Dec. 17, 1946. J. R. WILKERSON 2,412,642

ELECTRONIC TELEGRAPH TRANSMITTER DISTRIBUTOR

Filed Aug. 25, 1943 2 Sheets-Sheet 1

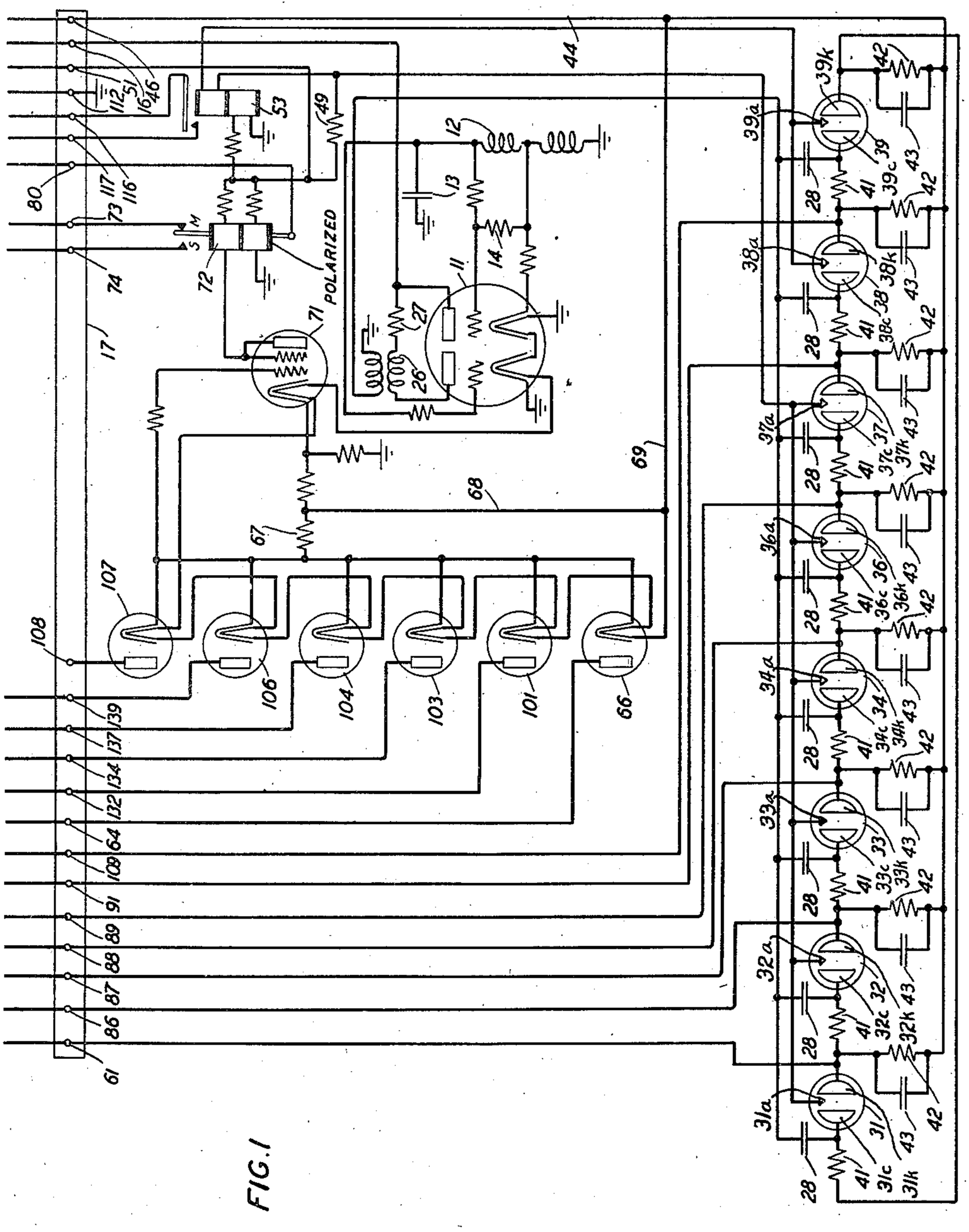

FIG. 1

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ELECTRONIC TELEGRAPH TRANSMITTER DISTRIBUTOR

Filed Aug. 25, 1943 2 Sheets-Sheet 2

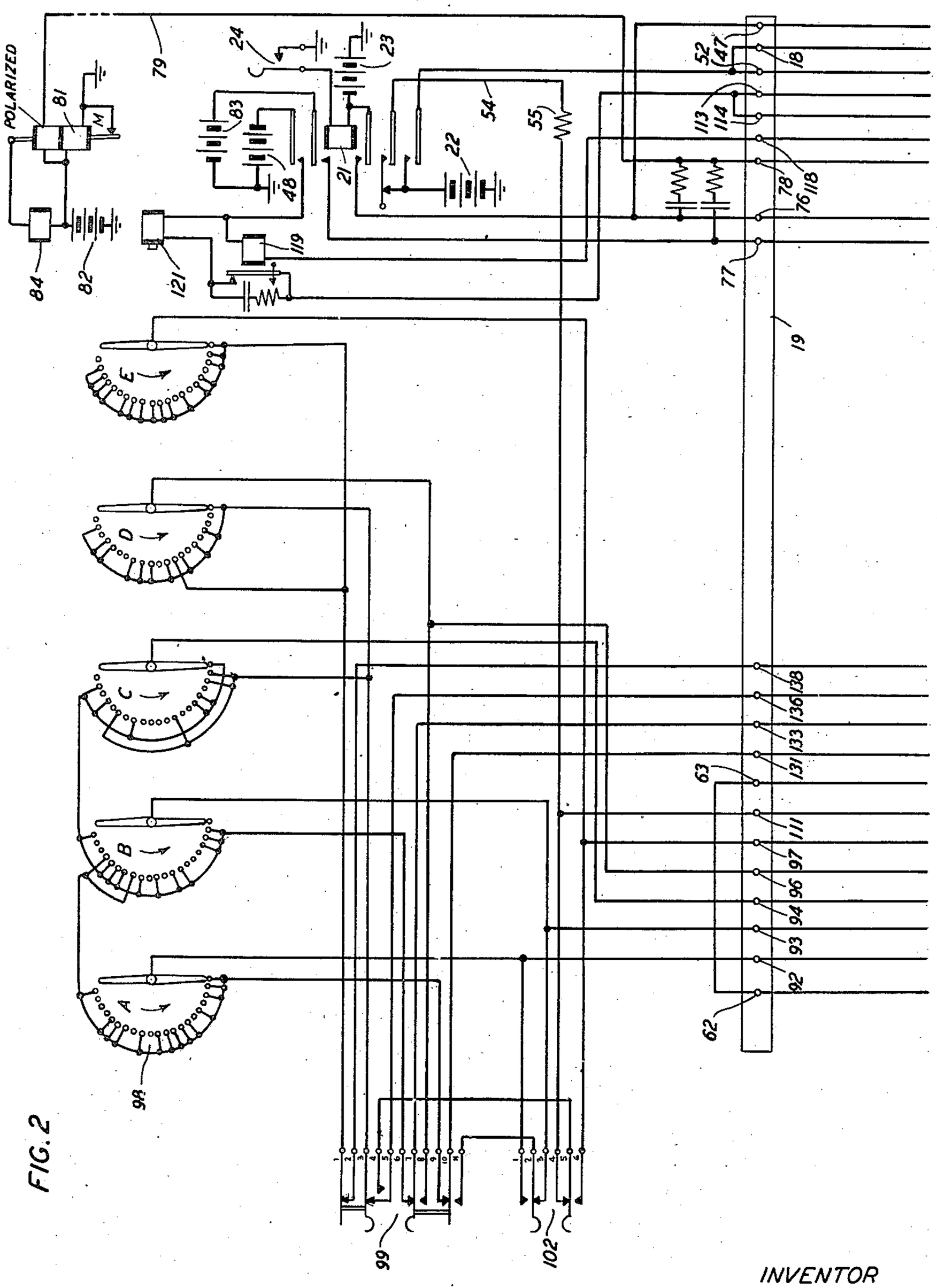

FIG. 2

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UNITED STATES PATENT OFFICE

2,412,642

ELECTRONIC TELEGRAPH TRANSMITTER DISTRIBUTOR

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Application August 25, 1943, Serial No. 499,949

24 Claims. (Cl. 178—69)

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This invention relates to telegraph transmitters and particularly to start-stop permutation code signal generators and transmitters.

