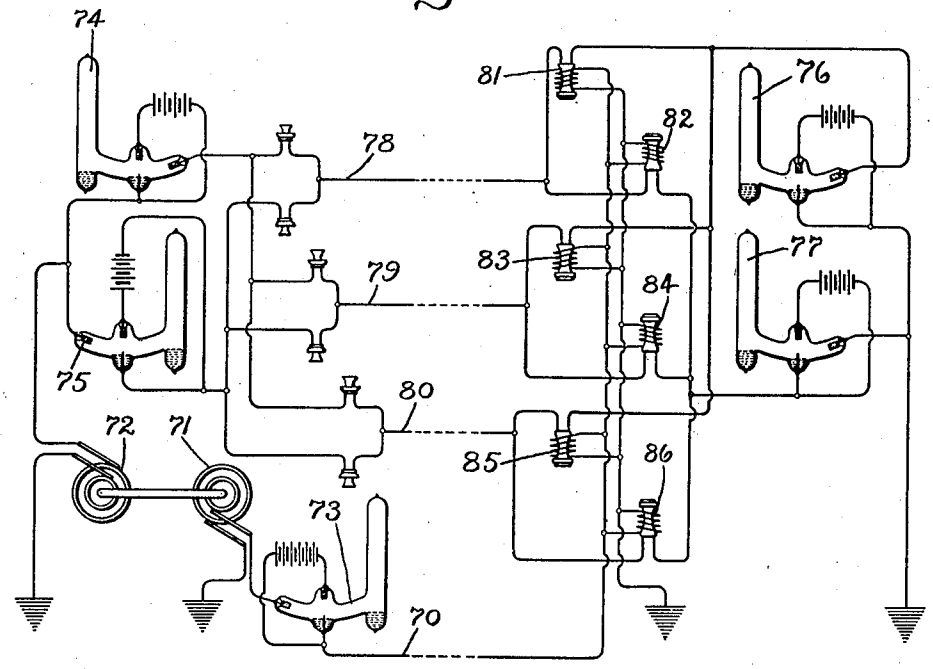
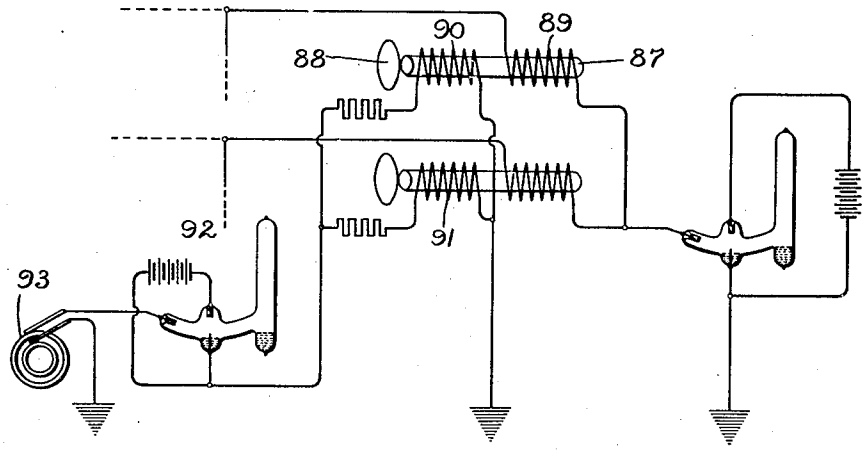


Fig. 9



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UNITED STATES PATENT OFFICE.

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MULTIPLEX TELEPHONY.

No. 913,521. Specification of Letters Patent. Patented Feb. 23, 1909.

Application filed May 27, 1905. Serial No. 262,543.

To all whom it may concern:

Be it known that I, MARIUS C. A. LATOUR, a citizen of France, residing at Paris, France, have invented certain new and useful Improvements in Multiplex Telephony, of which the following is a specification.

This invention relates to systems for transmitting intelligence in which two or more messages are simultaneously transmitted over a single line conductor.

Although my improved system is readily applicable to the transmission of signals of any sort, I contemplate using it principally for multiplex telephony with the object in view of permitting two or more persons to freely converse over the same wire at the same time.

