Sept. 15, 1953 A. E. FROST 2,652,452

INTERPOLATING CIRCUIT

Filed Dec. 18, 1951 2 Sheets-Sheet 1

FIG. 1

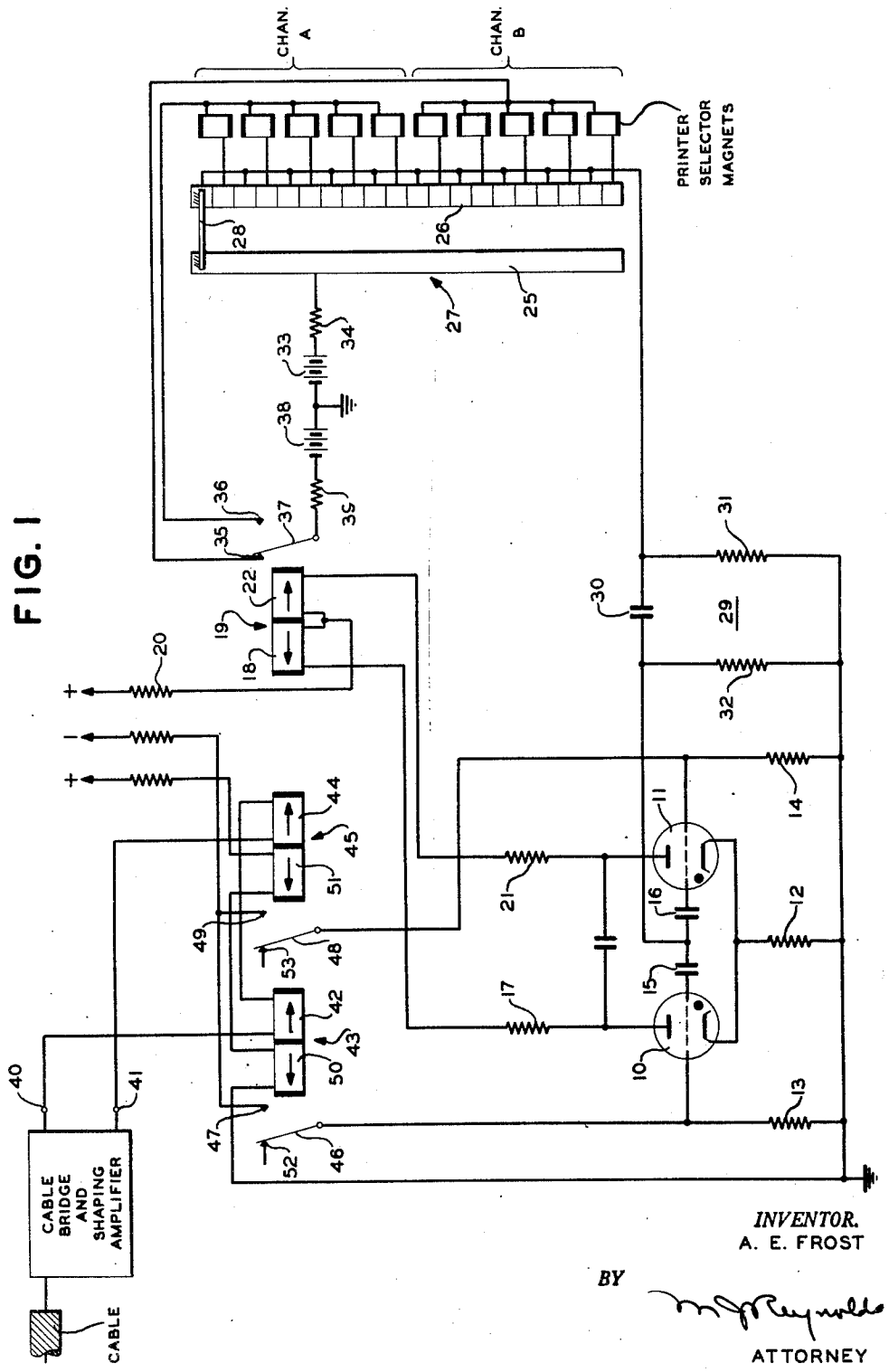

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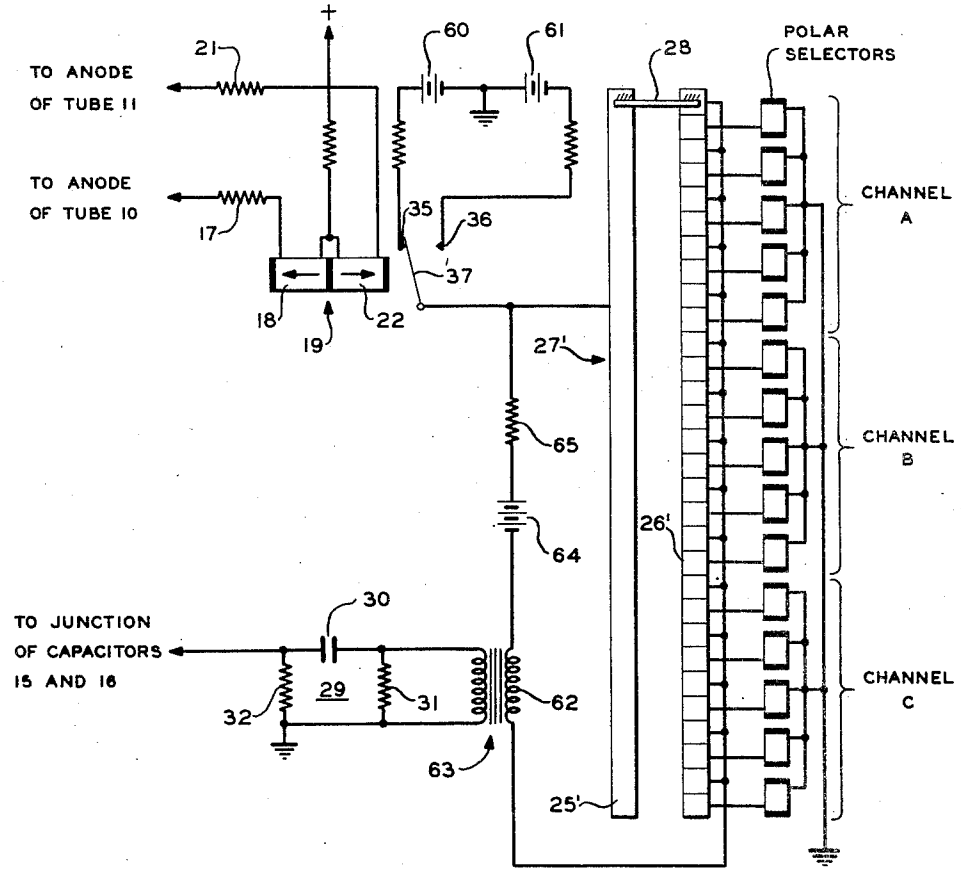
FIG. 2



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2,652,452

INTERPOLATING CIRCUIT

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8 Claims. (Cl. 178—70)

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The present invention relates to telegraph systems and more particularly to multiplex receiving apparatus for use with long transmission lines.

The multiplex signaling speed over a long transmission line, such as a submarine telegraph cable, is limited principally by attenuation of the single or dot frequency impulses. As the signaling speed is increased, it is found that dot frequency signals become attenuated below the effective operating level of the associated receiving apparatus.

It has heretofore been suggested to permit substantially complete attenuation of dot frequency signals relative to interference levels and to reinsert the dot frequency signals through automatic interpolation. One such arrangement is illustrated in U. S. Patent 1,788,477, issued on January 13, 1931, to M. H. Woodward. Another arrangement is disclosed in U. S. Patent 2,046,984, issued July 7, 1936, to H. F. Wilder.

The principal object of the present invention is to provide a novel and improved interpolating circuit.

More particularly, it is an object of the invention to provide an interpolating circuit suitable for use at relatively high frequencies.

Another object of the invention is to provide an interpolating circuit readily adaptable to use with a variety of dot frequencies.

A further object of the invention is to provide an interpolating circuit in which the distributor receiving ring may be employed to operate the interpolating apparatus and to energize the associated printer magnets.

