No. 689,415. Patented Dec. 24, 1901.

H. A. ROWLAND.

ELECTRIC TELEGRAPH.

(Application filed Mar. 11, 1901.)

(No Model.)

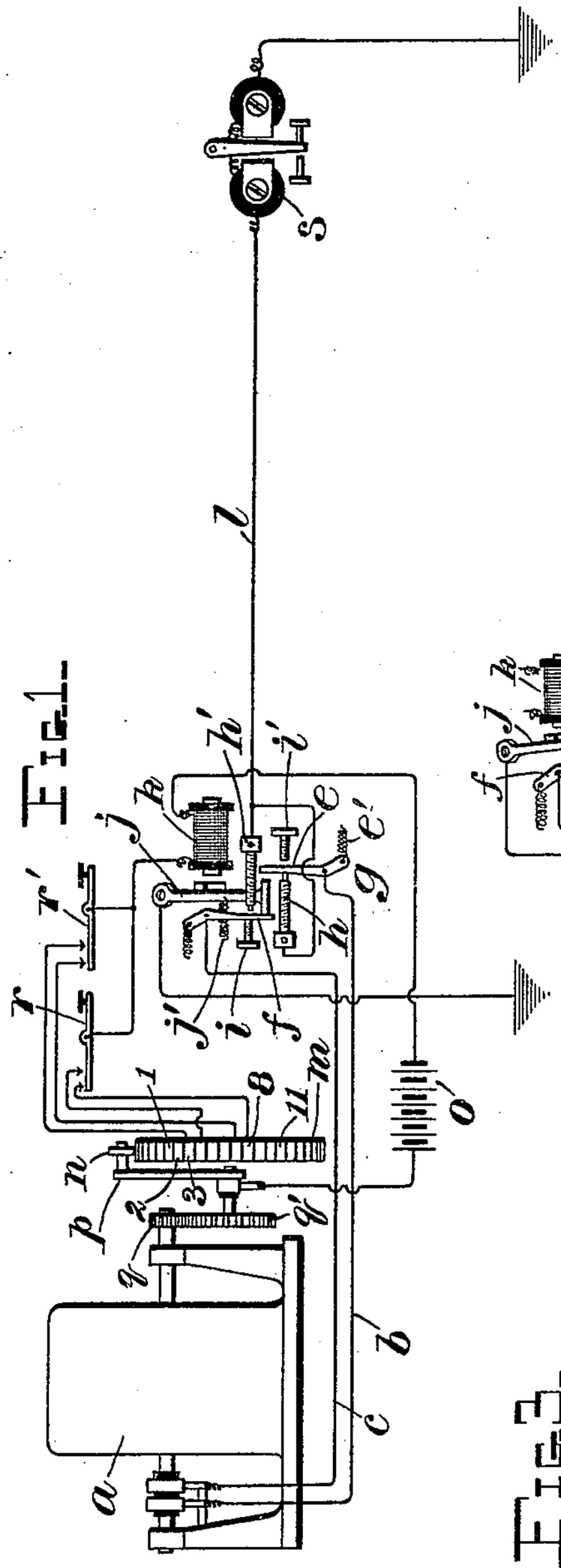

Fig. 1.

