(No Model.)

3 Sheets—Sheet 1.

S. D. FIELD.

TELEGRAPHY.

No. 389,883. Patented Sept. 25, 1888.

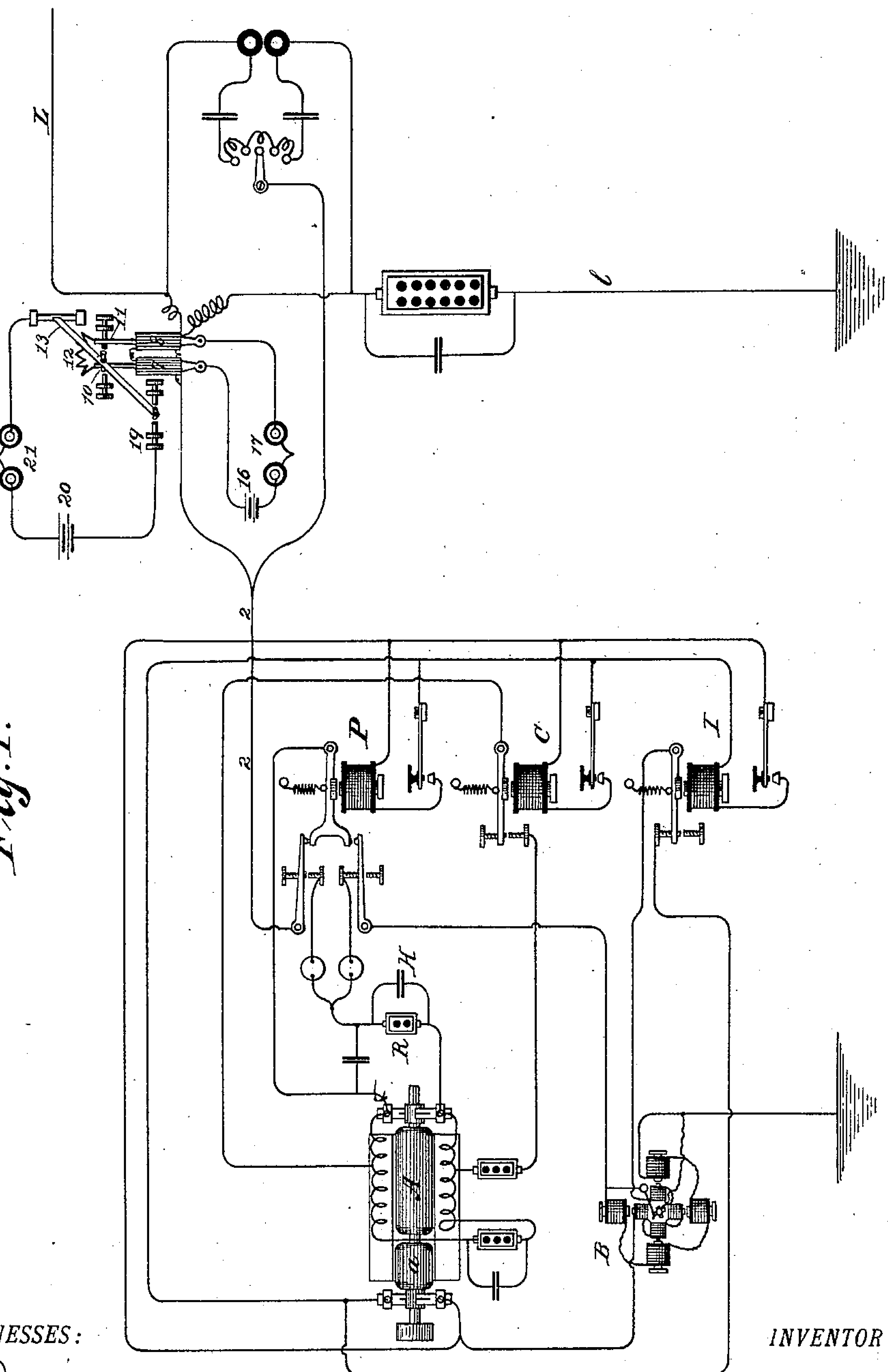

Fig. 1.

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(No Model.) 3 Sheets—Sheet 2.

S. D. FIELD.

TELEGRAPHY.

