A. G. BELL.
Telephone-Circuit.

No. 220,791. Patented Oct. 21, 1879.

Fig. 1.

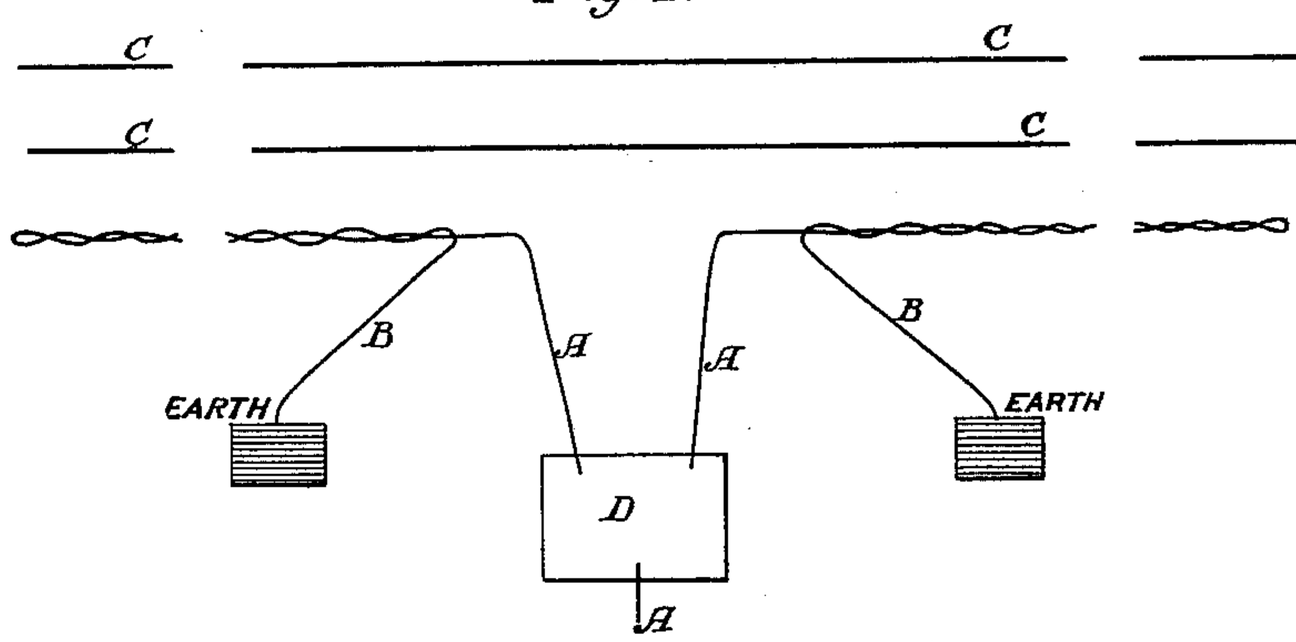


Fig. 2.