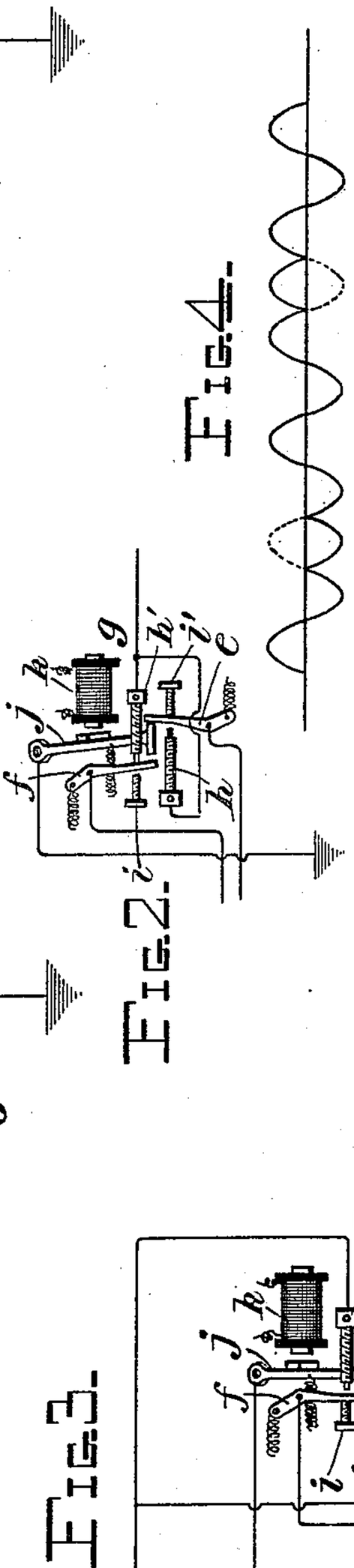

Fig. 2.

Fig. 4.

Fig. 5.

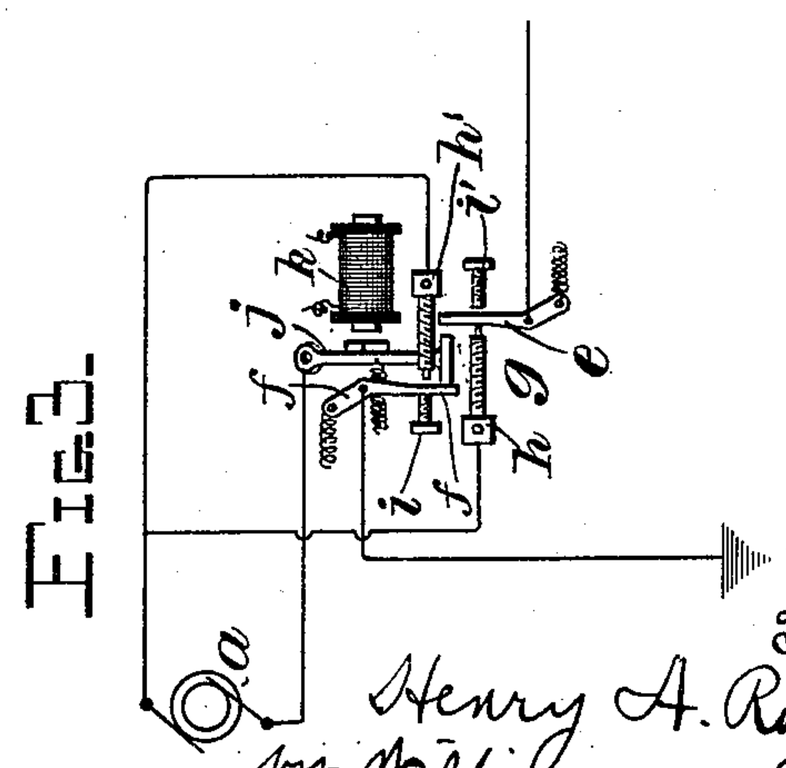

Fig. 3.

Witnesses

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UNITED STATES PATENT OFFICE.

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ELECTRIC TELEGRAPH.

SPECIFICATION forming part of Letters Patent No. 689,415, dated December 24, 1901.

Application filed March 11, 1901. Serial No. 50,721. (No model.)

To all whom it may concern:

Be it known that I, HENRY A. ROWLAND, a citizen of the United States, residing at Baltimore, in the State of Maryland, have invented certain new and useful Improvements in Electric Telegraphs, (Case H;) and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to improvements in electric telegraphs, and more particularly to an improved method of transmitting intelligence over an alternating-current circuit by selecting for each signal or character a predetermined number of the current impulses and modifying them by changing their polarity, but otherwise maintaining their form and characteristics.

This invention contemplates also the division of the line-current impulses into groups, each of said groups corresponding to a character or signal and in which a predetermined number of the impulses are reversed in sign, the order and relation of the reversed with respect to the normal impulses of a group determining the signal or the character of the code.

In carrying out my said invention I introduce into the alternating-current circuit a mechanism by which at will I may at any moment reverse the connections of the source of alternating currents, so as to reverse the polarity of any desired impulse or any number of impulses.