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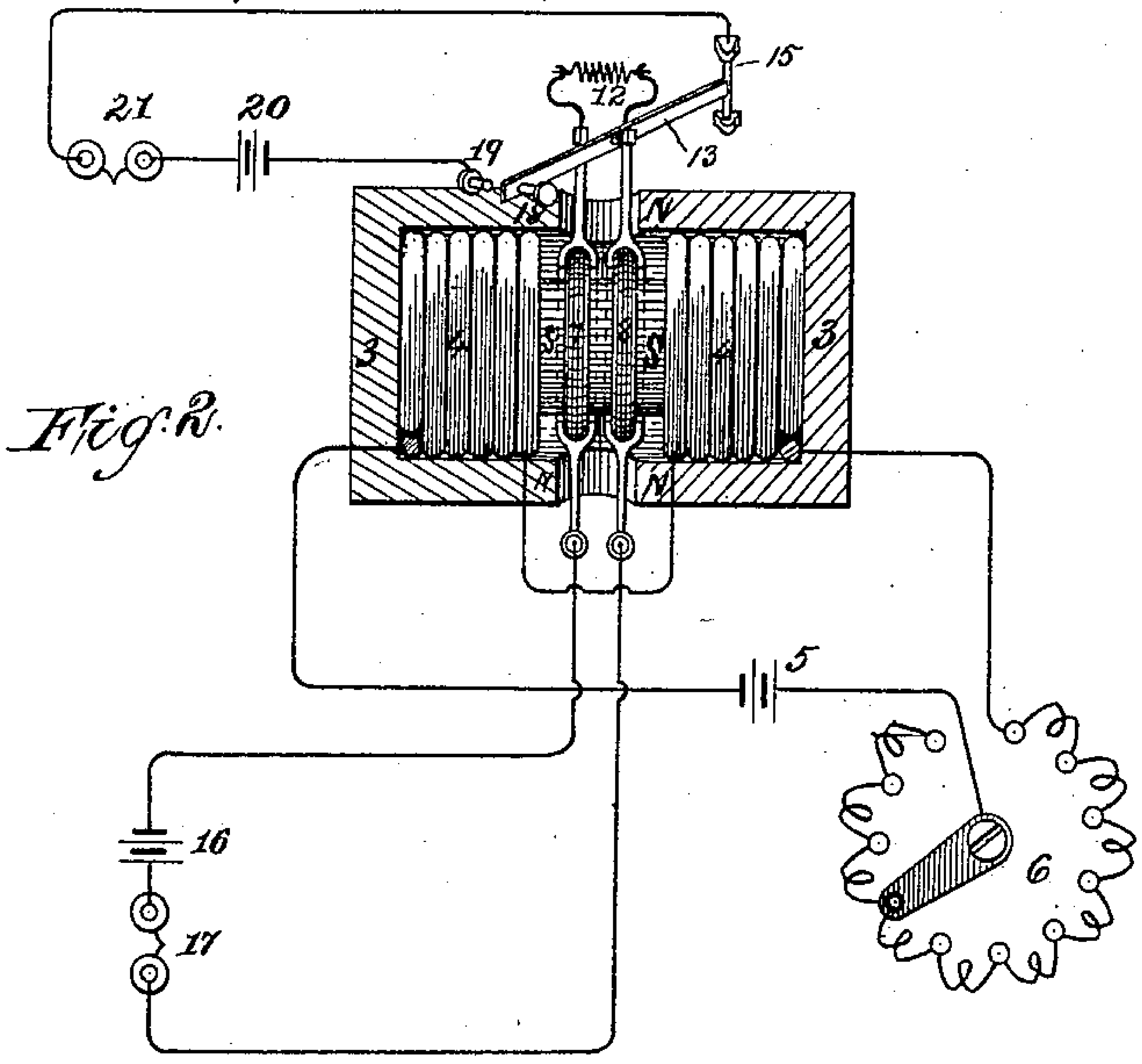

Fig. 2.

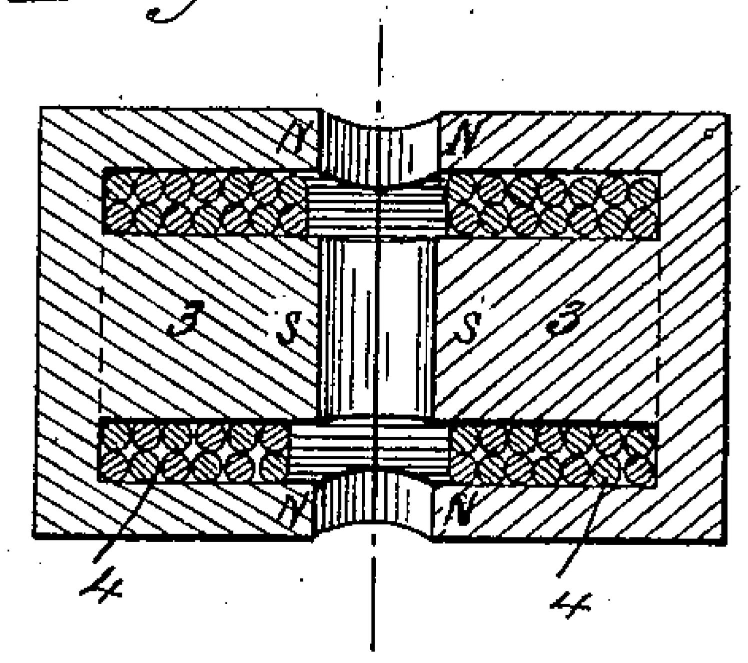

Fig. 3.

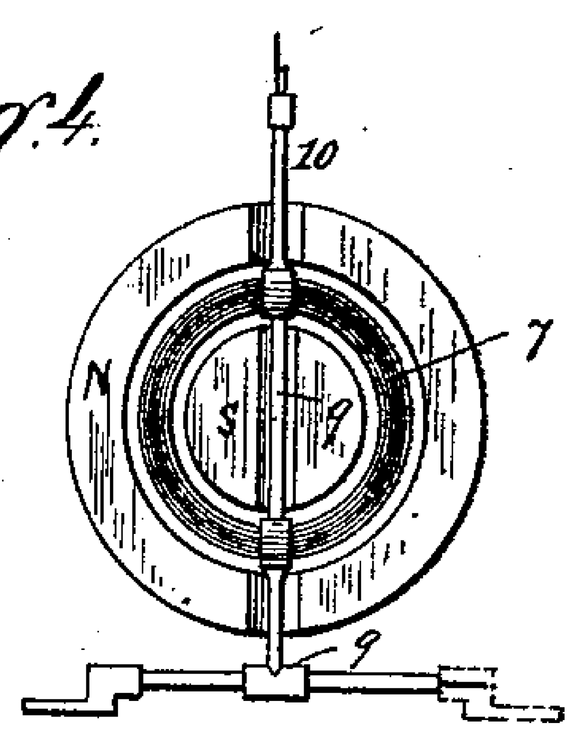

Fig. 4.