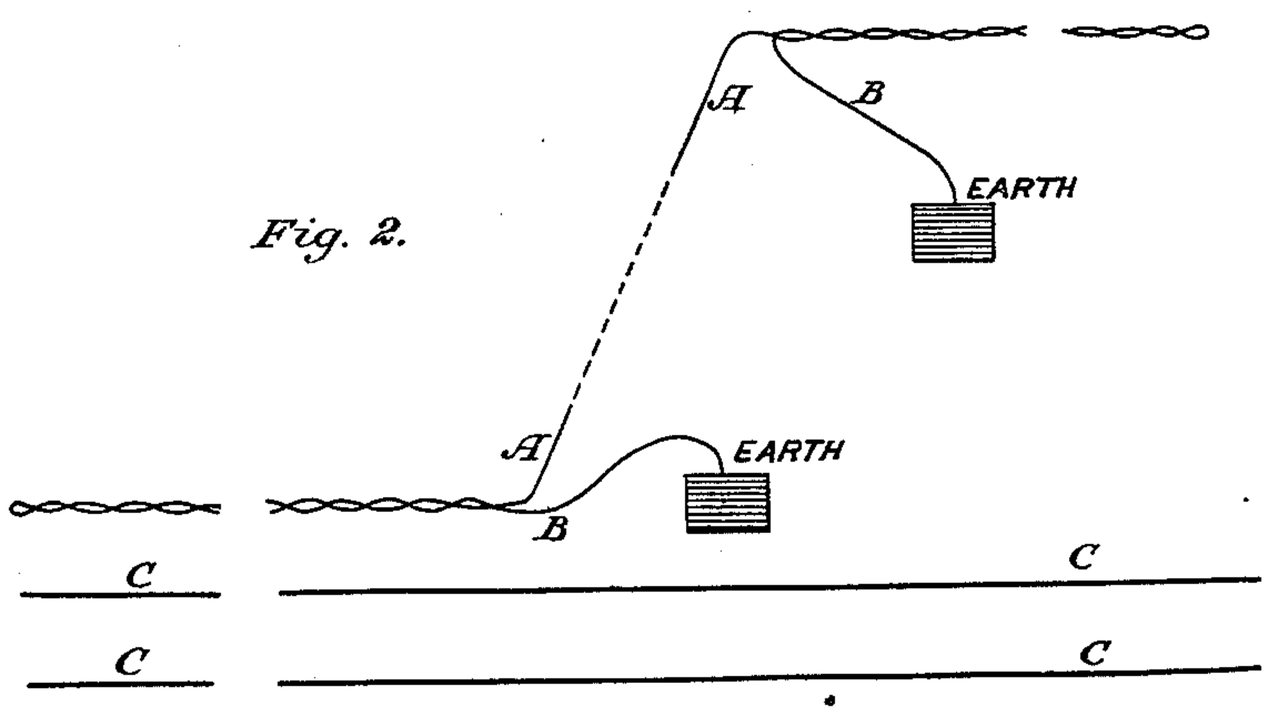
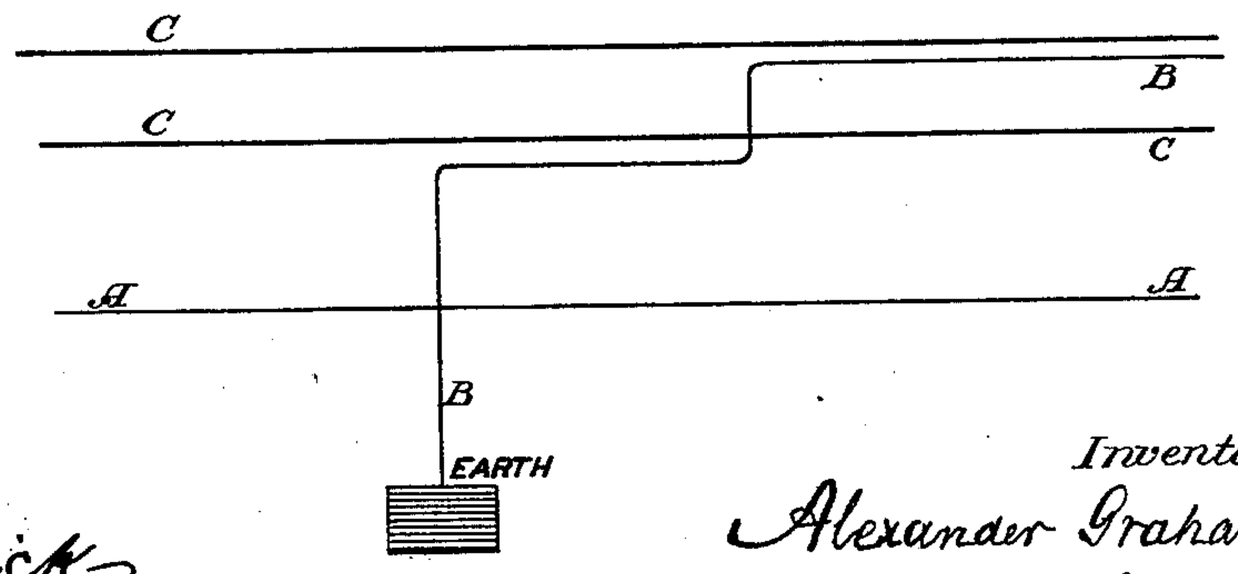


Fig. 3.