The said invention contemplates the reception of signals sent in the above manner in any way which will properly interpret them. I prefer, however, to interpret the messages upon such receivers as those shown and described in Patent No. 622,636, granted to me on April 4, 1899, or upon such as those shown in my pending applications, Serial Nos. 646,017, 659,629, 741,956, and 19,070, filed July 26, 1897, November 23, 1897, December 29, 1899, and June 4, 1900, respectively, the main feature of all of these devices, as far as the reception of the signals is concerned, being the employment of a main-line relay, either neutral or polarized, which will respond to the modified and unmodified impulses in such a manner as to energize local selecting-relays in combinations determined by the combinations of the modified and unmodified line impulses, and causing these selecting-relays to set up a signal-recording impulse adapted to actuate a type-printing machine. Though the employment of the main-line relay is embraced in the main idea prevailing in all of the devices referred to, they also embody the idea of passing the line-current directly through the local selecting-relays by the interposition of a current-selecting device.

It has formerly been my practice to modify the line impulses by changing their form or to entirely obliterate them, as by cutting them out; but in some cases that method has not the advantages of the present one, which consists simply in reversing the polarity of the impulses without otherwise changing their form or characteristics. According to the latter method the tongue of a relay acted upon by a reversed impulse is held against its contact more firmly than would be the case if the impulse were simply missing or cut out or reduced in intensity. The principal advantage, however, of the method of reversing the wave over that of cutting it out is that by the former (reversed-wave method) reversing two or more adjacent impulses of a group may form a combination when received upon a polarized relay, whereas with the cut-out wave this cannot be done, for if a polarized tongue is vibrated by an alternating current the effect of cutting out two adjacent impulses will be the same as cutting out a single impulse, as the tongue will remain against the contact to which it was last sent until an impulse of the opposite sign arrives, while in the case of the reversed impulse adjacent impulses may form a combination, since each will act differently upon the relay, and in this way a greater number of combinations may be gotten from a given number of impulses, which in turn reduces

the number of local selecting-relays when this method is employed with the receivers described in the above-mentioned patent and patent applications.

In order that the nature and objects of my said invention may be more fully understood, the same will be described in greater detail with reference to the accompanying drawings, which represent for illustrative purposes a means for carrying out this invention.

Figure 1 is a diagram illustrating the principle of my said invention. Fig. 2 represents parts of the transmitter of Fig. 1 as they appear when sending a signal to line. Fig. 3 is a diagram showing a different manner of connecting the transmitter of Figs. 1 and 2. Fig. 4 is a diagram representing a group of alternating-current impulses modified according to my invention; and Fig. 5 represents in diagram a series of polarized relay tongues and stops, showing the relative position of said tongues with respect to the impulses which actuate them.

Similar characters refer to similar parts throughout the several views.

I shall first describe, briefly, a special form of apparatus for carrying out my invention and then the manner in which the same is to be performed.

Referring to Fig. 1, *a* represents an alternating-current generator of any desired character delivering to the terminal wires *b* and *c* an electromotive force, preferably of sine or approximately sine-wave form. The generator *a* simply indicates any source of alternating currents as I may produce the current by any suitable device—such as a vibrating reed, relay-tongue, or commutator of any desired description—or I may derive it from a transformer. The wires *b* and *c* are connected, respectively, to the spring-controlled contact-levers *e* and *f* of an ordinary pole-changing transmitter *g*, which is provided also with adjustable forward stops *h h'* and back stops *i i'*, pivoted striker *j*, which is adapted to vibrate between the contact ends of the levers *e* and *f*, and with the electromagnet *k*, which actuates the said striker. The contact-stops *h* and *h'* are permanently connected to the main-line wire *l*, although both are not always in circuit with it, as will hereinafter appear, and the striker is connected to the ground, as shown.

The stops of the transmitter, especially the forward stops *h* and *h'*, are capable of accurate adjustment, so that the sparking and the time of short-circuiting the alternator will be reduced to a minimum. Even though the alternator is short-circuited in the operation of the transmitter in effecting the change over or reversal, the time is so extremely short that the self-induction of the alternator will prevent the current from rising to a sufficient extent to be appreciable or to produce any injurious effects. Moreover, the reversal occurs at or about the point of zero electromotive force, which is an additional reason for the fact that no injurious effect is produced by the short circuit.

