

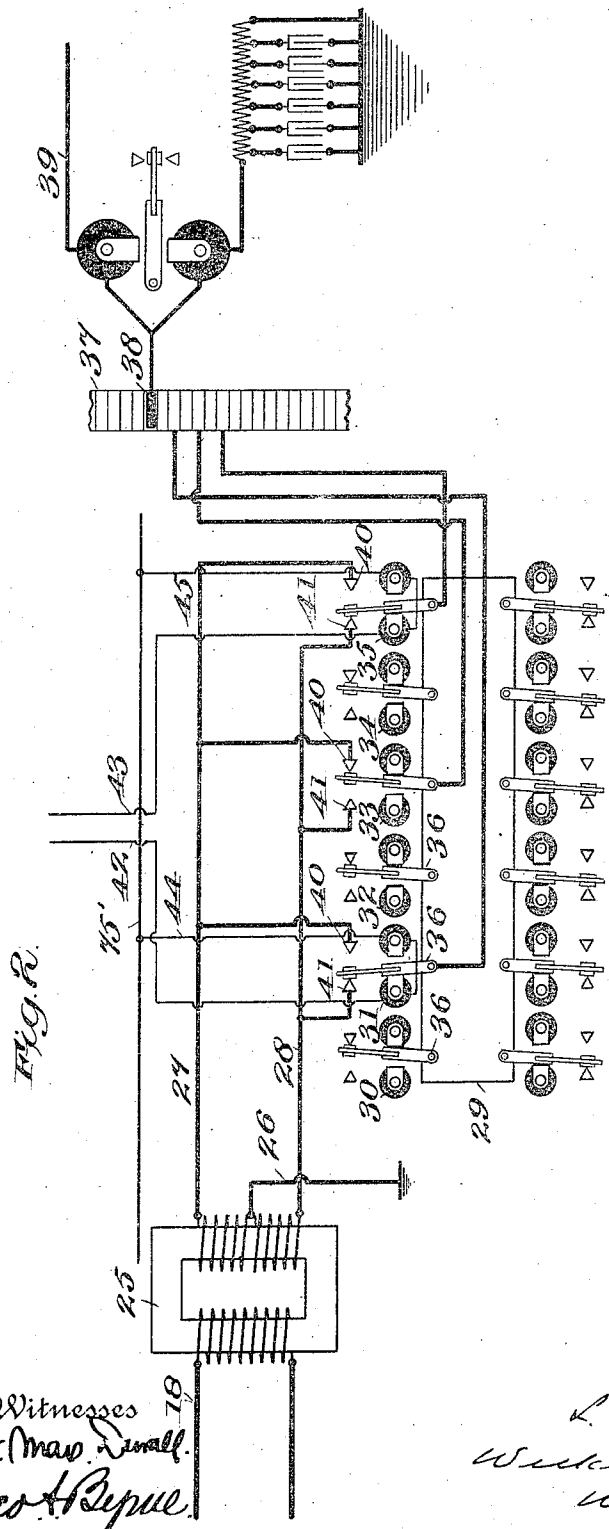
METHOD OF AND APPARATUS FOR TRANSMITTING SIGNALS OVER TELEGRAPHIC CIRCUITS.

Patented Feb. 13, 1912.

5 SHEETS--SHEET 1.



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METHOD OF AND APPARATUS FOR TRANSMITTING SIGNALS OVER TELEGRAPHIC CIRCUITS.
APPLICATION FILED JAN. 25, 1908.
1,017,169. Patented Feb. 13, 1912.

