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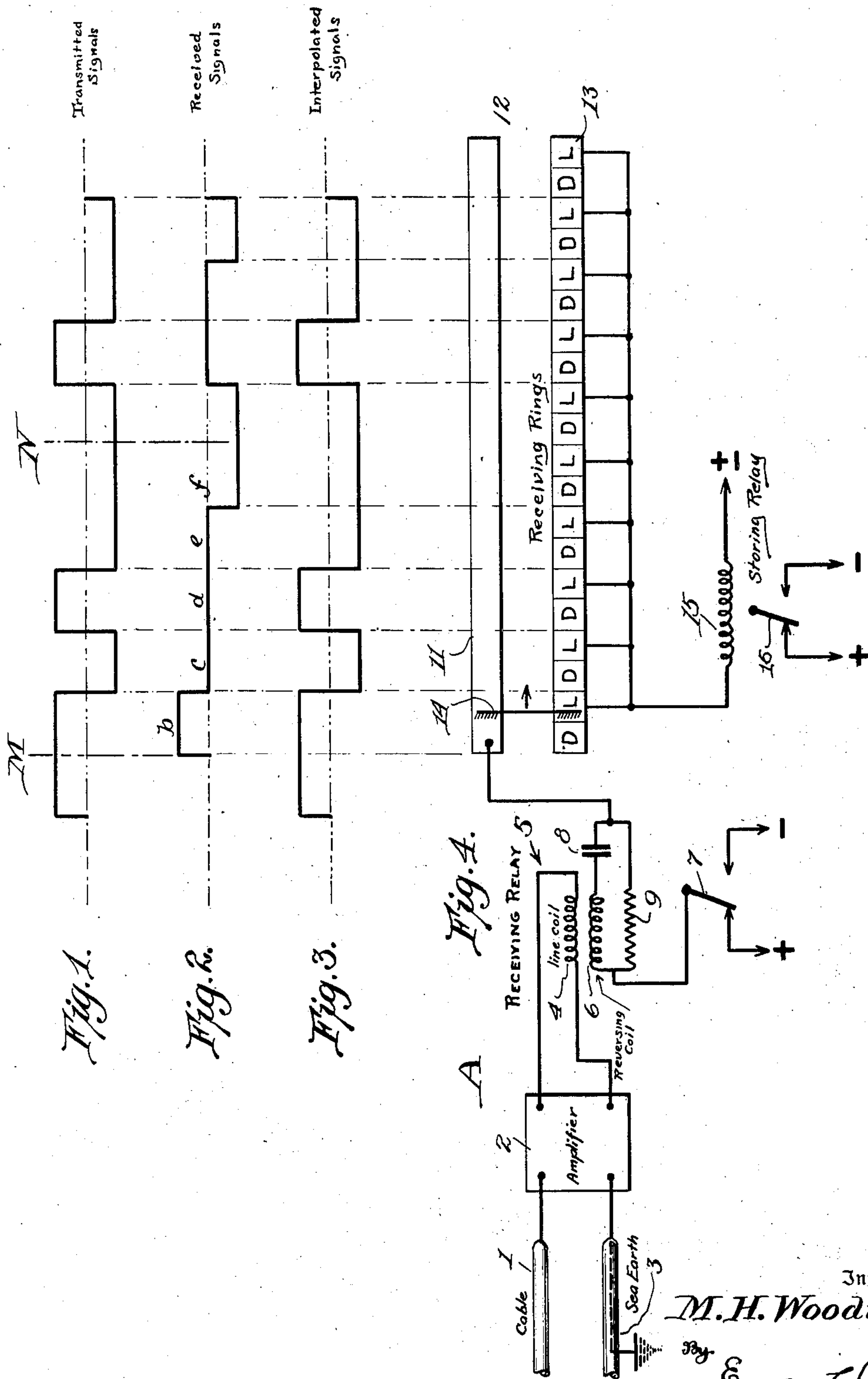
M. H. WOODWARD

