(No Model.) 2 Sheets—Sheet 1.

J. W. GIBBONEY.
TELEPHONY.

No. 587,120. Patented July 27, 1897.

FIG. 1.

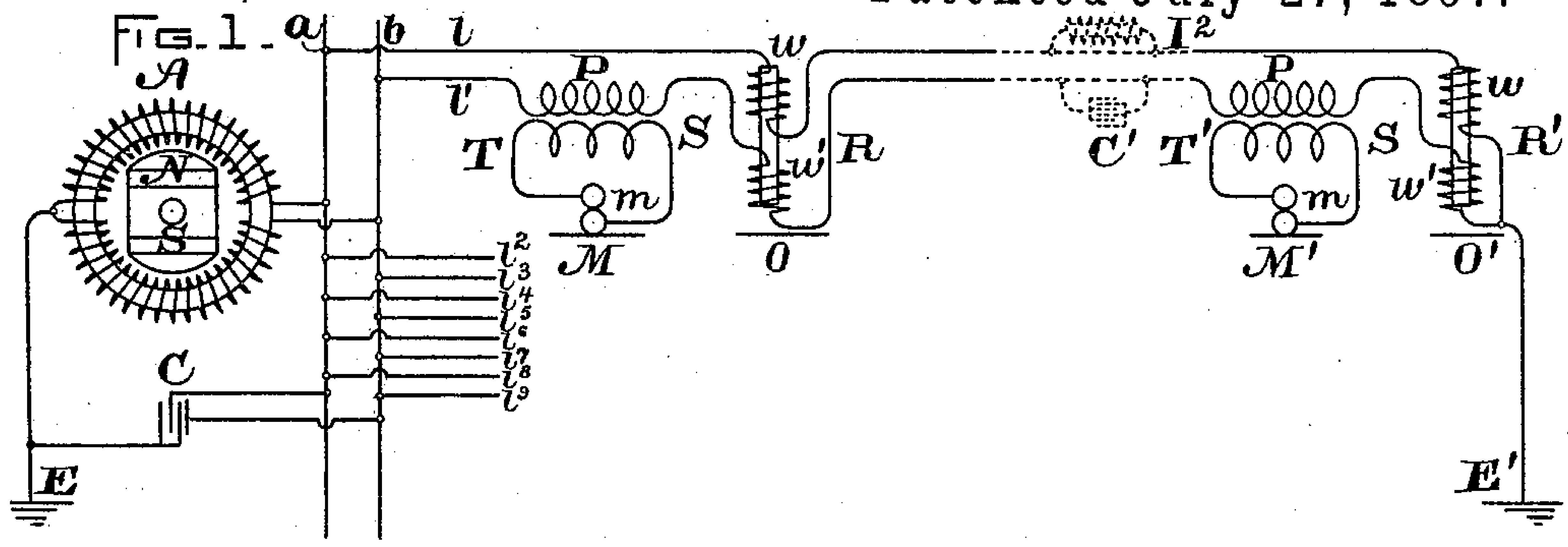


FIG. 2.

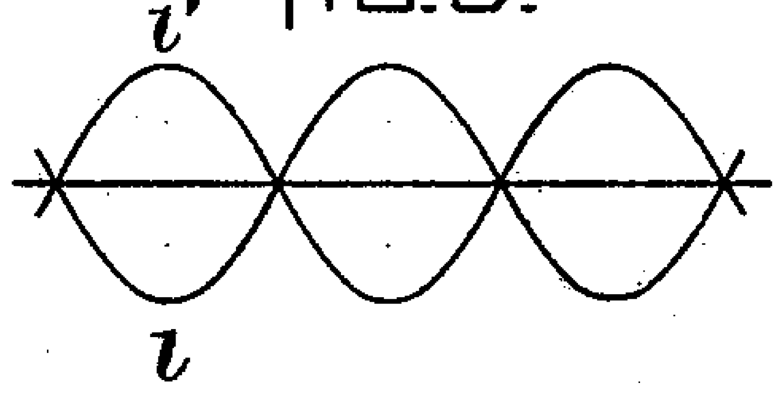


FIG. 3.

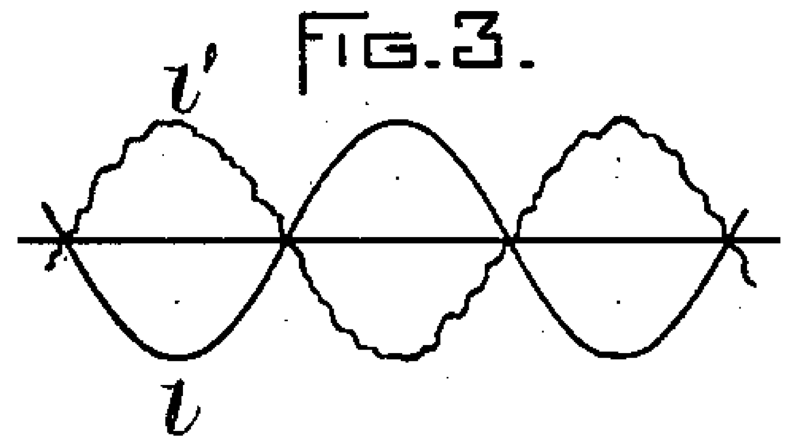


FIG. 4.

FIG. 5.

