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SIGNALING SYSTEM

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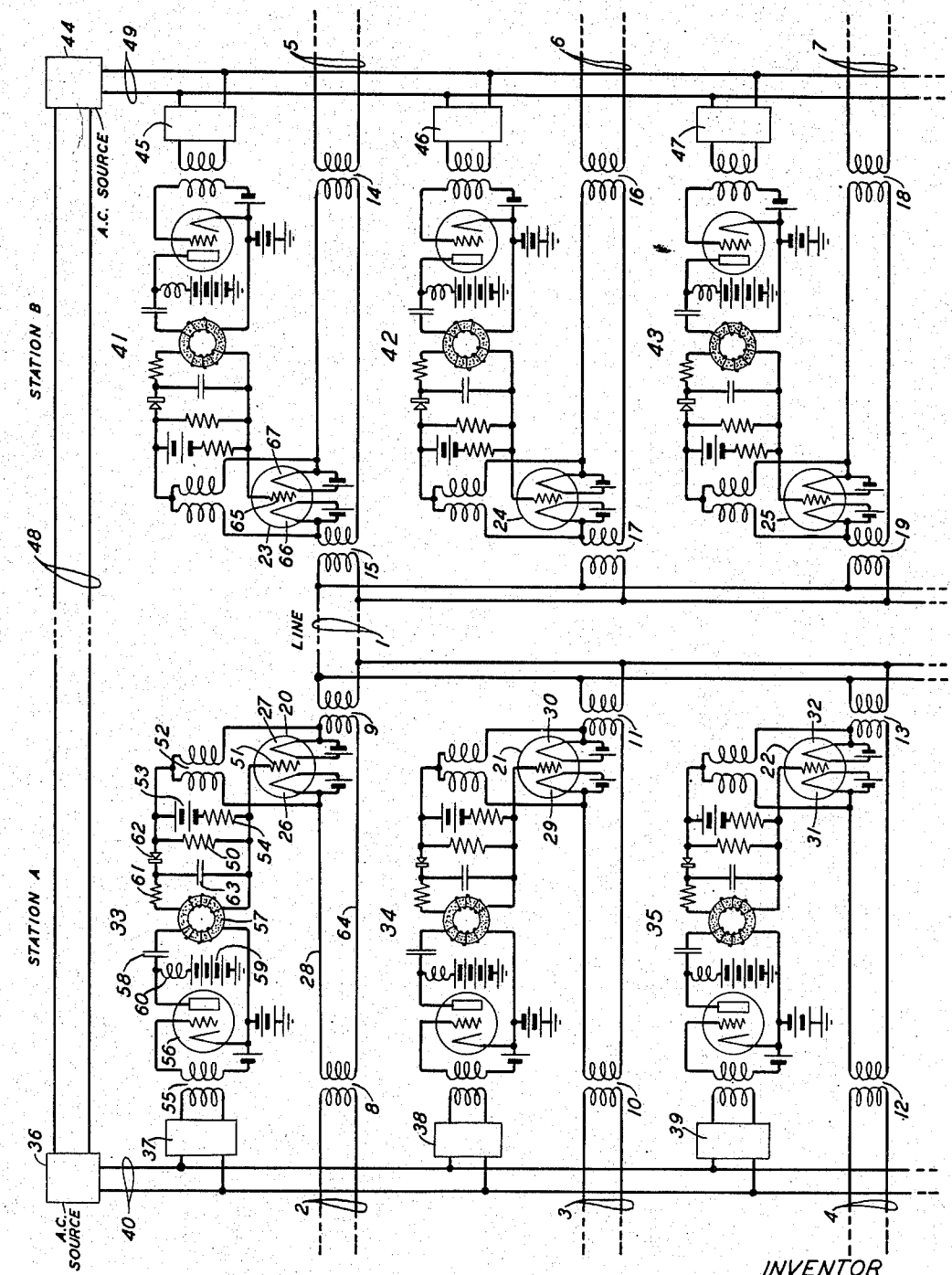

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SIGNALING SYSTEM

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This invention relates to electric signaling and particularly to multiplex systems for transmitting communications and other forms of signals.

An object of the invention is to effect both simplicity and economy in the switching and controlling devices used for the multiplex transmission of signals, conversations or other forms of communication.

Another object of the invention is to provide by means of simple controlling devices for multiplex operation in circuits carrying conversations or other signals in both directions.