Another object of the invention is to provide an interpolating circuit suitable for use with polar printer magnets.

Further objects of the invention will appear from the following description.

In accordance with the invention, these objects are achieved by providing a pair of gaseous discharge tubes arranged to conduct alternately in response to applied voltage peaks derived by differentiating voltage pulses picked up from a segmented distributor ring at a rate equal to the dot frequency, an output circuit responsive to the alternations in conduction of the tubes to produce a dot frequency output signal and an input circuit coupled to the tubes and responsive to the received signals for suppressing the alternations in conduction in accordance with the repetition rates of the received signals.

The invention will now be described in greater detail with reference to the appended drawing in which:

Fig. 1 illustrates one embodiment of the invention; and

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Fig. 2 illustrates a modification of a portion of the arrangement of Fig. 1.

Referring now to the drawing and more particularly to Fig. 1, then are shown two thyratron tubes 10 and 11 connected in a trigger inverter circuit. The cathodes of tubes 10 and 11 are interconnected and coupled to ground through a resistor 12. The grids of tubes 10 and 11 are coupled to ground through resistors 13 and 14, respectively, and are intercoupled through series connected capacitors 15 and 16.

The anode of thyratron 10 is coupled to a source of positive potential through a circuit extending from the anode thereof through a resistor 17, winding 18 of a polar selector relay 19 and a resistor 20 to a source of positive potential. The anode of thyratron 11 is coupled to a source of positive potential through a circuit extending from the anode thereof through a resistor 21, winding 22 of relay 19 and resistor 20 to the source of positive potential.

A solid ring 25 and a segmented receiving ring 26 of a distributor 27 are interconnected by a brush 28. Synchronous operation of brush 28 with the transmitter may be effected in a number of ways, none of which need be described herein as they are generally well known in the art.

Receiving ring 26 is provided with 20 segments for reception of two five-unit multiplex channels. The invention is, of course, equally applicable to a different number of channels, a different number of units per channel, or a different time distribution of units between channels. Alternate segments of ring 26, which will hereinafter be termed the pickup segments, are interconnected and coupled to the junction of capacitors 15 and 16 through a differentiating network 29 comprising a series capacitor 30 and shunt resistors 31 and 32. Solid ring 25 is provided with a positive potential with respect to ground by a battery 33 coupled to ring 25 through a resistor 34.

The other segments of receiving ring 26, which will hereinafter be termed the delivery segments, are each connected to a respective telegraph printer magnet. The upper set of printer magnets, comprising channel A, are provided with a common return to contact 36 of relay 19. The lower set of printer magnets, comprising channel B, are provided with a common return to contact 35 of relay 19. Armature 37 of relay 19 is connected to the negative terminal of a battery 38 through a resistor 39. The positive terminal of battery 38 and the negative terminal of battery 33 are grounded.

Thyratrons 10 and 11 are so coupled that,

when one tube is conductive, the other will be nonconductive. When the thyratron grid circuit is pulsed from a pickup segment on ring 26, the nonconducting tube is fired, thereby extinguishing the conducting tube. The triggering pulse must be sufficiently short to avoid exciting the tube being extinguished. A short duration triggering pulse is insured by providing differentiating network 29 intermediate the pickup segments and the thyratron grid circuit. Network 29 converts the generally rectangular positive voltage pulse delivered from a pickup segment into a sharp positive voltage peak corresponding in time to the leading edge of the rectangular pulse and a sharp negative peak corresponding in time to the trailing edge of the rectangular pulse. Since the grid circuit loses control of a conducting thyratron, only the positive voltage peak will be effective in producing the triggering action.

It is evident that, in the absence of other signals, thyratrons 10 and 11 will be caused to conduct alternately at a rate dependent on the speed of brush 28. The speed of brush 28 should be selected so that a complete thyratron switching cycle is effected in a time interval equal to the period of the dot impulses received over the associated transmission line.

