

Jan. 15, 1963

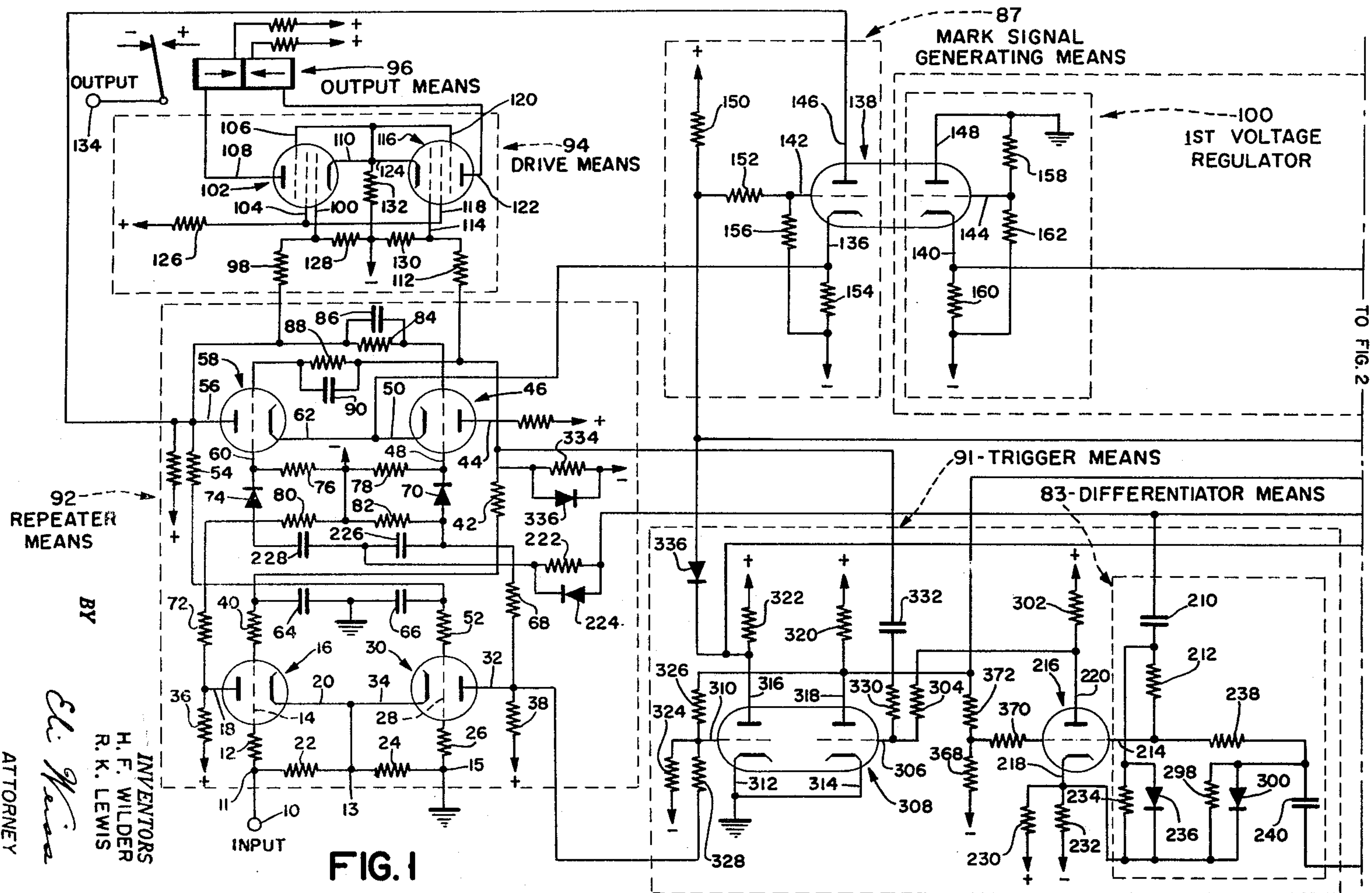
H. F. WILDER ET AL

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ELECTRONIC START-STOP REGENERATIVE REPEATER

Filed July 11, 1961

4 Sheets-Sheet 1



BY
H. F. WILDER
R. K. LEWIS
INVENTORS
ATTORNEY

Jan. 15, 1963

H. F. WILDER ET AL

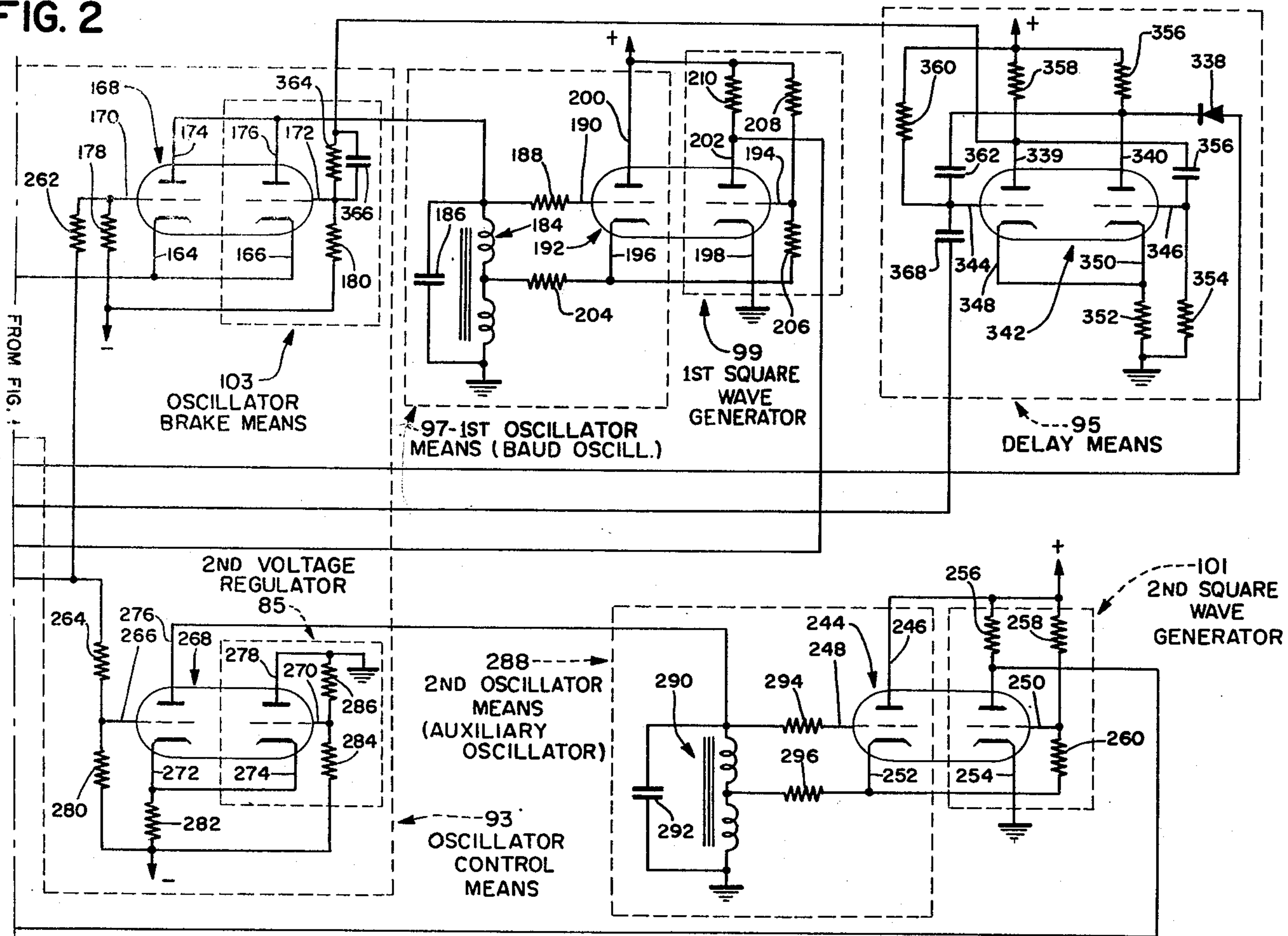
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ELECTRONIC START-STOP REGENERATIVE REPEATER