These and other objects of the invention are realized by means of a multiplex system comprising a plurality of signaling circuits, all of which are arranged to transmit two-way telephone communications or other forms of signaling, together with high-speed switching means for connecting the several signaling circuits to a common transmitting line in rapid succession and repeatedly in order that all of the concurrent conversations or other signals may be transmitted simultaneously over the common line. More specifically each of the several signaling circuits is provided with a discharge tube which is made alternately conducting and non-conducting to open and close one of the transmitting conductors of the corresponding circuit, thus effectively connecting the circuit to the common transmission line for a brief interval during each transmitting cycle of the system. The discharge tube comprises a pair of thermionic electrodes, connected in one of the conductors of the signaling circuit to form a discharge gap therein, together with a control electrode for rendering the discharge gap conductive during the proper time in the transmitting cycle. The tubes connected in the several circuits are rendered conductive in rapid succession by means of impulse generators which generate a succession of impulses of different phases during each cycle of an energizing source and apply these impulses successively and repeatedly to the control electrodes of the tubes. Thus each of the separate signaling circuits, on which conversations are taking place in both directions, is closed electrically for a brief instant during each cycle of the impulse source, and during this instant the conversation on that particular circuit is transmitted over the common transmission line. During the next instant the succeeding circuit is closed, and the conversation thereon is transmitted over the common line, and so on for each of the remaining circuits having simultaneous conversations thereon. This cyclical connection of the separate circuits to the common line is so rapid that the effect is the same as though each of the separate circuits were connected continuously to the common line. At the receiving end of the common line similar equipment is provided for receiving and separating the several conversations in corresponding individual circuits or channels.

A feature of the invention is a circuit arrangement in which the potential impulses which render the tubes conductive are applied to the electrodes of each tube through an impedance element designed to offer a high impedance to the signaling or conversational currents. This preserves the high impedance character of the discharge gap of the tube throughout all parts of the cycle, except the conducting period, and prevents any signals or conversation from passing to or from the common transmission circuit.

These and other features of the invention will be discussed more fully in the following detailed specification.

The drawing accompanying this specification discloses a multiplex transmission system incorporating the features of the invention.

Although numerous plans have been devised heretofore to enable the transmission over a common line of a multiplicity of separate and concurrent telephone or other communications, the means whereby these plans have been carried into effect have usually been complicated and expensive. Also it has generally been necessary, in view of the nature of the switching and controlling devices employed, to provide each channel with one means for transmitting the conversation thereover in one direction and with a similar and separate means for transmitting the conversation over said channel in the opposite direction. In the system disclosed herein however these disadvantages have been overcome by the use of a special switching mechanism comprising a high-speed discharge tube which is capable of closing the associated channel for momentary transmission in either direction.

Referring particularly to the drawing, the system here disclosed includes a transmission line 1 interconnecting two similar stations A and B between which it is desired to transmit a multiplicity of coexisting conversations or other forms of communication. At station A three of the multiplicity of channels or communication lines 2, 3 and 4 are illustrated, and at station B the three corresponding lines or channels 5, 6 and 7 are shown, and it will be understood, of course, that many more similar channels would be provided in practice. Two-way telephone conversa-

tions, telegraph communications and other forms of signaling may arise on these lines at random for transmission over the common line 1; and this may be accomplished in the system here disclosed by connecting each channel in timed spaced relation with respect to the other channels briefly and repeatedly to the common transmission line.

To this end the respective signal lines 2, 3 and 4 are connected in multiple directly to the common line 1 through suitable coupling transformers. Line 2 includes the coupling transformers 8 and 9, line 3 includes the transformers 10 and 11, and line 4 includes transformers 12 and 13. Similarly the lines 5, 6 and 7 at station B are provided respectively with the coupling transformers 14 and 15, 16 and 17, and 18 and 19. Furthermore, the respective signal lines or channels 2, 3 and 4 at station A are provided with individual switching tubes 20, 21 and 22, and the corresponding lines 5, 6 and 7 at station B are provided with individual switching tubes 23, 24 and 25. These tubes are preferably of the vacuum type, and each one comprises two separately heated and symmetrically disposed thermionic filaments together with a control element or grid located between the filaments. The conductive space formed by the two filaments of the tube is included in series with one side of the individual signal or communication channel. The tube 20, for example, has its filaments 26 and 27 connected in the conductor 28 of line 2. The gap formed by these filaments is normally non-conducting and serves therefore to prevent any transmission in the section of line 2 between the transformers 8 and 9. In other words, this normally non-conducting gap isolates the line 2 from the common transmission line 1. In like manner the filaments 29 and 30 of tube 21 form a non-conducting gap to isolate the line 3 from the common transmission line 1. And in like manner the filaments 31 and 32 of tube 22 form a non-conducting gap to isolate the line 4 from the common line 1. And the same is true at station B where the filaments of the tubes 23, 24 and 25 form normally non-conducting gaps to keep the lines 5, 6 and 7 disconnected from the transmission line 1.

