

Dec. 13, 1949

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2,490,833

ALL ELECTRONIC LINE FINDER AND SELECTOR SYSTEM

Filed April 26, 1947

6 Sheets-Sheet 1

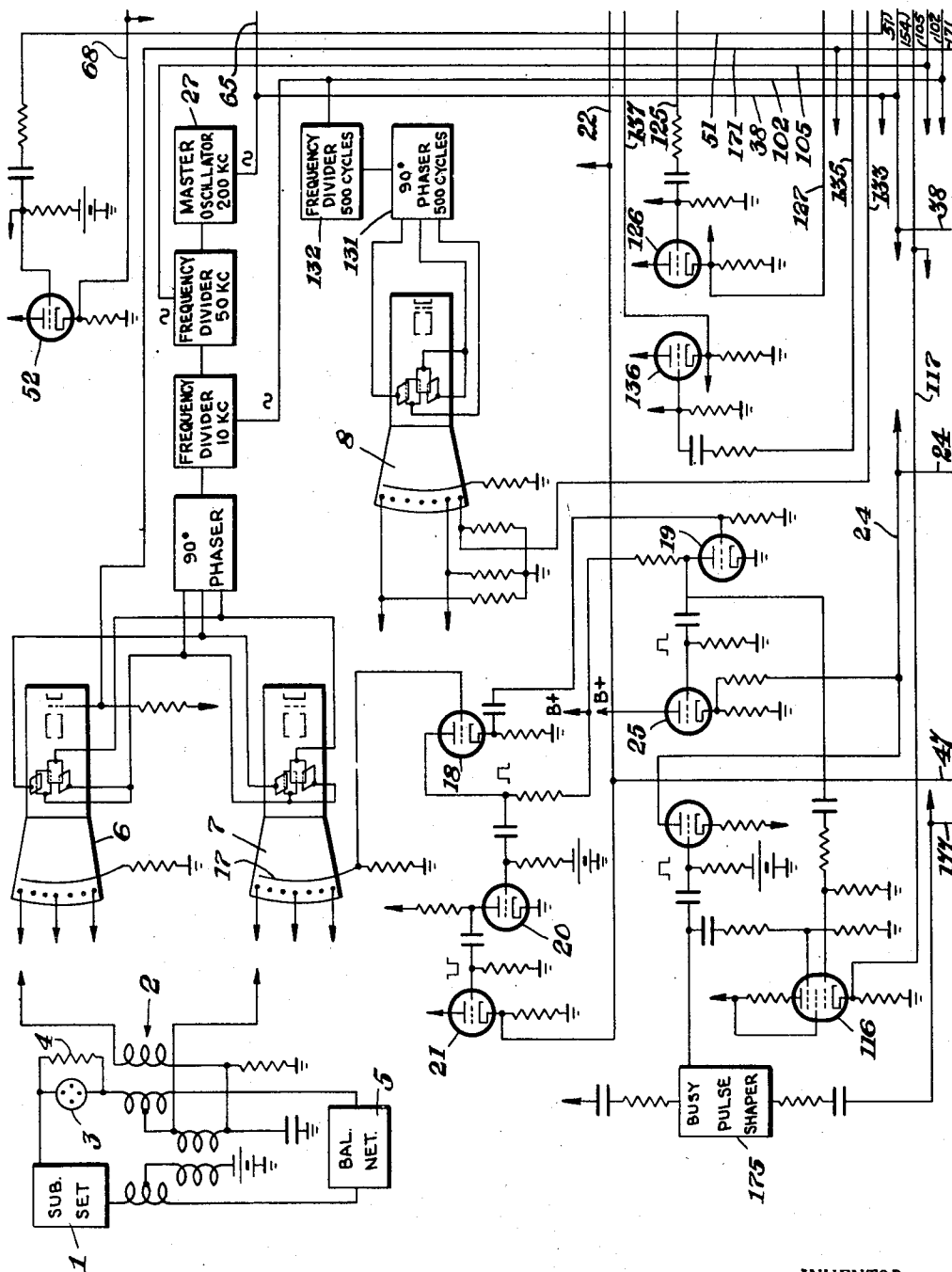


Fig. 1.

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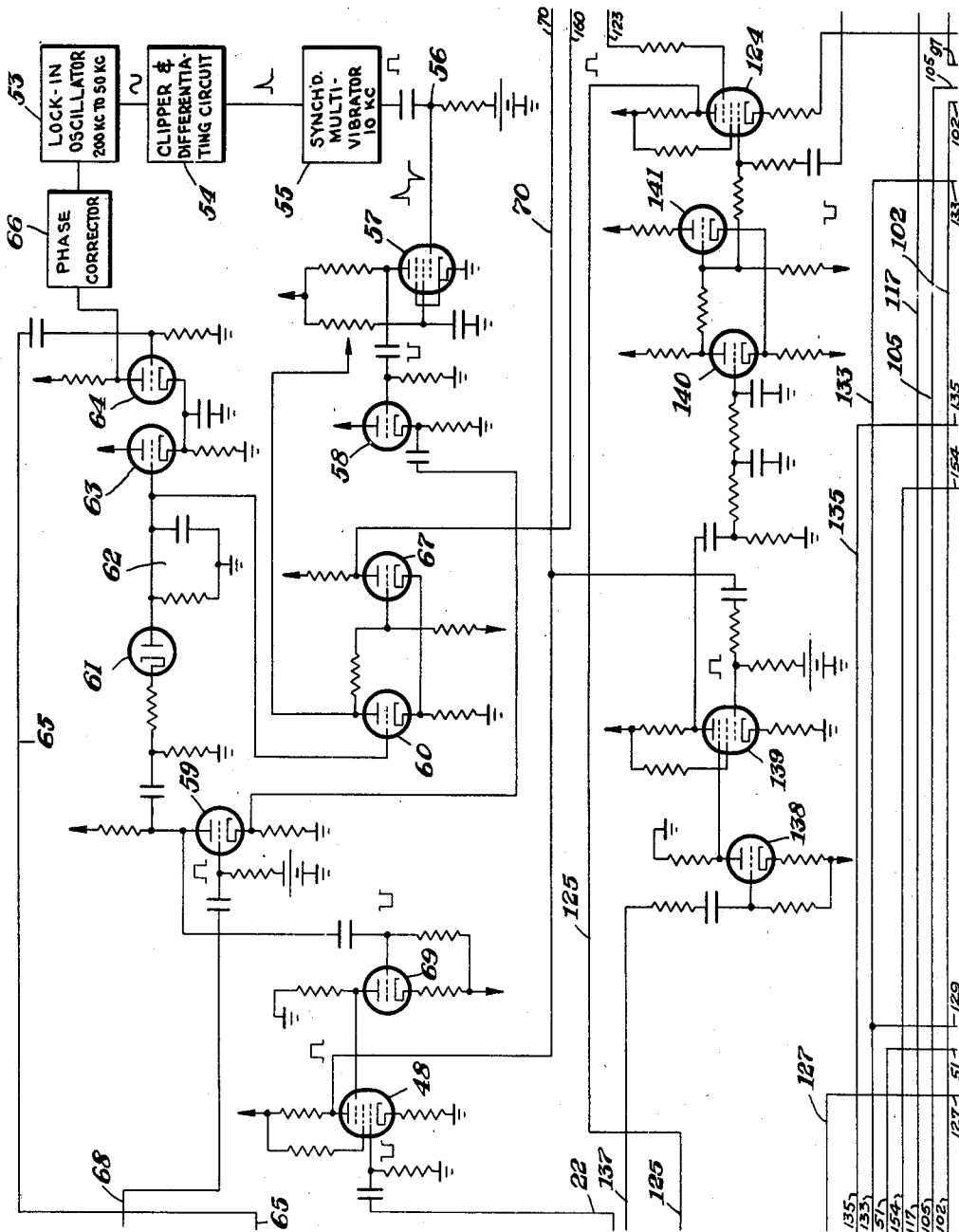
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6 Sheets-Sheet 2