An object of the invention is to generate and transmit permutation code signals without employing an electromechanical distributor.

Another object of the invention is to time the generation of telegraph signal impulses by means of an electronic generator of oscillatory current.

Another object of the invention is to effect the transmission of successive code impulses by means of a counting chain of electron discharge tubes.

Another object of the invention is to provide a counting chain of electron discharge devices in which each of said devices is primed by the electron discharge device preceding it and in which each such device upon being rendered conductive quenches any other of said devices that is then conductive.

The invention features cold cathode electron discharge tubes as the impulse counting elements of the counting chain.

The invention also features half-wave rectifiers of the electron discharge type controlled in succession by the counting chain and selectively in accordance with the impulse elements of signaling codes for controlling the generation of telegraph code signals.

According to the embodiment of the invention to be described hereinafter in detail, an electron discharge tube oscillator circuit continuously generates oscillatory current, the cycles of which are equal in length to telegraph signaling impulses of the permutation code type. An electron discharge tube arranged in a detector circuit is associated with the oscillator circuit to produce momentary impulses at the rate of one impulse per cycle of oscillatory current generated by the oscillator. The function of these impulses is to time the beginning of each telegraph code impulse to be transmitted.

A counting chain of cold cathode electron discharge tubes is provided comprising one tube to control the generation of a start impulse, one tube for each of the significant impulses of the telegraph code signals to be transmitted, which in the case of the present embodiment of the invention is a five unit code, wherefore five such tubes are provided, and one or two tubes for the stop impulse, depending upon whether that impulse is to have a duration equal to the duration of the start impulse and the significant code impulses or is to be longer than unit length. Each of the counting tubes has its cathode connected through a resistor to the control anode of the tube following it in the chain and the start tube has its control anode connected through a resistor to the cathode of the last stop tube so that the counting chain is in reality a closed ring circuit. The main anode of each of the tubes in the counting chain is connected to a common source of positive potential and the cathodes of the tubes are connected through individual cathode resistors shunted by condensers to a common negative source of potential. When any one of the tubes is conductive, current flows in its cathode resistor so that its cathode is at a more positive potential than the cathodes of all others of the tubes. When the next tube in the chain is rendered conductive, the condenser shunted across its cathode resistor absorbs the initial current in being charged, so that the development of a potential difference across the cathode resistor is delayed. It is a characteristic of cold cathode electron discharge tubes that upon the establishment of a discharge between the cathode and main anode of the tube, the potential existing between said cathode and main anode decreases from the firing potential to the discharge sustaining potential, and since in the present circuit the main anodes of all of the tubes are connected to the same source of positive potential, the potential difference between the main anode and the cathode in each of the tubes undergoes a like decrease. This collapsing of the potential difference between the main anode and cathode occurs before the cathode condenser has become charged and therefore before a normal potential difference has been developed across the cathode resistor. In the case of the tube which had previously been conductive, the cathode is more positive than the cathodes of the other tubes including that of the tube just fired, and therefore the potential difference between the main anode and the cathode in the tube previously conductive, upon decreasing becomes less than the discharge sustaining potential so that the tube becomes extinguished. After the cathode condenser associated with the tube which has just been fired becomes fully charged, a normal potential difference appears across the cathode resistor of that tube so that the potential difference between the main anode and cathode of the tube plus the potential difference across the cathode resistor is equal to the potential of the external power source and the potential of the cathode is more positive than the potential of the cathodes in the other tubes. With this arrangement involving individual cathode resistors and shunting condensers for the tubes and common

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connection of the main anodes of all of the tubes to the external source of power without individual anode circuit resistors, each tube upon being fired quenches any tube which has previously been conductive.

The control anode of each of the tubes is connected through an individual condenser to the secondary winding of a transformer, the primary of which is included in the output circuit of the previously described detector. Thus the potential resulting from an impulse produced by the detector for each cycle of the oscillator is impressed through the individual condensers upon the control anodes of all of the tubes simultaneously. However, only one tube is fired upon the production of any such impulse, such tube being the one that is primed due to the fact that the tube preceding it in the chain is then conductive.

The cathode of the counting tube which is identified with the start impulse is connected to the anode of a diode or half-wave rectifier tube. The cathodes of the five counting tubes identified with the five significant impulses of a code combination are connected to individual contact arms of a stepping switch which has five banks of contacts. The contacts of the several banks are connected in various combinations, according to permutation code combinations representing a fixed or predetermined message to be repetitiously transmitted, to the anodes of other diode tubes. For each position of the contact arms of the stepping switch, conductive paths from the cathodes of the five counting tubes pertaining to the significant code impulses to the anodes of the diode tubes are selectively provided or omitted according to the code combination to be transmitted. Thus as each counting tube becomes conductive and the potential of its cathode becomes more positive, the potential of the diode tube anode to which it is connected if the stepping switch provides such connection will be rendered more positive and the diode tube will be rendered conductive. In the case of the counting tube identified with the start impulse, its cathode is permanently connected to the anode of a diode tube and such tube is invariably rendered conductive.

The cathodes of all of the diode tubes are connected to the control grid of an amplifier tube, the output circuit of which includes the operating winding of a transmitting relay which is biased to drive its armature to the marking contact in the absence of current in its operating winding. As any one of the diode tubes becomes conductive, the potential of its cathode becomes more positive by virtue of the potential difference developing across a cathode resistor common to all of the diode tubes and thus the grid of the amplifier tube is made more positive and the tube is rendered conductive. The anode current in the amplifier tube energizes the operating winding of the transmitting relay and drives the armature to spacing. The armature of the transmitting relay is connected to a telegraph line over which the signals are to be transmitted and the marking and spacing contacts are connected to marking and spacing potentials respectively. From this it will be apparent that a spacing condition is represented by conductivity of one of the diode tubes and conductivity of the amplifier tube and that a marking condition is represented by non-conductivity of a diode tube and the amplifier tube, the transmitting relay being operated to marking by its biasing winding. Since the stop condition is invariably marking, and neither the amplifier tube nor a diode tube is to be operated to produce a marking signal, the counting tubes identified with the stop impulse have no connection to a diode tube.

The anode circuit of the two counting tubes identified with the stop impulse includes the operating winding of a relay which controls the stepping magnet of the stepping switch to step the switch contact arms and set up a new code to be transmitted. This function takes place during the transmission of the stop impulses, so that the positions of the contact arms of the stepping switch are not disturbed during the transmission of the significant impulses of a code combination.

For a complete understanding of the invention, reference may be had to the following detailed description to be interpreted in the light of the accompanying drawings wherein:

Fig. 1 is a schematic circuit view showing the impulse timing and generating apparatus according to the present invention; and

Fig. 2 which is complementary to Fig. 1 and is to be positioned above Fig. 1 is a schematic circuit view showing the power supply connections, line connections and code storage mechanisms.

Referring now to the drawings and particularly to Fig. 1, the reference numeral 11 designates an electron discharge tube of the vacuum type comprising two triode sections in one envelope which serve as oscillator and detector. It will be understood that two single triode tubes could be employed, if desired, instead of one double triode tube. The right-hand triode section of the tube is the oscillator section and the upper portion of a tapped inductance 12 is connected between the control grid and the cathode of the right-hand triode section of the tube. The lower portion of the inductance 12 is connected between the cathode and ground. A condenser 13 is connected in parallel with the inductance 12 and the inductance 12 and condenser 13 have such inductive and capacitative values respectively that the resonance frequency of the network is equal to the impulse frequency of telegraph signals to be transmitted, from which it follows that the duration of one cycle of the frequency to which the network is tuned is equal to the duration of one impulse to be transmitted. A leakage resistor 14 is connected between the control grid and the cathode of the right-hand triode section. The anode is connected to terminal 16 of a terminal block 17 which in turn is connected to terminal 18 of a terminal block 19 in Fig. 2. Terminal 18 of the terminal block 19 is connected to the outer lower armature of a relay 21, the outer lower front contact of which is connected to positive battery 22. Relay 21 is energizable over a circuit including a battery 23 and a manually operable locking key 24. Relay 21 is operable to establish all power connections to the apparatus shown in Figs. 1 and 2 and when relay 21 is energized, the positive terminal of battery 22 is connected to the anode of the right-hand triode section of tube 11. Since the lower section of inductance 12 is connected in the cathode return circuit of the right-hand triode section of tube 11, it serves to induce energy into the upper section of the inductance and thus to sustain oscillation so that with relay 21 energized, the right-hand triode section of tube 11 oscillates continuously at the frequency to which the network comprising inductance 12 and condenser 13 is tuned.

