TELEGRAPH ELECTRIC CIRCUITS.

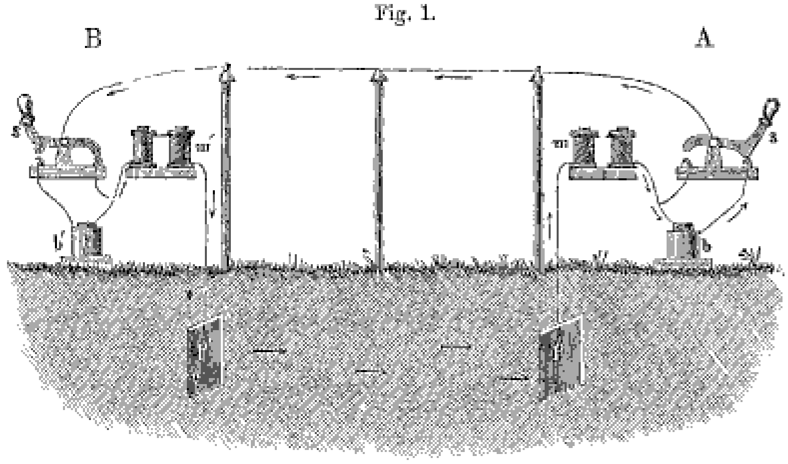
CHAPTER XXXV.

Electric Circuits on European Lines—Circuit of the Main Line described—Adjustment of the Line Batteries—Early Experimental Circuits—The Stager Compound Circuits—Combining of Electric Circuits.

ELECTRIC CIRCUITS ON EUROPEAN TELEGRAPHS.

In the present chapter it is my purpose to explain the simple and compound electric circuits as applied to the working of the telegraph, with special reference to the Morse system. As a preliminary, it is important for the reader to be informed, that

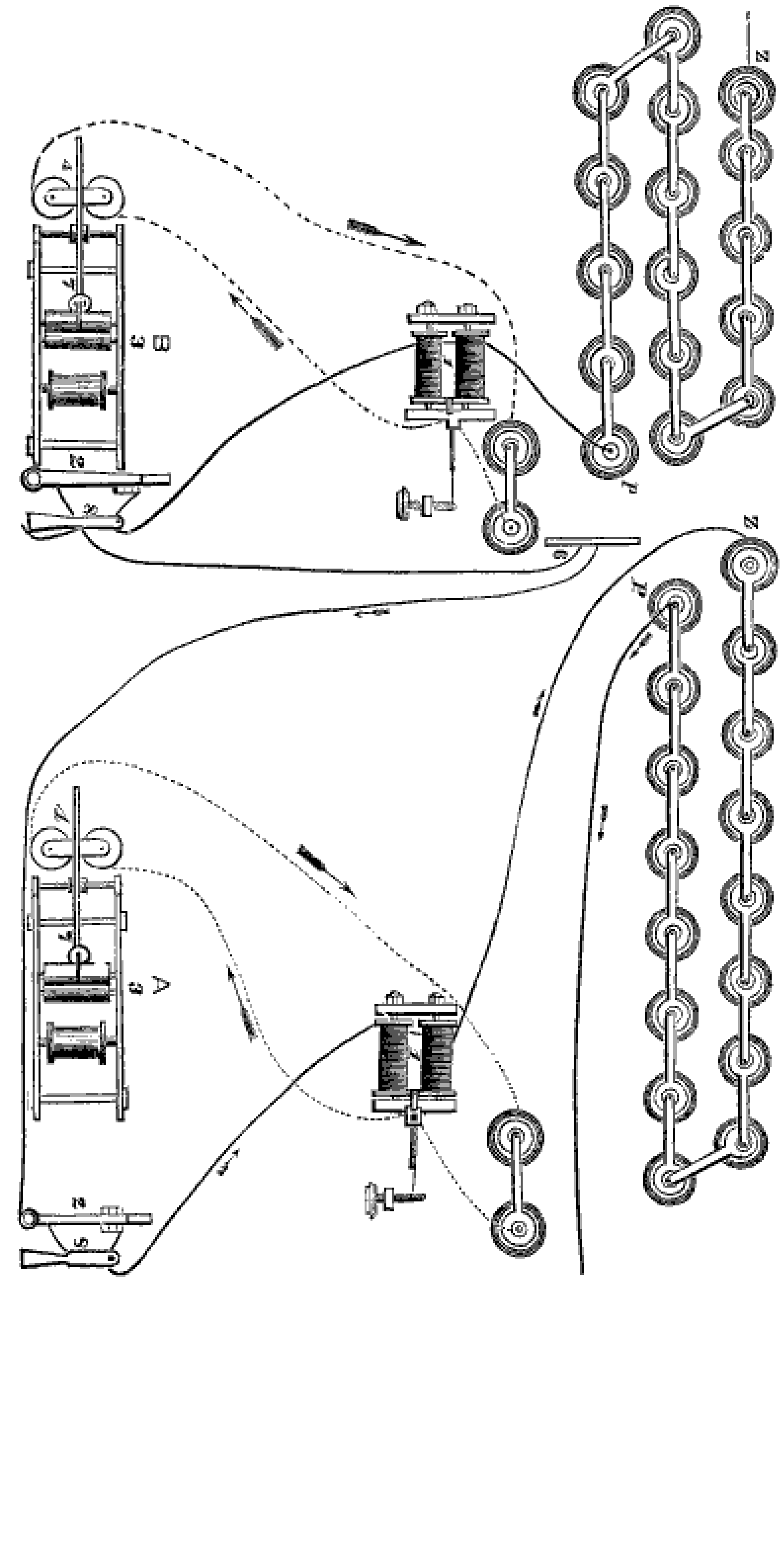
Fig. 1.



