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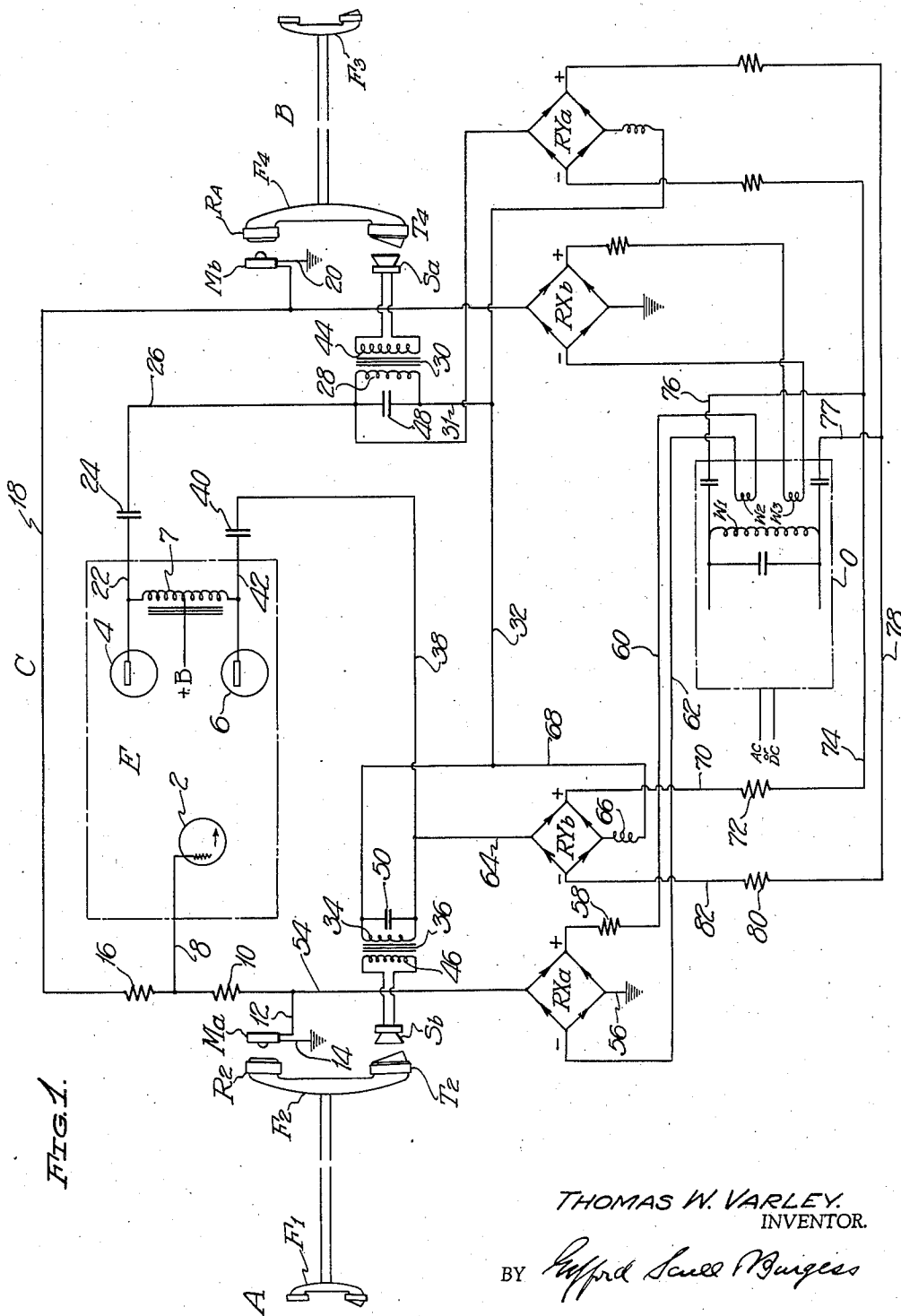
T. W. VARLEY

2,166,775

ELECTRONIC AMPLIFYING COUPLER AND SYSTEM THEREFOR

Filed July 1, 1937

3 Sheets-Sheet 1



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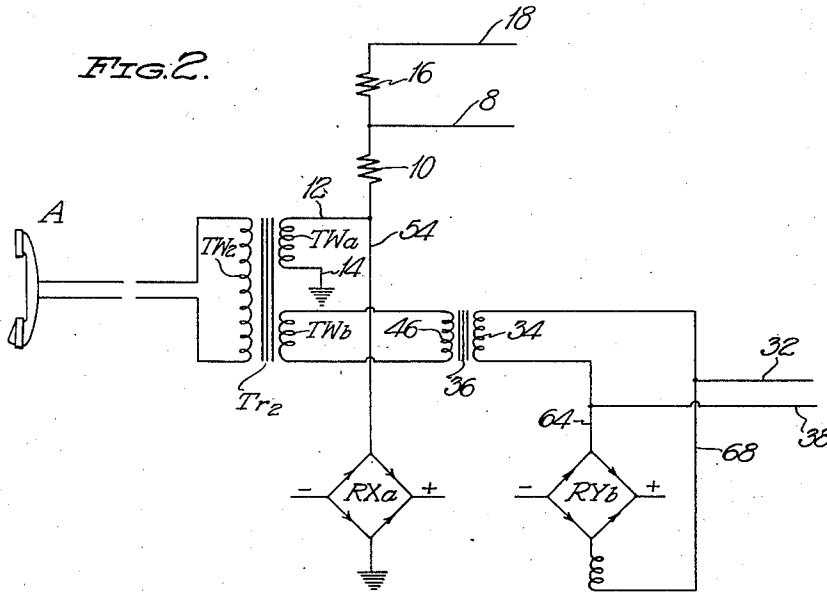
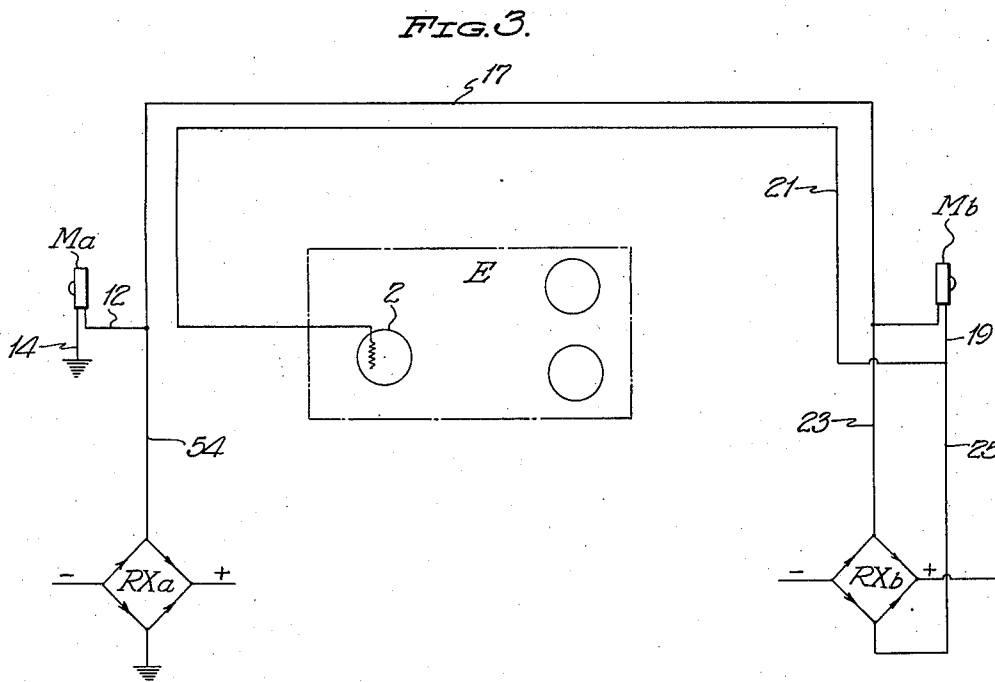
**T. W. VARLEY**

