(No Model.)

F. W. JONES.

DUPLEX TELEGRAPH.

No. 258,428. Patented May 23, 1882.

Fig 1.

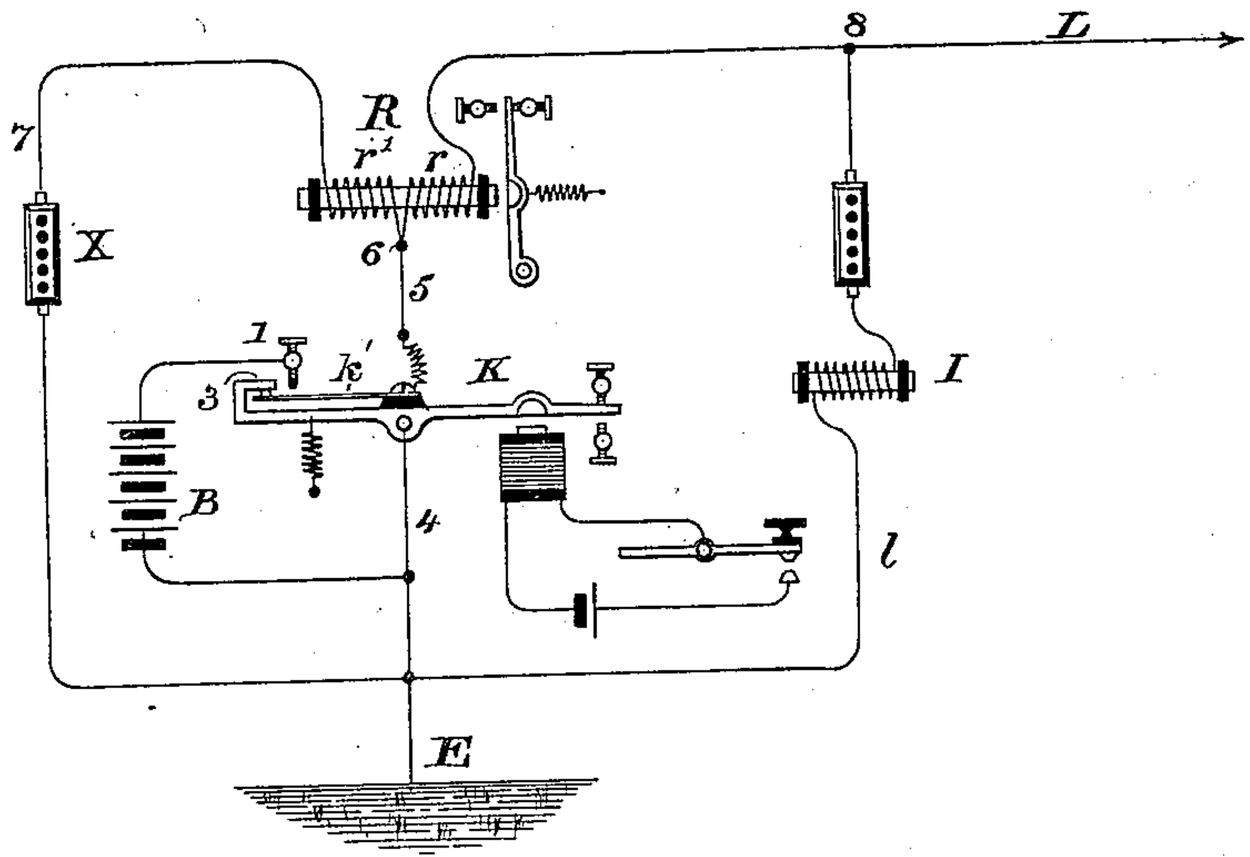
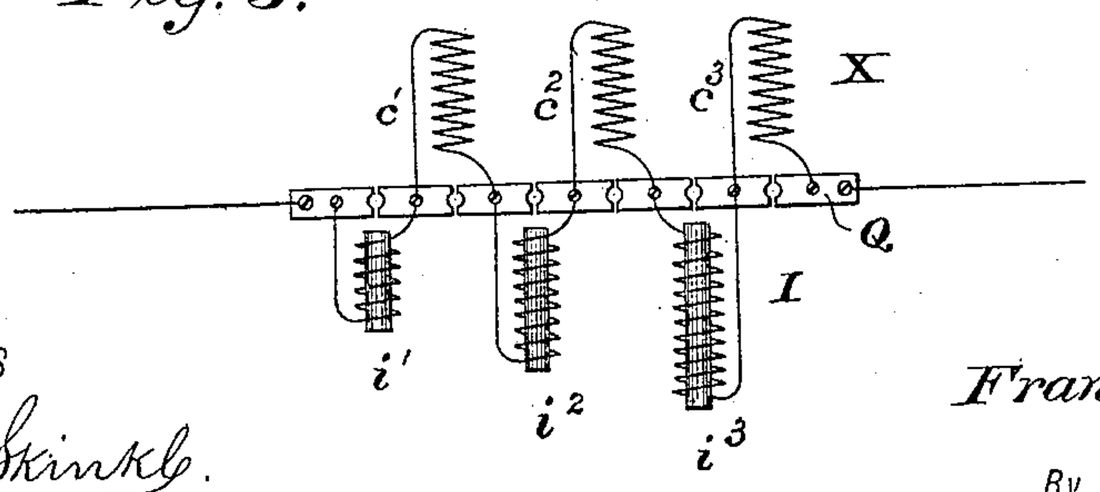


