

Feb. 12, 1935.

W. A. KNOOP

1,990,551

SYNCHRONOUS VIBRATING RELAY CIRCUIT

Filed Oct. 8, 1930

FIG. 1

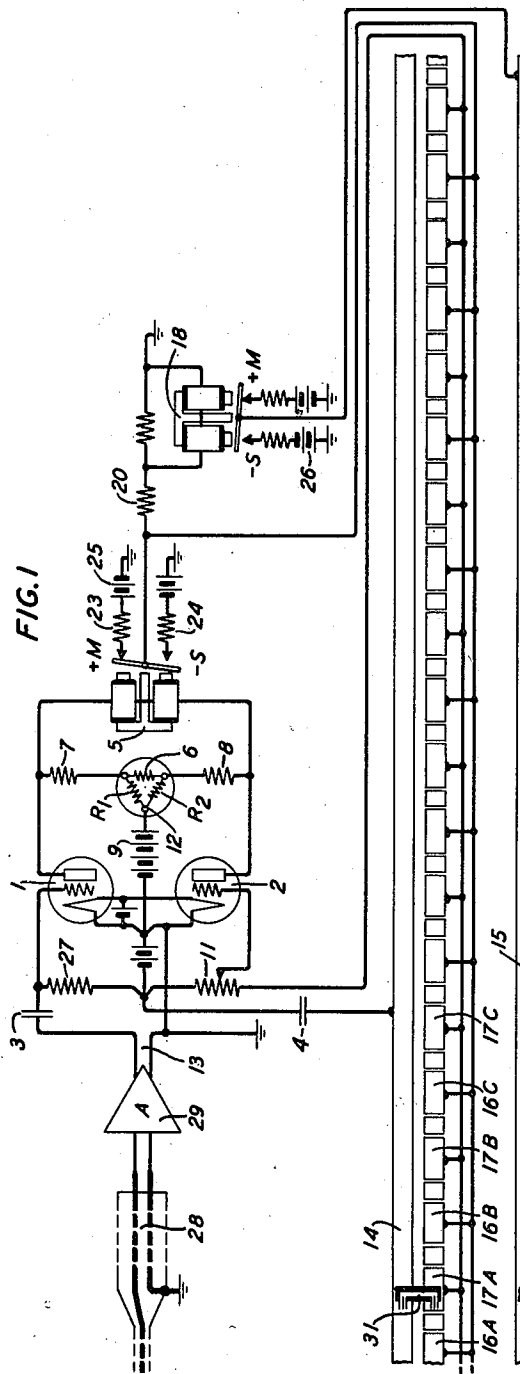


FIG. 2



INVENTOR
W. A. KNOOP
BY *J. W. Schmied*
ATTORNEY

UNITED STATES PATENT OFFICE

1,990,551

SYNCHRONOUS VIBRATING RELAY CIRCUIT

William A. Knoop, Hempstead, N. Y., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

Application October 8, 1930, Serial No. 487,173

4 Claims. (Cl. 178—88)

This invention relates to telegraph systems and apparatus, and more particularly to high speed synchronous telegraph systems adapted for long telegraph lines, such as submarine cables.

An object of this invention is to reproduce at a receiving station by more simple means than heretofore and/or more accurately the signals transmitted over a long telegraph line.

In operating telegraph apparatus by reversals of current over long transmission lines the short signal impulses are reduced in strength and altered in wave form by the transmitting medium to such an extent that they are incapable of operating a line relay, whereas impulses of greater than unit length are received with ample strength to operate a line relay. It has been the practice to rebuild or restore unit impulses at the receiving station by means of synchronous vibrating relay systems in which a relay or relays are vibrated under the control of a special distributor to automatically print signal impulses of unit length when no signal impulses are being received to operate a receiving relay. Such systems are disclosed in U. S. Patents granted to A. A. Clokey 1,521,870 of January 6, 1925 and 1,522,865 of January 13, 1925 and 1,680,550, granted to M. B. Kerr, August 14, 1928. In these three patents distributors are employed which rotate at the proper speed for maintaining the vibration of the armature of the relay in synchronism with the received impulses.