The grid of the left-hand detector section of tube 11 is connected to the upper terminal of inductance 12 so that the potential of the grid of the left-hand triode section is varied in accordance with the oscillatory operation of the network comprising inductance 12 and condenser 13. The cathode of the left-hand triode section is connected to ground and the anode is connected to terminal 16 of terminal block 17 through the primary winding of a transformer 26 in series with a load resistor 27. During the portion of each cycle of oscillation in which the upper terminal of inductance 12 is positive with respect to ground, the grid of the left-hand triode section will be positive with respect to the cathode of the tube and the tube will be conductive. During the rising portion of the positive half cycle, a voltage at one polarity is induced in the secondary winding of transformer 26 and during the falling portion of the half cycle, a voltage of the opposite polarity is induced in the secondary. During the negative half cycle, no voltage of any significance is induced in the secondary winding of transformer 26 because the grid of the left-hand or detector section of tube 11 is negative with respect to the cathode and little or no anode current flows, depending upon whether anode current is actually cut off. The secondary of transformer 26 has one terminal connected to ground and the other terminal connected through eight condensers 28 in parallel to the control anodes 31*c*, 32*c*, 33*c*, 34*c*, 36*c*, 37*c*, 38*c* and 39*c* of eight gas-filled cold cathode discharge tubes designated by the reference numerals 31, 32, 33, 34, 36, 37, 38 and 39.

The cathode 31*k* of tube 31 is connected through a resistor 41 to the control anode 32*c* of tube 32. The cathode 32*k* of tube 32 is connected through a similar resistance 41 to the control anode 33*c* of tube 33. In like manner the cathodes 33*k*, 34*k*, 36*k*, 37*k* and 38*k* of the tubes 33 to 38, inclusive, are connected through individual resistors 41 to the control anodes 34*c*, 36*c*, 37*c*, 38*c* and 39*c* of the tubes 34, 36, 37, 38 and 39, respectively. Finally, the cathode 39*k* of tube 39 is connected through a resistor 41 to the control anode 31*c* of tube 31. Thus there is a closed ring of interconnections between the cathodes and control anodes of the eight cold cathode tubes. The cathode of each of the cold cathode tubes is also connected through an individual resistor 42 shunted by an individual condenser 43 to a conductor 44 which extends to terminal 46 of terminal block 17. Terminal 46 of terminal block 17 is connected to terminal 47 of terminal block 19 from which a conductor extends to the inner lower front contact of relay 21, the inner lower armature of which is connected to the negative terminal of battery 23. The positive terminal of battery 23 is grounded. The main anodes 31*a*, 32*a*, 33*a*, 34*a*, 36*a* and 37*a* of tubes 31, 32, 33, 34, 36 and 37 are connected to one terminal of a resistor 49, the other terminal of which is connected to terminal 51 of terminal block 17. This terminal is connected to terminal 52 of terminal block 19 which in turn is connected to terminal 18 which receives connection from the positive terminal of battery 22 through the outer lower armature and front contact of relay 21. The main anodes 38*a* and 39*a* of the tubes 38 and 39 are connected through the operating winding of a relay 53 to the same terminal of resistor 49 to which the main anodes of tubes 31 to 37, inclusive, are directly connected. Thus the resistor 49 is common to the anode circuits of all of the tubes.

Upon the closure of manually operable key 24, relay 21 operates and connects the batteries for operating tube 11 and the cold cathode tubes. The right-hand triode of tube 11 at once begins to oscillate at the desired frequency and the detector section of the tube 11 generates one positive and one negative impulse in the secondary of transformer 26 during each positive half-cycle of oscillation of the oscillator section of tube 11. These potentials are applied through all of the condensers 28 simultaneously to the control anodes of the eight cold cathode tubes. As a result of each positive impulse, the control anode of each of the cold cathode tubes is made more positive with respect to the cathode than it previously was. However, the potential of such positive impulse is insufficient to fire the cold cathode tubes.

It is necessary to prime one of the tubes in order to set the counting chain in operation, and for this purpose the middle lower armature and make-before-break contact combination of relay 21 is employed. The armature is connected through conductor 54, resistor 55, terminals 111 and 109 of terminal blocks 19 and 17 to the left-hand terminal of the resistor 41 connected between cathode 38*k* of tube 38 and control anode 39*c* of tube 39. The make-before-break front contact is left unconnected, and the stationary contact with which it cooperates is connected to the positive terminal of battery 22. When relay 21 is operated, there is an instant when the middle lower armature of relay 21 has engaged the movable front contact and has not disengaged it from the stationary contact. During this instant battery 22 is connected over the path extending from the middle lower armature and applies a positive pulse to the control anode of tube 39 which fires the tube. The discharge transfers to the main gap, and as the middle lower armature of relay 21 completes its operation the battery 22 is disconnected from the control anode 39*c* of tube 39. The firing potential could be applied to any one of the cold cathode tubes, but when applied as hereinbefore described, it avoids starting the counting chain in the middle of a cycle. The discharge current in tube 39 flows through the cathode resistor 42 associated with the cathode 39*k* of the tube and raises the potential of the cathode with respect to the cathodes of all of the other cold cathode tubes, since no current is flowing in their cathode resistors 42. Since the control anode 31*c* of tube 31 is connected to the cathode 39*k* of tube 39 through resistor 41, the potential of the control anode 31*c* of tube 31 is made correspondingly more positive than the cathode 31*k* of that tube but this increase in potential is a priming potential only and is insufficient to fire tube 31. The condition now existing is that tube 39 is conductive and tube 31 is primed. Upon the production of the next positive impulse in the secondary of transformer 26, the positive voltage is impressed upon the control anodes of all of the tubes through condensers 28. In the case of tube 31 this positive potential further raises the potential of the control anode 31*c* with respect to the cathode 31*k* and tube 31 fires, the discharge transferring at once to the main anode 31*a*. None of the tubes 32 to 38 is fired because they are not primed.

The initial space current in tube 31 does not immediately develop a potential difference across the cathode resistor 42 associated with that tube,

as the current flows to charge condenser 43 which delays the development of full potential difference across the cathode resistor 42 with which the condenser is associated. Thus even though tube 31 is conductive between its cathode and main anode, there is a momentary interval during which the cathode 31*k* remains at substantially the same potential as the cathodes of all of the other tubes except tube 39, the cathode 39*k* of which is more positive than the cathodes of the non-conductive tubes because the condenser associated with its cathode resistor has become charged by this time and there is a potential difference across its cathode resistor. It is a characteristic of cold cathode gas-filled electron discharge tubes that as soon as the tube becomes conductive in its main gap, the potential difference between the main anode and the cathode decreases to the discharge sustaining potential which is considerably less than the potential difference which must exist between the main anode and the cathode in order to establish a discharge between those electrodes. Since the main anode 31*a* of tube 31 is connected directly to the main anodes of tubes 32, 33, 34, 36 and 37, and is connected to the main anodes of tubes 38 and 39 through the winding of relay 53, which is a low resistance winding, the potential difference between the main anode and the cathode of each of these other tubes is correspondingly decreased. The decrease occurs as a lowering of the anode potentials with respect to the cathodes, because all of the cathodes momentarily remain at the same potentials, while the drop across anode resistor 49 increases due to the anode current of tube 31 added to that of tube 39. The potential difference between the main anode 39*a* and the cathode 39*k* of tube 39 at this time is less than the potential difference between the main anode and cathode of any other tube due to the potential difference across the cathode resistor 42, associated with tube 39, and the decrease in potential difference as tube 31 adjusts itself to the steady operating condition reduces the potential difference in tube 39 below the discharge sustaining potential. This causes tube 39 to be quenched. Thereafter the potential difference across the main gap of tube 39 increases as the drop across anode resistor 49 is decreased due to cutting off of the anode current through tube 39, as the condenser 43 associated with its cathode resistor discharges through the cathode resistor and as the condenser 43 associated with the cathode resistor 42 of tube 31 charges through the main gap of tube 31. The value of these condensers is so chosen as to allow the extinguished tube time in which to deionize before the voltage across its main gap rises to the full value. As the condenser associated with the cathode resistor 42 of tube 31 becomes charged, the voltage across the cathode resistor rises to a value which is the difference between the discharge sustaining potential across the main gap of the tube and the voltage across resistor 49 and batteries 22 and 23 in series. Had any other tube or tubes than the tube 39 been conducting at the time that tube 31 was fired the voltage across the main gap of such other tube or tubes would have decreased below the discharge sustaining potential and such tube or tubes would have been extinguished in the same manner that tube 39 was extinguished. In this way the circuit is so arranged that any tube upon being rendered conductive quenches the tube preceding it in the chain or any other tube that may have been conducting at that time.

