L. M. POTTS.

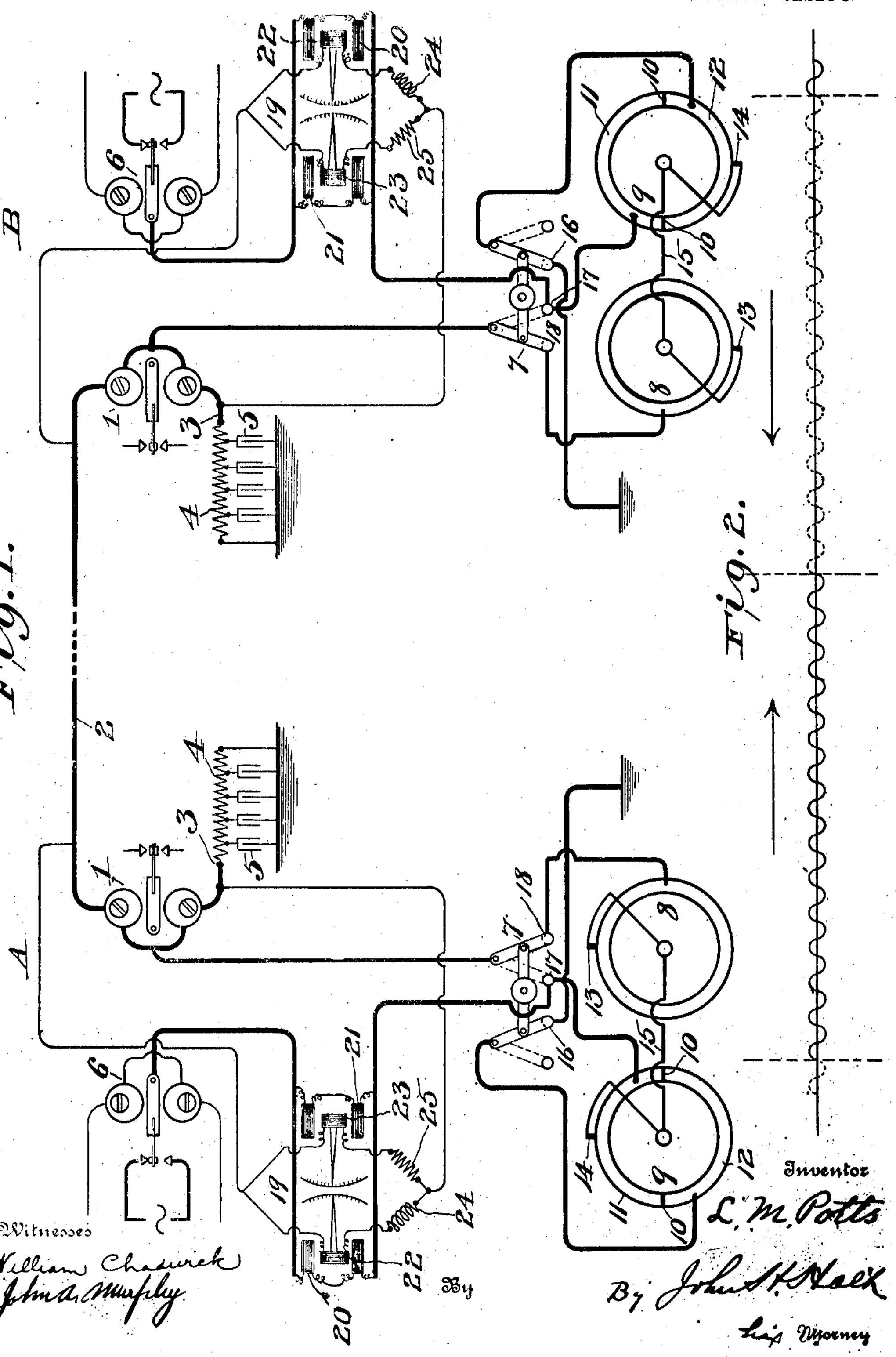
TELEGRAPHY.

APPLICATION FILED JULY 1, 1908.

988,811.

Patented Apr. 4, 1911.