1,788,477

INTERPOLATING SIGNAL IN HIGH SPEED TELEGRAPH CIRCUITS

Filed April 13, 1929

3 Sheets-Sheet 1



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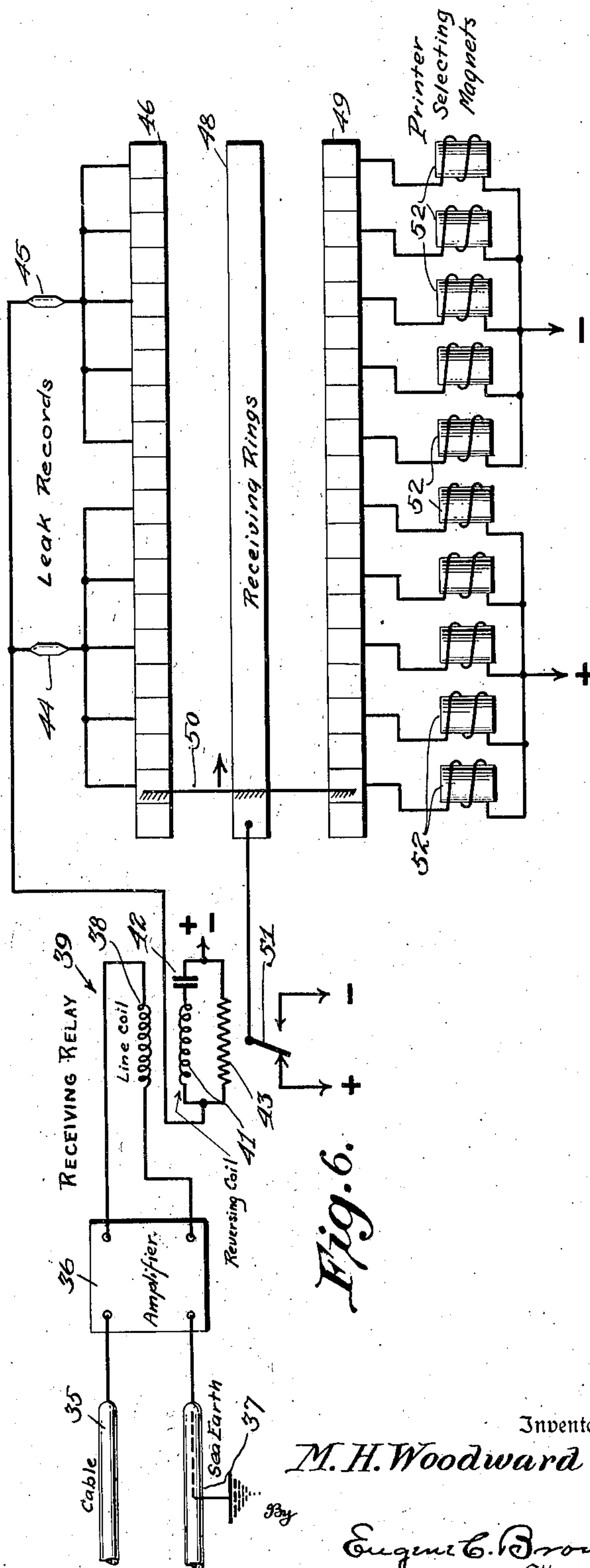
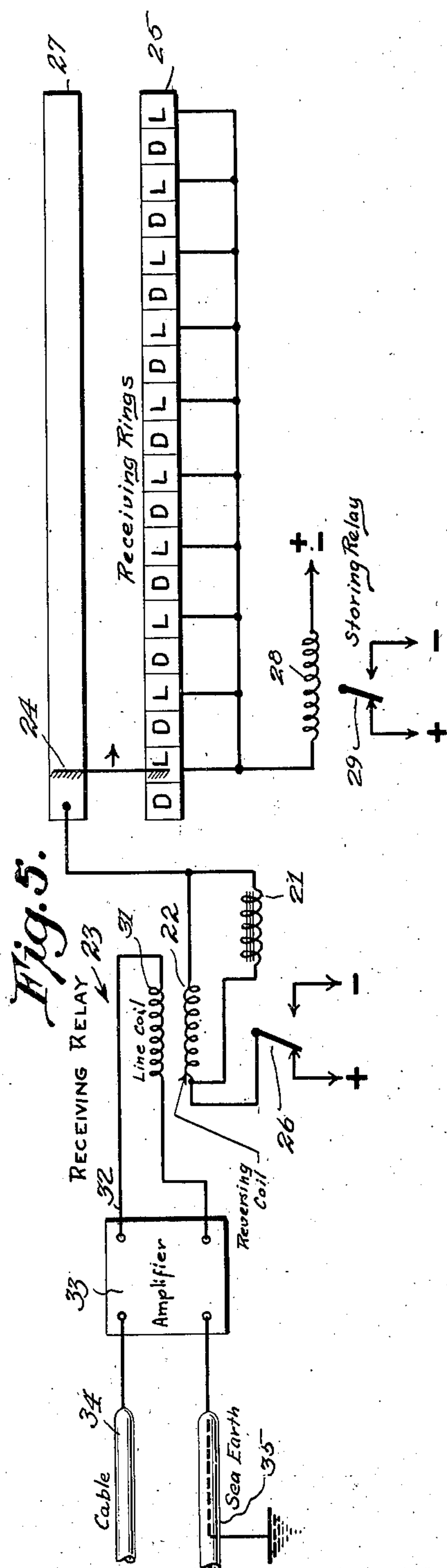
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3 Sheets-Sheet 2