Attest:

E. A. Dick
C. Hilson

Inventor:

Alexander Graham Bell
by A. Pollok
his attorney.

UNITED STATES PATENT OFFICE

ALEXANDER G. BELL, OF WASHINGTON, DISTRICT OF COLUMBIA.

IMPROVEMENT IN TELEPHONE-CIRCUITS.

Specification forming part of Letters Patent No. **220,791**, dated October 21, 1879; application filed July 17, 1879.

To all whom it may concern:

Be it known that I, ALEXANDER GRAHAM BELL, of the city of Washington, in the District of Columbia, have invented a new and useful Improvement in Telephone-Circuits, which improvement is fully set forth in the following specification.

In the use of ordinary telephone-lines much difficulty has been encountered when employed in the neighborhood of other lines through which electrical currents are passing from time to time, by reason of the induction of currents in the telephone-wires. This difficulty has been heretofore overcome by me by connecting a return-wire with the telephone, and arranging it so that it should be affected equally with the direct wire by the currents in the disturbing wire or wires, and the induced currents in the one be thus neutralized by those in the other telephone-wire.

For this invention I made application for Letters Patent, which was filed in the United States Patent Office June 10, 1878, and is now pending. The means described for carrying the invention into effect was to arrange the two telephone-wires equidistant, or practically so, from the neighboring disturbing wires, and both were connected with the telephone and formed a metallic circuit.

In order to obtain this equidistance from the neighboring wires, the two telephone conductors or wires were arranged within a much shorter distance of each other than from the disturbing wire or wires, or they were twisted together. The terms equidistance from the disturbing wires are not, however, limited in their scope to cover those cases only in which the telephone-wires are close together or twisted, or even when the two wires are practically parallel, as it is evident that they may be far apart or diverging or converging, and still be practically or absolutely equidistant from the disturbing wire or wires. For example, suppose there is only one disturbing wire, the telephone-conductors might be placed within the magnetic field, one on one side and the other on the opposite of the wire, and both might be made to diverge and converge in a regular or irregular way, so long as the distance of one from the disturbing wire is equal, or practically equal, to that of the other telephone-wire. Instead of placing the telephone-conductors on opposite sides of the disturbing wire, they may be placed one on top or underneath, and the other at the side or at any desired angle around the wire. If there are two or more disturbing wires, the equidistance from them all might be secured by running the two telephone-conductors now near one and now near the other, thus calling the disturbing wires *x y z* and telephone-wires *a b*. For a certain length *a b* could be placed within a determined distance of *x*, and then for the same length at the same distance of *y*, and then the same with reference to *z*, and so on; or *a* could run near *x* while *b* was near *y*, and then their position could be altered.

Under the last-named conditions it is evident that *a* and *b* would be equidistant from *z*, provided *x y z* are practically parallel with each other, which is the ordinary position of telegraph-wires. If they are not so parallel, care should be taken in arranging and disposing the telephone-wires that one does not happen to be nearer to any particular wire for an appreciable portion of its length than is the other.

If the telephone-wires are so disposed relatively to the disturbing wires that the effects of induction are the same, or practically the same, on both, so that the induced currents neutralize each other, the object of the invention is accomplished. Illustrations, it is obvious, therefore, might be multiplied; but it seems unnecessary here to further specify them.

In my before-mentioned application, as I have already stated, the telephone-circuit is described as metallic. It has, however, suggested itself to me, and I have found it to be so, that in certain cases special advantages may be derived from the use of telephonic conductors constructed in accordance with the principle of my said invention in connection with grounded circuits.

The use of a return-wire arranged relatively to the disturbing wire or wires, so as to neutralize the effects of induction in the direct telephone-wire, in connection with a grounded circuit or circuits, constitutes my present invention.

The following description will enable those skilled in the art to which it appertains to

make and use my said invention, reference being had to the accompanying drawings, which form a part of this specification, and in which the several figures represent dispositions of the telephone-wires in accordance therewith.

A represents the direct telephone-wires; B, the return-wires, and C disturbing wires, and D, Figure 1, the central office of a district or similar telephone system.