The several lines 2, 3, 4, etc., at the station A are connected in rapid succession, each for a brief interval, to the common line 1 by rendering the corresponding switching tubes 20, 21, 22, etc., conductive during these brief intervals. These tubes are rendered conductive in this manner by applying short voltage impulses to their control elements, and these impulses are supplied by the respective impulse generators 33, 34 and 35, which in turn are energized by a common source of alternating current 36. The source 36 is connected to the successive generators 33, 34 and 35 through individual phase-adjusting circuits 37, 38 and 39. These phase controlling circuits, which may be of any suitable and well-known type, control the phase of the voltage wave supplied over the common circuit 40 so that the resultant waves applied to the pulse generators 33, 34 and 35 are displaced in phase by substantially equal amounts. Similarly the impulse generators 41, 42 and 43 at station B are supplied with energy from the alternating current source 44 through corresponding phase-adjusting circuits 45, 46 and 47 to render the successive tubes 23, 24, 25, etc., conductive in rapid succession.

The sources 36 and 44 are of the same frequency and are operated in synchronism. If necessary a separate synchronizing circuit 48 may be provided for this purpose. On the other hand a single source of current may be provided if desirable for supplying the impulse generators at both stations A and B. Since, therefore, the voltage waves in the common circuits 40 and 49 are in synchronism, and assuming that the phase displacements produced by circuits 37, 38, 39, etc., are the same respectively as those produced by circuits 45, 46, 47, etc., it follows that tubes 20 and 23 are conductive simultaneously to join lines 2 and 5 for transmission during this brief interval of tube conductivity and that the same is true with respect to tubes 21 and 24 and tubes 22 and 25 and other tubes (not shown).

The impulse generators are connected to the control elements of the tubes by means of coupling resistors. For example, the output circuit of the generator 33 is connected to the coupling resistor 50, one terminal of the resistor being connected directly to the grid element 51 of tube 20 and the other terminal of the resistor being connected through the sections of coil 52 to the filaments 26 and 27. A biasing battery 53, connected in series with resistor 54 across the grid 51 and filaments 26 and 27, normally maintains a sufficient negative potential on the grid with respect to both filaments to prevent the tube from conducting. The sections of the coil 52 are so wound that they present a high impedance to the flow of signal currents in the conductor 28 of line 2, thus preventing the signal currents from passing around the gap of the tube when the latter is non-conducting. In a similar manner the remaining impulse generators disclosed in the drawing are coupled to the controlling elements of the associated switching tubes.

To explain the operation of the system in detail it will be assumed that a telephone conversation is taking place over the circuit formed by lines 2, 1 and 5 and that a second telephone conversation is taking place simultaneously over the circuit formed by lines 3, 1 and 6. Obviously as many other simultaneous conversations may be in progress as there are separate channels available. However, the discussion of two simultaneous connections will be sufficient to illustrate the operation of the system.

While these conversations are taking place and each time the voltage wave in the circuit 40 rises toward its maximum value, a voltage is applied through the phase circuit 37 and coupling transformer 55 to the grid of tube 56 to render the tube conducting. Each time the tube 56 conducts an impulse of current flows through the primary winding of the transformer 57 in a circuit including condenser 58 and the plate and filament electrodes of the tube. The plate supply battery 59 is connected to the circuit through a suitable inductance coil 60. The core of the transformer 57 is made of some highly saturable material with the result that each time the current changes in the primary winding of the transformer a brief sharp impulse is produced in the secondary winding thereof. For a better understanding of this method of generating impulses reference is made to the patent to Burton 1,936,153 of November 21, 1933.

