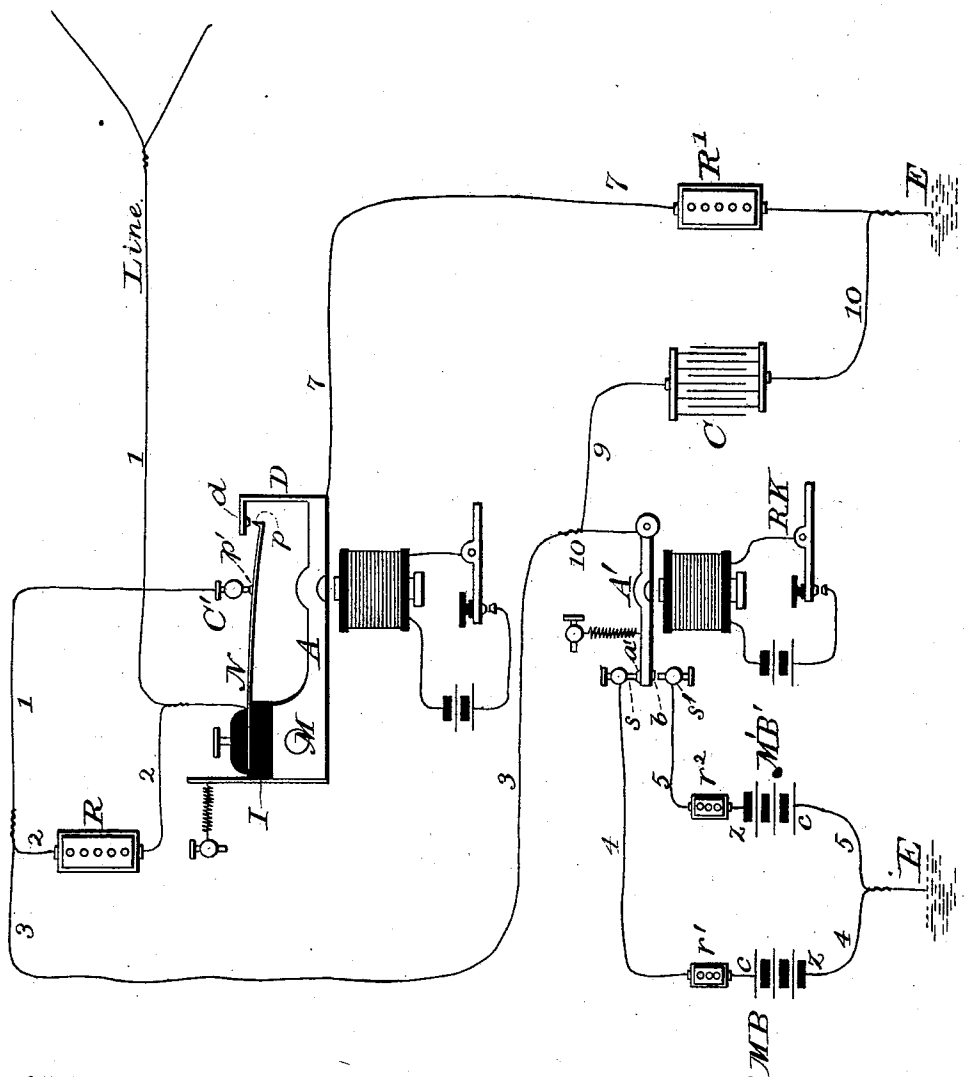
(No Model.)

S. D. FIELD.

QUADRUPLEX TELEGRAPH.

No. 243,698. Patented July 5, 1881.



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QUADRUPLEX TELEGRAPH.

SPECIFICATION forming part of Letters Patent No. 243,698, dated July 5, 1881.

Application filed December 18, 1880. (No model.)

To all whom it may concern:

Be it known that I, STEPHEN D. FIELD, of the city, county, and State of New York, have invented a new and useful improvement appertaining to the art of quadruplex telegraphy, of which the following is a specification, reference being had to the accompanying drawing, forming a part hereof.

