



Fig. 6

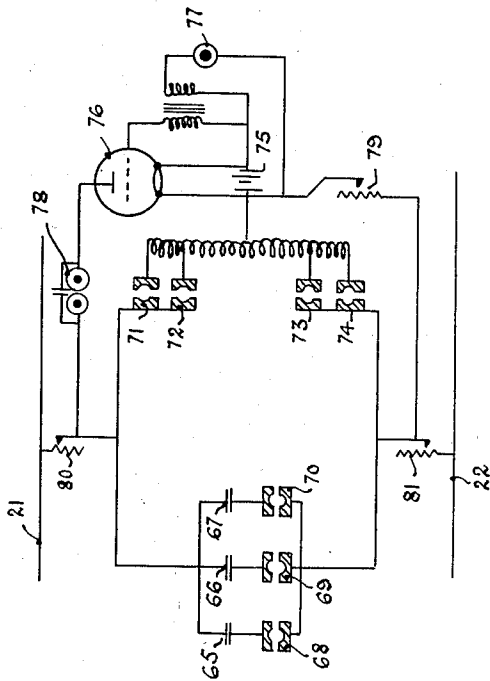
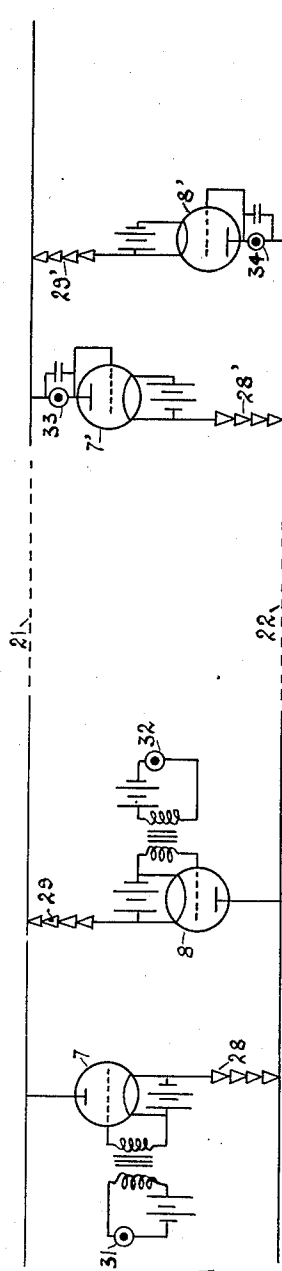