on the European lines the current of electricity is transmitted over the wires by the manipulating station. In its normal or rest state, the line wire is free from the voltaic current. The reverse of the above is the practice on the American lines. Their normal state is electrical. They are continuously charged with the voltaic force, and the manipulation for the transmission of information breaks the flow of the current.

In further explanation of the above, I would refer the reader to fig. 1, which represents the European line, when being operated. The two stations are A and B, and the former is transmitting to the latter. In the normal state of the line, the key S at station A would be closed in the rear and open in front, exactly as represented by the key S′ of station B. As the key is closed at A, the battery force of A charges the line. If the key of A was connected with the line, as the key of B, there would be no current on the line, because there would be no metallic circuit formed with the respective batteries. The base of the keys shown in the figure does not give a metallic circuit. The front is not metallically connected with the back part. The battery *b′* of station B is in its normal condition, that is, inactive. The course of the current generated by the battery *b*, of station A, follows the route indicated by the arrows, thus: through the anvil of the key, the key lever S, over the line wire to the lever S′ of station B; thence from the rear of the key through the magnet *m′* to the earth plate P′; thence through the earth to the plate P; from the plate P the current ascends with the earth wire of station A, and traverses the magnet *m*, and thence to the zinc end of the battery *b*. Thus the circuit is made complete. If the lever S of station A is elevated from the contact shown in the figure, there will be no current on the line. The moment the battery is placed in the circuit, the current flows over the whole route. The station B is receiving, and in case the operator at B wishes to respond to A, or to interrupt the transmission, he presses the lever S′ upon the anvil several times, and the effect upon the magnet *m* at A is at once seen, and the operator at A stops to ascertain the cause of the interruption. The operator at B then makes his explanations, during which process, the key lever S at A is elevated by a spring in front, so that the rear end is in contact with the metallic projection of the base; and the battery *b′* of station B is active, and the battery *b* of station A is inactive. The above explanations pertain wholly to the single or main circuit. The route of the current and the mode of interrupting it, by the opening and closing of the circuit, have been described. It is necessary, however, for the reader to remember, that the wires connecting the rear ends of the respective keys with the wires between the batteries and the magnets, are not used on the American lines; erase them from the figure, and the circuit will be composed as practically operated in America, excepting the key S′ of station B should be closed as represented at station A. Hav-

Fig. 2.