4 SHEETS—SHEET 1.



Witnesses

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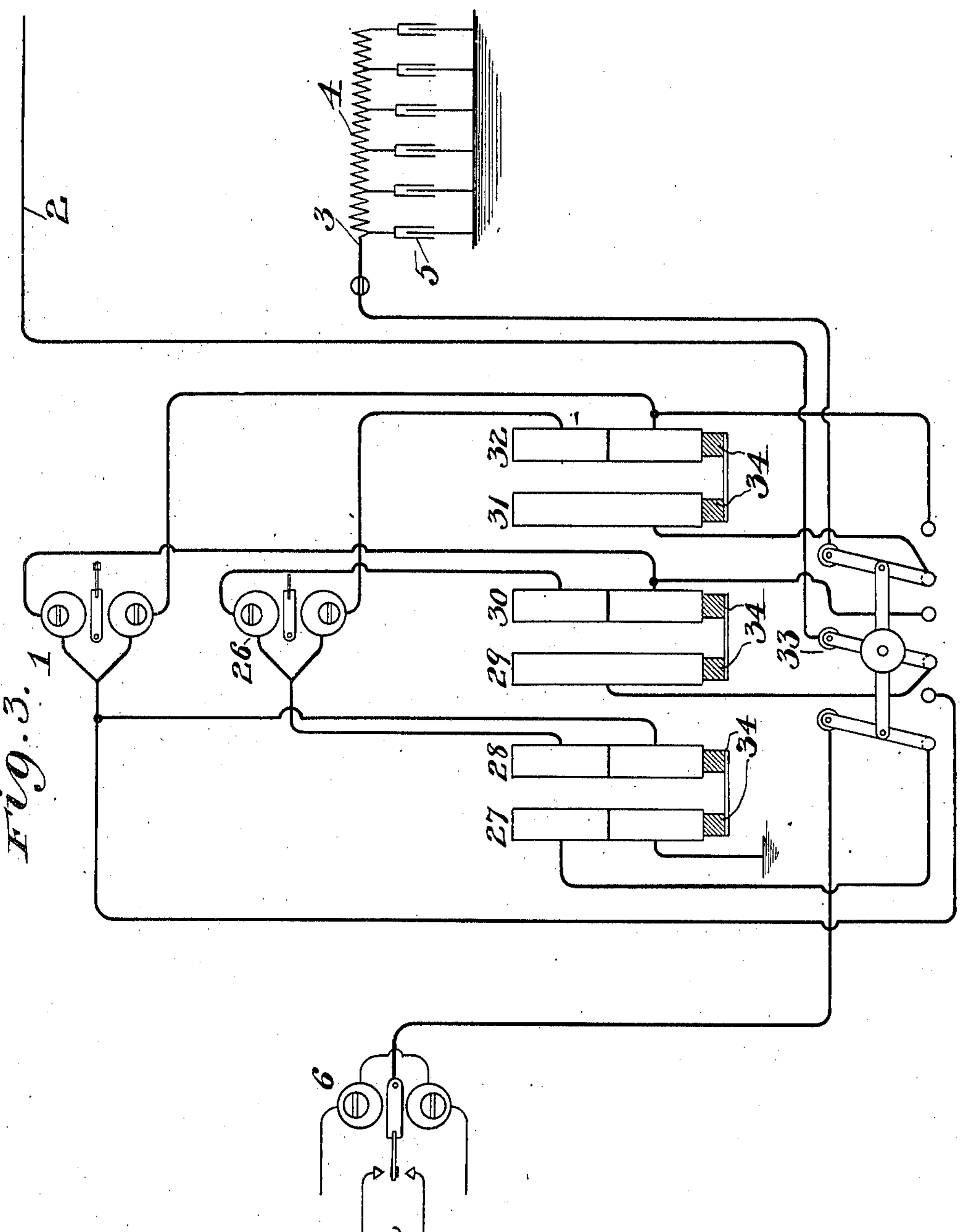
4 SHEETS—SHEET 2.

Fig. 3.



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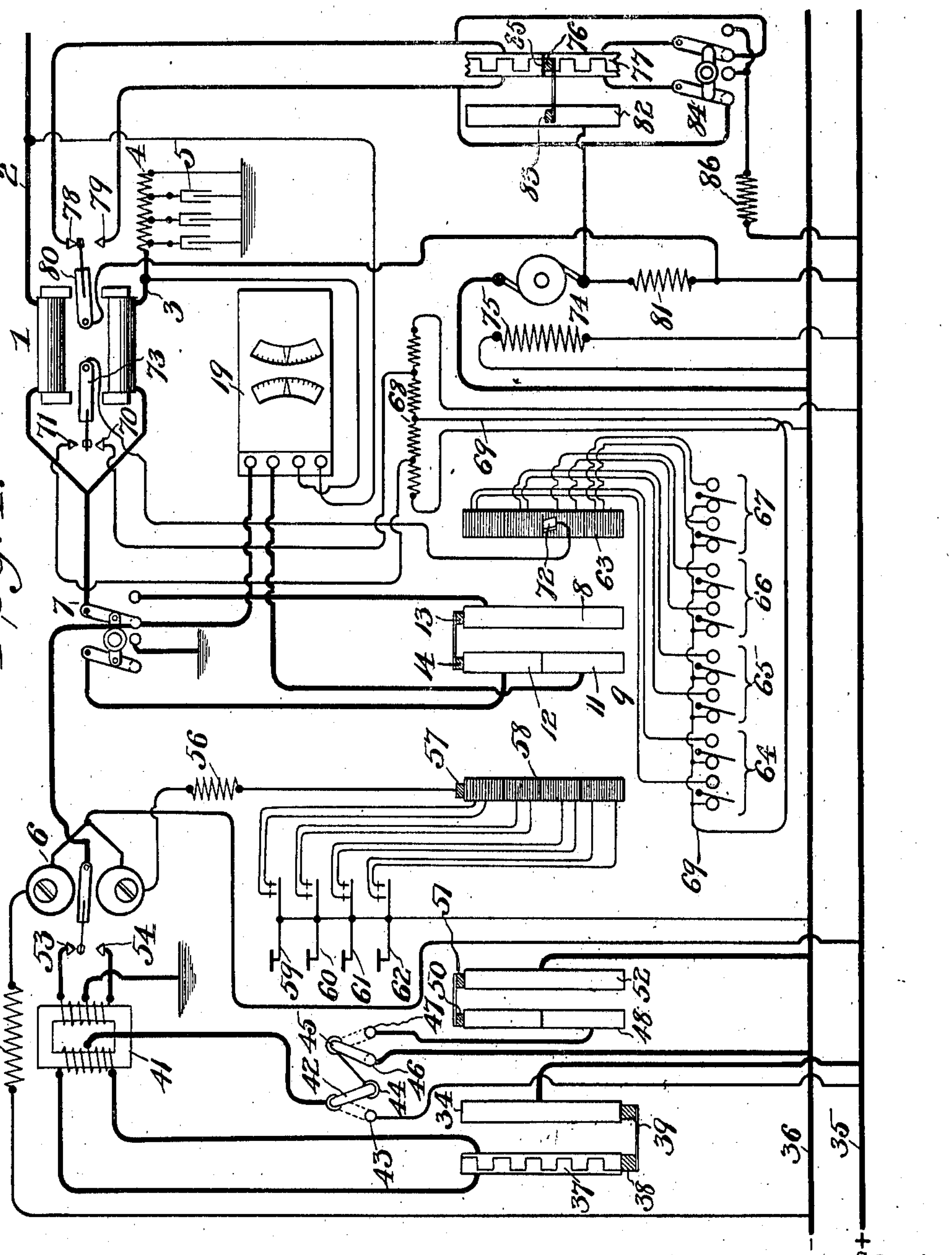