Systems of this kind are used in combination with amplifiers of the type disclosed in Fig. 1 of U. S. Patent 1,673,042 granted to A. M. Curtis January 12, 1928. A vacuum tube is employed in this type of amplifier to receive incoming signals and to control a polar relay. The curved characteristic of this vacuum tube is balanced against the linear characteristic of a resistance which is in series with the plate battery. A change in plate battery voltage tends to place a bias on the polar relay (which is normally balanced in a non-operated condition) and to operate the relay. In a system in accordance with the present invention the curved characteristics of the signal and interpolating tubes are balanced against each other in such manner that a change in plate battery voltage affects both tubes equally and the resultant changes of current neutralize each other in the windings of the relay.

An advantage of this arrangement is that only one vibrating relay is used instead of the two or more employed in one type of system previously suggested. The operation of fewer relays is favorable to proper maintenance of the apparatus and consequently there is less opportunity for trouble developing in the circuit.

A feature of this invention is the small capacity condenser employed to store pulses. This

condenser may be charged in a fraction of the time heretofore taken in the storing of pulses on condensers.

Another feature of this invention is the resistance potentiometer arrangement in a grid circuit of a tube functioning to control the regenerating relay to regenerate impulses of unit length.

In systems disclosed in a prior patent application of the applicant incoming impulses are impressed upon vacuum tubes over a circuit including distributor segments. In accordance with the present invention the impulses are impressed upon a vacuum tube over a circuit having a fixed state of continuity, i. e. not including distributor segments.

Referring to the drawing:

Fig. 1 illustrates a circuit diagram of a synchronous vibrating relay circuit embodying the features of this invention; and

Fig. 2 comprises a series of graphs explanatory of the operative action of the parts of Fig. 1.

In the circuit drawing submarine cable 28 is shown connected to receiving amplifier 29 and then to vacuum tube 1 of the vibrating relay circuit by means of line 13.

Tube 1, hereinafter called the line signal tube, controls the operation of a differentially wound relay 5 whenever signals of greater than unit length are received over the line conductor. Vacuum tube 2 is the vibrating impulse tube and controls differentially wound relay 5 when no signals or signals of unit length or less are received over line 13. This will be described later.

Tubes 1 and 2 are so arranged that when no signal impulses are being received the space currents of the respective tubes split equally at the center or junction point 12 of differential meter 6, one current flowing through resistance R1 of meter 6 and resistance 7 to the anode tube 1, the other current flowing through resistance R2 of meter 6 and resistance 8 to the anode of tube 2. Resistances 7 and 8 are equal and resistances R1 and R2 are equal. Consequently, the voltage drop across resistances 7 and 8 are equal and no voltage is applied to the windings of relay 5.

A developed portion of the distributor is shown having interpolating brush 31 and printing brush 30 with their associated common and segmented rings. The common ring 14 associated with brush 31 is connected with vibrating condenser 4 and the common ring 15 associated with printer brush 30 is connected to the armature of printer relay 18.

Vibrating condenser 4 is a condenser of small capacity, for example, .1 microfarad and will be fully charged in a very short period of time. This condenser stores the impulses applied to it and later impresses the stored impulses on

high resistance potentiometer 11 which is connected across the grid of tube 2. The values for the high resistances composing the potentiometer and the condenser may be proportioned so that the discharge is properly effected in a definite period of time. For instance, if the vibrating condenser 4 is .1 microfarad and the potentiometer is .50 megohm, the time constant of the circuit will be .05 second. At moderate speed the discharge would take place over a period of about .002. This would not greatly decrease the voltage on the condenser. A .1 microfarad condenser could be fully charged in this length of time through a brush contacting with a segment.

Relay 18 is a printer relay which follows the operations of relay 5 in turn impressing corresponding signals upon the printer magnets through commutator 15 and contacting brush 30.

Referring to Fig. 2, graph A represents a train of positive and negative impulses transmitted over submarine cable 28. Graph B shows the impulses received over line 13 and applied through blocking condenser 3 to the grid of signal tube 1. C is the voltage applied to the grid of vibrating tube 2. Graph D shows the voltage on the armature of vibrating relay 5.