Fig 2.

Fig. 3.



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DUPLEX TELEGRAPH.

SPECIFICATION forming part of Letters Patent No. 258,428, dated May 23, 1882.

Application filed January 14, 1882. (No model.)

To all whom it may concern:

Be it known that I, FRANCIS W. JONES, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Duplex Telegraphs, of which the following is a specification.

My invention relates to that system of telegraphy in which two or more independent signals or series of signals are simultaneously transmitted in opposite directions over one and the same telegraphic conductor. In the practical operation of this system the correct reception of the signals from the distant station is more or less interfered with and obstructed by false signals which are produced upon the receiving-instrument at the home station by the momentary charges and discharges of static or induced electricity, which pass to and from the line at the instant a connection is established between the battery and the line and between the line and the earth by means of the key or transmitter. These effects are especially troublesome when the line (if it be a land line) is of considerable length and well insulated, and also when a submarine cable constitutes the whole or any considerable portion of the line.

In another pending application for Letters Patent I have described and claimed an organization of apparatus for neutralizing or destroying the injurious effects of static charge and discharge upon the apparatus at the home station, which consists essentially of a branch line returning directly to the earth at the home station, in combination with a battery, a key which, when actuated, connects said battery simultaneously to both the main and branch lines, a receiving-instrument wound with independent assisting-coils, one of which is included in the main and the other in the branch line, and an inductor or core of soft iron surrounded by a coil, which coil is included in said branch line.

In carrying out my present invention I dispense with the assisting-coil upon the receiving-magnet of the home instrument and attach the branch line directly to the main line, or, strictly speaking, at a point between the main line and the home receiving-instrument, by which means I am enabled to apply the method to any of the ordinary systems of duplex telegraphy heretofore in use without in any way modifying the apparatus.

My invention further consists in an improved construction of the electro-magnetic inductor which is placed in the branch line and employed to produce the compensating currents, whereby the intensity or electro-motive force of these currents as well as their length or duration may be adjusted with any required degree of accuracy to meet the different conditions arising in practical use.

In the accompanying drawings, Figure 1 is a diagram illustrating the application of my invention to a differential duplex apparatus of the usual construction. Fig. 2 represents the same when applied to a bridge duplex of the usual construction, and Fig. 3 is a diagram illustrating in detail the construction of the electro-magnetic inductor.

In the drawings, Fig. 1 represents the arrangement of circuits, batteries, and apparatus at one of the terminal stations of a duplex-telegraph line, the other terminal station being arranged in precisely the same manner in every respect. The home receiving-instrument R, which may be a relay, sounder, or other equivalent electro-magnetic instrument, is provided with two separate coils, r and r', each of which should contain the same number of convolutions of wire surrounding the core. These two independent coils (usually termed "differential coils") are connected in circuit in the manner shown in the figure, so that when electric currents of equal strength pass through the respective coils simultaneously they will traverse them in opposite directions, and hence will exert an equal and opposite magnetic influence upon the inclosed soft-iron core. Each will therefore neutralize the effect of the other, no magnetism will be induced in the core, and no attraction will be exerted by the core upon its armature. One pole of the main battery B is connected directly with the earth at E and the other pole with the contact-stop 1 of the key or transmitter K. The lever of the key K carries a contact-stop, 3, and is connected directly to the earth by the wire 4.

k' is an insulated contact-spring, mounted upon the lever K, and normally resting against the contact-stop 3. From the spring k' a wire,

5, proceeds to the point 6, where it divides into two branches, one branch going through the right-hand coil, *r*, of the home receiving-instrument R to the point 8, and thence by the main line L to the distant station, and the other branch going through the left-hand or compensating coil, *r'*, of the receiving-instrument, and thence directly back to the earth at E by the wire 7. It is well understood that by making the resistance in the respective branches which diverge from the point 6 as nearly equal to each other as possible a current can be transmitted over the line L to the distant station by the depression of the key or transmitter K without affecting the armature of the home receiving-instrument R. This equality of resistance in the respective circuits is effected in a well-known manner by means of an artificial resistance, X, in the wire 7, which is made equal to the resistance offered by the line, including that of the apparatus at the distant station. The circuit which branches off at the point 6 and returns by the way of 7 to the earth is usually termed the "artificial line," in order to conveniently distinguish it from the actual line L.