5 SHEETS—SHEET 3.

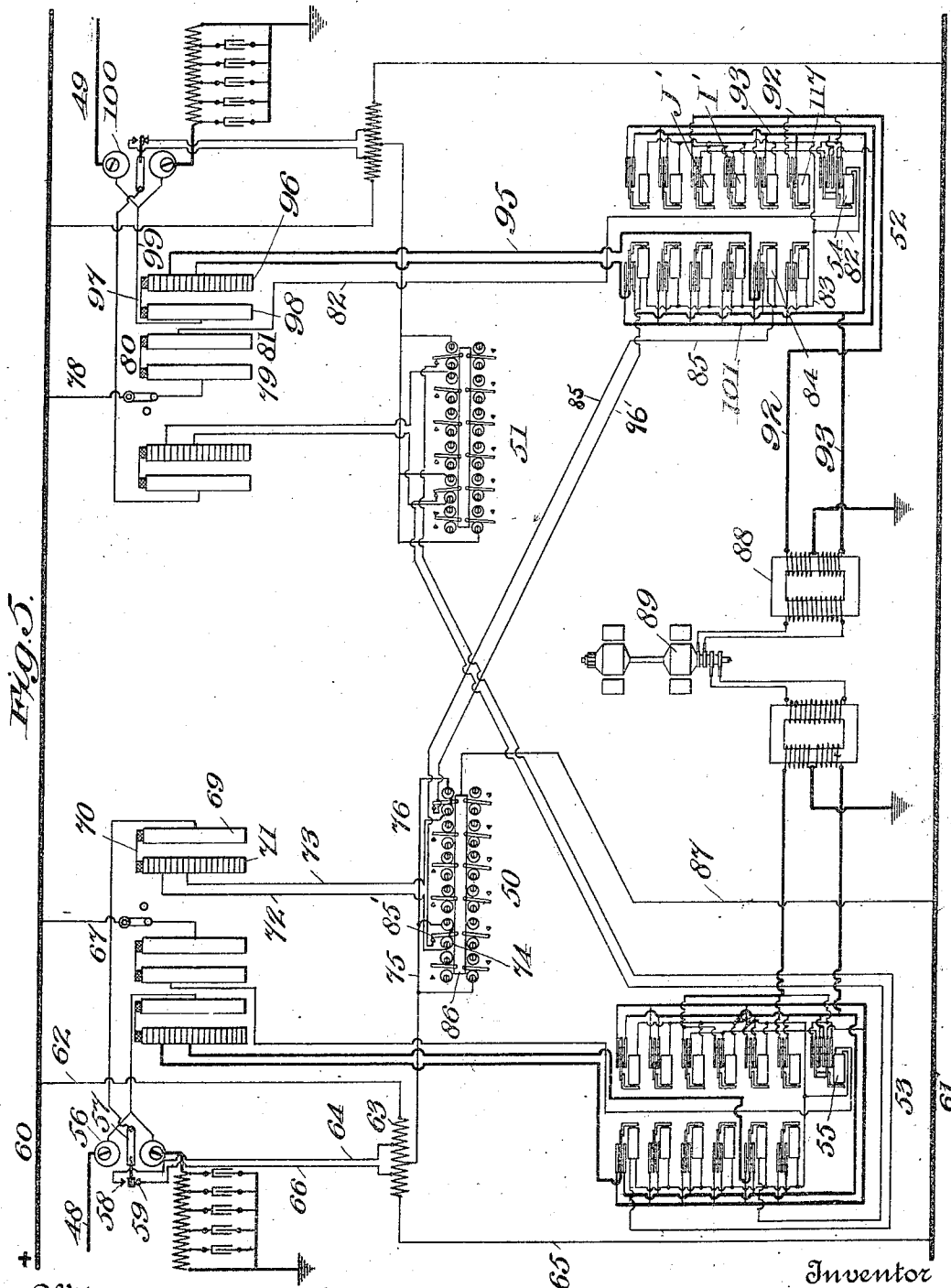


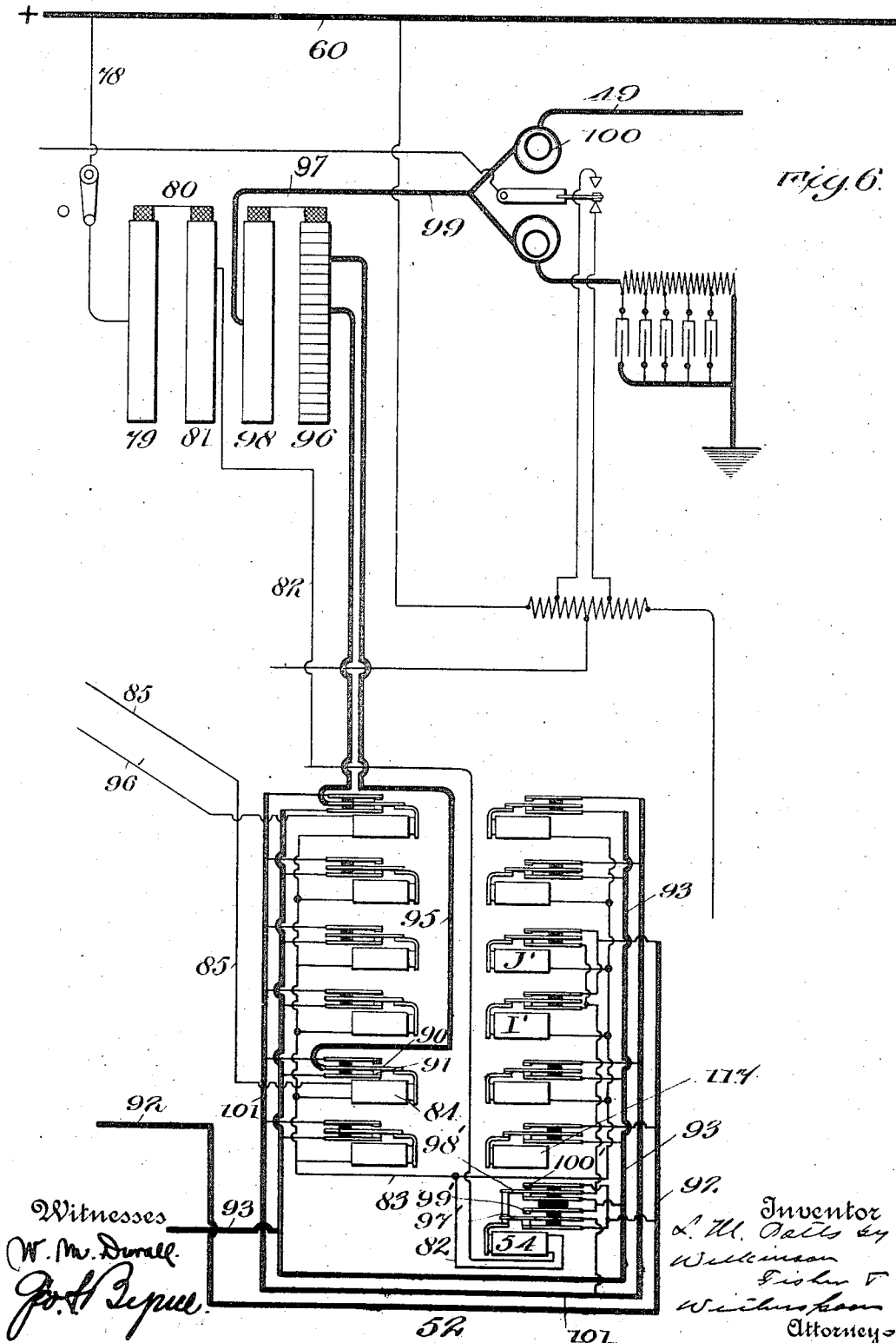
Fig. 5.

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5 SHEETS—SHEET 4.