Duplex transmission, or the simultaneous transmission of two messages in the same direction upon a single wire, is ordinarily effected by sending one set of signals by means of changes in tension of current independent of changes of polarity, while the second set of signals is transmitted by changes of polarity irrespective of strength of current.

My invention has for its object the sending of one set of signals by changes of tension of current sent to line irrespective of polarity through the agency of means to be fully hereinafter described, whereby the normal or maximum currents having their origin in a generator of a single and constant electro-motive force sent over a line in its natural condition may be partially dissipated and weakened to any desired amount by inserting in the main line an artificial resistance, and in connecting to said main line at the same time a leak-branch having an artificial resistance bearing a certain proportion to the said artificial main-line resistance.

In sending signals by changes in strength of current, where at the same time signals are sent by changes of polarity upon the same line, the maximum and minimum strengths are, relatively, about as 4 to 1, though under varying conditions other proportions, as 3 to 1 or 2 to 1, might be adopted; therefore, to partially dissipate the maximum strength of current, say 4, which would be sent over the main line to a distant station if the artificial main-line resistance were out of the main line, and the leak-branch were disconnected therefrom, I establish a certain relation between the artificial main-line resistance and the resistance of the leak-branch; and the proportions of these resistances may be varied to effect any desired degree of dissipation of currents sent to a distant station, or from a maximum of 4 to any desired minimum strength, say 1. But where, in addition to the two messages simultaneously sent over a single line from the home station, two messages are at the same time sent from a distant to the home station over the same wire, other conditions arise.

It is well understood in duplex telegraphy that the resistance of the main line or circuit must be maintained substantially constant; therefore the artificial main-line resistance and the leak-branch resistance must not be proportioned merely and solely to the end of effecting a desired change in strength of current sent from the home station over the main line, but the artificial main-line resistance and the leak-branch resistance must, if it is desired to send at the same time two messages from a distant station, be so proportioned that the main-line resistance shall be the same in respect to incoming currents from a distant station, both when the artificial main-line resistance is out of circuit and the leak branch is disconnected therefrom, and when the artificial main-line resistance is inserted in line and the leak-branch is connected thereto. The insertion in line of the artificial main-line resistance and the simultaneous connection to line of the leak-branch performs the definite function of changing the strength of current sent to line, to a predetermined amount, from an associated generator, by first breaking down the strength of current by the insertion of the artificial main-line resistance, and, second, by partially short-circuiting the said generator from the main line by way of the leak-branch; and my invention broadly embraces the combination of devices capable of performing such useful functions; and, as a second feature, it embraces the devices not only capable of effecting such results, but so arranged and proportioned as not to affect or change the main-line resistance to incoming currents from a distant station.

Heretofore others have attempted to transmit signals by changes in strength of current from a generator of one and a constant electro-motive force by two different methods: first, by inserting in the main line a very large resistance; second, by partially short-circuiting the gene-

rator from the main line through a leak-branch. The first method, however, is found defective, from the fact that as the home operator inserts resistances to change the strength of currents sent to distant stations he at the same time causes a change of line resistance in respect to incoming currents from a distant station, and consequently a mutilation of signals sent from a distant station upon the receiving-instrument of the home station. The second method is found to be no less defective, as by partially short-circuiting the home generator the main-line resistance in respect to incoming currents or signals from a distant station is changed, whereby the act of transmitting at a station causes mutilation of signals there received from a distant station.

If a leak-branch alone be employed to partially short-circuit a generator to effect sufficient changes in current strength the resistance of the leak-branch must be very low to effect any considerable variation in strengths sent to line; but if such leak resistance be made sufficiently low to effect a change from strength of current 4 to 1, not only will the resistance of the main line in respect to incoming currents be injuriously varied, but the generator so short-circuited by the leak-branch of low resistance will be so far short-circuited as to cause serious burning effects. A leak-branch whose resistance is sufficiently great to avoid burning from short-circuiting, and at the same time not to cause an injurious change of main-line resistance in respect to incoming currents, will be found inadequate to effect a change in current strength sufficient to effect the transmission of signals.