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6 Sheets-Sheet 3

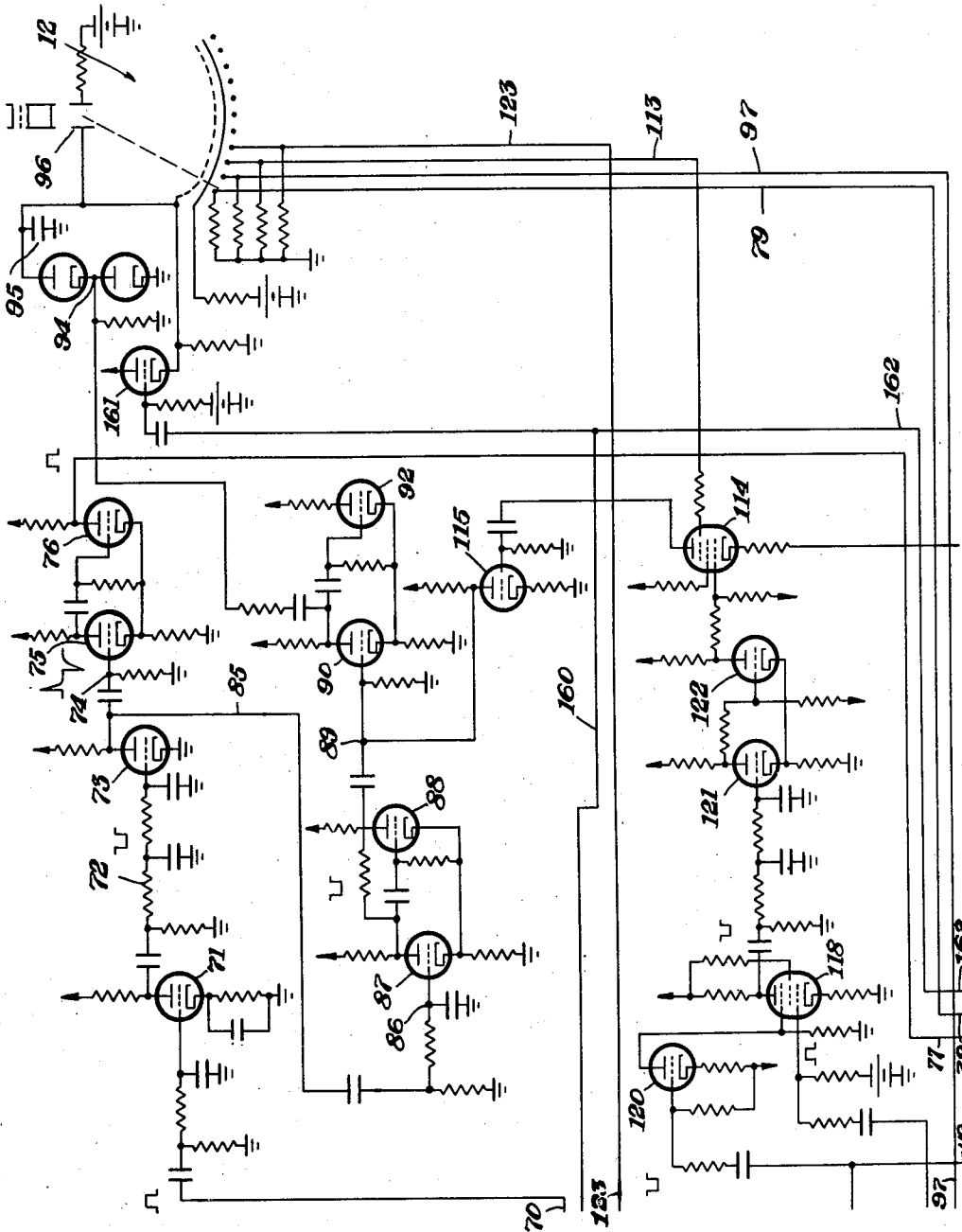


Fig. 3.

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6 Sheets-Sheet 4

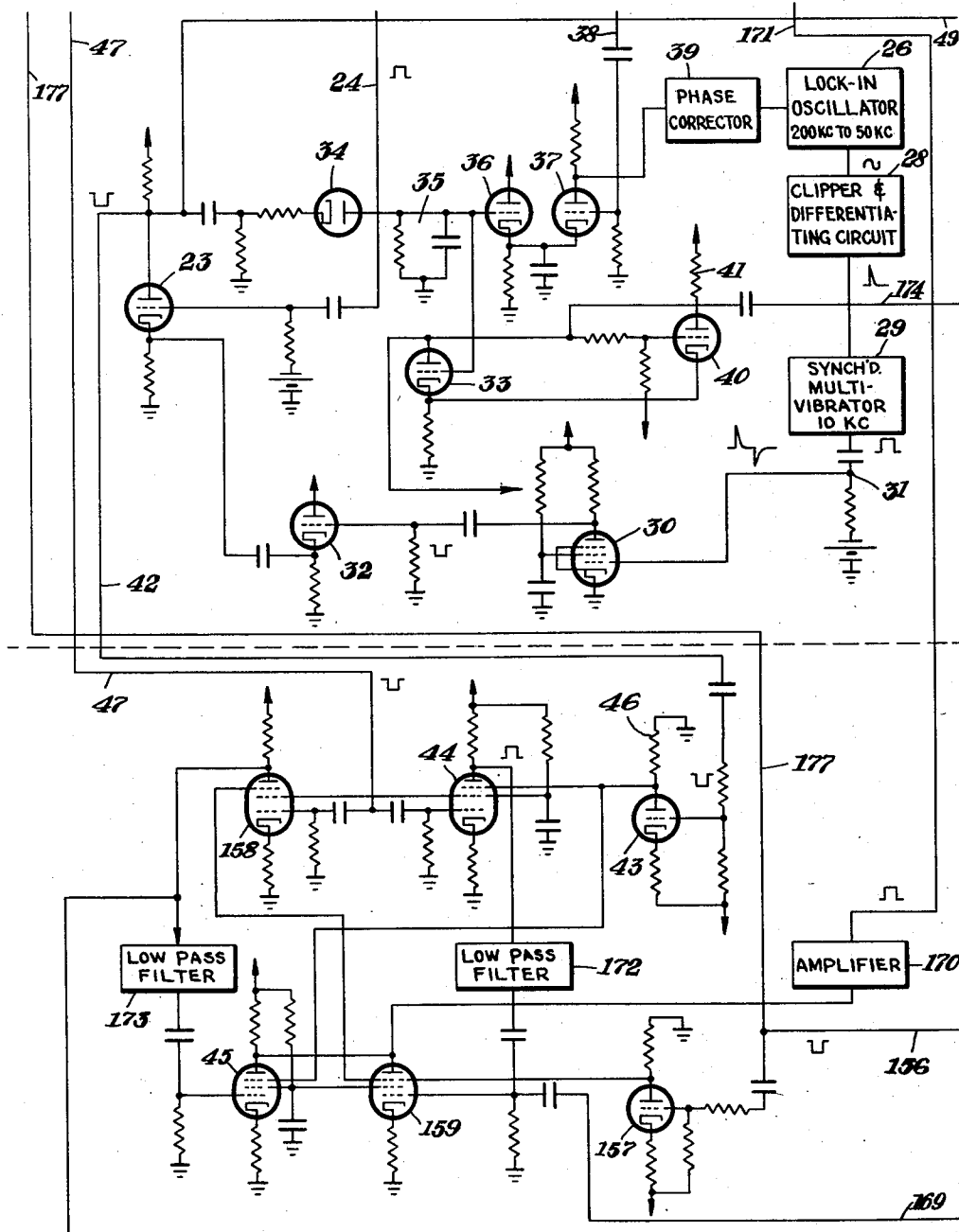


Fig. 4.