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FIG. 2



BY

INVENTORS
H. F. WILDER
R. K. LEWIS

H. F. Wilder

ATTORNEY

Jan. 15, 1963

H. F. WILDER ET AL

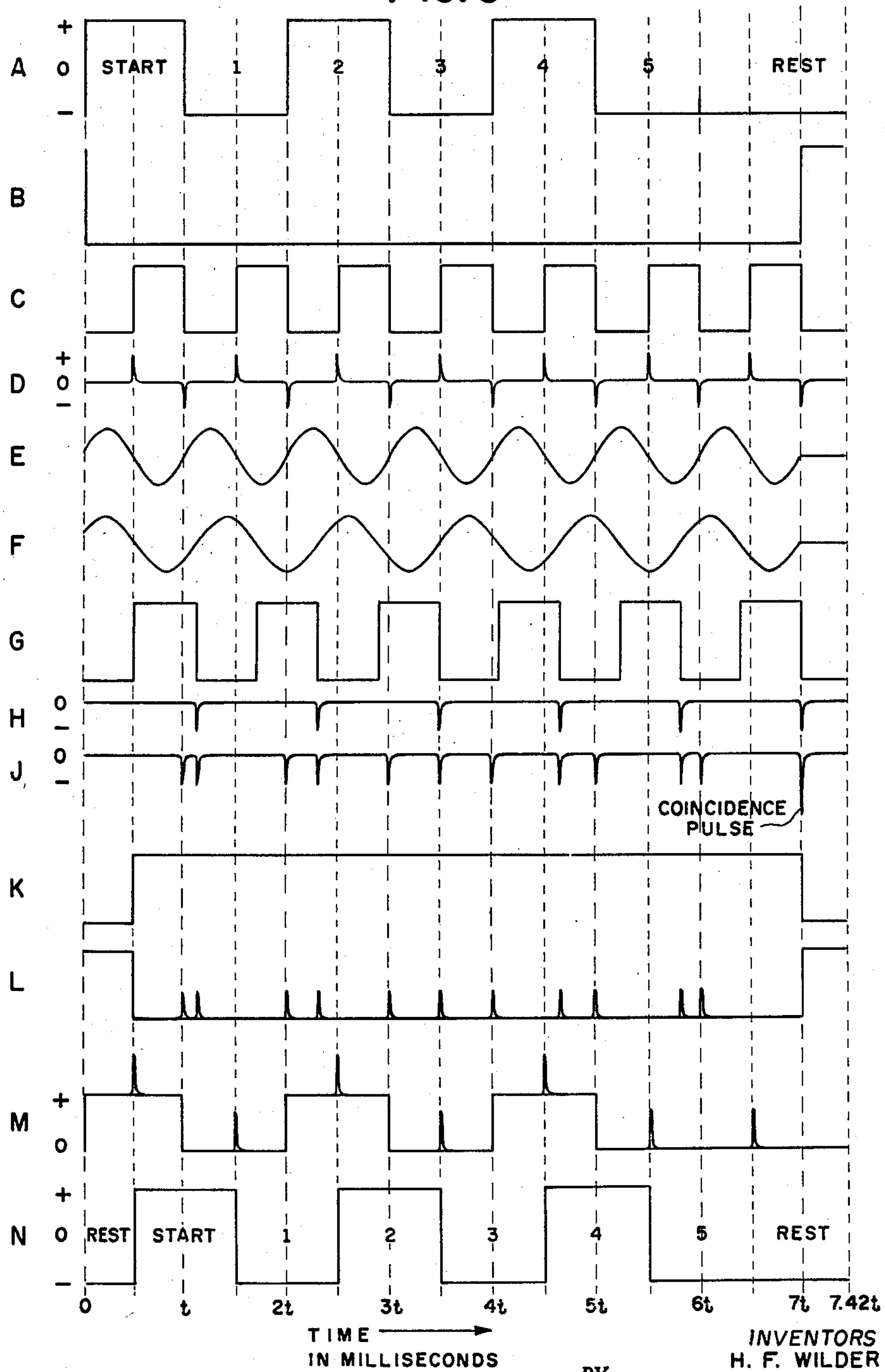
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FIG. 3



INVENTORS
H. F. WILDER
R. K. LEWIS
Eli Weiss
ATTORNEY.