Fig. 2



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COMMUTATING BALANCED MULTIFLEX TELEPHONY

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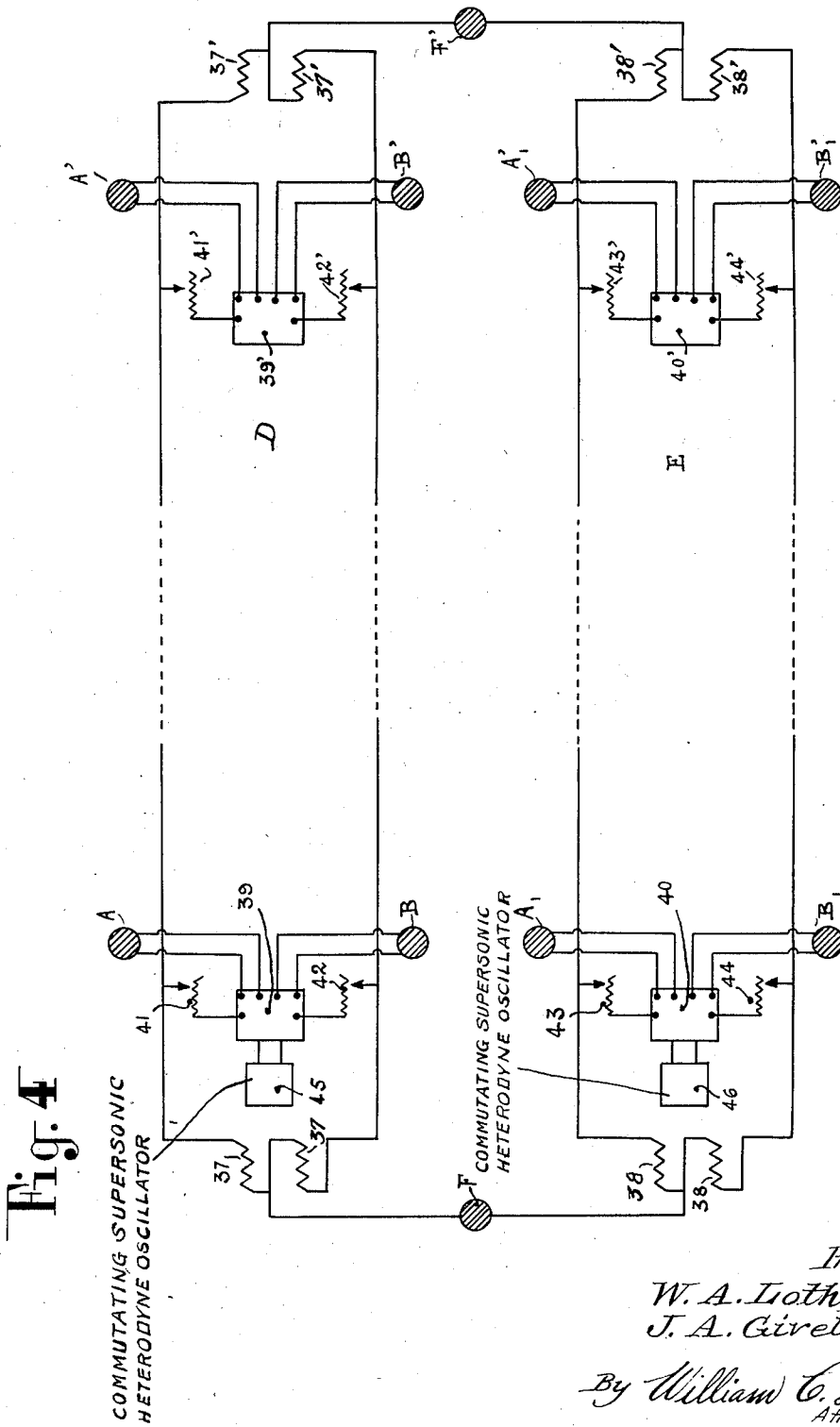


Fig. 4

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# UNITED STATES PATENT OFFICE

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## COMMUTATING BALANCED MULTIPLEX TELEPHONY

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9 Claims. (Cl. 179—15)

As is known, it is now possible to transmit two or more conversations simultaneously by interrupting or commutating at an ultra-audible frequency in combination with triodes of which the anodes are connected with the line wires in such a manner as to function only during the positive halves of the cycle. At each station, the circuit arrangement is symmetrical, a neutral point serving as potential zero being taken at the mid-point of a high resistance which connects the two line wires, and the cathodes of the three-electrode valves being connected to this mid-point. The conversations are heard by the listener by reason of the persistence of the acoustical impressions notwithstanding the cyclic interruptions.

The present invention concerns improvements in and relating to this system so as to permit on the one hand its practical application and on the other to render telephony (or telegraphy) secret.

In order to have an easy connection with the subscriber's stations, the external windings of the plate and grid transformers are connected in series with the line leading from the subscriber. In addition, the separation of the conversations is improved by placing complementary rectifiers, preferably of the copper oxide type, at suitable points in the circuits, and the high resistance connected to the neutral point is replaced by rectifiers or valves which have a definite finite resistance in one direction and an infinite resistance in the other direction. For currents in the latter direction, the conversation which is not to be heard is completely suppressed.

A simplification consists in using a single transformer for each subscriber's line, the said transformer having three windings, one for the subscriber, one for the plate and one for the grid. An electrostatic screen is provided between the winding of the subscriber and the other windings to prevent the high frequency from passing to the subscriber and to thus eliminate all interference from that source.

These systems can be applied to all circuit arrangements of tubes in push-pull and notably to superposed or combined circuits, as will be explained later.

If it is desired to obtain a secret transmission, the dead intervals of interruption or commutation are filled with a low audio frequency designed to produce garbling, the receiving apparatus being arranged to allow only the conversations to pass and to block the interfering garbling frequency. The interfering frequency or garbling

should be preferably different from that of the voice. It should be sufficiently low so as not to interfere with the normal operation of the system and if it produces a background noise by spreading over into the conversation intervals, this will be eliminated or greatly moderated by a filter or an anti-resonant circuit which allows the voice frequencies to pass but blocks the garbling frequency.

A tunable oscillating circuit can also be used at each station, comprising a variable inductance coil and a variable capacity to tune this circuit to the frequency of the commutating heterodyne. The above mentioned resistance device could be thus omitted.