The secondary winding of the transformer 57 is connected across the coupling resistance 50 in a circuit including the series resistor 61, series rectifier 62 and parallel condenser 63. Due to the presence of the rectifier 62 only the positive

impulses appearing at the lower terminal of the secondary winding of the transformer are permitted to flow through the coupling resistor 60 and the series resistor 61. Impulses of the opposite polarity are blocked by the rectifier 62. When, however, one of these positive impulses flows through the resistor 60 it opposes the biasing battery 53 and makes the grid 51 of the tube sufficiently positive with respect to the filaments to render the tube conductive in one direction or the other.

The direction in which the tube 20 conducts depends upon the relative potentials of the two filaments while the grid 51 is made positive. For example, assume that at any given instant while the grid 51 is positive the filament 26 is positive with respect to filament 27 by reason of the voice currents flowing in the line 2. In this case the filament 26 serves as an anode and filament 27 as a cathode, and the voice currents flow across the gap between the anode and cathode and in the local section of the line 2 comprising conductor 28, anode 26, cathode 27, coil of transformer 9, conductor 64 and the coil of transformer 8. These currents are induced in the line 1 through the transformer 9 and transmitted to the station B. At the same instant the grid 65 of tube 23 at station B is positive, and this tube becomes conductive since the voltage applied through the transformer 15 to the filaments 66 and 67 makes one of them an anode and the other a cathode. Thus the conversational currents flow at this instant from line 2 through the tube 20 over line 1 through the tube 23 and thence to line 5. If an instant later, while grid 51 is still positive, the potentials applied to the filaments 26 and 27 are such that filament 27 is positive with respect to filament 26, filament 27 acts as an anode and the other filament as a cathode, and the tube conducts in the corresponding direction permitting the conversational currents to flow through the tube 20 over the line and in like manner through the tube 23 to the line 5. If during this interval that the grids 51 and 65 are positive conversational currents are initiated in line 5, the operation is the same, namely, tube 23 becomes conductive in response to the voltage applied thereto by these conversational currents, and tube 20 at the distant end becomes conductive when these conversational currents arrive over the line 1 and apply corresponding potentials to the tube 20. Thus during the brief instant that the filaments 51 and 65 are positive, conversation may proceed from line 2 to line 5 or from line 5 to line 2. This procedure is repeated in rapid succession once for each cycle of the sources 36 and 44. As soon as the brief impulses from the generators 33 and 41 pass, the tubes 20 and 65 again become non-conducting and conversational current ceases to flow between lines 2 and 5 until the next cycle of the sources 36 and 44.

Following the termination of the conducting period of tubes 20 and 23, the voltage waves in the output circuits of the phase control devices 38 and 46 rise toward their maximum values, and generators 34 and 42 produce their impulses in the next phase position to render the tubes 21 and 24 simultaneously conductive. While these tubes are conductive conversational currents pass between the lines 3 and 6 over the common transmission line 1.

In the next phase interval impulse generators 35 and 43 produce their impulses to render the tubes 22 and 25 simultaneously conductive, and conversational currents pass between the lines 4 and 7 over the common line 1.

Thus by rendering the switching tubes of the various channels conductive for brief intervals during each cycle of a fixed source and by repeating the cycles in rapid succession, it is possible to connect a large number of lines in corresponding succession over a single transmitting circuit so rapidly that the effect is the same as if each line were permanently connected to the common line. Moreover, it is immaterial whether conversation or other signaling is taking place in one direction or the other at the time the lines are switched into operative relation with the common transmitting circuit.

Obviously numerous changes and variations may be made in the circuits and equipment disclosed in the drawing without departing from the spirit of the invention.

What is claimed is:

1. The combination in a two-way signaling system having a plurality of signal lines to which signal potentials are applied simultaneously and having a common line for transmitting the signals in all of said signal lines, of a plurality of discharge devices, one for each of said signal lines, each of said devices having a pair of electrodes connected in the corresponding signal line and forming in one of the conductors of such line an open gap which is conductive in either direction, and means for causing the gaps of said devices to conduct in either direction successively and cyclically to connect all of said signal lines in corresponding succession to said common line.

2. The combination in a two-way signaling system having a plurality of individual lines to which signal potentials are applied simultaneously and having a common line for transmitting the signals in all of said individual lines, of a plurality of discharge devices one for each of said individual lines, each of said devices having a pair of electrodes connected in the corresponding individual line and forming in one of the conductors of such line an open gap which is conductive in either direction, each of said devices having a control electrode, and means for generating impulses of different phases and applying them repeatedly to the control electrodes of the successive devices to cause the gaps of said devices to conduct in either direction successively and cyclically to connect all of said individual lines in corresponding succession to said common line.