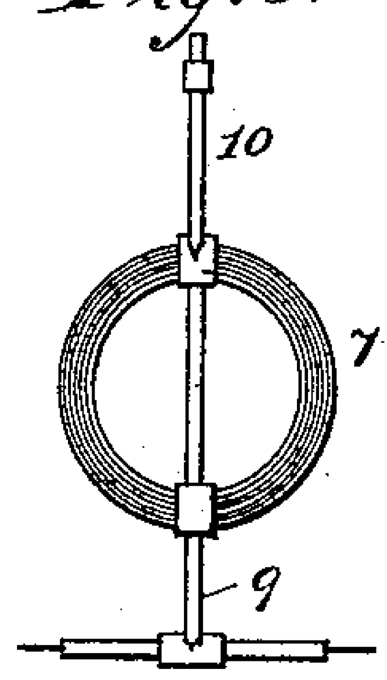

Fig. 8.

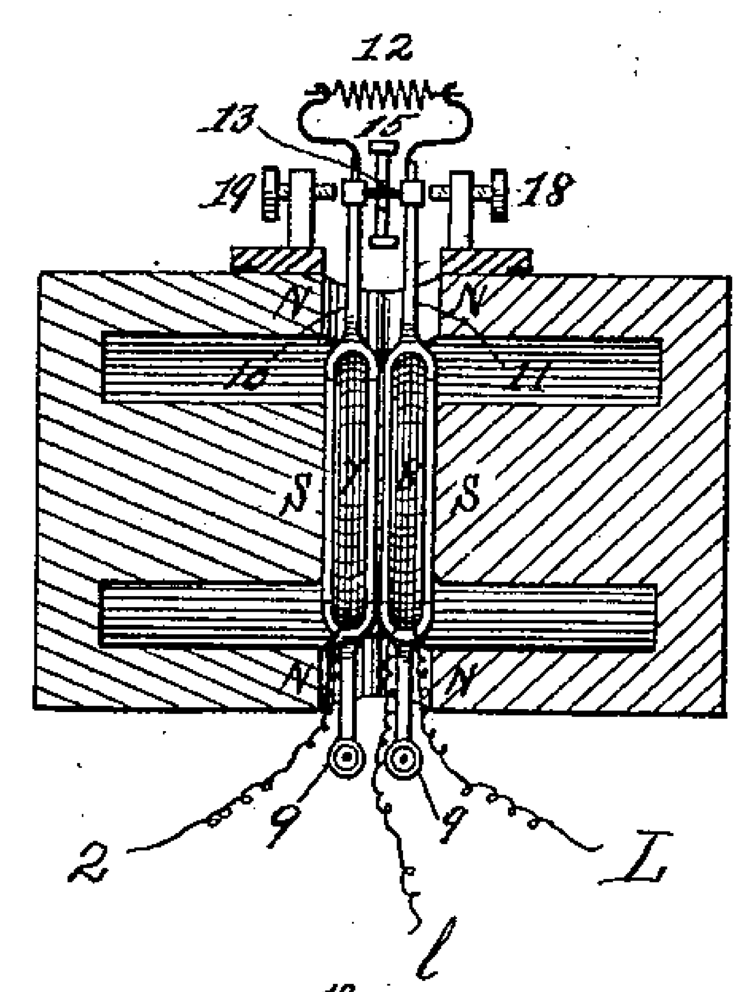

Fig. 5.

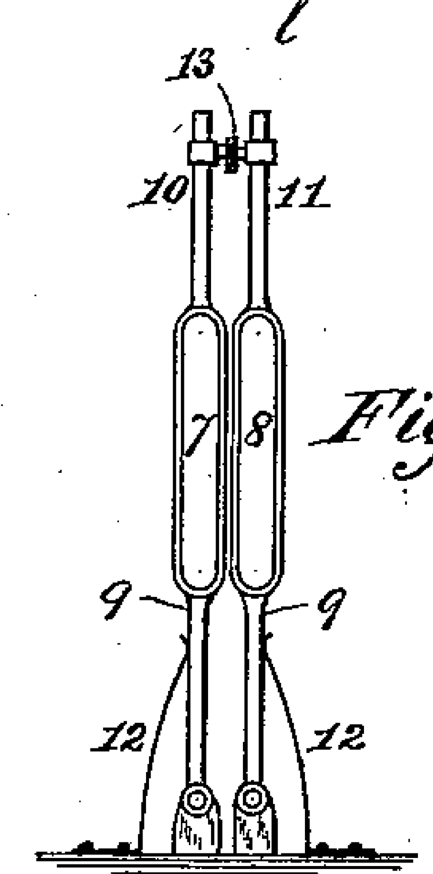

Fig. 9.