My invention, as above stated, involves the use of both an artifical main-line resistance and a leak-branch, and by means of this combination I accomplish, perfectly, results only defectively effected through the use of either separately.

To more fully explain my invention I will refer to the accompanying drawing.

A is an ordinary continuity-preserving key, which, in its normal position, serves to establish a short circuit for the main line around resistance R. When key A is depressed the normal short circuit around R is broken, thereby leaving the main-line circuit complete only through R. The depression of key A simultaneously, as it breaks the short circuit around R, connects to the main line the leak-branch 7, having resistance R′, which is connected to earth. When resistance R is short circuited and the leak-branch 7 is disconnected from the main line the whole current of the generator is concentrated upon the main line, and a current strength of 4 may be assumed to pass to a distant station; but when resistance R is inserted in line and the leak-branch 7 is connected thereto the main-line resistance is increased by the insertion of R, which of itself diminishes the strength of main-line current, while simultaneously the generator is in a measure short-circuited from the main line over the leak-branch 7, and the current of the generator which is first weakened by the insertion of resistance R in the main line is then distributed both upon the main line and the leak-branch or short circuit, and that portion of current passing to line which is not diverted by the leak-branch may, in respect to strength, be made to bear any desired proportion to the current when R is short-circuited and branch 7 is connected from line. The mere insertion of resistance R, if not sufficient to cause the movement of a distant relay, would so change the resistance of the main line, and therefore the strength of current thereon from a generator of uniform electromotive force, as to effect receiving-instruments upon the line. Thus it is obvious that the operator at the home station, without means of compensation by the operation of his own transmitting-key, would so vary the resistance of the line to incoming currents as to mutilate signals sent to line from a distant station. It is therefore necessary that the insertion of a resistance in the main line which will vary the entire main-line resistance be accompanied by the connection of a leak or local branch thereto, whereby upon the insertion of the resistance R, which increases the main-line resistance, the leak or local branch may be simultaneously connected to decrease the resistance to incoming currents to an amount sufficient for compensation, or to maintain uniformity of main-line resistance to incoming main-line currents.

If the local or leak circuit 7 7, having a resistance, R′, is connected to the main line at the same time that resistance R is inserted therein, and a proper proportion in respect to resistances of R, R′, M, B, r', or M′, B′, and r^2 is established, currents from a distant station, in passing to earth at the home station, will encounter the same resistance as when R is not in the main line, and the leak-branch having resistance R′ is disconnected therefrom.

A′ represents an ordinary pole-changing key, by means of which one operator may send signals by reversals of current independently of changes of strength, while a second operator is sending signals over the same wire by key A by changes in tension, and independently of polarity. Key A′, when on its back stop, connects the main line with battery M B, and when on its front contact the main line is connected to battery M′ B′. M B and M′ B′ respectively present copper and zinc poles to line and zinc and copper poles to earth.

For the purpose of illustrating my invention, it is obvious that the pole-changing key and the two batteries could be dispensed with by substituting a single generator connected to earth and to wire 3.

When key A is in its normal position and on its back stop a current passes from a distant station to earth at the home station over 1, N, p', 1, 3; but when A is depressed to front

contact p' and C′ are separated, and currents from a distant station pass to earth at the home station, both over 2, R, 2, 3, and over N, D, 7 through R′.

The fragmentary main-line resistance between R and the earth consists, alternately, first, of 3, key A′, 4, r', M, B 4; and, second, of 3, key A′, 5, r^2, M′ B′, 5, and is, for convenience, designated as fragmentary main-line resistance a.

s and s' are fixed anvils, and a' b hammers attached to key-armature A′.

r' and r^2 are resistances sufficiently great to prevent sparking and burning at the key-contacts of both A and A′.