Jan. 15, 1963

H. F. WILDER ET AL

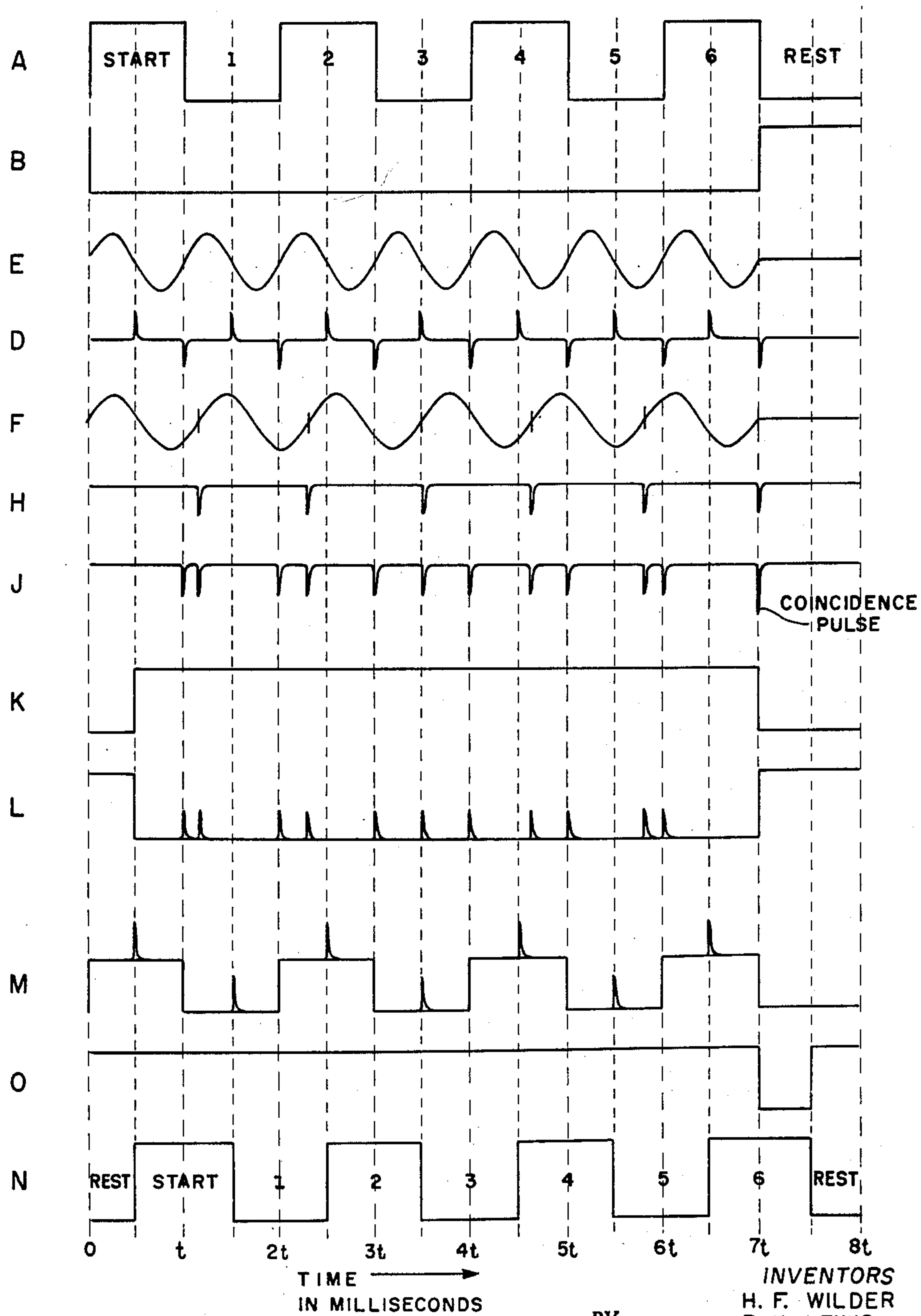
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ELECTRONIC START-STOP REGENERATIVE REPEATER

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FIG. 4



BY

INVENTORS
H. F. WILDER
R. K. LEWIS

Eli Weiss
ATTORNEY.

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3,073,898

ELECTRONIC START-STOP REGENERATIVE REPEATER

Harold F. Wilder, Wycoff, N.J., and Roy K. Lewis, Brooklyn, N.Y., assignors to The Western Union Telegraph Company, New York, N.Y., a corporation of New York

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19 Claims. (Cl. 178—70)

This invention relates generally to a start-stop regenerative repeater network and more particularly to a network which will assume an operative state during receipt of a character signal and an inoperative state during the absence of a character signal.

It is an object of this invention to provide a device which is selectively sensitive to the occurrence and absence of a character signal.

It is another object of this invention to provide a device which can anticipate the termination of a character signal without counting.

It is still another object of this invention to provide a device which can be set selectively to conform to the speed and code of the character received.

It is also an object of this invention to provide a device which utilizes components which are readily available in convenient values, sizes and weights.

It is an additional object of this invention to provide a device which is reliable in operation and economical to build.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the apparatus becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a partial schematic drawing of the structure of this invention;

FIG. 2 is also a partial schematic drawing of structures of this invention, which, when positioned to the right of FIG. 1 forms an embodiment of the present invention;

FIG. 3 illustrates graphically the wave forms occurring within this invention; and

FIG. 4 illustrates graphically other wave forms occurring within this invention.

Similar reference characters refer to similar parts throughout the several views of the drawing.

Briefly, in this invention a repeater means such as a start-stop regenerative repeater is coupled to receive permutation code signals such as the start-stop Baudot type of code. The first pulse signal or bit of each character fed to the repeater means is also fed to a trigger means which initiates operation of a baud oscillator means and an auxiliary oscillator means through an oscillator control means. The frequency of the baud oscillator is usually equal to the frequency of occurrence of the bits of a character. Thus, when operating with a start-stop system employing a seven and a fraction unit code wherein a start pulse is received at the beginning of each five unit character and a rest pulse representing a marking condition is received at the end of each character, the baud oscillator means will generate seven cycles starting with the occurrence of the start pulse (the first pulse of the character) and ending with the occurrence of the rest pulse (the last pulse of the character). The frequency of the auxiliary oscillator is six-sevenths that of the baud oscillator. Thus, the oscillators are first in phase at the beginning of the first cycle, and again at the end of the seventh cycle of the baud oscillator means and the sixth cycle of the auxiliary oscillator means. The occurrence of phase synchronism of the two oscillators at the end of seven cycles for the baud oscillator means

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and six cycles for the auxiliary oscillator means is utilized to condition the oscillator control means to stop the operation of the two oscillators during the rest pulse.

Thus, in this invention the signal from the baud oscillator means is compared with the signal from the auxiliary oscillator means—the occurrence of in phase synchronism of the two oscillators being utilized to stop the operation of the baud oscillator means at the termination of the character.

As used throughout the specification and claims, the terms "mark" and "space" refer to two opposite electrical conditions. In the telegraph art the term "mark" generally refers to a negative battery on a line or a closed line, while "space" customarily refers to a positive battery or open line. In a carrier system these terms will refer to two different frequencies. However, in practice it sometimes occurs that a mark condition will be positive battery while a space will represent negative battery. Therefore, the present specification uses these terms, "mark" and "space," in their broad sense as representing any two different electrical conditions selectively used to transmit intelligence. Also, the term "line" as used throughout the specification and claims is intended to include any connecting means between telegraph stations such as wires, cables or radio channels.

Detailed Description of Invention

With reference to FIGS. 1 and 2 there is disclosed structure in accordance with the principle of this invention. An input terminal 10 coupled to receive signals for regeneration is coupled through an impedance 12 to a grid terminal 14 of an electron vacuum tube 16 which supports an anode terminal 18 and a cathode terminal 20. Input terminal 10 is also coupled through resistors 22, 24, and 26 connected in series to the grid terminal 28 of an electron vacuum tube 30 which supports an anode terminal 32 and a cathode terminal 34. The junction of the resistors 22, 24 is coupled to the cathode terminals 20, 34; and the junction of the resistors 24, 26 is coupled to a ground terminal. A source of positive potential is coupled to the anode terminal 18 through impedance 36 and to the anode terminal 32 through impedance 38.

The grid terminal 14 of tube 16 is connected through the series combination of impedances 40, 42 to the anode terminal 44 of an electronic vacuum tube 46 which supports a grid terminal 48 and a cathode terminal 50; and the grid terminal 28 of tube 30 is connected through the series combination of impedances 52, 54 to the anode terminal 56 of an electronic vacuum tube 58 which supports a grid terminal 60 and a cathode terminal 62. The junction of the impedances 40, 42 is coupled to the junction of the impedances 52, 54 through two capacitors 64, 66 connected in series, and the terminal common to the two capacitors 64, 66 is connected to a ground terminal.

The anode terminal 32 of tube 30 is coupled through the series combination of an impedance 68 and a diode 70 to the grid terminal 48; and anode terminal 18 of tube 16 is coupled through the series combination of an impedance 72 and a diode 74 to the grid terminal 60. The cathode terminal of diode 74 is coupled to the cathode terminal of diode 70 through two impedances 76, 78 connected in series; and the anode terminals of the diodes 70, 74 are coupled together through two impedances 80, 82 connected in series. A source of negative potential is coupled to the terminal common to the impedances 76, 78; and to the terminal common to the impedances 80, 82.