**2,166,775**

## ELECTRONIC AMPLIFYING COUPLER AND SYSTEM THEREFOR

Filed July 1, 1937

3 Sheets-Sheet 2



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**July 18, 1939.**

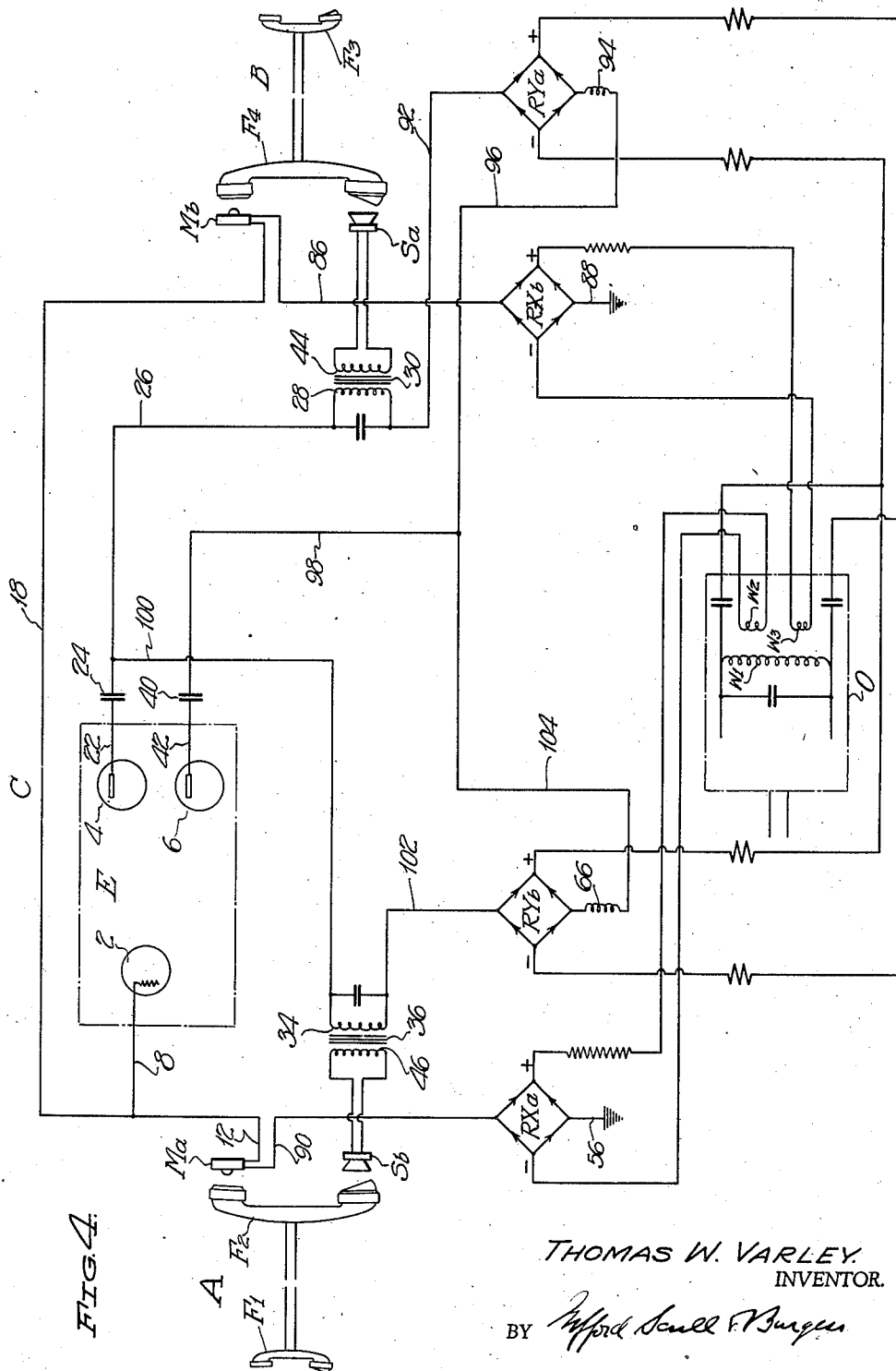
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**2,166,775**

ELECTRONIC AMPLIFYING COUPLER AND SYSTEM THEREFOR

Filed July 1, 1937

3 Sheets-Sheet 3



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## UNITED STATES PATENT OFFICE

2,166,775

ELECTRONIC AMPLIFYING COUPLER AND  
SYSTEM THEREFOR

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Stamford, Conn.

Application July 1, 1937, Serial No. 151,371

20 Claims. (Cl. 179—1)

This invention relates to improvements in electronic amplifying relays or couplers and systems therefor, and it has special reference to such devices as are employed in various systems of

two-way communication, such as signalling, telephone or other types of two-way communication, where it is desirable or necessary to compensate for energy losses by amplifying the electrical waves produced in response to signals or sounds.

The invention is applicable to many classes of service. One example is where it is desired to interconnect two separate and independent telephone or other systems of two-way communication, such as a public telephone system and a private interoffice telephone system of the same or of different types, so that any party on the interior telephone system may communicate with a party on the public telephone system. With my invention, such an interconnection can be established through the intermediary of my electronic amplifying coupler which is interposed between the two systems, either by means of acoustical couplings or by means of direct electrical connections.

It is also useful in business offices, where one or more persons, perhaps at a conference table, desire to discuss matters with another absent party over the telephone. Under such circumstances, the incoming messages are received over a speaker in the room, while a sensitive microphone enables any of the persons present to talk over the telephone with the absent party, without leaving his seat.

In telephone service, repeating relays of various types are frequently employed in long distance communication, and this field of service is another example of one to which my invention pertains.