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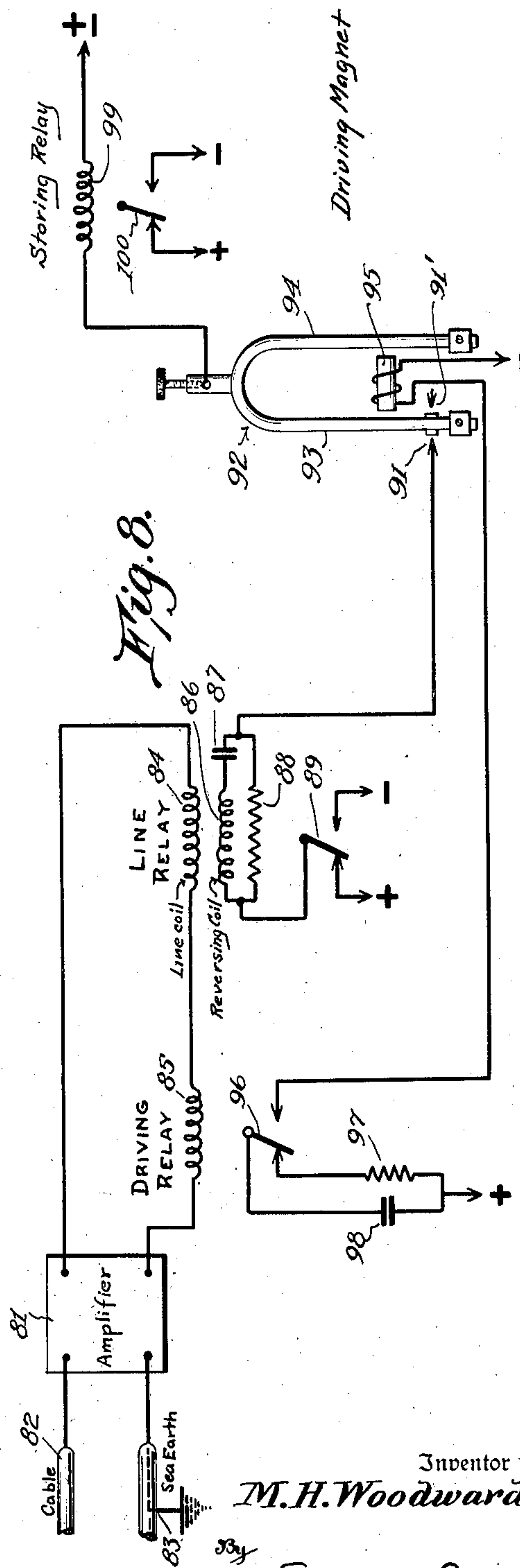
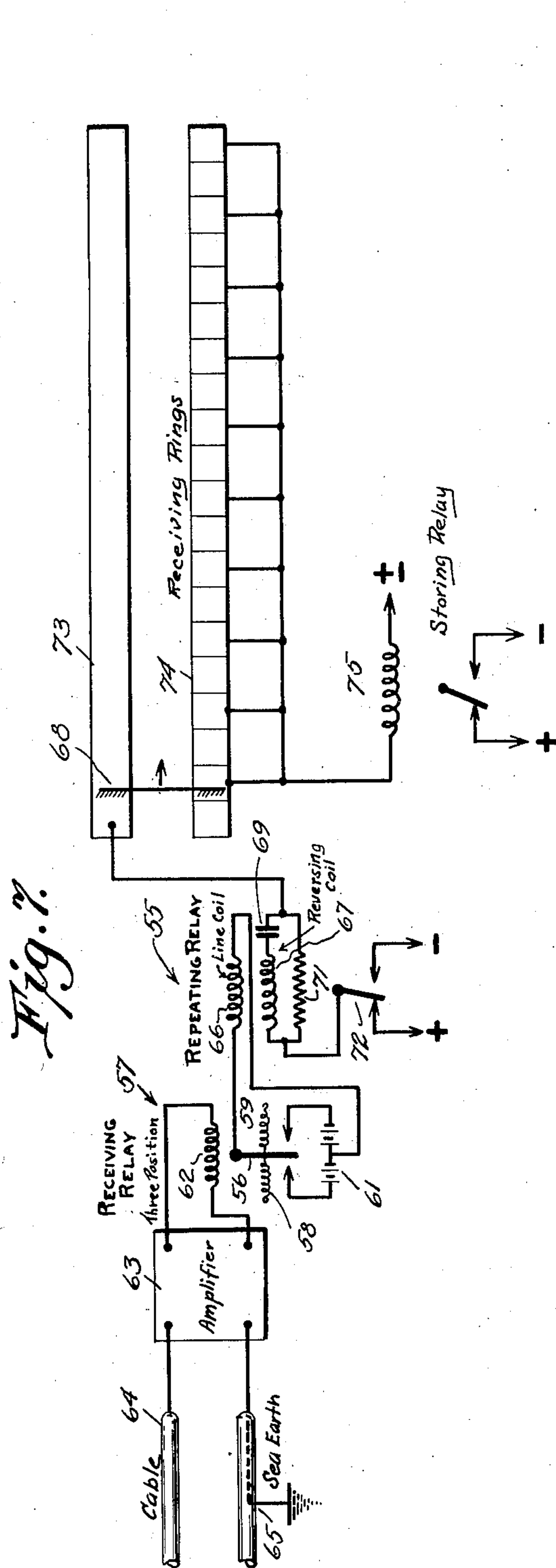
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INTERPOLATING SIGNAL IN HIGH SPEED TELEGRAPH CIRCUITS

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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INTERPOLATING SIGNAL IN HIGH-SPEED TELEGRAPH CIRCUITS

Application filed April 13, 1929. Serial No. 354,907.

My invention relates to telegraph systems and apparatus, and more particularly, to systems in which the signals reaching the receiver are considerably attenuated.

5 It is well known that in long telegraph systems the received signals are weakened and distorted to such an extent due to extraneous inductive effects and cable reactance that the receiving apparatus fails to respond
10 thereto unless the signals are transmitted at a very low rate of speed. Inasmuch, however, as high speed signaling for the commercial operation of a cable is a necessity, receiving mechanism must be provided which
15 will respond to signals transmitted at a comparatively high signaling rate. One method for accomplishing this which has met with great commercial success is to interpolate the
20 transmitted signals, i. e., to assume a normal transmission of periodic positive and negative impulses, a receiver being arranged to normally vibrate its armature under local control as if in response to such signaling. During a signaling period comprising regular
25 reversals of polarity, the weak received signals need not function as the receiver operates as if in response to such signals.

A different condition exists, however, when a particular code includes two successive signals of the same character, but in such an
30 event, the rate of signaling has really decreased and by the time the second of these impulses is flowing the current in the receiver has reached an amplitude sufficient to become operative. Advantage is taken of this
35 to control the local relay operation, a magnetic force being created opposing that of the local relay to prevent the armature from changing its position as if in response to two
40 succeeding impulses of the same polarity. It will be clear that the energy necessary to merely prevent an operation of the armature is considerably less than is necessary to actually operate the armature. Hence both
45 conditions comprised in code signaling, i. e., periodic reversals of impulses and successive signals of the same polarity, are properly interpolated. The receiver is thus operated in accordance with high speed telegraph signals which are considerably attenuated.
50

This method of signaling was first accomplished by the Gulstad relay, comprising a local and a line winding. For interpolating the received signals, the windings of the Gulstad relay are connected to impedances
55 through its armature in such a manner that alternate positive and negative currents flow through the local winding when no current is received from the line. When the armature is in engagement with one of its contacts, it
60 completes a circuit for its winding in such a direction that the armature is thrown to its opposite contact. As this winding is thus energized with successive impulses of both polarities its armature is thrown to its two
65 positions in synchronism with the rate at which the signals are being transmitted.

If the transmitted code comprises alternate spacing and marking signals which, as explained above, are so attenuated that they do
70 not affect the receiving relay, the Gulstad relay apparatus functions as described to successively throw its armature to its alternate positions as if in response to the code signals.

When on the other hand, a marking impulse
75 follows a marking impulse, the line current flowing in the line winding of the Gulstad relay is of sufficient amplitude to balance the effect of the current in the local winding
80 tending to throw the armature to its opposite position and hence the armature remains in the same position. It will be clear from the above description that although the received signals may be considerably attenuated, the receiver will be operated in accordance with
85 the transmitted code.