With the system of the tuned oscillating circuit, we have the advantage of being able to use plug connecting blocks allowing the variation of the capacity and of the inductance according to a code of combinations; the connecting blocks can be numbered. The number of communications can thus be changed according to arrangements between two communicating stations as frequently as desired, which fact gives a greater security for the secrecy of the communications.

With this combination of tuned oscillating circuits, variable in one way or the other, several of these circuits differently tuned can be introduced, and we then have on the same line wires, multiple telephony (or telegraphy) in secret, each receiving station being tuned in combination with the transmitting station which it is desired to receive, or the transmitting station alone can be tuned each time with the particular receiving station with which it is desired to communicate.

All these different devices are naturally adapted to all types of telephonic or telegraphic instruments.

The annexed drawings show by way of example diagrams of embodiments of telephonic connections according to the invention. On these drawings:

Fig. 1 shows a telephone line according to our invention connected simultaneously with two subscriber's stations at each terminus.

Fig. 2 shows a modification of the circuit with one tube connected to copper oxide rectifiers.

Fig. 3 shows a modification employing transformers with three windings.

Fig. 4 shows an application of the combined circuits to obtain an additional channel.

Fig. 5 shows a secrecy system with an interpolated garbling frequency using a garbling frequency source at one station and a filter at the

other station to eliminate the background noise, filling one cyclic group of intervals with a garbling frequency.

Fig. 6 shows an arrangement with tuned oscillating circuits and plug connecting blocks.

Referring to Fig. 1, the output of heterodyne oscillator 1 is inductively coupled by a winding 2 to a tapped secondary winding having two parts 3, 4, with symmetrical tap point 5. Rheostats 6 and 6' permit the adjustment so that tap point 5 is truly neutral or at zero potential. To this tap point 5 are connected the filaments of tubes 7 and 8, which are in push-pull. In order to only have two line wires for each subscriber A and B at one terminus (or A' and B' at the other terminus) connected respectively with the tubes 7 and 8 (or 7' and 8' at the other terminus) a transformer 9 has one winding which is its plate winding connected to the plate and another transformer 10 has one of its windings which is its grid winding connected to the grid of tube 7, and corresponding windings of transformers 11 and 12 are connected to the plate and grid of tube 8. The other or subscriber's circuit windings of the transformers 9 and 10 are connected in series to the subscriber's line from the subscriber A, and the other or subscriber's circuit windings of transformers 11 and 12 are connected in series to subscriber's line B. Each subscriber station has its microphone 13 and 17, its local talking battery 14 and 18, its microphone transformer 15 and 19, and its telephone receivers 16 and 20. The devices for calling, the switches, etc., have not been shown.

When the subscriber A speaks into his microphone 13, the secondary winding of transformer 15 delivers the modulation to the two subscriber's circuit windings of transformers 9 and 10. The transformer 10 modulates the grid of tube 7 and causes the transmission of speech on the line. The transformer 9 therefore allows the speaker to hear himself speaking, which fact presents no difficulty.

Conversely when the conversation arrives on the line, it passes into the corresponding plate circuit of tube 7 and therefore into the plate winding of plate transformer 9, which induces a current in its subscriber's circuit winding, which current is delivered to the receivers 16 after traversing the other windings in series with the subscriber's circuit winding of transformer 9, which fact also presents no difficulty.

The line wires 21 and 22 terminate in two tubes 7' and 8' connected in a similar manner and communicating with two respective subscriber's stations A' and B', but here there is no principal control oscillator at the receiver corresponding to 1 at the transmitter because it is unnecessary.

In order to separate the simultaneously transmitted staggered chopped conversations thoroughly and to permit the passage of the current in the desired direction, supplementary rectifiers are connected, preferably of the copper oxide type, at suitable points in the circuit and in the appropriate sense to permit the current to flow in the desired direction. We therefore have provided a group of primary rectifiers 23 and 24 connected in parallel with the windings 3 and 4. Rectifiers 25 and 26 are also connected between the plates of tubes 7 and 8 and the line 21 and 22. Other rectifiers 26a and 27a are connected between the tap point 5 and the cathodes of tubes 7 and 8. The same arrangement is provided for the tubes 7' and 8' at the other terminus. A common battery applies a suitable potential to