When the key or transmitter is depressed in order to transmit a signal and a contact is formed between the battery and the main and artificial lines, an unequal division of the outgoing current occurs during the first instant, which is due to the flow of what is termed the "charge" or "current of charge" into the line L in consequence of the electro-static or inductive capacity of the line, and which is not compensated by a similar flow of current into the artificial line 7, for the reason that this, being composed mainly of artificial resistances, has practically no static capacity. In consequence of this action—that is to say, the uncompensated action of the charging-current in the coil *r*—there is a momentary tendency to produce a false signal upon the home instrument R. On the other hand, at the termination of a transmitted signal, when the contact between the line and battery is interrupted at the point 1 and a contact formed directly with the earth at the point 3, another electrostatic current of discharge of momentary duration returns from the line, having a polarity or direction opposite to that of the outgoing current transmitted by the key. This discharge-current passes through the coil *r* of the receiving-instrument and produces, or tends to produce, another false signal.

The apparatus which I have devised in order to neutralize or destroy the effect of the currents of static charge and discharge upon the receiving-instrument at the home station will now be described.

It is well known that when a bar or mass of soft iron is surrounded by a helix it becomes magnetic when the said helix is traversed by an electric current; and it is furthermore known that the inductive action exercised by the several convolutions of such a helix upon each other tends to set up a current of contrary direction, which tendency is assisted by the magneto-electric action of the soft iron upon the helix during the process of magnetization. The moment, however, that the current ceases or is interrupted the disappearance of the magnetism which has been induced in the iron produces a powerful magneto-electric current in the same direction, or, in other words, of the same polarity as the original exciting-current, and which traverses the circuit of which the helix forms a part in the same direction as did that current. Thus the action of a mass of soft iron and its enveloping helix upon the electrical condition of the circuit of which said helix forms a part is to lengthen the time which is necessary either to establish or to interrupt a current that is to oppose and retard change of any nature. Hence it is obvious that if an electro-magnetic inductor of this character be placed in the circuit of a branch line, *l*, which extends from a point, 8, between the home receiving-instrument and the line, directly to the earth at the home station, when a current is transmitted to the line by the depression of the key K it will divide at the point 8, and a portion thereof will return directly to earth through the branch line *l*. It will nevertheless be understood from the explanation hereinbefore given that the current in said branch will not be established at the instant the connection with the battery is formed by the key K; nor, on the other hand, will it disappear instantly when the same is interrupted, but will be prolonged for a determinate period. The effect of this action upon the duplex apparatus is as follows: Let it be assumed that the resistance of the branch *l* is by artificial means made twice as great as that of the main line L, extending to the distant station. The joint resistance of the lines L and *l* will in such case necessarily be less than that of the line L alone. Hence, in order to render the home receiving-instrument R neutral to outgoing currents, it becomes necessary to reduce the resistance of the artificial line 7 by adjusting the rheostat X until it is equal to the joint resistance of the lines L and *l*. If, now, the key K is depressed, as for the transmission of a signal, and a connection established between the battery B and the wire 5, a current of charge tends to flow into the line L only, for the reason that its electro-static capacity is very great, while that of the artificial line 7 is practically null, while at the same time the portion of the current which tends to flow into the branch line *l* is opposed by the magnetic inertia of the inductor I. Hence at the instant the current commences to flow the branch *l* offers more than its normal resistance, while the line L offers less than its normal resistance. Nevertheless the normal joint resistance of both is not materially altered, by reason of which an equal, or nearly equal, division of the current takes place between the opposing coils *r* and *r'* of the home receiving-instrument R, and the inequality in any event is not

sufficient to produce a false signal. When, on the other hand, the battery B is detached from the line at the key K and the line connected directly with the earth, a discharge-current momentarily flows, or tends to flow, from the line L to the earth through the coil *r* of the home receiving-instrument, the polarity of which discharge is opposite to that of the outgoing current. At the same instant an electric discharge takes place from the electro-magnetic inductor I through the branch *l*, which has the same direction as the outgoing current. Hence it meets the discharge-current from the line at the point 8 and destroys it or neutralizes it to such an extent that it is unable to affect the receiving-instrument R.