In order, however, that the above described arrangement shall operate correctly, it is necessary that the armature shall vibrate at
90 a frequency synchronous with the rate of signaling and always in proper phase therewith. The Gulstad relay per se is not, however, provided with means for maintaining it in synchronous operation with the signaling, dependence for this purpose being placed
95 on the constants of the impedances employed in the circuits. Such reliance, however, for so important a phase of operation is unwarranted and as is to be expected, from time
100

to time, the relay falls out of step with the signaling.

To overcome this difficulty it has been proposed to connect the Gulstad relay electrically to a rotating distributor in such a manner that its armature vibrations are jointly controlled by the circuit impedances and the distributor. An illustration of this arrangement is shown in the patent to Clokey, 1,522,865, dated January 13, 1925. Inasmuch as motors for driving the distributor in synchronism with the received signals have been perfected to a degree which insures accurate synchronism for all practical purposes, this arrangement overcomes to a considerable extent, the difficulties experienced in maintaining the Gulstad relay in synchronism.

It will be noted, however, that to accomplish the desired results, Clokey resorts to elaborate, involved and complicated circuit arrangements and a large number of distributor sections, thereby rendering the system inflexible and obviously undesirable.

As disclosed in the Clokey patent, the vibrating relay operates in response to local currents which flow continuously through its windings and the received signals, in order to maintain the armature in its operated position in the event of a succession of two impulses of the same polarity, must be of sufficient amplitude over this same period of time to overcome the effects of the current in the local relay. The received signals under consideration, are however, attenuated and hence may not have the required continuous current amplitude. Clearly then, a system such as proposed by Clokey, is marginal, for unless the received impulse is continuously of sufficient intensity, the local relay winding, by reason of the continuous flow therethrough, will throw its armature to its alternate position in opposition to the current flow from the line relay.

Inasmuch as the Gulstad relay arrangement is employed to interpolate very weak and distorted received signals, it will be clear that the local operating circuits should be so adjusted with respect to line relay operation that the attenuated signal can make its presence effective. Furthermore, in order to insure positive operations of the receiver, the interpolation of the signals should take place a short interval in advance of the receiver operation, in accordance with the received code in order to prevent chattering or a weak operation of the receiver.

Accordingly, one object of my invention is to provide apparatus and circuits at the receiving station of a telegraph system for interpolating signals with local currents of short duration and having an amplitude sufficient to operate the armature but insufficient to operate the armature in opposition to a received signal which may be considerably attenuated.

Another object of my invention is to provide means which are not marginal for interpolating attenuated received signals.

A further object of my invention is to provide a simple arrangement requiring a minimum amount of apparatus for operating a relay arrangement of the Gulstad type in synchronism with signaling impulses.

A still further object of my invention is to provide simple and reliable receiving apparatus operating in response to attenuated and distorted signals.

These and other objects will appear in the following detailed description in which reference is made to the accompanying drawings.

Figure 1 is a diagram showing current curves of code signals impressed on a signaling line at the transmitting station.

Figure 2 illustrates the current curves of the same signals as they arrive at the receiving station.

Figure 3 illustrates the received current curve when interpolated in accordance with my invention.

Figure 4 is a diagrammatic view of the circuit and apparatus in one embodiment of my invention.

Figure 5 shows a modification of the arrangement disclosed in Fig. 4.

Figure 6 is a modification of Fig. 4 showing the condenser interpolating method at a terminal printing station.

Figure 7 is a modification of circuits and apparatus of the condenser interpolating method employing a three position relay interposed between the amplifier and the repeating relay at the receiver station.

Figure 8 is a diagram of the circuits and apparatus of a modified form of the condenser interpolating circuit employing tuning forks at the receiving station.

In Fig. 4, a cable 1 extending from a remote station (not shown), to station A is connected in series with the input of amplifier 2 comprising any well known type of distortion correcting network and current amplifier, the opposite terminal of the amplifier 2, being grounded at a sea earth 3. The output of the amplifier 2 is connected to a line winding 4 of relay 5 which comprises in addition to this main or line winding, a reversing winding 6. One terminal of the reversing winding 6 is connected to the armature 7 which is operated to either of its contacts connected to opposite terminals of a battery under joint control of the windings 4 and 6 in a manner to be described in more detail hereinafter. The other terminal of winding 6 is connected to one side of condenser 8. Winding 6 and condenser 8 are shunted by a resistance 9 which provides a discharge path for the condenser 8 as will be described in detail hereinafter.

Connected to the common terminal of the condenser 8 and resistance 9 is the continuous

ring 11 of the rotating receiver distributor 12. The receiver distributor 12, which in practice is circular in form, is here shown flat, for purpose of illustration and comprises in addition to the solid ring 11, a segmented ring 13 and a brush 14 bridging the segments of the ring 13 and the solid ring 11. The dimensions of the segments and speed of the brush rotation is so chosen that the brush 14 will wipe over two segments during a single impulse period and the phase relation is such that the brush 14 will move into engagement with a dead segment marked D during the first half of the impulse and will pass over the succeeding live segment L during the last half of the signal period as clearly indicated by a comparison with Figures 1-3 in which time is measured along the horizontal as in Fig. 4. By dropping vertical lines between a signal interval on Figs. 1-3, it will be noted that they included a D segment and an L segment on ring 13. No driving motor or synchronizing and phase correcting mechanism is shown as any well known apparatus may be employed.

As shown, the alternate segments L, of the segmented ring 13 are multiplied to each other and connected to the winding 15 of the storing relay, the other terminal of which is connected to the mid-point of the battery. The armature 16 of the storing relay is connected to the receiving magnets of a printer (not shown) or it may be connected to a cable for repeating the impulses to a remote station.

