Sheet 1-2 Sheets.

C. F. Varley.

Telegraph.

No. 78,495. Patented Jun. 2, 1868.

Fig. 1.

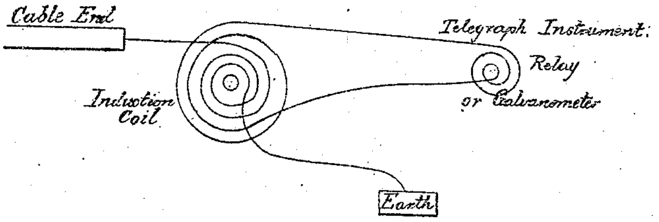


Fig. 2.

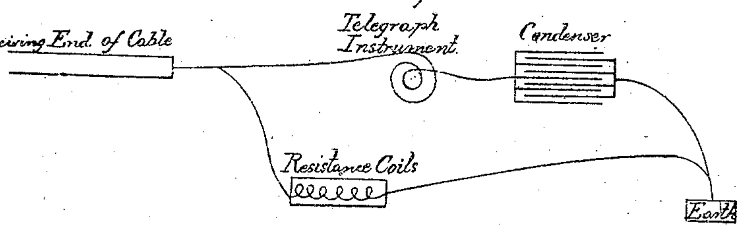


Fig. 3.

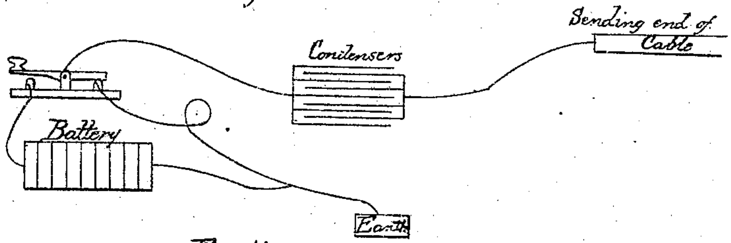
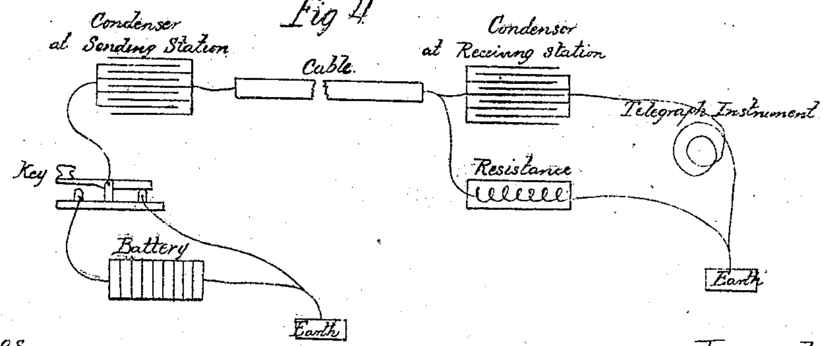


Fig. 4.



Witnesses.
M. Bailey
J. S. Page Jr.

Inventor
Cromwell Fleetwood Varley
by his attorney

Sheet 2-2 Sheets.

C. F. Varley.

Telegraph.

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Fig. 5.

