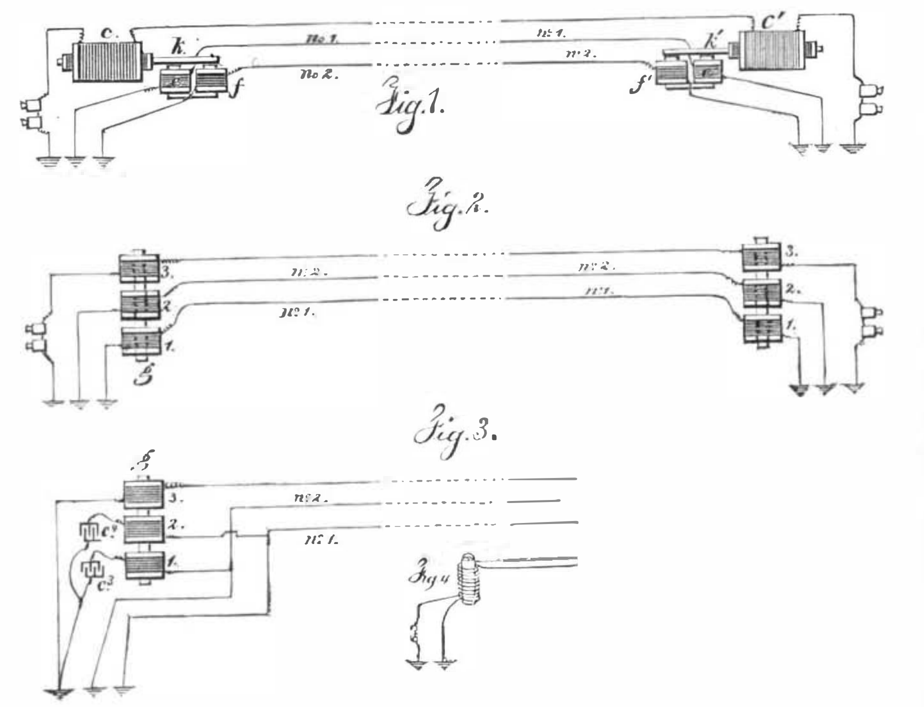
in the usual way. An improved application of the same principle is shown in Fig. 6. The bobbin of the electro-magnet is wound with two coils of equal length and thickness. Each of these coils is connected with its own separate line and battery, and the connections at the transmitting station are so made that a depression of the key sends a positive current through one line and a negative current through the other, but the coils of the magnet are so connected to the lines at the receiving station, that the positive current traverses its coil in one direction as regards the magnet core, and the negative current passes in the opposite direction, so that, by the process of double reversal, the effect is the same as that of a single current of double the strength traversing the magnet in the usual way.

We now come to that portion of Professor Hughes' researches which constitute the important contribution to electrical science and to telegraph engineering. We have but little doubt that Hughes' induction balance—by which term we would include all instruments based upon its essential principle—will ultimately take its place side by side with Wheatstone's bridge in the history of the electric telegraph, for by its means the telegraph engineer will be enabled to eradicate from his lines the retarding and cost-entailing effects of electrical induction. In Fig. 7, let D, E, and F represent three lines of telegraph, supported on poles and running parallel to one another; if a current of electricity be transmitted by the line D, it will induce in each of the lines E and F a current in the opposite direction, whose relative strength will be determined by the distance of its corresponding wire from the inducing or primary wire, D. Now, if at the moment of sending a current through the latter, it were possible to transmit through each of the lines, E and F, a current in the same direction as itself of exactly the same strength as the currents produced in the opposite direction by induction, the two, being equal and opposite, would completely neutralize one another, and although, as a matter of fact, the induction would be exactly the same, its effects would be completely eliminated and destroyed.

At the transmitting end each of the lines is connected to a small induction coil or ring, X, Y, or Z, similar to those figured in Fig. 1, and placed one in front of he other, so as to exercise an inductive effect, the one upon the other. Now, from what has been said, it is clear that if the coils were all similarly connected to their respective wires the effects of induction between one circuit and the other would be increased by the addition of the inductive effects of the coils being superposed upon and added to the inductive effect of the lines; but if at the moment of transmitting a current through the primary wire the two ends of its corresponding coil were reversed, then the inductive effects of the line and of its coil would be acting on the lines and coils of the other circuits and in opposite directions, and the aggregate induction would be diminished by the difference between the two influences. By making the length of wire contained in each coil, however, proportional to the length of its corresponding line, and the relative distances between the coils proportional to the mean distances of the lines from one another, the inductive effects of the coils are exactly equal to the inductive effects of the lines, and if their directions be in opposite directions as is accomplished by the reversal of the coils, then the problem is solved and all effects of induction are eradicated.