The anode terminal 56 of tube 58 is coupled to the grid terminal 48 of tube 46 through the resistor 84 and capacitor 86 coupled in shunt; and the anode terminal 44 of tube 46 is coupled to the grid terminal 60 of tube

58 through the resistor 88 and capacitor 90 coupled in shunt. The tubes 16, 30, 46, and 58, and the interconnecting components comprise a repeater means 92.

The output signals from the repeater means 92 are fed to a drive means 94 which is coupled to energize selectively an output means 96.

The anode terminal 56 of tube 58 is coupled through an impedance 98 to the grid terminal 100 of an electron vacuum tube 102 which supports grid terminal 104, grid terminal 106, anode terminal 108, and cathode terminal 110; and the anode terminal 44 of tube 46 is coupled through impedance 112 to grid terminal 114 of an electron vacuum tube 116 which supports grid terminal 118, grid terminal 120, anode terminal 122, and cathode terminal 124. Grid terminal 106 is coupled to cathode terminal 110; and grid terminal 120 is coupled to cathode terminal 124. A source of positive potential is coupled through an impedance 126 to the grid terminal 104 of tube 102 and to the grid terminal 118 of tube 116. The grid terminal 100 is coupled to grid terminal 114 through resistors 128, 130 connected in series. A source of negative potential is connected to the terminal common to the resistors 128, 130, and to the cathode terminals 110, 124 through a resistor 132.

The anode terminal 108 of tube 102 is coupled through one winding of a polar relay to a source of positive potential; and the anode terminal 122 of tube 116 is coupled through the other winding of the polar relay to the source of positive potential. The polar relay which, in this application is referred to as output means 96, supports two stationary contacts which cooperate with a movable contact. One stationary contact is coupled to a source of positive potential, and the other stationary contact is coupled to a source of negative potential. An output terminal 134 is connected to the movable contact. Energization of one coil or winding will urge the movable contact towards one stationary contact, and energization of the other coil or winding will urge the movable contact towards the other stationary contact. Thus, the potential present on the output terminal 134 is determined by selectively energizing one or the other winding of the relay—the energization of one winding resulting in the presence of a positive potential on the output terminal 134 and energization of the other winding resulting in the presence of a negative potential on the output terminal 134.

The cathodes 50, 62 of tubes 46, 58 are coupled together and to the cathode terminal 136 of dual triode vacuum tube 138 having another cathode terminal 140, grid terminals 142, 144, and anode terminals 146, 148. The anode terminal 146 is coupled to the anode terminal 56 of tube 58. A source of positive potential is coupled through two resistors 150, 152 connected in series to the grid terminal 142 and a source of negative potential is coupled to the cathode terminal 136 through a resistor 154 and to the grid terminal 142 through a resistor 156. The anode terminal 148 is coupled to a ground terminal and to the grid terminal 144 through a resistor 158. A source of negative potential is coupled through a resistor 160 to the cathode terminal 140 and through a resistor 162 to the grid terminal 144.

The cathode terminal 140 of tube 138 is coupled to the cathode terminals 164, 166 of a dual triode vacuum tube 168 which supports grid terminals 170, 172, and anode terminals 174, 176. A source of negative potential is coupled to grid terminal 170 through resistor 178 and to grid terminal 172 through resistor 180. The anode terminals 174, 176 are coupled together and to a ground terminal through a first oscillator means 97 composed of a center tapped coil 184 positioned in parallel with a capacitor 186 and the left triode section of a tube 192. The anode terminals 174, 176 of tube 168 are also coupled through a resistor 188 to the grid terminal 190 of a dual triode vacuum tube 192 which supports another grid terminal 194, cathode terminals 196, 198, and anode

terminals 200, 202. The center tap of the coil 184 is coupled through two resistors 204, 206 connected in series to the grid terminal 194. The junction of the resistors 204, 206 is coupled to the cathode terminal 196. The cathode terminal 198 is coupled to a ground terminal, and the grid terminal 194 is coupled through a resistor 208 to a source of positive potential. The source of positive potential is also coupled directly to the anode terminal 200 and through a resistor 210 to the anode terminal 202. The anode terminal 202 is coupled through the series combination of a capacitor 210 and resistor 212 to the grid terminal 214 of a vacuum tube 216 which supports a cathode terminal 218 and an anode terminal 220. Additionally, the anode terminal 202 is also coupled through the parallel combination of a resistor 222 and a diode 224 to the junction of resistors 82, 68 through a capacitor 226, and to the junction of resistors 80, 72 through a capacitor 228.

A source of positive potential is coupled to the cathode terminal 218 of tube 216 through a resistor 230, and a source of negative potential is coupled to the cathode terminal 218 through a resistor 232. The junction of the capacitor 210 and resistor 212 is coupled to the cathode terminal 218 through a resistor 234 connected in shunt with a diode 236. The grid terminal 214 is coupled through a resistor 238 in series with a capacitor 240 to the plate terminal 242 of a dual triode vacuum tube 244 which supports another anode terminal 246, grid terminals 248, 250, and cathode terminals 252, 254.

A source of positive potential is coupled directly to anode terminal 246, to anode terminal 242 through resistor 256, and to grid terminal 250 through resistor 258. Cathode terminal 254 is coupled to ground terminal and cathode terminal 252 is coupled through resistor 260 to grid terminal 250.

Grid terminal 170 of tube 168 is coupled through resistors 262 and 264 to the grid terminal 266 of a dual triode vacuum tube 268 which supports another grid terminal 270, cathode terminals 272, 274, and anode terminals 276, 278. A source of negative potential is coupled to grid terminal 266 through resistor 280, to cathode terminals 272, 274 through resistor 282, and to grid terminal 270 through resistor 284. Anode terminal 278 is coupled to a ground terminal and through resistor 286 to grid terminal 270. The right triode section of tube 268 and its associated components functions as a voltage regulator.

Anode terminal 276 is coupled to a ground terminal through a second oscillator means 288 composed of a coil 290 having an upper half and a lower half connected in shunt with a capacitor 292, and the left triode of tube 244. The anode terminal 276 of tube 268 is also coupled to the grid terminal 248 of tube 244 through a resistor 294; and the center of the coil 290 is coupled through a resistor 296 to the cathode terminal 252.

Returning briefly to tube 216, the junction of the resistor 238 and the capacitor 240 is coupled to the cathode terminal 218 through a resistor 298 and a diode 300 connected in shunt. A source of positive potential is coupled to the anode terminal 220 through a resistor 302, and the anode terminal 220 is coupled through a resistor 304 to the grid terminal 306 of a dual triode vacuum tube 308 which supports another grid terminal 310, cathode terminals 312, 314, and anode terminals 316, 318.

Cathode terminals 312, 314 are coupled together and to a ground terminal. A source of positive potential is coupled to anode terminal 318 through a resistor 320, and to anode terminal 316 through a resistor 322. Grid terminal 310 is coupled through a resistor 324 to a source of negative potential, through a resistor 326 to anode terminal 318, and through a resistor 328 to the anode terminal 32 of vacuum tube 30. Grid terminal 306 is coupled through the series combination of a resistor 330 and a capacitor 332 to the anode terminal 44 of tube 46, and

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to a source of negative potential through a resistor 334 connected in shunt with a diode 336.