The operation of the arrangement shown in Fig. 4 will be described in connection with the Figs. 1 to 3, which illustrate the wave shape of the transmitted and received signals. It will be understood that the brush 14 is driven by a synchronous motor (not shown) in synchronism with the transmission of the code signals. For the purpose of describing the operation of my invention, it will be assumed that a code combination of impulses as indicated between M and N Fig. 1, comprising a spacing-marking-spacing-marking marking combination of impulses is impressed on the cable 1 at the transmitting station. The shape of the wave received at station A will take a form approximating that shown in Fig. 2. It will be noted that the impulse preceding the first code impulse is a spacing signal. This received impulse is so attenuated that it has no effect on the line winding 4. Inasmuch however as the first code impulse which follows is of the same polarity, the amplitude of the current flow which gradually increases as the length of time during which the impulse is impressed on the line becomes longer, will become commensurable as shown at *b*, Fig. 2. That is, sufficient energy is developed by this time to produce a spacing signal during the second

impulse of the same polarity or in this case the first impulse of the code under consideration. The second, third, and fourth signal impulses, however, are high frequency unit length impulses and are therefore on the line an insufficient length of time to reach any measurable amplitude. Accordingly they produce no effect as indicated at *c*, *d* and *e*, Fig. 2. The fifth signal impulse, however, being the second of a prolonged marking signal, will have accumulated sufficient energy to produce an effect on the receiving coil as shown at *f* in Fig. 2.

It is evident from an inspection of Fig. 2, that some means are necessary for interpolating the high frequency signals which produce no effect on the receiver as indicated at *c*, *d* and *e*, Fig. 2, if the receiver is to be operated in accordance with the code shown in Figs. 1 and 3, the latter being obtained as a result of interpolation in accordance with my invention.

As explained above, the first or spacing impulse from the transmitting station which arrives when brush 14 is on the first segment D, just underneath the left half of impulse *b*, has a wave shape as indicated at Fig. 2 and flows over the cable 1 through the amplifier 2 to a sea earth return circuit at 3. As a result current of sufficient amplitude flows in the output circuit of the amplifier and through the coil 4 to operate the armature 7 to its spacing or left hand contact. A circuit is completed from the positive side of battery, to the left hand contact and armature 7, parallel paths through resistance 9 and winding 6 of the relay 5, the condenser 8, to solid ring 11, brush 14 and second segment L of ring 13 which is underneath the right half portion of the impulse *b*, over which it is assumed the brush is at that time moving. This circuit is completed through the winding 15 of the storing relay to the mid-point of the same battery. The current flowing over this circuit passes through the winding 6 in a direction to aid the current flow through winding 4, described above and accordingly maintains the armature 7 in engagement with its left hand contact.

An important distinction over the prior art will be observed from the description thus far given. Whereas in the Clokey arrangement, the line current, in order to prevent the armature from moving to its alternate contact, must be of sufficient amplitude to overcome the local currents, in the present case, the brush 14 is on a dead segment D during the interval at the beginning of the impulse period and the line current need overcome only the momentary discharge of condenser 8, as will be described hereinafter. During the second half of the signal period, the flow through the winding 6 is such as to help the line winding in maintaining armature 7 on its left hand contact. The mar-

ginal character is thus very much reduced over the arrangement proposed by Clokey.

As a result of the current flow through winding 15, armature 16 moves into engagement with its left hand contact to connect the positive side of battery to a local printer (not shown) or to another cable section.

When now the brush 14 moves into engagement with the second dead segment D, on the ring 13, the local circuit for winding 6 is opened. At this time the current of substantially zero amplitude arrives over the cable as indicated at *c* and there is therefore no current flowing through winding 4. The condenser 8 which had been charged, as described above, now discharges itself through the winding 6 and resistance 9 in the opposite direction from that traced above. As a result of this current flow in the opposite direction, the armature 7 is moved into engagement with its right hand contact.

This operation, it will be noted, takes place during the first half of the second signaling period *c*. When the brush 14 moves into engagement with the fourth segment L, a circuit is completed from the negative side of battery, through armature 7 and over the circuit including windings 6 and 15. This current flow is in the opposite direction from that produced by the positive side of battery but in the same direction as the first discharge from condenser 8 and hence maintains the armature 7 in engagement with its left hand contact. The current flow now to the winding 15 will swing the armature 16 into engagement with its right hand contact and will repeat a marking impulse.

As the brush 14 moves into engagement with the third dead segment D, the charged condenser 8 again discharges, causing a flow of current in the opposite direction from that described just above but in the same direction as the original flow of current produced from the positive side of battery and the armature 7 is accordingly thrown into engagement with its left hand contact, as in the first instance. Upon engagement of the 6th or live segment L, by the brush 14, a current flows through the winding 6 over a circuit as originally traced, as a result of which the armature 7 is maintained in engagement with its contact and the armature 16 is moved into engagement with its left hand contact. As the brush 14 moves into engagement with its 7th and 8th segments the same operations as described in connection with the 3rd and 4th segments occur.

When, however, the brush 14 moves into engagement with its 9th segment D, a change in operation from that already shown occurs. In Fig. 1 it will be noted that impulse *f* is the second of two succeeding impulses of the same polarity. The current amplitude therefore increases sufficiently during this impulse interval as indicated in Fig. 2 at *f*

to produce a current flow of operative amplitude in the winding 4. At the instant therefore that the distributor brush 14 engages the 9th segment D, a discharge occurs from the condenser 8 through the coil 6 which is in a direction to move armature 7 to its opposite position from right to left. The current flow through winding 4 is, however, of sufficient amplitude now to prevent this movement of armature 7 which is therefore maintained in engagement with its right hand contact instead of being moved to its left hand contact as would normally have occurred, had there been no current flow through the winding 4. When now the distributor brush 14 moves into engagement with its 10th segment, the current flow through the storing relay 15 is from the negative side of battery at armature 7, and accordingly the armature 16 is maintained in engagement with its right hand contact. At this time also it will be noted that the current flow through the coil 6 is in a direction to aid the coil 4.