My invention is applicable to other fields of use for handling two-way communications of various kinds, but the examples above referred to, together with others which will follow will indicate to some extent its broad range of usefulness.

It is one of the objects of my invention to provide a two-way communication system of the general character indicated in which the electronic amplifying coupler equipment employed is not only simple and inexpensive to construct and maintain, but which functions effectively to meet the service conditions, while at the same time preventing mutual interference and feed back disturbances and, furthermore, is so arranged that "breaking in" by either party to the conversation may take place at any time in the same manner as in ordinary telephone conversations.

Still another object of my invention is to provide a single electronic amplifying coupler in which the electrical waves of a two-way communication, are alternately interrupted at a high periodicity above audibility before being transmitted to the electronic amplifier, while the amplified and interrupted electrical waves emanating from the amplifier unit are passed on alternately at the same high periodicity above audibility to the respective outgoing circuits of the two-way system.

Another object of my invention is to provide such an electronic amplifying coupler in which suitable means, preferably but not necessarily employing oscillations of a high frequency above audibility from an extraneous source in connection with rectifying means, are utilized to intermittently interrupt the lower frequency electrical waves to be amplified before they reach the amplifying means, so that the amplification is effected upon a continuous series of unidirectional pulsations of a sufficiently high frequency that the intermittent or non-continuous character of the modulations of electrical waves being transmitted and amplified, is not detectable to the human ear when received as sound waves and therefore is heard or experienced as though it were actually unbroken and continuous.

Another object of my invention is to provide a unitary signal or telephone system, which either may include two separate and electrically independent signal or telephone systems, such as, for instance, an ordinary public telephone system and private interior or inter-office telephone system, or two successive sections or parts of a single telephone system such as is used for long distance communication, and in which the component independent systems or successive sections of a single system are interconnected by means of a single electronic amplifying coupler, operating in conjunction with a high frequency oscillator, in such manner that the single electronic amplifying device serves both circuits of the system in common but at alternate time periods, whereby controllable amplification of the electrical waves of a two-way communication is accomplished with complete absence of mutual interference or feed back disturbances.

Another object of my invention is to provide simple and effective means which is adapted to be readily interposed between two such two-way systems of communication or parts of a single two-way system and which embodies electronic amplifying coupling means of the above indicated type, which is arranged and adapted to sepa-

5 rately and alternately amplify or intensify the electrical waves being transmitted in both directions, while positively preventing any interference between the two-way communication and entirely eliminating the possibility of feed back disturbances.

10 A further object of my invention is to provide an electronic amplifying coupler adapted for signal, telephone or other service which embodies a single amplifier unit, which is permanently connected into the respective two-way operating circuits of the system or systems, but which is so constructed, arranged and controlled as to alternately transmit and amplify the electrical waves  
15 of a two-way communication, in such manner that a rapid succession of intermittent, alternate, unidirectional impulses are obtained, first from communication in one direction and then from the other, and at a sufficiently high frequency above audibility as to obviate any detectable audible effect to the listener upon the signals or sounds being received, while at the same time, by reason of the alternate 180° time phase displacement of the alternate unidirectional impulses through the amplifier unit, positively and  
20 definitely preventing any mutual interference or feed back disturbances.

Another object of my invention is to provide an acoustically coupled signal or telephone system in  
30 which two electrically independent and separate systems or two successive sections or portions of a single system, may be coupled together acoustically for two-way communication, by means of a single electronic amplifying coupler which serves both circuits of the two-way system in common but at rapidly alternating time periods, without interfering with the usual circuit connections or operation of the thus inter-connected systems or sections of a single system.

40 In accordance with one aspect of the invention, and quite apart from and independent of its application to any particular field of service, I contemplate the use of a single electronic amplifying coupler which is permanently connected with both circuits of a two-way communication  
45 system. The amplifying unit per se may be of any well-known type and embody one or more stages of amplification and, if desired, the usual push-pull power tubes. This single amplifying unit, however, which, of course, is uni-directional, functions for both circuits at all times, so far as can be detected by the human ear, so that either party to the conversation can "break-in" at any moment.

55 Thus, with but a single amplifying unit, apparent concurrent conversations between the parties can take place, and yet without mutual electrical interference or feed back.

This is accomplished by the manner and the means by which the amplifying unit is controlled and permitted to function. To effect the desired control, I preferably utilize a high frequency oscillator in conjunction with suitable rectifying devices so as to alternately interrupt the incoming electrical waves from each direction to the amplifier at a high rate or periodicity above audibility. By similar means I alternately interrupt the respective outgoing electrical waves from the amplifier in the same manner and, moreover, I  
70 do so in exact step with the interruptions of the incoming waves.

In other words, the incoming and outgoing waves passing through the system in one direction are simultaneously interrupted in precise step or time relation, whereas the incoming and

outgoing waves passing in the opposite direction are similarly simultaneously interrupted, although the interruptions of the waves travelling in opposite directions through the system occur at 180° time phase displacement, so that there is no possibility of mutual interference.

The auxiliary high frequency oscillator definitely insures the positive and alternate timing of the respective interruptions, when used in conjunction with suitable rectifying devices, preferably of the well-known "Rectox" type.

The result of this control feature, is that while the amplifying unit per se is operative at all times to pass uni-directional waves through it in a succession of rapid intermittent pulsations, still every alternate pulsation constitutes a part of the electrical waves passing through the system in one direction, while the intermediate alternate pulsations constitute parts of the electrical waves passing through the system in the opposite direction.

Yet, the frequency of the respective interruptions is so high with respect to the normal frequency of the electrical waves being transmitted and amplified, that the interruptions are not discernible when received as sound waves by the human ear, and the amplified signals or sounds heard by the listener appear as continuous and clear.

By reason of the character of control of the amplifying unit per se whereby it functions alternately on electrical waves passing in opposite directions through the system, it will be understood that it is active to waves passing through the system in one direction during every alternate pulsation, and at the same time dead to waves in the opposite direction. Similarly, the intermediate alternate pulsations are active to the waves passing through in the other direction and dead to those of the first direction. Therefore, there is no possibility of feed back disturbances or mutual interference, no matter how close together the receiver or speaker may be placed to the transmitter or microphone at either end of the system, and also entirely independent of the degree of amplification or intensity.

The oscillator may be of any well-known construction and in general is preferably designed to deliver oscillations at a frequency above audibility. Ordinary voice frequencies range generally from 100 to 1000 cycles per second, while music may range from perhaps 60 to 6000 cycles per second. In my invention, an oscillator having a frequency of 20,000 cycles per second will give excellent results, although in some instances, it may well range from about 5000 to 45,000 cycles or even higher. The particular frequency is not critical, so long as it is sufficiently higher than that of electrical waves being transmitted and amplified, as to obviate any objectionable interference.