From the transmitting apparatus the line-wire *l* passes to the desired receiving-station, where it is connected to suitable receiving apparatus, which I have represented in the drawings as a polarized line-relay *s*, though various other devices may be employed, as will also hereinafter more fully appear. From the relay *s* the line-wire passes to the ground, as shown.

As a part of the transmitting apparatus I employ the sunflower *m*, composed of a number of insulated metallic segments—say, for example, fifty-two—and over these segments sweeps a trailer *n*, mounted upon an arm *p*, driven by any suitable power, preferably by the alternator through suitable gearing *q q'*. The width of the segments of this sunflower and the velocity of the trailer are such that the said trailer passes over one segment for each impulse or semicycle of the current generated—that is to say, if there are fifty-two segments in the sunflower the alternator generates once in each revolution of its armature fifty-two semicycles, or twenty-six complete alternations or periods. The segments of the sunflower are divided into a number of separate groups, consisting, say, of eleven segments each, one of such groups being represented as composed of the segments 1 to 11, inclusive. Each of the said segments is connected through a proper circuit making and breaking device, such as a keyboard, perforated or other prepared tape, or the like, with the coil of the electromagnet *k*, only two keys *r* and *r'* of a keyboard being shown. The individual keys of each keyboard are in this special case so arranged that each when operated connects in the transmitter-magnet circuit two different segments of the sunflower of the group operated by that particular keyboard or equivalent device. Hence it is possible to connect the segments of the group specified to the transmitter-magnet in fifty-five combinations, taking two segments for each combination, so that if we allow each combination to represent a signal fifty-five signals may be transmitted from a group of eleven impulses. A battery *o* or other source of local direct current is connected to the trailer and to one terminal of the transmitter-magnet coil, as shown.

The manner of carrying out my said invention is as follows: Let it be assumed that the generator *a* is delivering an uninterrupted alternating current to the wires *b* and *c* and that no signals are being sent to line. Then the successive positive and negative impulses will take the following courses through the transmitter to line and back to the alternator, and the reverse: One impulse (positive, for example) will pass from the wire *b* through the contact-lever *e*, forward stop *h*, the former being normally held against the said stop by the spring *e'*, and thence to the line *l*, which passes to the receiving-station, and in the