It will be clear from the above description, that the received signals are interpolated in such a manner as to operate the receiving apparatus with signaling waves of the same wave shape as those transmitted from the transmitting station. The operations are performed by a simplified mechanism in which a single distributor ring functions in cooperation with a condenser, which is arranged to charge and discharge alternately, producing as is well known, momentary surges. Accordingly, the line relay 4 is not opposed by a continuous current flow in the reversing coil but rather by a single instantaneous current flow and during part of the impulse interval is aided by current in the reversing coil. As will be noted from a comparison with the patent referred to above, the interpolating operations are here performed by a single condenser which had previously required an additional set of distributor rings and extra reversing coils in which the opposing winding flow is continuous. It will further be noted that the relay 15 is operated during the second half of the impulse interval when the line winding is being aided by winding 6. Furthermore during the first portion of the impulse interval, the reversing relay functions independently of the distributor although in synchronism with the signals.

As shown in Fig. 4, the condenser is connected in series with the reversing coil 6 for receiving the charge during the period while the distributor brush 14 is on a live segment L. It will be clear, however, that any impedance for receiving this charge will also function in the same manner. Thus for example, as shown in Fig. 5, an inductance 21 is connected across the reversing coil 22 of the relay 23. While the brush 24 is on a live

segment L of the segmented ring 25, a circuit is completed from battery through armature 26, ring 27 and the storing relay 28 for operating the armature 29 connected to a printer or repeating circuit (not shown). Current also flows at this time through the inductance 21 which shunts the coil 22. When the brush 24 moves into engagement with a dead segment D the charge in inductance 21 discharges through the reversing coil 22 in the opposite direction from that of the original flow of current for operating the armature 26 to its opposite contact.

The main line winding 31 is connected to the output circuit 32 of the amplifier 33, the input circuit of which is connected to the cable 34 and sea earth 35. The operation in this figure is otherwise similar to that described in connection with Fig. 4.

It will be noted in connection with the operation described in Figs. 4 and 5, that the line relay is operated in accordance with both positive and negative impulses to operate a two position storing relay, such as relay 15. In operating a printing telegraph apparatus, however, it is more usual to employ magnets which will respond to marking impulses and fail to respond to spacing impulses or vice versa. In such cases it is necessary to arrange the circuits so that no current flows during the spacing impulse interval and accordingly no charge will collect on the condenser 8 for reversing its armature in the manner described above. In order to overcome this difficulty an arrangement such as disclosed in Fig. 6 may be employed.

In this case, the cable 35 extending from the remote station is connected to the input side of the amplifier 36, the opposite terminal of which is connected to the sea earth 37. The output circuit of amplifier 36 is again connected as described in the first modifications above to the line winding 38 of the relay 39. In addition to the line winding, the relay 39 comprises a reversing winding 41, one terminal of which is connected to a condenser 42. The winding 41 and condenser 42 are shunted by a resistance 43 which at the terminal connected to the condenser 42 is connected to the mid-point of a battery. The opposite terminal of winding 41 is connected through a leak record 44 and 45 to the alternate even numbered segments of ring 46.

The receiving distributor comprises in addition to ring 46, a solid ring 48 and a segmented ring 49, bridged by a rotating brush 50, driven by a motor in synchronism with the received impulses as described above. The solid ring 48 is connected to the armature 51 of the vibrating relay 39. The segments of ring 49 are connected to the receiving magnets 52 of the printers.

As the armature 51 is moved into engagement with one of its contacts in the manner

described above and brush 50 moves into engagement with an even numbered segment, a circuit is completed from the battery through armature 51, ring 48, brush 50, segmented ring 46, through the leak record instrument 44, winding 41, condenser 42 and to the mid-terminal or split of the battery. The condenser 42 is charged and will later discharge through the coil 41 and resistance 43 when the brush 50 is on a dead or odd numbered segment. A circuit is also completed from the battery over the armature 51 and through a magnet coil 52 to battery.

If the brush 50 is on any segment of the first channel including the first five printer magnets 52, no circuit will be completed while armature 51 is in engagement with the positive side of battery. When, however, the armature 51 moves into engagement with its right hand contact, the condenser 42 will still be charged in the opposite direction but the current will divide, some flowing through the receiving magnets 52 from the negative terminal of battery at armature 51 through the receiving magnet to the positive terminal of battery and the remainder flowing over the circuit traced above through condenser 42. It will be clear from this description that while the printer magnets are operated or not operated in accordance with current and no current conditions, the reversing winding 41 and condenser 42 are alternately charged and discharged.

In the apparatus disclosed in Figs. 4, 5 and 6, a two position receiving relay is shown. In some systems it is desirable to employ a three positioned relay interposed between the amplifier and the repeating or printing relay. This is accomplished in the manner illustrated in Fig. 7.

Relay 55, instead of being connected directly to the amplifier, as in the above described figures, is connected to the armature 56 of the three positioned relay 57. As shown, the armature 56 is normally maintained by springs 58 and 59 in a mid-position between its contacts. These contacts are connected to the opposite terminals of battery 61. The winding 62 of the three position relay is connected to the output of the amplifier 63, the input of which is connected to the cable 64 extending from a remote station and to ground at 65.

The armature 56 is connected to one terminal of the winding 66, the other terminal of which is connected to the mid-point of the battery 61. Line winding 66 and the reversing winding 67 comprise the repeating relay 55 which is similar in structure to the repeating relay employed in the above described modifications.