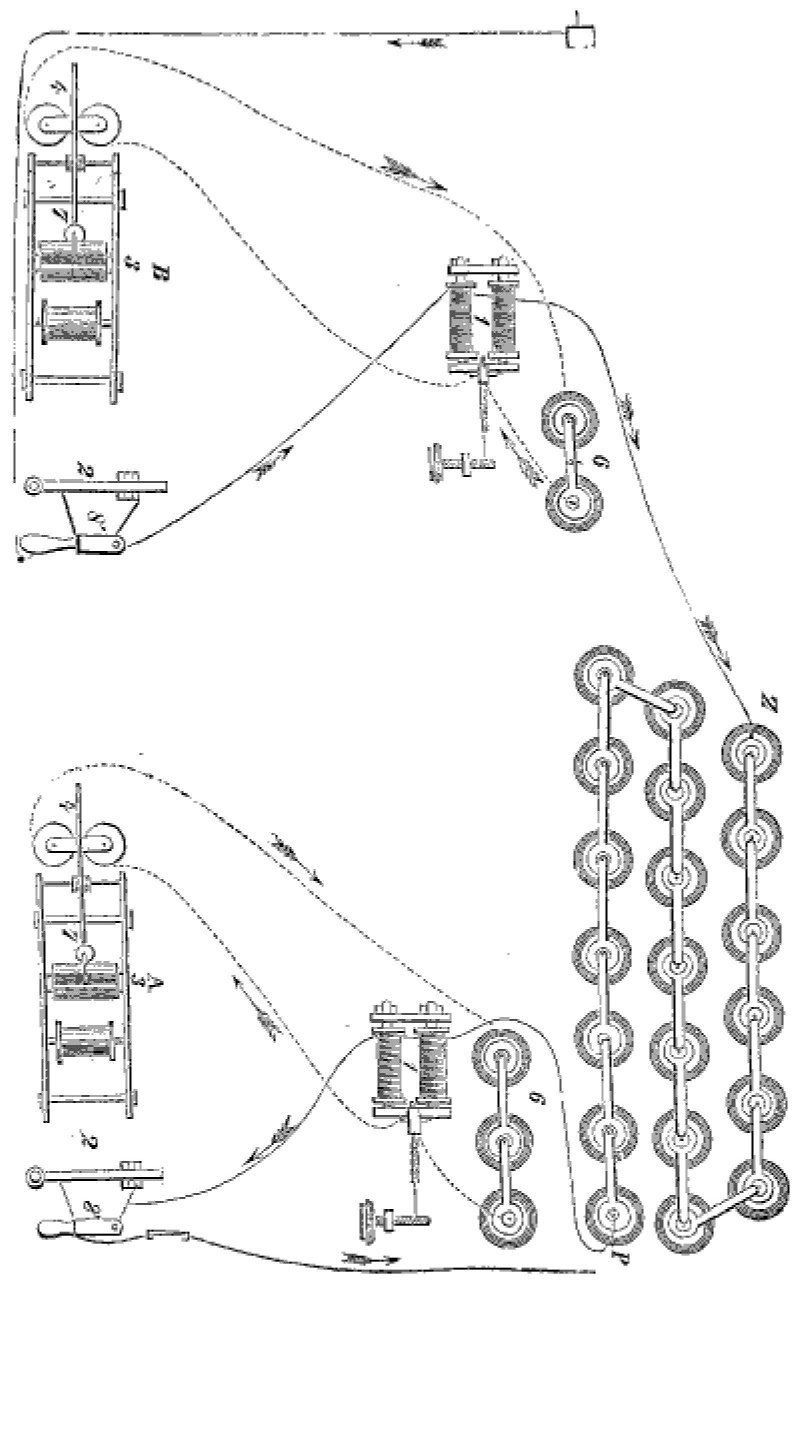
ing fully explained the main circuit, I will now proceed to describe its functions telegraphically applied.

THE CIRCUIT OF THE MAIN LINE DESCRIBED.

Figure 2 represents two stations, for example, New-York and Washington, distance 250 miles. The normal state of the line is shown, the current flowing continuously as indicated by the arrows. The right hand station A, is New-York, and the left hand, B, is Washington. The numerals at the two stations indicate the same parts at each respectively: 1, 1, are the electro or relay magnets; 2, 2, the base frames of the keys; 8, 8, are the key levers; 3, 3, are the register frames; 4, 4, the register or local magnets; 6, the line; and 7, 7, the pen lever; P, P, are the platina or positive poles of the batteries, and Z, Z, are the zinc or negative poles of the batteries. The zinc end of the battery at Washington is connected with the earth, and the platina end is joined to the line wire. At New-York, the platina end of the battery is joined to the earth wire. In figure 1, the battery is placed between the magnets and the keys; in figure 2, it is placed between the magnet and the earth. The proper place for the battery is as represented in fig. 2, that is, next to the earth.

In fig. 2, the current generated at Washington, follows the wire to and traverses the magnet 1, thence to the key 8 over the line 6, to New-York, thence into the office to the key 8, thence to and through the coils of the magnet 1, thence to the zinc pole of the battery, and after traversing the different cells it proceeds from the pole P to the earth. The reader will observe that the batteries are always constructed, so that the poles will be in the same direction. If the poles P and P were united, the battery would be ineffective. The special function of this circuit is to generate magnetism in the soft iron cores of the magnet 1 and 1. When the current flows through the coils, the iron cores become magnetized, and when it ceases to flow they are demagnetized. The passage of the voltaic current over the wire and through the spools or bobbins, instantaneously produces magnetism in the iron cores. When the line and the iron cores are thus charged, the armatures of the magnets are immediately attracted, which action closes other independent circuits. The dotted lines indicate the latter, or local circuits, which run from the armatures of the magnets 1, 1, to the batteries L, L; thence to and traverses the spools of the magnets 4, 4, of the registers, and thence to the armatures of the magnets. The opening and closing of these local currents attract or let go, the armatures 7, 7, of the

Fig. 3.



registers. The special and only function, therefore, of the main circuit is to open and close the local circuits in each office on the line, and the local circuit gives motion to the writing or imprinting pen levers, 7, 7, in each register.