Fig. 4.

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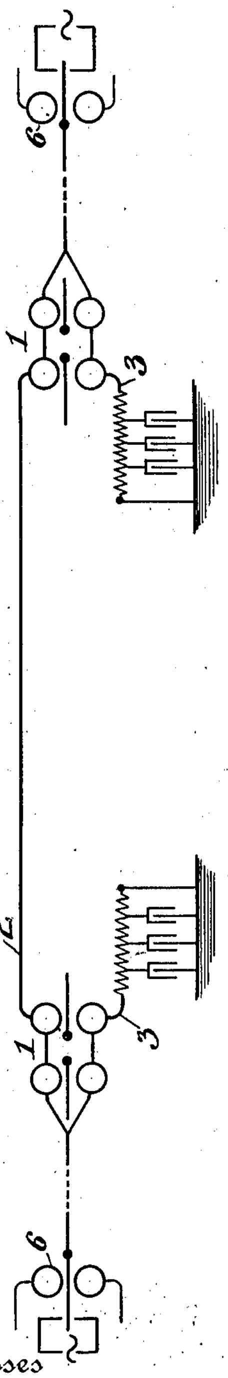

Fig. 5.

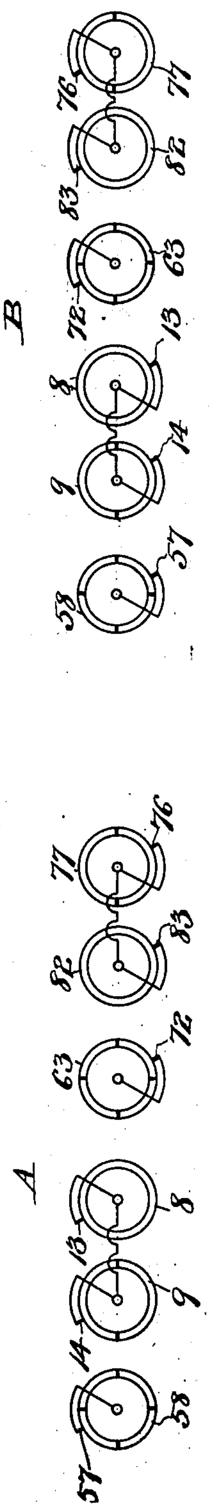

Fig. 6.

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UNITED STATES PATENT OFFICE.

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TELEGRAPHY.

988,811. Specification of Letters Patent. **Patented Apr. 4, 1911.**

Application filed July 1, 1908. Serial No. 441,357.

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 Telegraphy, of which the following is a specification.

The primary object of this invention is to improve the operation of that class of telegraph lines wherein the home receiving instrument is in the normal operation of the line non-responsive to current sent out from its own station, but responsive to current received from a distant station. The rendering of the home receiving instruments operative in this manner is generally known in the art as duplexing.

In the duplexing of telegraph lines it is necessary that an artificial line be used which is composed of electrical resistance and capacity, the value of which must be regulated so as to correspond to those of the real line. This process may take considerable time, particularly when the condition of the wire is changeable or unstable; or when other conditions are such as to demand a very accurate balance. In systems where the artificial line is composed of a considerable number of sections, with distributed capacity, it is necessary to separately adjust each section, so that the length of time consumed may be considerable. In any case, by present methods, it is necessary to stop the transmission in both directions and cut off the signaling current at one terminus while the other balances. When the first terminus has balanced, the process is then reversed; and not until both ends have balanced can the line be again operated; and, during this interval, the wire has been completely out of use. The present invention proposes a method and means by which this condition is obviated, and makes it possible to operate the wire at a fraction of its full capacity continuously without an artificial line balance. While the line is operating at this capacity, both ends can be simultaneously balancing. When both ends are balanced the throwing of a switch at each station makes possible the full duplex operation of the line.

A further object of this invention is to provide for the maintenance of synchronism under the above conditions.

Other objects of the said invention will hereinafter more fully appear.

Although applicable to any system in which a definite time relation can be established between the signals passing in opposite directions on the same wire, the present invention has been developed with special reference to the Rowland telegraphic system, a form of which is shown and described in U. S. Patent No. 713,497 to Henry A. Rowland granted Nov. 11, 1902.

In the Rowland system an alternating current is sent over the line continuously and this current is employed both for transmitting signals and synchronizing: the signals consisting in reversing certain combinations of the waves of said alternating current. The multiplex feature of the system is accomplished by synchronous operation of current distributers located at the terminal stations.