The main-line resistance between key A and the earth, when resistance R is short-circuited and leak-branch 7 is disconnected, is equal to a. Also, when resistance R is directly in the main line and the branch 7 is connected thereto the resistance to earth from key A to incoming main-line currents remains unchanged and equal to a, the resistances R and R′ being so proportioned that the joint resistance of the two branches, one having the combined resistance of a and R and the other having a resistance, R′, shall be equal to a. Therefore, whatever be the position of key A, the main-line resistance to incoming currents will remain constant.

The resistance of the system in respect to outgoing currents from M B or M′ B′ will be changed with each movement of key A. When key A is upon its back stop, as shown in the drawing, the resistance offered to outgoing currents is equal to resistance a and the whole main line resistance between key A of the home station and the earth at the distant station; but when key A is closed on its front stop the resistance R is thrown directly into the main-line circuit, while at the same time leak-branch 7 is connected thereto. Under such circumstances the resistance offered to outgoing currents from either M B or M′ B′ is the resistance of a and R added to the joint resistance of the two branches—one, the main-line from key A to earth at a distant station, the other, leak-branch 7, having resistance R′. The aggregate resistance, consisting of a R, and the joint resistance of the main line and leak-branch 7, differs widely from the aggregate resistance of a and that of the main line from key A to the earth of the distant station.

From the above description it will be observed that the main-line and station instruments at any one station offer a constant resistance to incoming currents from a distant station, but a variable resistance to all outgoing currents from the home station. However, while the resistance is changed in respect to outgoing currents, which of itself will tend to cause a change in strength of current, the strength of line-current is also greatly decreased, from the fact that a large proportion which would otherwise pass to line is diverted over leak-branch 7.

In effecting a general solution for values of R and R′, which may be adopted in different cases, I let n designate the ratio of the weak current to the strong—*e. g.*, if it be desired that the weak and strong currents shall be relatively as 1 to 4, n would equal one-fourth, or, if relatively as 1 to 3, n would equal one-third. On establishing general equations so conditioned that such values of R and R′ shall be obtained as will enable any desired change in current strength sent to line—*e. g.*, from 4 to 1 or 3 to 1, as the case may require, and also that the resistance in respect to incoming currents may remain constant, the values of resistances R and R′ in ohms is found in terms of the fragmentary main-line resistance a in ohms and the ratio n, which is numerically expressed as one-fourth, one-third, or other quantity. The values of R and R′ which will fulfill the above specified conditions are $R=a\left(\frac{1-n}{n}\right)$ $R'=\left(\frac{a}{1-n}\right)$.

In ordinary cases the fragmentary main-line-resistance a is substantially equal to the internal resistance of the generator added to the spark resistance r' or r^2, which may be assumed to equal 500 ohms, and it is desired generally that the weak current sent to line shall equal in tension one-fourth the strength of the strong current; wherefore n is equal to one-fourth. The value of R therefore equals 500 ohms $\times\left(\frac{1-\frac{1}{4}}{\frac{1}{4}}\right)$, or 1,500 ohms. The value of R′ equals $\frac{500 \text{ ohms}}{1-\frac{1}{4}}$, or $666\frac{2}{3}$ ohms.

In like manner, if a equal 1,000 ohms, and n is equal to one-half, R and R′ will equal 1,000 ohms and 2,000 ohms respectively.

It will be observed that the values of R and R′ are procured without reference to the resistance of the main line between key A of the home station and the earth at the distant station.

By assuming the values of a and n, values are procured for R and R′ which may be adopted upon a line either of 10 ohms, 1,000 ohms, or other resistance without violating the essential prerequisites of the system—viz., that a proper change in current strength upon the main line shall be effected and that the resistance to incoming currents shall remain unchanged.