Having described the arrangements of the two end stations of a telegraph line, I will now explain the organization of a line having on it one or more local stations. The terms *main* and *local* apply to the special arrangement of the batteries; for example, New-York, being the end of the line, the main battery is located at that station, Philadelphia, Baltimore, and other places, do not require batteries other than on their local circuits. Practically, however, the above places have main batteries for general application, on one or more of the many wires connecting those cities with others. The batteries at the two ends are fully sufficient to work the whole line, except under circumstances of bad insulation. The localization of the main batteries give those places the name of "main stations," and the use only of local batteries and the fact of their intermediate positions give to the other stations the name, "local stations." If an intermediate office has a main battery, it is called a "main station;" as, for example, the arrangement represented by fig. 3: A, is a "main station," and the other, B, is a "local station," the former, A, representing Philadelphia, and the latter, B, Baltimore. The Baltimore station, it will be observed, has no main battery, and the current from the Washington line wire enters the station, passes through the key, 2, 8, to the magnet coil 1, and thence to the main auxiliary battery at Philadelphia, where the current proceeds from the platina end of the battery through the magnet coils, thence to the key, and thence to New-York. The local batteries are marked 6, 6, one of which has two cells, and the other has three. It is usual to use but two; occasionally, however, when it is not sufficiently effective, owing to its decay, or from some other reason, the number is increased to three or more.

Figure 2 represents the two termini stations with their main and local batteries; and figure 3, two intermediate places, one a "local" and the other a "main" station.

A line of telegraph 300 miles long, can be successfully operated when properly insulated, in one circuit. In many cases, lines have worked a longer distance, but as a practical circuit on the American lines, 300 miles is a fair average. When the length of a line exceeds the power of the end batteries to charge it effectually with the voltaic current, it is the practice to place a main battery at an intermediate station, as represented by fig. 3. Suppose, for example, the line is 300 miles, and the stations are thus arranged.

A d e f g B h i k l C

300 miles.

Stations A, B, and C, have main batteries and stations; *d e f g h i k* and *l* are local. The current traverses the whole line from A to C, passing through the coils or spools of the electro-magnets throughout the whole line. If A transmits a message to B, or C, all the other stations can receive the same. Every magnet attracts and lets go its armature, every local circuit is opened and closed, and every pen lever is put in motion. If A wishes to send a message to all the stations, he transmits a signal, which indicates that fact, and in proper time every operator puts in motion the clock-work of his apparatus, and the dispatch is indented upon the ribbon paper.

If the line be 600 miles long, and the battery arrangements fail to charge it sufficient for telegraphing, it is the practice to operate it by "compound circuits," and the application of an apparatus called a repeater.

To thus arrange a line, it is necessary to sever the circuit at the half-way station B, as represented by the following diagram. The line is divided at B. The section between A and B is 300

A d e f g B h i k l C

ooo 300 miles. ooo ooo 300 miles. ooo

miles long, and at A and B are earth wires and main batteries. The section between B and C is the same as the former. At B, there are two batteries and an apparatus that opens and closes the next circuit in succession, from the station manipulating. Thus, when A transmits to C, the circuit between A and B is opened and closed by the operator at A, which, by the aid of magnets, opens and closes the circuit between B and C. If C wishes to respond, he opens his circuit and manipulates with his key, which action is immediately perceived by the operator at A. In the same manner *d* and *l*, or any other of the stations, can communicate one with the other. In general practice, it is the custom for the lesser intermediate stations to transmit their dispatches for places on other circuits, to the end station of the section on which the local or intermediate station is situated.

ADJUSTMENT OF THE LINE BATTERIES.

As to the amount of battery necessary to charge a line of 300 miles there is no fixed rule. It is a question depending upon the climate, the quality and size of the wire, and the insulation of the line wire. Ordinarily, in good dry weather, a Grove battery of 60 cells will be sufficient to effect successful operation. If the weather is damp, or the insulation at fault, the circumstances of the case must determine the amount required. It very often occurs on the American lines, that the station at one end of the line can receive well, and the other end can not receive anything intelligible. For example, on line A B, 300 miles long, B cannot understand the faint signals received from A, but at the same time A receives perfectly from B. This diffi-

culty is occasioned, sometimes by atmospheric electricity, but more generally by faults of the line insulation. The metallic conductor is imperfect near B. The battery at B becomes active as a quantity battery. Its quantitative development is plus, and does not harmonize with the intensity stream coming from A. One of the remedies in such cases, is the reduction of the number of cells at B, and the increasing of the battery at A. I have sometimes found benefit in the polarization of the batteries to meet the emergency; thus, by placing the platina or positive pole of the battery at A, directed toward B, and the zinc pole to the earth. The battery at B should also be reversed. Some experts are of the opinion, that the direction of the poles have no particular value in the working of a line; in my experience, I have found the fact to be otherwise, and entitled to consideration.