In the case of the Rowland octoplex each of the four operators at each end of the line is given the use of the line wire for one-fourth of the time at regular recurring intervals, and in addition the line is duplexed by the polar duplex method which allows two transmissions to take place simultaneously, so that four transmissions in each direction or eight in all may take place over the same wire. Hitherto it has been necessary to stop all transmissions over such a line when balancing the artificial line for duplexing. The present invention contemplates, in such a case, that during the balancing of the line at least two of the operators at each end of the line shall have use of the line without interfering with each other or with the balancing.

In order to more fully describe my said invention, reference will be had to the accompanying drawings, wherein,

Figure 1, is a diagram of a duplex telegraph line embodying my said invention; Fig. 2, a diagram to illustrate the grouping of the signaling current waves; Fig. 3, a diagram of an arrangement for indicating the state of balance of a duplex line; Fig. 4, a diagram of some circuit connections of one end of a Rowland octoplex line equipped with my invention; Fig. 5, a simplified diagram showing both ends of a line duplexed as in Fig. 4, with the commutators or switches and other parts shown in Fig. 4, omitted, and Fig. 6, indicates in diagram the relative positions at the two ends of the line of the several brushes of said commutators omitted from Fig. 5.

In Fig. 1, A and B indicate two stations at opposite ends of a duplex telegraph line; 1 the receiving main line relays, which may be of the usual form of polar duplex relay having two windings, one for the real line 2, and the other for the artificial line 3, connected in the usual manner through resistance 4 and capacity 5 to earth; 6 the main line transmitters, the tongues of which are connected in series with the main line and vibrate between two contacts each of which is connected to a source of current for supplying the main line; in the present case indicated as a source of alternating current. The transmitters shown are of the form shown and described in said Rowland patent. Briefly their operation is as follows:—Normally their tongues rest against one of the contacts connected to the source of alternating signaling current. During this time an unmodified alternating current is transmitted to line through said contact. When a signal is sent, which occurs through the operation of a key of a keyboard, this causes the tongue of the transmitter to pass over to the other contact sending an alternating current wave to line of different polarity from the normal. The reversal of these waves in certain combinations form the signals. The time intervals of the several transmissions are provided for by using in connection with the keyboard, a current distributer or sunflower which allows the respective operators the use of a given transmitter at definite intervals, all of which is fully described in said patent to Henry A. Rowland.

The present invention is not directed to any particular form of line transmitter and means for operating the same. This same holds true with respect to the receiving apparatus. The relays 1 which I have shown may be the regular line relays of the Rowland system and record the message by actuating printers, such for example, as described in said Rowland patent; but I do not wish to limit my invention except wherein specifically pointed out to said system or any part thereof.

In order to continue the operation of the line while the artificial lines are being adjusted, I have provided means whereby the receiving line relay at one station may be made to receive signals only at such times as current from its station is not being sent out, which permits the artificial line at a given station to be adjusted while current is being sent out from that station without interfering with the reception of signals from the other station. The means which I have shown for accomplishing this, comprise a rotary circuit-changing device connected at each station in circuit with the main line between the transmitter and the receiving line relay through a two-pole double-throw switch 7. These rotary circuit-changing devices comprise each conducting rings 8 and 9, the former being of continuous metal while the latter is divided by insulation 10 into two half sections or segments 11 and 12. These rings are provided respectively with brushes 13 and 14 which are in permanent electrical connection with each other, as through conductor 15, and are driven preferably in synchronism in any suitable way, the brushes 13 and 14 at one end of the line being staggered 180° from those at the other end. The segment 12 of each ring 9 is connected permanently to that one of the blades of the switch 7 which is adapted to engage a contact 16 connected to earth. The contact segment 11 is in permanent electrical connection with a contact 17 of the double-throw switch which in turn permanently connects to the transmitter side of the line and is adapted to be engaged by a blade of the switch 7 permanently connected to the receiving relay side of the main line as shown. Each ring 8 is permanently connected to contact 18 of its respective switch. 19, 19, are instruments, hereinafter more fully described, for indicating the correct adjustment of the artificial lines.

With the switches 7 thrown as shown in the full line position in Fig. 1, the line will operate at half capacity, during which time the artificial lines at both stations may be balanced simultaneously.

When the switches 7, Fig. 1, are thrown to the full line positions shown, it will be seen that while brush 14 at station A is passing over segment 11 the tongue of the transmitter 6 at that station is in electrical connection through switch contact 17, segment 11, brush 14, conductor 15, brush 13, ring 8 and switch contact 18 with the split of the main line relay at that station, and while brush 14 is thus passing over transmitting segment 11 at station A, brush 14 at station B is passing over segment 12 which is grounded through switch contact 16 at that station. Connection at this time will be complete from the split of the receiving relay at station B, through switch contact 18, ring 8, brush 13, conductor 15, brush 14, segment 12, switch contact 16 to earth. Therefore, while brush 14 at station A is passing over segment 11, signals may be sent out from the transmitter at station A and received on the receiving relay at station B, and during this time the receiving relay at station A may respond to these signals, but the transmitter at station B cannot during this time send signals to station A for the reason that the brush 14 at station B is, during such interval, out of engagement with the transmitter segment 11. The conditions are exactly reversed at the two stations when the brushes 13, 14 occupy the halves of the rings opposite those upon which they are shown in the drawings. Therefore, the artificial lines at both stations may be adjusted simultaneously until a proper balance is had without in the least affecting the reception of signals at the other end. With the apparatus shown, the line will then be operated at one half its full capacity during the balancing.