Assuming the condition illustrated in Fig. 1, i. e., tube 10 conducting, tube 11 nonconductive and armature 37 made with contact 35, tube 11 will be rendered conductive and tube 10 nonconductive by the positive voltage pulse provided as brush 28 wipes the first pickup segment of channel A. When tube 11 is conductive, winding 22 will be energized, causing armature 37 to make with contact 36. Accordingly, when brush 28 wipes the first channel A delivery segment, an energizing circuit for the associated printer magnet will be completed from the positive terminal of battery 33 through resistor 34, brush 28 the delivery segment and printer magnet, contact 36 and armature 37, resistor 39 and battery 38 to the negative terminal of battery 33. When brush 28 wipes the second channel A pickup segment, tubes 10 and 11 will return to their initial conditions. Accordingly, when brush 28 wipes the second channel A delivery segment, the energizing circuit for the associated printer magnet will be open at contact 36. It is evident that the first, third and fifth channel A printer magnets will be energized, while the second and fourth will remain deenergized. Since the printer returns for channel B are connected to contact 35 rather than to contact 36, the same relationship will exist as the channel B segments are wiped.

The operations described above will continue in the absence of received signals, so that the printer magnets will be energized in the same manner as if a continuous train of dot frequency impulses were received.

Terminals 40 and 41 are connected to the incoming transmission line or, in the case of a submarine cable, to the shaping amplifier output terminals. Terminal 40 is connected to one end of a winding 42 of a polar line relay 43. Terminal 41 is connected to one end of a winding 44 of a second polar line relay 45. The other ends of windings 42 and 44 are interconnected. Windings 42 and 44 are so connected that a current of positive polarity will attract armature 46 to marking contact 47 of relay 43 while a current of negative polarity will attract armature 48 to marking contact 49 of relay 45. Windings 50 and 51 of relays 43 and 45, respectively, are connected in series and supplied with a positive potential to bias armature 46 to spacing contact 52 of relay 43 and armature 48 to spacing contact 53 of relay 45.

The marking contacts of relays 43 and 45 are connected to a source of negative potential. The armatures of relays 43 and 45 are connected, respectively, to the grids of thyratron tubes 10 and 11.

When one of the line relays goes to its marking position in response to a received signal, a negative potential is applied to the grid of the associated thyratron, thus preventing the thyratron from firing in response to a positive voltage peak from a pickup segment. For example, if thyratron 10 is in conductive condition and brush 28 is about to wipe the first pickup segment of channel A, a negative signal pulse applied to terminal 40 will energize winding 44, thereby causing armature 48 to make with marking contact 49 and applying a negative potential to the grid of thyratron 11. This negative potential will overcome the positive peak from the pickup segment thus keeping tube 10 conductive and tube 11 nonconductive. It is evident, therefore, that winding 22 of relay 19 will not become energized and that armature 37 will not make with contact 36. Accordingly, when brush 28 wipes the first channel A delivery segment, the return circuit for the associated printer magnet will remain open at contact 36. It will be remembered that, in the absence of a signal at terminal 40, this printer magnet circuit was closed. The length of time during which the thyratron circuit switching operation will be suppressed depends on the length of the signal applied to terminals 40 and 41, or, in other words, the frequency of the multiplex impulse. Since, as was observed above, the dot frequency signals are lost in the transmission line, the frequency of the multiplex impulses applied to terminals 40 and 41 may vary between one-half and one-fifth or less of the dot frequency.

Positive multiplex signals applied to terminals 40 and 41 will cause armature 46 of relay 43 to make with marking contact 47, thereby tending to keep thyratron 11 conductive and thyratron 10 nonconductive, so that winding 22 will remain energized and armature 37 will remain made with contact 36.

In effect, the signals appearing at the contacts of selector relay 19 are regenerated multiplex impulses corresponding to the multiplex impulses received at terminals 40 and 41 with dot frequency impulses interpolated whenever absence of a signal at terminals 40 and 41 permits the thyratron circuit to vibrate.

The printer returns for channels A and B are returned to opposite selector relay contacts because, in accordance with well known practice, alternate multiplex channels mark on opposite polarities in order to facilitate synchronization of sending and receiving distributors.

In order to simplify the receiving distributor and in order to permit the interpolating circuit to be used with existing distributors, it is important that the receiving distributor ring be used for operating both the thyratron circuit and the printer mangets. Since the common distributor ring can be supplied conveniently with only one polarity, it is evident that, in the arrangement of Fig. 1, only this polarity may be supplied to the printer magnets. However, it is sometimes desirable to employ polar printer magnets or polar selector devices.