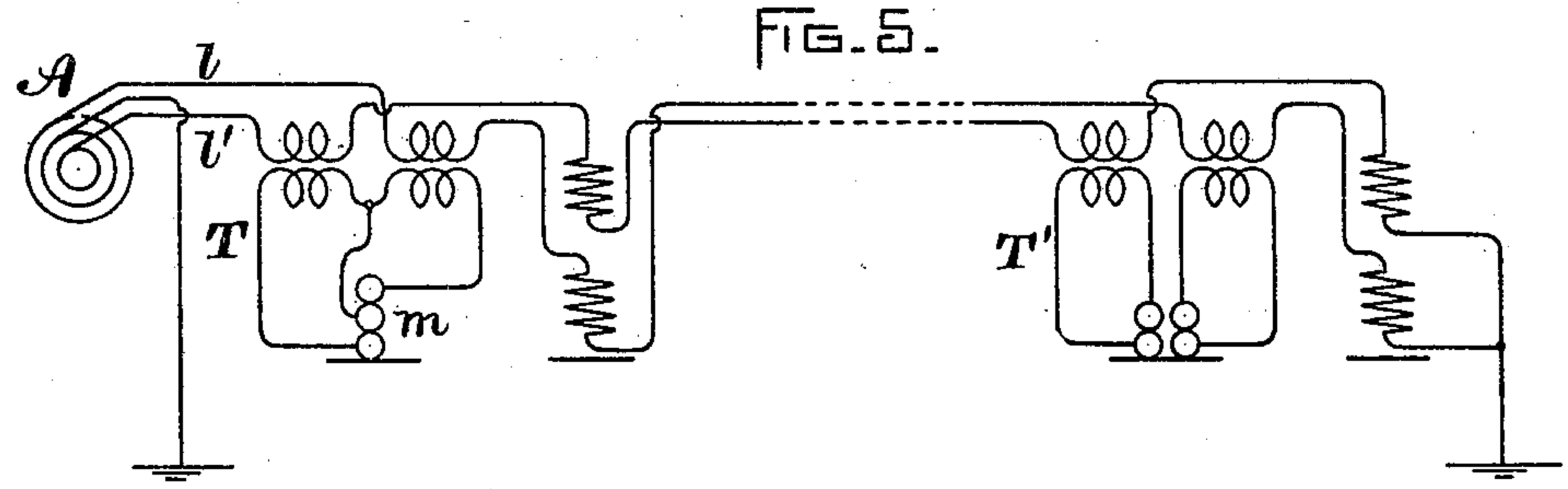


FIG. 6.

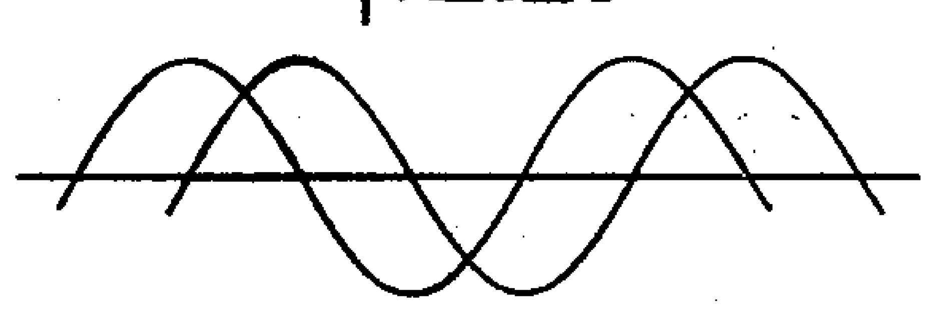
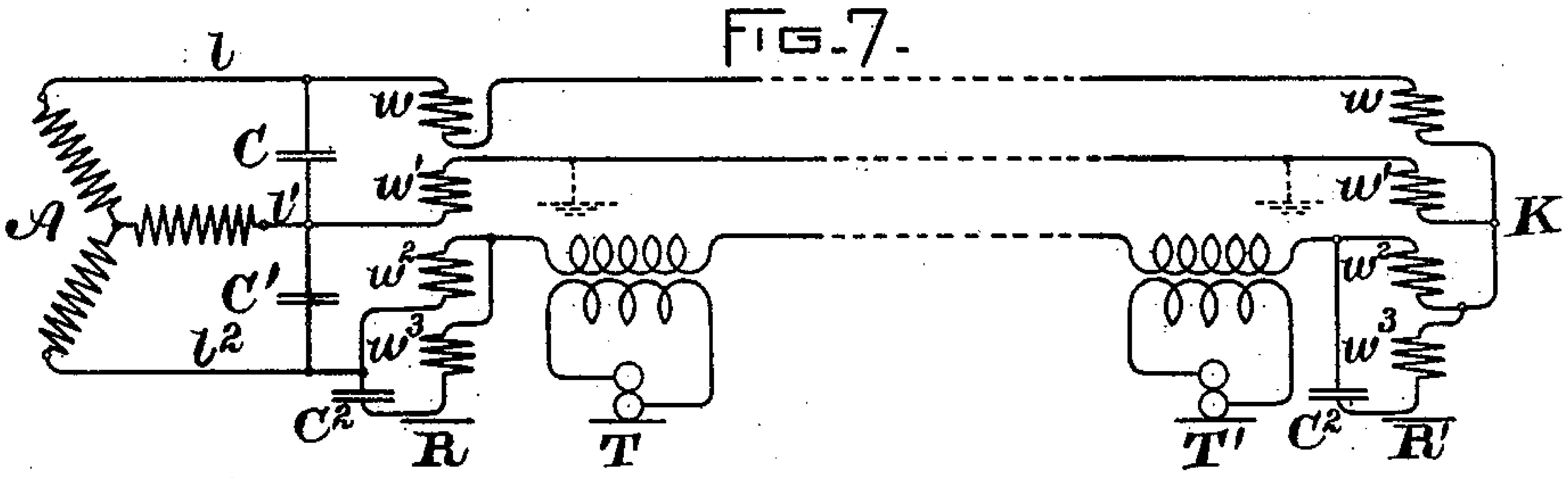


FIG. 7.



WITNESSES.

A. H. Abell,

B. B. Hull

INVENTOR.

John W. Gibboney,

by J. J. Johnston,

Atty.

(No Model.) 2 Sheets—Sheet 2.

J. W. GIBBONEY.
TELEPHONY.

No. 587,120. Patented July 27, 1897.

FIG. 8.