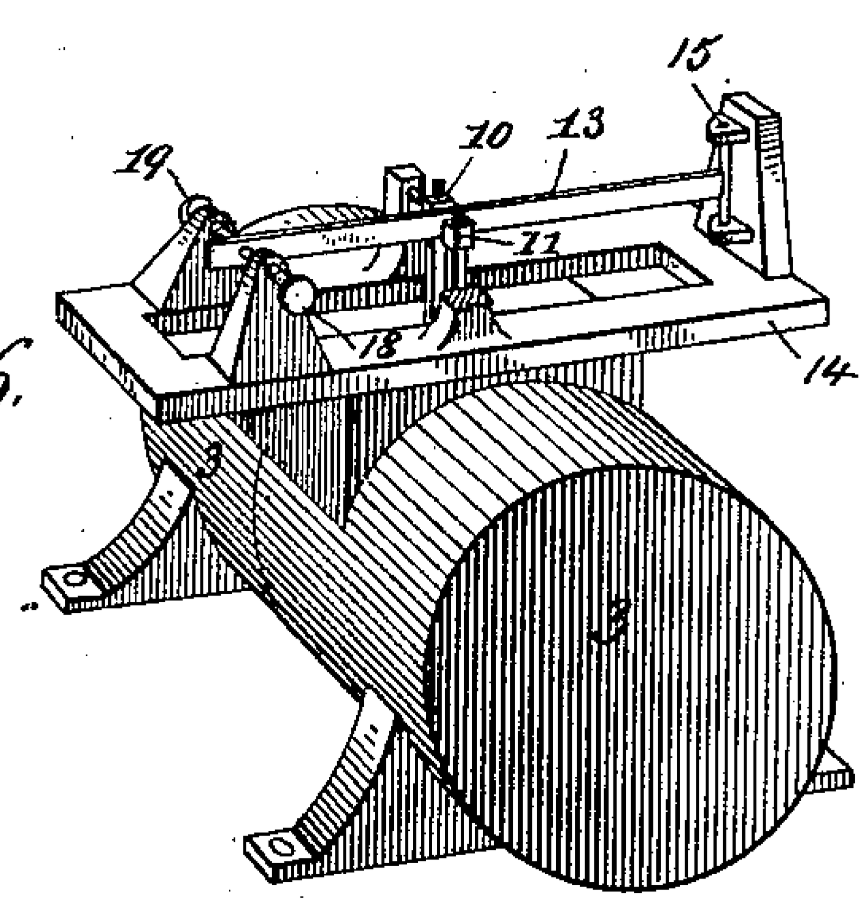

Fig. 6.

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(No Model.)

3 Sheets—Sheet 3.

S. D. FIELD.

TELEGRAPHY.

No. 389,883.

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Fig. 7.

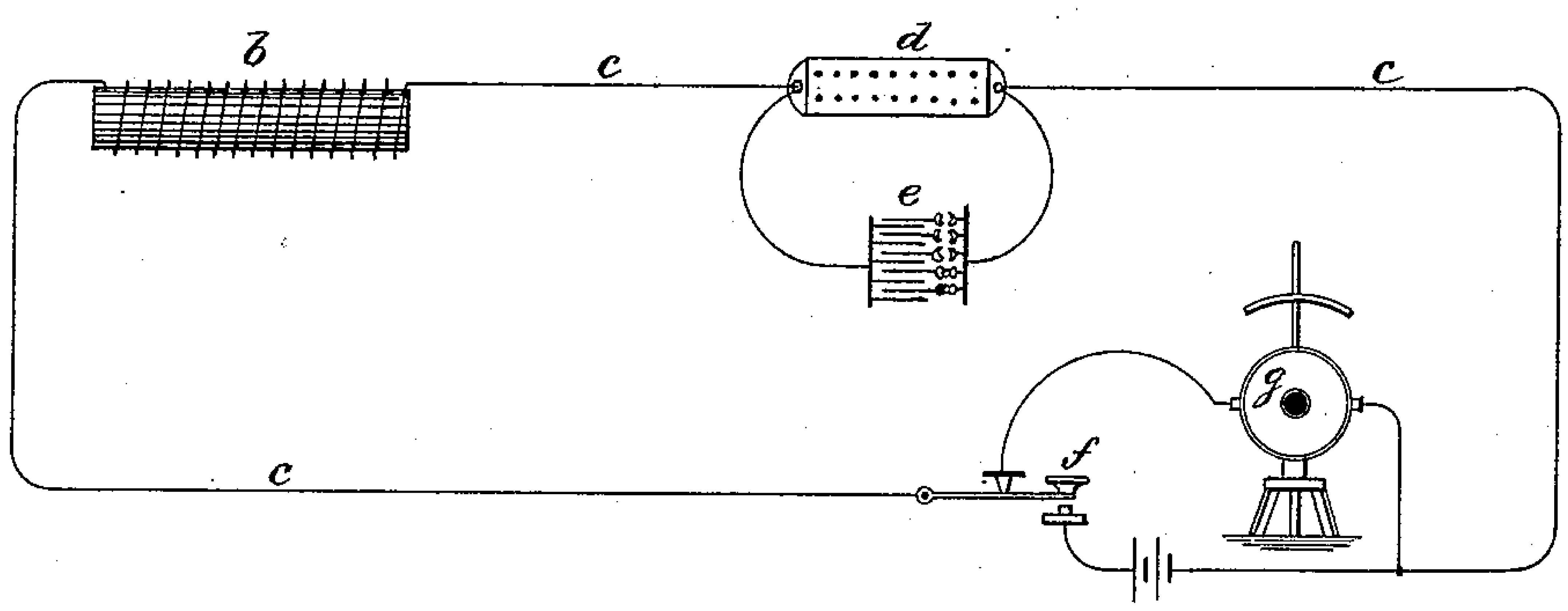


Fig. 10

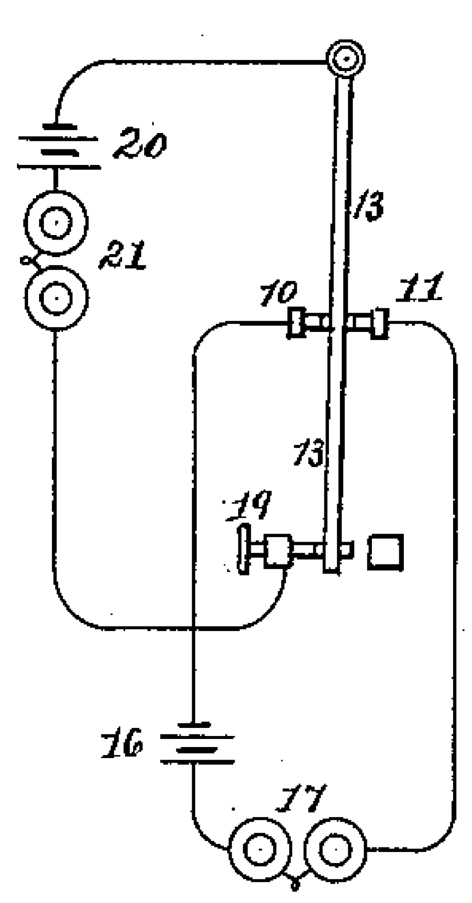


Fig. 11.