Upon receipt of a signal of sufficient amplitude to make the coil 62 effective, which as explained above occurs when two or more successive impulses of the same polarity are

transmitted over the cable 64, the armature 56 is moved into engagement with one of its contacts to cause a corresponding flow of current through winding 66 of the line relay 55. Line winding 66 of relay 55, in conjunction with the winding 67, condenser 69 and the shunting resistance 71, controls the vibrating operations of the armature 72 which, through the solid ring 73 and segmented ring 74 operates the storing relay 75, for either repeating the received impulses or operating a printer (not shown). The operation of this arrangement is similar to that of the previous modifications and need not therefore be described in detail. During the interval of high frequency signaling, i. e., of alternate marking and spacing impulses, each of a single impulse length, there is substantially no current flowing in coil 62 as explained above. When, however, a succession of impulses of the same polarity flows through coil 62, current of sufficient amplitude is built up to operate armature 56 into engagement with one of its contacts, thereby closing a circuit for winding 66. At this instant, the brush 68 is moving over an odd numbered or dead segment and condenser 69 will be discharging a current through winding 67, tending to throw armature 72 to its opposite contact. The current in 66 tends, however, to hold armature 72 in engagement with the same contact and is of sufficient amplitude to overcome the effect of the discharge current through 67. Armature 72 accordingly remains on the same contact and maintains the current through storing relay 75 in the same direction, when the brush 68 moves on to the succeeding even numbered segment. At the same time the current through winding 67 is such as to maintain armature 72 in the same position and condenser 69 is again charged in such manner that upon discharge, it will energize coil 67 for throwing armature 72 to its opposite contact.

It will be recalled that the present invention is directed to replacing the distributors and extra auxiliary vibrating relays and vibrating rings and brushes in the method proposed by Clokey, by impedances which are so arranged as to perform substantially the same function.

In Fig. 8 I disclose a further modification of my invention in which the distributor and its accompanying problem of synchronization is entirely eliminated. In this figure, the input of amplifier 81 is connected at one terminal to the cable 82 extending from a remote station to the local station, and the other terminal is connected to the earth at 83. The output of the amplifier is connected to the line coil 84 and driving relay winding 85 in series. As in the previous cases, the line relay comprises in addition to the line coil 84, a reversing coil 86 connected in series with a condenser 87,

the relay 86 and condenser 87 being shunted by a resistance 88. One terminal of this network is connected to the armature 89 of the reversing relay 86 and the other terminal to a contact 91 of the tuning fork 92.

The tuning fork 92 is of the usual construction employed in synchronous telegraph systems, comprising tines 93 and 94 properly supported on a base and provided with weights or other means for adjusting the frequency at which these tines vibrate. A driving magnet 95 is connected to one contact of the armature 96 of the driving relay 85. The other terminal is connected through a resistance 97 to the positive side of the battery. A condenser 98 is connected to armature 96 and shunts resistance 97 over which it discharges when armature 96 engages its left hand contact as will be described hereinafter.

The fork 93 is connected to the winding of the storing relay 99, the opposite terminal of which is connected to the mid-point of battery. The armature 100 of storing relay 99 operates between its contacts to complete a circuit for a printer magnet or for repeating over a cable in a manner well understood.

The operation of the apparatus described in Fig. 8 is as follows:—The tuning fork 92 is first adjusted to vibrate at a frequency equal to the rate at which signals are being received, so that the fork 93 for example, will oscillate from one contact to its alternate contact during an impulse interval, the phase relation being such that it will engage contact 91 at the beginning of a signaling period. As shown, the fork tine 93 is in engagement with its contact 91 during the latter half of a signaling period and the current flows from the positive side of battery through the armature 89, parallel paths through resistance 88 and the winding 86, condenser 87, to contact 91, fork tine 93 and the winding of relay 99 to the mid-point of the battery. The relay 99 is energized to operate its armature 100 in engagement with its left hand contact for completing a circuit from the positive side of battery to either a repeating cable or receiving printer magnet as the case may be. The current flowing through the winding 86 is such as to maintain the armature 89 in engagement with its left hand contact. As the tuning fork now moves into engagement with the opposite contact at the beginning of the succeeding impulse period, the condenser 87, which was charged by the current flow described above, now discharges and causes a current to flow through the winding 86 in the opposite direction. This discharge is completed through the resistance 88 to the opposite terminal of the condenser 87. As a result of this current flow, the armature 89 is moved into engagement with its right

hand contact, if there is no current flowing in winding 84. When now the tuning fork again engages its left hand contact during the second half of the second impulse period, an impulse from the negative side of battery is sent through the windings 86 and 99. The current flows through the winding 99 in the opposite direction from that originally described and moves armature 100 into engagement with its right hand contact. The current flow in this case is in such a direction through the winding 86 as to maintain the armature 89 in engagement with its right hand contact. The above described cycle of operations will then be repeated.

When, however, a current of the same polarity continues for two signaling periods, the current flow through the coil 84 is in the opposite direction and of sufficient amplitude to overcome the current flow through the winding 86 and, as a result, the armature 89 is held against whichever contact it happens at that time to engage. The storing relay 99 is thus operated by two successive impulses of the same polarity, as the tuning fork makes two complete cycles. Thus for example, if the fourth and fifth impulses are of the same polarity as illustrated in Fig. 1, the armature 89 remains in engagement with its right hand contact during the fourth and fifth impulses. The fork tine 93 engages its contact 91 and completes a circuit through the condenser 87. The current flow through the coil 84, however, is at this time of sufficient amplitude to maintain the armature in engagement with its right hand contact, and when thereafter the tuning fork again engages its contact 91, a circuit from the negative side of battery is a second time completed for the storing relay 99.

At this time the current flow through the relay 85 will also be sufficient to move the armature 96 into engagement with its right hand contact and a circuit is completed from the positive battery through the condenser 98, armature 96 and through the driving magnet 95 of the tuning fork to negative battery. It will be noted that the current flows through relay 85 at the beginning of the impulsing period when the fork tine 93 should normally be in engagement with its right hand contact 91'. The energization of relay 95 at this time will therefore pull the forks inwardly in the event that they are out of synchronism with the signals. In this manner synchronization of the tuning fork occurs at periodic intervals under control of the signaling impulses themselves to pull the fork into synchronism in case it is out of synchronism to any extent at that instant.