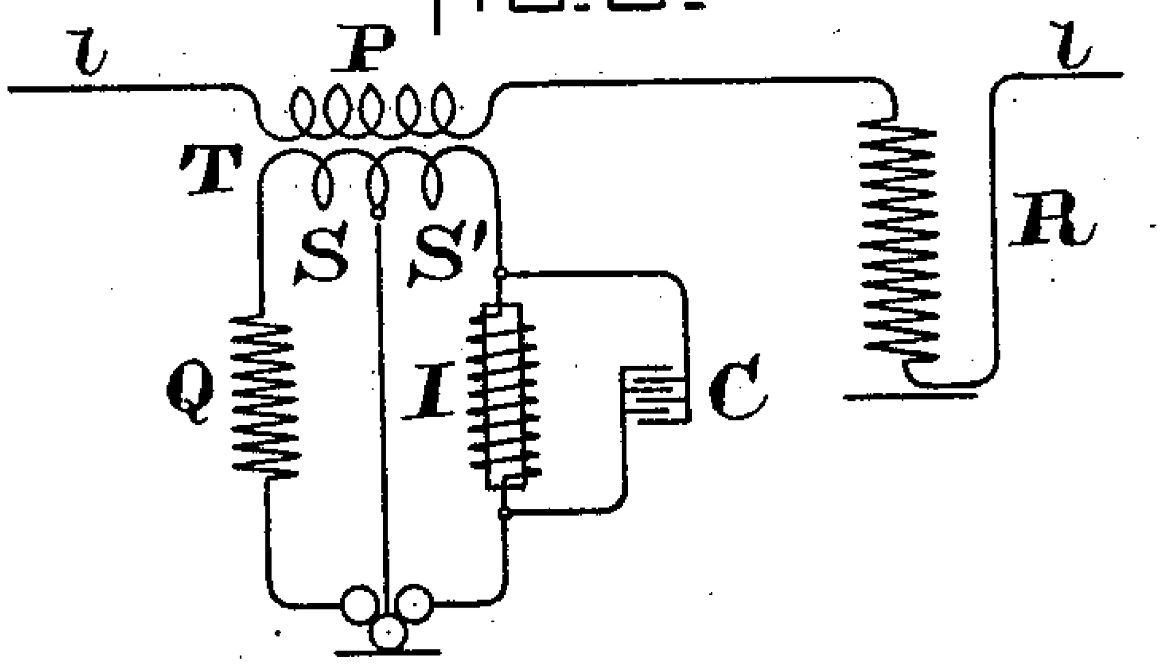


FIG. 9.

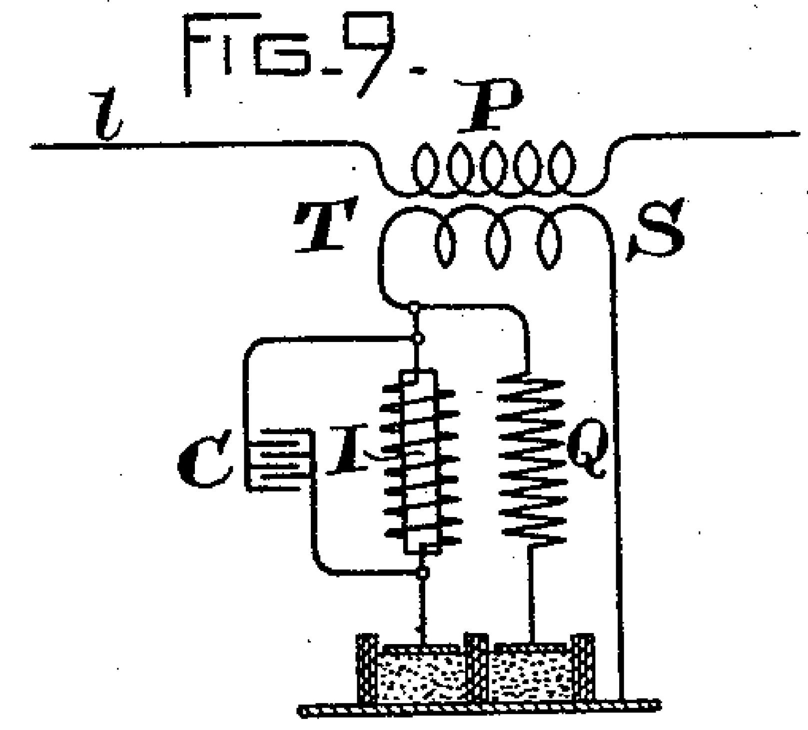


FIG. 10.