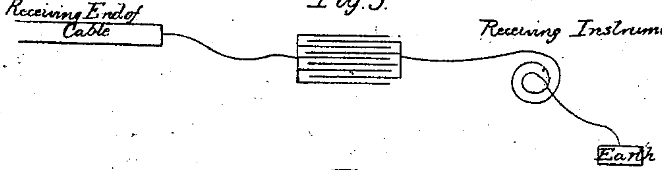

Fig. 7

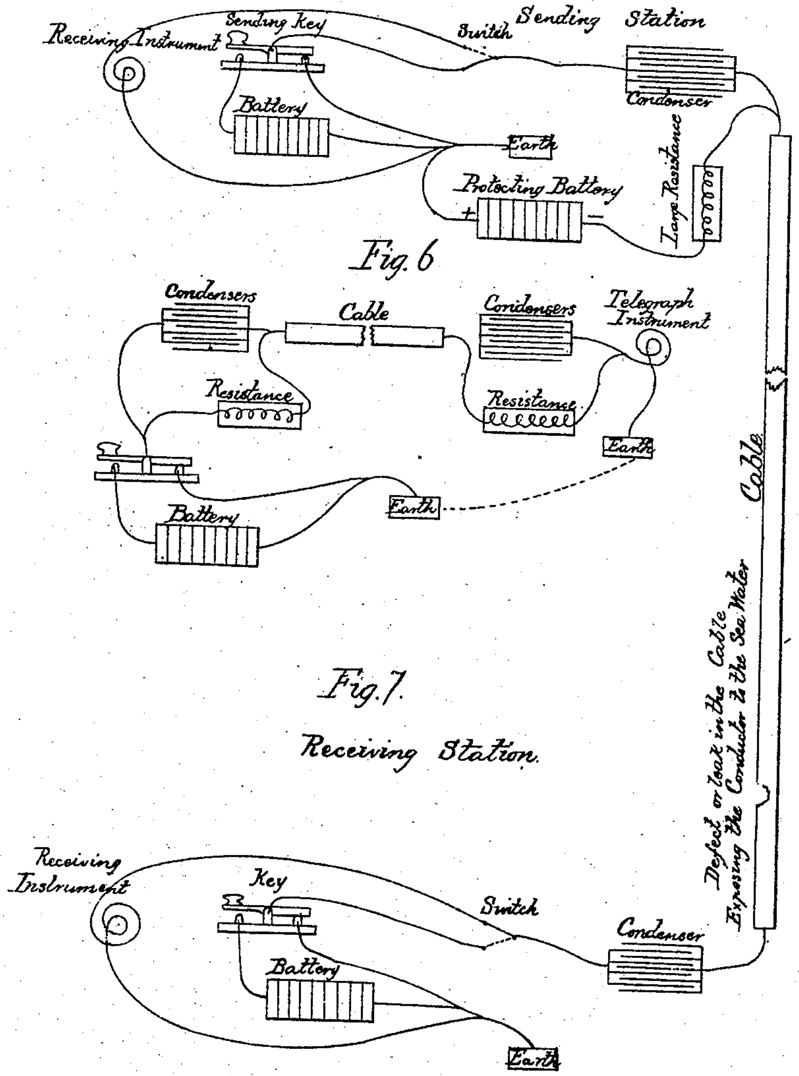

Fig. 7.

Receiving Station.

Witnesses

[illegible]

[illegible]

Inventor

Cromwell Fleetwood Varley
by his attorney

UNITED STATES PATENT OFFICE.

CROMWELL FLEETWOOD VARLEY, OF LONDON, ENGLAND.

IMPROVEMENT IN TELEGRAPHING.

Specification forming part of Letters Patent No. **78,495**, dated June 2, 1868.

To all whom it may concern:

Be it known that I, CROMWELL FLEETWOOD VARLEY, of London, England, temporarily residing in New York, county of New York, and State of New York, have invented certain new and useful Improvements in Electric Telegraphs; and I hereby declare the following to be a full, clear, and exact description of the same.

The objects of my invention are to cut off the disturbance arising from earth-currents, to obtain a high speed of signaling through long circuits, and, should the conductor become partially exposed, to preserve it from being eaten away by electrolytic action.

No means, prior to my invention, had been devised for effecting the first and third of these results. I have devised several other methods less perfect than those hereinafter described, but all embodying the general principle of my invention.

The invention consists of the arrangement of well-known apparatus, whose action, being of an electric and magnetic character, cannot be explained by drawings or models; but the accompanying diagrams and specification will enable those skilled in the art to understand the invention.

The telegraphic signals in this invention are made to depend upon the rate of change of electrical potential, and not upon the strength of the current or charge in the cable.

As the earth-currents—*i. e.*, the electric variations in the earth itself—change their strength slowly, the indications produced by them with this invention, in which the strength of the signals depends upon the rate of change of strength, are so feeble as to escape notice, and the embarrassment arising from this cause on long lines is, to all practical purposes, avoided.

There are two modes by which this is effected and a higher rate of signaling through long cables obtained. The first plan is by means of an induction-coil. The cable, at the receiving end of the circuit, is connected to the primary wire of an induction-coil, and through it to the earth. The secondary wire is connected to the telegraph-instrument. This arrangement is represented by Diagram No. 1.

Explanation of its action: On a current passing through the primary wire of the induction-coil, the iron core becomes magnetized, and this magnetization produces a current in the secondary wire, which acts upon the telegraphic instrument.

When the current in the primary wire has reached its maximum force, and is flowing steadily through, the iron core is magnetized to a certain fixed amount, and then the current in the secondary wire ceases. If, now, any change in the strength of the current through the primary wire occurs, the amount of magnetization of the iron core will vary, and a corresponding current in the secondary wire will result.

The earth-currents seldom pass from zero to their maximum and back again to zero (prior to changing sign) in less than five or six minutes, while the telegraphic signals are generally produced in a small fraction of a second.

With the former, although the currents are often very strong, the rate of change of strength is extended over several minutes, and consequently the current in the secondary wire is very feeble, as its strength is mainly dependent upon the rate of variation of the magnetism of the iron core.

The signaling currents or impulses are much more rapid or sudden, and consequently the variation of the magnetism of the iron core is much more sudden, and the currents generated thereby in the secondary wire are comparatively powerful and distinct.