It will be clear that by the use of tuning fork, synchronism is much more readily obtained than with distributors. The mechanism employed is not only simpler but more

rugged, more easily adjusted and generally better adapted for the purpose in hand. Although I have disclosed my invention in connection with a specific form or application thereof, it will be clear that there are many other forms in which the invention may be practiced and I do not intend to limit myself by this specific arrangement except insofar as set forth in the appended claims.

I claim:

1. In combination, a receiving relay comprising a line winding and a reversing winding, a distributor connected to said reversing winding, a circuit independent of the distributor for energizing said reversing winding during the first half of each signal interval and means including said distributor for completing an energizing circuit for said reversing winding during the remaining period of each signal interval.

2. In combination, a receiving relay comprising a line winding and a reversing winding, a condenser connected in series with said reversing winding, a distributor, means including said distributor for completing a circuit for said reversing coil and said condenser and circuit means independent of said distributor for energizing said reversing coil during the remaining portion of the signal interval.

3. In a telegraph system over which the received signals are considerably attenuated, and in which the receiving apparatus includes a relay having an armature, the method of operating the receiver with respect to the signals which comprises vibrating the armature in synchronism with the signals, maintaining the relay armature open-circuited during the first half of a signal interval and in a closed circuit during the second half of the signal interval.

4. In a telegraph system over which the transmitted signals are considerably attenuated, and in which the receiving apparatus includes a relay having an armature, the method of operating the receiver which comprises operating the relay in accordance with the received signals, maintaining the relay armature open-circuited during the first portion of a signal interval and in a closed circuit during the remaining portion of the signal interval.

5. The method of operating a relay arrangement of the Gulstad type including a reversing winding and armature, which comprises causing a momentary flow of current through the reversing winding tending to reverse the armature position at the beginning of each impulse interval and invariably producing a current flow in the reversing winding to maintain the armature in whichever position it has assumed during the remaining portion of the signal interval.

6. The method of operating a relay arrangement of the Gulstad type including

a local winding and its armature, which comprises producing currents in the local winding tending to reverse the armature position during the first portion of a signal interval and thereafter invariably producing currents to maintain the armature in whichever position it has assumed during the remaining portion of the signal interval.

7. The method of operating a relay of the Gulstad type provided with a line winding, a local winding and an armature, which comprises sending a momentary current flow through the local winding tending to reverse the armature position, sending a current in the line winding in the event of a succession of impulses of the same polarity of sufficient amplitude to prevent the armature from moving to its opposite position and thereafter producing a current flow through the first mentioned winding in such a direction as to maintain the armature in its position.

8. In a relay arrangement of the Gulstad type comprising a line winding, a reversing winding and an armature, the method of signaling which comprises sending a current through the reversing winding at the beginning of each signal interval, successively alternating in direction with each signal interval, and tending to throw the armature to its opposite position, producing a current flow in the line winding in the event of a succession of impulses of the same polarity of sufficient amplitude to prevent the armature from moving to its alternate position at the beginning of the impulse interval and thereafter during the remainder of the signal interval producing a current flow in the reversing winding in the opposite direction to that produced during the beginning of the signal interval for maintaining the armature in its position.

9. In combination a telegraph cable, a line coil connected to said cable, a condenser and a reversing coil, said reversing coil being connected in series with said condenser and its armature, a relay, means including circuit connections for maintaining said reversing coil circuit open during the beginning of a signal interval, said means being arranged to connect said reversing coil to said relay during the remaining portion of said signal interval.

10. In combination a cable, a relay comprising a line coil connected to said cable, a reversing coil and the armature; a distributor comprising segmented rings connected in series with said reversing coil and a relay connected to the segments of said segmented ring.

11. In combination a receiving relay comprising a line coil and a reversing coil, a condenser connected in series with said reversing coil, a distributor connected to said condenser and means including said distributor for charging the condenser and a circuit for

discharging said condenser through said reversing coil.

12. In combination a receiving relay comprising a line coil and a reversing coil, a condenser connected in series with said reversing coil, a resistance connected in shunt to said reversing coil and said condenser, means including a distributor for charging said condenser, said distributor being arranged to successively permit said condenser to charge through said reversing coil and to discharge through said resistance.

13. In combination, a receiving relay comprising a line coil and a reversing coil, a condenser connected in series with said reversing coil, a resistance connected across said condenser and reversing coil, a battery, means including said distributor for connecting said condenser and reversing coil to said battery, said distributor being arranged to periodically disconnect said battery from said condenser, whereby said condenser discharges through said reversing coil and said resistance.

14. In combination, a receiving relay comprising a line coil and a reversing coil, a condenser connected in series with said reversing coil, a resistance connected across said condenser and said reversing coil, a battery, means including said distributor for connecting said condenser and reversing coil to said battery, said distributor being arranged to periodically disconnect said battery from said condenser, whereby said condenser discharges through said reversing coil and said resistance, and a second relay connected to said condenser through said distributor an interval after the beginning of the impulse interval.

15. In combination a receiving relay comprising a line winding, a reversing winding and armature, a condenser and resistance connected in series with said reversing winding, a distributor comprising a first and a second segmented ring, a plurality of magnets connected to said second segmented ring, said first segmented ring being arranged to successively connect said receiving relay to its own armature and said second segmented ring being arranged to connect said magnets to said armature.

16. In a telegraph receiver comprising a distributor provided with a segmented ring having alternating live segments and open or dead segments, and a brush wiping thereover, the method of operating the distributor with respect to the signaling impulses, which comprises rotating the brush over an open circuited segment during the beginning of an impulse interval and over a live segment during the remaining portion of the signal interval.

17. In a telegraph receiver, a segmented ring distributor, a brush moving over said distributor, alternate segments of the dis-

- tributor ring being multiplied, a relay connected to said multiplied segments, and the remaining segments of said distributor being open-circuited, the method of operating the distributor with respect to the signaling
- 5 impulses which comprises moving the brush over one of the open circuited segments during the beginning of a signal interval and over a multiplied segment during the remaining portion of the signal interval.
- 10 In testimony whereof I affix my signature.
MARION H. WOODWARD.