A circuit arranged to energize polar printer

magnets is illustrated in Fig. 2 wherein elements which are the same as elements in Fig. 1 are given like reference characters.

Referring now to Fig. 2, it will be noted that distributor 27' of Fig. 2 is the same as distributor 27 of Fig. 1 except that thirty segments on receiving ring 26' are provided in order to accommodate three multiplex channels. Selective energization of windings 18 and 22 of relay 19 is identical with the operation of Fig. 1.

The positive terminal of a battery 60 is connected to contact 35. The negative terminal of a battery 61 is connected to contact 36. The negative terminal of battery 60 and the positive terminal of battery 61 are grounded.

Neither battery 60 nor 61 supplies current to the pickup segment circuit because the pickup segment circuit is isolated from ground. The pickup segments are included in a series circuit including brush 28, a primary winding 62 of an isolating transformer 63, a battery 64 and a resistor 65. The secondary winding of transformer 63 is connected to the junction of capacitor 15 and 16 of Fig. 1 through differentiating network 29. Battery 64 is so poled that the exponential rise in current through winding 62, which occurs when brush 28 wipes a pickup segment, produces a positive voltage peak at the junction of capacitors 15 and 16.

When brush 28 wipes a delivery segment, the polarity of the potential applied thereto depends on the position of armature 37. If armature 37 is made with contact 35, a positive potential is supplied to the polar selector device. If armature 37 is made with contact 36, a negative potential is supplied to the polar selector device. Whether the polar selector device will be energized to the marking side or not depends upon whether the polarity of the potential applied thereto is the right one for such operation. It is evident that application of a negative potential to a positive poled selector device will operate at the spacing or non-selecting side.

While the invention has been described in specific embodiments thereof and in a specific use, it is not desired that it be limited thereto, for obvious modifications thereof will occur to those skilled in the art without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. An electrical circuit arrangement for regenerating periodic input signals having varying repetition rates and in which dot frequency components are attenuated below the effective operating level, comprising a pair of gaseous discharge tubes arranged to conduct alternately in response to applied positive voltage peaks, a source of voltage pulses having a repetition rate equal to said dot frequency, a differentiating network intercoupling said source and said tubes for generating voltage peaks and applying said voltage peaks to said tubes thereby to cause said tubes to conduct alternately, whereby alternations in conduction of said tubes may occur at said dot frequency, an output circuit coupled to said tubes, means in said circuit responsive to said alternations in conduction to produce periodic output signals having a repetition rate equal to said dot frequency, an input circuit coupled to said tubes and arranged to receive said input signals, means in said input circuit for selectively suppressing said alternations in conduction of said tubes for time intervals determined by the repetition rates of said input signals whereby said output signals correspond in repetition rates to said input signals with said dot frequency components interpolated therein.

2. An electrical circuit arrangement for regenerating periodic input signals having varying repetition rates and in which dot frequency components are attenuated below the effective operating level, comprising a pair of gaseous discharge tubes arranged to conduct alternately in response to applied positive voltage peaks, a distributor operated in synchronism with said dot frequency for supplying voltage pulses having a repetition rate equal to said dot frequency, a differentiating network intercoupling said distributor and said tubes for generating voltage peaks and applying said voltage peaks to said tubes thereby to cause said tubes to conduct alternately, whereby alternations in conduction of said tubes may occur at said dot frequency, an output circuit coupled to said tubes, means in said circuit responsive to said alternations in conduction thereof to produce periodic output signals having a repetition rate equal to said dot frequency, an input circuit coupled to said tubes and arranged to receive said input signals, means in said input circuit for selectively suppressing said alternations in conduction of said tubes for time intervals determined by the repetition rates of said input signals whereby said output signals correspond in repetition rates to said input signals with said dot frequency components interpolated therein.