L. M. POTTS.

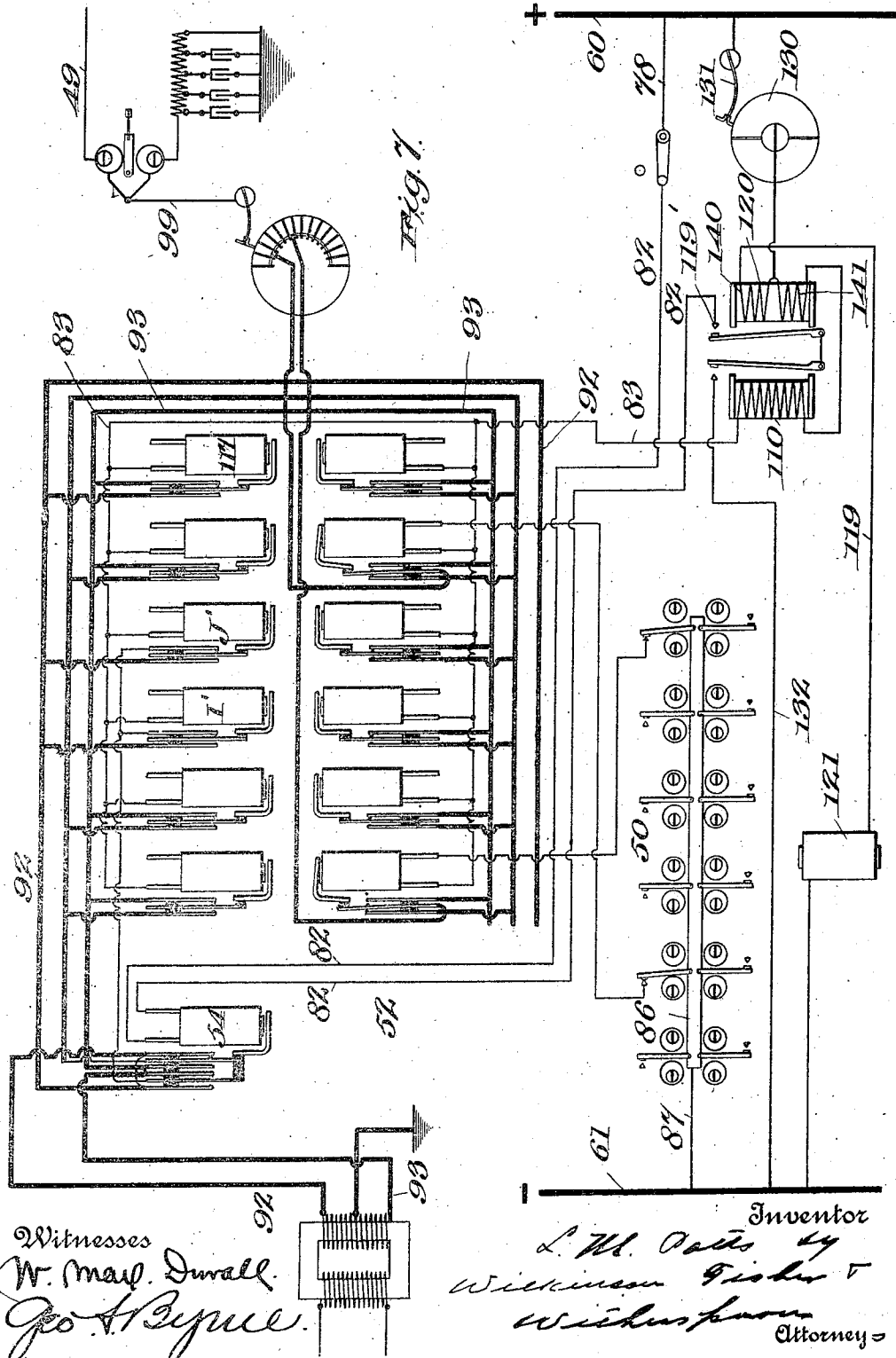
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1,017,169.

5 SHEETS—SHEET 5.



UNITED STATES PATENT OFFICE.

LOUIS M. POTTS, OF BALTIMORE, MARYLAND, ASSIGNOR, BY MESNE ASSIGNMENTS, TO
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METHOD OF AND APPARATUS FOR TRANSMITTING SIGNALS OVER TELEGRAPHIC CIRCUITS.

1,017,169.

Specification of Letters Patent.

Patented Feb. 13, 1912.

Application filed January 25, 1908. Serial No. 412,628.

To all whom it may concern:

Be it known that I, LOUIS M. POTTS, a citizen of the United States, residing at Baltimore, in the State of Maryland, have invented certain new and useful Improvements in Methods of and Apparatus for Transmitting Signals Over Telegraphic Circuits; 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.

My invention relates to a method of and apparatus for transmitting signals over telegraphic circuits, and the object of my invention is to produce such a method and apparatus as will be certain in action, easy to operate, and will be capable of using the present reversed wave method of transmission without requiring the use of a transmitting relay which must operate accurately and regularly.

To these ends my method consists in the employment of the now well known reversed wave method of transmission, coupled with a method of connecting directly the normal or reverse sides of the transformer secondaries, to the segments of the sending commutator by means of a switch which may be operated electro-magnetically, or otherwise.

My invention further consists in the application of this method to a repeater.

My invention further consists in the method of making the operations of a repeating station automatic in so far as interruptions outside of said station are concerned, and thereby involving the use of my novel overload signal relay.

My invention further consists in the novel apparatus for carrying out my method, and my invention further consists in the details of both the method and apparatus more fully hereinafter disclosed and particularly pointed out in the claims.

Referring to the accompanying drawings forming a part of this specification in which like numerals indicate like parts in all the views:—Figure 1, represents a diagrammatical view of a sending apparatus for use

in connection with my method at a terminal station. Fig. 2, a like view of an apparatus for use in connection with my method at a repeating station. Figs. 3 and 4, diagrammatic illustrations respectively, of the unmodified and modified currents employed. Fig. 5, a diagrammatic view of a quadruplex repeater suitable for use in connection with my method, and provided with extra, or overload relays. Fig. 6, an enlarged detail view of a bank of relays employed in the apparatus illustrated in Fig. 5, and having an extra, or overload relay, and, Fig. 7, a diagrammatic view of a modified form of an overload relay and its connections.

In the sending apparatus illustrated in Fig. 1, which is suitable for use at a sending terminal station, 1, represents a static transformer which is supplied with an alternating current. This transformer has two secondary windings 2 and 3; and the common terminal 4, of these secondaries is grounded at 5. The other terminals 6 and 7, are connected respectively to the contacts 8 and 9, on the key board as shown. This particular connection of the secondaries is such that when one of the line terminals is positive, the other is negative and vice versa. That is to say, the normal side 6, and the reverse side 7, of the secondaries of this transformer, are connected directly to the segments of the sending commutator by the means now to be described, and the electromotive forces furnished by these two transformer line terminals always differ by 180°, as is well known.