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ALL ELECTRONIC LINE FINDER AND SELECTOR SYSTEM

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6 Sheets-Sheet 5

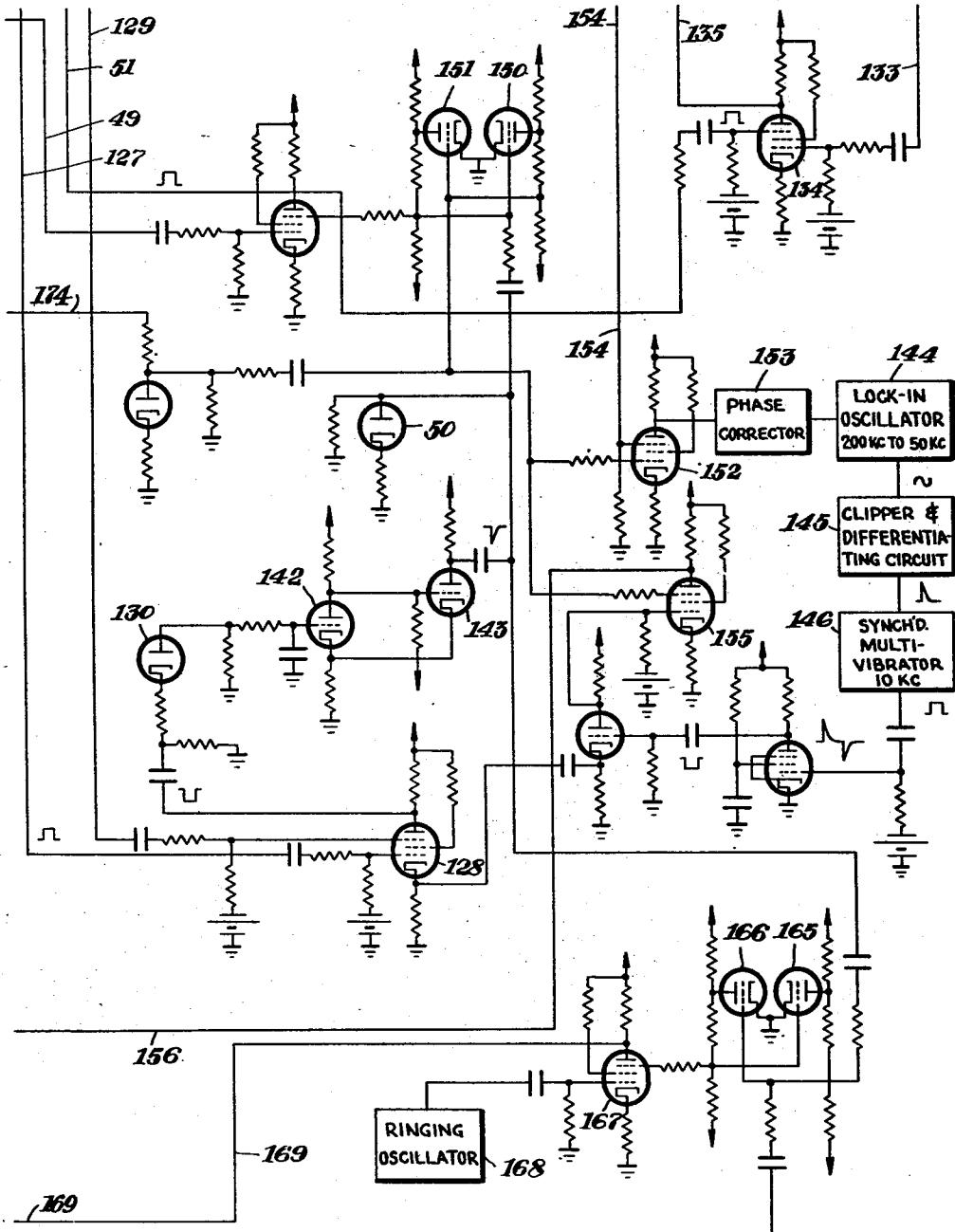


Fig. 5.

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ALL ELECTRONIC LINE FINDER AND SELECTOR SYSTEM

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6 Sheets-Sheet 6

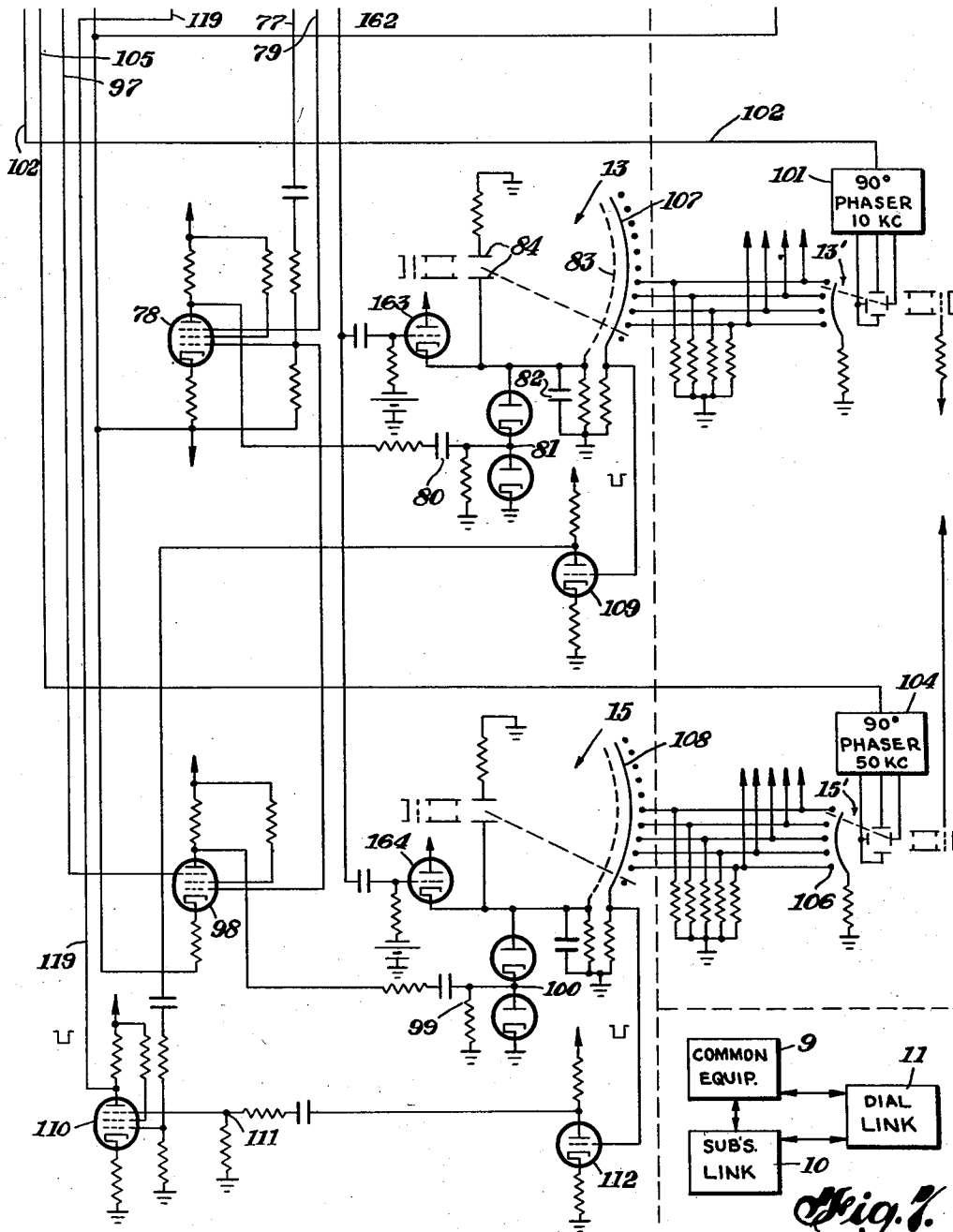


Fig. 6.