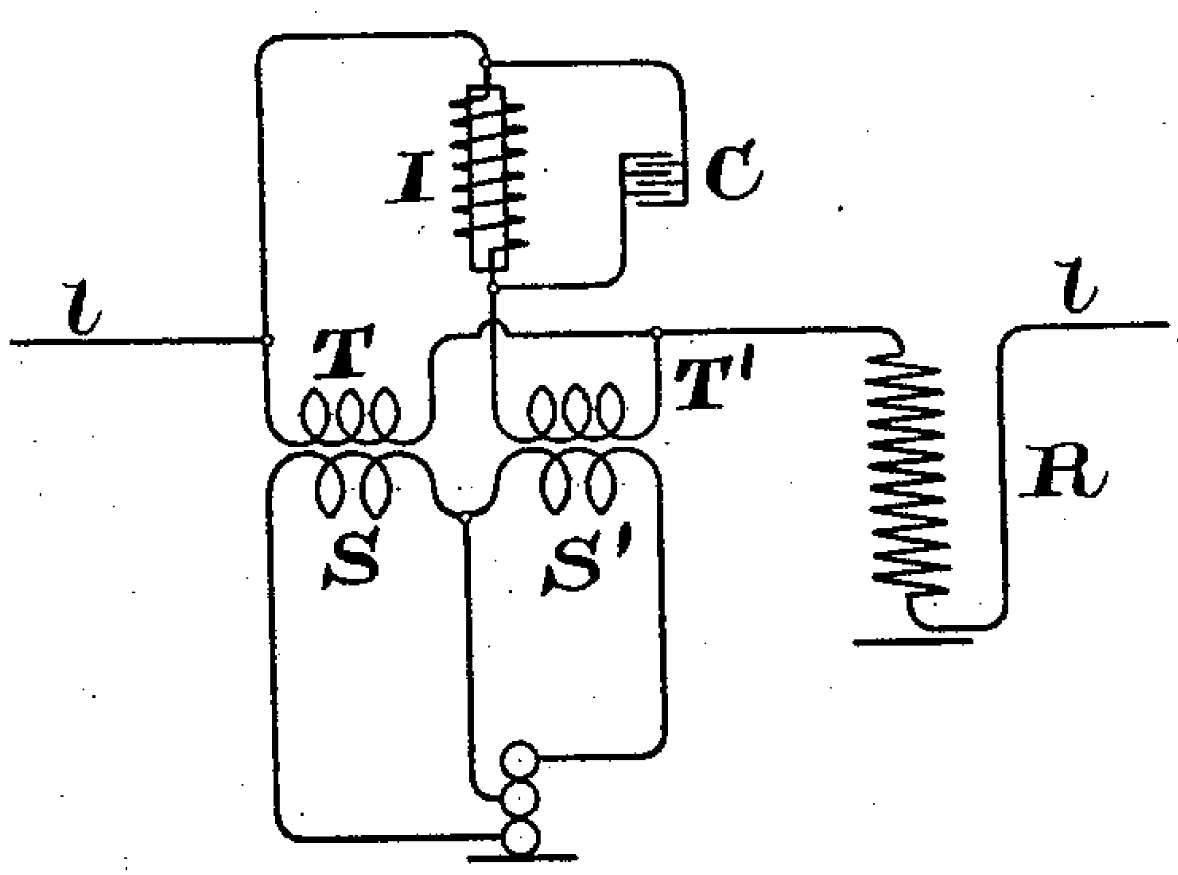


FIG. 11.

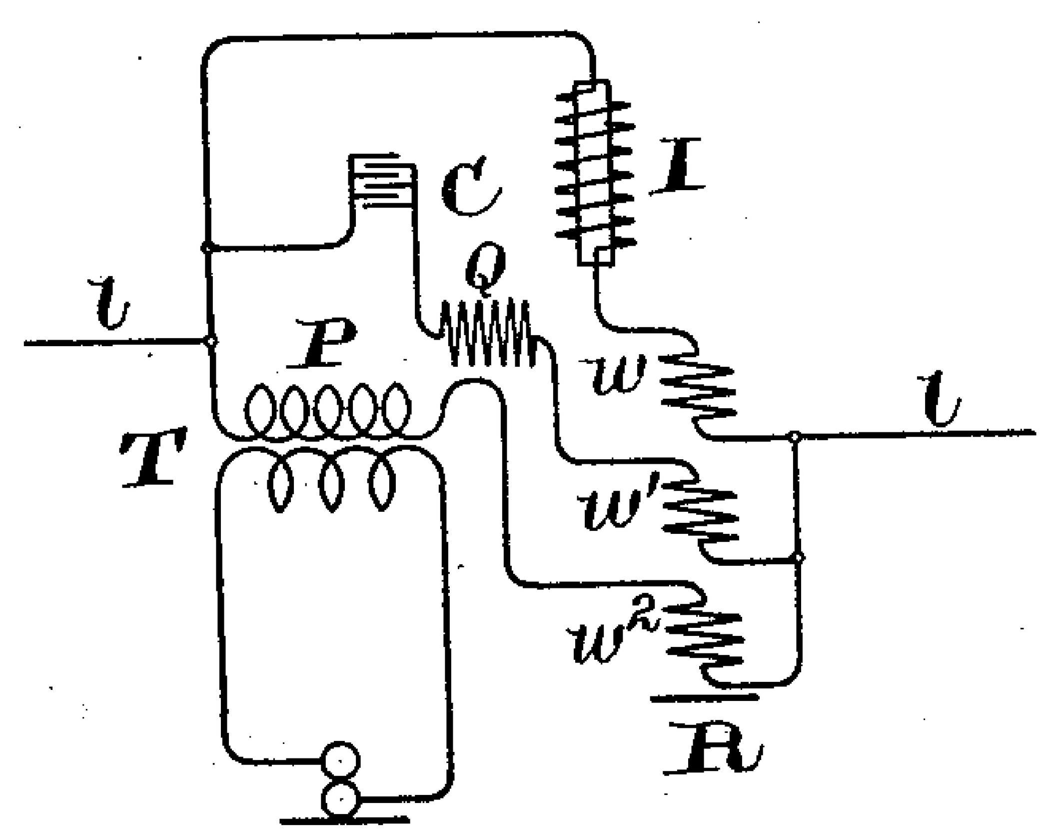
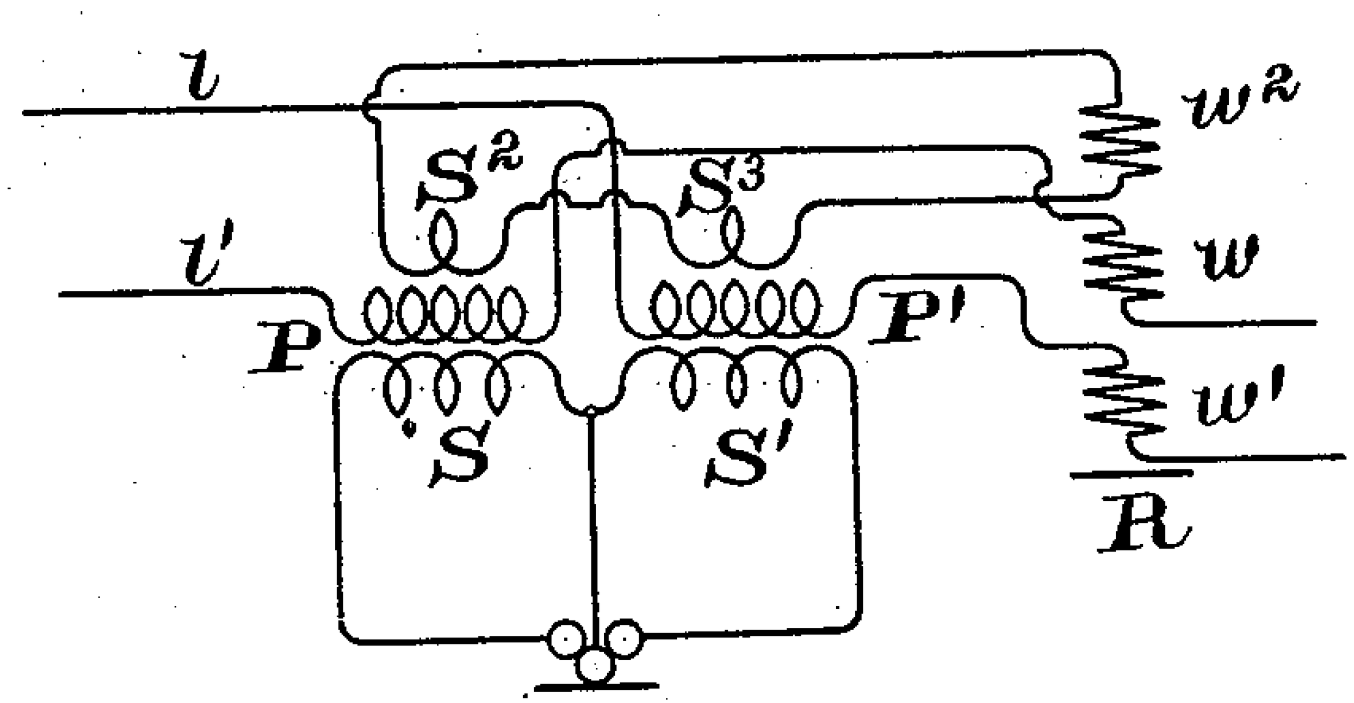