The rectifying devices employed in connection with the oscillator are preferably of the dry copper oxide type, known in the art as "Rectox", such as that described in Patent #1,640,335 granted August 23, 1927, to Grondahl, although my invention is not limited to rectifiers of this specific class.

These and other objects of the invention and features by means of which they are accomplished will become more apparent from the following description of the invention in connection with the accompanying drawings in which

Fig. 1 is a diagrammatic view of the circuit

connections of a telephone system embodying my invention;

Fig. 2 is a diagrammatic view of a portion of the circuit connections of a modified form of telephone system embodying my invention;

Fig. 3 is a diagrammatic view of a portion of the circuit connections of a further modification, and

Fig. 4 is a diagrammatic view of a still further modification of my invention.

Referring now to the drawings, and particularly to Fig. 1 thereof, my invention is illustrated as interconnecting a plurality of electrically independent telephone systems A and B, which are connected together so as to function as a single system of two-way communication through the interposition of my amplifying coupler C.

The telephone system A may, for example, comprise an ordinary public telephone system having a plurality of subscribers' stations, only two of which are indicated in the drawings and are represented for illustrative purposes by the French telephone sets  $F_1$  and  $F_2$ , the latter of which comprises a receiver  $R_2$  and a transmitter  $T_2$ . The telephone system B, which is entirely independent of the telephone system A, typifies any ordinary private interoffice telephone system having a plurality of party stations, only two of which are indicated and are represented by the French telephone sets  $F_3$  and  $F_4$ , the latter of which is provided with a receiver  $R_4$  and a transmitter  $T_4$ . Both of these independent telephone systems, A and B, are adapted for two-way conversation and are connected and operated in any of the usual well-known manners.

For purposes of explanation it will be assumed that the French telephone set  $F_2$  of the public telephone system and the French telephone set  $F_4$  of the interoffice system are located on or near the desk or in the room of the telephone operator in a private business office or factory where the desired telephone connections for the public telephone system or for the interoffice system may be readily effected by the operator.

In order to make provisions for enabling two-way communication between any party to the interoffice telephone system and a party to the outside or public telephone system, the amplifying coupler C, constituting my invention, is located within convenient reach of the operator and is arranged so that it may be readily connected as an intermediary agency between the two systems.

The amplifying coupler C comprises an electronic amplifier unit E of any conventional type and may embody one or more stages of amplification, together with one or more power tubes, which, if desired, may be arranged in the well-known push-pull relation, as will be readily understood without further description. In the drawings, only the first amplifying tube 2 and the push-pull power tubes 4 and 6, are shown, together with the usual choke coil 7 connected between the power tubes and having a positive battery connection +B at its midpoint in accordance with customary practice.

The input side of the amplifier unit E has its first amplifying tube 2 connected to a microphone  $M_a$  through conductor 8, resistance 10 and conductor 12, the other terminal of the microphone being connected to ground by conductor 14. The amplifying tube 2 is also connected to microphone  $M_b$  through conductor 8, resistance 16 and conductor 18, the other terminal of the microphone being connected to ground through

conductor 20. The two microphones  $M_a$  and  $M_b$  are therefore connected in parallel relation.

The output side of the amplifier unit E has its power tube 4 connected through conductor 22, condenser 24 and conductor 26 to one terminal of a winding 28 of an auxiliary transformer 30, and thence from the other terminal of winding 28 by conductors 31 and 32 to one terminal of a winding 34 of an auxiliary transformer 36, and from the other terminal of winding 34 thence by conductor 38, condenser 40 and conductor 42, to the other power tube 6. The two windings 28 and 34 are thus connected in series relation across the power tubes 4 and 6.

The auxiliary transformer 30 is provided with a winding 44 having its terminals connected to a speaker  $S_a$ , while the auxiliary transformer 36 is provided with a winding 46, the terminals of which are connected to a speaker  $S_b$ . The windings 28 and 34 of the respective transformers have condensers 48 and 50, respectively, connected across or in parallel thereto.

In order to make use of the amplifying unit E, the operator establishes acoustical couplings between the unit and the respective telephone systems A and B, by placing the French telephone  $F_2$  with its receiver  $R_2$  and transmitter  $T_2$  in proximity to and in acoustical relation with the microphone  $M_a$  and speaker  $S_a$ , and also by placing the French telephone  $F_4$  with its receiver  $R_4$  and transmitter  $T_4$  in proximity to and in acoustical relation with the microphone  $M_b$  and speaker  $S_b$ , respectively. It will be understood that when associated in this manner, the sound waves are transmitted acoustically to and from the amplifying unit E without any electrical connection whatever with the telephone systems A and B being necessary.

So far as already described, it will be evident that since microphones  $M_a$  and  $M_b$  are both connected to the input side of the amplifying unit E, and the speakers  $S_a$  and  $S_b$  are connected to the output side thereof, the amplifying unit is arranged to amplify incoming electrical waves or messages emanating from either one or both of the telephone systems A and B. This, of course, would be entirely impractical by reason of inherent mutual interference and feed back disturbances.

For the purpose of avoiding such difficulties, I provide suitable control devices and connections to regulate and govern the operation of the electronic amplifier E in such manner as to effectively and completely separate the electrical waves produced in response to speech and traversing the interconnected systems in opposite directions, from one telephone system A to the other telephone system B, or vice versa. This is accomplished by controlling the operation of the electronic amplifier E so that, while functioning at all times, it alternately operates upon electrical waves passing in opposite directions. In other words, it is rendered active upon the electrical waves passing in one direction for a very brief increment of time during which it is inactive upon the electrical waves passing in the opposite direction, and then becomes active for a like time increment upon the waves passing in the latter direction while being inactive upon the waves passing in the first direction, and so on in timed alternation.

Similarly, the output side of the amplifying unit E is correspondingly controlled so that when the amplifier E is active upon electrical waves set up through microphone  $M_a$ , these amplified waves

are passed on through speaker  $S_a$ , while when the amplifier unit E operates upon electrical waves emanating from microphone  $M_b$ , these amplified waves are passed on through speaker  $S_b$ .

This time control of the operation of the electronic amplifier E may be accomplished in any suitable manner and by means of any suitable devices. I have illustrated, however, certain apparatus which I now consider preferable and by means of which I have secured excellent results. This apparatus includes an oscillator O, which in most instances should be of a relatively high frequency, as compared with that of the electrical waves produced by sounds or speech, being transmitted over the system, the general range of frequency having already been hereinbefore set forth. The oscillator O may be of any well-known type of construction and, therefore, it is not shown and will not be described in detail, except insofar as is necessary to a clear understanding of my invention. As shown, the oscillator includes a plurality of windings  $W_1$ ,  $W_2$  and  $W_3$ , although a single winding may well take the place of windings  $W_2$  and  $W_3$  or, if desired, only a single winding may be used, provided proper taps therefor are employed.