If there be an earth connection at *a* near B, the quantitative development at B will be plus, and in practical service I have found that it had a retarding or hindering influence of the intensity current from A. The reduction, therefore, of the battery at B lessens that hinderance, and the current from A becomes more effective. The earth connection at *a* will carry off a part of the electric force from A, but if the conductor from *a* to the earth be insufficient to lead off the whole, enough will pass on to the station B, to effect the ends of telegraphing. Suppose that seventy-five per cent. is carried off to the earth at *a*, and the remaining twenty-five per cent. continues on to B, that, or even a less amount, will be sufficient. Station B, under such a state of the electrical force, can communicate with A. The magnet at A can not be wholly demagnetized, but the strength of the magnet force will be minus and plus, according to the manipulation of B. The armature of A will have to be removed farther from the cores of the spools, so that the breaking of the circuit at B, will be effective in the attraction of the armature of the magnet at A. When the circuit at B is broken, the seventy-five per cent. current that passes off at *a*, creates in the soft iron cores at A, seventy-five per cent. of attractive force. The adjustable spring of the armature may draw it beyond that power, but the moment B closes the circuit, the magnetic force of the cores at A, becomes increased twenty-five per cent., and the spring no longer holds the armature, and it is attracted so that the armature-lever closes the local circuit, and thus the apparatus at A becomes subservient to the will of the operator at B.

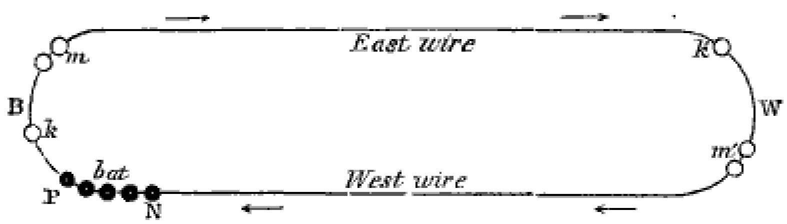
The difficulties hereinbefore described are not always chargeable to the causes given. Sometimes the fault will be found in the connections of the wire, and many times I have found it to be with the earth wire. The earth must be moist where the connection with the telegraphic conductor is made. The metal surface in the earth should be large. In my experience, for an iron wire line, I have found it best to have an earth wire of copper, number 12, Birmingham gauge, well soldered to a copper plate, at least two feet square, or its equivalent surface, and buried in the wet earth. If the earth be not wet, the working of the whole line will be less effective. Dry earth is considered a non-conductor; therefore, in order to consummate a perfect circuit, it is necessary for the metallic surface, in contact with the water of the earth, to be commensurate with the conductibility of the line wire. If the earth connection be inferior, the electrical action of the battery will be minus in the same proportion. It is better to have the conductor uniform, equalling the generative powers of the battery, so that the voltaic streams can be sufficient for the consummation of the most certain and effective telegraphic manipulation.

EARLY EXPERIMENTAL CIRCUITS.

In July, 1747, Dr. Watson, Bishop of Llandaff, together with several other electricians, ascertained the passage of electricity through the water, by sending shocks across the Thames, and in August, 1747, they transmitted shocks through two miles of wire and two miles of earth at Shooter's Hill.

On the experimental line, erected by Professor Steinheil from Munich to Bogenhausen, in 1836, two lines of wire were erected to complete the electric circuit. It was not then known that the earth would serve as one half of the conducting circuit. Soon thereafter, he discovered that the earth would answer, and that only one wire was sufficient for telegraphic purposes. When Morse constructed the experimental line from Baltimore to Washington, he did not know that the earth would answer for the half circuit, and therefore he erected two wires, and the voltaic current was sent over one wire and it returned over the other, as represented by fig. 4: B is Baltimore, and W is Washington. One of the wires is east and the other west. The

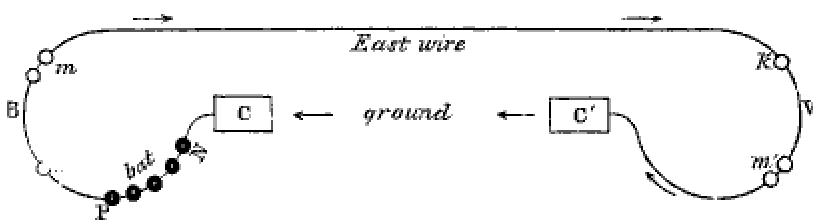
Fig. 4.



current starts from P, the positive pole of the battery, passes through the key, *k*, and the relay magnet *m*, at the Baltimore station, thence over the east wire to Washington, where it passes through the key *k'*, the relay magnet *m'*, and thence over the west wire to Baltimore, whele it enters the negative pole of the voltaic battery.