FIG. 12.



WITNESSES.
A. H. Abell.
B. B. Hull

INVENTOR.
John W. Gibboney, by
S. J. Johnston,
Atty.

UNITED STATES PATENT OFFICE.

JOHN W. GIBBONEY, OF LYNN, MASSACHUSETTS, ASSIGNOR OF ONE-HALF TO THOMAS J. JOHNSTON, OF SCHENECTADY, NEW YORK.

TELEPHONY.

SPECIFICATION forming part of Letters Patent No. 587,120, dated July 27, 1897.

Application filed August 3, 1896. Serial No. 601,437. (No model.)

To all whom it may concern:

Be it known that I, JOHN W. GIBBONEY, a citizen of the United States, residing at Lynn, county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Telephony, (Case No. 367,) of which the following is a specification.

My invention relates to telephony, and more particularly to systems by which I am enabled to use, for the transmission of speech or other sounds through telephone apparatus, alternating currents generated in any suitable way. It is in some respects an improvement upon the method disclosed in my Patent No. 481,529, dated August 23, 1892. In that patent I have disclosed the fundamental idea of employing alternating currents for the transmission of acoustic vibrations. Speech-waves are imposed upon the alternating current by suitable transmitters and carried along with it to receivers situated at a distance. Without being limited to any precise rate of vibration that patent disclosed the use of currents of inaudible period, or those setting up in the receivers no vibration perceptible to the ear, so that the only vibrations affecting the diaphragm would be those superimposed upon the alternating-current wave.

On account of inductive and other difficulties connected with the transmission of alternating currents to any distance I preferred in the case above mentioned to use currents of low periodicity; but this gives rise to a difficulty which, while not preventing the use of the system disclosed in that patent, renders some modification of it desirable. With currents of low periodicity waves of current cause a certain "fluttering" of the diaphragm, and while in spite of this the speech-waves are generally perceptible there come at times dead-points or very brief periods of discontinuity of the speech-vibrations. It is to overcome this difficulty that I have devised the present invention, which is not the only means of overcoming it which I have conceived, but which I have found to be an efficacious one; and it consists in a method of telephoning by polyphase alternating currents in contradistinction to the use of the single-phase alternating current, such as has been used and the application of which has been described in my patent above referred to, the object being to obtain a smooth and continuous transmission of speech of substantially the same equality as that obtained in the use of ordinary battery arrangements.

In embodying my invention I prefer to make use of two-phase alternating currents, although currents of other number of phases could be readily applied by suitable modifications of mechanism which would be manifest to those skilled in the art from a study of this specification. The two-phase currents may be either audible or inaudible in period, and they may differ in phase either by just such an amount as would cause the overlapping of the current-waves in the receiver, and thus obtain continuity of speech, or they may be opposed in phase, so that where the receiver is, as I prefer, differentially wound the two primary or main currents neutralize each other and no magnetizing effect is produced upon the core of the receiver except such as is due to the vocal or other sound vibrations superimposed upon or modifying one or the other of the currents. This latter is the preferred form of my invention, as by it I reduce the necessary wiring to the lowest amount, and this arrangement can be carried out whether or not the rates of alternation produce audible vibrations in telephone-receivers.

In the method as thus briefly outlined polyphase currents are ordinarily generated at a single central station and distributed over a large system by the suitable switchboards and other appliances commonly used to effect the interchange of communications. My invention is not, however, limited to this form of apparatus, but I may employ in the central station single-phase apparatus using only a single line and depending upon the earth-return or using a complete metallic circuit, and in this case I provide a proper phase-splitting device in the subscriber's station. This ordinarily would be the most economical arrangement, as it would embrace only a single line of communication with the central station.

Where I use here the term "phase-splitting device," I refer to any of the well-known methods used in the art for obtaining from a single-phase current polyphase alternating waves, and this whether the polyphase currents be of two or three or any other number of phases.

Various combinations of resistance, inductance, and capacity in any convenient forms for ready application to my improved system may be used for the purpose described. I have illustrated several different ways of carrying this part of my invention into effect; but nothing in the description or claims hereto annexed is to be taken as limiting me in this regard, as the essence of my invention consists not so much in particular apparatus (although some forms thereof are described as well adapted to the invention) as in the combinations by which I am enabled to employ polyphase alternating currents for the transmission of speech, at the same time preserving a smooth and continuous effect in the receivers, overcoming the annoying pulsations due to ordinary variations of current in telephone-lines as commonly constructed, and enabling me to derive the advantages incident to the use of alternating currents in systems of distribution. So far as I am aware I am the first to employ this class of currents for the purposes described and believe myself to be entitled to claims covering, broadly, not only the improvement in the art of transmitting sound electrically which consists in so employing polyphase currents, but also the combinations of apparatus which I have devised for carrying these improved methods into practical use.

The accompanying drawings show diagrammatically arrangements capable of carrying out the methods proposed.