With the development of a voltage across the cathode resistor 42 associated with tube 31, the tube 32 is primed by having the potential of its control anode 32*c* raised above the potential of its cathode 32*k* to the same potential as the cathode 31*k* of tube 31. The next positive impulse generated in the secondary of transformer 26 and applied through all of the condensers 28 will cause tube 32 only to become conductive and this tube in becoming conductive will quench tube 31 in the same manner that the tube 31 quenched tube 39. As the detector section of tube 11 continues to generate impulses the cold cathode tubes are fired in succession and when tube 39 is fired, it primes tube 31 by virtue of the connection between the cathode 39*k* of tube 39 and the control anode 31*c* of tube 31. From this it will be apparent that the counting chain of cold cathode gas-filled tubes goes through repeated cycles of counting operations as long as power remains connected to the oscillator and rectifier tube 11 and to the cold cathode tubes. In each cycle of the chain of cold cathode tubes, eight intervals are counted. The interval between the firing of tube 31 and the firing of tube 32 is allotted to the start impulse, the interval between the firing of tube 32 and the firing of tube 33 is identified with the first code impulse, the interval between the firing of tube 37 and the firing of tube 38 is identified with the fifth code impulse and the interval between the firing of tube 38 and the refiring of tube 31 is identified with the stop impulse which has a duration twice as great as the start impulse and the code impulses by virtue of the provision of the two tubes 38 and 39.

There is a connection from the cathode 31*k* of tube 31 to terminal 61 of terminal block 17 which is connected to terminal 62 of terminal block 19. Terminal 62 of terminal block 19 is strapped to terminal 63 of the same block which in turn is connected to terminal 64 of terminal block 17. Terminal 64 is connected to the anode of an electron discharge tube 66 which is a diode or half-wave rectifier tube. The cathode of diode tube 66 is connected through resistor 67 and conductors 68 and 69 to conductor 44 to which the cathodes of the cold cathode tubes are connected through their respective cathode resistors, as previously described. When tube 31 is not conductive its cathode 31*k* is at the potential of conductor 44 and the anode of rectifier tube 66 is at this potential. The cathode of tube 66 is also at the potential of conductor 44 so that no current flows in tube 66. When cold cathode tube 31 becomes conductive and its cathode 31*k* becomes more positive than conductor 44 by the potential difference across its cathode resistor 42, the anode of tube 66 becomes more positive than the cathode of that tube and tube 66 draws current.

The cathode of tube 66 is connected to the grid of electron discharge tube 71. Due to the flow of current through the cathode resistor 67 of rectifier tube 66, the cathode becomes more positive when the tube draws current than it previously was. Thus the grid of amplifier tube 71 is rendered more positive with respect to its cathode and the conductivity of amplifier tube 71 is increased. The anode of tube 71 is connected through the operating winding of a transmitting relay 72 to terminal 51 of terminal block 17 which as previously described has positive battery connection through the outer lower armature and front contact of relay 21. Relay 72 is a biased polar relay and the current through the biasing

winding is in the direction to drive the armature into engagement with its marking contact. The anode current of tube 71 flowing through the operating winding of relay 72 drives the armature to the spacing contact. The armature of relay 72 is connected to terminal 80 of terminal block 17 which is connected to terminal 78 of terminal block 19. A telegraph line 79 extends from terminal 78 of terminal block 19 to a remote station where it is connected through the operating winding of biased polar receiving relay 81 to line battery 82 which is connected in series- aiding relation to the marking battery 23 connected through the inner lower armature and front contact of relay 21, terminal 76 of terminal block 19, terminal 73 of terminal block 17 to the marking contact of relay 72, and therefore is in opposition to the spacing battery 83 connected through the inner upper armature and front contact of relay 21, terminal 77 of terminal block 19 and terminal 74 of terminal block 17 to the spacing contact of relay 72. While tube 71 is conductive, the armature of transmitting relay 72 is held on its spacing contact and no current flows in line 79 because batteries 82 and 83 are in opposition. Current through the biasing winding of relay 81 when unopposed by current through the operating winding, drives the armature away from the marking contact which is connected to ground. The armature of relay 81 is connected to battery 82 through the winding of selector magnet 84 of a receiving printer which may be of any suitable type such as the printer shown in Patent 1,904,164, granted April 18, 1933, to S. Morton et al. The disclosure of the Morton patent is incorporated herein by reference as part of the present specification. The spacing condition impressed on line 79 while rectifier tube 66 remains conductive represents the start impulse of a telegraph code signal.

The cathodes 32*k*, 33*k*, 34*k*, 36*k* and 37*k* of tubes 32, 33, 34, 36 and 37 are connected to terminals 86, 87, 88, 89 and 91, respectively, of terminal block 17. These terminals are connected to terminals 92, 93, 94, 96 and 97 of terminal block 19. Terminal 92 is connected to the double-ended contact arm associated with the bank A of a stepping switch 98 having four other banks of contacts B, C, D and E. Certain of the contacts of contact bank A of stepping switch 98 are connected to spring 9 of a key 99. Key 99 is shown in the unoperated condition, in which case spring 9 engages spring 10 which is connected through terminals 131 and 132 of terminal blocks 19 and 17, respectively, to the anode of diode tube 101 which has its cathode connected in parallel with the cathode of diode tube 66 to resistor 67 and to the grid of amplifier tube 71. Those of the contacts of stepping switch bank A that are connected to spring 9 of key 99, when engaged by the contact arm associated with bank A complete a conductive path from the cathode 32*k* of tube 32 to the anode of tube 101 and thus represent a spacing condition for the first significant impulse of various code combinations set up on the contacts of the stepping switch. The contacts of bank A which have no connection will provide no conductive path from the cathode 32*k* of tube 32 to the anode of diode 101 and therefore represent a marking condition.

Terminal 93 of terminal block 19 is connected to the contact arm associated with contact bank B and also to contact spring 3 of the key 102 which in the unoperated condition engages spring 2, which is connected to spring 11 of key 99.

Spring 11 of key 99 is not engaged by spring 10 at this time so that this path may be disregarded, the path to the contact arm associated with stepping switch bank B being the only one that is of interest at this time. Certain of the contacts of stepping switch bank B are connected along with the connected contacts of bank A to spring 9 of key 99 but it will be noted that these contacts of stepping switch bank B correspond to some but not necessarily all of the unconnected contacts of bank A. From this it will be apparent that a conductive path is extended from the cathode 33*k* of tube 33 through the contact arm associated with stepping switch bank B and springs 10 and 11 of key 99 to the anode of diode tube 101 only if no conductive path has been established from the cathode 32*k* of tube 32 through the contact arm of stepping switch bank A and springs 9 and 10 of key 99 to the anode of tube 101. Thus tube 101 may be activated to effect the generation of a spacing impulse for the second significant impulse of the telegraph code only if the first significant impulse of the code has been marking. It also follows that diode tube 101 is employed alternatively to establish a spacing condition for either the first or second significant impulse of the code. Others of the contacts of stepping switch bank B are connected to spring 6 of key 99 which engages spring 7 which in turn is connected through terminals 133 and 134 of terminal blocks 19 and 17 respectively to the anode of diode tube 103 which has cathode connections identical with those of the diode tubes 66 and 101. Still others of the contacts of stepping switch bank B have no connection to the anode of a diode tube and these contacts represent marking conditions. Thus at the several contacts of contact bank B, a conductive path may be established for activating diode tube 101 if it has not been activated from bank A, a conductive path may be established for activating tube 103 if the first and second significant impulses of the code are both of spacing nature and tube 101 had been activated from contact bank A, or no conductive path to a diode tube may be established, this being a marking condition for the second significant impulse of the code.