special case shown in Fig. 1 this impulse will traverse the coil of the relay *s*, returning through earth to the striker *j*, and then into the lever-arm *f*, against which arm the said striker is normally held by the spring *j'*. From the lever-arm *f* the impulse will pass through the wire *c* back to the generator. The next succeeding or negative impulse, as will be readily understood, will traverse the same parts, but in a reverse direction. As long as this operation continues the tongue of the relay *s* will continue to vibrate between its contact-stops in unison with these impulses. Let it be assumed next that for each character or signal to be transmitted there is a corresponding group of impulses—eleven, for example—that pass to the line, but that out of this group there is selected for each character or signal a certain number—two, for example—which have their relation to the normal impulses changed. This change of relation is effected by reversing the polarity of the selected impulses or changing their phase on the line one hundred and eighty degrees, but without otherwise altering their characteristics—that is, they retain their same form, but differ in sign. Such a group of impulses is graphically represented in Fig. 4, which we will assume is the group or combination of the code which represents the letter "A," from which it will be seen that the impulses which normally would have been impulses No. 3 positive and No. 8 negative are now still Nos. 3 and 8, but have opposite signs to that which they would have normally, so that wherever there is an impulse modified in this manner there will be a series or set of three of the same sign, and hence where there are two modified in each group this gives rise to two sets of three impulses each in every group. Assuming now any arbitrary character, such as the letter "A," the manner in which the impulses are modified to represent this letter is as follows: The operator desiring to send the letter operates, for example, the key *r'*. This will connect segments 3 and 8 of the group 1–11 to the transmitter-magnet coil. Then as soon as the trailer starts upon segment 1 the propagation of an impulse corresponding to the first impulse on the left, Fig. 4, will commence, rise to its maximum as the trailer reaches the center of the segment, and then descend to zero, arriving at that point as the trailer leaves the segment. In order, though, for this to take place, it is first necessary to adjust the sunflower until the spaces or insulation between its segments will exactly correspond with times of zero-current—that is, of the line-current—and if there be a difference of phase between the impressed electromotive force and the resultant current, which would ordinarily be the case, this adjustment would be made relative to the point of zero-current and not the electromotive force, the former being the region of minimum sparking. As the trailer then reaches segment 2 the second impulse will be sent to line in the same manner, but of opposite polarity to the one preceding it; but when the trailer begins to pass upon segment 3 this will complete the circuit from the local battery through the coil of the transmitter-magnet, which circuit will remain completed for the length of a complete impulse, beginning at the point where the last preceding impulse left off or the point of zero-current. At the instant, however, that this circuit is completed the said magnet becomes energized and attracts its armature, which is carried by the striker *j*. This, as will readily be seen, sends the striker to the right, when its hammer portion will engage the contact-lever *e*, and the lever *f*, hitherto engaged by it, will be sent by its spring against the stop *h'*, as shown in Fig. 2. As the last positive impulse passed to line from the wire *b* by way of the contact-stop *h* the present impulse takes the opposite direction, whence it becomes upon the line a negative impulse passing to line by way of lever *e*, striker *j*, and thence to earth, returning by way of line *l* and stop *h'*. As soon, however, as the trailer passes off of segment 3 the local circuit will be broken, when the striker will quickly be returned by spring *j'* back to the position shown in Fig. 1. The succeeding fourth, fifth, sixth, and seventh impulses will then pass to line, as described for the first two, but when the trailer reaches segment 8 the local circuit will again be completed through the coil of the transmitter-magnet, since segment 8 is connected with said coil through the key *r'*. When this takes place, the parts of the transmitter again assume the positions shown in Fig. 2, when the impulse No. 8, normally negative, will pass to line as a positive impulse, which will begin at the point of zero-current, rise to its maximum, and then descend again to zero, when the trailer will pass from segment 8 and the succeeding impulses pass to line in the normal positions. By a similar operation any other arbitrary sign or character may be transmitted, it being necessary simply to select a different combination of impulses in each group for the respective signals, so that in this way we have a clearly-defined telegraphic code, the characters or signs of which may be recorded in various ways—as, for example, upon a type-printing machine, chemically or otherwise prepared tape, as upon a Bain receiver or upon a Morse register, or in any of the well-known ways. The relay *s* comprises a part of the printing telegraphic apparatus shown and described in my several patent applications for improvements in electric telegraphs above referred to, the function of the said relay being simply to vibrate its tongue in unison with the alternating current between its contact-stops, and thus to periodically complete certain local circuits to the printing apparatus and to alter these local circuits

by remaining against one or the other of its contacts in certain combinations for each signal.

The effect produced upon the relay *s* by transmitting a signal to line is graphically represented in Fig. 5, which shows the various positions occupied by the relay-tongue during the passage of the group of impulses shown in Fig. 4 through its coils, from which it will be seen that the modified or changed impulses Nos. 3 and 8 cause the relay-tongue to remain against the contact to which it was last attracted. The positions of the tongue, however, would be the same if instead of changing the selected impulses from their normal sign they were simply cut out of the circuit altogether; but the practical result may not be the same. In practice the tongue of the relay *s* is very sensitively mounted, so that once having been thrown against one of its contacts it is very easily carried back to the other, and in the case of the cut-out semicycle there would be no positive force acting to hold it against the stop to which it was last attracted after the impulse which sent it there had died out. Hence in such a case there is more or less danger of an error, as the correct reception of the signal is dependent upon the accuracy of the relay. On the other hand, it will be readily seen that where the impulses are reversed or simply changed from positive to negative, or vice versa, an extra force, due to the current, holds the tongue against the contact to which it was last sent—viz., an impulse of the same polarity as the next preceding one—which insures greater accuracy in the reception of the signals than would otherwise be the case. It will also be noted that if the striker of the transmitter has been sent forward in a direction to reverse an impulse all of the succeeding impulses will be reversed as long as the striker stays over, sending along the line a series of impulses just the same as the normal impulses, but of opposite polarity, it not being necessary to perform two operations with the transmitter in order to reverse two adjacent impulses. In other words, one operation of the transmitter will reverse as many consecutive impulses as desired. Therefore if there are a series of polarized relays which respond to a corresponding series of reversed impulses it is necessary to operate the transmitter only once to affect the whole series. This is quite an advantage over the method of cutting out waves which does not admit of the use of combinations of consecutive impulses with a polar line-relay, and hence requires a greater number of selecting receiving-relays.