The operation of the circuit will now be described. Assuming for the moment that no signal impulses are being received over line 13 and that brush 31 is in such position as to make contact with segment 16A, storing condenser 4 will have impressed upon it a positive charge from the armature of relay 5. This circuit is traced from battery 25, marking contact and armature of relay 5, segment 16A, brush 31, commutator 14 to condenser 4. A short time later when brush 31 makes contact with the next live bar, segment 17A, the positive charge on 4 will be transferred to potentiometer 11 and then to the grid of tube 2. This circuit is traced from condenser 4, commutator 14, brush 31, segment 17A to potentiometer 11. A portion of this voltage is applied to the grid of tube 2 thus increasing its space current to a value greater than the space current of tube 1. This will upset the balance across the windings of relay 5 and will cause relay 5 to move its armature against the negative or spacing contact. This movement of the armature of relay 5 will operate printer relay 18 over an obvious circuit, the printer relay in turn will apply a corresponding impulse to later operate printer magnet 32 when brush 30 makes contact with segment 33 over a circuit traced from battery 26, spacing contact and armature of relay 18, ring 15, brush 30, segment 33 and winding of printer magnet 32. The brushes are so arranged that the movement of the armature of printer relay 18 takes place when brush 30 is passing the center portion of a dead segment. This permits printing of one pulse and the storing of the charge corresponding to the next pulse at approximately the same time in a manner well known in the art. Resistance 20 is a protective resistance to limit the value of current applied to relay 18.

The movement of the armature of relay 5 to its spacing or negative contact will cause a negative charge to be impressed on condenser 4 when brush 31 reaches segment 16B. This negative charge will be transferred to the grid of tube 2 when brush 31 makes contact with segment 17B in the same manner hereinbefore described in

connection with transferring a positive charge to the grid of tube 2. The negative charge on the grid of tube 2 will decrease the space current of tube 2 below that of tube 1 and cause relay 5 to move its armature to the positive or marking contact. This alternate movement of the armature of relay 5 from one contact to the other will continue as long as the distributor brush 31 revolves and the space current of tube 1 remains normal. Printer relay 18 will follow the operations of relay 5 and will cause the printer magnets to function in a manner well known in the art.

Referring to Fig. 2, graph A shows a train of positive and negative impulses transmitted over the system from a distant station. The distorted and attenuated impulses which are received and are impressed upon the grid of signal tube 1 are illustrated by graph B. C designates the voltage pulses applied to the grid of tube 2, and D shows the voltage on the armature of relay 5.

Assuming at time *a* that the armature of relay 5 is on its negative contact and that a negative impulse of greater than unit length, (see graph A), is transmitted by the distant station, then a negative impulse will be received over line 13 (see graph B). The application of the negative polarity to the grid of signal tube 1 will decrease the space current in tube 1. At this time brush 31 will be making contact with segment 17A and a negative charge will be applied from charged condenser 4 to the grid of vibrating tube 2. This will decrease the space current of tube 2 as illustrated by the first negative pulse of graph C. Relay 5 will not move its armature at this stage in spite of the vibrating impulse applied to the grid of tube 2 because the incoming negative signal impulse on the grid of tube 1 is sufficiently strong to hold the relay tongue against its negative contact.

At time *b*, referring to graph B, it will be noted, that the received pulse is still negative. Another negative charge will now be applied to the grid of tube 2, (graph C) but as explained hereinbefore, the tongue of relay 5 will remain against its negative contact.

At time *c*, referring to curve B, it will be seen that the incoming signal B has fallen away to zero and is changing from a negative polarity of greater than unit length to a positive polarity of unit length. This last impulse will increase the space current of tube 1 but not enough to move the contact of relay 5 to its positive contact. At this time, referring to curve C, another negative pulse will be applied to the grid of tube 2 which will decrease the space current of tube 2 and cause the armature of relay 5 to move to its positive contact.

At time *d*, referring to curve B, the incoming signal will again have fallen away to zero and have started changing from a positive impulse of unit length to a negative impulse of unit length. These impulses of unit length or less are not of sufficient strength to cause the movement of relay 5. A positive pulse therefore, will now be applied to the grid of tube 2, see curve C, at time 4 and will cause the armature of relay 5 to move from its positive to its negative contact.

At time *e* the incoming signal will be changing to an impulse of greater than unit length. This will not attain sufficient strength to move relay 5 at this time but the negative impulse stored on condenser 4 and applied to tube 2 will assist in

causing the relay armature to move to its positive contact. Tube 2 is chiefly effective in the movement of relay 5 at this stage.

At time *f* the incoming positive signal is sufficiently strong to keep the armature of relay 5 against its positive contact in spite of the positive pulse applied to the grid of tube 2 by the vibrating condenser 4.