For the purposes of practically demonstrating the system of compensation, Professor Hughes constructed the apparatus shown to the right of the general perspective view. The five rings of insulated iron wire attached to the board represent three lines of telegraph running parallel. The two coils of each of the outside pair are joined so as to form one circuit, consisting of one black ring and one white one, each pair representing one line of a certain length, and between them is a single coil representing an intermediate telegraph line of a shorter length; this difference of length was adopted by Professor Hughes in his experimental model in order to represent a somewhat complicated case, and to show that no matter what the relative lengths and distances apart of telegraph lines, their mutual induction may be compensated by suitably constructed and adjusted compensating coils. The compensation portion of the apparatus consists of three rings whose distances apart can be adjusted by sliding in or out the cylinder to which each of the outer coils is attached. On the left front corner of the board is the commutator, consisting of six stiff elastic wires, which can be sprung against twelve brass nails, and the connections are so arranged that the battery circuit may be sent through any one of the lines, with or without the balance in the circuit, and each line can be made either a primary microphone circuit, or a secondary line in connection with a telephone, by simply placing the commutator wires against their proper contact pins. The microphone and clock, which is the source of sound, and which is shown below, was placed in a distant room, and the direction of the currents throughout the whole apparatus was under perfect control by means of the commutator to which we have referred.



EDISON'S INDUCTION BALANCE.

PROF. EDISON'S INDUCTION BALANCE FOR TELEPHONE LINES.

On the opposite page we give a full description of Professor Hughes' induction balance—an invention for which he claims originality, and for which he is receiving great credit in England. It is, however, identical in principle, and almost exactly the same in construction and arrangement as Professor Edison's apparatus, patented in England July 30, 1877, and in the United States April 30, 1878. The fact that Prof. Edison perfected his invention, patented it, and brought it into use so long before Prof. Hughes brought out his alleged invention, is *prima facie* evidence that he—Edison—is the first inventor of the induction balance.

From Edison's U. S. Patent Specification.

In telegraph lines there are very often numerous wires running in the same direction upon the poles, and it has long been known that currents passing through one or more of said wires set up induced currents in the other wires. These, ordinarily, are harmless in the Morse and other systems of telegraphy; but where a wire for a telephone, acoustic, or speaking telegraph, runs parallel to or within the field of the electric influence of another wire, there are false and confusing sounds at the receiving instrument that greatly interfere with hearing the message sent upon such acoustic lines.

The object of the invention is to compensate, neutralize, and destroy the extraneous or induced currents from contiguous circuits, so that the messages will not be in any manner interfered with by false currents. The invention consists, in the combination with the telephonic circuit, of an induction coil, connected with the contiguous circuits in such a manner that a reactionary induction is established in the telephonic line of a power corresponding and similar to the primary inductive action, but opposed to the same, so as to neutralize the action of the same.

In the engraving, Fig. 1 is a diagram representing one of the forms in which the compensation is effected. The large coils, *c c'*, are included in the telephonic circuit at each end of the line. In the coils are iron cores, surrounded by a primary coil, the ends of which may or may not be connected together, according to the compensation desired.

The iron core extends outside of the coils some distance. The circuits, No. 1 and No. 2, running in close proximity to the telephone wires, induce a momentary current in it every time the circuits are opened or closed, the strength of which is proportionate to the proximity of the wires to each other and the number of miles that they run side by side. These induced currents are in one direction in closing the circuit, and the opposite direction on opening the circuit. To neutralize the induced current from, say, No. 1 circuit, electro-magnets, *e e'*, are placed at each terminal in the circuit of circuit No. 1.

These magnets are then adjusted to approach the iron cores, *k k'*, until the induced current thrown into the coils, *c* and *c'*, and telephone line by the action of the magnets, *e* and *e'*, is equal, but opposite to, the induced current from the circuit No. 1 thrown into the telephonic wire by running parallel to it. Thus a perfect compensation is attained.

If the two lines run parallel for long distances the two ends of the primary coil on *c* and *c'* are connected together, and thus retard the magnetism and demagnetization of the cores, *k k'*, and consequently lengthen the induced currents thrown into *c* and *c'* by the action of *e'* and *e*.