Figure 1 is a central-station apparatus employing two-phase currents on the three-wire system. Figs. 2, 3, and 4 are diagrams illustrating the operation of the parts shown in Fig. 1. Fig. 5 shows a system employing the same class of currents in the same way, but more particularly adapted for those of inaudible period. Fig. 6 is a diagram of the current-waves as employed in Fig. 5. Fig. 7 is a diagram of a three-phase apparatus. Fig. 8 is a diagram illustrating a single-phase transmission with phase-splitting devices in the transmitter. Fig. 9 is a modification of the arrangement shown in Fig. 8 with a different form of transmitter. Figs. 10 and 11 are other modifications, and Fig. 12 is a three-phase apparatus with a single line for transmission.

In Fig. 1, A is an alternating-current generator having two windings disposed so as to deliver alternating currents differing in phase by one hundred and eighty degrees. I have illustrated a winding, like that of the Gramme ring, divided into two parts, communicating with the bus-bars or main conductors *a b* of the station. The usual switching and connecting devices are employed and are not illustrated, as they form no part of the present invention. I have indicated at l^2 l^3 l^4, &c., connections to the switchboard, but as all these details may be indefinitely varied I do not illustrate them in full. I prefer a permanent magnet for the field-magnet of the generator, although for this I may substitute a wound field-magnet supplied, preferably, from a storage battery, this giving the smoothness of current best adapted for telephone work. The permanent-magnet field is indicated at N S. The generator has the common junction of the two opposed windings connected to ground at E, and shunting the machine is a condenser C, so arranged that the self-induction of the generator may be avoided. Lines l l' lead from the generator, and their common termination is grounded at E′. The current in the line l is of phase one hundred and eighty degrees displaced from that in the line l'. The line l is carried through windings upon the receivers R R′, but does not include the transmitters. The line l' is carried through other windings upon the receivers, but also passes through the fine-wire windings P of the transformers T T′. The windings S S of the transmitters form closed circuits with microphone-contacts *m m* and diaphragms M M′.

The operation of the system illustrated in Fig. 1 is as follows: The phase relation of the currents in the two lines being at one hundred and eighty degrees displacement, or in direct opposition, there is no audible effect in the receivers from the principal currents, their magnetizing effects in the coils w w' being equal and opposed. If, however, speech be uttered against the diaphragms M M′ of the transmitters or any other sound be communicated to them, the current in the line l' has inductively superimposed upon it the vibrations caused by the action of the coil S as a transformer-primary. These vibrations are carried to the coils w w upon the receivers R R′ and there cause corresponding vibrations in the diaphragms O O′ of these receivers.

The relation of the line-currents is illustrated in Figs. 2, 3, and 4. In Fig. 2 the upper curve represents the energy transmitted through the line l', the lower one that through the line l. These two waves are in opposition. When, however, sounds are produced before the transmitters, the higher-frequency speech-waves are superimposed upon the wave of current in the line l', as illustrated in Fig. 3, and by it are carried along to the receivers R R′. At this point the two coils w w' come into play, the magnetizing effect of the two being equal and (by reason of the phase displacement) opposite, the two fundamental currents are wiped out in the receiver, only the speech-vibrations represented by the broken line in Fig. 4 being left to affect the diaphragms O O′.

With the arrangements pointed out it will be evident that the circuit for speech actually comprises a metallic line l' and an earth-return, but the effect is as though an entire metallic circuit were used, it being evident that for all extraneous induction and leakage currents the two lines l and l' act in parallel as a single circuit in connection with the earth-circuit; but all these exterior currents pass through the two windings w w' upon the receiver, and therefore their effect is neutralized, it being manifest that in practice only those current-fluctuations which pass through one coil alone of the receivers can affect the diaphragms O O' to a sufficient extent to be audible. At C', I indicate in dotted lines a small condenser which may be employed, if desired, to neutralize the difference in inductance between the lines l l', caused by including the transmitter-secondaries in one only of these lines. A balancing artificial inductance in the other line (similarly indicated at I^2) might be used for the same purpose.

Referring now to Fig. 5, I illustrate a different arrangement of apparatus, although operating upon substantially the same principles, it being assumed that the system shown in this figure, which also is operated by two-phase currents, is adapted for inaudible periods or rates of alternation of the currents, while that in Fig. 1 would be adapted for either audible or inaudible alternations. As before, A is the generator delivering two currents, which may have any desired phase relation, both passing through the lines l l', as before, and returning by the earth. It may be assumed that the currents are ninety degrees out of phase, and their relation would be illustrated by the two sine-waves shown in Fig. 6; but as they are to be primarily inaudible in character the exact phase relation is immaterial, so long as one current is rapidly changing in value while the other is not. In this case, however, I employ a modified form of transmitter, which I believe to be new with me. The transformer portion of the transmitter is made in two parts—that is, there are two magnetic cores, each having a winding connected in one or the other of the lines l l', and a divided circuit in the transmitter closed through the microphone-contacts—the two circuits being in inductive relation to the coils included, respectively, in the lines l l'. In the transmitter T the microphone-contacts m are in series, but in the transmitter T' these contacts are in multiple. In each case the circuits to the microphone-contacts from the primary coils of the transformers are substantially independent, at least to such an extent that no compound wave would be formed in the microphone to give a pulsating or fluttering effect in the receiver.

Fig. 7 shows an arrangement employed with three-phase apparatus. It is not the preferred system, as it introduces several difficulties, a general complication of apparatus, and multiplicity of circuits both in the apparatus and exterior thereto, and also necessitates special arrangements for getting a proper magnetizing effect in transmitters and receivers, it being known that this effect with three currents differing by one hundred and twenty degrees in phase is zero; but as the combination of apparatus embraces the same principles it is illustrated as a modification of the main idea in my invention.