Any apparatus which will suitably and at the proper times complete the transmitter-magnet circuit may be substituted for that shown—such, for example, as a prepared tape adapted to travel in synchronism with the alternator or, indeed, any of the well-known devices or such as I may hereafter devise; but in practice when employing the sunflower and keyboard the keys of the latter are so arranged that they may be operated at the proper time only and when so operated are locked until the trailer has passed over the segments to which they are connected before they may be again operated, substantially as described in Patent No. 622,636, granted to me on April 4, 1899, and in my patent application filed June 4, 1900, and serially numbered 19,070. Therefore, while I have designated the device *g* the "transmitter," this apparatus is only a part of the true transmitting apparatus, which comprises, first, the sunflower upon which the messages are "set up," which messages are sent as the trailer passes over the segments; second, the keys or their equivalents by which the messages are set up upon the sunflower, but which do not actually operate the transmitter *g*, and, third, the transmitter *g*.

The sunflower is the equivalent of perforated or other prepared tape and the keys *r* and *r'* the equivalents of the device (usually punching device) for setting the messages up upon the tape. Therefore by either the device shown in Fig. 1 or its equivalent tape-transmitter the messages are automatically sent to line, the device shown being what is termed a "key-operated automatic transmitter," while the tape devices are usually designated simply "automatic transmitters."

Having thus described a form of my invention, I do not wish to confine it to the various particular cases which it was necessary to assume in order to clearly describe the same—such, for example, as the modification of two impulses in groups of eleven—as I may, if desired, select other numbers of impulses, nor do I wish to limit my invention to the sine-wave alternating current as derived from a commercial alternator, as shown, as I may derive the current from any suitable source so long as it is periodically-varying electric current, and likewise with other special cases herein described; but

What I do claim, and desire to secure by Letters Patent of the United States, is—

1. The improvement in the art of telegraphy, which consists in impressing upon the line an electromotive force of a periodically-varying character having alternate impulses of opposite polarity, and changing the polarity of a predetermined number of the current impulses to represent a signal, substantially as described.

2. The improvement in the art of telegraphy, which consists in impressing upon the line an electromotive force of a periodically-varying character having alternate impulses of opposite polarity, and changing the polarity of the same number of the resultant current impulses for each signal, substantially as described.

3. The improvement in the art of telegraphy, which consists in impressing upon the line an electromotive force of periodically-

varying character having alternate impulses of opposite polarity, changing the polarity of a predetermined number of the resultant current impulses for each signal and maintaining the current upon the line unbroken, substantially as described.

4. The improvement in the art of telegraphy, which consists in impressing upon the line an electromotive force of periodically-varying character having alternate impulses of opposite polarity, and modifying a preselected number of the current impulses to represent a signal by commencing at a point of zero current and changing the polarity of said impulses, substantially as described.

5. The improvement in the art of telegraphy, which consists in impressing upon the line an electromotive force of periodically-varying character having alternate impulses of opposite polarity, and modifying a preselected number of the current impulses to represent a signal by commencing at the point of zero current and changing the polarity of said impulses without altering the form or other characteristics thereof, substantially as described.

6. The improvement in the art of telegraphy, which consists in impressing an alternating electromotive force of sine or approximately sine wave form upon a line, and modifying a preselected number of the current impulses for each signal by changing the polarity of the said selected impulses substantially as described.

7. The improvement in the art of telegraphy, which consists in impressing an alternating electromotive force of sine or approximately sine wave form upon a line and modifying a preselected number of the current impulses for each signal by beginning at the point of zero current and changing the polarity of the said selected impulses, substantially as described.