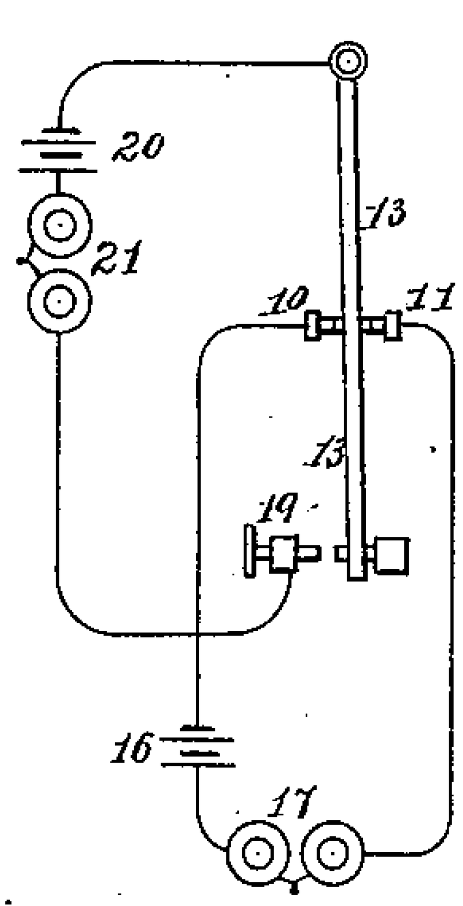


Fig. 12.

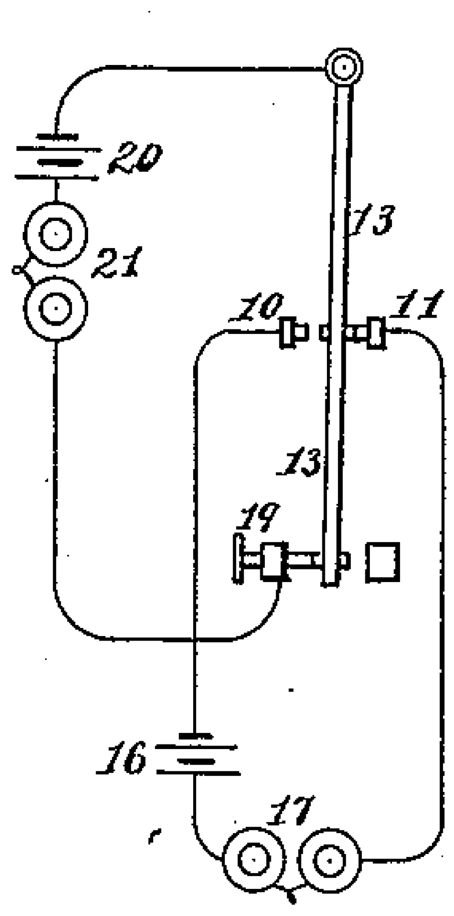
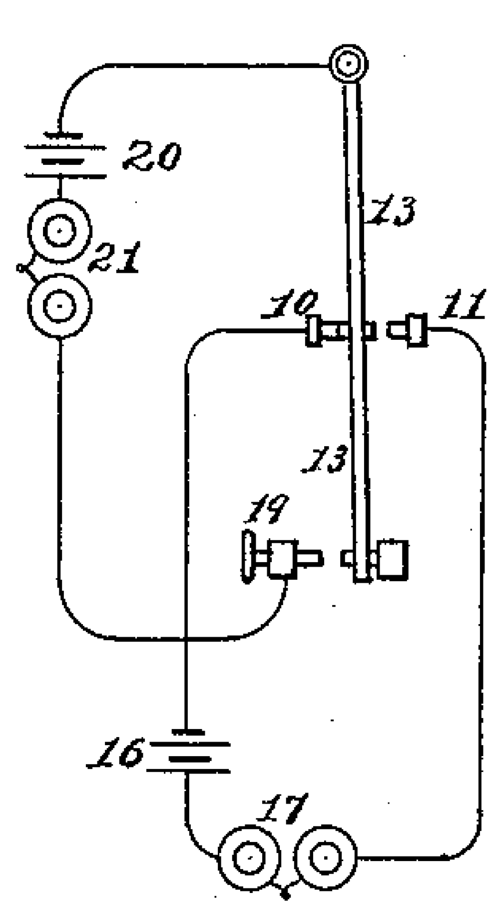


Fig. 13.



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UNITED STATES PATENT OFFICE.

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TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 389,883, dated September 25, 1888.

Application filed May 3, 1888. Serial No. 272,684. (No model.)

To all whom it may concern:

Be it known that I, STEPHEN DUDLEY FIELD, a citizen of the United States, residing at Yonkers, in the county of Westchester and State of New York, have invented certain new and useful Improvements in Multiplex Telegraphy; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to that class of systems of telegraphy known as "multiplex," and is more particularly designed for use in those quadruplex telegraph systems wherein one communication is sent by reversal of the battery, while the other is accomplished by a variation in the current strength irrespective of its polarity, or in other words one communication is made by what we may conveniently term "polarity transmission," and the other communication is had by means of what may be termed "increase" and "decrease" transmission.