Thus, then, suppose the earth to send a current through the line—say a positive (+) current from the sending to the receiving station—and to slowly magnetize the iron core, and, for ease of explanation, suppose this earth-current to remain for a time steady and uniform in strength; let, now, the sending-station make a signal. In doing so his battery adds its strength to or opposes the earth-current, accordingly as the signal sent is + or —, (positive or negative.)

This sharp and comparatively sudden addition to or subtraction from the earth-current produces a rapid augmentation or diminution of the magnetism in the iron core, and thus produces a distinct signal in the secondary wire.

For still further explanation, suppose the earth-current to be +, and to have a strength of 100 plus or positive, and the signal-current to have a strength of 10, if a positive signal be sent, the current will rapidly rise at the receiving end in the proportion of 100 to 110. This rapid increment of magnetism will produce a positive signal in the secondary wire, corresponding to the increment 10. But if a negative signal be sent, then the battery will be opposed to the earth-current, and the current will rapidly fall at the receiving end in the proportion of 100 to 90, the magnetism in the iron coil will experience a rapid decrease, and a negative signal will be produced in the secondary wire corresponding to the decrement (or negative increment) 10, although the current through the line or cable still remains strongly positive.

As the strength of those secondary signals is almost entirely dependent upon the rate of increment and decrement of the current through the primary wire, and as the slowest line yet constructed need not require so much as half a second to produce a clear signal, while the earth takes five minutes or six hundred half-seconds, the current arising in the secondary wire from the earth-current (which, although assumed to be ten times stronger, is six hundred times slower) is $\frac{10}{600} = \frac{1}{60}$ part only of the strength of the signal, and the effects of the earth-current are consequently practically cut off.

When signaling through a very long cable, a rapid succession of signals charges the cable and produces an electric wave, which is a long while subsiding, and acts at the receiving end in a somewhat analogous manner to the earth-current just described. This prevents signals from being transmitted in rapid succession by the ordinary means.

The above apparatus, which may be popularly described as disentangling the short high-crested waves from the large long swells, enables clear distinct signals to be produced rapidly one after the other.

The strength of the signals through the cable or telegraph-circuit is produced by the rate of the increments and decrements of current, and not by the current itself; and, as an imperfect illustration, if the great earth-current through the cable be compared with an Atlantic swell whose height is five fathoms, but spreading horizontally over five or six hundred fathoms, and whose sides will have an angle of, say, one hundred and seventy-eight degrees, and if the signals be compared with the ripples produced by the wind upon the back of the swell, and whose angles are each, say, sixty degrees, then an apparatus that will indicate these angles would scarcely notice the angle of one hundred and seventy-eight degrees, which is nearly a straight line, (or one hundred and eighty degrees,) while the small waves, with an angle each of sixty degrees, would be distinct, and such apparatus would disentangle the small signals from the big swell, paying almost no attention to the latter. Electric waves are entirely different from water waves; but the illustration may serve to explain the action of the former.

The second plan of effecting the above is more expensive in construction, but more perfect in action. A large condenser is inserted in the circuit at one or both ends, according to the circumstances of the case. At the receiving end of the line I prefer the following arrangement, (Diagram No. 2,) which gives a rapid rate of signaling.

The cable is connected to the one armature of the condenser through the telegraph receiving-instrument, and the other armature is connected with the earth. The cable is also connected to the earth by means of a resistance-coil, which is best when made of a long length of insulated copper wire wound round an iron core.

On a current running through the line or cable, it finds at the distant end two routes or channels, viz., the resistance-coil and the condenser. The condenser-route at the first moment offers no other sensible resistance than that of the receiving-instrument, while the other, owing to the magnetic inertia of the iron core, offers at the first moment a considerable resistance. The condenser is rapidly charged, and, as soon as it is charged to the full force or potential of the current in the cable, all the rest of the electric current goes through the resistance-coil to earth, and no more current is shown upon the receiving-instrument. If, now, the potential in the cable be reduced or increased a little, the charge in the condenser is reduced or increased in proportion, and a negative or positive signal can be distinctly produced at pleasure, although the electric current or charge in the line or cable has not changed sign, but only varied in strength. The resistance-coil between the cable and the earth may be dispensed with; but then the little signal-wave does not reach its maximum so rapidly, and consequently the signals are not so rapid. (*Vide* Diagram 6.)