In Fig. 2, is indicated diagrammatically blocks of signaling current impulses, wherein waves shown in full lines indicate those sent out from station A during the time the trailer 14 at that station is passing over segment 12, and the waves in dotted lines those received from station B while the said trailer 14 is passing over segment 11 at station A. The diagram Fig. 2, shows the current as it would appear at one end of the line; at the other end there would be a relative displacement between the two currents sent out from opposite ends due to the retarding effect of the line capacity. In the Rowland octoplex each of these blocks of signal impulses represent two transmissions, to each of which is devoted fourteen impulses. This particular division of the waves is convenient in the Rowland system, but the present invention is not limited to any particular classification or grouping of signals.

When the proper balance is obtained the switch 7 may be thrown to the dotted line position shown in Fig. 1, when the line may be worked at its full capacity. In this latter position of the switch 7, the line from the transmitter is connected direct to the split of the receiving relay through the switch contact 17, thus short circuiting the rings 8 and 9.

The adjustment of the artificial lines to obtain a correct balance, may be indicated in any of many different ways, and I do not limit my invention to any of these except where specifically pointed out in the claims. The method of indicating a balance illustrated in Fig. 1, consists in connecting two instruments of the electro-dynamometer type in circuit in such a manner that the currents in the two movable coils shall differ in phase from each other, and connecting the fixed coils in such a way that they shall be excited by a strong current similar in character to the signaling current, and balancing the line until there is no deflection of either instrument. The instruments 19, which I have shown in Fig. 1 for accomplishing this, comprise each two instruments of the electro-dynamometer type wherein the fixed coils 20 and 21 are connected in series with the main line between the transmitter tongue and the split of the main line receiving relay, while the moving coils 22 and 23 are connected in branch circuits from the beginning of the real line to the beginning of the artificial line, the coil 22 in series with either capacity or self induction 24 and the coil 23 in series with a resistance 25, the current in one movable coil being dephased with respect to the other movable coil 23 of the same combined instrument 19. When there is no deflection of either movable coil of the two instruments making up the combined instruments 19, there will be a balance between the real and the artificial lines.

It will be readily seen that when the switches 7 are thrown to that position shown in the full lines in Fig. 1, when the line is worked at half capacity, the balancing instruments at the respective stations will not be affected by incoming currents but only by currents generated at the home station, so that the adjustment of the artificial line may be carried on until the needles of the instruments 19 indicate zero, when a balance will have been obtained. This operation at each station being independent of the received current at that station may be carried on at both ends of the line simultaneously while two transmissions are taking place in each direction.

In Fig. 3, I have shown another arrangement for indicating a balance of the lines, which may replace that shown in Fig. 1. The ordinary way of indicating a balance of a duplex telegraph line is by feeling the tongue of the main line receiving relay and noting thereby the effect of the out going current thereon. The method illustrated in Fig. 3, is based upon this general idea. In this case, I employ in addition to the main line receiving relay 1, an indicating relay 26 which may be an exact duplicate of relay 1; replace the circuit-changing devices 8 and 9 (Fig. 1) by a commutator having six rings 27, 28, 29, 30, 31 and 32, and replace switch 7 (Fig. 1) by a three-pole double-throw switch 33. The commutator rings 27, 28, 30 and 32 are divided into two insulated segments while the rings 29 and 31 are metal all around as indicated, the said rings being shown developed. The commutator brushes 34 are electrically connected in pairs and may be driven at the desired speed in any desired way.

With the parts connected as shown and the switches 33 thrown to the position indicated in full lines in the drawing, the relay 1 is connected in circuit when current is being received from the distant end, and the relay 26 is connected in circuit when current is being sent out from the home station, since the said relays are connected in circuit with opposite segments of the split rings 27, 28 30 and 32. It is evident, therefore, that the relay 1 will be affected only by the incoming current and relay 26 by out going current only. Now if the line is properly balanced, the out going current will have no effect upon relay 26, therefore, by simply feeling the tongue of relay 26 to determine when the outgoing current has no effect upon it, an indication of the balance is obtained. When the switch 33 is thrown to the other position, or the full capacity position, the segments of the rings 30 and 32 connected to the relay 26 will be short circuited, thereby cutting the relay 26 out of circuit. The relay 1 will then be in circuit continuously until it is found necessary to throw switch 33. This method of line operation whereby the line may be continued in use during the balancing though operating at reduced capacity is shown in Fig. 4 as applied to the Rowland octoplex synchronous system. In this diagram, 35 and 36 indicate respectively the positive and negative local supply mains of a 110 volt D. C. circuit, 37 a split crown commutator, the brush 38 of which connects through a brush 39 on a collector ring 34 to the positive local main 35; 41 a transformer, the outer terminals of the primary of which connect to opposite sections of the commutator 37; while an intermediate terminal of said primary is connected to a switch blade 42, which, if thrown to contact 43 connects all the terminals of the primary of the transformer to the same side of the line 35, 36, thus cutting the transformer out of operation. When the switch blade 42 is thrown to contact 44, normally in electrical circuit with a switch blade 45, the transformer will be operative continuously if the switch blade 45 is on contact 46, which is connected direct to the negative supply main 36, or the transformer will be operated at regularly occurring intervals or half the time if the switch blade 45 is thrown to contact 47 while the blade 42 is on contact 44, the said contact 47 being connected to an insulated half or segment of the split ring 48 having a contact brush 50 permanently electrically connected through a contact brush 51 on ring 52 to the negative supply main 36. This transformer supplies the alternating current to the main line, and for this purpose the outer terminals of the secondary coil are connected to opposite contacts 53 and 54 of the main line transmitter 6, while an intermediate terminal of said secondary is connected to earth as shown. Normally, that is as long as no signals are being sent by transmitter 6, its tongue is biased so as to rest normally against contact 53.