The objects of the invention are to reduce the working resistance of the circuit to the lowest possible degree and eliminate the magnetic lag in the receiving-instruments, and by so doing remove two of the principal difficulties in the way of the operation of the system; further, to provide means whereby a very small line-current can, upon its arrival at the receiving station, be magnified to produce any desired mechanical effect; further, to sharpen up the rendering of the signals at the receiving-instruments, and thus increase the speed of transmission and the efficiency of the apparatus and diminish inductive effects upon adjoining circuits.

The invention comprises, in connection with the other devices hereinafter referred to, a special character of compound relay constructed for use in connection with the multiplex system, as before noted, and further comprises the general and particular organization and the arrangement and combination of devices, as hereinafter fully described and claimed.

In the drawings which form part of this specification, Figure 1 is a diagram illustrating the general arrangement of apparatus at a terminal station. Fig. 2 is a detail showing the compound relay and its local connections. Fig. 3 is a longitudinal vertical section of the relay field-magnet. Fig. 4 is a face elevation of one-half the relay with vibrating coil. Fig. 5 is a longitudinal vertical section of the relay. Fig. 6 is a perspective view of the same. Fig. 7 is a diagram illustrating the principle used to eliminate the magnetic lag. Fig. 8 is an elevation of one of the vibrating coils of the relay. Fig. 9 is a modified arrangement of the spring-pressure. Figs. 10, 11, 12, and 13 are diagrams illustrating the four operative relations of the relay-contacts.

As the general transmitting apparatus and dynamo-generator are not of the essence of the present invention further than their use in connection therewith, and as I have preferred to adopt the form and arrangement which are fully described and illustrated in Letters Patent issued to me November 23, 1886, No. 353,128, for improvements in multiple telegraphy, reference is hereby made to the said patent without further than a general description of the same.

A represents the generating-armature of the dynamo, having a small independent armature, *a*, as in the aforesaid patent.

B represents a device for obtaining harmonic alternating or vibratory impulses.

P represents the polarity-transmission key and pole-changing devices.

C represents the current-changing key, and I represents the impulse-key, all located at one terminal station as the various sending-instruments, the key P controlling the direct current from the armature *a*, and key C controlling a shunted current taken from intermediate points on the field-magnet coils of the dynamo, and the key I controlling the impulses taken from the independent special generator B. The finger-keys of each of these sending-instruments respectively act to close and open a local circuit through the actuating-magnets of said keys, so as to energize the said magnets from a common source of current—namely, the supplementary armature *a* of the generating-dynamo.

The relations and operation of the foregoing devices are fully set forth in said Letters Patent, and, as they form no essential part of this invention, I need not further describe them, as they may be all replaced by other devices and arrangements.

It is sufficient for my present purpose to say that the key P by opening and closing sends currents of alternately opposite polarity through the working circuit or line, that the key C by opening and closing sends currents of alternately different strengths but of constant polarity through the line, and that key I by opening and closing causes makes and breaks in a succession of rapid vibratory impulses, which are also transmitted over the line.

For the purpose of eliminating the annoyances of magnetic drag, which might be strongly developed when the coils of the dynamo-generator do not bear precisely the relations to each other in number of turns or resistance which they should, and thus produce the evils due to the extra current at moments of break in the transmission of signals, I make use of the following arrangement, which will be clearly understood by reference to Fig. 7. The retarding effect of magnetic coils *b* in a circuit, *c*, can be exactly compensated by inserting a resistance, *d*, in the circuit, and shunting this by a condenser, *e*, as shown. Either *d* or *e* may be adjustable, and by adjusting correctly the condenser will store just enough charge of opposite character during periods of "make" to exactly counterbalance the "kicking" effect of the magnet *b*, so that on opening the key *f* and instantly closing the circuit of galvanometer *g* no deflection can be discovered. I apply this principle, as shown in Fig. 1, by inserting a suitable resistance, R, and its shunted condenser H in the line between the dynamo-armature A and the pole-changer, and thus entirely prevent all the bad effects of magnetic retardation on the signals by the transmitting-instruments.

2 represents the trunk-line, over which are sent the various signals from all the keys.

L represents the line to the distant station, and *l* is what I have termed the "equating" or "balancing" circuit, as described in said previous patent.

The various currents in passing out of the sending-station to the line must traverse the receiving apparatus, which must be inert to them, but responsive to all impulses or signals coming from the distant station, and obviously must automatically effect the sorting out or selection, so that each of the ultimate receiving-instruments will respond to the signals intended for it and to these alone. These complex and delicate functions are performed in the most vigorous manner by my improved compound relay, which I will now describe in detail in the form preferred, stating generally the structure is that of two tubular electro-magnets, 3, brought face to face, having their similar poles in contact, the energizing-coils 4 being located in the annular space formed in the magnet, but not entirely filling the same, so as to leave an annular chamber inside at the mid-length of the structure. The two energizing-coils are so connected in series or multiple as to give the cores similar polarity, and the result is a completely-closed magnet having an intense consequent polarity, whose lines of force flow from the inner consequent pole to the surrounding outer consequent pole across the annular space between the two. The energizing-coils 4 are included in a local circuit with a battery, 5, and an adjustable resistance, 6, so that the strength of this annular magnetic field may be regulated to any desired or necessary extent and with great facility by one of the operators, and the adjustable resistance may be placed under the sole control of that operator whose instruments may require the most frequent adjustment—namely, the one who receives the increase and decrease impulses. Before placing the two halves of the magnet 3 together I insert therein two separate helices of insulated wire, (marked, respectively, 7 and 8,) which are coiled and shaped so as to freely move within the annular polar region of the magnet 3, and are carried on their own separate pivotal centers by means of the light frame 9, which frames 9 are provided with the respective tongues 10 and 11. The core and shell of the magnet 3 are perforated for the passage of these frames 9, as shown, in order to have the pivot and the tongue extending outside the said magnet 3.