3. The combination in a signaling system of a plurality of individual lines in which two-way conversations are being transmitted concurrently, a common transmission line to which all of said individual lines are permanently connected, a plurality of discharge devices, one for each of said individual lines, each of said devices having a pair of electrodes forming a discharge gap in one of the conductors of the corresponding individual line, said gap being normally non-conductive to prevent the transmission of conversation in either direction in said individual lines, and means for rendering the gaps of said devices conducting successively, momentarily, and repeatedly to connect all of said individual lines in corresponding succession to the common transmission line.

4. The combination in a signaling system of a plurality of individual lines in which two-way conversations are being transmitted concurrently, a common transmission line to which all of said individual lines are permanently con-

nected, a plurality of discharge tubes, one for each of said individual lines, each of said tubes having a pair of electrodes, one of which acts as an anode and the other as a cathode depending upon the direction of transmission, the gap formed by said electrodes serving normally to prevent transmission of conversation between the individual line and the common transmission line, and means for rendering the gaps of said tubes conductive momentarily, in rapid succession, and cyclically to connect all of said individual lines in corresponding order to said common transmission line.

5. The combination in a signaling system of a plurality of individual lines in which two-way signaling is taking place concurrently, a common transmission line to which said individual lines are permanently connected, discharge tubes, one for each of said individual lines, each tube having a pair of main electrodes forming a gap in the corresponding individual line to prevent the transmission of signals therein, each of said tubes also having a control electrode for rendering said gap conductive, impulse generating means, circuits for connecting said impulse generating means to both of the main electrodes and to the control electrode of each of said tubes for applying momentary impulses to the electrodes of said tubes successively and repeatedly to render said gaps conducting, and an impedance element in the impulse circuit interconnecting the main electrodes of each tube which offers a high impedance to the flow of signal currents in the corresponding individual line.

6. The combination in a two-way signaling system having a plurality of signal lines to which signal potentials are applied simultaneously and having a common line for transmitting the signals in all of said signal lines, of a plurality of space discharge devices, one for each of said signal lines, each of said devices having a pair of electrodes enclosed in a vacuum and connected in the corresponding signal line to form an open gap conductive in either direction in series with such line, and means for causing the gaps of said discharge devices to conduct in either direction in rapid succession and cyclically to connect all of said signal lines in corresponding succession to said common line.

7. The combination in a signaling system of a plurality of individual lines in which two-way conversations are being transmitted concurrently, a common transmission line to which all of said individual lines are connected, a plurality of discharge tubes, one for each of the individual lines, each of said tubes having a pair of electrodes either of which may act as an anode and the other as a cathode depending upon the direction of transmission, the gap formed by said electrodes serving normally to prevent transmission of conversation between the individual line and the common transmission line, and means for rendering the gaps of said tubes conductive momentarily in rapid succession and cyclically to connect all of said individual lines in corresponding order to said common transmission line.

8. The combination in a signaling system of a plurality of individual lines in which signaling currents are flowing concurrently, a common transmission line to which said individual lines are permanently connected, discharge tubes, one for each of said individual lines, each tube having a pair of main electrodes forming a gap in the corresponding individual line to prevent the passage of signals between said individual line and the common transmission line, each of said tubes also having a control electrode for rendering said gap conductive, impulse generating means, and circuit means for applying momentary impulses from said generating means to the control electrodes of said tubes successively and repeatedly, the application of said impulses to each one of said control electrodes serving to render the corresponding gap conductive in either direction depending on the direction of the signal currents flowing in the associated individual line.

9. The combination in a signaling system having a plurality of signal lines in which signal currents are flowing simultaneously and having a common line for transmitting the signals in all of said signal lines, of a plurality of discharge tubes, one for each of said signal lines, each of said tubes having a pair of symmetrically disposed main electrodes and a control electrode, said main electrodes forming an open gap in series with the associated line and capable of conducting signal currents in either direction, and means for applying momentarily and repeatedly impulses of different phases to the control electrodes of said tubes to render said gaps conductive in rapid succession and cyclically to connect all of said signal lines in corresponding succession to said common line, the direction of conductivity of each of said gaps depending on the direction of current flow in the associated individual line.

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