Observe, the receiving-instrument may be placed between the second armature of the condenser and the earth or ground, instead of between the cable and the first armature. A condenser may also be employed at the sending end of the line or cable, either with or without a condenser at the receiving end of the line or cable. When a condenser is inserted at the sending end only of the line, the resulting signal is very similar to that produced by a condenser at the receiving end only; but the disturbing action of the earth-current, however, is more felt when the condenser is only placed at the sending end, because the earth-current has to charge the cable in addition to the condenser, all of which charging-current has to pass through the receiving-instrument. When the condenser is used at the sending end of the cable or line (Diagram 3,) the cable is connected to the one armature of the condenser and the telegraph-key to the other armature of the condenser. An ordinary double or reversing key is generally used, so that when the one is depressed a positive charge is communicated to the condenser-armature attached to it, and when the other is depressed a negative charge is communicated to it.

If the key had been connected to the line or cable in the usual manner, a constant or permanent current would have been produced through the cable so long as the contact was maintained, and this current would only begin to die away when the contact with the battery was broken or reversed. But when the condenser is interposed in the circuit, as described, so soon as the current from the battery has charged the condenser the current from the condenser is arrested, and variations in the length of the battery-contact beyond a fixed amount will produce no change in the amount of current thrown into or induced in the cable. In this way great uniformity and regularity of signals are obtained.

At the sending end of the line it is sometimes advisable to use a smaller condenser than at the receiving end, and higher battery-power, because the more sharp and sudden the impulse is given the quicker will the signal appear at the distant end.

If the dimensions of the condenser be reduced—say halved—and the battery-power be augmented in the inverse ratio, then the shock or impulse will be the same in amount, but more sudden, producing a rather more rapid signal at the distant end; but the disturbing action of the earth-currents is reduced as the dimensions of the condenser are reduced at the receiving end.

In some cases—such, for example, as where the Morse instrument is used—it is advisable to connect together the two armatures by means of a very large resistance, as shown in Diagram 6, so that after the condenser is charged the current through the cable shall not entirely cease. Thus the sharp, sudden impulse of the condenser charges the cable, and would produce a dot, but not a line or dash. The weak current through the large resistance, however, maintains the current in the cable, and a dash is produced, the Morse armature being held down by this weak current so long as the key is held down.

On the key being elevated, the charged condenser is connected to the ground, if the condenser be at the sending end; and in discharging itself the condenser produces a short, sharp current in the cable in the opposite direction, which rapidly terminates the signal at the distant end of the cable.

All cables are liable to have their insulation impaired. When this is the case, and the copper conductor is exposed to the sea-water, the copper is decomposed whenever a positive current is permitted to flow from the copper into the water, forming chloride of copper, which is soluble, and diffuses itself and floats away.

If the cable be kept always negative to the water, the action of the positive current flowing into the wire from the water is to preserve the wire from decomposition. To effect this I place a condenser at each end of the cable, (Diagram 7,) and also connect to the cable, through a large resistance, (or long coil of fine wire,) a battery whose positive pole is connected to the earth and negative pole to the resistance-coil. This keeps the cable always negative to the water, and yet the signals through it and the condensers are either positive or negative, at pleasure. Suppose the signal-impulse to be a positive one, it weakens the negative character of the charge in the cable and also in the distant condenser, and immediately a corresponding positive signal is produced in the distant instrument.

If the signal-impulse be negative, it increases the negative charge in the cable and also in the distant condenser, and therefore produces a negative signal in the distant instrument, and thus, although positive and negative impulses are produced at the distant end, the cable has been only less or more negative, but never positive, to the sea, and therefore, the conductor has been constantly under the preservative action of the negative current. Thus, then, the action of the condensers and battery has been not only to cut off the effect of the earth-currents and to expedite the transmission of signals, but also to preserve the conductor of the cable from destruction, if exposed to the sea-water.

In Diagram 7 the place of the switches or commutators is shown. These have been omitted in the other diagrams to simplify them. These commutators are of the ordinary well-known form common to most systems of submarine telegraphing, and are not a part of this invention.

Having now described my 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. In so arranging telegraphic apparatus as to work by the variation of the increment and decrement of electric potential, and not by the direct action of the electric current itself, as and for the purposes set forth.

2. The use of an induction-coil at the receiving end of the cable, one of its wires being connected between the cable and the ground, and the other or secondary wire connected with the receiving-instrument, as and for the purposes set forth.

3. The use of a condenser or condensers between the receiving end of the cable and the earth, with or without resistance-coils between the cable and the earth, as and for the purposes set forth.

4. The use of a condenser at the sending

end of the cable, with or without resistance-coils connecting its two armatures, as and for the purposes set forth.

5. The use of a condenser at each end of the cable, the cable being connected with the ground through a resistance-coil and a battery, so as to keep the cable always negatively electrified, as and for the purposes set forth.

In testimony whereof I have signed my name to this specification before two subscribing witnesses.

C. F. VARLEY.

Witnesses:
W. BAILEY,
C. G. PAGE, Jr.