In carrying out my invention I impress on the line wire an alternating current and I provide suitable means for superimposing on the positive half waves of this current a series of fluctuations such as are given out by an ordinary telephone transmitter when that instrument is subjected to sound vibrations produced by the human voice. Similarly I superimpose on the negative half wave fluctuations produced in a second transmitter. As all of one message is carried by the positive half waves of the alternating current and all of the other message is carried by the negative half waves, certain special means are necessary at the sending station for impressing on each of these half waves the proper fluctuations and for subsequently delivering these two kinds of half waves to the line conductor as an alternating current. Similarly there must be provided at the receiving station means for sorting out the positive half waves from the negative half waves, and thus delivering to the receiving instruments their respective messages. To effect this selective action on the alternating current I may make use of the peculiar property of a mercury vapor rectifier whereby half waves of one polarity are freely transmitted while half waves of the other polarity are entirely suppressed.

The details of my invention will be better understood by reference to the drawing forming a part of this specification, and the novel features are set forth with particularity in the appended claims.

Figure 1 shows an arrangement of mercury rectifiers and telephone instruments whereby two messages may be simultaneously transmitted in either direction over the same line wire; Fig. 2 is a diagram showing various wave forms of the alternating current together with the fluctuations superimposed thereon by a telephone transmitter; Fig. 3 is a modification in which the long distance transmission is made with high potential alternating current; Fig. 4 shows a special means of compensating for the fluctuations produced in the receiving circuit by the alternating current so that these pulsations produce no appreciable sound in the receiver; Fig. 5 is a diagram showing the neutralizing action of the current carried by the compensator wire; Fig. 6 shows an arrangement whereby my improved system may be applied to telephone systems of a type in common use; Fig. 7 is a diagram showing the advantage obtained by using an alternator or other current source having a rectangular current wave. Fig. 8 shows the compensator energized by a separate source, and Fig. 9 illustrates the use of a local circuit for magnetizing the core of the receiver.

In several of the figures of the drawing I have shown mercury rectifiers, and as these are all of the same type and operate in the same way it will suffice to describe in detail only one.

Referring to Fig. 1, the rectifier 1 comprises an evacuated tube 2 of glass, or other suitable material having sealed therein two carbon electrodes 3 and 4, and also carrying a mercury electrode 5. A condensing chamber 7 is located near the cathode 5. A storage battery 6 or other source of direct current is connected between the electrodes 4 and 5, and when current has once been established between these electrodes by shaking or tilting the tube to form an arc, this storage battery 6 causes a continuous flow of current through the tube from electrode 4 as anode to electrode 5 as cathode. It has been found that such a flow of current will make a mercury vapor tube conductive for current flowing toward the excited cathode, while the tube will remain nonconductive for current tending to flow from the cathode. Thus if an alternating pressure is impressed on electrodes 3 and 5 current will flow for the half waves during which time electrode 5 is cathode, but will not flow during the other half period. In this manner each of the mercury rectifiers shown in the several figures of the drawing operates as a

valve to permit the passage of current of one polarity, but entirely cuts off the flow of the other polarity. I find it desirable to provide a small platinum wire 5′ projecting above the surface of the mercury as I am thereby enabled to operate the rectifier on smaller currents and with less liability of disturbing fluctuations in the arc.

In Fig. 1 the line conductor 8 is supplied by current from an alternator 9, and two mercury rectifiers 1 and 10 are interposed between the alternator 9 and the line wire 8 and so connected that the half waves of current flowing to the line will pass through rectifier 1, while the half waves of current flowing from the line will pass through rectifier 10. These half waves of current pass respectively through the transmitters 11 and 12 and the receivers 13 and 14. At the receiving station the rectifiers 15 and 16 are also arranged in opposition so that current from the line wire 8 will pass by way of rectifier 15, whereas current to the line wire 8 will pass through rectifier 16. These rectifiers are provided respectively with transmitting instruments 17 and 18 and receiving instruments 19 and 20.