Having thus compensated for circuit No. 1, the compensation for circuit No. 2 is exactly similar. If the latter circuit does not affect the telephone circuit as strongly as No. 1, the electro-magnets, *f* and *f'*, are placed a greater distance from *k* and *k'*; the latter may be elongated, and compensation attained from many circuits by employing separate magnets in each circuit which affects the telephonic circuit.

Owing to the great diversity in the character of the induced currents thrown into telephonic wires from wires in close proximity—due to different lengths and the employment of different battery powers and systems of transmission—many methods to meet special conditions are necessary. Thus in Fig. 2, where the circuits 1 and 2 employ powerful batteries and reversals, and many magnets are in circuit, the induced currents thrown into the telephonic wire are exceedingly powerful; hence a more powerful means of compensation is necessary.

In Fig. 2, *g* is an iron core, over which there are three or more coils—one for each line circuit. The coils 1 and 2 are in the ordinary or Morse circuits Nos. 1 and 2, while coil 3 is in the telephonic circuit. The coils are so wound and arranged, in relation to the induced currents thrown into the telephone wire by the proximity of the other wires, that they will act in the iron core, *g*, to set up a magnetism therein that will cause a powerful induced current to pass into coil 3 and telephonic line opposite in direction to the induced currents in the telephonic line due to the proximity of the other wires.

In cables containing a number of wires there is not only dynamic induction, but static induction. The latter appears sooner than the former, and is of exceedingly short duration, so that magnetic compensation alone is too sluggish. In Fig. 3 is shown a modification of Fig. 1 to meet this condition, which it does to a considerable extent, but not entirely. The induction coils, 1 and 2, are included in derived circuits from the line circuits, 1 and 2, that pass to the condensers, c^3 and c^4, and to the earth. To obtain perfect compensation, both the state and dynamical induced currents must be set up in the compensations so they will circulate in the telephonic wire in a direction opposite to those induced by proximity of the wires; and to obtain these conditions both magnets and condensers are necessary—the former to set up dynamical induction currents, and the latter statical currents. If current No. 1 is opened there first appears a short wave of current due to static induction, then an interval, and then the dynamical inducted current appears, which gradually dies away to nothing, hence a compensation which will eradicate the dynamical current will leave that due to static induction free to circulate, and this cannot be eradicated by an induced current from a magnet, because time is required to charge and discharge the cores and the consequent production of the induced current.

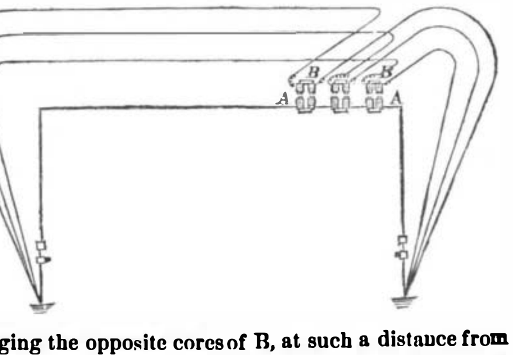
Upon short circuits a coil with two or more wires, wound side by side upon a wooden bobbin is used, as shown in Fig. 4. One wire is placed in the telephonic circuit, while the others are placed in the circuits to be compensated for, and so connected therewith that the currents thrown into the telephonic coil are equal but opposite to those due to induction resulting from the wires running parallel.

By employing large wire, and a large quantity of it, I am enabled to obtain nearly perfect compensation, as the coils set up both dynamical and statical currents, no iron cores being used to retard the appearance of the currents.

From Edison's English Specification.

When several line wires run near each other, the wire used for the acoustic or speaking telegraph is influenced by induction, and false sounds will be produced. I counteract this tendency by placing one or more electro-magnets, A (Fig. 5), in the circuit of the speaking telegraph, and one or more electro-magnets, B, in the circuit of the adjacent wires, and bringing the opposite cores of B, at such a distance from the cores of A, that a certain magnetic action will be set up in A by induction in the opposite direction to the induction currents from the adjacent line or lines.

Fig. 5.



By adjusting the distance between these magnets when the speaking telegraph is not in use, until there is no sound at the diaphragm from the induction currents, then these currents will be neutralized, whether strong or weak.

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Les Mondes calls attention to the success with which M Ravel, a merchant of Montagnac, near Riez, is cultivating the truffle. He is in a position at present to furnish thousands of these fungi, of excellent quality, at about 75c. each. He suggests that vines destroyed by phylloxera be replaced by truffle yielding oaks where the soil is calcareous or argillo-calcareous; this would be a means of recovering from the loss sustained. The products would be quickly realized, for M. Ravel has oaks six, seven, and eight years planted, which already yield truffles.