Anode terminal 316 of tube 303 is coupled to the junction of resistor 262 with resistor 264, and through a diode 336 to the junction of resistors 150, 152 and through a diode 338 to the anode terminal 340 of a dual triode vacuum tube 342 which supports another anode terminal 339, grid terminals 344, 346, and cathode terminals 348, 350.

With reference to tube 342, cathode terminals 348, 350 are connected together and coupled to a ground terminal through a resistor 352. Grid terminal 346 is coupled to a ground terminal through a resistor 354 and to the anode terminal 339 through a capacitor 356. A source of positive potential is coupled to anode terminal 340 through a resistor 356, anode terminal 339 through a resistor 358, and to grid terminal 344 through a resistor 360. A capacitor 362 is interposed between anode terminal 340 and grid terminal 344. The anode terminal 339 is coupled through a resistor 364 in shunt with a capacitor 366 to the grid terminal 172 of tube 168, and grid terminal 344 is coupled through a capacitor 368 to the anode terminal 318 of tube 308.

A source of negative potential is coupled through two resistors 368, 370 connected in series to the grid terminal 214 of tube 216. A resistor 372 is interposed between the junction of the resistors 368, 370 and the anode terminal 318 of tube 308.

The function of the parts of FIGS. 1 and 2 is indicated by means of functional titles assigned to particular parts indicated by boxes formed by dash lines. The network incorporating the tubes 16, 30, 46 and 58 is the repeater means 92 and operates the output means 96 through the output drive means 94. The network incorporating the tubes 168 and 268, and the right triode section of tube 138 is referred to as the oscillator control means 93—the right triode section of tube 138 being further referred to as first voltage regulator 100, the right triode section of tube 268 being further referred to as second voltage regulator 103, and the right triode section of tube 168 being further referred to as oscillator brake means 103; the left triode section of tube 138 and its associated structure comprises a mark signal generating means 87; the tubes 308 and 216 and their associated structure comprises a trigger means 91 which supports a differentiator means 83; and the tube 342 and its supporting structure comprises a delay means 95. Additionally, a resonant circuit and its associated drive means—the left triode section of tube 192 comprises a first oscillator means 97; another resonant circuit and its associated drive means—the left triode section of tube 244 comprises a second oscillator means 288; and networks each incorporating a triode tube comprises a first square wave generator 99, and a second square wave generator 101.

Now, with reference to the operation of the structure of this invention as illustrated in FIGS. 1 and 2, and to the associated waveforms illustrated in FIG. 3 the input terminal 10 is coupled to receive intelligence bearing pulse signals consisting of mark pulse signals and space pulse signals.

To facilitate the description of the operation of this invention it is assumed the space pulse signals have a positive polarity and that mark pulse signals have a negative polarity relative to ground. A typical input signal is illustrated as waveform A in FIG. 3.

The waveforms illustrated in FIG. 3 are for the 7.42 unit code and those in FIG. 4 are for the 8.00 unit code. Each curve illustrated in the FIGS. 3 and 4 represents a signal further identified as follows:

- A—Input signal.
- B—Signal at anode terminal 316 of left triode section of tube 308.
- C—Signal from square wave generator 99.
- D—Timing pulse signals from baud oscillator.
- E—Signals from the baud oscillator.

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F—Signal from the auxiliary oscillator.

G—Signal from square wave generator 101.

H—Negative timing pulse signals from auxiliary oscillator.

J—Combination of negative pulse signals from the baud and auxiliary oscillators fed to grid terminal 214 of tube 216.

K—Signal at anode terminal 318 of right triode section of tube 308.

L—Signal at anode terminal 220 of tube 216.

M—Signal fed to grid terminal of tube 46 showing signal from plate of tube 58 and pulse signals from baud oscillator.

N—Output signal.

O—Signal on anode terminal 340 of right triode section of tube 342.

Description of Operation

Each signal fed to the input terminal 10 produces a potential across the resistors 22, 24. If the received signal is a marking pulse signal then terminal 11 will be more negative than terminal 13, and terminal 13 will be more negative than terminal 15. Thus, the signal fed through the resistor 12 to the grid terminal 14 of vacuum tube 16 is more negative than the signal fed to the cathode terminal 20 of tube 16, and tube 16 is urged to its cut-off state. However, the signal fed to the grid terminal 28 of vacuum tube 30 is positive relative to the cathode terminal 34 of tube 30, and tube 30 becomes conductive.

A positive pulse signal from the plate or anode of the cut-off tube 16 is fed to the grid terminal 60 of tube 58 through resistor 72 and diode 74. A negative pulse signal is fed to the grid terminal 48 of tube 46 through resistor 68 and diode 70 from the lowered plate potential of tube 30. These pulse signals are not of sufficient amplitude to affect the states of the tubes 46 and 58. However, when a positive pulse signal from the first oscillator means 97 through the first square wave generator 99 is fed through the capacitor 228 and is added to the positive pulse signal from tube 16, the resultant is sufficient to drive tube 58 to its conductive state. Multiplier action drives tube 46 to its nonconductive state via capacitor 86 and resistor 84.

The positive potential now present at the plate or anode terminal 44 of tube 46 is fed through resistor 112 to the grid terminal 114 of the tube 116. The current which flows in the plate circuit of tube 116 urges the output means 96 which can be a polar relay to feed a marking pulse signal to the output terminal 134. The decrease of the plate potential of the tube 58 fed to tube 102 through resistor 98 urges tube 102 to its nonconductive state.

Now, if the signal fed to the input terminal is a spacing pulse signal, junction 11 becomes positive relative to junctions 13 and 15 and tube 16 is urged to its conductive state while tube 30 is urged to its nonconductive or cut-off state. A positive pulse signal is fed from tube 30 through resistor 68 to the grid terminal 48 of tube 46, however, the states of the tubes 46 and 58 will not change until a positive potential pulse signal generated by the first oscillator means 97 and shaped by the first square wave generator 99 is fed through the capacitor 226 to tube 46. This pulse signal generated by the oscillator adds to the positive pulse signal from the tube 30 to drive tube 46 to its conductive state. Activation of tube 46 operating through resistor 88 and capacitor 90 urges tube 58 to its nonconductive state. Waveform M illustrates the signal fed to the grid terminal 48 of tube 46 and shows the pulse signals from the tube 30 and the added pulse signals or spikes generated by the first oscillator means 97 and shaped in the first square wave generator 99.