The operation of the transmitters in Fig. 4 is the same as described with relation to Fig. 1. In Fig. 4, however, I have indicated diagrammatically the keyboard and the transmitting commutator connections of the Rowland octoplex for operating the transmitter. As shown the transmitter has its split connected to the positive side of the supply line; one of the coil terminals connected through a high resistance 55 to the negative side of said circuit, and its other coil terminal connected through resistance 56 to the brush 57 of a sending commutator 58, which is divided into four equal groups of insulated segments, each group of which connects to a separate keyboard indicated by the four keys 59, 60, 61 and 62, all of which connect to the negative side of the local circuit 35, 36. The commutator 58 is shown in Fig. 4 in development. In practice, each key of a keyboard is provided with two contacts which connect to two segments in its respective group on the sending commutator. Means are also provided whereby the keys of the keyboard may be operated at certain times so as not to interfere with each other; but these are details which form no part of the present invention, and for a description of which the reader is referred to the Rowland patent before referred to.

63 represents in development the receiving commutator, which like the sending commutator, is divided into four equal groups of insulated segments, these groups being connected respectively to four banks of selecting relays 64, 65, 66 and 67. In practice there are eleven such relays in each bank, each connected to a different segment of its group on the receiving commutator.

A resistance 68 of 600 ohms is shunted across the 110 volt direct circuit 35, 36, the middle point of this resistance being connected to the common return wire 69 of the selecting relays. The contacts 70 and 71 of the main line receiving relay are connected to points about 100 ohms from the terminals of the 600 ohms resistance. The brush 72 is driven in synchronism with the vibration of the tongue 73 of the line relay 1 so that the main line current is reproduced locally through the relays 64, 67, each alternate relay in a given bank receiving current in the same direction, but adjacent relays in opposite directions. Through the reversal of the line current impulses as above described, the tongue of the relay 1, by remaining against the opposite contact from the normal for the time of such reversal, causes a reversed impulse to be sent to the selecting relay connected to the segment of the receiving commutator at that instant under the brush of said commutator, thereby causing the movement of the tongue of the selecting relay out of its normal position, which may be made to record the signal thus received in any desired way, as for example, by the operation of a printer as shown and described in said Rowland patent. The operation of the receiving and transmitting commutators in the present case, however, differs from their mode of operation in said patent in the following respect: In said patent there is synchronous operation between the transmitting commutator at one end of the line and the receiving commutator at the distant end, but as between the sending and receiving commutators at the same station there is absolutely independent operation. Moreover, in the patent referred to, the generators of the alternating current at the opposite ends of the line operate independent of each other.

In the case of the present invention, the brushes of both sending and receiving commutators, as well as the brushes 38, 39, 50, 51, 14 and 13 are all driven by a common (the same) motor 74 of which 75 represents the shunt field. The motors 74 at each end of the line are driven in synchronism with the line alternating current and therefore with each other, which synchronism may be maintained in the following way: On the shaft driven by the motor 74 is a trailer carrying a brush 76 which travels in contact with a crown commutator 77, shown in development in Fig. 4. The segments of this crown commutator are of such a number and the brushes driven at such a speed that the time occupied by the brush in passing over one segment will correspond to the time interval between the two successive zero points of the signaling current. In other words, each segment will correspond to a half wave of the line current. Alternate segments connect to opposite contacts 78 and 79 of the line receiving relay 1 which is provided with an auxiliary synchronizing tongue 80 adapted to vibrate between said contacts. In series with the armature of the motor 74 is a resistance 81, and on one side of this resistance is connected the synchronizing tongue 80, while the other side of said resistance is connected to brush 76 through a collector ring 82 and brush 83 thereon, the latter being mounted on the same trailer with and permanently electrically connected to brush 76. The connection between the commutator 77 and the double-pole switch 84 will for the present be disregarded.

The tongue 80 of the main line relay 1 is kept in continuous vibration by the alternating current from the distant station, and the trailer or brush 76 is kept in continuous rotation by the motor. If the tongue 80 of the relay is on the side contact which is connected to the set of segments of the crown commutator which the trailer is touching at the same time, (contact 78 Fig. 4) it will be seen that the resistance 81 is short circuited; while if the tongue 80 of the main line relay is on the side contact of the relay which is not connected to the set of segments of the crown commutator which the brush is touching at the same time, the resistance will be in series with the armature of the motor. In one case the armature will receive a much greater current than in the other.

Consider, first, the case when the vibrations of the tongue of the main line relay and the rotation of the brush arm bear such a relation to one another that as long as the tongue is against a given contact the brush 76 is in contact with the segments connected to that contact. If this condition is maintained it will be seen that the resistance 81 is continuously shunted.

Secondly, consider the case when the vibrations of the tongue of the main line relay bear such a relation to the rotation of the brush arm that when the tongue is on the contact 78 the brush is on the segments connected to contact 79, and when the tongue is on the contact 79 the brush is on the segments connected to contact 78. If this condition is continuously maintained it will be seen that the resistance 81 is continuously in circuit with the armature.