Operating in conjunction with and connected to the oscillator in the manner hereinafter described, I employ a plurality of rectifying devices, of which I have found those of the dry copper oxide type, known in the art as Rectox, is particularly suitable. These rectifying devices are indicated diagrammatically in the drawings and identified by reference characters  $RX_a$ ,  $RX_b$ ,  $RY_a$  and  $RY_b$ . These several Rectox rectifiers are also marked in the drawings with arrows in their several legs, as is conventional in the art to indicate the direction of flow of current permissible therethrough, while the positive and negative terminals thereof are indicated in the conventional manner by plus and minus signs.

The rectifying device  $RX_a$  is connected in shunt to the microphone  $M_a$  by means of a conductor 54 which is connected to its upper terminal and a conductor 55 which connects its lower terminal with ground. The positive terminal of the device is connected through resistance 58 and conductor 60 to one terminal of winding  $W_2$  of the oscillator O, while the other terminal of said winding is connected by conductor 62 to the negative terminal of the rectifying device. In a similar manner the rectifying device  $RX_b$  is connected in shunt to the microphone  $M_b$ .

The rectifying device  $RY_b$  is connected in shunt to the winding 34 of auxiliary transformer 36, which is associated with the speaker  $S_b$ , through a conductor 64 which connects to the upper terminal of the rectifying device, while its lower terminal is connected through a reactance 66 and conductor 68 to the other terminal of the transformer winding 34. The positive terminal of the rectifying device is connected by conductor 70 through resistance 72, conductor 74 and conductor 76 to one terminal of the oscillator winding  $W_1$ , while the other terminal of said winding is connected by conductor 77, conductor 78, resistance 80 and conductor 82 to the negative terminal of the rectifying device. In a similar manner, the rectifying device  $RY_a$  is connected in shunt to the transformer coil 28 of auxiliary transformer 30 which is associated with the speaker  $S_a$ , while the positive and negative terminals of the rectifying device  $RY_a$  are connected across the oscillator winding  $W_1$ , as will be readily understood.

Since the various rectifying devices above referred to are similar in construction and operation, except that devices  $RY_a$  and  $RY_b$  are of greater capacity in view of the fact that they are required to handle amplified electrical waves, it is deemed sufficient to briefly outline the operation of a single one of these devices, for instance rectifying device  $RX_a$ , which is connected in shunt to the microphone  $M_a$ .

For purposes of illustration, let it be assumed that sound waves are transmitted acoustically from receiver  $R_2$  of the French telephone set  $F_2$  to microphone  $M_a$ , which is connected, as already described, to the input side of the electronic amplifier E, with the rectifying device  $RX_a$  connected in shunt to microphone  $M_a$ . Obviously, the electrical waves set up in the microphone  $M_a$  will tend to divide between that branch of the circuit which is connected to the amplifier tube 2, and that branch which is connected in shunt to the microphone  $M_a$  through the rectifying device  $RX_a$ , the microphone  $M_b$  being rendered ineffective by reason of the high resistance 16 in the conductor 18 which is connected thereto. The degree or amount of energy of the electrical waves passing to the amplifier tube 2 will depend upon the degree and the amount of energy of these waves which are permitted to pass to ground through the rectifying device  $RX_a$  in shunt to the microphone  $M_a$ , and this in turn will depend upon the polarity and amount of voltage generated by the alternating current oscillator at any particular instant. If the voltage developed in the oscillator winding  $W_2$  at any particular instant is positive and also equal to or greater than the voltage of that portion of the electrical waves passing through the rectifying device at that instant, no current will be allowed to flow from the positive terminal of the rectifying device through the winding  $W_2$  and thence to the negative terminal of the rectifying device. Under such circumstances, no effective shunt circuit from the microphone  $M_a$  to ground is established and the entire energy of the electrical waves being transmitted from the microphone  $M_a$  will pass to the first amplifying tube 2 of the amplifier unit E.

This condition prevails throughout that portion of the high frequency positive oscillation during which the generated voltage is equal to or greater than the voltage of the electrical waves, and throughout this interval the amplifier E is operative or active to transmit and amplify the electrical waves passing from the telephone system A to the telephone system B. During this particular time interval, however, the rectifying device  $RX_b$ , which is connected in shunt to the microphone  $M_b$ , is rendered active to pass current to ground by reason of the fact that the voltage of positive polarity generated by winding  $W_3$  is added to that of the electrical waves emanating from the microphone  $M_b$ . Thus, the microphone  $M_b$  is rendered inoperative by reason of the shunt circuit established through the rectifying device  $RX_b$ . Hence, during the time interval in question, the amplifying unit E is active as to electrical waves passing from telephone system A to telephone system B, but is inactive to electrical waves in the opposite direction.

On the succeeding negative oscillation of the oscillator O, reverse polarities will obtain, and consequently the rectifying device  $RX_b$  will not pass current in shunt to microphone  $M_b$ , while rectifying device  $RX_a$  will pass current in shunt to microphone  $M_a$ . Under these conditions the

electronic amplifier unit E will be operative and active upon electrical waves passing from telephone system B to telephone system A, while it will be inactive to electrical waves passing in the opposite direction.

For proper operation, it is not only necessary to properly control the amplifying action of the amplifier unit E, but to definitely control the output circuits of the amplifier in order that the amplified waves shall be transmitted on in the right direction to the proper telephone systems A and B. For this purpose the oscillator winding  $W_1$  and the rectifying devices  $R_{Y_a}$  and  $R_{Y_b}$  are employed, and operate in a generally similar manner to that already described to control shunt circuits across the windings 28 and 34 of the auxiliary transformers 30 and 36, respectively, which are associated respectively with the speakers  $S_a$  and  $S_b$ .

For instance, at the same instant and throughout the duration of the increment of time that the oscillator winding  $W_2$  opposes the voltage of the rectifying device  $R_{X_a}$ , the oscillator winding  $W_1$  generates a voltage of positive polarity which is added to that of the rectifying device  $R_{Y_b}$ . Therefore, current or energy passes from the positive terminal of the device  $R_{Y_b}$  through the winding  $W_1$ , to the negative terminal of the device  $R_{Y_b}$  and thence to ground. Thus, a shunt circuit is established across the winding 34 of the transformer 36, which transformer and its associated speaker  $S_b$ , become inoperative. The opposite is true with respect to the transformer winding 28 of transformer 30, and its associated speaker  $S_a$ —that is, no shunt circuit is established across the transformer winding 28, which therefore operates to pass on the amplified electrical waves through the transformer 30 to the speaker  $S_a$ . Accordingly, during the same interval of time when the electronic amplifier E is active upon electrical waves passing from telephone system A, and inactive on waves in the opposite direction, the speaker  $S_a$  is active to pass on the amplified waves to the telephone system B, while the speaker  $S_b$  is inactive and thus prevents the electrical waves from being passed on back to telephone system A.