It is well known that the amount of the static accumulation upon a given telegraph-line is not uniform, but, on the contrary, varies at different times in consequence of changes in the insulation of the conductor; and therefore the force and duration of the discharge-current will be greater at some times than at others. The actual resistance of the line itself as presented to the battery at the home station also varies from time to time, but not always in proportion to the variation in the static charge. Hence it becomes essential, in order to adapt the apparatus to different atmospheric and other conditions, there should be means provided whereby the resistance of the branch line *l* and the force and duration of the discharge from the electro-magnetic inductor may be regulated independently of each other. In order to accomplish this result, I prefer to construct the inductor substantially in the manner shown in the diagram Fig. 3, in which the total resistance is made up of a series of graduated artificial resistances, of which a greater or less number may be placed in circuit at pleasure. In the drawings I have shown three such, for the sake of illustration; but I remark that any required number, either greater or less, may be used, as circumstances require. I prefer, also, to construct the electro-magnetic inductor I in several sections, three of which are shown in the diagram Fig. 3. The sections are composed of soft-iron cores of different lengths, as shown at i', i^2, and i^3. By means of a peg-commutator, Q, of well-known construction, any one or more of these inductor-sections may be placed in circuit at pleasure, the length or duration of the charge or discharge depending upon the length of the particular iron core in circuit, i' being the shortest, and consequently charging and discharging with the greatest rapidity, while i^3 is the longest and requires the longest time for its charge and discharge. In like manner the force or intensity of the discharge may be independently regulated by including a greater or less number of the artificial resistances c', c^2, and c^3 in the circuit. It is obvious that the capacity of the several inductor-sections and resistances may be graduated or graded with reference to each other so that any required combination may be effected, and that the number of sections may be increased to suit circumstances.

The application of my improved organization to the bridge form of duplex is shown in Fig. 2. The operation of it in this case being precisely similar to that hereinbefore described in connection with the differential duplex, it need not be repeated, as the action of the device is unaffected by the particular form of receiving-instrument employed.

It is obvious that the hereinbefore-described method and apparatus for testing the static charge and discharge currents is equally applicable to any other system of duplex telegraphy, whether employed on land lines or on long submarine cables, the only modification necessary being to employ a greater number of inductor-sections having cores of various sizes and wound with a greater or less number of convolutions of wire, and being provided with artificial resistances so graduated as to admit of an approximately exact compensation of the electro-static charge and discharge from the cable.

I claim as my invention—

1. The combination, substantially as hereinbefore set forth, of a main line, an artificial line, a main battery, a key or transmitter which connects said battery simultaneously to said main and artificial lines, a receiving-instrument upon which the outgoing currents upon the main and artificial lines produce equal and opposite effects, a branch line extending from a point between the main line and the receiving-instrument to the earth, and an electro-magnetic inductor included in said branch line.

2. The combination, substantially as hereinbefore set forth, of a main line, an artificial line, a main battery, a key or transmitter which connects said battery simultaneously to said main and artificial lines, a receiving-instrument upon which the outgoing currents upon the main and artificial lines produce equal and opposite effects, a branch line extending from a point between the main line and the receiving-instrument to the earth, an electro-magnetic inductor included in said branch line, and means for varying the normal electrical resistance of said branch line.

3. The combination, substantially as hereinbefore set forth, of a main line, an artificial line, a main battery, a key or transmitter which connects said battery simultaneously to said main and artificial lines, a receiving-instrument upon which the outgoing currents upon the main and artificial lines produce equal and opposite effects, a branch line extending from a point between the main line and the receiving-instrument to the earth, an electro-magnet included in said branch line, and means for varying the intensity of force of the electric discharge from said inductor.

4. The combination, substantially as hereinbefore set forth, of a main line, an artificial line, a main battery, a key or transmitter which

connects said battery simultaneously to said main and artificial lines, a receiving-instrument upon which the outgoing currents upon the main and artificial lines produce equal and opposite effects, a branch line extending from a point between the main line and the receiving-instrument to the earth, an electro-magnetic inductor included in the branch line, and means for varying the length or duration of the electric discharge from said inductor.

5. In a duplex telegraph, the combination, substantially as hereinbefore set forth, of a main line extending to the distant station, an artificial equating-line returning directly to the earth at the home station, having a resistance less than that of the main line, and a branch line extending from a point between the main line and the receiving-instrument to the earth, having a resistance greater than that of the main line.

In testimony whereof I have hereunto subscribed my name this 30th day of December, A. D. 1881.

FRANCIS W. JONES.

Witnesses:
MILLER C. EARL,
CHARLES A. TERRY.