With the arrangement of circuits above described it is possible by talking in a sending transmitter, as for instance transmitter 11, to superimpose on the alternating half wave passing through rectifier 1, a series of pulsations corresponding to the fluctuations in sound produced by the voice of the operator. This relation is shown in Fig. 2 in which 21 is the normal half wave of current supplied by the alternator, and 22 shows the effect of the superimposed fluctuations. This half wave of current 21 passes through the line wire 8 and through rectifier 15 to the receiver 19 where the fluctuations originally produced by the transmitter 11 are reproduced as sound vibrations. After the half wave of current 21 has passed through the transmitter 11 there follows an interval of time corresponding to 180 electrical degrees during which no current flows through the transmitter, and consequently during which the sound vibrations delivered thereto are entirely lost. If the frequency of alternator 9 is low enough, entire syllables may be lost in this way so that the speech transmitted to the receiving station is inarticulate. I find however, that this difficulty does not occur, unless the frequency is lower than about forty cycles per second, and that with a frequency higher than this no difficulty whatever is experienced from the loss of these sound vibrations. In other words, what may be called the persistency of the human ear bridges over the spaces not filled in by the transmitter.

During the transmission of the message as above described a second message may be transmitted from the transmitter 12 to the receiver 20, or from the transmitter 18 to the receiver 14. As this second message is transmitted by the missing or negative half waves it may be transmitted in either direction on the line wire 8 without interfering in any way with the message first mentioned.

Although I have shown a ground connection for the alternator and the distant end of the telephone system, it is obvious that a metallic return may be used, if such an arrangement appears desirable. It is also obvious that instead of the alternator 9, delivering a sine curve as shown at 21 in Fig. 2, I may use an alternator delivering a rectangular half wave 23 on which the fluctuations of the transmitter may be superimposed, as shown at 24, or I may use a rotating switch driven in any suitable manner and serving to impress on the system the pressure of a storage battery or other source of direct current.

It has been noted that under certain conditions of excitation a mercury rectifier offers an appreciable counter E. M. F., and if the alternator gives a sine curve, there may elapse a small interval of time during each half wave before the alternating pressure builds up to a value sufficient to over-power this counter E. M. F. of the arc. To obviate this difficulty I may, if desired, insert storage batteries 25 and 26 in series with the mercury arcs and having an electromotive force approximately equal to the counter E. M. F. of the arc. These batteries are connected in series with the arcs in such a way that they assist the flow of current through the arc, or in other words just counter-balance the counter E. M. F. and therefore permit the flow of current when the potential difference between the electrodes is very small.

Fig. 3 shows an arrangement in many respects similar to that described in Fig. 1 except that the long distance transmission is made with current at a higher potential than that used to operate the instruments. The rectifiers 27, 28, 29 and 30 are in all respects similar to those described in connection with Fig. 1, but the pulsating current delivered by rectifier 27, instead of passing through the line wire to the distant receiver passes through the primary 31 of a transformer and then back to the alternator 32. Similarly the current transmitted by rectifier 28 comes from the alternator 32 through the transformer winding 31, and as a result an alternating pressure is generated in the winding 33 and transmitted through the line wires to the distant transformer winding 34 at high pressure. At the distant station it is transformed down and delivered from the low pressure winding 35 to the rectifiers 29 and 30. By the use of high potential currents in the line wires I reduce the resistance loss in the wires, and am able to transmit over longer distances than are practicable with low potential currents. In addition to the

fluctuations which produce speech there is also noticeable in the receiving instruments a humming sound due to the pulsations of the main alternating current. To overcome the disturbing influence of the alternator current I make use of a compensating current to neutralize the large pulsations in the receiving instruments without interfering in any way with the speech fluctuations. This arrangement is shown diagrammatically in Fig. 4, though it is to be understood that I may apply this compensating effect to any of the receivers shown in the various figures of the drawing. The system shown in Fig. 4 is in many respects similar to the system illustrated in Fig. 1, except for the presence of the compensating line wire, and a transformer for rendering the current carried by the compensator available for neutralizing the current flow in the receiving instruments. The rectifiers 36 and 37 are connected in opposition to the alternator 38, and are also connected through transmitters 39 and 40 to the line wire 41. The receiving instruments are not connected in series with branches of the line wire as shown in Fig. 1, but in lieu of that arrangement are connected to the secondaries of transformers. Receiver 42 is connected to the secondary 43 of the transformer on the core of which are also located two primaries 44 and 45. Primary 44 receives current from the line wire 41, whereas primary 45 receives current from the compensator wire. The magnetic effects of these currents are in direct opposition with the result that they completely neutralize, leaving coil 43 uninfluenced by the pulsations of the alternator 38. Fig. 5 shows, in curve 46, the magnetic fluctuations established by the current passing through the primary 44 when the system is not being used for the transmission of speech, and in curve 47 the magnetic variations established by current transmitted through the compensator. Curve 48 shows the magnetic variations established by speaking in the transmitter 39; while curve 49 shows the resultant magnetic fluctuations available for establishing a varying potential in coil 43. It is obvious that the current supplied through the compensating line wire must be in synchronism with that transmitted by the main line and must be of proper magnitude to just blot out the effect of the alternating half wave transmitted through the line. To secure the proper division of current through the line wire, and through the compensator, I introduce a resistance 50 in the compensator.

