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APPARATUS FOR PRODUCING SHARPLY DEFINED SIGNALING IMPULSES

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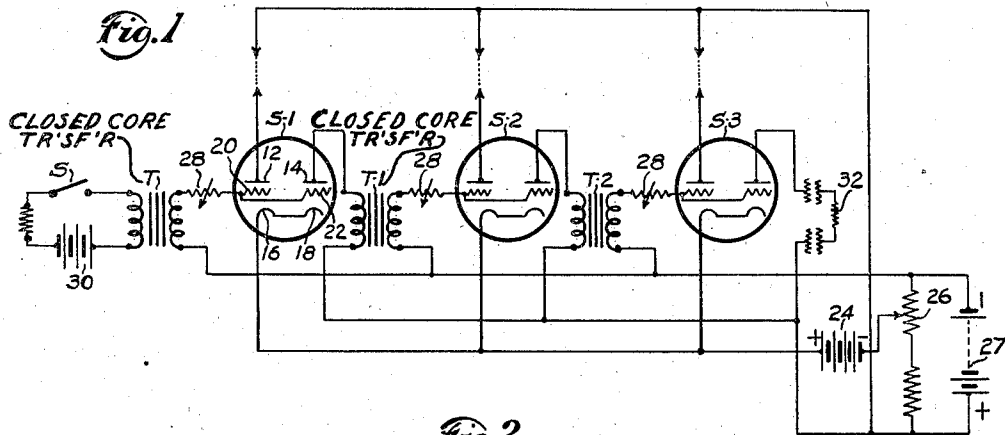


Fig. 2.

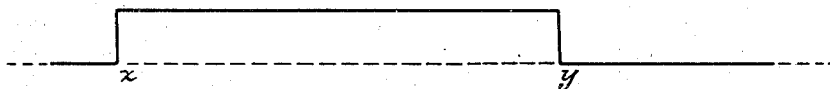


Fig. 3.

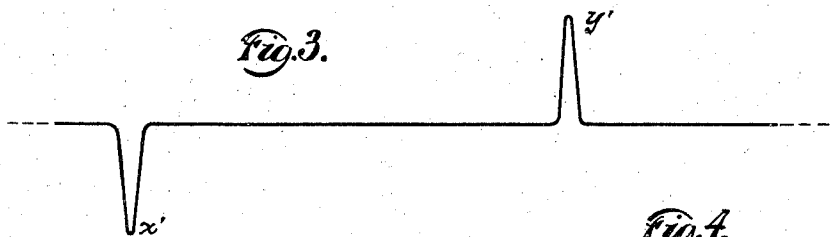


Fig. 4.

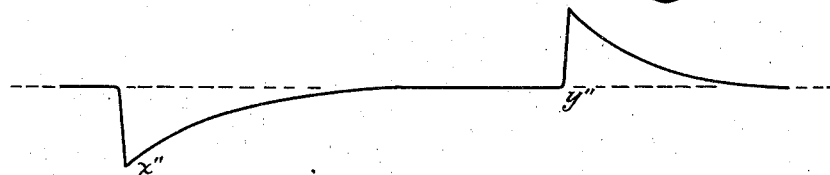


Fig. 5.



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APPARATUS FOR PRODUCING SHARPLY
DEFINED SIGNALING IMPULSESClyde J. Fitch, Endicott, N. Y., assignor to Inter-
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4 Claims. (Cl. 250—27)

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The present invention relates to an apparatus for producing sharply defined, signaling impulses of the type employed in connection with electronic start-stop distributing systems wherein the transmitter and the receiver tend to close corresponding work circuits in substantial synchronism in such a manner that there is durational overlapping of impulses at the transmitter and receiver, during which overlapping certain control circuits are conditioned for selective operation.

