(No Model.)

J. J. CARTY.

ELECTRIC CIRCUIT.

No. 399,377. Patented Mar. 12, 1889.

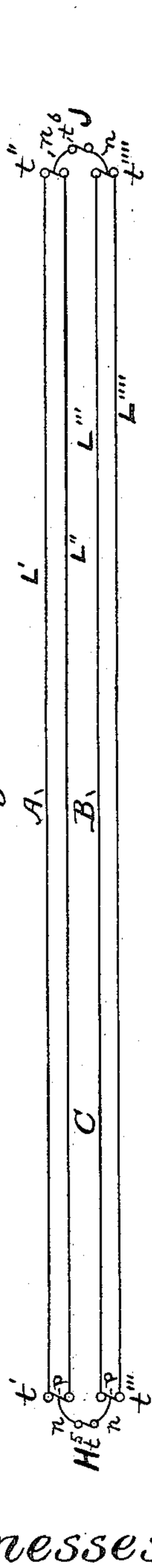

Fig. 1.

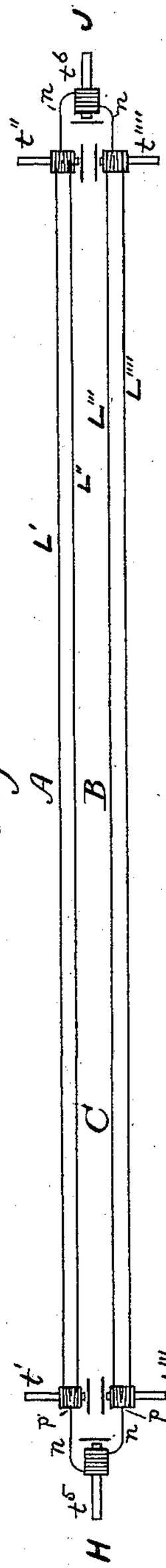

Fig. 2.

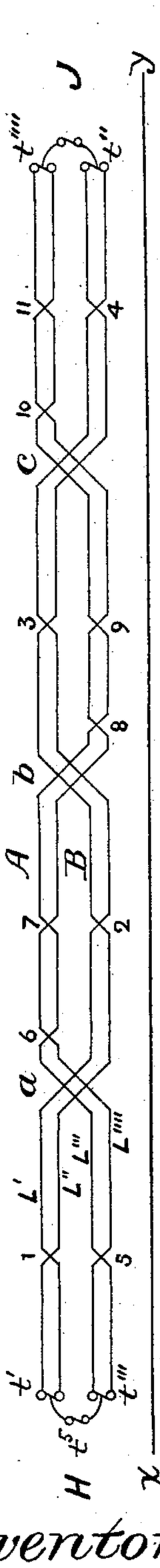

Fig. 3.

Witnesses.

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UNITED STATES PATENT OFFICE.

JOHN J. CARTY, OF NEW YORK, N. Y., ASSIGNOR TO THE AMERICAN BELL TELEPHONE COMPANY, OF BOSTON, MASSACHUSETTS.

ELECTRIC CIRCUIT.

SPECIFICATION forming part of Letters Patent No. 399,377, dated March 12, 1889.

Application filed January 23, 1889. Serial No. 297,270. (No model.)

To all whom it may concern:

Be it known that I, JOHN J. CARTY, a citizen of the United States, residing in New York, in the county and State of New York, have invented certain new and useful Improvements in Electric Circuits, of which the following is a specification.

The inventiou relates to certain improvements in the construction of telegraph or telephone lines. Its primary objects are to provide means for preventing, in so far as is possible, the detrimental effects occasioned by induction and to decrease the resistance of long circuits.