Fig. 6 shows the manner in which I contemplate applying my invention to telephone systems of the type now in common use. The four transmitters 51, 52, 53 and 54 are each supplied by current from a storage battery and are each connected through the primary of a transformer. An alternator 55 sends current through the rectifiers 56, 57, 58 and 59 in the directions shown by the arrows. If when a half wave of current is passing through transformer coil 60 toward the rectifier 56, the operator talks in the transmitter 51, fluctuations will be impressed on this half wave of current which fluctuations will be reproduced in the receiver 61 at the other end of the line. This half wave passes through the rectifiers 56 and 59, and does not in any way affect the circuit through rectifiers 57 and 58, so that a second message may be simultaneously transmitted through this path. From an inspection of the direction of the current flow through rectifiers 56 and 57 it will be seen that there is a comparatively low resistance path from transformer coil 60 through rectifiers 56 and 57 and back to coil 60, and it might be supposed that the fluctuations produced in this coil would take this shorter path at the sending station, and would not pass out over the line conductors as above described. I find, however, that such is not the case, at least when the fluctuations are produced by vibrations of the voice, although I have found that if the sound is a prolonged sound, such for instance as may be produced by whistling, there is under certain conditions a flow of current in this local path so that vibrations impressed on the transmitter 51 may be heard in the receiver 62. To overcome possible interference of the two messages in this way I introduce two batteries 63 and 64 in this local circuit so connected that their voltage is in the same direction as the counter E. M. F. of the arcs in the rectifiers 56 and 57, or in other words in such a direction as to oppose the flow of current through a local circuit including both rectifiers.

When the arrangement just described is used, I find it is possible to substitute for the alternator 55 a rotating commutator driven in any suitable manner and serving to impress on the line conductor current waves of a rectangular form. The reason for this will be better understood by reference to Fig. 7 in which the line 65 may be considered to represent the base line of the alternating current wave and in which the height of dotted line 66 above this base line may represent the pressure of battery 63. It will be noticed that when a pressure wave 67 is impressed on such a system there is a certain interval of time represented by the space 68 during which no current flows through the circuit, and consequently during which the fluctuations produced by the voice vibrations are lost. If on the other hand the wave form of pressure is rectangular as shown in curve 69, the pressure jumps immediately to its maximum value and all the fluctuations due to voice vibrations are preserved.

The system just described has the impor-

tant advantage that it may be built up out of a telephone system of ordinary form by the simple addition of mercury rectifiers and other minor details.

Fig. 8 illustrates a system in which the compensator 70 operates from a separate source consisting of an alternator 71 and a lamp or valve 73. The alternator 71 operates in synchronism with the main alternator 72. The lamps 74, 75, 76 and 77 have ample capacity for supplying all the lines 78, 79 and 80, and the single compensator 70 serves to control the magnetization of all the receivers 81, 82, 83, 84, 85 and 86. In the drawing the telephone receivers 81 to 86 are illustrated diagrammatically as having an auxiliary winding connected to the compensator circuit. Such arrangement will be readily understood by a person skilled in the art and might properly be represented diagrammatically as in Fig. 9, wherein 87 is the telephone core, 88 the diaphragm, 89 the winding receiving line current, and 90 the winding connected to the compensator circuit. This construction differs somewhat from the construction shown in Fig. 4, and the latter was used more for purposes of clearly illustrating the arrangement than as a commercial form of device.