The improved apparatus comprising the present invention is particularly well adapted for use in connection with signaling apparatus of the type shown and described in the patent to Fitch, No. 2,210,574, dated August 6, 1940, for a Signaling system, wherein a plurality of electronic discharge devices exercise control over the grid circuits of succeeding devices. Normally the electronic discharge devices are maintained non-conductive until a control circuit of the electronic distributing means is conditioned in such a manner as to render the electronic discharge devices automatically conductive in succession until the last device of the series is rendered conductive, whereupon the normal control conditions are restored to render the devices non-conductive to thus prepare and condition the distributing means for further signaling conditions. One series of electronic discharge devices is employed at the transmitter for effecting certain signaling operations, while a similar series of devices is employed at the receiver to initiate certain control operations for recording purposes and the electrical characteristics of both sets of devices are so designed and correlated that approximate synchronism of operation at both locations is attained. In this manner an overlapping of impulses at the transmitter and at the receiver is effected, during which overlapping the control operations above referred to become effective for recording purposes. Specifically, the present invention relates to an apparatus whereby such overlapping of impulses at the two locations may be accurately controlled, thus minimizing any tendency for the receiver to get out of phase with the transmitter and insuring the positive closing of the proper character-recording control or work circuits at the receiver at predetermined intervals according to the selective closing of corresponding signaling circuits at the transmitter.

In the above mentioned patent sequential operation of the various electronic discharge devices, both at the transmitter and at the re-

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ceiver, is attained by means of an inductive coupling between each electronic device and its succeeding device, utilizing a specially designed iron core transformer having a magnetic air gap and whose primary winding exists in the plate circuit of the preceding electronic device and whose secondary winding exists in the grid circuit of the succeeding device, together with a condenser-shunt-input, resistor-load combination of such value that upon energization or deenergization of the primary winding and consequent creation therein of a corresponding flux change, a voltage impulse of a predetermined and desired duration and magnitude is created in the secondary winding.

The present invention is designed as an improvement over the above mentioned patent and, in a signaling device of the character under consideration, has as its principal object the provision of an improved means for coupling the various electronic discharge devices to their respective succeeding devices in the series in order to obtain uniform characteristics and, consequently, signaling impulses of greater accuracy, whereby more positive operation of the apparatus is made possible and wherein the margin of overlapping of durational impulses at the transmitter and at the receiver is materially improved.

By thus controlling the characteristics of the electronic devices and rendering their wave forms more uniform in duration and more nearly rectilinear, more positive signaling impulses are attained and the tendency of the receiver to fall out of synchronism or become displaced in phase relation with the transmitter is minimized.

A further object of the invention is to effect a wider range of control, wherein the signaling impulses can uniformly be varied through a wider range in duration by simple circuit adjustments, thus making it possible to quickly adjust the electronic devices for operating speeds of say 60 words per minute or 100 words per minute as desired.

An additional advantage of the present invention over the apparatus shown in the above mentioned patent resides in the fact that whereas in the patent means are provided for collectively varying the duration of impulses applied to all of the electronic discharge devices, the present apparatus additionally provides for individually varying the durational characteristic of the impulses applied to each of the electronic discharge devices, thus resulting in an extremely flexible apparatus.

Because of the fact that in the apparatus dis-

closed in the above mentioned patent, the transformer coupling between adjacent electronic devices is of special design, certain constructional limitations are present. Transformers of this character require special care and attention in their construction in that the magnetic air gaps must be accurately proportioned so that all transformers in the circuit are identical in their characteristics. In addition to this, the various tuning condensers and load resistors employed are required to be held to very close tolerances, thus materially increasing the cost of manufacturing the apparatus. The present invention is designed to overcome the various above noted limitations that are attendant upon the apparatus shown in the above mentioned patent and, by its coupling arrangement between the adjacent electronic devices, makes it possible to employ relatively inexpensive standard closed core transformers of the type commonly in use in vacuum tube audio amplifiers.

A further advantage of the present invention resides in the fact that because of the creation of successive signaling impulses having substantially rectilinear or square wave forms, both at the transmitter and at the receiver, which impulses are initiated simultaneously at the commencement of each cycle of operation and which are designed for substantial synchronism during each cycle, as determined by the individual coupling arrangements as described above, the duration of the individual cycles of operation may be materially decreased, while at the same time insuring proper overlapping of impulses for proper and positive operation of the control circuits by means of which recording operations are effected. By thus shortening the cycle of operation, a more rapid sequence of events may take place without sacrificing dependability of operation and, as a consequence, the apparatus may operate at full efficiency at a more rapid rate than has heretofore been possible with apparatus of the type under consideration.