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UNITED STATES PATENT OFFICE

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ALL ELECTRONIC LINE FINDER AND
SELECTOR SYSTEM

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24 Claims. (Cl. 179—18)

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This invention relates to new and useful improvements in telecommunication switching systems and, more particularly, to systems in which all or most of the switching operations are performed by electronic as distinguished from electromechanical switching devices.

The present is an improvement of the system disclosed in my copending applications, Serial Nos. 628,610, filed November 14, 1945, issued U. S. Patent No. 2,462,896, March 1, 1949; 628,611, filed November 14, 1945; 643,285, filed January 25, 1946; 646,169, filed February 7, 1946; 648,758, filed February 19, 1946; 654,271, filed March 14, 1946, and the applications referred to therein.

The objects of the present invention are to increase the flexibility of the system, thus making possible its expansion into or connection with large switching systems, and to reduce the equipment which is held busy during conversation to a minimum.

With these objects in view, when an electronic line finder seizes a calling line or, as stated in my prior applications, locks into a calling line, then one of a plurality of links becomes appropriated for the connection with which a register becomes associated only during the building up of the connection and is released once the called line is seized.

According to one feature of the present invention, each link has a line finder for locking into the calling line and also a selector for locking into the called line, the selector being controlled in accordance with the designation of the called line by means associated with the link only during the building up of the connection.

A constantly operating cathode ray distributor is provided for associating the lines with a selected link for rapidly recurring brief periods of time, and another cathode ray tube distributor is employed for identifying the selected link.

According to another feature of the invention, the means for signaling, e. g. ringing, the called line is associated with the selector.

This and other features of the invention will more clearly appear from the appended claims and the detailed description of the system which will now be given with the aid of the drawings, which diagrammatically illustrate as much of a telephone exchange system as is necessary for an understanding of the invention.

Fig. 1 shows one subscriber's line and the equipment common to a group of twenty lines;

Fig. 2 illustrates a link finder of the dial link equipment;

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Fig. 3 illustrates the dial pulse and sequence equipment of a dial link;

Fig. 4 illustrates the line finder and talking equipment;

Fig. 5, the selector equipment by which the called line may be locked into a connection;

Fig. 6, the register and line selector equipment, and

Fig. 7 is a block diagram indicating the relationship between the various circuits.

The subscriber's line equipment comprises a substation set 1, a hybrid coil 2 with a suitable low pass filter, a dial 3 which is arranged to send dialing pulses by cutting a resistance 4 in series with the line, and a balancing network 5. The subscriber's set comprises a gas tube relay adjusted to operate at voice frequency.

The central exchange equipment comprises two continuously operating distributors; a sending tube 6 and a receiving tube 7. These are cathode ray tubes of the kind whose beams are arranged to rotate at 10 kc. per second successively to engage twenty dynode electrodes in which the twenty subscribers' line circuits terminate. A third such distributor type of cathode ray tube which is common to the group of twenty lines is indicated at 8 and is provided with dynodes in which the links or trunks accessible to the various subscribers terminate. Busy test circuits complete the common equipment.

In Fig. 7, the common equipment for twenty lines (Fig. 1), is indicated in rectangle 9. The subscribers link circuit (Figs. 4 and 5) is shown at 10 and dial link (Figs. 2, 3 and 6) at 11. This general set up will help in following the complete circuit diagram.

A plurality of links is provided at the central exchange. Upon the initiation of a call the line finder of Fig. 4 locks into, i. e. becomes connected with, the calling line, and thus selects a link for the connection. The pulse generator 8 identifies the selected link and the line finder which was taken into use. Each line finder has means associated with it for establishing the talking connection. The line finder and the talking equipment are shown, respectively, above and below the dotted line in Fig. 4.

Link finder equipment shown in Fig. 2 connects with the selected link the dial link or register equipment 11 (Fig. 7 and Figs. 2, 3 and 6) for receiving and registering the digits of the called number.

In addition to the talking equipment, each line finder (Fig. 4) and link has associated with it also selector equipment (Fig. 5) which receives the in-

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formation as to the identity of the called line from the dial link and locks the called line to the selected link.

The ringing of the called line is controlled from the selector circuit (Fig. 5), as is the opening of the talking gate (Fig. 4).

The dial link comprises dial pulse forming and timing circuits, shown in Fig. 3, which form the pulses from the breaks in the pulse trains sent out by the subscriber's dial 3, and control the timing of the group or train of pulses which make up the digit. The dial pulse circuit is provided with a cathode ray tube 12 which functions as a switching tube for successively effecting the dialing of the first digit, the second digit, the testing of the called line and the final establishment of the connection.

The dial link comprises also a dial register and called line selector circuit (Fig. 6), including group and units digit registers consisting of paired cathode ray tubes 13, 13' and 15, 15'.

The dial link (Figs. 2, 3 and 6) is used only during the establishment of the connection and is released when the called subscriber answers. Only equipment shown in Figs. 1, 4 and 5 is employed during conversation between the calling and called parties.

We shall now trace the establishment of a connection.

When a subscriber at a station like 1 initiates a call, a negative potential is applied to the dynodes in tubes 6 and 7 in which the line terminates. This negative potential will be conveyed via the anode 17 of tube 7 to the grid of a cathode follower and inverter tube 18. From the cathode of tube 18 the negative pulse will be applied to the grid of a clipper tube 19, and the positive pulse appearing in the anode circuit of tube 18 to the grid of clipper 20. Clipper tube 20 will apply a negative pulse to the grid of a cathode follower 21. From the cathode circuit of tube 21 the amplified negative pulse will be applied over conductor 22 to all the subscribers' link circuits which, as indicated in Fig. 1, are all multiplied together.

The clipper amplifier 19 is normally biased to draw current and the signal amplitude is so adjusted that each negative impulse applied to its grid will drive it beyond cut-off, clipping the variation produced by transmitter modulation or dial pulse. The positive plate output of 19 is fed also to the grid of cathode follower 25, and the positive pulses appearing in the cathode circuit thereof are fed over conductor 24 to the grids of all the line finder gate tubes 23 which are connected in multiple.

The tubes 23 are normally biased far enough beyond cut-off so that the signal applied to their grids will not affect their plate output. A lock-in oscillator 26 in each line finder operates at a frequency slightly less than the scanning frequency of master oscillator 27 (200 kc.) controlling the rotation of the beams in 6 and 7. The output of 26 is divided to a frequency of approximately 50 kc. and the resulting sine wave is passed through a clipper amplifier and differentiating circuit 28 to a multi-vibrator 29 arranged to synchronize at approximately 10 kc. The output of the multi-vibrator 29 is differentiated in a circuit 31 and applied to the grid circuit of a clipper tube 30. The constants and the bias of this tube are adjusted to cause the leading edge of the differentiated pulse to produce in the plate circuit of tube 30 a short, square negative pulse of approximately 5 micro-seconds' dura-

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tion. The trailing edge of the differentiated pulse obtained from the differentiating network 31 is suppressed.

The negative pulse is passed through a cathode follower 32 to the cathode of the line finder gate tube 23, but the amplitude of the pulse is adjusted by the delayed gain tube 33 so that normally the line finder gate tube 23 will remain cut off. This tube thus has a negative pulse applied to its cathode and a positive pulse to its grid, neither of which is strong enough to drive it beyond cut-off. Since, however, the frequency of the line finder lock-in oscillator 26 is slightly less than that of the master oscillator 27, the negative and positive pulses applied to line finder gate 23 will drift until they occur simultaneously. When this happens, gate 23 will be opened to pass a negative pulse through its plate circuit to a rectified tube 34 and an integrating network 35 to drive a gate control tube 36 beyond cut-off, permitting a lock-in gate 37 to open and pass a signal applied to its grid from the master oscillator 27 over a conductor 38. From the plate of the lock-in gate 37 the pulse is applied over a phase corrector 39 to the oscillator 26, synchronizing the latter with the master oscillator 27.