At time *g*, it will be seen by referring to curve B, that the incoming signal is changing to a negative impulse of greater than unit length. During the weak signal period the vibrating impulse moves relay 5 to its negative contact.

The actions of relay 5 and tubes 1 and 2 for times *h*, *i* and *j* will be similar to those for times *a*, *b* and *c* since the same cycle of operations is repeated.

The above detailed description of operations is sufficient to indicate how the system responds to signal impulses of different lengths and polarities.

Printer relay 18, as hereinbefore described, will follow the operations of relay 5.

Synchronizing apparatus, amplifiers, etc. have not been disclosed since such means are well known in the art and are not a part of this invention.

What is claimed is:

1. A synchronous distributor impulse transmission receiver of the type in which unit length impulses are regenerated and plural unit impulses are received having means whereby the received impulses are impressed upon a space discharge device over a circuit having a fixed state of continuity, said device being connected to control a regenerating relay, a circuit connecting said relay to a second space discharge device whereby said relay is controlled in part by said second space discharge device, and interconnecting circuits whereby said regenerating relay controls said second space discharge device.

2. A synchronous distributor impulse receiving system in accordance with claim 1, in which said second space discharge device is connected to be responsive to electrical charges stored on a condenser.

3. A synchronous distributor impulse receiving system in accordance with claim 1, characterized in this that said second space discharge device is connected to be responsive to electrical charges stored on a condenser and in which there are means whereby said relay in operating to any one position always imparts a charge to said condenser, which upon application to said second space discharge device tends to move said relay to its opposite position.

4. In an impulse interpolating circuit, an incoming line, a thermionic repeater fixedly connected thereto, a pole changing device (5) operatively connected to the output circuit of said repeater, a second thermionic repeater, an operative connection between said second repeater and said device whereby said device controls said second repeater, and a circuit connecting said device and repeater whereby said second repeater controls said device.

5. A system in accordance with claim 4, wherein each thermionic repeater is connected to said device through the same winding of said device.

6. A system in accordance with claim 4, including a synchronous distributor whereby said pole changing device at each impulse cycle of said distributor acts on said second thermionic

repeater in a manner tending to move said device to its opposite position.

7. A system in accordance with claim 4, including a synchronous distributor and a condenser, circuits whereby said device stores a charge on said condenser over said distributor for each operative position of said device, and circuits whereby the charge operates over said distributor in a manner tending to move said device to its opposite position.

8. In an impulse interpolating circuit, an incoming line, a thermionic repeater connected thereto, a pole changing device operatively connected with the output circuit of said repeater, a second thermionic repeater, and means interconnecting said device and said second repeater whereby each is alternately controlled by the other.

9. Impulse regenerating means comprising a space discharge device, a pole changing relay, a storing device, means connecting the output circuit of said space discharge device with said relay, and means connecting said storing device alternately with said relay and with the input circuit of said space discharge device.

10. Impulse regenerating means comprising a space discharge device having an input circuit and an output circuit, a pole changing relay, means connecting the output circuit of said space discharge device with the input circuit of said relay, a storing device, and commutator means adapted to connect said storing device alternately with the output circuit of said relay and the input circuit of said space discharge device.

11. Impulse regenerating means comprising a thermionic vacuum tube, a pole changing relay, means connecting the output circuit of said tube with said relay, a condenser, and synchronous distributor means including commutator and brush apparatus for connecting said condenser alternately with said relay and with said vacuum tube.

12. Impulse regenerating means comprising a space discharge device, a pole changing device, means continuously connecting said devices, a storing device, and synchronous distributor means adapted to connect said storing device with said pole changing device to charge said storing device and successively to connect said storing device with said space discharge device to actuate said pole changing device.

13. Impulse regenerating means comprising a thermionic vacuum tube having a control grid and a plate, a pole changing relay having a winding and switching means controlled thereby, a circuit connecting said plate with said winding, a condenser, and means including commutator apparatus for connecting said condenser successively with said switching means and with said control grid.

14. Impulse regenerating means comprising a vacuum tube having an input electrode and an output electrode, a pole changing relay having a winding and switching means controlled thereby, a circuit connecting said output electrode with said winding, impedance potentiometer means connected with said input electrode, a condenser, and means including commutator apparatus for connecting said condenser alternately with said switching means and with said impedance potentiometer means.

WILLIAM A. KNOOP