Other objects and advantages of the invention not at this time particularly enumerated will become more readily apparent as the nature of the invention is better understood.

In the accompanying single sheet of drawings forming a part of this specification, a purely illustrative embodiment of the invention has been shown. In these drawings:

Fig. 1 is a diagrammatic view of a signaling system employing interstage inductive coupling mechanisms constructed in accordance with the principles of the present invention, and

Figs. 2, 3, 4 and 5 are schematic views graphically illustrating the principles of the invention.

Referring now to the drawings in detail, the invention has been illustrated in connection with a simplified form of signaling apparatus in lieu of the more detailed apparatus of the above mentioned patent to Fitch. It will be distinctly understood, however, that the principles of the present invention as shown herein are applicable to and designed for use with the signaling apparatus of the Fitch patent, both as regards the transmitter and the receiver thereof.

Referring now to Fig. 1, the signaling system includes a series of electronic discharge devices S—1, S—2 and S—3. The individual discharge devices are in the form of well-known double triode types of electronic vacuum tubes having dual anodes 12, 14, cathodes 16, 18, and grids 20, 22. While three such discharge devices have been shown in the accompanying drawings, it will be

understood that any number thereof may be employed, if desired. The anode or plate circuit leading from the plate 14 of each preceding tube is electrically coupled to and is adapted to control the input or grid circuit of the next succeeding discharge device in the series. The grids 20, 22 of the devices S—1, S—2 and S—3 are normally biased by means of a battery 24 and the grid biases are of such values as to render the various devices normally non-conductive. By varying the grid bias of the various discharge devices, the time interval required for the generation of impulses by the devices may be varied, depending upon the degree of bias supplied. Thus, by adjusting the tap on the control potentiometer 26, which forms a part of a voltage divider across the source of plate power 27, the time interval required for generating the entire group of impulses by the individual devices may be increased or decreased equally so that the complete cycle required for generation of the individual impulses may be set to any predetermined value.

The impulses generated by the individual devices S—1 and S—2 are impressed upon the next succeeding devices by means of interstage transformers T—1 and T—2, the primary windings of which are disposed in one of the anode or plate circuits leading from the anodes 14 of these devices. Interposed in the grid circuit between the secondary winding of each transformer T—1 and T—2 and the grid elements 20, 22 of the next succeeding discharge device is a variable resistance 28, the function of which is to vary the grid or secondary current which opposes the flux change in the transformer core.

A transformer T, similar to the transformers T—1 and T—2, is disposed in the grid circuit of the first electronic discharge device S—1 and the primary winding thereof is contained within a local circuit including a battery 30 and a starting switch S. Upon closing of the switch S, it will be seen that a circuit is immediately established through the primary winding of the transformer T, thus inducing a secondary voltage in the grid circuit of the discharge device S—1. Such an induced voltage, however, will assist the battery 24 in applying a negative bias on the discharge device and the latter will remain non-conductive until such time as the switch S is opened. Upon opening of the switch S, the induced voltage in the secondary winding of the transformer T, due to collapse of the magnetic field therein, will be in such a direction as to oppose the negative bias on the device S—1 and drive the grids 20, 22 slightly positive, thus rendering the device conductive. The impulse thus generated by the first discharge device S—1 will serve to pass current momentarily through the primary winding of the transformer T—1 and the induced voltage in the secondary winding of this latter transformer will at first increase the negative bias of the device S—2. Upon decline of the impulse delivered by the anode 14 of the device S—1, a voltage is induced across the secondary winding of the transformer T—1 which will oppose the negative bias placed upon this latter tube so that it, too, will in turn conduct current. In this manner, each tube in the series S—1, S—2 and S—3 will successively become conductive momentarily. The last device S—3 in the series is provided with a load resistor 32 disposed in the anode or plate circuit leading from the anode 14 of the device. The anode or plate circuits leading from the anodes 12 of the various discharge devices may be employed as work circuits for signaling or

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other purposes. Each time the switch S is closed and again opened, a similar series of timed impulses will be initiated in the various devices S—1, S—2 and S—3.