A portion of the rectified output of diode 34 is fed to the grid of delayed gain tube 33 which is driven beyond cut-off after a few impulses, causing release tube 40 to become conductive. Since the plate resistor 41 of this tube is common with the screen of clipper gate 30, the screen voltage of the latter will rise and increase the amplitude of the negative pulse applied via 32 to the cathode of line finder gate 23. This, in turn, will cause the grid of the line finder gate to be driven positive by the pulse applied thereto over conductor 24, and clipping by grid current will occur, reducing the signal amplitude of the incoming pulse to a value insufficient to affect any other link.

The negative plate output of the line finder gate 23 is applied also over conductor 42 to the grid of a gain control tube 43 controlling the effective connection of the calling line with the talking circuit. The positive pulses thus produced in the plate circuit of 43 are applied in parallel to the suppressor grids of an input gate tube 44 and output gate tube 45 which are normally biased to cut-off by the plate resistor 46 of tube 43. The negative pulse applied over conductor 42 will drive the grid of 43 beyond cut-off reducing the voltage drop across its plate resistor 46 to zero. This raises the bias on the suppressor grids of 44 and 45 and permits signals applied to their control grids to pass, and thus affords a channel for signaling from the calling line.

Returning now to the common circuit, it is assumed that speech and dial pulses will modulate a line signal about twenty-five percent. The clipping action of tube 19 will cut off the modulated portion of the signal so that the positive pulses applied to the grid of the line finder gate 23 will be uniform, irrespective of dial or microphone modulation. However, the clipper tube 20 is biased so that only the modulated portion of the positive pulses applied to its grid from the plate of the inverter 18 will produce negative pulses in the plate circuit of 20 and the grid of cathode follower 21. The output of 21 will represent, therefore, the modulated pulses which are applied over conductors 22, 47 to the control grid of the input gate tube 44 (Fig. 4) in parallel to the control grid of dial pulse gate tube 48 (Fig. 2).

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As soon as the line finder lock-in oscillator 26 has been synchronized by the calling signal, a negative pulse is transmitted from the plate of the line finder gate tube 23 over conductor 49 to the control grid of a dial link selector gate 50 (Fig. 5). This tube is biased to pass a signal until the called line selection equipment of Fig. 5 is locked to the subscriber's link and thus to the called line. The positive pulses appearing in the plate circuit of gate 50 are fed over a conductor 51 to the control grids of the make-busy tubes 52 (Fig. 1) of all the dial links which are multiplied to conductor 51. This is an indication to all the dial links that a particular subscriber's link has become associated with a calling line and that, therefore, the register circuits must be prepared to take and store pulses sent from the calling line via said particular link and representing the number of the called subscriber.

The dial link (Fig. 2) comprises a finder circuit similar to the subscriber's line finder circuit of Fig. 4. A lock-in oscillator 53 operating at a frequency slightly less than the master oscillator 27 (200 kc.) supplies its output to a clipper and differentiating network 54 and thence to a multi-vibrator 55 arranged to synchronize at 10 Kc. The output of 55 is differentiated in network 56 and applied to the control grid of a clipper gate tube 57. The constants and bias of this tube are adjusted to produce from the leading edge of the differentiated output of multi-vibrator 55 a short, square negative pulse of approximately 5 micro-seconds' duration. The trailing edge is suppressed. This negative pulse is passed through a cathode follower 58 to the cathode of dial link finder 59. As in the case of the line finder, the amplitude of the pulse passing through gate 57 is adjusted by delay gain tube 60 so that normally the link finder gate 59 remains cut off.

It will be seen, therefore, that the dial link finder gate 59, just as the line finder gate tube 23, receives two signals; a positive pulse on its grid applied under the control of the master oscillator 27, via 23, 50 and the dial link make-busy tube 52, and a negative pulse on its cathode from the lock-in oscillator 53, via 57, 58. Neither pulse alone will drive gate 59 beyond cut-off to conduction, and only that particular gate 59 can be operated whose dial link is connected with the calling subscriber's link.

The frequency of the oscillator 53 being slightly less than that of oscillator 27, the two will drift until a coincidence occurs which will cause the gate tube 59 to pass a negative signal on its plate over a rectifier 61 and an integrating network 62. A gate control tube 63 will be driven to cut-off after a few pulses, permitting a lock-in gate 64 to pass a signal from master oscillator 27 over conductor 65, the plate of 64, and a phase corrector network 66 to the oscillator 53 and synchronize the two oscillators.

A portion of the output of network 62 is applied to the grid of the delayed gain tube 60 which is driven to cut-off after a few pulses, causing a tube 67 to become conductive. The plate resistor of the delayed gain tube 60 is common with the screen grid of the clipper gate tube 57 whose screen voltage will, therefore, rise and increase the amplitude of the negative pulse which is applied as a pedestal pulse to the cathode of the finder gate 59. This will cause the grid of tube 59 to be driven positive by the positive pulse applied thereto over conductor 68 from the cathode of the make-busy tube 52 and clipping by grid current

will occur. The signal amplitude of the pulse over conductor 68 will be reduced to a value which is insufficient to affect the dial link finder tube 59 of another dial link finder connected in multiple, since their cathodes do not receive properly timed pedestal pulses. The plate output of the gate tube 59 controls a tube 69 which, in turn, controls the dial pulse gate tube 48 through which the dial pulses are sent from the calling line to the register.

Normally a series of pulses will be passed from the pulse separating circuits (Fig. 1) comprising clipper tube 20 and cathode follower 21 over conductor 22 to the dial pulse gate tube 48 to control the forming and relaying of the dial pulses. The selective action of the input clipper tube 20 interrupts the pulses with each pulse from the subscriber's dial 3. The positive pulses appearing in the output circuit of the gate tube 48 are applied over a conductor 70 to the grid of an amplifier tube 71 after the associated network has shaped them to form square waves. The amplified negative pulses are again shaped in a network 72 before they are applied to the grid of a second amplifier tube 73, are then differentiated in a network 74 and applied to the grid of a triode 75 which, with a second triode 76, forms the dial pulse generator flip-flop circuit in which tube 76 is normally conducting. The leading edge of each of the differentiated dial pulses in the output of circuit 74 flips conduction from tube 75 to tube 76 for a period determined by the circuit constants, whereby a timed positive pulse will be produced by the pulse generator and applied to conductor 77 and therethrough to the control grid of a gate tube 78 controlling the registering of the first or group digit.

The switching tube 12 is so adjusted that its beam is normally centered on the No. 1 dynode causing a positive potential to be applied over conductor 79 to the suppressor grid of the group digit gate 78. The first series of dial pulses produced at the calling station, as reproduced in the dial pulse generator (Fig. 3), will, therefore, be sent over conductor 77 to the control grid of 78 and appear as negative pulses in the plate circuit of 78. These are applied over a network 80 to a rectifier and limiter 81, whose output will charge deflecting plates 84 and a condenser 82 which is connected with anode 83 of the group digit register tube 13. This will cause the step-by-step advance of the beam of tube 13. Normally this beam is centered, as shown in Fig. 6, in the first dynode opening. As the charge leaks off the condenser the beam will fall on the edge of the opening where equilibrium is established between the beam and the leakage currents.

Upon the completion of the first or group digit pulses, the beam of the switching tube 12 is moved to its second dynode in the following manner:

The dial pulses formed in the integrating circuit and amplifiers 71-73 (Fig. 3) are passed over a conductor 85 to a second integrating network 86 connected with the grid of triode 87 which, together with a second triode 88, forms a flip-flop circuit, with 88 normally conducting. This circuit constitutes the digit pulse generator. The integrated dial pulses will cause 87 to become conducting for the portion of the series of pulses representing one digit. An ineffective negative pulse is generated at the beginning of a series of pulses in a differentiating network 89 and thence to a transfer pulse generator com-

prising triodes 90 and 92, forming a flip-flop circuit in which 92 is normally conducting.