A is, as before, a generating source, represented as a Y-wound three-phase armature, the field-magnet (of any form or type) not being represented. Lines l l' l^2 lead therefrom and include in their respective circuits to a common point K the coils w w' w^2 w^3 of receivers R R'. In one of the circuits are placed transmitters T T', which may be of common form and are represented as working most conveniently by transformation. The coils w w', &c., are shunted by the condensers C C', &c., connected between the mains l l' l^2, they being of selected capacity, substantially "transparent" (employing a term commonly used) to speech-waves. The condenser C^2 is arranged in series with the coil w^3 upon the receiver, the same arrangement being shown in the receiver R', the condenser C^2 and the coil w^3 forming a shunt around the coil w^2. The resultant magnetizing effect of the three coils in the three-phase system being zero, no sound will be heard in the receiver with any periodicity of alternation, provided the currents be equal; but if one or two of the circuits be differently influenced then the receivers will be correspondingly affected. If the transmitters T T' be operated, the speech-waves will be conveyed to the receivers R R', when the current-undulations affect but one or two of the receiver-coils. The coils w^2 w^3 are therefore wound differentially, the circuit through w^3 being by way of the condenser C^2, of such capacity as will readily pass voice-current vibrations and yet suppress the main fundamental waves from the alternating-current source. The circuit for voice-currents is thus from T in parallel by way of w^2 and w^3 C^2, the latter two in series (the coil w^3 being given sufficiently-increased inductance to balance the capacity reactance of the condenser, the parallel circuits thus producing no effect in the receivers) through the condensers C C' to the receiver-coils w w'. By these latter coils the receiver is magnetized and responds to the speech-waves. As shown in dotted lines, one of the circuits might be an earth-circuit, but this is not preferred.

In the practical working of my present invention it is not necessary that polyphase currents be primarily generated at a central station and sent out over several conductors, but the out-of-phase currents may be produced locally at a subscriber's station by means of inductive coils, condensers, polarization-cells, or other apparatus possessing similar phase-modifying properties. Several arrangements embodying these principles will now be described.

In Fig. 8 I show a single line l conveying single-phase alternating current from a central station, the line connecting communicating subscribers. A transformer T has a winding P in the line and another secondary or winding of coarse wire, (for ordinary microphone working,) divided into two parts S S′. The circuit of the section S is completed through a resistance Q, a pair of microphone-contacts, and the middle conductor. That of the section S′ is completed through the inductive coil I, a pair of microphone-contacts, and the middle conductor, while in shunt to the inductance I is a condenser C of definite, limited, and selected capacity, such that it forms a shunt around I practically for voice-currents only. The line l is continued through the receiver R and the distant similar apparatus.

The method of operation of the apparatus shown in the figure is substantially as follows: Alternating currents of a period below audibility, or nearly inaudible, being passed over the line l, a secondary current is induced in the windings S S′. The current in S′, however, lags behind that in S, owing to the inductance I. There are thus fed through the independent circuits which include the transmitter-contacts two alternating currents, the phase difference of which will depend upon the value of the inductance. If sounds be produced at the transmitter, there will be superimposed upon the current flowing in S modifying variations corresponding to the voice-vibrations. Similar vibrations will also be imposed upon the out-of-phase current flowing in S′. The fundamental currents being out of phase have but negligible action upon the main line, but the voice-currents in S S′ are in phase, and, reinforcing each other, are inductively transferred to the primary P. It may be noted here that it is the condenser C which renders this working practicable, as the quick undulations corresponding to speech-waves can only pass with difficulty the inductance I, while the condenser is quite transparent to them. At the same time the condenser is of such limited capacity that no material part of the fundamental wave is affected. As the apparatus illustrated utilizes polyphase currents for the transmitting instruments, and there are therefore no times when one or the other of the microphone-contacts is without current, continuous speech is heard in the receivers R.

In Fig. 9 is illustrated a method employing analogous principles, but with some modification in the apparatus. Here the line l, the transformer, inductance, condenser, and multiple-contact transmitter are as before, but the circuits are different. The coil has one path through the resistance Q and a set of microphone-contacts and another circuit through the inductance I and another set of contacts. These are illustrated as of the granular carbon or "dust" type, which is well adapted to my invention, as in its exercise a sort of unison of action in the divided contacts of the transmitter is desirable. In the type described this is obtained by the average of a practically infinite number of minute contacts in each circuit. The resistance Q is made to about equal the ohmic resistance of the inductance I. Around the inductance is placed a condenser of definite and limited capacity. In this arrangement out-of-phase currents for the two transmitters circulate as before, but the main waves through the resistance and the inductance produce a compound wave in S. Speech uttered before the transmitter finds, as before, a current flowing through one or the other of the microphone's divided paths, and the voice-currents avoid the inductance I by passing through the condenser C.

It will be seen that in the arrangement in Figs. 8 and 9 the inductance-coils I act as local current-generators at those times when the current in the other branch is reversing, and that the quick undulations corresponding to speech do not need to traverse the inductance, but find a ready by-path by way of the condenser-shunt provided. The condenser has no material effect in cutting down the current given out by I on account of its limited capacity.

In Fig. 10 I show a further modification, in which the primary line is itself divided, one branch including a transmitter-coil T and the other branch a coil T′, the circuit to the latter including an inductance I, shunted by a condenser C. The coils S S′ deliver out-of-phase currents to independent microphone-contacts, as before, and the voice-currents from both sources add themselves upon the line l and in the receivers R, &c., the arrangement being practically a reversal of that shown in Fig. 8.

Fig. 11 shows another arrangement which may be employed when the fundamental wave is of audible frequency instead of inaudible or only slightly audible, as with the apparatus shown in Figs. 8, 9, and 10. In this instance the receiver is wound with additional coils whose function it is to wipe out or neutralize the main or fundamental wave. To obtain this result, the main line is divided, one branch going through an inductance I, adapted to cause the current in this branch to lag by one hundred and twenty degrees. Another branch passes by a condenser C of such capacity as to advance the phase of the current by one hundred and twenty degrees, while a third branch includes the primary coil of the transformer. Each of the circuits includes one of the coils w w' w^2 upon the receiver R, thus obtaining in the receiver a three-phase current with zero magnetizing effect, as in the case of Fig. 7. The branches, including the coils w P, being alone affected by the voice-currents, speech transmission is rendered possible, while no effect or only a negligible effect is produced by the fundamental waves of the system. A resistance Q is also included in the condenser branch of the circuit, sufficient in amount to adjust the resistance of the condenser branch to about equal that of the line branch passing through the transformer.