After the line had been in operation for some six months, the earth was made a part of the circuit, according to the following diagram.

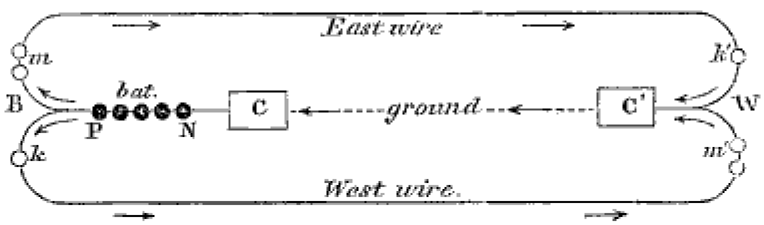
Fig. 5.



The route of the current is precisely the same as the diagram before described, except that the earth is made a part of the circuit. The current arriving at copper plate C' passes through the earth as indicated by the arrows, to copper plate C, which is also buried in the moist earth, and thence to the N. pole of the battery. The plates used by Professor Morse were five feet long, and two and a half feet broad; at Baltimore, it was buried in the water at the bottom of the dock, near Pratt street; at Washington it was placed in the earth under the Capitol.

A subsequent experiment demonstrated the practicability of working the two wires, arranged as represented in the following diagram.

Fig. 6.

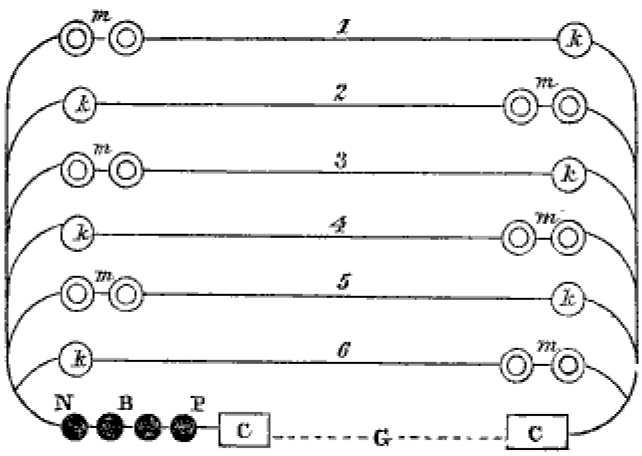


By this arrangement the keys were not required to be closed. Each station had its wire, independent of the other. At that time it was a discovery of great import, and to Mr. Alfred Vail the credit is due. They were called independent circuits. It will be seen that the west wire was used for transmitting from Baltimore to Washington, and the east wire from W to B. The battery at B was used in common for both circuits. When B transmitted to W, the current proceeded from P of the battery to *k*, then over the west wire, then to *m'* at W, thence to C', thence through the earth to C at B, and thence to the N, or negative pole of the battery as shown by the arrows. When W transmitted to Baltimore, the current proceeded from the P of the battery to *m*, then over the east wire, then to *k'*, at W, thence to C', thence through the earth to C at B, thence to the N, or negative pole of the battery, as shown by the arrows. In the above arrangement Mr. Vail used but one battery, and the same earth-plates common to both lines. The circuits were called "open circuits," because the keys at each station were always open, unless when used for transmitting intelligence.

In 1844, Mr. Vail experimented on the line between Baltimore and Washington, with the two telegraph wires then erected. There were none others in America. When he ascertained that the two wires could be practically worked, as described hereinbefore, he advanced the opinion, that several circuits could be operated with one battery, or by a series of batteries.

In the following fig. 7, let the right-hand side represent Washington, and the left Baltimore. The lines 1, 2, 3, 4, 5, and 6, between *m* and *k*, respectively, represent the six wires connecting (for example) Washington with Baltimore; *m* 1, *m* 3, and *m* 5, represent the three magnets, or registers, and *k* 2, *k* 4, and *k* 6, the three keys, or correspondents, at Baltimore; *k* 1, *k* 3, and *k* 5, are the three keys or correspondents, and *m* 2, *m* 4, and *m* 6, the three magnets or registers, at Washington.