3. An electrical circuit arrangement for regenerating multiplex telegraph signals in which dot frequency components are attenuated below the effective operating level, comprising a pair of grid-controlled gaseous discharge tubes arranged to conduit alternately in response to applied positive voltage peaks, a distributor operated in synchronism with said dot frequency for supplying voltage pulses having a repetition rate equal to said dot frequency, a differentiating network intercoupling said distributor and said tubes for generating positive voltage peaks and applying said voltage peaks to the grids of said tubes thereby to cause said tubes to conduct alternately, alternations in conduction of said tubes occurring at said dot frequency, an output circuit coupled to said tubes and responsive to said alternations in conduction thereof to produce periodic output signals having a repetition rate equal to said dot frequency, an input circuit coupled to the grids of said tubes and arranged to receive said telegraph signals, said telegraph signals selectively suppressing said alternations in conduction of said tubes for time intervals determined by the repetition rates of said telegraph signals whereby said output signals correspond in repetition rates to said telegraph signals with said dot frequency components interpolated therein.

4. An electrical circuit arrangement for regenerating multiplex telegraph signals in which dot frequency components are attenuated below the effective operating level, comprising a pair of grid-controlled gaseous discharge tubes arranged to conduct alternately in response to applied positive voltage peaks, a distributor operated in synchronism with said dot frequency for supplying voltage pulses having a repetition rate equal to said dot frequency, a differentiating network intercoupling said distributor and said tubes for generating positive voltage peaks and applying said voltage peaks to the grids of said tubes thereby to cause said tubes to conduct alternately, alternations in conduction of said tubes

occurring at said dot frequency, an output circuit including a polar relay having a pair of windings each included in a respective anode circuit of one of said tubes and responsive to said alternations in conduction of said tubes to produce periodic output signals having a repetition rate equal to said dot frequency, an input circuit arranged to receive said telegraph signals and including a pair of polar line relays each responsive to a different polarity telegraph signal, a source of negative potential, means including said line relays to intercouple said source and the grids of said tubes whereby said telegraph signals selectively overcome said positive voltage peaks thereby to suppress said alternations in conduction of said tubes for time intervals determined by the repetition rates of said telegraph signals whereby said output signals correspond in repetition rates to said telegraph signals with said dot frequency components interpolated therein.

5. In a plural unit printing telegraph system, the combination comprising a source of periodic input signals having varying repetition rates and varying polarity and in which dot frequency components are attenuated below the effective operating level, a triggering circuit including a pair of thyratron tubes arranged to conduct alternately in response to applied voltage peaks, a distributor having a solid ring, a segmented receiving ring having at least twice as many segments as said number of units and a brush for connecting said rings and operating in synchronism with said dot frequency, means to apply a positive potential to said solid ring, a differentiating network, means interconnecting alternate ones of said segments and said differentiating network to produce a positive voltage peak each time one of said alternate segments is wiped by said brush, means to apply said positive voltage peaks to the grids of said thyratron tubes thereby to cause said thyratron tubes to conduct alternately at a rate equal to said dot frequency, a plurality of printer magnets each connected to a respective one of the other segments of said receiving ring, said plurality of printer magnets being at least as great as said number of units, a polar relay having a pair of oppositely poled windings each included in a respective anode circuit of said thyratron tubes, means responsive to energization of one or the other of said windings for selectively energizing said printer magnets in accordance with said dot frequency, means intercoupling said source of input signals and the grids of said thyratron tubes thereby selectively to suppress alternations in conduction of said thyratron tubes for time intervals determined by the repetition rates of said input signals whereby said printer magnets are selectively energized in accordance with the repetition rates of said input signals interpolated with said dot frequency.