Referring now to Figs. 2, 3, 4 and 5, the graph shown in Fig. 2 represents the application of an impulse of voltage across the primary winding of the transformer T when the secondary winding thereof is open and which is effected by momentarily closing the switch S. Voltage appears abruptly as at x when the switch S is closed and disappears substantially instantaneously as at y when the switch S is opened. The graph shown in Fig. 3 represents the corresponding voltage impulses induced in the secondary winding of the transformer T as a result of momentarily closing the switch S. The downwardly projecting curve x' in this latter figure represents the impulse in the secondary winding when the switch S is first closed and while the magnetic flux is being built up. The upwardly projecting curve y' represents the impulse in the secondary winding when the switch S is opened and the magnetic field is collapsing. Since the secondary voltage is proportional to the rate of change of the magnetic flux in the core of the transformer T, and since the rate of change thereof is high when the switch is closed or opened, the voltage appearing across the secondary winding of the transformer is high and of a very short duration.

The graph shown in Fig. 4 represents the voltage conditions across the secondary winding of the transformer T when this latter winding is shunted with a fixed load. In such an instance, the secondary winding delivers current in such a direction as to oppose the changing flux which is producing it. Therefore, the rate of change of the flux is less when the switch is opened or closed and the voltage induced in the secondary winding lasts for a longer duration. Obviously, the shape of the curves shown at x'' and y'' in Fig. 4 will be affected by the impedance value of the load employed.

The graph shown in Fig. 5 shows the substantially square secondary voltage wave shape obtainable according to the present invention and which is adaptable for use in the circuits employed in the above mentioned patent to Fitch. This wave shape makes use of both of the transformer characteristics shown in connection with the graphs shown in Figs. 3 and 4 and represents the voltage conditions occurring across the plate load circuits of the various discharge devices S—1, S—2 and S—3. In this instance, as previously described, the variable resistances 28 are connected in series with the secondary winding of the transformers and are interposed between these windings in the grids of the succeeding discharge devices.

If the grid of the discharge device S—1 is given a predetermined negative bias and the preceding transformer T is so connected that when a current impulse is applied to the transformer the voltage delivered to the grid is also negative, then no voltage drop will appear across the plate load of the discharge device. When the switch S is opened, the voltage impulse delivered to the grid will be positive and thus plate current will be caused to flow and produce a voltage drop across the plate load. The wave shape of this voltage occurring across the plate load will assume substantially the form shown at y''' in Fig. 5 and its length may be varied by varying the resistance at 28 or by varying the normal grid bias voltage or both. Substantially, the

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square wave form shown at y''' is obtained by virtue of the fact that at the instant the switch S is opened the voltage occurring across the secondary winding of the transformer T follows the curve y' in Fig. 3. When the voltage across the secondary winding of the transformer T reaches the normal grid bias voltage of the discharge device and overcomes the same, the grid being positive with respect to the cathode will cause the tube to become conductive and to pass grid current. The secondary winding of the transformer will then become loaded, as in the case where a resistor was connected thereacross. A decline in voltage, as shown in the graph of Fig. 4, will then be evidenced. Since there is current flowing through the variable resistance 28 there will be a voltage drop across this resistance so that the voltage existing across the secondary winding of the transformer will be greater than the grid bias voltage. The voltage at the grid will remain slightly positive with respect to the cathode and during this time conditions simulating the substantially flat topped portion of the curve y''' in Fig. 5 will be attained. The grid current flowing through the secondary winding of the transformer T, when declining, induces a counter voltage which tends to reinforce the initial induced voltage and thus the grid voltage declines relatively slowly, the rate of collapse depending upon the value of the variable series resistor 28 and the grid-to-cathode conductivity of the device. The voltage across the load resistance in the anode circuit of the device S—1 will therefore behave substantially as shown by the graph of Fig. 5. Since the grid assumes its positive potential quickly, as shown at y' in Fig. 3, plate current will immediately start to flow at its maximum value. Since, as previously mentioned, the grid voltage declines in the manner shown in Fig. 4, plate current will remain substantially at its maximum value until the grid voltage decreases to a value wherein the grid is zero or slightly negative with respect to the cathode and grid current ceases. The grid voltage will then quickly fall below the cut-off value as provided by the bias supplied to the grid, as during this interval of time the transformer secondary may be considered open as no grid current flows, and the secondary voltage wave will abruptly cease similar to curve y' , Fig. 3. The plate current will then abruptly cease. The top part of the impulse y''' shown in Fig. 5 is in reality sloping slightly downwardly, the degree of slope depending upon the particular portion of the I_p — E_g curve of the tube which is utilized.