Each of the helices 7 and 8 is differentially wound with two circuits, and the connections of these will be described farther on. While the two helices 7 and 8 are each separately pivoted, their upper ends or tongues are drawn toward each other with a moderate tension by means of the spring 12, which is insulated in any suitable way from both tongues. With such construction the coils 7 and 8 may be said to float in the annular magnetic field produced between the consequent poles of the magnet 3, and as they have no cores they are exceedingly sensitive with a small amount of wire in their construction, a few turns with a very small current passing being sufficient to produce a very strong movement of the coils and their tongues 10 and 11, and the sensitiveness for a given pair of coils may be increased or diminished to almost any extent by varying the current passing in coils 4 in accordance with the object aimed at.

The sensitive helices 7 and 8 are, as stated above, each differentially wound, and the two circuits so constituted are respectively connected at one side to the main line L and the equating circuit *l*, and on the other side are both joined to the trunk-line 2, as clearly indicated in Fig. 1. Hence the helices 7 and 8 will not be affected by outgoing signals.

As seen, the tongues 10 and 11 project upwardly through the opening in the top of the magnets 3 and clasp between them the pivoted contact-lever 13, which is set on a suitable frame, 14, so as to extend transversely across the magnet 3, as shown at Fig. 6, and the situation is such that the tongues 10 and 11 are about opposite the middle of the lever 13, which is substantially rigid throughout its length, but moves quite freely on its bearings 15. Both tongues 10 and 11 are provided with platinum contacts at the point where they bear against the lever 13, and the latter is always provided with a platinum contact to correspond. A local battery, 16, and sounder 17 are connected to the respective frames 9, which thus complete the circuit through the tongues 10 and 11 and the lever 13. The other sounder-circuit is arranged in the following manner: The lever 13 extends considerably beyond the tongues 10 and 11, and is provided with a suitable back-stop, 18, and contact 19, Contact 19 and lever 13 respectively form the terminals of the other local sounder-circuit containing the battery 20 and sounder 21, as shown. The lever 13 is perfectly free to move in either direction, having no retracting-spring, and its motion depends entirely upon the action of the tongues 10 and 11, which in turn of course depends upon the movements of the sensitive coils 7 and 8 either acting jointly or alone. The sounder 17 signals by breaking the local circuit and responds only to the increase and decrease signals from the distant station, while sounder 21 signals by closure of its local circuit and responds only to changes of polarity transmitted from the distant station.

In actual practice I prefer to have the magnet-coils 4 of a total resistance of about thirteen ohms and the interposed resistance 6 also about thirteen ohms.

Thus constructed the operation of my improved relay will be as follows: For the sake of clearness I will term the currents of alternating polarity as "positive" and "negative," and the currents of increased and decreased strength as "strong" and "weak." Now, the windings and connections of the floating coils 7 and 8 are such that the incoming weak positive and negative currents cause them both to vibrate together, while the incoming impulses of strong current will cause either one or the other of said floating coils to move away from its companion, so as to break the circuit through the sounder 17, which therefore becomes the recipient of the increase and decrease signals, such signals being given by the intermittent closing of the local circuits through the said sounder 17, and the signals due to the positive and negative currents of polarity transmission are given at sounder 21 by the break of its local circuit at the contacts 13 19 made by the vibration of the lever 13, which is caused by one or both tongues 10 and 11; or the condition of things may be better understood by the following table:

Weak positive: 13 19 closed; 10, 13, and 11 closed, Fig. 10.

Weak negative: 13 19 open; 10 13 and 11 13 closed, Fig. 11.

Strong positive: 13 19 closed; 10 13 open, Fig. 12.

Strong negative: 13 19 open; 11 13 open, Fig. 13.

It will thus be clearly seen that the polarity-transmission signals will not in any manner interfere with the increase and decrease transmission signals, or vice versa, and that in all cases the signals sent over the line by the distant-impulse key will consist of vibratory currents of such a high rate of vibration that they will not overcome the inertia of the sensitive coils 7 and 8 at the receiving-relay, but, on the contrary, will pass along the branch line through other special receiving apparatus, as in my former patent above mentioned.

The instrument is so sensitive that the parts need no adjustment whatever for polarity signals, and adjustment is required or desirable only for the increase and decrease signals, and therefore the means of adjustment which I provide is entirely under the control of one operator, and his actions in this respect to adjust his own side do not in any way affect the signals or the operation of the apparatus under the control of the other operator. In such adjustment, by means of the rheostat 6, the density of the lines of force cutting the sensitive coils 7 and 8 may be adjusted to any degree within the range of the power of the battery 5 or other source of current which might be substituted therefor. It is to be observed in following out the above description that there is no communication between the tongues 10 and 11 through the spring 12, as the latter is entirely insulated, and contact from 10 to 11 can be established only by the contact of both of them with the lever 13.

Many important advantages arise from the use of the foregoing apparatus in quadruplex or multiplex telegraphy. It does not depend for operation upon electro-magnetic attraction, since the sensitive coils 7 and 8 have no cores and consequently there will be none of the usual bad effects due to residual magnetism. As the sensitive coils float in a magnetic field and the sensitiveness depends upon the density of the lines of force in such field, I can secure all the desired results with a small number of convolutions of wire in said coils, with the result of eliminating much of the self-induction and consequent magnetic retardation. The adjustment is required only on the increase and decrease transmission devices, and as it is in the shape of an adjustable resistance placed in the local circuit its operation is accomplished with the utmost facility, and the resistance may be placed at a distance from the receiving-instruments, if so desired.