the anodes. As shown in Fig. 1 this common battery 5a is connected to apply to the plates of tubes 7 and 8 a potential negative with respect to their filaments, the negative terminal of the common battery 5a being connected to the mid-point 5 of the transformer secondary winding between its two halves 3 and 4. The voltage of battery 5a is necessarily less than the peak voltage applied to windings 3 and 4 by heterodyne oscillator 1. Tubes 7 and 8 are respectively operative only when their plates are positive, and hence only during that portion of the cycle of the heterodyne oscillator when the instantaneous alternating voltage in windings 3 or 4 exceeds the voltage of battery 5a. Hence neither tube 7 nor 8 is operative at the instant when the potential of heterodyne oscillator 1 passes through zero, nor for an interval before and after that instant, the length of this inactive interval depending on the voltage of battery 5a. There is therefore an appreciable time interval between cessation of the operation of one tube and the commencement of the operation of the other tube, which fact avoids interference between the outputs of the two tubes.

Fig. 2 shows a simplified diagram with the tubes 7, 8 and 7', 8', each connected with a rectifier 28, 29 and 28', 29', connected in the desired sense to ensure the blocking of the undesired one of the simultaneous conversations.

The described arrangements are also applicable to telegraphy, the microphones being replaced by keys and the receivers by any appropriate telegraphic receiving apparatus. The control heterodyne oscillator 1 is then not necessarily of an ultra-audible frequency.

Fig. 3 shows the connection between the office C which has two subscriber's stations I and III and the office C' which has two subscriber's stations II and IV. This is a balanced system in which the neutral points are at 30 and 30' and the series of valves or copper oxide rectifiers at 31, 32, 31', 32'. Here are the transformers 33, 34, 33', 34', across whose plate windings are shunted a condenser 35, 36, 35', 36', and these transformers also have a third winding connected with the corresponding subscriber's station. There is therefore only one single winding in the circuit of the subscriber instead of two windings as in Fig. 1, which in Fig. 1 reduce the current in the circuit because there are two impedances. It is therefore possible to have a better result and have one transformer frame instead of two, and save one winding by having three instead of four as for the two transformers of Fig. 1. The assembly is simpler and the required space much less.

An electrostatic screen such as a thin metal band, tin foil or similar conducting plate, between the circuit winding of the subscriber and the other windings, is connected with the filament battery and thence with the ground, which screen is not shown. This prevents all passage of high-frequency currents to the subscriber, through capacity coupling between the windings, and therefore suppresses all interference from that source.

In Fig. 4, the devices are applied to a system of combined balanced circuits D and E, each of which is equipped with our system for multiple transmission as shown in Fig. 1.

At the extremities of each circuit, one-to-one auto-transformers such as 37, 38, 37', 38', are connected with respect to one of the talking circuits, the two windings of each of these auto-transformers are in series, in such a manner that

the ampere-turns are added, and that their self-inductance prevents the mixing of conversations transmitted by each of the windings. These windings act as choke coils as to the high-frequency currents as well as to the telephone frequency currents circulating in the circuits.

Between the taps of the auto-transformers 37 and 38 on the one side and 37' and 38' on the other, the additional subscribers' stations F and F' are respectively connected. The currents to F and F' circulate in opposite directions in each half of the transformer winding and produce opposite magnetic effects, the ampere-turns are thus cancelled and the telephone currents can pass to F and F'. Accordingly the two sets F and F' can communicate. In this case, each of the wires of the circuit D functions in parallel with the other wire of the same circuit. The same is the case with the two wires of the circuit E which also function as two wires in parallel as to stations F and F'.

The other subscribers' stations connected in multiple as in the arrangement of Fig. 1, are shown at A, B, A', B', and A<sub>1</sub>', B<sub>1</sub>', A<sub>1</sub>, B<sub>1</sub>, and they are not interfered with by the conversations of F and F' because the points of connection respectively of the distributing switchboards 39, 40, 39', 40', with the wires of the circuits D and E, have respectively balancing resistances 41, 42, 43, 44, and 41', 42', 43', 44', which are connected with the lines, at equipotential points with respect to the currents flowing from F and F'. No current from stations F and F' will therefore pass to the switchboards and the subscribers A, B, etc. connected to it will not hear the conversations of stations F and F'.

The sources of control oscillations 45, 46 supply the switchboards of the circuits D and E and this can be arranged by having the principal single control oscillator I (Fig. 1) to have, in addition to its primary winding which serves to maintain oscillations, two secondary windings, one for the distributing switchboard of the first circuit and the other for that of the second circuit.