It has been customary to twist the outgoing and return wires of metallic circuits about each other for the purpose, as shown in Letters Patent issued to David Brooks, February 22, 1881, No. 238,195, of placing each wire in the same relation to external single-wire circuits, so that whatever effect may be developed inductively by such circuits upon the outgoing conductor will be exactly neutralized by an equal but oppositely-acting effect upon and in the return-conductor. In a patent issued to me August 31, 1886, No. 348,512, there is described a system in which two conductors are employed in place of a single main line for operating apparatus by currents transmitted upon both lines, and in a pending application, Serial No. 218,029, I have described certain modifications of such a system. The present invention is designed to be employed in connection with such an arrangement of circuits, and in general terms it provides that the two wires of a single pair twisted, transposed, or crossed with one another symmetrically, so as to be neutral to a similar metallic circuit adjacent thereto, may in turn constitute one side of an independent circuit of which the other side is formed of the two wires of a second pair, and that when so arranged the two pairs of wires forming the said independent circuit shall also be crossed or caused to change places with one another in a manner analogous to the crossings of the two wires of each of the said two pairs, for the purpose of maintaining neutrality between the said independent compound circuit and an adjacent external circuit. These circuits so formed and transposed may either be strung upon poles, or, the wires of each pair being twisted together, the circuits may in a manner well understood be formed into a cable. The proper crossings of the two members of the compound circuit being made at convenient distances apart, the initial transpositions between the two wires of each of the first pairs are in cables unnecessary, the twisting of the said two wires together serving in lieu thereof.

In the accompanying drawings, Figure 1 is a diagram illustrating the construction of a compound circuit constructed in accordance with this invention. Fig. 2 shows a similar circuit in which the instruments and their relative positions in the circuit are more clearly indicated, and Fig. 3 shows a compound metallic circuit in inductive proximity to an external circuit illustrative of the mode in which reciprocal neutrality is effectuated between such circuits by my invention.

Referring to Figs. 1 and 2, A and B represent main metallic circuits of a telephonic system, L′ L″ being respectively the two wires of one circuit, while L‴ and L⁗ represent the two wires of another. These may be joined up, as shown, to form a third metallic circuit, C, extending between terminal stations H and J, of which A forms one conductor and B the other. Each of the original circuits A and B is provided with electrical transmitting and receiving instruments *t′*, *t″*, *t‴*, and *t⁗*, the said instruments being respectively included in their several circuits in the usual way, *t′* working reciprocally with *t″* in circuit A, and *t‴* with *t⁗* in circuit B.

The several instruments *t* connected with the initial circuits are shown in Fig. 2 as magneto-telephones, each provided with two separate coils, and these coils are so connected with respect to one another that the currents traversing the receiving-instrument coils of the circuits A and B, in their individual sense, re-enforce each other in the coils of their respective instruments. It will, however, be observed that the conducting-links *n*, which at the stations H and J unite the two circuits A and B to form the third and compound circuit, connect with the said circuits A and B at a point between the two coils of the several instruments *t′ t″* and *t‴ t⁗*; or, if there

be but one continuous coil to the said instruments, the ends of the said link *n* would connect with points *p* at the center thereof. Considering now the circuit C as a whole, it will be seen that it also is provided with communicating-instruments t^5 t^6, shown also as magneto-telephones, which may be and preferably are included in the connecting-links *n* which unite the two initial circuits to form the third.

The currents from the instrument t^5 serve to operate the instrument t^6, and, conversely, t^5 is responsive to t^6; but the currents from these instruments do not operate the instruments t', t'', t''', or t'''', because the two lines of the circuit A constitute one side, while the two lines of B constitute the other side, of the circuit traversed by the currents developed by t^5 or t^6, and thus the instruments t^5 or t^6, when operated, develop at any given time currents in the same direction in the line L′ and L″, but in opposite direction thereto, in the lines L‴ and L⁗. While, therefore, these currents combine to operate their respective receivers t^6 or t^5, as the case may be, they are adapted to exercise equal and opposing effects in the coils of the instruments t' t'' and t''' t'''' interposed directly in the respective circuits A and B, these being necessarily, therefore, irresponsive.

To sum up: The instruments t' and t'' are reciprocally responsive to one another, their currents circulating in the two wires L′ and L″ of the metallic circuit A only. So, also, instruments t''' and t'''' are reciprocally responsive to one another and in the same way serve their circuit B exclusively, their currents traversing in one direction the line L‴ and in the other the line L⁗, and in like manner the instruments t^5 and t^6 reciprocally operate each other exclusively in the compound circuit C, their currents traversing the two wires of the elemental circuit A in one direction and returning by way of the two wires of the other elemental circuit, B.