In the transfer pulse generator the tube 90 is made conducting for a period of time determined by the circuit constants and generates a timed negative pulse which indicates the termination of the dialing of the first digit. This pulse is fed over conductor 93 to a rectifier and limiter 94 which will charge a condenser 95 and thus affect the deflecting plates 96 of the beam tube 12 to move its beam from dynode 1 to dynode No. 2.

When the beam is centered on dynode 2 positive potential will be applied over conductor 97 to the suppressor grid of units digit gate 98. This gate will, therefore, pass the dial pulses which are applied to its control grid over conductor 77 from the dial pulse generator 75, 76. The units digit pulses appearing in the plate circuit of gate 98 are then applied through an integrating network 99 to limiters 100 to step the beam of units digit tube 15 by a number of steps corresponding to the units pulses.

Once again the digit pulse generator 87, 88 operates at the end of the units digit and causes the operation of the transfer pulse generator 90, 92 which, over conductor 93, will apply a timed negative pulse to the limiters 94 and operate the control circuit switching tube 12 to center its beam on dynode No. 3.

The dialing operation is now completed and pulses will be generated in the register digit tubes 13, 13' and 15, 15' in accordance with their setting by the pulses which were dialed.

The beam of tube 13' is rotated at 10 kc. under the control of a 90° phaser 101 which is controlled over conductor 102 from the 10-kc. frequency divider (Fig. 1) in the control equipment of the distributors 6 and 7, insuring thus the rotation of the beams of all these tubes at the same rate. The beam of tube 13' contacts each of the four dynodes 103 for a period corresponding to the period required by the beams of distributor tubes 6 and 7 to sweep over five of their dynodes, the assumption being that twenty lines are divided into four groups of five. Thus, a pulse will be generated to designate a particular one of the four groups of five lines and will be applied to the dynodes of all the tubes 13.

The beam tube 15' in the units digit register is rotated at 50 kc. per second under the control of a 90° phase changer 104 which is controlled over conductor 105 from the 50-kc. frequency divider in the control equipment (Fig. 1) of the distributors 6 and 7. The beam of tube 15' will, therefore, sweep over five of its dynodes, such as 106, while the beam of tube 13' in the group register sweeps over a single dynode. Units pulses will be generated of the proper time duration and will be applied to the dynodes of all the units digit beam tubes 15 provided for the various links.

Negative pulses produced by the beams of tubes 13' and 15' will be transferred to the common anodes 107 and 108, respectively, of the tubes 13 and 15 whose beams are centered on the proper dynodes. The negative pulse on anode 107 will, through an inverter 109, be applied as a positive pulse to the control grid of a pulse gate 110. The suppressor grid of this gate tube will be similarly pulsed over a differentiating network 111 in the output circuit of an inverter 112 whose control grid receives negative pulses from the common anode 108 of units digit tube 15. The negative pulses appearing in the output circuit of pulse gate 110 identify, therefore, the time position of the called line.

When, upon the completion of the dialing, the beam of the control circuit switching tube 12 was advanced onto dynode 3, it applied over conductor 113 a pulse to the suppressor grid of busy test gate 114. If the called line is idle, then the control grid of gate 114 is positively biased, whereby a single negative pulse will be transmitted to the control grid of an inverter 115 which, in turn, will transmit a positive pulse to the transfer pulse generator 90, 92. When this functions, it will transmit a negative pulse over conductor 93 to advance the beam of the switching tube 12 onto dynode 4.

If, however, the called line is busy, then the control grid of busy test gate 114 is biased to cut-off to block the call by preventing the moving of the beam of tube 12 into position 4. This is accomplished under the control of a busy test tube 116 in the subscribers' common circuit (Fig. 1). In a manner to be described below, positive pulses will be generated on the cathode of tube 116 if the called line is busy, and will be transmitted over conductor 117 to the control grid of a busy test tube 118 (Fig. 3) which is biased to cut-off. The negative pulse identifying the called line is fed from the plate of pulse gate 110 (Fig. 6) over conductor 119 and then through an inverter 120 to the suppressor grid of busy test tube 118. When these two positive pulses are simultaneously applied to the control and suppressor grids of 118, this tube will generate a negative pulse in its plate circuit which, after integration, will actuate a stop pulse generator comprising tubes 121 and 122. The pulse generator is a flip-flop circuit, with 121 normally conducting. The integrated pulses will flip conduction to tube 122 which, in turn, will apply a negative pulse to the control grid of busy test gate 114 to block the call as above described.

Assuming, however, that the called line is idle and that, therefore, the beam of the switching tube 12 has been moved into position 4, it will apply over conductor 123 a positive pulse to the suppressor grid of selection pulse gate 124 (Fig. 2) to bias it to conduction whenever a negative pulse is applied to its control grid over conductor 119 from pulse gate 110 which, as above stated, identifies and now permits the locking-in of the called line in the following manner:

Whenever tube 124 is conducting called line selecting bursts of positive pulses are passed over conductor 125 to the control grid of selection pulse test tube 126 (Fig. 1) in every link. The cathode output of 126 is fed over conductor 127 to the control grid of the selection synchronizing gate tube 128 (Fig. 5). If the positive pulses are received on the control grid of tube 128 at the same time as those sent over conductor 129 to the screen grid of 128 by generator 8 and which identify the subscriber's link, and if these two pulses coincide with the negative signal appearing on the cathode of the selection synchronizing tube 128, then a negative pulse will be passed from the plate of 128 to a rectifier 130 and an integrating network in the grid circuit of the selection synchronizing control flip-flop circuit.

The link identification pulse generator 8 has its beam rotated at 500 cycles per second under the control of a 90° phaser 131 and a frequency divider 132 which is fed from the frequency divider of the common equipment of tubes 6 and 7. Whenever the beam of tube 8 sweeps over the dynode appertaining to the link to which the calling line has been locked, the positive pulse applied to conductor 133 will reach the control grid

of the selection identifying gate tube 134 (Fig. 5) simultaneously with the appearance on the suppressor grid of this tube of a positive pulse from the dial link selector gate 50 which identifies the link with which the calling line is associated because the line finder 23 is locked thereto. The gate 134 is thus biased to conduction and amplified negative pulses appearing in its plate circuit are applied over conductor 135 to the control grid of an identification pulse tube 136 in the link circuit (Fig. 1).

Each subscriber's link is represented by an identification pulse which is long as compared with the repetition rate of the signal pulses. In the present case, it is assumed that the identification pulse is twenty times as long as the signal pulse. Therefore, twenty signal pulses will be fed over conductor 135 to the control grid of the identification pulse tube 136 (Fig. 1) while the beam of link identification pulse generator 8 is passing over the dynode representing the link with which this particular tube 136 is associated. The cathode output of the identification pulse tube 136, and of each such identification pulse tube associated with the other links, is fed over conductor 137 to the control grid of an inverter 138, and the positive pulses appearing in the plate circuit of the inverter are compared with the positive pulse output of the dial pulse gate 48 (Fig. 2) in a gate tube 139.

Whenever the identification pulse generator 8 engages the dynode of the selected link, the positive pulses will appear at the same time in the control and suppressor grids of the identification pulse gate 139 because the control and suppressor grids of dial pulse gate 48 are appropriately pulsed over conductors 22 and 68. While the link identification pulse persists, gate 139 will pass a signal over an integrating network to the control grid of identification control tube 140 which is normally conducting. The integrated signal will flip conduction to tube 141 and, when the signal ceases, the action will be reversed. The resultant output of the identification control circuit 140, 141 will be applied to the control grid of the selection pulse gate 124 which, as above stated, will compare it with the signal received in position 4 of the switching tube 12 (Fig. 3).

We have seen that the selection synchronizing control circuit (Fig. 5) receives the output of the pentode 128 which compares the pulses produced by the selection pulse gate 124 (Fig. 2), received via 126, with the pulses produced by the generator 8 (Fig. 1). The two triodes 142 and 143 (Fig. 5) of the selection synchronizing control are connected in a flip-flop circuit.