To initiate operation of the oscillators, the positive pulse signal from the plate terminal 32 of tube 30 is fed

through resistor 328 to drive the left triode section of tube 308 into its conductive state. Waveform B illustrates the signal present on the plate terminal 316 of tube 308. The drop in potential present at the plate terminal 316 of tube 308 which results when it assumes its conductive state urges the left triode section of tube 168 into its non-conductive state. The steady D.C. which was flowing from the source of negative potential through resistor 160, the left triode section of tube 168, and the coil 184 is now stopped and oscillations in the coil 184 begin at a rate determined by the values of the coil 184 and capacitor 186. Waveform E illustrates the signal generated by the first oscillator means 97. The output signal from this first oscillator means (baud oscillator) is fed to the grid terminal 194 of the right triode section of tube 192. This right section of tube 192 is the first square wave generator 99 and converts the output signal from the oscillator 97 into square waves. Waveform C illustrates the signal from the first square wave generator 99. The positive pulse signal of the square wave will occur exactly one-half of a signal pulse length after the incoming pulse signal. The positive pulse signals pass through diode 224 to the capacitors 226 and 228 where they are differentiated to obtain spike pulse signals. The positive going spike signal in combination with the positive pulse signal from tube 30 will urge tube 46 to its conductive state. Either signal separately will not urge tube 42 to its conductive state—both signals are required. The diode 224 is oriented to provide a very high resistance path for negative pulse signals from the first square wave generator 99 thus compelling them to pass through and be attenuated by the resistor 222 to prevent the negative pulse signals from changing the states of the tubes 46 and/or 58. The positive spike pulse signals only are used to trigger the tubes 46 or 58.

The left triode section of tube 308 must now be maintained in a conductive state for the duration of the occurrence of the character being received or seven cycles of the baud oscillator 97 when the 7.42 unit code is being used. When the tube 46 is driven to its conductive state (one half cycle after the start pulse enters the tube 30) a negative pulse signal is fed through capacitor 332 and resistor 330 to the grid terminal 306 of the right triode section of tube 308 to drive the triode to its nonconductive state. Immediately, the plate potential rises and this rise in potential is fed through resistor 326 to the grid terminal 310 to lock the left triode section in its conductive state. The left triode section of tube 308 maintains its conductive state and it will not be changed by the subsequent occurrence of negative pulse signals from the plate terminal 32 of tube 30. At the same instance that the right triode section of tube 308 becomes nonconductive a positive pulse signal is fed through resistors 372 and 370 to the grid terminal 214 of tube 216, and tube 216 becomes conductive. The decrease in plate potential now present on the plate terminal 220 of tube 216 is fed through resistor 304 to the grid terminal 306 to lock the right triode section of tube 308 in its nonconductive state. Waveform K illustrates the signal present at the plate terminal 318 (right triode section) of tube 308.

At the same time that operation of the first oscillator means (baud oscillator) 97 was initiated the negative pulse signal from the left triode section of tube 308 is fed to and cuts off the left triode section of tube 238 which initiates activation of the second oscillator means (auxiliary oscillator) 288. The second oscillator means has a frequency which is six-sevenths ($\frac{6}{7}$) that of the first oscillator means (baud oscillator) 97. The two oscillators are in phase only at the beginning of the first cycle and at the end of the seventh cycle of the baud oscillator and the sixth cycle of the auxiliary oscillator. Waveform E illustrates the signal from the baud oscillator, and waveform F illustrates the signal from the auxiliary oscillator.

The negative pulse signals generated by the baud oscil-

lator are fed to the tube 216 after they are first fed to the right triode section of tube 192 which is the first square wave generator 99 and they are converted to square waves and then fed to the capacitor 210 and resistor 212 in the differentiator means 83 where they are differentiated. The positive pulse signals are attenuated through the action of the diode 236 and, therefore, do not appear at the grid terminal 214 of tube 216.

The negative pulse signals fed to the grid terminal 214 of tube 216 do not have a magnitude which is sufficient to drive tube 216 to its inactive or cut-off state. However also appearing at the grid terminal 214 of tube 216 are the negative pulse signals generated by the auxiliary oscillator which are first fed to the right triode section of tube 244—the second square wave generator 101, where they are converted to square waves and then to the capacitor and resistor 238 in the differentiator means 83 where they are differentiated. The positive pulse signals originating from the auxiliary oscillator are attenuated through the action of the diode 300 and, therefore, do not appear at the grid terminal 214 of the tube 216.

The pulse signals fed to the grid terminal 214 of tube 216 from the auxiliary oscillator are out of phase with those from the baud oscillator and, by themselves, are also of a magnitude which is not sufficient to drive the tube 216 to its cut-off state.

The negative signals illustrated in waveform D from the baud oscillator are fed to the grid terminal 214 of tube 216; and waveform H illustrates the negative signals from the auxiliary oscillator which are fed to the grid terminal 214 of tube 216. Waveform J illustrates the combined signals from the baud and auxiliary oscillators received by the grid terminal 214 of tube 216.

After the occurrence of the seventh cycle for the baud oscillator and the sixth cycle for the auxiliary oscillator the negative signals will be exactly in phase and will produce a signal having a maximum magnitude (see waveform J). The magnitude of the resultant signal produced by the simultaneous occurrence of the two signals is sufficient to drive the tube 216 to its cut-off state.

Cut-off of tube 216 produces a rise in its plate potential which is fed to and produces a positive pulse signal at the grid terminal 306 of the right triode section of tube 308. This positive pulse signal drives the right triode section of tube 308 into its conductive state. Upon assuming a conductive state the plate potential of the right triode section of tube 308 is lowered and produces a negative pulse signal which is fed to the grid terminal 214 of tube 216 to maintain tube 216 in its nonconductive or cut-off state. Waveform L illustrates the signal which appears at the plate or anode terminal of tube 216. At the same instant a negative pulse signal from the right triode section of tube 308 is also fed to the grid terminal 310 of the left triode section of tube 308 to drive this section into its nonconductive or cut-off state. The potential fed from the anode terminal 32 of tube 30 through resistor 328 to the grid terminal 310 of the left triode section of tube 308 is also negative as the presence of a marking input signal from the signal rest pulse will drive tube 30 into its conductive state. The urging of the left triode section of tube 308 into its cut-off state generates, at the anode terminal 316, a positive pulse signal which is fed to the grid terminal 170 of the left triode section of tube 168 and to the grid terminal 266 of the left triode section of tube 268. This generated positive pulse signal urges each of the associated triodes (left triode section of tube 168 and tube 268) to its conductive state and a steady current is fed through the coils of the baud and auxiliary oscillators to stop them from oscillating. This is illustrated in waveforms E and F.

The next occurring spacing pulse signal fed to the input terminal 10 will initiate operation of the oscillator as described. However, the signal which appears at the output terminal 134 is displaced one-half of a pulse

width relative to the received signal. See waveform N—the signal on the output terminal 134.

The stopping and starting of the oscillators always insures proper timing of the output signals.

For the 7.42 unit code the oscillators are stopped for 0.42 of the rest pulse signal. When operating this invention with even unit codes (for example 7 or 8 unit codes) an extra fraction of a rest pulse signal in which to stop the oscillators must be provided. In the use of this invention with 8.00 unit code, the oscillator generates seven (7) cycles and is stopped during the rest or eighth (8th) pulse signal. However, the rest pulse is not regenerated by the oscillators, but is produced by other means.

When the left triode section of tube 308 cuts off and stops the operation of the oscillators, a positive pulse signal is fed through diode 336 and resistor 152 to the grid terminal 142 to drive the left triode section of tube 138 into its conductive state. It should be noted that this triode—the left triode section of tube 138—is coupled in parallel with triode 58. Thus, when the left triode section of tube 138 becomes conductive the tube 58 cuts off and causes a mark signal to appear at the output terminal 134.