The keys 10, 11, of the key board are so arranged that the depression of each key lever raises a certain number of contact bars 12, which overlie the said levers. Each of these bars 12, is connected to one of the segments 13, of the sending commutator 14, the brush 15, of which is connected to the split of the main line relay 16. The brush 15, is rotated by the same motor (not shown) which furnishes the alternating current for the transformer 1, as is customary in the Rowland telegraphic system; and it is so geared to said motor that the said brush will pass over one segment in the brief in-

terval of time occupied by the semi-cycle, or half wave of the alternating current.

When no key lever on the key board is depressed, the contact bars rest against the lower contact strip 8, and as the brush 15, passes over the sending commutator an unmodified alternating current of the form shown in Fig. 3, is sent to line. When a key is depressed, however, certain of the bars 12, are raised (two in the Rowland system) which are thereby disconnected from the contact strip 8, and connected with the contact strip 9. When now the brush passes over the commutator 14, an alternating current is sent to line, as in the previous case, but the half waves corresponding to the bars 12, that have been raised are sent to line reversed, so that the general character of the current is that illustrated in Fig. 4. In other words, the key levers, bars 12 and contact strips 8 and 9, act as a mechanically operated switch for connecting the normal secondary 6, or the reverse secondary 7, of the transformer, to the commutator segments at will.

A lock 19, is provided over the ends of the key levers which is so operated by the cam 20, and lever 21, contacting therewith, as to release said keys once in each revolution of the brush on the sending commutator. By this means the key levers raised are also locked in their upper positions as the brushes pass over the segments corresponding to the half waves sent out at the particular key board in question. In other words in this system a plurality of key boards are used, and the keys on any particular key board cannot be operated when the brush on the sending commutator is making contact with any segments allotted to the key board in question, as is well known in the Rowland system.

The signals sent out from this apparatus traverse the real line 18, and artificial line 18', in the manner well known; and may be received by any suitable means.

If it is desired to repeat these signals, it is only necessary to cause the same to pass through a relay such as that shown in Fig. 5, and consisting of the magnet 56, tongue 57, contacts 58 and 59, and direct current mains 60 and 61, suitably joined to said contacts by the conductors 62, 64, 65, 66 and resistance 63, as shown. In this figure the said tongue 57, is joined to the receiving commutator composed of the disks 69 and 71, connected by the brushes 70, and leading from this receiving commutator are a series of conductors 72, 73 etc., one for each segment of the commutator, that is one for each half wave that is to be used at a single key board, or eleven in all. These eleven conductors 72, 73 etc., are reversely connected to the coils of alternate magnets in the bank

50, so that the successive half waves of an unmodified alternating current will throw all the tongues of said magnets against their back stops, and the other ends of said conductors are joined in parallel to the conductor 75, which in turn joins the resistance 63, at or about its middle, all as is well known in the Rowland system. It is evident, from an inspection of Fig. 5, that if an unmodified alternating current is passed through the coil of magnet 56, that the tongue 57, will vibrate in synchronism therewith, and if the brushes 70, of the receiving commutator 69, 71, are rotated in synchronism with said tongue, so that a new wire 72, 73, etc., is joined in circuit for each new half wave received, then the positive current flowing from main 60, when contact 58, is in circuit, will traverse wire 62, a part of resistance 63, wire 64, contact 58, tongue 57, wire 67, disk 69, brushes 70, disk 71, one of the wires 72, 73 etc., one of the coils of one of the magnets in bank 50, thence to wire 75, resistance 63, wire 65, to the negative main 61. And it is also evident, that when contact 59, is in circuit, the positive current will pass down wire 62, through a part of resistance 63, to wire 75, thence through the coil of that magnet of bank 50, that happens to be selected by the commutator, out by way of one of the wires 72, 73 etc., that has been brought into circuit by the commutator, through the commutator, wire 67, tongue 57, contact 59, wire 66, a part of resistance 63, and wire 65, to the negative main 61. In both cases, owing to the reversed connections above mentioned of the wires 72, 73 etc., at every alternate magnet in the bank 50, the tongues of said magnets will all be thrown against the back stops, as above explained. But if one or more of the half waves passing through magnet 56, are sent reversed, from the distant station, then the tongue 57, will remain touching a single contact 58 or 59, for the period of three half waves; (in the case of adjacent half waves being reversed, this contact will be for the period of two half waves) and the commutator brushes will connect one or more of the wires 72, 73 etc., each with a current in the reverse direction to its normal current, and the corresponding relays will have their tongues thrown against their front contacts. All this will be clearer from Fig. 2, wherein the bank of magnets 29, is identical with the bank 50, in Fig. 5, and the wires 42, 43, and 75', correspond to the wires 72, 73 and 75, in Fig. 5, and the connections 44 and 45, of the wires 42 and 43, to the wires 75', are shown. The connections for energizing all of these magnets in bank 29, except those belonging to magnets 31 and 35, have been omitted from Fig. 2, for the sake of clear-

ness; and besides these connections are well known in the Rowland system.

Going back now to my method of transmitting signals through a repeating station, with especial reference to the apparatus disclosed in Fig. 2, 25, represents a transformer similar to transformer 1, and having the ground terminal 26, and the secondary or line terminals 27 and 28, as shown. In this figure the key board is replaced by the bank of relays 29, having the individual relays 30, 31, 32, 33, 34, 35 etc., one relay corresponding to each of the eleven semi-cycles of the alternating current used at this particular bank of relays. The tongues 36, of these relays, in the manner above described, are operated by the signals received from the line from which the messages are to be repeated, and said tongues are also connected to the sending commutator 37, whose brushes 38, are connected to the line 39, which is being repeated into.