In actual practice, the various transformers are connected to operate in the circuit of the above mentioned patent to Fitch, while the series resistances 28 are adjusted to values that will give impulses of extremely accurate and uniform duration and the local bias of the various grids 22 are adjusted to give an easily controlled working range. Unlike the apparatus shown in the Fitch patent, ordinary commercial closed core transformers which are machine wound and have uniform characteristics are employed and the various stages of the system will seldom need individual adjustments after the apparatus has initially been adjusted for the desired operation.

The invention is not to be limited to the exact arrangement shown in the accompanying drawings or described in this specification as various modifications are contemplated within the scope of the appended claims.

What is claimed is:

1. In a signaling system, an electronic self-timing stop-start apparatus comprising a series of normally non-conductive vacuum tubes, inductive coupling means linking each preceding tube with its next succeeding tube for rendering the tubes successively conductive at predetermined intervals of time, said inductive coupling means comprising a closed iron core transformer having a primary winding and a secondary winding, said primary winding being disposed in the output circuit of a preceding tube and said secondary winding being disposed in the input circuit of a succeeding tube, the sole external path between the terminals of said secondary winding being through said succeeding tube, and a variable resistance disposed in said input circuit for controlling the interval of time said tubes remain conductive.

2. In a signaling system, an electronic self-timing stop-start apparatus comprising a series of normally non-conductive electronic discharge devices in the form of dual triode vacuum tubes, each having a pair of separate anode circuits and common grid and cathode circuits, one anode circuit of each tube constituting a signaling work circuit and the other anode circuit being inductively coupled to the grid circuit of the next succeeding tube in the series, the coupling means for said anode circuits comprising a closed iron core transformer having a primary winding and a secondary winding, said primary winding being disposed in the anode circuit of a preceding tube and said secondary winding being disposed in the common grid circuit of a succeeding tube, the sole external path between the terminals of said secondary winding being through said succeeding tube, and a variable resistance disposed in series with the secondary winding of each transformer.

3. In a signaling system for producing sequences of timed impulses, a network including a uni-directional source of voltage, a series of vacuum tubes, each having a plate, cathode, and grid, the output circuits of said tubes being connected in parallel to said source of voltage, means coupling each tube except the last one in the series with the next succeeding tube in the series,

each coupling means including an iron core transformer having a primary winding in the output circuit of the preceding tube and a secondary winding having its terminals connected only by a single circuit through the grid-cathode path of the succeeding tube, means to bias the grids of all of the tubes to render the tubes normally non-conductive, and means to reduce the bias of the grid of the first tube of the series for a brief period to render said first tube conductive for said period, the winding of the transformers and the constants of the network being such that, when any tube becomes non-conductive, an impulse is transmitted through the related transformer to the grid of the next succeeding tube to render said grid positive and said succeeding tube conductive for a definite period.

4. In a signaling system, means for producing sequences of timed impulses comprising a series of normally non-conductive electronic discharge devices each including a control grid and cathode for respectively passing the successive impulses of each sequence, inductive coupling means linking each preceding device with its next succeeding device for rendering the devices successively conductive at predetermined intervals of time, said coupling means comprising a closed iron core transformer having primary and secondary windings, each primary winding being disposed in the output circuit of a preceding device and each secondary winding being disposed in the input circuit of a succeeding device, the sole external path between the secondary winding terminals of each transformer existing through the control grid to the cathode of the succeeding electronic discharge device.

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REFERENCES CITED

The following references are of record in the file of this patent:

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