Fig. 5 shows a system wherein the voice current is periodically interrupted at a super-audible frequency for intervals forming an appreciable part of the period of such voice current frequency, and such intervals of interruption are filled with a low audible frequency from an auxiliary source, to produce garbling, and means is provided in reception to eliminate the garbling frequency. There is only one receiving subscribers' station in the arrangement shown in Fig. 5, since if there were another station it would simply receive the interfering garbling frequency generated by source 55 at the transmitter.

In Fig. 5 there are two tubes 47 and 48 connected in push-pull between the wires 21 and 22. The tube 47 has its plate connected with the wire 21 through the head receiver 49 shunted by the capacity 50. The microphone 51 is connected with the common filament heating battery and it is applied to the grid of tube 47 through the transformer 52. An oscillator 55 of musical audio frequency is applied to the grid of tube 48 with energy at a suitable level through the transformer 54. The balancing of the two circuits is ensured by the adjustable resistances 56 and 57, which circuits can be considered as arms of a bridge.

At the other end of the line 21, 22, a tube 58 is provided on a single bridge arm between the wire 21 and a neutral point 59 which is the

common point of the two resistances 60 and 61. These resistances can be advantageously replaced by detectors, and preferably by copper oxide rectifiers in the circuit arrangement shown in Fig. 1. The tube 58 is connected similarly to the tube 47 with head receivers 49' shunted by the capacity 50', microphone 51', microphone transformer 52', and the filament battery supplying the microphone. Likewise, a filter 62 formed by suitable resistances and capacities is inserted ahead of the telephone receivers.

The operation of the secrecy system of Fig. 5 is as follows:

When the terminal 63 is positive, the plates of tubes 47 and 58 are also positive. When speaking into the microphone 51, the conversation is heard in the receivers 49' and vice-versa in receivers 49 when speaking into microphone 51'.

If the oscillator 55 is in operation and supplying a current which is preferably at low frequency, 60 cycles, for example, the noise of the garbling frequency passes into the line when the terminal 64 is positive, therefore when terminal 63 is negative, hence at the moment when the conversation between the two stations cannot pass on account of the negative voltage on the terminal 63, and the plate of tube 47. Conversely, when the receiving station is receiving conversation, the garbling frequency cannot pass because at that instant there is a negative voltage on terminals 64 and the plate of tube 48. It is known that these interruptions at ultra-audible frequency of the heterodyne for chopping are not perceptible to the ear.

During the intervals reserved for conversation, it is possible however, for a little garbling frequency to pass into the tube 47, because of imperfect insulation, or internal capacity of the tubes etc., which causes a background noise in the garbling frequency. This noise is reduced by means of the filter 62 which is connected, if necessary, to each transmitting tube. If the garbling frequency is 60 cycles, the smoothing circuit 62 will reduce in the same proportion the 60 cycle frequency component of the voice, which fact offers no difficulty, because the important part of the voice frequencies are close to 800. For this reason, it is recommended to employ a garbling oscillation of very low frequency.

The secrecy of the conversation is obtained, for if an eavesdropper connects himself with an ordinary head-set between the wires 21 and 22, he will receive at the same time the voice and the garbling low frequency whose intensity is adjusted to drown the voice, and the clandestine listener will not understand the conversation.

A further improvement consists in having the tube such as 47 or 48 or 58 of Fig. 5 connected to each station in shunt with a tuned circuit having a variable capacity and a variable inductance coil, whose mid-point is a neutral point connected with the filament battery through balancing resistances. The secrecy is even better assured than with the previously described arrangements, for if the tuned oscillating circuit is not tuned to the corresponding transmitting station, it is impossible to hear the conversation, or to transmit.