The secondary terminal 27, of the transformer 25, which sends out a normal or unmodified alternating current is connected in parallel to the back stops 40, of all the relay magnets, and the terminal 28, which sends out reversed half waves, is connected in parallel to the front stops 41, of said magnets, as shown.

When no signals are being sent, an unmodified current is passing over the line 18, and the tongues 36, are held against their back stops 40, for the reasons above stated. The terminal 27, of the transformer will therefore send an unmodified alternating current, such as is illustrated in Fig. 3, to the line 39, as the brush 38 revolves. If signals, or reversed, half waves are received, by said relay bank 29, however, since each magnet coil in said bank is connected to its corresponding segment on a receiving commutator, as above explained in connection with Fig. 5, by means of the connections 42, 43 etc., the tongues 36, corresponding to said signals will be thrown against their front stops 41, and reversed half waves as illustrated in Fig. 4, will be sent to line from the transformer 25, through the sending commutator 37, precisely as if the sending apparatus shown in Fig. 1, were used. In other words, this whole bank 29, of relays at a transmitting station; acts as an electro-magnetically operated switch for directly connecting at will the normal secondary 27, or the reverse secondary 28, of the transformer 25, to the sending commutator segments.

It will be observed that in Figs. 3 and 4, there are eleven half waves shown and each of the half waves are lettered consecutively from A to K inclusive. There is of course a separate key or relay magnet for controlling a normal and a reverse contact for each

of these half waves, as shown in Figs. 2 and 5, and of course it is understood that by suitably reversing different half waves of this group, as many different signals as are necessary for commercial messages may be produced, all as is well known in the Rowland system.

So far my method has been disclosed in connection with the sending apparatus shown in Fig. 1, and the signals from which may be, if desired, repeated from the apparatus shown in Fig. 2. But my method is equally adapted for a quadruplex, an octuplex, or other apparatus and is especially useful when combined with my novel signal overload relay to be described below, in connection with a quadruplex repeater, as shown for example in Fig. 5, wherein the use of the switch apparatus 29, and its connections illustrated in Fig. 2, is disclosed as a part of a quadruplex repeater. In said Fig. 5, 48 and 49, represent the main lines over which signals are sent and received, 50 and 51, banks of relay magnets in all respects similar to the bank 29, in Fig. 2, and each containing a magnet corresponding to each of the half waves from A to K, that are used in signaling.

52 and 53, represent banks of transmitting neutral or unpolarized relay magnets. Each of these latter banks likewise contains a magnet and a normal and a reverse contact for each of the half waves lettered from A to K, in Figs. 3 and 4. Each of the transmitting relay banks 52 and 53, is provided with an extra relay 54 and 55, which I call a signal overload relay, the purpose of which will now be described.

When a repeater, by which the messages are retransmitted from the repeating station, is used in a synchronous telegraph system, it is necessary that the terminal station be in synchronism with the repeating station.

If for any reason the synchronism is interrupted between a terminal station, and a repeating station, it is obvious that a considerable number of the receiving relays on the receiving or terminal station side of the repeater will be thrown against their front stops, and consequently a large number of reversed waves or false signals will be sent out from the opposite or sending side of the repeater; and as a further consequence, the terminal on said opposite side of said repeater will be thrown out of synchronism. In addition to this, even after the cause of the original disturbance has been removed, it is generally found impossible to get the machine into synchronism again, until the attendant at the repeater station is called in, and the repeater cut out. Putting the instruments into synchronism again, involves what is called finding the letter, or the

shifting of the brushes of the commutators, so that they are on corresponding segments. But even after the two terminals have regained synchronism and found the letter, it will still be necessary for the attendant at the repeater station to connect the repeater through.

On account of the necessity of calling in the attendant at the repeater station, when synchronism has been interrupted, the length of time lost is many times increased.

My signal overload relay above mentioned has for its object the prevention of such delays, but in order to make its operation clear, I will first continue the description of the operation and of the mechanism of the other parts of the quadruplex repeater disclosed in Fig. 5. In said figure, if no signals are being sent, the unmodified alternating current waves are received, we may suppose over the main line 48, by the relay magnet 56, which causes the tongue 57, to make connections with the contacts 58 and 59, in synchronism with the sending commutator at the distant transmitting station. The receiving commutator 69, 71, on the receiving side of the quadruplex repeater being likewise in synchronism with the said sending commutator at the distant station, all the tongues of the relay magnets in bank 50, will be thrown and held against their back stops for the reasons above explained. When, however, a modified alternating current containing reversed waves is received over the line 48, and sent through the bank 50, the tongues corresponding to the waves reversed will be thrown against their front stops as also explained above in connection with Fig. 2. When this happens, current from the local direct current main 60, passes along wire 78, through disk 79, brushes 80, and disk 81, of the sending commutator, through wire 82, to and through the signal overload relays 54, (see Fig. 6) to wire 83. On wire 83, the current traverses the coil of the relay magnet 84, of the bank 52, the wire 85, the front stop and the tongue 85', in the bank 50, which corresponds to the particular reversed half wave constituting the signal sent over the line 48, through the tongue in question to the plate 86, of the bank 50, and by way of wire 87, finally reaches the local direct current negative main 61.

88, represents a static transformer in all respects similar to the transformer 25, in Fig. 2, which is fed by the generator 89.

The normal current terminal 93, of this transformer is connected in parallel to the back contacts of all the magnets in bank 52, except those corresponding to the half waves I and J, in Figs. 3 and 4. These excepted magnets are lettered I' and J', respectively in Figs. 5 and 6. The reverse terminal 92, of said transformer is connected to the cor-

responding front contacts of the relay magnets through the wire 101, as will appear below. Therefore, when any magnet such as 84, Fig. 6, is not energized by current from the mains 60 and 61, as above described, its tongue 90, will bear against its back contact 91, and a normal wave from transformer terminal 93, will pass through said contact and tongue to the wire 95, as the sending commutator makes contact therewith, to wire 99, magnet 100, and real line 49; thereby impressing on the real line 49, an unmodified alternating current, so long as no signal is received in the bank 50. When, however, any magnet such as 84, in bank 52, is energized by means of a corresponding tongue in bank 50, being thrown against its front contact; then current from the mains 60 and 61, will pass through the coils of said magnet as well as the coils of signal overload magnet 54, as above described; and a reverse wave will pass from transformer terminal 92, to the back contact of overload magnet 54, tongue 97', of the same, wire 101, to the front contact of magnet 84, the tongue of said magnet 84, wire 95, sending commutator 96, 98 brushes 97, wire 99, and real line 49, thereby impressing a modified alternating current on said line, such as is illustrated in Fig. 4.