From the foregoing description it will be manifest that the amplifier unit E operates alternately on the electrical waves passing through the interconnected system in opposite directions, while the speakers  $S_a$  and  $S_b$  are alternately rendered effective to pass the amplified electrical waves on in the proper direction and to the proper telephone system A or B, as the case may be.

The electrical waves being amplified and passing through the interconnected systems in opposite directions are thus alternately interrupted and amplified at a frequency depending upon the frequency of oscillator O, which may be sufficiently high, if desired, with respect to the frequency of the electrical waves passing through the system that the successive interruptions are above audibility and therefore have no discernible effect upon the ear of the listener who hears the sound waves emanating from his receiver, exactly as though they were uninterrupted or continuous.

By this method of control of the operation of the amplifier unit E, whereby the microphone  $M_a$  and the speaker  $S_a$  are simultaneously operative, and the microphone  $M_b$  and the speaker  $S_b$  are inoperative, and vice versa, in alternation, it is a physical impossibility for mutual interference and feed back disturbances to result from a two-way conversation, each part of which is definitely and

positively separated from the other by the 180° time phase displacement utilized in the control of the amplifier operation by reason of the high frequency oscillator O, and irrespective of the volume or intensity of the sound emanating from the receiver or speaker at the receiving end of the system, or its degree of proximity to the transmitter or microphone at that end of the system.

While my invention has been described in connection with Fig. 1 as an amplifying coupler for two separate and independent telephone systems, such as a public telephone system and an inter-office telephone system, it is also applicable in a similar manner to interconnect two sections of a single telephone system, as is done in long distance telephone transmission. Moreover, the interconnection of sections of a single system may be effected acoustically as shown and described in connection with Fig. 1 or the interconnecting amplifying coupler may be electrically directly connected between the sections of the system, as will be later set forth.

Another field of service for which my invention is adapted is in connection with business conferences, where it is desired that any one or all of a group of men present at the conference may take part in a two-way communication over the telephone with an absent member at a distant station.

For a better understanding of such an application of my invention, it may be assumed that in Fig. 1 of the drawings the French telephone set  $F_2$  is the regular subscribers' set of the usual public telephone system which is located in the conference room. The rest of the system shown, (except that the French telephones  $F_1$  and  $F_3$  previously indicated as representing an independent telephone system, are omitted), including the microphone  $M_b$  and the speaker  $S_a$  of the amplifying coupler, constitute the instrumentalities by means of which any of the parties to the conference may communicate with the absent party. The microphone  $M_b$  is of a sufficient sensitivity to receive messages from any part of the room, while the speaker  $S_a$  delivers incoming messages at sufficient volume for all present to hear with ease.

Obviously, in an installation, such as just referred to, it is not necessary that the coupling between the public telephone system and my amplifying coupler be of the acoustical type, but the amplifying coupler may be electrically connected directly to the public telephone system, if desired, as will now be set forth with reference to Fig. 2 of the drawings.

In this figure, instead of employing an acoustical coupling, as is shown in Fig. 1 between French telephone set  $F_2$  and the microphone  $M_a$  and speaker  $S_b$ , the telephone set  $F_2$  is replaced in Fig. 2 with a transformer winding  $TW_2$  of an auxiliary transformer  $Tr_2$ , while the microphone  $M_a$  is replaced by a transformer winding  $TW_a$  and the speaker  $S_b$  replaced with a transformer winding  $TW_b$ . The rest of the circuit connections are the same as in Fig. 1, some of which are shown and identified by reference numerals. The rectifying device  $R_{X_a}$  in Fig. 2 is connected in shunt to the transformer winding  $TW_a$ , and the rectifying device  $R_{Y_b}$  is connected in shunt to the transformer winding 34 of the auxiliary transformer 36.

The operation of the system, partially shown in Fig. 2 and including direct electrical connections between the amplifying coupler and the telephone system A, will be generally the same as that already described, and no further description thereof is deemed necessary.

Of course, when telephone systems A and B are interconnected, the amplifying coupler C may also be operatively associated with the two telephone systems by means of direct electrical connections to both the input side and output side of the amplifying unit, in lieu of employing acoustical couplings, as illustrated in Fig. 1. In this case, the electrical connections from telephone system A to the amplifier unit E will be as shown in Fig. 2, while the electrical connections to telephone system B will also be similar to those of Fig. 2, as will be understood.

In the foregoing description, microphones  $M_a$  and  $M_b$  have been set forth as connected in parallel relation, while the windings 28 and 34 of the auxiliary transformers 30 and 36, associated with the respective speakers  $S_a$  and  $S_b$ , have been set forth as connected in series relation. However, the microphones  $M_a$  and  $M_b$  are not necessarily connected in parallel relation, but may be arranged in series relation. For a better understanding of these connections, I have shown this series relation of the microphones  $M_a$  and  $M_b$  in Fig. 3, to which reference is now made.

In this figure, the microphone  $M_a$ , having one terminal connected by conductor 14 to ground, has its other terminal connected by conductors 12 and 17 to one terminal of microphone  $M_b$ , while the other terminal thereof is connected by conductors 19 and 21 to the first amplifying tube 2 of the amplifying unit E. Microphone  $M_a$  is provided with a shunt circuit through the rectifying device  $RX_a$  by means of conductor 54, while a shunt circuit is provided around microphone  $M_b$  by means of conductor 23 which is connected to the upper terminal of the rectifying device  $RX_b$ , while its lower terminal is connected by conductors 25 and 19 to the other terminal of the microphone  $M_b$ .

The general operation of the system with this series connection of microphones is so similar to that already described, that no further description is deemed necessary.

Of course, if it is desired to connect the amplifying coupler by electrical connections to the respective telephone systems A and B, as in Fig. 2, the respective transformer windings  $TW_a$  and its corresponding winding  $TW_b$ , (not shown but assumed to be that of the transformer associated with the telephone system B), may be connected in series relation, as will be understood from the foregoing description in connection with Figs. 2 and 3, without further description.

While I now prefer to secure the desired control of the amplifier unit in the general manner hereinbefore indicated by means of rectifying devices operated in conjunction with an oscillator, with the rectifying device connected in shunt circuit to the respective microphones  $M_a$  and  $M_b$  and the transformer windings of the speakers  $S_a$  and  $S_b$ , in some instances it may be found desirable and expedient to utilize the rectifying devices in series circuit with the foregoing instrumentalities in such manner as to secure the same general operation of the amplifier unit.

In Fig. 4 I have illustrated a system similar to that set forth in Fig. 1, with the exception that the microphones  $M_a$  and  $M_b$  are connected in parallel relation, with the rectifying devices  $RX_a$  and  $RX_b$  respectively connected in series therewith to ground, and the transformer windings 28 and 34 of the auxiliary transformers 30 and 36 are similarly connected in parallel but with the rectifying devices respectively connected in series therewith, instead of in shunt thereto.