6. In a plural unit printing telegraph system, the combination comprising a source of multiplex telegraph signals having varying polarities and in which dot frequency components are attenuated below the effective operating level, a triggering circuit including a pair of thyratron tubes arranged to conduct alternately in response to applied positive voltage peaks, a distributor having a solid ring, a segmented receiving ring having at least twice as many segments as said number of units and a brush for connecting said rings and operating in synchronism with said dot frequency, means to apply a positive potential to said solid ring, a differentiating network, means interconnecting alternate ones of said segments and said differentiating network to produce a positive voltage peak each time one of said alternate segments is wiped by said brush, means to apply said positive voltage peaks to the grids of said thyratron tubes thereby to cause said thyratron tubes to conduct alternately at a rate equal to said dot frequency, a plurality of printer magnets each connected to a respective one of the other segments of said receiving ring, said plurality of printer magnets being at least as great as said number of units, a polar relay having a pair of oppositely poled windings each included in a respective anode circuit of said thyratron tubes, means responsive to energization of one or the other of said windings for selectively energizing said printer magnets in accordance with said dot frequency, a pair of polar line relays coupled to said source of telegraph signals, each of said line relays being responsive to a different polarity telegraph signal, a source of negative potential, means including said line relays for intercoupling said source of negative potential and the grids of said thyratron tubes thereby selectively to suppress alternations in conduction of said thyratron tubes for time intervals determined by the repetition rates of said telegraph signals whereby said printer magnets are selectively energized in accordance with the repetition rates of said input signals interpolated with said dot frequency.

7. In a plural unit multiplex printing telegraph system, the combination comprising a source of periodic input signals having varying repetition rates and varying polarity and in which dot frequency components are attenuated below the effective operating level, a triggering circuit including a pair of thyratron tubes arranged to conduct alternately in response to applied voltage peaks, a distributor having a common ring, a segmented receiving ring having at least twice as many segments per multiplex channel as said number of units and a brush for connecting said rings and operating in synchronism with said dot frequency, means to apply a positive potential to said common ring, a differentiating network, means interconnecting alternate ones of said segments and said differentiating network to produce a positive voltage peak each time one of said alternate segments is wiped by said brush, means to apply said positive voltage peaks to the grids of said thyratron tubes thereby to cause said thyratron tubes to conduct alternately at a rate equal to said dot frequency, a plurality of printer magnets each having one terminal thereof connected to a respective one of the other segments of said receiving ring, said plurality of printer magnets per multiplex channel being at least as great as said number of units, a polar relay having a pair of oppositely poled windings each included in a respective anode circuit of said thyratron tubes, a front contact, a back contact and an armature arranged to make selectively with said contacts, means interconnecting said armature and said brush, means interconnecting the other terminals of said printer magnets and one or the other of said contacts thereby selectively to energize said printer magnets in accordance with said dot frequency, means intercoupling said source of input signals and the grids of said thyratron tubes thereby selectively to suppress alternations in conduction of said thyratron

tubes for time intervals determined by the repetition rates of said input signals whereby said printer magnets are selectively energized in accordance with the repetition rates of said input signals interpolated with said dot frequency.

8. In a plural unit multiplex printing telegraph system, the combination comprising a source of periodic input signals having varying repetition rates and varying polarity and in which dot frequency components are attenuated below the effective operating level, a triggering circuit including a pair of thyratron tubes arranged to conduct alternately in response to applied voltage peaks, a distributor having a solid ring, a segmented receiving ring having at least twice as many segments per multiplex channel as said number of units and a brush for connecting said rings and operating in synchronism with said dot frequency, means to apply a positive potential to said solid ring, a differentiating network including an isolating transformer, means interconnecting alternate ones of said segments and said differentiating network to produce a positive voltage peak each time one of said alternate segments is wiped by said brush, means to apply said positive voltage peaks to the grids of said thyratron tubes thereby to cause said thyratron tubes to conduct alternately at a rate equal to said dot frequency, a plurality of polar selector devices each having one terminal thereof connected to a respective one of the other segments of said receiving ring, said plurality of selector devices per multiplex channel being at least as great as said number of units, a polar relay having a pair of oppositely poled windings each included in a respective anode circuit of said thyratron tubes, a pair of contacts and an armature arranged to make selectively with said contacts, means to apply a different polarity potential to each of said contacts, means interconnecting said armature and said brush thereby selectively to energize said selector devices in accordance with said dot frequency, means intercoupling said source of input signals and the grids of said thyratron tubes thereby selectively to suppress alternations in conduction of said thyratron tubes for time intervals determined by the repetition rates of said input signals whereby said selector devices are selectively energized in accordance with the repetition rates of said input signals interpolated with said dot frequency.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,832,308	Knoop	Nov. 17, 1931
2,135,581	Knoop	Nov. 8, 1938
2,470,677	Anderson	May 17, 1949