In Fig. 6, a combination of this kind is shown with the use of plug connecting blocks (called Bavarian commutators) for connecting in the different values of capacity and inductance of the tuned oscillating circuit. Fixed condensers 65, 66, 67, etc., are connected in parallel, each connected with a split connecting block 68, 69, 75

70, etc., having a hole for a connecting plug. In the same way, the winding of the inductance coil is tapped and connected to split connecting blocks (71, 72, 73, 74, etc.), also apertured to receive plugs. By placing a plug in one of the blocks 68, 69, 70 and in one of the blocks 71, 72, 73, 74, an oscillation generating circuit is established connected with the filament battery 75 of the tube 76, with its microphone 77 and its receivers 78. The tuning of this oscillating circuit is varied according to the values of capacity and inductance plugged in, and the circuit can be tuned to any desired value of the carrier frequency. Resistance 80 is connected as shown between line 21 of Fig. 5 and one side of the capacities and inductances, and resistance 81 is connected between line 22 of Fig. 5 and the other side of the resistances and inductances. Tube 76 of Fig. 6 corresponds to tube 58 of Fig. 5. In Fig. 5, the tubes 47 and 58 perform corresponding functions. These arrangements for tuning are in addition to the chopping and garbling method described for Fig. 5. The resistance 79 serves as balance and the resistances 80 and 81 likewise, and these moderate also a too sharp tuning. If the connecting blocks are numbered, a numerical combination can be arranged and the tuning in of two stations together will only be possible if the agreed combination is realized with the plugs at each station, which increases further the security of secrecy.

The connecting blocks with plugs can also be connected at desired places to interrupt the current when the plug is removed or to short circuit an element when the plug is inserted, the system only operating with an arranged and secret combination or code.

With the arrangement of oscillation generating circuits, one can have several stations, of any desired number, tuned in two by two on different wave lengths and thus obtain multiple telephony in secrecy.

We claim:—

1. In a multiplex telephone system, a two-conductor telephone transmission line, a terminal office at each end of said line, each of said offices comprising a pair of telephone subscriber's stations and a pair of subscriber's lines respectively connected thereto, a pair of electron tubes at each of said offices connected in push-pull balanced relationship with their cathodes interconnected and their plates connected respectively to the conductors of said transmission line, a unilaterally conducting resistance connected between the plate and cathode of each of said tubes, a source of alternating voltage of super-audible frequency, and means for applying said super-audible voltage to the plate circuits of said tubes symmetrically about the cathodes of said tubes, each of said subscriber's lines being coupled to the plate circuit and grid circuit of a corresponding one of said tubes respectively.

2. In a multiplex telephone system, a two-conductor telephone transmission line, a terminal office at each end of said line, each of said offices comprising a pair of telephone subscriber's stations and a pair of subscriber's lines respectively connected thereto, a pair of electron tubes at each of said offices connected in push-pull balanced relationship with their cathodes interconnected and their plates connected respectively to the conductors of said transmission line, a unilaterally conducting resistance connected between the plate and cathode of each of said

tubes, a source of alternating voltage of super-audible frequency, means for applying said super-audible voltage to the plate circuits of said tubes symmetrically about the cathodes of said tubes, and an individual subscriber's transformer respectively for each of said subscriber's stations, each of said transformers comprising three windings, one of said windings being connected to a corresponding subscriber's line, and said other windings being connected respectively to the plate circuit and grid circuit of a corresponding one of said tubes.

3. A pair of similar multiplex telephone systems as set forth in claim 1 connected between the same two offices, a pair of one-to-one auto-transformers respectively connected across the conductors of the line of each of said systems, a superposed additional subscriber's station at each of said offices connected between the common points of said auto-transformers at each of said offices respectively, and variable rheostat means connected between said lines and said push-pull circuits of said tubes for varying the potential relationships between said tubes and said lines.

4. In a secrecy telephone system, a two-conductor telephone transmission line, a terminal office at each end of said line comprising a microphone and telephone receiver, a pair of electron tubes at a first one of said offices connected in push-pull balanced relationship with their cathodes interconnected, said microphone and receiver at said first office being respectively connected in the input and output circuits of a first one of said tubes at said first office, a source of alternating current of audible frequency connected to the input circuit of a second one of said tubes at said first office, the plates of said tubes at said first office being respectively connected to said conductors of said transmission line, a source of alternating voltage of super-audible frequency, means for applying said super-audible voltage to the plate circuits of said tubes symmetrically about the cathodes of said tubes, one-to-one voltage dividing means connected across said conductors of said transmission line at a second one of said offices, an electron tube at said second office having its output circuit connected between one of said transmission conductors and the mid-point of said voltage dividing means, the receiver and microphone of said second office being respectively connected in the output circuit and input circuit of said last mentioned tube, whereby the sounds impressed on said microphones are reproduced on said receivers faithfully without interference, but telephone receivers connected directly across said conductors of said transmission line receive said audible frequency superposed on the sounds impressed on said microphones.