More specifically, the first amplifying tube 2

of the electronic amplifying unit E is connected by conductors 8 and 18 to one terminal of the microphone  $M_b$ , while its other terminal is connected by conductor 86 to the upper terminal of the rectifying device  $RX_b$  having its lower terminal connected through conductor 88 to ground. In parallel circuit therewith is the microphone  $M_a$  which is connected from the first amplifying tube 2 through conductors 8 and 12 to one terminal thereof, while the other terminal is connected by conductor 90 to the upper terminal of the rectifying device  $RX_a$ , having its lower terminal connected by conductor 56 to ground.

On the output side of the amplifier unit E, power tube 4 is connected through conductor 22, condenser 24, conductor 26 to one terminal of transformer winding 28, while the other terminal is connected by conductor 92 to the upper terminal of the rectifying device  $RY_a$ , having its lower terminal connected through reactance 94, conductors 96 and 98, condenser 40 and conductor 42 to the power tube 6.

In parallel relation therewith is the transformer winding 34 of the auxiliary transformer 36. The circuit for this transformer winding is from power tube 4 through conductor 22, condenser 24, conductor 100 and thence through transformer winding 34, conductor 102 to the upper terminal of rectifying device  $RY_b$  and from its lower terminal through reactance 66 and conductors 104 and 98, condenser 40 and conductor 42 to the power tube 6.

The rest of the circuit connections are like those already shown and described with respect to Fig. 1 and further description thereof will therefore be omitted, although the general operation of the system, insofar as it is affected by the series connections of the several rectifying devices, will be outlined briefly.

Whenever rectifying device  $RX_a$  in series circuit with the microphone  $M_a$  is, by reason of the operation of the oscillator O, rendered active to pass current to ground, the microphone  $M_a$  is operative and the amplifier unit E functions upon the electrical waves passing from telephone system A to telephone system B. At this same time, by reason of its reverse connection to the oscillator O, the rectifying device  $RX_b$  is inactive to pass current therethrough to ground, and hence microphone  $M_b$  is inoperative and the amplifying unit E is also inoperative upon the electrical waves passing from telephone system B to telephone system A.

During the same time interval rectifying device  $RY_b$  is inactive to pass current therethrough and hence the transformer 36 and its associated speaker  $S_b$  are inoperative. Similarly, during the same time interval the rectifying device  $RY_a$  becomes active to pass current and therefore auxiliary transformer 30, together with its associated speaker  $S_a$ , is rendered operative, as will be understood.

In this way by a somewhat different method of control, the amplifying unit E is arranged to operate alternately on the electrical waves passing through the interconnected system in opposite directions in the same general manner as previously described.

Of course, this series arrangement of the rectifying devices, which has been set forth in connection with Fig. 4, is equally applicable to systems in which the amplifying unit is directly connected electrically to the respective telephone systems A and B, or sections of a single telephone system, and also when my electronic coupler is

employed as an agency for permitting a two-way conversation between a conference room and a party to the public telephone system, as set forth in connection with the foregoing description of Fig. 1.

While I have shown my invention as embodying more or less specific details of construction, arrangement, circuit connections and mode of operation, it will be understood that many modifications may be made therein without departing from the spirit of my invention, and only such limitations should be imposed as are indicated in the appended claims.

I claim as my invention:

1. An amplifying coupler for interconnecting two component sections of an electrical system adapted for two-way communication, comprising in combination, an electronic amplifier interconnecting both circuits of the respective sections, and means for causing the amplifier to operate alternately at a frequency above audibility upon the electrical waves passing through the system in opposite directions.

2. An amplifying coupler for interconnecting two component sections of an electrical system adapted for two-way communication, comprising in combination, an electronic amplifier interconnecting both circuits of the respective sections, and means for alternately interrupting the electrical waves traversing the system in opposite directions at a high frequency above audibility, and causing the interrupted waves in opposite directions to pass through the amplifier alternately in a succession of intermittent pulsations of such rapid frequency that the interruptions are inaudible to the listeners.

3. An amplifying coupler for interconnecting two component sections of an electrical system adapted for two-way communication, comprising in combination, an electronic amplifier interconnecting both circuits of the respective sections, and electrical means comprising a high frequency oscillator and rectifying devices for interrupting the electrical waves passing through the system in opposite directions in alternation and at a frequency above audibility to cause the amplifier to operate alternately first on the waves passing through the system in one direction and then on the waves passing through the system in the opposite direction.

4. An amplifying coupler for interconnecting two component sections of an electrical system adapted for two-way communication, comprising in combination, an electronic amplifier interconnecting both circuits of the respective sections, means including a high frequency oscillator and rectifying devices in conjunction therewith and associated with both the incoming and outgoing circuits of each of said sections for simultaneously interrupting the electrical waves passing in one direction through the system at points both ahead of and beyond the electronic amplifier and for simultaneously interrupting the electrical waves passing through the system in the opposite direction at points both ahead of and beyond the electronic amplifier, the respective simultaneous interruptions occurring alternately and at 180° time phase displacement the one with the other and at a high frequency above audibility.

5. An amplifying coupler adapted to interconnect two component sections of an electrical system adapted for two-way communication, comprising in combination, a single electronic amplifying unit adapted to transmit and amplify

electrical waves of a two-way conversation and permanently connected in both circuits of both sections, a pair of rectifying devices of the Rectox type respectively connected in shunt to the two incoming circuits, a pair of similar rectifying devices respectively connected in shunt to the two outgoing circuits, and a high frequency oscillator connected to the several rectifying devices to simultaneously cause the rectifying device associated with one of said incoming circuits to become active to pass current while the rectifying device associated with the other incoming circuit is rendered inactive to pass current, and in 180° time phase displacement therewith, to simultaneously cause the rectifying device associated with the outgoing circuit corresponding to the first named incoming circuit to become active to pass current while the rectifying device associated with the outgoing circuit corresponding to the second named incoming circuit is rendered inactive to pass current, whereby the electronic amplifier is operative at all times, but operates alternately upon the electrical waves passing in opposite directions through the system.

6. An amplifying coupler for interconnecting two component sections of an electrical system adapted for two-way communication, comprising in combination, a single electronic amplifying unit having operative connections to both circuits of the respective sections, and electrical means operatively independent of the direction of flow of the electrical waves for definitely controlling the operation of said amplifying unit to cause it to alternately operate upon the electrical waves passing through the interconnected sections in opposite directions.

7. An amplifying coupler for interconnecting two component sections of an electrical system adapted for two-way communication, comprising in combination, a single electronic amplifying unit having operative connections to both circuits of the respective sections, and means including an extraneous source of alternating current and rectifying means associated therewith for controlling the operation of the amplifying unit to render it operative alternately upon the electrical waves passing through the interconnected sections in one direction and then upon the waves traversing the interconnected sections in the opposite direction.