Terminal 94 of terminal block 19 is connected to the contact arm associated with contact bank C of the stepping switch. This bank has certain contacts connected to spring 6 of key 99 along with certain contacts of bank B as previously mentioned for completing a conductive path to the anode of diode tube 103, other contacts connected through springs 3 and 5 of key 99 which are engaged when the key is unoperated, and through terminals 136 and 137 of terminal blocks 19 and 17 respectively to the anode of diode tube 104 which has the same cathode connections as the diode tubes 66, 101 and 103, and the contact bank C has still other contacts unconnected for setting up marking conditions of the third significant pulse of telegraph signals. Terminal 96 of terminal block 19 is connected to spring 8 of key 99 which is not engaged by spring 7 when the key is in the normal condition and is also connected to the contact arm associated with the contact bank D of stepping switch 99. Certain contacts of bank D are connected to spring 3 of key 99 for establishing a conductive path to the anode of diode tube 104, other contacts are connected through springs 1 and 2 of key 99 and through terminals 138 and 139 of terminal blocks 19 and 17 respectively to the anode of diode tube 106 and still other contacts are unconnected for

setting up marking conditions for the fourth significant impulse of code combinations. Terminal 97 of terminal block 19 is connected to the contact arm associated with bank E of the stepping switch 98. Certain contacts of bank E are connected through springs 1 and 2 of key 99 to the anode of diode tube 106 and other contacts are left unconnected for setting up marking conditions as the fifth and final significant impulse of code combinations.

It will be noted that the five banks of contacts in the stepping switch are arranged to establish conductive paths to the anodes of four diode tubes 101, 103, 104 and 106. This arrangement is predicated upon the assumption that there will be no occasion to have set up in the contacts of the stepping switch the blank or all spacing combination. Should it be desired to provide for this combination as one of the codes stored in the stepping switch 98, this may be accomplished by providing two separate sets of connections from the connected contacts of contact bank E, the second set, which would be those arranged to set up a spacing condition for the five significant impulses in the all spacing combination, to establish a conductive path through additional springs of key 99 to the anode of a sixth diode tube 107 which has been provided in Fig. 1 with its anode connected to terminal 108 of terminal block 17. Since the all spacing code has not been included among the codes set up on the contacts of the stepping switch and since all other code combinations in a permutation code have at least one significant impulse of marking nature, in a five unit code the five stepping switch banks may be connected to establish conductive paths to anodes of a minimum of four diode tubes as previously described.

As each of the cold cathode tubes 32, 33, 34, 36 and 37 is rendered conductive in succession, relay 72 is operated to marking or spacing, according to the code set up at the particular position of the contact arms of stepping switch 98. Assuming that during the cycle of the chain of cold cathode tubes now under consideration, the contact arms of the stepping switch are in the positions shown, engaging the last contact of each of the contact banks, a conductive path will be completed through bank A to diode tube 101, for a spacing condition as the first significant impulse of the code, a marking condition will be established for the second impulse of the code, since the last contact of bank B is unconnected, a conductive path will be established through bank C to tube 103 for a spacing condition as the third significant impulse of the code, a conductive path will be established through contact bank D to diode tube 104 as a spacing condition for the fourth significant impulse of the code and a conductive path will be established through bank E to the tube 106 as a spacing condition for the fifth impulse of the code. Each time that a cold cathode tube from the cathode of which a conductive path had been established to the anode of a diode tube is quenched, the cathode of the cold cathode tube will return to normal potential, reducing the potential of the anode of the diode tube to that of the cathode of the tube so that the tube no longer draws current and the biasing winding of relay 72 may restore the armature to marking if the next impulse is marking. Since the cold cathode tubes fire in overlap manner, the quenching of any one occurring as a result of the firing of the one following it, the diode tubes will be operated in overlap manner in the case of two or more spacing signals in succession, such as the impulses 3, 4 and 5 stored in the last contacts of the banks of the stepping switch, so that there will be continuity between successive spacing signal impulses and the armature of transmitting relay 72 will not be operated to marking momentarily between successive spacing impulses.

Upon the firing of tube 38, tube 37 will be quenched. It will be noted that there is a connection from the cathode 38K of tube 38 through terminal 109 of terminal block 17, terminal 111 of terminal block 19, springs 4 and 5 of key 102 to spring 4 of key 99 which is engageable with spring 5 when the key is operated but which is now out of engagement with the spring. Thus no circuit is established from the cathode 38K of tube 38 to a diode tube and the armature of sending relay 72 will be operated to marking for transmission of the stop signal. The main anode circuit of tube 38 includes the operating winding of relay 53, as previously stated, so that this relay will be operated. The armature of relay 53 has a ground connection supplied through terminal 112 of terminal block 17, strapped terminals 113 and 114 of terminal block 19 and terminal 116 of terminal block 17 to which the armature is connected. The front contact of relay 53 is connected through terminal 117 of terminal block 17, terminal 118 of terminal block 19, winding of slow-release relay 119 and outer upper front contact and armature of relay 21 to grounded battery 48. Relay 119 becomes energized over this circuit and attracts its armature out of engagement with its back contact. Prior to the operation of relay 119, the stepping magnet 121 for stepping switch 98 has been energized in a circuit from grounded battery 48 through the outer upper armature and front contact of relay 21, winding of stepping magnet 121, back contact and armature of relay 119, terminal 113 of terminal block 19 and terminal 112 of terminal block 17 to ground. Stepping magnet 121 is preferably of the type that advances the contact arms of the stepping switch on the release of the stepping magnet and picks up the next tooth of the stepping ratchet upon energization of the stepping magnet. Assuming this arrangement, the stepping magnet 121 upon being released due to energization of magnet 119 will advance the contact arms, which are double-ended, one step thus moving the lower arm out of engagement with the last contact of each of the contact banks and moving the upper arm into engagement with the first contact.

When tube 39 is fired one impulse interval after the firing of tube 38 and quenches tube 38, relay 53 will remain operated due to the fact that the main anodes 38*a* and 39*a* of tubes 38 and 39 are connected together so that the operating winding of relay 53 is in the main anode circuit of tube 39 also, and relay 119 will remain energized, thus holding the energizing circuit of stepping magnet 121 open. One impulse interval following the firing of the tube 39 which primes tube 31, the latter tube will be fired, quenching tube 39 and again rendering diode tube 66 conductive to operate transmitting relay 72 to spacing for the transmission of the start impulse. Upon the cessation of the discharge current through tube 39, relay 53 is released and in turn opens the energizing circuit for slow-release relay 119. After an interval which is dependent upon the slow-release characteristic of relay 119, the

armature of that relay will be released and will reestablish the energizing circuit for stepping magnet 121. The only effect of energization of stepping magnet 121 is to advance its operating pawl into engagement with the next tooth of the operating ratchet in preparation for advancement of the contact arms to the second contact of each of the contact banks when tube 38 again becomes conductive after the transmission of the last significant impulse of the code. In the meantime, tubes 32, 33, 34, 36 and 37 are rendered conductive in succession to transmit the code combination which is stored on the first contacts of the contact banks of stepping switch 98. It will be noted that banks A and B have connections on the first contact and banks C, D and E do not. Accordingly, the first and second significant impulses of the code will be spacing and diode tubes 101 and 103 will be activated in succession and the third, fourth and fifth significant impulses will be marking and diode tubes 104 and 106 will not be activated.

The transmitter will repeatedly transmit the series of codes set up on the contacts of stepping switch 98 until locking key 24 is opened. The series of codes may, for example, represent a test sentence which is to be transmitted repetitiously for the purpose of testing the operation of a receiving printer. It may also be a fixed text or message which has a special significance and is to be transmitted at stated intervals or upon request. Under these circumstances, an attendant could close the key 24 when the fixed message is to be transmitted and could open it when the sending switch 98 had completed one cycle and thus had accomplished the transmission of the message.