5. The secrecy telephone system set forth in claim 4, and variable rheostat means connected between the plate of each of said tubes and the corresponding conductor of said transmission line for varying the voltage relations therebetween, and a controllably variable tuned circuit at each of said offices connected between said conductors of said transmission line symmetrically, said tuned circuit comprising an inductance coil whose mid-point is connected to the cathode of the tube at the corresponding office.

6. In a telephone system, a two-conductor telephone transmission line, a terminal office at each end of said line, each of said offices comprising a telephone subscriber's station and a subscriber's line connected thereto, a pair of mutually polarly

opposed balanced unilaterally conducting resistances connected in series balanced relation between the conductors of said transmission line at each of said offices, a subscriber's circuit electron tube at each of said offices having its plate and cathode connected between a first conductor of said transmission line and the common point of said opposed resistances connected in series, means for applying a speech input current from said subscriber's station to the input terminals of each of said subscriber's circuit tubes at each of said offices, complementary means at a first one of said offices connected across the other of said resistances of said office for applying an audio-modulated carrier frequency between the second conductor of said transmission line and the common point of said resistances at said office connected in series, said complementary means comprising a complementary electron tube having its plate and cathode connected between said second conductor and said common point in push-pull relation to said subscriber's circuit tube at said first office, said complementary means further comprising means for applying an audio-frequency signal to the input of said complementary electron tube, a source of alternating current of super-audible frequency, and means for applying said super-audible frequency to the plate circuits of said tubes symmetrically about said common point at said first office.

7. In a telephone system, a two-conductor telephone transmission line, a terminal office at each end of said line, each comprising a pair of sources of audio-frequency signal and a pair of signal lines respectively connected thereto, a pair of electron tubes at a first one of said offices connected in push-pull balanced relationship with their cathodes interconnected, said signal lines at said first office being respectively in electrical relation with the input circuits of said tubes at said first office, the plates of said tubes at said first office being respectively connected to said conductors of said transmission line, a source of alternating voltage of super-audible frequency, means for applying said super-audible voltage to the plate circuits of said tubes symmetrically about the cathodes of said tubes at said first office, one-to-one voltage dividing means connected across said conductors of said transmission line at a second one of said offices, a pair of electron tubes at the second of said offices having their output circuits respectively connected between each of said transmission lines and the mid-point of said voltage dividing means, said signal lines of said second office being respectively connected to the input circuits of said tubes at said second office, and individual electrical sound reproducing means respectively connected to the output circuits of each of said tubes at each of said offices.

8. In a telephone system, a two-conductor tele-

phone transmission line, a terminal office at each end of said line each comprising a pair of sources of audio-frequency signal and a pair of signal lines respectively connected thereto, a pair of mutually polarly opposed balanced uni-laterally conducting resistances connected in series balanced relation between the conductors of said transmission line at each of said offices, a pair of electron tubes at each of said offices connected in push-pull balanced relationship with their cathodes connected together to the common point of said resistances at said respective office, said signal lines at each of said offices being respectively in electrical relation with the input circuits of said tubes at said office, the plates of said tubes at each of said offices being respectively connected to said conductors of said transmission line, a source of alternating voltage of super-audible frequency, means for applying said super-audible voltage to the plate circuits of said tubes symmetrically about the cathodes of said tubes at a first one of said offices, and individual electrical sound reproducing means respectively connected to the output circuits of each of said tubes at each of said offices.

9. In a telephone system, a two-conductor telephone transmission line, a terminal office at each end of said line comprising a microphone and a telephone receiver, a pair of mutually polarly opposed balanced unilaterally conducting resistances connected in series balanced relation between the conductors of said transmission line at each of said offices, a pair of electron tubes at a first one of said offices connected in push-pull balanced relationship with their cathodes connected together to the common point of said resistances at said first office, said microphone and receiver at said first office being respectively connected to the input and output circuits of a first one of said tubes at said first office, a source of alternating current of audible frequency connected to the input circuit of a second one of said tubes at said first office, the plates of said tubes at said first office being respectively connected to said conductors of said transmission line, a source of alternating voltage of super-audible frequency, means for applying said super-audible voltage to the plate circuits of said tubes at said first office symmetrically about the cathodes of said tubes, and an electron tube at said second office having its output circuit connected between the conductor of said transmission line which is connected to the plate of said first tube at said first office and the common point of said resistances at said second office, the receiver and microphone of said second office being respectively connected to the output and input circuit of said tube at said second office.

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