8. An amplifying coupler for interconnecting two component sections of an electrical system adapted for two-way communication, comprising in combination, a single electronic amplifying unit having operative connections to both circuits of the respective sections, the connections to the two incoming circuits to the amplifying unit being arranged in parallel and the connections to the two outgoing circuits of the amplifying unit being arranged in series, rectifying devices severally arranged in shunt to each of the four connections, and electrical means associated with each of said rectifying devices and operating upon a definite time cycle to cause the rectifying devices associated with the connections of the corresponding ingoing and outgoing circuits of the amplifying unit in one direction, and the rectifying devices associated with the corresponding incoming and outgoing circuits of the amplifying unit in the opposite direction to be alternately active and inactive whereby the electronic amplifier unit operates alternately on the waves traversing the interconnected sections in opposite directions.

9. An amplifying coupler for interconnecting two separate and independent telephone systems both of which are adapted for two-way communication, comprising in combination, a single electronic amplifying unit, means including acoustical couplings for connecting the receiving circuits of both telephone systems to the input side of said amplifying unit and the transmitting circuits of both telephone systems to the output side of said amplifying unit, and control means operatively independent of the direction of flow of the electrical waves and operating in a definite 180° time phase relation for simultaneously rendering inoperative the amplifier input connection of one telephone system and the amplifier output connection of the other system and then simultaneously rendering inoperative the amplifier input connection of the second system and the amplifier output connection of the first system, whereby the amplifying unit operates alternately on the waves passing through the interconnected systems in opposite directions.

10. A system of two-way telephone communication, comprising in combination, two electrically independent telephone systems, such as a public telephone system and a private inter-office telephone system, each system being adapted for two-way communication, an electronic amplifying coupler separate and electrically independent of both telephone systems and adapted to interconnect the said systems and including acoustical couplings between each telephone system and both the input and output sides of the amplifying coupler, whereby the connections and operation of the separate systems remain intact.

11. A system of two-way telephone communication, comprising in combination, two electrically independent telephone systems, such as a public telephone system and a private inter-office telephone system, each system being adapted for two-way communication and each being provided with the usual telephone set comprising a receiver and a transmitter, an electronic amplifying coupler adapted to interconnect the respective telephone systems for two-way through communication, means for acoustically coupling the receiver and transmitter of each telephone system to said amplifying coupler, the receivers being connected to the input side of the amplifying coupler and the transmitters to the output side thereof, and control means associated with said coupler for causing the alternate amplification of portions of the electrical waves passing through the interconnected telephone systems in opposite directions.

12. An amplifying coupler for interconnecting two component sections of an electrical system adapted for two-way communication, comprising in combination, a single electronic amplifying unit having operative connections to both circuits of the respective sections, the connections to the two incoming and the two outgoing circuits to the amplifying unit being arranged in series relation, rectifying devices severally arranged in shunt to each of the four connections, and a high frequency oscillator associated with each of the rectifying devices to cause the rectifying devices connected in shunt to one of the incoming and one of the outgoing circuits to the amplifying unit to become active simultaneously to pass current, and then to cause the rectifying devices connected in shunt to the other incoming and the other outgoing circuit connections to the amplifying unit to become active

simultaneously to pass current, whereby the amplifying unit operates alternately upon the waves traversing the interconnected system in opposite directions.

13. A system of two-way telephone communication, comprising in combination, a public telephone system adapted for two-way communication, a microphone, a speaker, an electronic amplifying unit interposed between and interconnecting the telephone system with said microphone and speaker, and electrical means operatively independent of the direction of flow of the electrical waves for controlling the operation of said amplifying unit to cause it to alternately operate upon electrical waves from the telephone system to said speaker and from said microphone to said telephone system in opposite directions.

14. An amplifying coupler adapted to interconnect two component sections of an electrical system adapted for two-way communication, comprising in combination, a single electronic amplifying unit adapted to transmit and amplify electrical waves of a two-way conversation and permanently connected in both circuits of both sections, the two input circuits to the amplifying unit being connected in parallel and the two output circuits from the amplifying unit being connected in parallel, a pair of rectifying devices of the Rectox type respectively connected in series to the two input circuits, a pair of similar rectifying devices respectively connected in series to the two output circuits, and a high frequency oscillator connected to the several rectifying devices to simultaneously cause the rectifying device associated with one of said input circuits to become active to pass current while the rectifying device associated with the other input circuit is rendered inactive to pass current, and in 180° time phase displacement therewith, to simultaneously cause the rectifying device associated with the output circuit corresponding to the first-named input circuit to become active to pass current while the rectifying device associated with the output circuit corresponding to the second-named input circuit is rendered inactive to pass current, whereby the electronic amplifier is operative at all times, but operates alternately upon the electrical waves passing in opposite directions through the system.

15. A method of operating an electronic amplifying coupler interconnecting two component sections of a telephone system adapted for two-way conversation which comprises modifying the operation of the amplifying coupler at a high frequency above audibility to cause it to alternately function on electrical waves passing through the system in opposite directions.

16. A method of operating an electronic amplifying coupler interconnecting two component sections of a telephone system adapted for two-way conversation, which comprises passing electrical waves in a series of interrupted pulsations at a high frequency through the amplifying coupler and causing it to function alternately upon electrical waves passing from one section to the other and then from the second-named section to the first-named section.

17. A method of repeating and amplifying a two-way telephone conversation over two component sections of a telephone system, which are interconnected by a single electronic amplifying unit, which comprises modifying the input and output connections of the amplifying unit at a high frequency above audibility to cause the amplifying unit to first repeat and amplify mes-

sages passing from one section through the amplifying unit to the other section, while concurrently preventing its operation upon messages passing in the opposite direction, and then repeating and amplifying the messages passing from the second section through the amplifying unit to the first section while preventing its operation upon messages passing in the first-named direction.

10 18. A system of two-way telephone communication comprising in combination two electrically independent telephone systems such as a public telephone system and a private inter-office telephone system, both of which are normally adapted for independent and conventional two-way communication, and means electrically independent of both telephone systems and including a single electronic amplifying coupler and acoustical means for interconnecting said independent telephone systems to cause them to function together as a single system for two-way telephone communication while maintaining the electrical independence of said telephone systems.

20 19. A system of two-way telephone communication comprising in combination two electrically independent telephone systems such as a public

telephone system and a private inter-office telephone system, both of which are normally adapted for independent and conventional two-way communication, and means electrically independent of both of said systems for operatively coupling said systems together to cause them to function at amplified intensity as a single system for two-way communication.

20. An amplifying coupler for interconnecting two electrically independent component sections of an electrical system of two-way communication, each of said component sections being adapted for conventional two-way communication and comprising a single electronic amplifying unit electrically separate and independent of both of said component sections, means for establishing an operative acoustical connection between each of said component sections and said amplifying unit, whereby said amplifying unit is operatively interposed between said component sections, and means for controlling the operation of said amplifying unit to cause it to alternately function on electrical waves passing through the interconnected system in opposite directions.

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