The cathode of the selection synchronizing gate 128 is fed with pulses generated in a 200-kc. lock-in oscillator 144 (Fig. 5). The lock-in oscillator 144 operates in a manner similar to the lock-in oscillators 26 and 53 of the line and link finder circuits. Its frequency is slightly less than that of the master oscillator 27 so that there is a drift between the two. The output is divided to 50 kc. and is fed through a clipper and differentiating circuit 145, a 10-kc. synchronizing multi-vibrator 146, and a differentiating network 147 to the control grid of a clipper gate tube 148. The leading edge of the differentiated 10-kc. pulses are clipped and amplified in this tube, and the trailing edge is suppressed, generating in the plate output of 148 a negative selection pulse of approximately five microseconds duration. These pulses are passed by a cathode follower 149 to the cathode of the selection synchronizing tube 128.

Three signals will, therefore, be applied to the selection synchronizing gate 128, i. e. (1) negative pulses applied from the lock-in oscillator 144 to the cathode, (2) positive pulses applied to the control grid in position 4 of the switching tube 12 via 124, 126 and conductor 127, and (3) positive pulses applied to the suppressor grid from the dynode of the pulse generator 8 via conductor 129. When these three signals occur simultaneously, then a negative plate signal is passed to the rectifier 130 which builds up a potential on the control grid of 142 to flip the conduction to the normally non-conducting tube 143. This, in turn, puts out a negative pulse which flips conduction from a tube 150 to tube 151 in a selection gate control flip-flop circuit. The latter biases the control grid of a lock-in gate tube 152 which, through a phase correcting network 153, synchronizes the lock-in oscillator 144 with the master oscillator 27 which is connected with the suppressor grid of the lock-in gate 152 over a conductor 154 which is multiplied to the conductors 38 (Fig. 1) of all the links.

Thus, the negative called line gate pulses are produced in the output of the clipper gate 148 in the same manner as was described in connection with the clipper gates 57 and 80 of the line and link finder circuits. These negative pulses are not only passed through the cathode follower circuit of 149 but are also inverted by this tube and applied to the control grid of a called line control tube 155 whose suppressor grid is biased to conduction by the selection gate control circuit 150, 151. Whenever 155 passes a negative pulse over its plate circuit and a conductor 156 to the control grid of a called gate control tube 157 (Fig. 4), then this tube will open the input gate 158 and the output gate 159 in the talking equipment as will be explained below.

The selection gate control circuit 150, 151 (Fig. 5) also applies a bias potential to the suppressor grid of the dial link selector gate 50 to cut off the selecting signals which this gate applied over conductor 51 to the dial link make-busy tube 52. Therefore, the application of positive pulses over conductor 68 will also cease, and the dial link line finder gate 59 (Fig. 2) and associated equipment will release. When the sending of negative pulses from the plate of the dial link finder tube 59 ceases, then the gate control 63 and the release control or delayed gain tube 60 again become conducting. 63 will first cut off the lock-in gate 64 so that the associated oscillator 53 may again drift in time. The release control tube 60 causes the sending of a pulse from the plate of the associated tube 67 which is applied over conductor 160 to the control grid of a triode 161 (Fig. 3) for restoring to normal the beam switching tube 12. The pulse is applied also over conductor 162 to the control grids of the release tubes 163 and 164 (Fig. 6) to control the restoration to normal of the beams of the group and unit digit registers, respectively.

The dial link and associated register may now be used for the building of another connection.

When the lock-in gate 152 (Fig. 5) functions, the pulses from the selection synchronizing control 142, 143, which flips the selection gate control 150, 151, flips also the ringing gate control circuit comprising triodes 165, 166. Normally 166 is triggered so that 165 conducts and biases ringing gate control tube 167 which permits ringing signals to pass from ringing oscillator 168 over conductor 169 to the control grid of output gate 159. Through 159 the signal passes via an am-

plifier 170, conductor 171, to the control grid of the sending distributor 8. The distributor is normally cut off by the bias on its grid so that a signal applied thereto over conductor 171 drives it to conduction only when its beam passes the dynode in which the called line terminates. The modulation applied by the ringing oscillator 168 to the signal pulses actuates a gas relay in the subset of the called subscriber which, in turn, operates a visual or audible signal.

When the called subscriber answers, the receiving distributor will, when passing the dynode in which the called line terminates, generate pulses in the same manner as was described in connection with the initiation of a call from the calling line. These pulses will be passed through the cathode follower 21 and conductor 47 to the control grid of the input gate 158. The input gate will, therefore, be opened only during the called line period by the pulses applied to its suppressor grid from the called gate control tube 157. The application of the signals will continue until the ringing gate control circuit is flipped from 165 back to 166 and cuts off the ringing gate tube 167. The application of the ringing current to the called line will then stop.

Conversation may now take place between the calling and called lines. The talking channel may be traced from the calling line dynode in the receiving distributor 7, the anode 17 of this distributor, the cathode follower and inverter 18, the clipper amplifier 20, the cathode follower 21, conductor 47, the input gate 44 in the associated line finder link, and thence through a low pass filter 172, the output gate 159, amplifier 170, conductor 171, to the grid of the sending distributor 6 and the dynode in which the called line terminates, and thence through the hybrid coil 2 in the called line to the called subset. The channel in the opposite direction is the same, except that it is effective when the beam of the distributor 7 passes over the dynode of the called line, and the beam of the distributor 6 passes over the dynode of the calling line, and the gate timing is controlled by 158 and 45 over a low pass filter 173.

When the called subscriber answers, no new call will be initiated because a busy pulse shaper 175 (Fig. 1) will apply positive pulses to the grid of busy gate 176 when it receives negative pulses over conductors 177 and 156 from the called line control gate 155 (Fig. 5). Busy gate 176 will, therefore, apply negative pulses to conductor 24 which prevent the operation of any line finder gate 23. The positive pulses from the shaper 175 are applied also to the suppressor grid of busy test tube 116 with consequences already explained.

Upon the termination of the conversation, both parties hang up. Since pulses are no longer generated for the calling line in the receiving distributor 7, the subscriber's link will be released. In the line finder circuit the lock-in gate control tube 36 (Fig. 4) will again become conductive and render conductive the delayed gain tube 33 which will cut off the release tube 40 and cause the sending of a negative pulse over conductor 174 to the selection gate control circuit 150, 151 (Fig. 5), restoring it to normal with 151 conducting.

The lock-in gate 152 and the dial link selector gate 50 are then restored to normal and the subscriber's link is prepared to receive the next call.

What I claim is:

1. In a telephone exchange system, a plurality of numerically designated lines, a calling device

for each line operable in accordance with the number of the called lines, a cathode ray tube having electrodes in which said lines terminate, means for causing the beam of said tube to sweep over said electrodes, a plurality of normally inactive electronic line finders, a link associated with each line finder, means responsive to the initiation of a call for actuating a line finder to connect the calling line with the associated link whenever the beam of the tube engages the terminals of the line, a normally inactive electronic selector for each link, impulse responsive means variably operated under the control of the calling device for controlling said selectors, and means for actuating the selector of the selected link whenever the beam of the tube engages the terminals of the called line.

2. The system according to claim 1, and means operable when the called line answers for releasing the impulse responsive means.

3. The system according to claim 1, means associated with each selector for signaling the called line, and means jointly controlled by the impulse responsive means and the called line for operating the last-mentioned means.

4. The system according to claim 1, and electronic means for associating the impulse responsive means with the link of the actuated line finder.

5. The system according to claim 1, electronic switching means for each line finder to establish two-way talking connection over the associated link, and means jointly controlled by the actuated line finder and selector for actuating the switching means whenever the beam of the tube sweeps over the terminals of the calling and called lines.