Coming now more particularly and again to my overload signal relay 54, its coil is connected in series with the tails of the coils of all the other transmitting relays through the wires 82 and 83, as shown, except lamp magnet 117. This overload relay is so adjusted that the current of three relays must pass through it before it will operate.

If my overload relay is employed in the Rowland system, when a signal is transmitted, a pair of the transmitting relays will be furnished current which will pass through the coil of the overload relay as above explained, but the tongues of said relay will not be thrown against their front stops unless at least three of the transmitting relays are operated as above stated. When this happens, the overload relay operates, and its tongues 97' and 98', connect with the front contacts 99' and 100', respectively, thereby connecting the normal transformer terminal 93 to the wire 101, which is joined in multiple with all the reverse contacts of the relays in bank 52, except the relays I' and J', and thereby connects both the normal and reverse contacts of said relays with the normal side of said transformer.

The front contacts of the relay magnets I' and J', are also connected to the reverse side of the transformer, directly, as shown. In other words, whenever more than a predetermined number of transmitting magnets preferably three operate, the signal

overload relay causes a normal or unmodified current to be sent to line, except the I and J half waves are reversed.

A special character is provided on the receiving type wheel corresponding to these two reversed I and J half waves; and when this character is printed, it indicates that there is trouble at or beyond the repeating station.

For the proper working of the system employing the signal overload relay, it is necessary that no more than two relays should be forward at the same time as above stated. But it is evident, since the separate signals are received consecutively, that if in one revolution of the sending commutator brushes, there be thrown forward two relays that are in the last half of the bank of selecting relays, while in the next succeeding revolution there be thrown forward two other relays that are in the first half of the bank of selecting relays, then there will be four relays forward at one time. Then, the overload relay might receive sufficient current to be operated when it should not be operated. In order that this may not occur, the tail connection 82, of the overload relay coil 54 does not go directly to the positive main, but through the sending commutator, as shown, and the parts are so timed that it is not connected to the positive main during the interval in which the brushes of the receiving commutator 69, 71 are passing over the segments corresponding to that particular bank of transmitting relays.

It is evident that the application of this overload device is not confined to a repeating station, and that it may be found equally useful at a terminal station, although the object of using it at a terminal station would be quite different from that at a repeater station. Since a defective transmission or a defective operation due to a bad balance, bad adjustment, etc., usually manifests itself by causing more than two relays to be front at the same time, the overload device when so used would indicate defective operation at the terminal station; it is also evident that this device could be used at the terminal station to operate in such a way that, when more than two relays are front at the same time, a special character would be printed on the receiving printer.

In case more than one overload device is used in series on any given circuit, as for example, on each of two repeaters, a different combination could be used for the special character corresponding to the two overload devices, and the particular character printed at the terminal station would localize the source of trouble. Another way of doing this would be to use one overload device on the bank of relays corresponding to one of the transmissions in each direction

at one of the repeating stations, and one overload device on a bank of relays corresponding to another transmission at the other repeating station, and thus differentiate the errors caused by the two repeating stations.

It will be seen from the above that the transmitting relay need not operate so accurately and regularly, as heretofore, for although the timing of the impulses is always by means of a commutator; yet the selection is by means of secondary contacts closed in each case a considerable time before the signals actually pass through the selected circuit; and furthermore, that my signal overload device will, whenever synchronism is interrupted, at once connect both the normal and reverse sides of the transformer secondaries to the sending commutator segments; and thereby cause an unmodified alternate current of standard frequency to be sent to line, except for the reversed I and J waves, which serve to notify the receiving station that there is trouble on the line, at or beyond the repeating station.

I have only described the operation of one set of instruments, shown in Fig. 5, which receives signals from the line 48, and repeats them over the line 49; but it is evident that the other set comprising the banks 51 and 53, would operate precisely the same way, to receive signals over the line 49, and to repeat them over the line 48.

In order that the local and repeating circuits may be the more easily traced and distinguished, the latter are shown in heavy lines.

Instead of the signal overload device above disclosed, I may use the one illustrated in Fig. 7, which is the same as that disclosed in Figs. 5 and 6, with certain additions comprising two relays 110 and 120, a coil 121 and a commutator 130. The relay 120, is duplex wound, and the relay 110 is single wound, as shown. The relay 120, is connected by the wire 119, to the coil 121, which is equal in resistance and self induction to two of the transmitting relay coils in the bank 52, when joined in parallel, or when a combination of two of such transmitting coils is used, as in the Rowland system; but, of course, for other systems the constants of this coil 121, would be correspondingly changed. The other portions of this modified mechanism which are identical with corresponding portions of the mechanism disclosed in Figs. 5 and 6, have received the same reference numerals, and need not be further described, beyond stating that the commutator 130, is connected to the local direct current main 60, through its brush 131, and to the negative direct current main 61, through the relays 110, 120 and wire 132. The signal overload mag-

net 54, is connected to said main 60, through the wires 78 and 82, as in Figs. 5 and 6, but the wire 82, instead of joining the wire 83, as in said figures, joins the relay contact 119'.

5 The wire 83, joins the tails of all the relay magnets in bank 52, but also joins the coil of relay 110. The normal transformer secondary 93, joins in parallel all the back contacts of the relay magnets in bank 52, except those of the I' and J', magnets, as 10 well as a front and a back contact of the overload magnet 54, as shown.