Key 99 is provided for making circuit changes to permit transmission of uniform telegraph reversals, by which is meant alternate marking and spacing impulses of uniform length each such impulse having a duration equal to one telegraph code impulse. Assume now that key 99 is operated. The generation of a spacing impulse in the start interval is not altered since the cathode 31*k* of tube 31 is permanently connected to the anode of diode tube 66. The conductive path from the contacts of stepping switch bank A are interrupted at springs 9 and 10 of key 99 so that tube 32 upon being fired will not activate the diode tube 101 and the impulse corresponding to the first significant impulse of a code combination will invariably be marking. The path from the cathode 33*k* of tube 33 is now traced not to the contact arm associated with stepping switch bank B but in the alternate path through springs 3 and 2 of key 102 and springs 11 and 10 of key 99 to the anode of diode tube 101 so that the impulse corresponding to the second significant impulse of a telegraph code will invariably be spacing. There is no alternate path branching off intermediate the cathode 34*k* of tube 34 and the contact arm associated with contact bank C, but the path from those of the contacts of bank C that are connected to certain contacts of bank B is open at the springs 6 and 7 of key 99 and the path from the other connected contacts of bank C is open at the springs 3 and 5 of key 99 so that no conductive path is established from the cathode 34*k* of tube 34 to an anode of a diode tube and the impulse corresponding to the third significant impulse of a telegraph code will invariably be marking. From the conductive path extending from the cathode 36*k* of tube 36 to the contact arm associated with stepping switch bank D, a branching path extends through contacts 8 and 7 of key 99 to the anode of diode tube 103 so that at contact bank D a conductive path from the cathode 36*k* of tube 36 to the anode of diode tube 103 cannot be interrupted and the impulse corresponding to the fourth significant impulse of a telegraph code will invariably be spacing. The impulse corresponding to the last significant impulse of a code combination, the transmission of which is controlled by tube 37 will invariably be marking because the path from the contacts of stepping switch bank E, to the contact arm of which the cathode 37*k* of tube 37 is connected, is open at the springs 1 and 2 of key 99.

A previously mentioned connection from the cathode 38*k* of tube 38 which is the first stop impulse timing tube is now of interest. This connection extends to spring 4 of key 102 from which the path is continued through spring 5 and springs 4 and 5 of key 99 to the anode of diode tube 104. Thus the first half of the impulse which is ordinarily the stop impulse of marking nature will invariably be spacing. As there is no provision for any connection whatsoever from the cathode 39*k* of tube 39 to a diode tube, the second half of the impulse which ordinarily corresponds to the stop impulse will have a normal characteristic, namely, marking. It will be apparent from the foregoing that in each cycle of operation of the counting chain of cold cathode tubes, four spacing and four marking impulses are transmitted, the two types of impulses being alternated in an unbroken series. Stepping magnet 121 will be released and reenergized once for each cycle of the chain but the various codes set up on the contacts of the stepping switch will have no effect upon transmitting relay 72 while key 99 remains operated, because the key 99 provides predetermined shunt paths around the contacts and contact arms of stepping switch 98 or interruptions in the conductive paths from the contacts thereof.

Key 102 when operated along with key 99 provides circuit connections for telegraph reversals at one-half the frequency of the reversals afforded by key 99 alone, each impulse being twice the length of the impulses afforded by key 99. No change is made by key 102 in the conductive path from the cathode 31*k* of tube 31 to the anode of diode tube 66 so that the impulse transmitted during the interval between the activation of tube 31 and the activation of tube 32 is spacing. From the cathode 32*k* of tube 32 a path is traced, not through the contact arm and contact of bank A, the circuit of which is opened at the springs 9 and 10 of key 99 but through a branching conductor, springs 1 and 2 of key 102 now closed, springs 11 and 10 of key 99, now closed, to the anode of diode tube 101 so that the impulse transmitted during the interval between the activation of tube 32 and the quenching of that tube by activation of tube 33 is of spacing nature, continuing the spacing impulse corresponding to the start impulse transmitted by the activation of diode tube 66 and providing a spacing impulse having a length equal to two impulse intervals. The branching path extending from the conductor connected between the cathode 33*k* of tube 33 and the contact arm of stepping switch bank B is now open at the springs 2 and 3 of key 102 so that the path must be traced through the contact arm associated with the contacts of bank B, some of which are connected to the spring 9 of key 99 now disengaged from spring 10, others of which are

connected to the spring 6 of key 99 now disengaged from spring 7 and the remainder of which have no connection. Thus no conductive path is extended to a diode tube in any position of the contact arm of contact bank B and the impulse corresponding to the second significant impulse of a code combination, transmitted under the control of the tube 33, is of marking nature. The conductor connected between the cathode 34k of tube 34 and the contact arm of contact bank C has no branching path and certain of the connected contacts of bank C are connected to spring 6 of key 99 which is disengaged from the spring 7 while the remainder of the connected contacts are connected to spring 3 of key 99 which is disengaged from spring 5. Thus the marking impulse initiated under the control of tube 33 will be extended over the interval during which tube 34 is conductive. The conductor which is connected between the cathode 36k of tube 36 and the contact arm of contact bank D has a branching conductor extending to spring 8 of key 99 which is now engaged by spring 7 from which a conductive path extends to the anode of diode tube 103. Thus the diode tube 103 will be activated during the interval that tube 36 is conductive and the impulse transmitted will be of spacing nature. The conductor connected between the cathode 37k of tube 37 and the contact arm of contact bank E has a branching conductor through which a path is traced through springs 6 and 5 of key 102, now closed, springs 4 and 5 of key 99, also closed, to the anode of diode tube 104. Tube 104 will therefore effect the generation of a spacing impulse during the interval that tube 37 is conductive which continues the spacing impulse generated during the interval that tube 36 is conducting. The conductor which extends from the cathode 38k of tube 38 is connected to spring 4 of key 102 which is now disengaged from spring 5 so that no conductive path is established to an anode of a diode tube. The impulse generated during the conductivity of tube 38 will be of marking nature which is the impulse normally transmitted during the conductivity of tube 38 as distinguished from the spacing impulse transmitted during the conductivity of this tube when key 99 alone is operated. As previously stated the cathode 39k of tube 39 has no provision for a connection to the anode of a diode tube so that the impulse generated during the conductivity of tube 39 is invariably of marking nature. This impulse will continue the marking impulse transmitted while tube 38 is conductive.

From the foregoing it will be apparent that the signals transmitted during each cycle of the counting chain of cold cathode tubes with keys 99 and 102 operated are spacing during the conductivity of tubes 31 and 32, marking during the conductivity of tubes 33 and 34, spacing during the conductivity of tubes 36 and 37 and marking during the conductivity of tubes 38 and 39, this sequence being repeated for each cycle of operation of the counting chain. Thus there are two spacing and two marking signals in alternating relation as distinguished from four spacing and four marking signals in alternating relation when key 99 alone is operated, the impulses being twice as long and the impulse frequency being one-half of that afforded when key 99 alone is operated. These reversals at the two different frequencies may be used for testing purposes.

Although a particular embodiment of the invention has been shown in the drawings and described in the foregoing specification, it will be understood that the invention is not limited to the particular embodiment, but is capable of modification and rearrangement without departing from the spirit of the invention within the scope of the appended claims.

What is claimed is:

1. In a code transmitter, means for generating current oscillations consisting of cycles equal in length to code signaling impulses, individual means for counting a predetermined number of said cycles as a group to identify them as pertaining to start impulses, signaling code impulses and stop impulses of code signals, means for setting up signaling codes, a transmisison line, a line keying device associated with said line, and means controlled jointly by said counting means and said code setting-up means for controlling said keying device.

2. In a telegraph transmitter, means for generating current oscillations consisting of cycles equal in length to telegraph signaling impulses, individual electron discharge means for counting a predetermined number of said cycles as a group to identify them as pertaining to start impulses, signaling code impulses and stop impulses of telegraph signals, means for setting up telegraph signaling codes, a telegraph line, a line keying device associated with said line, and means controlled jointly by said counting means and said code setting-up means for controlling said keying means.

3. In a code transmitter, means for generating current oscillations consisting of cycles equal in length to coded signaling impulses, means controlled by said generating means for producing momentary timing impulses at the rate of one impulse per cycle of current oscillations, individual electron discharge means for counting a predetermined number of said timing impulses as a group to identify them as pertaining to start impulses, signaling code impulses and stop impulses of coded signals, means for setting up signaling codes, a transmission channel, a keying device associated with said channel, and means controlled jointly by said counting means and said code setting-up means for controlling said keying means.

4. In a telegraph transmitter, means for generating current oscillations consisting of cycles equal in length to telegraph signaling impulses, means controlled by said generating means for producing momentary timing impulses at the rate of one impulse per cycle of current oscillations, means for counting said timing impulses to identify them as pertaining to start impulses, signaling code impulses and stop impulses of telegraph signals, said counting means comprising a plurality of electron discharge devices interconnected in a closed ring circuit so that each is primed by the electron discharge device preceding it in said ring circuit and is fired by said timing impulse producing means, means for setting up telegraph signaling codes, a telegraph line, a line keying device associated with said line, and means controlled jointly by said code setting-up means and said counting electron discharge devices for controlling said keying means.