6. In a telephone exchange system, a plurality of numerically designated lines, a calling device for each line operable in accordance with the number of the called line, a cathode ray tube having electrodes in which said lines terminate, means for causing the beam of said tube to sweep over said electrodes, a plurality of normally inactive electronic line finders, a link associated with each line finder, means responsive to the initiation of a call for actuating a line finder whenever the beam of the tube engages the terminals of the calling line, a normally inactive electronic selector for each link, normally inactive means variably operated under the control of the calling device and controlling said selectors, means for associating the last-mentioned means with the selected link, and means for actuating the selector of the last-mentioned link whenever the beam of the tube engages the terminals of the called line.

7. In a telephone exchange system, a plurality of numerically designated lines, a calling device for each line operable in accordance with the number of the called line, a cathode ray tube having electrodes in which said lines terminate, means for causing the beam of said tube to sweep over said electrodes, a plurality of normally inactive electronic line finders, a link associated with each line finder, means responsive to the initiation of a call for actuating a line finder to connect the calling line with the associated link whenever the beam of the tube engages the terminals of the line, a normally inactive electronic selector for each link, a plurality of registers variably operable under the control of a calling device and controlling said selectors, an electronic link finder associated with each register means for actuating a link finder for connecting the associated register with the link of the actuated line finder, and means controlled by the actuated register for ac-

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tuating the selector of the link of the actuated line finder whenever the beam of the tube engages the terminals of the called line.

8. The system according to claim 7, and in which the link finder comprises a normally blocked electric discharge device having anode, cathode and grid electrodes, a grid circuit for said device controlled by the actuated line finder, an oscillator associated with the link finder, means for synchronizing said oscillator with the sweep of the cathode ray tube beam, and means operative thereupon for passing a pulse to the anode of the discharge device to complete the connection of the calling line and a link finder with the selected link.

9. The system according to claim 7, and means controlled by the actuated selector for releasing the actuated link finder and associated register.

10. The system according to claim 7, and in which the link finder is a discharge device having a control electrode, and a circuit for said control electrode controlled by the selector of the selected link.

11. The system according to claim 7, and in which the selector comprises a normally blocked electric discharge device, having anode, cathode and grid electrodes, a grid circuit for said device controlled by the actuated line finder, an oscillator associated with the selector, means for synchronizing said oscillator with the sweep of the cathode ray tube, and means operative thereupon for passing a pulse to the anode of the device to complete the connection of the selected link over the selector to the called line.

12. The system according to claim 7, and in which the selector comprises a normally blocked electric discharge device, having anode, cathode and grid electrodes, a grid circuit for said device controlled by the actuated line finder, an oscillator associated with the selector, means for synchronizing said oscillator with the sweep of the cathode ray tube, and means operative thereupon for passing a pulse to the anode of the device to complete the connection of the selected link over the selector to the called line, and means operative thereupon for releasing the actuated dial link and associated register.

13. The system according to claim 7, and in which the link finder comprises a normally blocked electric discharge device having anode, cathode and grid electrodes, a grid circuit for said device controlled by the actuated line finder, an oscillator associated with the link finder, means for synchronizing said oscillator with the sweep of the cathode ray tube beam, and means operative thereupon for passing a pulse to the anode of the discharge device to complete the connection of the calling line and a link finder with the selected link, a normally inoperative pulse receiver in the register responsive to the operation of the calling device, and means actuated upon the synchronization of said oscillator for rendering said pulse receiver operative.

14. The system according to claim 7, and in which the selector comprises a normally blocked electric discharge device, having anode, cathode and grid electrodes, a grid circuit for said device controlled by the actuated line finder, an oscillator associated with the selector, means for synchronizing said oscillator with the sweep of the cathode ray tube, and means operative thereupon for passing a pulse to the anode of the device to complete the connection of the selected link over the selector to the called line, a normally inoperative switching means associated with

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the operated line finder for establishing a talking circuit to the called line, and means actuated upon the synchronization of said oscillator for rendering said switching means operative.

15. In a telephone exchange system, a plurality of numerically designated lines, a calling device for each line operable in accordance with the number of the called line, a first cathode ray tube having electrodes in which said lines terminate, means for causing the beam of said tube to sweep over said electrodes, a plurality of normally inactive electronic line finders, a link associated with each line finder, means responsive to the initiation of a call for actuating a line finder to connect the calling line with the associated link whenever the beam of the tube engages the terminals of the line, a normally inactive electronic selector for each link, register means variably operated under the control of the calling device for controlling said selectors, a second cathode ray tube having an electrode for each link and means for causing its beam to sweep over the electrodes in a predetermined relationship to the sweep of the first tube, and means for actuating the selector of the link connected with the calling line whenever the beam of the first tube engages the terminals of the called line and the beam of the second tube sweeps over the electrode of the selected link.

16. The system according to claim 15, and in which the last-mentioned means for actuating the selector comprises means controlled by the first tube for producing signal pulses of a certain duration, and means controlled by the second tube for producing link identification pulses of longer duration.

17. The system according to claim 15, and in which the last-mentioned means comprises a multi-electrode discharge device having an output circuit controlling the actuating of the selector, an oscillator for applying potentials to one electrode of the device at a rate corresponding to the sweep of the first tube, a circuit for applying potentials to a second electrode of the device controlled by the register means, and a circuit for applying potentials to a third electrode of said device controlled by the second cathode ray tube.

18. In a telephone exchange system, a plurality of numerically designated lines, a calling device for each line operable in accordance with the number of the called line for controlling the setting up of a connection, a cathode ray tube having electrodes in which said lines terminate, means for causing the beam of said tube to sweep over said electrodes, a plurality of normally inactive electronic line finders, a link associated with each line finder, means responsive to the initiation of a call for actuating a line finder to connect the calling line with the associated link whenever the beam of the tube engages the terminals of the line, a normally inactive electronic selector for each line, normally inactive register means variably operated under the control of the calling device for controlling said selectors, means for seizing and connecting the register means with the selected link, means operative thereupon for preventing the seizure of the register means by another calling line, and means for actuating the selector of the selected link whenever the beam of the tube engages the terminals of the called line.

19. The system according to claim 18, and means operable upon the actuation of said selector for releasing the register means.

20. In a telephone exchange system, a plurality

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of numerically designated lines, a calling device for each line operable in accordance with the number of the called line, a cathode ray tube having electrodes in which said lines terminate, means including a master oscillator for causing the beam of said tube to sweep over said electrodes, a plurality of normally inactive electronic line finders, a link associated with each line finder, a first oscillator associated with each line finder, means responsive to the initiation of a call for actuating a line finder, means operative thereupon for synchronizing the first oscillator of the actuated line finder to connect the calling line with the associated link whenever the beam of the tube engages the terminals of the line, a normally inactive electronic selector for each link, a plurality of registers variably operable under the control of the calling device and controlling said selectors, a link finder for each register, a second oscillator associated with each link finder, means operable upon the synchronization of the first oscillator for operating a link finder, means operative thereupon for synchronizing the second oscillator of the operated link finder with the master oscillator, a third oscillator for each selector, and means for synchronizing the third oscillator of the selector of the selected link with the master oscillator.

21. In a telecommunication system, a plurality of lines, an exchange at which said lines terminate and comprising links over which calling and called lines may communicate, means for establishing cyclically recurring time channels during which a calling line may utilize a link, a selector for each link, means at the exchange including

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a register common to said links for operating the selector of the link taken into use by the calling line to connect the called line therewith, means operable upon the completion of connection for releasing the register, and means operable upon the termination of the communication for releasing the line finder and selector employed therein.

22. The system according to claim 21, and in which each link has a line finder for connecting it with the calling line during a time channel.

23. The system according to claim 21, a line finder for each link, means operative upon the initiation of a call for connecting the line finder of a link to connect it with the calling line during a time channel reserved for the calling line, and means controlled by the register for operating the selector of the link taken into use to connect it with the called line during a time channel reserved for the latter.

24. The system according to claim 23, and means associated with the link for delaying communication signals from one of the interconnected lines until the occurrence of the time channel reserved for the other line.

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