In Fig. 12 I show an arrangement somewhat similar to that of Fig. 5. In this case, however, the currents in the lines l l' are displaced by one hundred and twenty degrees. The receiver also has an additional reversely-wound coil w^2, receiving current from two coils S^2 S^3 in inductive relation to the coils P P', included, respectively, in the lines l l'. The result of this arrangement is to produce a compound wave in the circuit S^2 S^3 W^2, displaced by one hundred and twenty degrees from the currents in the other coils, and thus to obtain a three-phase effect in the receiver R, annulling the effect of the fundamental waves, which may be audible or inaudible in periodicity.

In any of the arrangements above described it is to be understood that the values given to the inductances, condensers, &c., are so selected or adjusted as to give the phase relations to the currents which may be desired. This can readily be done in many ways now well known and understood in the electric art and which are not specially described or claimed by me.

In addition to the broader aspects of this case set out in my statement of invention, I believe it to be new with me to employ a divided circuit-transmitter, or one having practically independent paths for current from the transformer-coils, and this I wish to broadly cover.

An advantage arises in the use of the methods herein pointed out, as I can materially reduce the size and cost of the instruments as compared with those employing low periodicity, and thereby also lessen inductive disturbances.

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

1. The improvement in the art of electrically transmitting sound-waves, which consists in generating alternating currents of relatively-displaced phase, superposing upon one or more of such currents electrical undulations or vibrations corresponding to the sound-vibrations to be transmitted, and by such superposed electrical undulations or variations actuating a suitable receiver.

2. The improvement in the art of electrically transmitting sound-waves, which consists in transmitting over suitable conductors alternating currents of relatively-displaced phase, superposing upon one or more of such currents electrical undulations or variations corresponding to the sound-waves to be transmitted and by such electrical undulations or variations actuating a suitable receiver, while preventing the operation of the receiver by the fundamental currents of displaced phase.

3. The improvement in the art of electrically transmitting sound-waves, which consists in transmitting over suitable conductors two currents of normally-displaced phase, superposing upon one of such currents electrical undulations corresponding to the sound-vibrations to be transmitted, by such undulations actuating a suitable receiver, and causing the two out-of-phase currents to neutralize each other so as to prevent the effective magnetization of the receiver by the fundamental currents.

4. In combination, means for generating a plurality of alternating currents of relatively-displaced phase, a transmitter for superposing upon one or more of such currents electrical undulations or variations corresponding in character to the sound impulses communicated to the transmitter, and a telephone-receiver included in circuit with the transmitter.

5. In combination, a source or sources of a plurality of alternating currents of relatively-displaced phase, conductors connected therewith, a transmitting device for imposing upon one or more of such alternating currents electrical undulations or variations corresponding to the sound impulses communicated to the transmitting device, a receiver in circuit with the transmitter, and means for preventing the effective magnetization of the receiver by the fundamental currents.

6. In combination, a generating source of two alternating currents of opposite phase, line conductors extending therefrom, a transmitter connected in one of the line conductors, a receiver in circuit with the transmitter, and means for causing the two alternating currents to neutralize one another and prevent the effective magnetization of the receiver by such fundamental currents.

7. In combination, a generating source of two alternating currents of displaced phase, lines extending therefrom, a transmitter inductively superposing upon one of such lines electrical vibrations corresponding to the sound impulses communicated to the transmitter, and a receiver in circuit with the transmitter comprising differentially-connected coils, one in each of the line-circuits.

8. In combination, a generator of alternating currents of relatively-displaced phase, lines extending therefrom, a transmitting device inductively superposing upon one of such lines electrical vibrations corresponding to the sound impulses produced in the transmitter, and a differentially-connected receiver included in the lines.

9. A source of alternating currents of relatively-displaced phase, lines extending therefrom, a transmitting device inductively superposing upon one of the lines carrying the alternating currents electrical variations or undulations corresponding to the sound impulses communicated to the transmitter, a differentially-wound receiver in the lines, an earth connection for the generator, and an earth connection for the lines.

10. A generator of alternating currents of relatively-displaced phase, lines extending therefrom, a transmitting device for inductively superposing upon the current in one of such lines electrical undulations corresponding to the sound impulses to be transmitted,

a differentially-wound receiver included in the lines, and a condenser shunting the generator.

11. A transmitting device for a telephone-receiver, comprising a transformer-coil furnishing energy to two substantially independent circuits closed by different microphone-contacts, one or both of such circuits including means for displacing the phase of the current in one circuit relatively to that in the other.

12. A transmitting device for a telephone-circuit, comprising a coil or coils upon the transforming part of the transmitter furnishing energy to two substantially independent circuits closed by different transmitter-contacts; the independent circuits carrying alternating currents of relatively-displaced phase and being substantially equally transparent to the variations of the fundamental alternating current produced by the transmitter-contacts.

13. A transmitter for a telephone-circuit, comprising transformer-coils having two independent circuits closed by granular carbon or dust microphone-contacts, and means included in one or both of such circuits for producing currents of relatively-displaced phase therein.

14. A receiving-telephone having a plurality of coils arranged to be connected in different circuits, the circuits carrying currents of relatively-displaced phase, one of such circuits including a transmitter.

15. A receiving-telephone having a plurality of differentially wound or actuated coils, the differentially-wound coils connected in different circuits carrying substantially equal alternating currents of relatively-displaced phase, and one of such circuits including a transmitter.

16. A receiving-telephone comprising a core, a plurality of coils on the core differentially wound and connected the different circuits carrying fundamental alternating currents of relatively-displaced phase, one of the circuits including a transmitter and a diaphragm responding to variations of magnetism produced in the core by the coils.

17. In a telephone transmitting apparatus, the combination of an iron core having magnetizing-coils therein, a microphone-transmitter having a plurality of sets of contacts, and separate circuits connecting the coils and the transmitter, one of said circuits containing a self-inductive device with a condenser in shunt thereto, and the other containing a compensating resistance.

18. In a telephone system, the combination of a microphone-transmitter having a plurality of sets of microphone-contacts, a source of alternating currents of relatively-displaced phase, separate circuits connecting the source of current and the transmitter-contacts, and a telephone-receiver.

In testimony whereof I have hereunto set my hand, in the presence of two witnesses, this 25th day of July, 1896.

JOHN W. GIBBONEY.

Witnesses:
WM. D. POOL,
HENRY M. HOBART.