5. In a telegraph transmitter, means for generating current oscillations consisting of an integral number of cycles per telegraph impulse interval, means controlled by said generating means for producing momentary timing impulses at the rate of one impulse per telegraph impulse interval, means for counting said timing impulses to identify them as pertaining to start impulses,

signaling code impulses and stop impulses of telegraph signals, said counting means comprising a plurality of electron discharge devices interconnected in a closed ring circuit so that each is primed by the electron discharge device preceding it in said ring circuit and is fired by said timing impulse producing means, means for setting up telegraph signaling codes, a telegraph line, a line keying device associated with said line, and means controlled jointly by said code setting-up means and said counting electron discharge devices for controlling said keying means.

6. In a telegraph transmitter, means for generating current oscillations consisting of cycles equal in length to telegraph signaling impulses, means controlled by said generating means for producing momentary timing impulses at the rate of one impulse per cycle of current oscillations, means for counting said timing impulses to identify them as pertaining to start impulses, signaling code impulses and stop impulses of telegraph signals, said counting means comprising a plurality of electron discharge devices interconnected in a closed ring circuit so that each is primed by the electron discharge device preceding it in said ring circuit and is fired by said timing impulse producing means, means for setting up telegraph signaling codes, a plurality of normally non-conductive electron discharge devices adapted to be rendered conductive selectively and successively under the joint control of said counting electron discharge devices and said code setting-up means, a telegraph line, a line keying device associated with said line, and means controlled by said last-mentioned plurality of electron discharge devices for controlling said keying means.

7. In a telegraph transmitter, a plurality of electron discharge tubes, means for activating said tubes in succession at intervals equal in length to telegraph signaling impulses, a cathode resistor associated with each tube, a plurality of other electron discharge tubes, means for selectively connecting the activating electrodes of certain of said other electron discharge tubes to the terminals of certain of said cathode resistors in combinations corresponding to telegraph signals whereby to cause the connected ones of said other electron discharge tubes to be rendered conductive concomitantly with the first-mentioned electron discharge tubes served by said certain ones of said cathode resistors, and means controllable by said other electron discharge tubes for generating telegraph signal impulses of one characteristic during the conductivity of any one of said other electron discharge tubes and for generating telegraph signal impulses of another characteristic during non-conductivity of all of said other tubes.

8. In a telegraph transmitter, a plurality of gas-filled electron discharge tubes, means for activating said tubes in succession at intervals equal in length to telegraph signaling impulses, a cathode resistor associated with each tube, a plurality of vacuum electron discharge tubes, means for selectively connecting the activating electrodes of certain of said vacuum electron discharge tubes to the terminals of certain of said cathode resistors in combination according to telegraph signals whereby to cause the connected ones of said vacuum electron discharge tubes to be rendered conductive concomitantly with the gas-filled electron discharge tubes served by said certain ones of said cathode resistors, and means controllable by said vacuum electron discharge tubes for generating telegraph signal impulses of one characteristic during the conductivity of any one of said gas-filled electron discharge tubes and for generating telegraph signal impulses of another characteristic during non-conductivity of all of said vacuum electron discharge tubes.

9. In a telegraph transmitter, a plurality of gas-filled cold cathode electron discharge tubes, means for activating said tubes in succession at intervals equal in length to telegraph signaling impulses, a cathode resistor individual to each tube, a plurality of unidirectionally conductive devices, means for selectively connecting certain of said unidirectionally conductive devices across certain of said resistors in combinations according to telegraph signals whereby to cause the connected ones of said devices to be rendered conductive concomitantly with the cold cathode tubes served by said certatin ones of said resistors, and means controllable by said devices for generating telegraph signal impulses of one characteristic during the conductivity of any of said devices and for generating telegraph signal impulses of another characteristic during non-conductivity of all of said devices.

10. In a telegraph transmitter, a plurality of gas-filled cold cathode electron discharge tubes, means for activating said tubes in succession at intervals equal in length to telegraph signaling impulses, a cathode resistor individual to each tube, a plurality of unidirectionally conductive devices having one terminal connected together and to the low potential terminals of said cathode resistors, means for selectively connecting the other terminals of certain of said diode tubes to the high potential ends of certain of said resistors in combination according to telegraph signals whereby to cause the connected ones of said unidirectionally conductive devices to be rendered conductive concomitantly with the cold cathode tubes served by said certain ones of said resistors, and means controllable by said devices for generating telegraph signal impulses of one characteristic during the conductivity of any of said devices and for generating telegraph signal impulses of another characteristic during non-conductivity of all of said devices.

11. In a telegraph transmitter, a plurality of gas-filled cold cathode electron discharge tubes, means for activating said tubes in succession at intervals equal in length to telegraph signaling impulses, a cathode resistor individual to each tube, a plurality of hot cathode vacuum diode electron discharge tubes, having their cathodes connected together and to the low potential ends of said cathode resistors, a permanent conductive connection between the anode of one of said diode tubes and the high potential terminal of one of said cathode resistors whereby to cause said diode tube to be rendered conductive concomitantly with the cold cathode tube served by said cathode resistor, means for connecting the anodes of others of said diode tubes to the high potential terminals of others of said cathode resistors in combinations according to telegraph signals whereby to cause the connected ones of said diode tubes to be rendered conductive concomitantly with the cold cathode tubes served by said resistors, and means controllable by said diode tubes for generating telegraph impulses of spacing nature during the conductivity of any of said diode tubes and for generating telegraph impulses of marking nature during non-conductivity of all of said diode tubes, the diode tube having the permanently connected anode controlling

the generation of the start impulse of start-stop telegraph signals.

12. In a telegraph transmitter, a plurality of gas-filled cold cathode electron discharge tubes comprising one pertaining to the start impulse, one pertaining to each of the significant code impulses and at least one pertaining to the stop impulse of start-stop telegraph signals, means for activating said tubes in succession at intervals equal in length to telegraph signaling impulses, a cathode resistor individual to each tube, said resistors having their low potential terminals connected together, a plurality of hot cathode vacuum diode electron discharge tubes having their cathodes connected together and to the low potential terminals of said resistors, a permanent conductive connection between the anode of one of said diode tubes and the cathode of the cold cathode tube pertaining to the start impulse whereby to cause the diode having the permanently connected anode to be rendered conductive concomitantly with the cold cathode tube pertaining to the start impulse, means for selectively connecting the anodes of the others of said diode tubes to the cathodes of the cold cathode tubes pertaining to the significant code impulses in combination according to telegraph signals whereby to cause the connected ones of said other diode tubes to be rendered conductive concomitantly with the cold cathode tubes to which the anodes have been connected, and means controlled by said diode tubes for generating telegraph signal impulses of spacing nature during the conductivity of any of said diode tubes and for generating telegraph signal impulses of marking nature during non-conductivity of all of said diode tubes.

13. In an impulse counting system, a plurality of cold cathode tubes, a source of operating potential therefor, means for firing said tubes successively, a cathode resistor individual to each of said tubes for absorbing a part of the difference between the potential of said source and the main gap discharge sustaining potential of the tube served by said resistor, an anode resistor common to all of said tubes for absorbing the remainder of said difference between the potential of said source and said discharge sustaining potential, and a shunt circuit for each of said cathode resistors including means for delaying the appearance of a voltage across the cathode resistor when its associated tube becomes conductive to permit the initial discharge current to increase the potential across said anode resistor and thereby reduce the potential of the anodes of said tubes correspondingly without altering the potential of any of the cathodes, said reduction carrying the anode potential relative to the cathode potential of any tube having a steady-state potential across its cathode resistor below the sustaining potential of said tube and quenching it.

14. In an impulse counting system, a plurality of cold cathode tubes, a source of operating potential therefor, means for firing said tubes successively, a cathode resistor individual to each of said tubes for absorbing a part of the difference between the potential of said source and the main gap discharge sustaining potential of the tube served by said resistor, said part of the difference being less than said discharge sustaining potential, an anode resistor common to all of said tubes for absorbing the remainder of said difference between the potential of said source and said discharge sustaining potential, said remainder being less than the sustaining potential of the tube, and a shunt circuit for each of said cathode resistors including means for delaying the appearance of a voltage across the cathode resistor when its associated tube becomes conductive to permit the initial discharge current to increase the potential across said anode resistor and thereby reduce the potential of the anodes of said tubes by the amount of said increase without altering the potential of any of the cathodes, said reduction carrying the anode potential relative to the cathode potential of any tube having a steady-state potential across its cathode resistor below the sustaining potential of said tube and quenching it.