The oscillators stop operation as soon as the seventh pulse signal of the input or received signal is received by the regenerator (FIG. 4, waveforms E and F) and, as indicated previously the operation of the tubes 46, 58 lags behind the operation of the tubes 16, 30 by one-half of a pulse length. Therefore, the left triode section of tube 138 must be kept from conducting for one-half of a pulse length to prevent the sixth pulse of the output signal from being shortened when the left triode section of tube 138 conducts. Tube 342 is a one shot multivibrator utilized as a delay means to delay the operation of the left triode section of tube 138.

When the right triode section of tube 308 conducts (when the oscillators are stopped) a negative pulse signal is fed through capacitor 368 to the rigid terminal 344 of the left triode section of tube 342, and this triode section cuts off, and a positive pulse signal is fed through capacitor 356 to the grid terminal 346 to drive the right triode section of tube 342 to its conductive state. Now, a negative charge on capacitor 362 locks the left triode section of tube 342 to its nonconductive state. The capacitor 362 begins to recharge positively through the resistor 360 until (after one-half of a pulse length) it accumulates a positive charge sufficient to urge the left triode section of tube 342 to its conductive state. When the left triode section of tube 342 becomes conductive it feeds a negative pulse signal through capacitor 356 to the grid terminal 346 and the right triode section of tube 342 cuts-off.

When the right triode section of tube 342 started to conduct, its plate potential decreased (FIG. 4, waveform O) and a negative pulse signal was fed through diode 338 and overrode the positive potential through the diode 336 to maintain the grid terminal 142 at a negative potential to prevent the left triode section of tube 138 from conducting. However, at the termination of one-half pulse length when the right triode section of tube 342 stopped conducting the grid terminal 142 went positive and the left triode section of tube 138 conducts to generate the marking rest pulse signal.

The right triode section of tube 168 is utilized as an oscillator brake means and operates only when even unit codes are being received. If the incoming signals received are heavily spacing biased tube 30 will not be driven to its conductive state by a marking rest pulse signal at the end of 7 cycles and, therefore, the operation of the oscillators will not be terminated at the proper time. A positive pulse signal will be fed through resistor 328 to the grid terminal 310 of the left triode section of tube 308 to nullify the negative pulse signal fed to the grid terminal 310 through the resistor 326.

Unfortunately, in this instance the first oscillator means could generate a fraction of an oscillation which could cause premature turn-over of the tubes 58 and 46 thereby reducing the length of the seventh pulse signal (when 8.00 unit code is being utilized). The right triode section of tube 168 prevents the occurrence of this condition by assuming its conductive state when the left triode section of tube 342 is in its cut-off state. This condition occurs at the end of the seventh cycle. Activation of the oscillator brake means 103 stops the operation of the first oscillator means. The right triode section of tube 168 continues to conduct until the tube 342 flips back. However, before the tube 342 flips back the left triode section of tube 168 has taken over the braking function as the left triode section of tube 308 is now in its cut-off state.

The right triode section of tube 138 and the right triode section of tube 268 are inverse amplifiers used as voltage regulators to maintain the cathode voltage of their respective oscillator brake means constant.

During the armature travel time of the relay feeding the signal to the input terminal 10, particularly when this travel time is increased because of the effects of interfering line currents, there is an absence of signal voltage on the input terminal 10. If the timing pulse signals from the square wave generators is received by the grid terminals of the tubes 46, 58 during this interval a signal can not be regenerated. Therefore, an inverse feed-back network is utilized to anticipate the polarity change across terminals 11, 13, and 15 caused by the input relay travel. The inverse feed-back network comprises the resistors 52, 54 and the resistors 40, 42.

This inverse feed-back network insures the appearance of a potential at the grid terminals of tubes 16 and 30. This potential anticipates the new output potential of the relay and will cause tubes 16 and 30 to change from a conducting state to a nonconducting state (or vice versa) only during the absence of a potential between terminals 10, 13, and 15.

Naturally, in the construction of this invention all vacuum tubes referred to as dual triodes can be replaced by two single triodes and, in a like manner two single triode vacuum tubes can be replaced by a dual triode vacuum tube. Furthermore, in an attempt to maintain a clear yet concise and full description of this invention the heater circuits of each tube and the usual sources of positive and negative potentials have not been shown.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A regenerative repeater comprising a first oscillator means to generate a signal having a first frequency, a second oscillator means to generate a signal having a second frequency different from the first frequency, an oscillator control means coupled to initiate and terminate operation of said first and second oscillator means, a trigger means interposed between said first and second oscillator means and said oscillator control means to terminate operation of said first and second oscillator means upon the occurrence of in phase pulse signals from said first and second oscillator means, a repeater means selectively conditioned by said first oscillator means to pass received line pulse signals coupled to said trigger means to initiate operation of said first and second oscillator means upon receipt of a line pulse signal, output means, and drive means interposed between said repeater means and said output means.

2. A regenerative repeater comprising a first capacitor; a first coil coupled to said first capacitor to provide a first network having a first resonant frequency; a second capacitor; a second coil coupled to said second capacitor

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square wave generator to pass received line pulse signals coupled to said trigger means to initiate operation of said first and second oscillator means upon receipt of a line pulse signal, output means, and drive means interposed between said repeater means and said output means.

10. A regenerative repeater comprising a first capacitor; a first coil coupled to said first capacitor to provide a first network having a first resonant frequency; a first square wave generator fed by said first network; a second capacitor; a second coil coupled to said second capacitor to provide a second network having a second resonant frequency; a second square wave generator fed by said second network; an oscillator control means coupled to initiate and terminate operation of said first and second networks; a trigger means interposed between said first and second square wave generators and said oscillator control means to terminate operation of said first and second networks upon the occurrence of in phase pulse signals from said first and second networks; a first differentiator interposed between said first square wave generator and said trigger means; a second differentiator interposed between said second square wave generator and said trigger means; a repeater means selectively conditioned by the signal from said first network through said first square wave generator to pass received line pulse signals coupled to said trigger means to initiate operation of said first and second networks upon receipt of a line pulse signal; output means; and drive means interposed between said repeater means and said output means.

11. A regenerative repeater comprising a first oscillator means to generate a signal having a first frequency; a first square wave generator fed by said first oscillator means; a second oscillator means to generate a signal having a second frequency; a second square wave generator fed by said second oscillator means; an oscillator control means coupled to initiate and terminate operation of said first and second oscillator means; a first network fed by said first and second square wave generators to indicate the occurrence of in phase signals; a first differentiator interposed between said first network and said first square wave generator; a second differentiator interposed between said first network and said second square wave generator; a second network fed by said first network coupled to said oscillator control means to terminate operation of said first and second oscillator means upon the occurrence of in phase pulse signals from said first and second square wave generators, a repeater means selectively conditioned by said first square wave generator to pass received line pulse signals coupled to said second network to initiate operation of said first and second oscillator means upon receipt of a line pulse signal; output means; and drive means interposed between said repeater means and said output means.