Thirdly, consider any case in which the vibrations of the relay tongue and the rotation of the brush arm have some relation between the above two. If any relation between the first two mentioned is continuously maintained, it will be readily seen that at rapidly recurring intervals the resistance will be in circuit and out of circuit. Depending upon the relation between the vibration of the tongue and the rotation of the brush arm, the intervals during which the resistance 81 is in circuit and out of circuit will vary in length, and in addition to the regular current flowing through the armature, there will be a pulsating current flowing through the same and the strength of these impulses will depend upon the relation existing between the vibrations of the tongue and the rotation of the brush arm. Consequently, while the relay tongue is vibrating in unison with the rotation of the brush arm, there can be various amounts of current flowing through the armature of the motor, depending upon the relation of the relay tongue and the rotation of the brush arm. This is in brief the theory and operation of the Potts synchronizer employed in the Rowland system.

When operating the line at half capacity, as herein described, during the adjustment of the artificial line, it will be seen that the main line relay is available for synchronizing purposes during that time only when current is received from the distant end. In order to better maintain the synchronism, it is desirable to provide means whereby the armature of the motor shall receive the same current during the time that the main line relay is not receiving current from the distant station as during the time that it is receiving such current. In order to accomplish this, I divide the crown commutator 77 into two insulated sections indicated in the drawings by the two halves of the commutator lying respectively on opposite sides of the insulator 85, and connect opposite crown sections of the half below said insulation to the blades of a two-pole double-throw switch 84, while the other segments above said insulation are connected to the relay contacts. Two of the contacts of switch 84 connect respectively to the relay contacts 78 and 79, while the other two contacts of said switch connect through a compensating resistance 86 to the positive main 35.

With the switch thrown as shown in the drawings, it will be seen that the halves of the commutator 77 on both sides of the insulation 85 are connected to the contacts 78 and 79 of the line relay. In this position of the switch, therefore, the motor 74 will be subject to the synchronizing action of the main line relay tongue continuously. When the switch 84 is thrown to the other contacts shown, this cuts off connection from the lower half of the commutator 77, and the line relay contacts, so that the motor 74 will receive synchronizing action from the line relay only while the brush 76 is passing over that half of the commutator 77 above the insulation 85. During the other intervals, that is when the main line relay is not receiving current from a distant station, the armature of motor 74 receives current through compensating resistance 86 approximately equal to that received by way of the main line relay tongue, thereby preventing a tendency to oscillations in synchronism which would otherwise be present.

In Fig. 4, the apparatus at one end of the line only is indicated. This is of course duplicated at the other end except as to the relative positions of the commutator brushes which are as indicated in Fig. 6. Calling one end of the line station A and the other station B, it will be seen that corresponding brushes at the two stations have a relative displacement of 180°. Assuming that each end of the line is equipped with the apparatus and connections shown in Fig. 4, the method of starting up the machines at the two stations is as follows:—The motor 74 at one of the stations is started and run up to the proper speed. The switches 7 and 84 are set to the full on position shown in Fig. 4, and the switch arms 42 and 45 also occupy full on positions in which they are shown. This station then sets the speed. At the other station, the one synchronizing, the line switch 7 and the synchronizing switch 84 are set to the full on position and the switch arm 42 shifted to contact 43 completely cutting off the source of signaling current at that station. The motor 74 at the station synchronizing being started, the "letter" is then found. The process of "finding the letter" is fully described in said Rowland patent hereinbefore referred to and need not here be described in detail. Briefly it consists in causing the receiving sunflower brush at one station, the station synchronizing, to automatically so adjust its angular position relative to the brush of the sending sunflower at the distant station that the two brushes will arrive upon corresponding segments simultaneously. The line switch 7 at the synchronizing end is then turned to the half-time position; the signaling current switch blade 42 shifted back to contact 44, connecting the source of signaling current at that end of the line, after which the synchronizing switch 84 at that end is turned to the half-time position. As soon as the operator at the end setting the speed perceives by the vibration of the main line relay tongue that the distant station switches are set for half-time operation, he in turn throws his switches 7 and 84 to the half-time positions, when the machines are ready for operation at half capacity. The artificial lines at the two ends are then adjusted to obtain a balance, during which time the line may be operated at a fraction of its full capacity as described. The operators at the two stations notify each other when a balance is obtained, and when this fact has been exchanged, line and synchronizing switches 7 and 84 at both stations are thrown to full on positions. If it is desired to test the balance at any time when the machines are operating at full capacity, the request for half-time operation is sent to the distant terminal and the switches are thrown to the half-time positions, the end synchronizing throwing its switches first so as not to disturb the synchronism.

It will be seen by a reference to Fig. 4, that when the line switch 7 is thrown to the full capacity position in which it is shown in said figure, the operators at all four keyboards 59, 60, 61 and 62 as well as all of the receivers operated by relays 64, 65, 66 and 67 may have use of the line. When, however, the switch 7 is thrown to the half time position, operators at keyboards 61 and 62 alone at a given station may use the line, and receivers operated by banks of relays 64 and 65 alone may receive. At the other station, during the half time operation, keyboards corresponding to keyboards 61 and 62 and receivers operated by relays corresponding to banks 66 and 67 are operative.

What I claim is:—

1. The method of operating a duplex telegraph line which consists in operating the line duplex at a fraction of its full capacity without the use of the artificial line, and adjusting the artificial line during such time.