15. In an impulse counting system, a plurality of cold cathode tubes having a common anode resistor and individual cathode resistors, means for firing said tubes at intervals in succession, and a shunt circuit for each of said cathode resistors including means for delaying the appearance of an ohmic potential difference across the cathode resistor when its associated tube becomes conductive to permit the characteristic main gap potential difference reduction in a tube as it is fired to be manifest across the main gap of each other tube and to quench any other conductive one of said tubes by reduction of its main gap potential difference below the discharge sustaining potential.

16. In an impulse counting system, a series of cold cathode tubes having a main anode, a control anode and a cathode forming a main discharge path and a control discharge path, means for interconnecting the cathode of each tube and the control anode of the next tube in the series, a cathode resistor individual to each tube and effective during conductivity of the tube for applying a priming potential across the control discharge path of the next tube in the series, means for producing impulses spaced in time, an impulse conducting connection between said impulse producing means and the control anode of each of said tubes for aiding the priming potential and firing the primed one of said tubes, a common main anode resistor for said tubes, and a shunt circuit for each of said cathode resistors including means for delaying the appearance of a potential difference across the cathode resistor when its associated tube becomes conductive to permit the characteristic main gap potential difference reduction in a tube as it is fired to be manifest across the main gap of each other tube and to quench any other conductive one of said tubes by reduction of its main gap potential difference below the discharge sustaining potential.

17. In an impulse counting system, a series of cold cathode tubes having a main anode, a control anode, and a cathode forming a main discharge path and a control discharge path, means for interconnecting the cathode of each tube and the control anode of the next tube in the series, and for interconnecting the cathode of the last tube in the series and the control anode of the first tube in the series whereby to form a closed ring system, a cathode resistor individual to each tube and effective during conductivity of each tube to apply a priming potential across the control discharge path of the next tube in the series, means for producing impulses spaced in time, an impulse conducting connection between said impulse producing means and the control anode of each of said tubes for aiding the priming potential and firing the primed one of said tubes, a common main anode resistor for said tubes, and

a shunt circuit for each of said cathode resistors including means for delaying the appearance of a potential difference across the cathode resistor as its associated tube becomes conductive to permit the characteristic main gap potential difference reduction in a tube as it is fired to be manifest across the main gap of each other tube and to quench any other conductive one of said tubes by reduction of its main gap potential difference below the discharge sustaining potential.

18. In an impulse counting system, a source of impulses spaced in time, a plurality of gas-filled electron discharge tubes having a main anode, a control anode and a cathode, a connection between the cathode of each of said tubes and the control anode of the following tube for priming said following tube, a connection between said source of impulses and each of said control anodes for firing only any one of said tubes that is primed, a source of main anode potential, a common anode resistor connected between the main anodes of all of said tubes and one terminal of said source of potential, whereby all of said main anodes assume substantially the same potential, a cathode resistor individual to and connected between each of said cathodes and the other terminal of said source of potential whereby the potential difference of said source of potential is divided between the cathode resistor, the main discharge gap of any of said tubes that is conductive and said common anode resistor whereas said potential difference is divided between said common anode resistor and the main discharge gap of non-conductive ones of said tubes, and a shunt circuit for each of said cathode resistors including means for delaying the appearance of an ohmic potential difference across the cathode resistor when its associated tube becomes conductive to permit the characteristic main gap potential difference reduction in a tube as it is fired to be manifest between the main anode and the cathode of each other tube and to reduce the potential difference between the main anode and the cathode of any tube then having a potential difference across its cathode resistor below the main gap discharge sustaining potential.

19. In a telegraph transmitter, means for producing timing impulses at intervals equal to the duration of telegraph code impulses, a counting chain of electron discharge tubes for identifying said timing impulses as pertaining to start impulses, significant code impulses and stop impulses of telegraph signals, a stepping switch having contact banks equal in number to the number of significant code impulses, a telegraph line, means for keying said line, a plurality of electron discharge tubes equal in number to the maximum number of spacing impulses occurring in telegraph codes to be transmitted for controlling said keying means, a contactor for each of said contact banks, a conductive path from the counting tubes identified with the significant code impulses to said contactors for applying potentials to said contactors in accordance with the counting activation and deactivation of said counting tubes, and conductive paths from non-corresponding contacts of pairs of said contact banks to said keying means controlling tubes for impressing the potentials of said contactors on said tubes whereby each of said tubes is controllable non-sequentially from a pair of said contact banks, said connected contacts representing spacing impulses.

20. In an electron discharge tube system, a plurality of trigger-type tubes to be activated individually, a source of operating potential for said tubes, a cathode resistor individual to each of said tubes for absorbing a part of the difference between the potential of said source and the discharge potential across the tube served by said resistor, an anode resistor common to all of said tubes for absorbing the remainder of said difference between the potential of said source and the discharge potential across any conductive one of said tubes, means for activating said tubes individually, and a shunt circuit for each of said cathode resistors including means for delaying the appearance of a potential difference across the cathode resistor when its associated tube becomes conductive to permit the initial discharge current to increase the potential across said anode resistor and thereby reduce the potential of the anodes of all of said tubes correspondingly with respect to their cathodes, said reduction carrying the anode potential relative to the cathode potential of any tube having a steady-state potential across its cathode resistor below the minimum discharge potential of said tube and quenching it.

21. In an electron discharge tube system, a plurality of trigger-type tubes to be activated individually, a source of operating potential for said tubes, a cathode resistor for each of said tubes connected between the cathode thereof and said source and comprising the sole inter-cathode couplings among said tubes, a common anode resistor connected between the anodes of all of said tubes and said source, means for activating said tubes individually, and a shunt circuit for each of said cathode resistors including means for delaying the appearance of a potential difference across the cathode resistor when its associated tube becomes conductive to permit the initial discharge current to increase the potential across said anode resistor and thereby reduce the potential of the anodes of all of said tubes correspondingly with respect to their cathodes, said reduction carrying the anode potential relative to the cathode potential of any tube having a steady-state potential across its cathode resistor below the minimum discharge potential of said tube and quenching it.

22. In an impulse counting system, a plurality of cold cathode tubes having a common anode resistor and individual cathode resistors, means for firing said tubes at intervals in succession, and a capacitor connected in parallel with each of said cathode resistors for conducting the initial discharge current of the associated tube as it is fired and thereby delaying the appearance of an ohmic potential difference across the cathode resistor to permit the characteristic main gap potential difference reduction in a tube as it is fired to be manifest across the main gap of each other tube and to quench any other conductive one of said tubes by reduction of its main gap potential difference below the discharge sustaining potential.

23. In an electron discharge tube system, a plurality of trigger-type tubes to be activated individually, a source of operating potential for said tubes, a cathode resistor for each of said tubes connected between the cathode thereof and said source, a common anode resistor connected between the anodes of all of said tubes and said source, means for activating said tubes individually, and a capacitor connected in parallel with each of said cathode resistors for conducting the initial discharge current of the asso-

ciated tube as it is fired and thereby delaying the appearance of a voltage across the cathode resistor to prevent the initial discharge current to increase the potential across said anode resistor and thereby reduce the potential of the anodes of said tubes correspondingly relative to their cathodes, said reduction carrying the anode potential relative to the cathode potential of any tube having a steady-state potential across its cathode resistor below the minimum discharge potential of said tube and quenching it.

24. In an electron discharge tube system, a plurality of trigger-type tubes to be activated individually, a source of operating potential for said tubes, a cathode resistor individual to each of said tubes for absorbing a part of the difference between the potential of said source and the discharge potential across the tube served by said resistor, an anode resistor common to all

of said tubes for absorbing the remainder of said difference between the potential of said source and the discharge potential across any conductive one of said tubes, and a capacitor connected in parallel with each of said cathode resistors for conducting the initial discharge current of the associated tube and thereby delaying the appearance of a voltage across the cathode resistor to permit the initial discharge current to increase the potential across said anode resistor and thereby reduce the potential of the anodes of said tubes correspondingly relative to their cathodes, said reduction carrying the anode potential relative to the cathode potential of any tube having a steady-state potential across its cathode resistor below the minimum discharge potential of said tube and quenching it.

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