12. A regenerative repeater comprising a first capacitor, a first coil coupled to said first capacitor to provide a first network having a first resonant frequency; a first square wave generator fed by said first network; a second capacitor; a second coil coupled to said second capacitor to provide a second network having a second resonant frequency; a second square wave generator fed by said second network; an oscillator control means coupled to initiate and terminate operation of said first and second networks; a third network fed by said first and second square wave generators to indicate the occurrence of in phase signals; a first differentiator interposed between said third network and said first square wave generator; a second differentiator interposed between said third network and said second square wave generator; a fourth network fed by said third network coupled to said oscillator control means to terminate operation of said first and second networks upon the occurrence of in phase pulse signals from said first and second square wave generators, a repeater means selectively conditioned by said first square wave generator to pass received line pulse

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signals coupled to said fourth network to initiate operation of said first and second networks upon receipt of a line pulse signal; output means; and drive means interposed between said repeater means and said output means.

13. A regenerative repeater comprising a first oscillator means to generate a signal having a first frequency; a second oscillator means to generate a signal having a second frequency; an oscillator control means coupled to initiate and terminate operation of said first and second oscillator means; a first network fed by said first and second oscillator means to indicate the occurrence of in phase signals from said first and second oscillator means, a second network fed by said first network coupled to said oscillator control means to terminate operation of said first and second oscillator means upon the occurrence of in phase pulse signals from said first and second oscillator means, a repeater means selectively conditioned by said first oscillator means to pass received line pulse signals coupled to said second network to initiate operation of said first and second oscillator means upon receipt of a line pulse signal; output means; drive means interposed between said repeater means and said output means; mark signal generating means fed by said trigger means coupled to feed a generated mark pulse signal to said repeater means; and delay means coupled to retard the operation of said mark signal generating means.

14. A regenerative repeater comprising a first capacitor; a first coil coupled to said first capacitor to provide a first network having a first resonant frequency; a second capacitor; a second coil coupled to said second capacitor to provide a second network having a second resonant frequency; an oscillator control means coupled to initiate and terminate operation of said first and second networks; a third network fed by said first and second networks to indicate the occurrence of in phase signals from said first and second networks; a fourth network fed by said third network coupled to said oscillator control means to terminate operation of said first and second networks upon the occurrence of in phase pulse signals from said first and second networks, a repeater means selectively conditioned by said first network to pass received line pulse signals coupled to said fourth network to initiate operation of said first and second networks upon receipt of a line pulse signal; output means; drive means interposed between said repeater means and said output means; mark signal generating means fed by said fourth network coupled to feed a generated mark pulse signal to said repeater means; and delay means coupled to retard the operation of said mark signal generating means.

15. A regenerative repeater comprising a first oscillator means to generate a signal having a first frequency; a first square wave generator fed by said first oscillator means; a second oscillator means to generate a signal having a second frequency greater than the first frequency; a second square wave generator fed by said second oscillator means; an oscillator control means coupled to initiate and terminate operation of said first and second oscillator means, a trigger means interposed between said first and second square wave generators and said oscillator control means to terminate operation of said first and second oscillator means upon the occurrence of in phase pulse signals from said first and second oscillator means, a repeater means selectively conditioned by the signal from said first oscillator means through said first square wave generator to pass received line pulse signals coupled to said trigger means to initiate operation of said first and second oscillator means upon receipt of a line pulse signal; output means; drive means interposed between said repeater means and said output means; mark signal generating means fed by said trigger means coupled to feed a generated mark pulse signal to said repeater means; and delay means coupled to retard the operation of said mark signal generating means.

16. A regenerative repeater comprising a first oscillator

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means to generate a signal having a first frequency; a first square wave generator fed by said first oscillator means; a second oscillator means to generate a signal having a second frequency; a second square wave generator fed by said second oscillator means; an oscillator control means coupled to initiate and terminate operation of said first and second oscillator means; a first network fed by said first and second square wave generators to indicate the occurrence of in phase signals; a second network fed by said first network coupled to said oscillator control means to terminate operation of said first and second oscillator means upon the occurrence of in phase pulse signals from said first and second square wave generators, a repeater means selectively conditioned by said first square wave generator to pass received line pulse signals coupled to said second network to initiate operation of said first and second oscillator means upon receipt of a line pulse signal; output means; drive means interposed between said repeater means and said output means; mark signal generating means fed by said second network coupled to feed a generated mark pulse signal to said repeater means; and delay means coupled to retard the operation of said mark signal generating means.

17. A regenerative repeater comprising a first oscillator means to generate a signal having a first frequency; a first square wave generator fed by said first oscillator means; a second oscillator means to generate a signal having a second frequency; a second square wave generator fed by said second oscillator means; an oscillator control means coupled to initiate and terminate operation of said first and second oscillator means; a trigger means interposed between said first and second square wave generators and said oscillator control means to terminate operation of said first and second oscillator means upon the occurrence of in phase pulse signals from said first and second oscillator means; a first differentiator interposed between said first oscillator means and said trigger means; a second differentiator interposed between said second oscillator means and said trigger means; a repeater means selectively conditioned by the signal from said first oscillator means through said first square wave generator to pass received line pulse signals coupled to said trigger means to initiate operation of said first and second oscillator means upon receipt of a line pulse signal; output means; drive means interposed between said repeater means and said output means; mark signal generating means fed by said trigger means coupled to feed a generated mark pulse signal to said repeater means; and a one shot multivibrator coupled to retard the operation of said mark signal generating means.

18. A regenerative repeater comprising a first oscillator means to generate a signal having a first frequency; a first square wave generator fed by said first oscillator means; a second oscillator means to generate a signal having a

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second frequency; a second square wave generator fed by said second oscillator means; an oscillator control means coupled to initiate and terminate operation of said first and second oscillator means; a trigger means interposed between said first and second square wave generators and said oscillator control means to terminate operation of said first and second oscillator means upon the occurrence of in phase pulse signals from said first and second oscillator means; a repeater means selectively conditioned by the signal from said first oscillator means through said first square wave generator to pass received line pulse signals coupled to said trigger means to initiate operation of said first and second oscillator means upon receipt of a line pulse signal; output means; drive means interposed between said repeater means and said output means; mark signal generating means fed by said trigger means coupled to feed a generated mark pulse signal to said repeater means; delay means coupled to retard the operation of said mark signal generating means; and oscillator brake means coupled to said first oscillator means.

19. A regenerative repeater comprising a first oscillator means to generate a signal having a first frequency; a first square wave generator fed by said first oscillator means; a second oscillator means to generate a signal having a second frequency; a second square wave generator fed by said second oscillator means; an oscillator control means coupled to initiate and terminate operation of said first and second oscillator means; a trigger means interposed between said first and second square wave generators and said oscillator control means to terminate operation of said first and second oscillator means upon the occurrence of in phase pulse signals from said first and second oscillator means; a first differentiator interposed between said first oscillator means and said trigger means; a second differentiator interposed between said second oscillator means and said trigger means; a repeater means selectively conditioned by the signal from said first oscillator means through said first square wave generator to pass received line pulse signals coupled to said trigger means to initiate operation of said first and second oscillator means upon receipt of a line pulse signal; output means; drive means interposed between said repeater means and said output means; mark signal generating means fed by said trigger means coupled to feed a generated mark pulse signal to said repeater means; a one shot multivibrator coupled to retard the operation of said mark signal generating means; and oscillator brake means coupled to said first oscillator means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,859,279	Oberman	Nov. 4, 1958
2,945,092	Gardberg	July 12, 1960