The reverse transformer secondary 92, joins in parallel other front and back con- 15 tacts of the overload magnet 54, the front contacts of the I' and J', magnets, and also the front contact of the lamp magnet 117, as shown. Therefore, when more than two front contacts of the magnets in the bank 20 52, are connected, a normal unmodified current, except for the I and J waves, is sent to line as heretofore. But as the brush 131, revolves over the commutator 130, it is connected to the split of the relay 120, for a 25 half rotation (assuming two messages are being transmitted in one direction); and this half rotation is opposite to the half rotation of the commutator during which the coils of the selecting relay bank 50, 30 receive their impulses.

At the split of the relay 120, the current divides, part going by way of coil 121 to negative, and part through the other side and through relay 110, by way of wire 83, 35 through any of the coils of the transmitting magnets in bank 52, which have had their forward contacts closed, through the operation of corresponding selecting magnets in the bank 50. The current then passes from 40 the coils of said transmitting magnets to the tongues of the same, through the forward contacts and tongues of said corresponding selecting magnets in bank 50, to the base 86 and wire 87, and to the negative 45 main 61, all as above described in connection with Figs. 5 and 6. If, however, when the relay 120 is operated, no selecting relay magnet in the bank 50, is forward, said relay 120, will receive an impulse while the relay 50 110, will not, and no current passes through magnet 54, and wire 82. But if only one selecting relay is forward, a greater current will pass through the coil 141, than through the coil 140, of relay 120, so that both the 55 relays 110 and 120, will be operated, and there will be passed through the coil of magnet 54, a current by way of the wires 82 and 132, and contact 119', sufficient to make magnet 54, go forward. If, on the other hand, 60 two selecting relays are forward, equal currents will pass through the coils 140 and 141, but in opposite directions, and the relay 120, will not operate while the relay 110, will.

If more than two selecting relays are for-

ward, the coil 140, will receive a greater 65 current than will the coil 141, for the reason that the resistance and self induction of coil 121, is only equal to the resistance and self induction of two of the relay magnets, as above stated. Therefore, both the relays 70 120 and 110, will operate, and the magnet 54, will be again forward. In other words, both the relays 110 and 120 will operate, and the overload signal magnet will send in a normal, or unmodified current, except for 75 the waves I and J, for all conditions, except when no selecting relays are forward and when two selecting relays are forward.

It will be observed that in both forms of my overload device, I have only illustrated 80 a system where combinations of two relay magnets are employed to reverse the signal waves, but it is evident that my invention is adapted for various other combinations.

In a telegraphic system using combina- 85 tions of pairs of waves, the only two conditions necessary for its perfect operation with my device are:—The overload relay must not be forward when no selecting relay is forward, and it must not be forward 90 when two selecting relays are forward; but it must be forward under all other circumstances, and my device fulfils these conditions in every respect, as above shown. Of course, it could happen that one selecting 95 relay could go forward when it should not, and another relay could, at exactly that instant, fail to operate when it should, but the chance of such simultaneous errors due to the line, or the mal-adjustment of the machine is too remote to warrant consideration. 100

My invention therefore furnishes an absolute safeguard against errors due to causes other than the operator.

It is furthermore evident that my device 105 may be readily adapted to other arrangements of combinations. For example, if only combinations of three were used the coil C would be made to balance three relays. If combinations of two and three were used 110 an additional duplex wound relay in series with A and B would be required. One duplex relay will be balanced by a coil C equal to two coils in parallel and the other duplex wound coil would be connected in series 115 with the coil C equal to three relay coils in parallel. The contacts of the three relays would be connected in series.

Of course, it is also evident that my invention is of the greatest use on a terminal 120 machine.

The operation of my machine may be briefly summarized as follows:—In sending over a line that does not include a repeating station, it is only necessary to depress the 125 proper keys, and to have the signals recorded at the distant station in the usual way. If the line includes a repeating station, my in-

vention automatically transmits the signals over the next line, whether my overload signal relay is or is not used at said station. If my signal overload device is not used at a repeating station, however, the advantages of my direct connecting switch between the secondaries of the transformer and the segments of the sending commutator are greatly lessened; for should the wire open for any cause, on one side of the repeater, the terminal machine on that side of the repeating station will be thrown out of synchronism. This in turn will cause the selecting relays on the same side of the repeater to all go front or all go back as the phase of the received current at the receiving station varies. The "going front" of the selecting relays will in turn intermittently operate all or nearly all the transmitting relays on the opposite side of the repeater; and if no overload device is present, as above stated, a large number of the waves sent out on the second side of the repeater will be reversed at intervals. This will probably cause the machine on the second side of the repeater to also lose synchronism. When this happens, in order that the machines may again come into synchronism, it is necessary that the attendant at the repeating station shut off the current from the coils of his transmitting relay, as above stated, so that an unmodified alternating current leaves the repeating station on both sides, and to thereby allow both terminal stations to come again into synchronism, and to find the letter. When this is accomplished, the attendant at the repeating station must then close the switches giving current to the coils of the transmitting relay and the circuit is again ready for operation. But in those cases when my overload devices are placed on the repeating machines, the second side will not be thrown out of synchronism because not more than two waves can be reversed from any one bank of relays. The overload device thus automatically prevents the second side of the repeater from falling out of synchronism, and it is not necessary for the attendant at the repeating station to throw any switches. Therefore, as soon as the terminal which has been thrown out of synchronism comes into synchronism again, and finds the letter, the circuit is ready to operate.

In addition to the above, my overload device in itself facilitates operation when the reception becomes defective. That is to say, if the attendant at a terminal station notes extra characters being brought in which result from more than two selecting relays being forward he knows at once that the trouble is in his own station, if the repeating station is furnished with my overload device, but not otherwise. In such

case therefore he does not first have to ask if the signals are passing the repeating station before proceeding to find the cause of the bad reception. And again, if he notes that the special character assigned to the overload device is being printed, he knows at once that the trouble is not in his own station, and he does not therefore change his own adjustment in an attempt to correct the defects which do not exist, as would be the case where my invention is not used; but he at once notifies the repeating station.