To illustrate the results obtained by the use of my improvements in comparison with the regular standard quadruplex, the following figures are worthy of consideration. Taking the line resistance at four thousand ohms, instruments one thousand ohms, seven hundred cells of battery at three ohms each, or two thousand one hundred ohms total, gives a grand total of seven thousand one hundred ohms resistance, which, under three hundred and fifty volts potential, would permit the flow of 0.05 ampères of current, whereas with my improvements (which permit the use of a dynamo-generator) I have line resistance four thousand ohms, instruments one hundred and twenty ohms, dynamo one hundred and fifty ohms, making a total of four thousand three hundred ohms, which, under three hundred and fifty volts potential, will permit the flow of 0.08 ampères of current—that is, sixty per cent. greater current than in the former case.

I am aware that a coreless coil has been made use of in the siphon-recorder for duplexing purposes; but in such use the conditions do not obtain, nor are the results similar, except in part. In a quadruplex or multiplex a wholly different state of affairs exists, and an entirely different problem is presented for solution. In a duplex system the difficulties due to residual magnetism do not arise, because the current is not varied in strength, and the tongue of the relay is moved forward or backward solely by reversal of the current in the line, whereas in a quadruplex system the relay-tongue is frequently caused to move in one direction with the full strength of current available, while in the opposite movement only one-third of the battery can be reliably employed to both move the relay-tongue and overcome the residual magnetism left by the full strength current of opposite polarity.

In my arrangement, as will be understood, the residual magnetism is substantially eliminated, as so few turns of wire are in the line-circuit that their effect upon the iron core may be neglected. Further, in a duplex system the resistance of the relay may be quite high without producing any disadvantages, because the entire battery strength is available for signaling purposes, whereas in a quadruplex but one-third of the whole battery strength can be always depended upon.

One of the principal advantages arising from the use of my herein-described improvements lies in my ability to use a very small current upon the line at all times, because the effect of the current from the distant station is greatly magnified at the receiving-relay to produce the desired mechanical effects. I do not mean by this that the strength of the line current is in any way increased by the presence of my special form of relay, but that the strength and sharpness of the signal transmitted over the line are very largely increased or magnified by the local polarization of the field whose lines of force the receiving coils 7 and 8, or either of them, cut in their movement. The practical result of this is that the strength of the arriving signal is equal to the strength of the line-current multiplied by the local polarization, and, as this local polarization may be of any desired strength or density, it is manifest that a very small arriving current can be made to effect a very pronounced armature movement at the receiving-station. A further result is in the fact that the local polarization is produced entirely by local means existing at the receiving-station, and cannot in any way whatever be affected by the leakage which may occur in the line, or by any changes of resistance therein, or by currents induced in said line from external sources. A further result of the foregoing invention, owing to the very small current which can be successfully used on the line, is in the fact that it cannot be the cause of any injurious inductive effects upon adjoining circuits.

I claim as my invention—

1. In telegraph apparatus, a receiving-relay consisting of coreless coils vibrating in a fixed magnetic field of adjustable strength.

2. In multiplex-telegraph apparatus, a receiving-relay having two coreless coils, each differentially wound, and said differential windings included, respectively, in the main circuit and an artificial or equating circuit, substantially as described.

3. In a multiplex-telegraph system, one or more suspended coils included in the main circuit and an independently-energized magnetic field of adjustable strength combined therewith, substantially as described, whereby the mechanical or visual effect of the line-currents is capable of enlargement to any required extent.

4. In a multiplex-telegraph system, a receiving-relay having a coreless vibrating coil included in the main circuit and an independently-excited annular field-magnet of adjustable strength whose lines of force cut said coil radially.

5. A receiving-relay having a coreless vibrating coil included in the main circuit, in combination with a separately excited field-magnet and local-current adjusting devices therefor independent of said relay.

6. A receiving-relay having two coreless coils differentially wound, mounted on separate centers of vibration, and a field-magnet common to both.

7. A receiving-relay having two coreless coils differentially wound and included in the main circuit, both located in a single magnetic field and capable of independent movement.

8. A receiving-relay having two electro-magnetic movable coils differentially responsive to polarity and current changes and a single magnetic field common to both.

9. A receiving-relay having two coreless coils differentially wound and capable of independent movement, in combination with a magnetic field energized from an independent source.

10. In multiple-telegraph apparatus, a receiving-relay having two coreless coils differentially wound and included in the main circuit and capable of independent movement, in combination with a separately-excited magnetic field of adjustable density.

11. In multiple-telegraph apparatus, a receiving-relay having two differentially-vibrating coils in a single magnetic field responsive to both polarity and current changes and two local sounder-circuits adapted to be independently closed and opened by the movement of said vibrating armatures.

12. In multiplex-telegraph apparatus, a receiving-relay having two vibrating tongues, in combination with an interposed pivoted lever

and suitable contacts, and an insulated spring normally holding the tongues in contact with said lever, and a local sounder-circuit completed through said tongues and lever when the three are in mutual contact, substantially as described.

13. A receiving-relay having two vibrating tongues, an interposed pivoted lever, a contact within the range of movement imparted to the lever by said tongues, and a local sounder-circuit completed through said lever and contact, substantially as described.

14. A receiving-relay having two differentially-wound vibrating coils suspended in a fixed magnetic field within inductive range of each other, two independent local sounder-circuits controlled by the movements of said coils, and means for adjusting the strength of said magnetic field, substantially as described.

15. A telegraph-relay comprising a closed tubular electro-magnet with consequent annular field around the middle of its core, in combination with one or more vibrating coils suspended therein, so as to surround the core, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

STEPHEN DUDLEY FIELD.

Witnesses:
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W. L. CANDEE.