2. The method of operating a duplex telegraph line which consists in operating the line duplex at a fraction of its full capacity without the use of the artificial line, adjusting the artificial line during such time, and then operating at full capacity after the balance is obtained.

3. The method of operating a duplex tele-

graph line which consists in operating the line in multiplex capacity at a fraction of its full capacity without the use of the artificial line, adjusting the artificial line during such time, and then operating the line at full capacity with the use of the artificial line after the balance is obtained.

4. The method of operating a duplex telegraph line which consists in operating the line in multiplex capacity at one-half its full capacity without the use of the artificial line, adjusting the artificial line during such time, and then operating the line at full capacity with the use of the artificial line after the balance is obtained.

5. The method of operating a duplex telegraph line which consists in operating the line duplex at a fraction of its full capacity, and during this time simultaneously adjusting the artificial lines at both ends to obtain a balance.

6. The method of operating a telegraph line supplied with a periodically varying signaling current which consists in dividing the impulses of this current into groups which are transmitted to the line intermittently and establishing between the groups thus sent out from one station and those sent out from a distant station a definite time interval, and from each station during a portion of the time only that the line is operative.

7. The method of operating a telegraph line supplied with a periodically varying signaling current which consists in dividing the impulses of this current into groups which are transmitted to the line intermittently and establishing between the groups thus sent out from one station and those sent out from a distant station a definite time interval so that the transmissions shall take place alternately, and from each station during a portion of the time only that the line is operative.

8. The method of operating synchronous telegraphs which consists in utilizing the same current for signaling and synchronizing and sending said current in the two directions over the line intermittently and at different times.

9. The combination with a telegraph line, of circuit connections for sending out signals from a given station a fraction of the time and receiving signals during a fraction of the time, said sending and receiving occurring intermittently and at different times, circuit connections for sending and receiving signals at said station all the time during the operation of the line, and means operative at will for rendering the line operative in either of said capacities.

10. The combination with a duplex telegraph line, of a main line transmitter and receiving relay at each end of said line, and automatic means to intermittently connect and disconnect the said transmitter and relay to and from each other at each station.

11. The combination with a telegraph line and a source of signaling current connected thereto at each of two stations, of automatic means at said stations to permit said current to be sent out to line from said stations intermittently and at alternate times from the two stations, and switching means operative at will to cause current to be sent to line continuously from both stations.

12. The combination with a duplex telegraph line, of a switch operative at will for changing the line from full capacity to a fraction of its full capacity, and an automatic circuit-changing device connected to said switch and adapted to time the transmission of signals over the line when said switch is thrown to the position in which the line is operated at a fraction of its full capacity so that signals in opposite directions may be sent intermittently and at different times only.

13. The combination with a duplex telegraph line, having a receiving relay and a transmitter connected therein, a circuit-changing device and a switch connected between said transmitter and receiving relay, said circuit-changing device in one position of said switch acting to connect the transmitter to the line through the receiving relay during half the time and to disconnect the transmitter from line during the remaining half of the time, the receiving relay during the latter half being connected to receive signals from a distant station.

14. The combination with a duplex telegraph line, of a balancing instrument to indicate the correct adjustment of the artificial line, and circuit connections and automatic means to render said instrument operative at such times only as current is not being received from the distant station.

15. The combination with a duplex telegraph line, of a balancing instrument to indicate the correct adjustment of the artificial line, and intermittently acting means to render said instrument operative when current is being sent out from the balancing station and to render said instrument inoperative when current is being received from a distant station.

16. The combination with a duplex telegraph line, of means for indicating a correct adjustment of the artificial line at a given station, comprising an instrument responsive to current from a distant station only and an instrument responsive to current sent out from the home station only.

17. The combination with a duplex telegraph line, of means for indicating a correct adjustment of the artificial line at a given station, a main line signal receiving relay, a second relay, and switching apparatus to render the said first relay operative only

by current from a distant station and the second relay operative only by current from the home station.

18. The combination with a telegraph line, of synchronizing apparatus at two stations in said line regulated primarily by the effect of the main line current, the synchronizing apparatus at one station being responsive only to current sent out from the distant station, and means for sending out said current intermittently and at such times only as current is not being received from the distant station.

19. The combination with a telegraph line, of a source of current connected thereto, synchronous apparatus regulated primarily by the effect of the current from said source, and means to render said synchronous device responsive to the synchronizing action of said current during half of the time of the operation of the line and intermittently.

20. The combination with a telegraph line, of a main line transmitter and relay, local transmitting means comprising a circuit-changing device for operating the transmitter, local receiving means comprising a circuit-changing device coöperating with the main line relay, a circuit-changing device whereby current may be sent to line through said transmitter only a part of the time and intermittently, a synchronous motor driving said circuit-changers, and synchronized primarily by the effect of the main line current, and a circuit-changing device and connections whereby said motor is synchronized by said current at such times only as current is being received at its station from a distant station, said times occurring intermittently.

21. The combination with a telegraph line, of a source of current connected thereto, synchronous apparatus regulated primarily by current from said source, and means to render said synchronous device responsive to the synchronizing action of part of said current during a portion of the time of the operation of the line and intermittently, and local compensating means operative during the rest of the time to maintain the synchronism.

22. The combination with a telegraph line, of means to operate said line in duplex capacity, means to automatically render the line operative for signals in opposite directions intermittently and at different times, and switching means operative at will to render operative either of the foregoing means.

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

LOUIS M. POTTS.

Witnesses:

HEYWARD E. BOYCE,

F. BURNS BLAKE.