In the system shown in Fig. 9, the compensator circuits 90 and 91 are in a local circuit supplied with energy through a lamp 92. It will be understood that the alternator 93 may be maintained in proper synchronism with the system in a manner well known to electricians.

What I claim as new, and desire to secure by Letters Patent of the United States, is,—

1. In a system of electrical communication, a line conductor, means for impressing on said conductor a current which periodically reverses in sign, means for impressing on the current waves of one sign fluctuations corresponding in frequency and magnitude to the signals or messages to be communicated and means for diverting current waves of the opposite sign through a shunt path.

2. In a system of electric signaling, a line conductor, means for impressing on said conductor a current which periodically reverses in sign, means for impressing on the current waves of one sign fluctuations corresponding in frequency and magnitude to the signals to be transmitted, and means for independently impressing on the waves of the other polarity a second series of fluctuations for the transmission of a second signal.

3. In a system of telephony, a line conductor, means for impressing on said line conductor current pulsations of one polarity which succeed each other at regular intervals, means for superimposing on said current pulsations, fluctuations corresponding in frequency and magnitude to voice vibrations, means for utilizing said fluctuations to produce sound and independent means for transmitting current waves of opposite polarity to said line conductor.

4. In a system of multiplex telephony, a line wire, a transmitter connected thereto, means for passing an alternating current through said line wire, and an asymmetrical conductor for preventing the flow of current in one direction to said telephone transmitter but permitting the flow of the current in the opposite direction therethrough.

5. In a system of multiplex telephony, a line conductor, a telephone receiver connected thereto, means for impressing an alternating current on said line conductor, and an asymmetrical conductor preventing the flow of current in one direction through said receiver but permitting the flow of current in the opposite direction therethrough.

6. In a system of electric signaling, a line conductor, a source of alternating current connected thereto through a plurality of paths, asymmetric conductors for causing the current of one polarity to pass through one of said paths and current of the opposite polarity to pass through another of said paths, means associated with each of said paths for superimposing on the current passing therethrough fluctuations corresponding to the signals to be transmitted, and means for utilizing the fluctuations in the current of either polarity for producing sound waves.

7. In a telephone system, receiving instruments, means for subjecting said instruments to the influence of unidirectional current pulsations which succeed each other at regular intervals and which have superimposed thereon fluctuations of a higher frequency than said pulsations, and means for neutralizing the effect of said pulsations on said receiver.

8. In a system of telephony, a line conductor, a vapor electric device for transmitting to said line conductor current pulsations of one polarity, and a transmitter for superimposing on said pulsations fluctuations corresponding in frequency and magnitude to voice vibrations.

9. In a system of electrical signaling, a vapor electric device for transmitting positive pulsations to said conductor, a second vapor electric device for transmitting negative impulses to said conductor, means for impressing high frequency fluctuations on said positive and negative pulsations, and means for utilizing said high frequency fluctuations to produce sound waves.

10. In a system of electric communication, a line conductor, means for impressing on said conductor a current which periodically reverses in sign, means for changing the wave form of current pulsations of one sign, vapor electric means for separating pulsa-

tions of different sign, and means for detecting said changes in the wave form of said pulsations.

11. In a telephone system, the combination of a line conductor, a source of alternating current, vapor rectifiers connected therewith for separating pulsations of unlike polarity, a transmitter for current of each polarity for superimposing fluctuations thereon, means for recombining the currents of unlike polarity for transmission through said line conductor, means for again separating currents of unlike polarity, and receiving instruments operated by said separated currents.

12. In a telephone system, the combination of a transmitter connected through a battery to a transformer winding, a second winding for said transformer, a mercury rectifier connected therewith, means for supplying unidirectional pulsations through said mercury rectifier and its associated transformer winding, line conductors in circuit therewith, and a receiving instrument actuated by energy transmitted through said line conductors.

13. In a system of multiplex telephony, a line wire, a transmitting means connected thereto, means for transmitting an alternating current through said line wire, and a mercury vapor device for transmitting current of one polarity to said transmitting means but opposing a prohibitive resistance to current of opposite polarity.

In witness whereof, I have hereunto set my hand this twelfth day of May, 1905.

MARIUS C. A. LATOUR.

Witnesses:

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