8. The improvement in the art of telegraphy, which consists in impressing upon a line an alternating electromotive force, changing the polarity of a predetermined number of the resultant current impulses to represent a signal, adjusting the times of the commencement of said changes with respect to the phase of the current and electromotive force, so that the said times shall occur at points of zero current, substantially as described.

9. The improvement in the art of telegraphy, which consists in impressing upon a line an alternating electromotive force, changing the polarity of a predetermined number of resultant current impulses to represent a desired signal, adjusting the times of commencement of said change with reference to the phase of the impressed electromotive force and resultant current so that the said times shall occur at points of zero current, the selected impulse rising to its maximum, and then descending to zero at a point where it would naturally have been zero had its polarity not been changed, substantially as described.

10. The improvement in the art of telegraphy, which consists in impressing upon the line an alternating electromotive force, dividing the resultant current impulses into groups, modifying a predetermined number of the impulses of a group by changing the polarity of said impulses, the number and position of said modified impulses relative to the unmodified impulses of each group representing the respective signals transmitted, substantially as described.

11. The improvement in the art of telegraphy, which consists in impressing upon the line an alternative electromotive force, dividing the resultant current impulses into groups, modifying a predetermined number of the impulses of a group by changing the polarity of said impulses, the number and position of said modified impulses relative to the unmodified impulses of each group representing the respective signals transmitted, and maintaining the current in each group unbroken, substantially as described.

12. The improvement in the art of telegraphy, which consists in impressing upon the line an electromotive force of a periodically-varying character, and having alternate impulses of opposite polarity, dividing the resultant current impulses into groups, modifying a predetermined number of the impulses of a group by commencing at the point of zero current and changing the polarity of said impulses, the number and position of said modified impulses relative to the unmodified impulses of each group representing the signal transmitted, substantially as described.

13. The improvement in the art of telegraphy, which consists in impressing upon a line an electromotive force of a periodically-varying character and having alternate impulses of opposite polarity, causing groups of resultant current impulses to pass a selected point at regular recurring periods of time, selecting from the total number of said impulses comprising a group, impulses predetermined both as to number and position, and modifying these impulses by changing their polarity, substantially as described.

14. The improvement in the art of telegraphy, which consists in impressing upon a line an alternating electromotive force of sine or approximately sine wave form, causing groups of the resultant current impulses to pass a selected point at regular recurring periods of time, selecting from the total number of impulses comprising a group impulses predetermined, both as to number and position, modifying these selected impulses by changing the polarity of said impulses and adjusting the times of said change with respect to the phase of the current and electromotive force, so that the said times shall occur at points of zero current, substantially as described.

15. The method of impressing the characters of a telegraphic code upon a line carrying an alternating electric current, which consists in selecting for each character a group of the impulses of said current, each group comprising the same number of impulses, forming a plurality of separate sets of impulses in each group by the reversal of the polarity of one impulse in each set, each set comprising successive distinct impulses of the same polarity, the position of one set with respect to the other in a particular group determining the character of the code represented by that group, substantially as described.

16. The method of transmitting intelligence over a line carrying a periodically-varying electric current and having alternate impulses of opposite polarity, which consists in representing a desired signal by a group of unbroken line current impulses, selecting in this group impulses predetermined both as to number and position, and changing the polarity of said selected impulses, substantially as described.

17. The method of transmitting intelligence, which consists in impressing an alternating electromotive force on a line, dividing the alternating current into groups of impulses, reversing one or more of the said impulses for a signal, and recording the signal by selecting the special group representing the signal from the remaining impulses, substantially as described.

18. The method of transmitting intelligence, which consists in impressing an alternating electromotive force on a line, dividing the alternating current into groups of impulses, reversing two of the said impulses for a signal, and recording the signal by selecting the special group representing the signal from the remaining impulses, substantially as described.

19. The method of transmitting intelligence, which consists in impressing an alternating electromotive force on a line, dividing the alternating current into groups of impulses, one group for each signal to be transmitted, reversing the same number of impulses in each group, the signal being determined by the order of said reversed impulses, and recording the signal by selecting the special group representing the signal from the remaining impulses, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

HENRY A. ROWLAND.

Witnesses:

JOHN R. HOOPER,

A. J. GRAPE.