Having now described my invention what I claim is:—

1. The art of transmitting and repeating signals which consists in normally transmitting half waves over the line when no signals are being sent and in suitably transmitting over the line a sufficient number of reversed half waves to constitute the signals in question in repeating said reversed half waves; and in causing a distinctive signal to be transmitted whenever more than a given number of said reversed half waves are on the line, substantially as described.

2. The art of transmitting and repeating signals which consists in synchronously transmitting and repeating signals and causing a distinctive signal to be automatically sent to the receiving station, whenever synchronism is lost, substantially as described.

3. The art of transmitting and repeating signals which consists in synchronously transmitting and repeating signals from a sending station to and through a repeating station, and causing a distinctive signal to be automatically sent from the repeating station to the receiving station, whenever synchronism is lost whereby the attendant at the receiving station is automatically informed that the trouble is at or beyond the repeating station, substantially as described.

4. In the art of synchronously transmitting and repeating signals, the steps which consist in transmitting and in automatically repeating the said signals and sending a distinctive signal to the receiving station whenever synchronism is interrupted, substantially as described.

5. The steps in the art of transmitting and repeating signals which consist in automatically transmitting and in sending from the repeating instrument a distinctive signal whenever synchronism is interrupted, substantially as described.

6. The steps in the art of synchronously transmitting and repeating signals employing alternate half waves of a modified character when signals are sent and an unmodified character when no signals are sent, which consist in automatically transmitting and in sending from the repeating station a distinctive signal whenever synchronism

is interrupted, and in causing at the same time except for said signal only unmodified half waves to leave the said station, substantially as described.

5 7. The steps in the art of synchronously transmitting and repeating signals employing alternating unmodified and reversed half waves when no signals are sent and when signals are sent respectively, which
10 consist in suitably sending and repeating both said unmodified and reversed half waves when synchronism is not disturbed, and in repeating to line unmodified half waves when synchronism is interrupted, and
15 simultaneously sending to line at a distinctive signal consisting of a plurality of half waves, substantially as described.

8. The steps in the art of synchronously transmitting and repeating signals employing
20 reversed and unmodified alternating half waves when no signals are sent and when signals are sent respectively, which consist in suitably transmitting both of said kinds of waves, suitably repeating both of
25 said kinds of waves while synchronism is not disturbed, and in repeating to line both of said sets of waves with the reversed waves in their unmodified form, when synchronism is lost except a sufficient number
30 of the latter to constitute a distinctive signal which are left in their reversed condition, substantially as described.

9. In a telegraphic apparatus the combination of a plurality of sources of alternating current half waves; a commutator; a
35 switch directly connecting said commutator with said sources, and adapted to cause unmodified and reversed half waves to be sent to line; a relay at a distant station adapted
40 to be operated by said half waves; a commutator at said distant station; and a second switch at said station operated by said relay, directly connected with said commutator, and adapted to repeat said unmodified and reversed half waves received by
45 said relay, substantially as described.

10. In a telegraphic apparatus the combination of a plurality of sources of alternating current half waves; a commutator; a
50 switch directly connecting said commutator with said sources and adapted to cause unmodified and reversed half waves to be sent to line; a relay at a distant station adapted to be operated synchronously with said commutator by said half waves; a commutator
55 at said distant station also synchronous with said relay; and a second switch at said station operated by said relay, directly connected with said commutator, and adapted
60 to repeat said unmodified and reversed half waves received by said relay, substantially as described.

11. In a telegraphic apparatus the combination of a plurality of sources of alternating

current half waves; a sending commu- 65
tator; a switch adapted to directly connect said sources and said commutator and to send both unmodified and reversed half waves to line; a relay at a distant station adapted to be operated by said half waves 70
in synchronism with said commutator; a receiving commutator at said distant station in synchronism with said relay; a sending commutator at said station in synchronism with said receiving commutator; a magnetic 75
switch directly connecting said commutators at said station, and adapted to cause the waves received by said relay to be repeated, substantially as described.

12. In a telegraphic apparatus the combination of a suitable transmitting instrument; a suitable repeater connected to said transmitter and adapted to employ reversed half waves of current; and means for sending a distinctive signal, whenever an abnormal 85
number of half waves are sent to line, substantially as described.

13. In a telegraphic apparatus the combination of synchronous transmitting and repeating instruments; and means for sending 90
from the repeater a distinctive signal, whenever synchronism is lost, substantially as described.

14. In a telegraphic apparatus the combination of synchronous transmitting and repeating instruments; and means for automatically sending from the repeater station a distinctive signal, and thereby notifying the attendant beyond whenever synchronism is lost, substantially as described. 100

15. In a telegraphic apparatus the combination of a repeater adapted to be operated by reversed half waves of current; and means for automatically sending therefrom a distinctive signal, whenever said repeater 105
receives an abnormal number of said half waves, substantially as described.

16. In a telegraphic apparatus the combination of a repeater adapted to be operated by reversed half waves of current; and 110
means consisting of a signal overload relay for automatically sending therefrom a distinctive signal, whenever said repeater receives an abnormal number of said half waves, substantially as described. 115

17. In a telegraphic apparatus the combination of a repeater and a signal overload relay magnet provided with a coil through which normal signals may pass without operating said relay, but adapted to operate 120
when abnormal or false signals pass there-through, substantially as described.

18. In a telegraphic apparatus the combination of a repeater a relay magnet provided with a differential winding and a plurality of front and back contacts, said winding adapted to permit normal signals to pass 125
without operating said front contacts, but

adapted to close the same upon the passage of false signals, substantially as described.

19. In a telegraphic apparatus the combination of a repeater provided with a bank
5 of relay magnets having front and rear contacts of a signal overload relay magnet, also, provided with a plurality of front and back contacts, the winding of said relay magnet adapted to permit signals to pass there-
10 through without closing its own front contacts when a normal number of the front contacts in said bank are closed, but adapted

to close its said front contacts when an abnormal number of said front contacts in said bank are closed, and to thereupon send
15 out a distinctive signal, substantially as described.

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

LOUIS M. POTTS.

Witnesses:

J. PARK JACKSON,
ROBERT P. MARSHALL.