Referring now to Fig. 3, which shows the essence of my invention, the former figures being largely of an explanatory character, a description will be given of the construction of the elemental and composite metallic circuits with reference to any external conductor, whereby inductive neutrality is maintained between the said metallic circuits and the said external conductor and between the said several metallic circuits themselves. In the figure *xy* represent an external circuit, adjacent, however, and within inductive proximity to the compound circuit C and its elements A and B. In a manner well understood, the two wires of the elemental circuits A and B are each crossed with one another or exchange places at suitable points, so as to achieve neutrality between each of the said metallic circuits and the foreign circuit *xy*, the wires L′ and L″ of A being crossed at points 1, 2, 3, and 4, and those of circuit B being crossed at points 5, 7, 9, and 11. It is, however, also known that if the circuits A and B be crossed in the same manner as each other, while it is true that both are rendered neutral with respect to the external circuit *xy*, their inductive influence upon each other remains undiminished. Care therefore must be taken to prevent this. To this end, in addition to crossing the two wires of each of the two circuits A and B at like points and at regular distances, the wires of one of the circuits—in this instance B—are also crossed with one another or exchange places at intermediate points, and thus interference between the two elemental metallic circuits A and B is prevented. The same method of transposition is employed when the four wires are used in forming the third circuit C, using the conductors L′ and L″ as one side and L‴ and L⁗ as the other, as it will be seen that the pairs of wires are so crossed at *a*, *b*, and *c* and their positions so changed relative to each other that any external conductor or circuit, as *xy*, is under the influence of equal lengths of both sides of the circuit, and reciprocally exerts its influence equally on both sides A B of the circuit, setting up at the same time induced currents of like direction in both sides, which oppose one another and have a *nil* effect on the instruments in the said circuit.

The cross-connecting can be done either at intermediate stations or on the poles, or in the case of subterranean lines at suitable test-boxes.

It is not always necessary that the cross-connecting should be continued throughout the entire lengths of the line, but only in those positions where the induction is most troublesome. Again, the lengths of the sections and the frequency of the cross-connecting need not be the same in all of the lines, but may be changed to suit the varying conditions of different systems. The system is of course not limited to four lines, but may be extended as desired. The invention is particularly applicable to cables in which multiple arrangements of conductors are to be made, and where, owing to the proximity of the conductors to each other, the effects of induction tend to be emphasized.

The conductors may be formed into a cable and caused to assume the positions toward each other which have been described by dividing the cable into sections and cross-connecting; but the wires may be twisted or grouped together in any well-known manner, provided that the outgoing and return members of all of the circuits, whether the said members be elemental or compound, as herein described, shall be so arranged that any of the circuits composed of them in the said group may be brought under the influence of equal lengths of the two sides of any other given circuit, as set forth. In this invention the fact that multiple telephone-circuits, or metallic circuits in which each side thereof is composed of the outgoing and return wires of

one or more complete metallic circuits, for the purpose of multiplying the number of messages which can be transmitted simultaneously over a given number of wires, or for the purpose of reducing circuit-resistance, require equally with simple metallic circuits to be made neutral with respect to external circuits, is fully recognized, and a mode is devised for accomplishing the said neutralization, for it is evident that by the construction shown and described four wires are arranged so as to constitute three independent circuits, in which A is formed of the two wires L′ and L″, B of the two wires L‴ and L⁗, and C of the circuits A and B, each treated as a single conductor, and that not only are A and B both made neutral to an external conductor, *xy*, by proper cross-connections of their respective outgoing and return wires, and made neutral to one another by intermediate crossings of the two wires of one of them, but the compound circuit C is also made neutral to the said external circuit by cross-connecting the two pairs of wires A and B forming its sides.

I claim as my invention—

1. In a telephone system an electrical circuit consisting of two pairs of main lines, the lines composing each pair being transposed at intervals, and said pairs being transposed at intervals.

2. An electrical circuit or system of circuits consisting of two pairs of main lines, the outgoing and return conductors of each pair being transposed at intervals, and said pairs being transposed at intervals, in combination with electrical instruments for producing currents in each pair and an electrical instrument for producing currents in all of the lines, substantially as described.

In testimony whereof I have hereunto subscribed my name this 22d day of January, A. D. 1889.

JOHN J. CARTY.

Witnesses:
DANL. W. EDGECOMB,
CAROLINE E. DAVIDSON.