Fig. 7.



The battery is represented by four black dots, marked N, B, P. The course of the fluid in this case is from P to C, the copper plate on the left side; then through the ground to C, the copper plate on the right; then through the single wire to any of the six wires, which may be required, then to the single wire on the left side to N, of the battery. It is obvious that in this arrangement there is a division of the power of the battery, depending upon the number of circuits that may be closed at one instant. For example: if circuit 1 is alone being used, then it is worked with the whole force of the battery. If 1 and 2 are used at the same instant; each of them employ one half the force of the battery. If 1, 2, and 3, are used, then each use one third its power. If 1, 2, 3, and 4, then each circuit has one fourth the power; if 1, 2, 3, 4, and 5, are used at the same moment, then one fifth is only appropriated to each circuit, and if 1, 2, 3, 4, 5, and 6, then each employ a sixth part of the voltaic fluid generated by the battery.

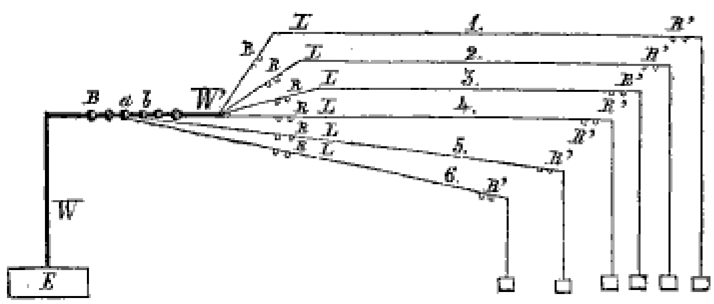
THE STAGER COMPOUND CIRCUITS.

On the extension of the lines, their continual use becoming necessary for commercial purposes, the working of the lines with open circuits, according to the plan adopted by Mr. Vail, was found impracticable for successful telegraphing.

The plan was then adopted, to keep the circuits always closed, and the battery current continuously on the line wires. This occasioned the necessity of placing upon each wire a battery, each independent of the other. It was maintained at a very great expense, but there seemed to be no law known by which it could be avoided.

For several years the lines throughout America thus worked. Various plans were tried to economize in the battery organization, but without success. The most skilled experts had their attention directed to the subject, and it fell to the lot of Mr. Anson Stager, of the Cincinnati station, to devise a plan by which might be successfully operated any number of lines from the same battery. This discovery made by Mr. Stager, in December, 1850, gave additional evidence of the very superior skill which had before and since characterized his telegraphic career. Mr. Stager thus explains his plan of operating a series of lines by the same battery.

Fig. 8.



The improvement consists in working a "multiplicity of main circuits with a *single main battery*, instead of a battery to each circuit, as was practised previous to this discovery." It is described as follows:

B, is a main battery, W, W′, large wires leading from the poles of the battery; E, the earth-plate; L, L, L, L, four main lines branching from the large wire of the battery at W′, and extending to the several terminal stations, each finally connecting with a ground plate. In their course each of the main lines may include at any point, or points, where stations are required, receiving magnets, represented by R, R′, &c., connected in each instance with registers and the usual telegraphic apparatuses.

Mode of Operation.—The single battery, B, being in action, any one or all of the apparatuses in the several main circuits, may be used and operated in the same manner as though each main circuit was a separate and independent circuit, supplied with a separate and independent battery; and, herein consists the novelty and utility of the improvement, viz.: A multiplicity of circuits at even twenty or more, each extending several hundreds of miles, can thus be worked by means of a *single* battery, instead of one to each circuit, as was practised previous to this improvement. In this use of a single battery, according to the above described plan, there is no interference of circuits, one with another; each performing its functions, precisely as it would do if it were a complete and independent circuit. Nor does the single battery, thus used to supply many main lines, seem to be consumed faster than the single battery of a single circuit as formerly used.

In case one or more of the main circuits be short, for example, 5 and 6, they need but a small voltaic force, and they may be supplied by branches, starting out at intermediate points of the battery, as at *a* and *b*. The voltaic force, thus taken from a section of the battery, will not diminish perceptibly the current on the other main circuits.

It is a condition necessary to the success of this mode of working, that each main circuit include a receiving magnet, or a resisting wire equal to that of a relay magnet. There must be no "cut off," or earth conductor, between the main battery and a contiguous receiving magnet. If a circuit be thus made, the battery force will be withdrawn from the other circuits, and they may cease to operate effectively. If the earth connection be made beyond the receiving magnet, as at L, thus compelling the electricity to traverse the fine wire of magnet R, before reaching the earth, and returning to the prime ground plate E, there will be no interference with the other main circuits, though they may be of great lengths, and the other circuit very short. This affords to the operator the advantage of working one or more registers within the same station with the battery, independently of all other registers, and without any interference with them.