If it be desired to render the resistance of the system at the home station constant to incoming currents without at the same time effecting any predetermined change in strength of current sent from the home station, many different values for R and R′ may be assumed; any desired value for R may be assumed, and a corresponding value for R′ can be determined; but if it be desired to effect a predetermined change in strength of current sent to line from the home station, only one value of R fulfilling the physical conditions of the case will be found if values of a and n are unchanged; also there can be but one amount of resistance for R′.

It is also to be noticed that many different values may be assumed for R, and correspond-

ing ones computed for R′, if it is desired only to effect a predetermined change in strength of current sent to line from the home generator without at the same time maintaining the resistance at the home-station constant to incoming currents from a distant station.

My invention is applicable to any species of telegraphic transmission in which signals are transmitted by changes in strength of current, and also for the purpose of dissipating or breaking down a current from a generator whose electro-motive force is comparatively too great to provide a line of little resistance with a sufficiently weak or modified strength of current.

What I claim, and desire to secure by Letters Patent, is—

1. In a telegraphic system for simultaneous transmission, a resistance at each station which may be placed in or taken out of the main-line circuit, in combination with a leak-branch circuit which is joined to and disconnected from the main line simultaneously as the said resistance is inserted in or removed from the main line, the whole being so arranged that the equilibrium of the main-line-circuit resistance in respect to currents sent from a distant station shall not be disturbed.

2. At a station on a telegraph-line, the combination of an electrical generator for charging said main line, and artificial main-line resistance, and a leak or local branch having an artificial resistance, the said artificial main-line and leak resistances being proportioned substantially as specified, whereby the currents sent from the generator are partially and to any desired extent dissipated by being first rendered weak through the agency of the artificial main-line resistance, and, second, by partially short-circuiting the generator from the main line through the leak-branch.

3. The combination of an artificial main-line resistance, a leak-branch having a resistance, and means at each station whereby the main-line resistance is placed in and out of the main line as the leak-branch line is connected to and disconnected from said main line, substantially as specified.

4. The combination of the fragmentary main-line resistance *a*, artificial main-line resistance R, and local or leak branch having resistance R′, the said resistances being so proportioned that the main-line resistance at the home station shall be the same in respect to currents sent from a distant station, both when the main-line resistance is in line and the leak-branch is connected thereto, and when the main-line resistance is out of the main line and the local branch is disconnected therefrom.

5. The combination of the fragmentary main-line resistance *a*, artificial main-line resistance R, and leak or local branch having resistance R′, the said resistances being so proportioned that the strength of current sent to line from the home station, when resistance R is in line, and local branch, having resistance R′, is connected thereto, shall bear a certain relation to the strength of current sent to line when resistance R is out of the main line and the local branch is disconnected therefrom, substantially as specified.

6. The combination of the fragmentary main-line resistance *a*, artificial main-line resistance R, and local or leak branch having resistance R′, the said resistances being so proportioned that the strength of current sent to line from a home station when resistance R is in the main-line and the local or leak branch is connected thereto, shall bear a certain proportion to the current strength sent to line when resistance R is out of line and the local or leak branch is disconnected therefrom, and also so proportioned that the resistance to currents from a distant station shall be the same, both when resistance R is in circuit and local or leak branch is connected thereto, and when resistance R is out of circuit and local branch having resistance R′ is disconnected therefrom, substantially as specified.

7. In a telegraphic system, the method of varying the strength of currents which are sent to line for the purpose of effecting telegraphic transmission, which consists in inserting in the line a resistance normally out of the line, and at the same time of partially short-circuiting the generator, as specified.

8. A telegraph-circuit joining two stations, in combination with station-instruments at each station, the electrical resistance of said circuit and instruments at any one station being constant in respect to currents from a distant station, but subject to variation in respect to currents sent from the home station, substantially as set forth.

In testimony whereof I have hereunto subscribed my name this 10th day of November, A. D. 1880.

STEPHEN DUDLEY FIELD.

Witnesses:
SILAS R. GRAMMER,
WM. ARNOUX.