In Fig. 1 are shown three telephone-lines leaving the central office D. Two of these lines, being in the neighborhood of disturbing wires C, are provided with return-wires B, which are connected with the direct wires at the end of the line at all times, and at intermediate stations when the operators are using their telephones. The third line, as it is not near any disturbing wire, may be of the ordinary grounded class. The return-wires are grounded, and the central office is also provided with a ground-connection. The wires A are connected with switches, so that they may be connected with the ground or with each other. For this purpose a switch-board of ordinary or any suitable construction, such as now in use, may be employed. No difficulty will be, therefore, experienced in connecting either of the two line-wires with return-wires, with the other, or with the ordinary line.

It is evident that it would be impossible to connect a metallic circuit-line with an ordinary grounded circuit without first making of it a grounded circuit.

In Fig. 2 is illustrated a disposition of a grounded telephone-circuit with return-wire which can be advantageously employed when the disturbing-wires accompany the telephone-line part of the way only. The return-wire is grounded at the point where the telephone-wire leaves the disturbing wires, and it may be formed of two portions, which are connected with opposite ends of the direct wire, as indicated on the drawings. It need hardly be said that it is not practicable to use a wire for neutralizing induced currents which is grounded at both ends and is unconnected with the direct wire.

In Fig. 3 is represented a disposition whereby the return-wire may extend only part of the distance through which the telephone and disturbing wires are in the neighborhood of each other, whether this be all or a portion only of the length of the telephone-line.

The return-wire, although it is for a less distance under the inductive influence of the neighboring wires, is affected equally with the direct wire on account of its greater proximity. The laws governing the inductive influence of currents are well known, and the length of the return-wire and the nearness of it to the disturbing wires may be readily determined, the length of the direct wire and its distance from the disturbing wires being given.

In order to equalize the effect on the return-wire when two or more disturbing wires are in the neighborhood, it is carried first near one and then close to another, so that the effect upon it of each wire separately will be practically the same as of that wire upon the direct telephone-wire.

Instead of having the return-wire straight, it might be coiled around the disturbing wires for a portion of their length; but this would increase the resistance of the telephone circuit.

It is evident in using the disposition shown in Fig. 3 that the grounding of the telephone or the disturbing wires at intermediate points, or the connection of the direct telephone-wire with the return-wire, would disturb the balance unless additional wire coils or other devices were connected in circuit at the time of grounding or of making the other connection, whereas in the dispositions shown in Figs. 1 and 2 the direct telephone-line might be connected with the return-wire at any point, or grounded in those portions of the line where there is no return-wire; or the disturbing wires might be grounded at any point, and the inductive effects of currents in the disturbing wires would still be avoided.

In Figs. 1 and 2 the two telephone-wires are shown as twisted, so that they are practically equidistant from the disturbing-wires. Instead of twisting them, other dispositions to maintain them at a practically equal distance might be employed, as indicated in my former application, to which I have before referred; or the two wires may be separated from each other a considerable distance, and run now near one and now near another, so long as the effect of the induction of currents passing through each and every disturbing wire are practically the same on both of the telephone-wires.

In certain cases it may be practicable and desirable to employ a single return-wire for several telephone-lines, the said wire being so arranged that the inductive effects of the disturbing wires will equal the aggregate influence in the several direct wires.

When the telephone-lines are of different length they should be grounded, and the common return-wire should also be grounded, at the end.

Having thus fully described my said invention, and the manner in which the same is or may be carried into effect, what I claim, and desire to secure by Letters Patent, is—

1. The method herein described of constructing grounded telephone-circuits, in which the disturbing effects of induction by currents in a neighboring wire or wires are prevented by means of a return-wire, by arranging the direct and return telephone-wires relatively to the disturbing wire or wires as indicated, so that they shall be equally affected by the inductive influence of currents passing through the neighboring wire or wires, and connecting said direct and return telephone-wires with each other and with the ground, substantially as set forth.

2. A telephone-circuit provided with a re-

turn-wire arranged in the neighborhood of a disturbing wire or wires, as described, so that the direct and return telephone-wires shall be equally affected by currents passing through the disturbing wire or wires, the said telephone-wires being connected with each other and with the ground, substantially as set forth.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

ALEXANDER GRAHAM BELL.

Witnesses:
H. G. OLMSTED,
W. P. PREBLE, Jr.