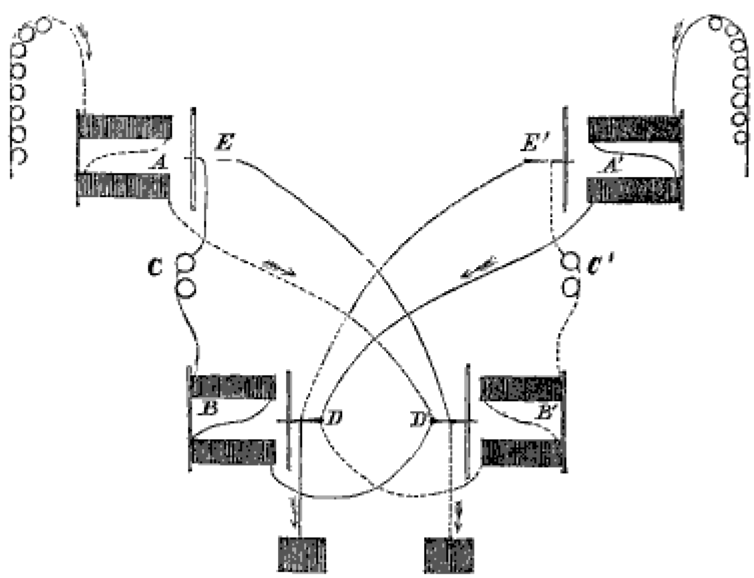
In the plan as heretofore practised, of having a battery in each circuit, the quantity of electricity generated, was more than sufficient for supplying the single circuit; and the plus was retarded by the resisting coils of the magnets. It has been practically demonstrated, that when there are several main circuits connected with one main battery, *each with its receiving magnet or coils of resistance, prevents the electricity from taking one circuit exclusively*, and the voltaic force will be diffused over all the circuits sufficiently for telegraphic service. The surplus electricity which was on the single circuit system wasted or returned, by return shocks through the battery, is, by this improvement, brought into actual service.

Another valuable advantage resulting from this arrangement is, that an operator, having a key in the main common circuit between E and W, can work all of the registers on all the main circuits, and can thus multiply and diffuse identically duplicate copies of important documents, or newspaper reports, to all points at the same moment.

COMBINING ELECTRIC CIRCUITS.

As soon as the telegraph lines were extended over long ranges, it was found to be impracticable to operate them in long circuits. Various experiments were then made to remedy the difficulty. Mr. Ezra Cornell, arranged the apparatus of one station to open and close the next succeeding circuit. This

Fig. 9.



was called the "Cornell switch." By this arrangement, the second circuit could not respond without a transfer of the switch instrument at the central station, done by the operator. When B answered A, the operator at the central station, with a spring, changed the register magnets, or the local circuit, from the relay magnets of the circuit of A, to the circuit of B.

The next arrangement operated, was one proposed by Col. John J. Speed, Jr., and is represented by fig. 8. The instruments in the figure are supposed to be at Cleveland. On the right, the wires run to Detroit, and on the left, to Buffalo. A A′ are relay magnets, constructed with a platina point to close the connecting circuit, through the action of a spring, when the main circuit is broken; B B′ are the connector magnets; C C′ are local batteries, to operate the connector magnets; D D′ are closing points, to each of which is attached one main wire and one of the connectors; E E′ are the closing points to which the connecting circuits are attached.

The manner of operating this instrument, commonly called a "repeater," is as follows, viz.:

When Buffalo breaks the circuit, the armature of the relay magnet A, at Cleveland, will be drawn back by means of the spring, against the closing point E. This will put in action the battery C, and the magnet B will break the connection at D, thus breaking the circuit of the Detroit line at D, and also breaking the connecting circuit, from the battery C′ at the point D. The breaking of the battery current C′, prevents the magnet B′ from breaking the Buffalo line at the point D′. When Buffalo closes the circuit, the relay magnet A, will break the connecting circuit, from the battery C, at E. The armature of the connector magnet B will be drawn back, by means of a spring, against the point D, and close the Detroit circuit at the point D, at which time the connecting circuit C′, is also closed on the same point, and at the same instant. The main battery on the Detroit circuit having the greater number of cells, will break the connecting circuit C′, at the point E′ before the small battery C′ will operate the magnet B, and break the Buffalo circuit at D′. The law being, that the battery of the greatest *intensity* will make its magnet first, or, in other words, the *velocity* of a current of electricity is in proportion to its *intensity*. This arrangement is now obsolete.