(No Model.) 3 Sheets—Sheet 1.

S. D. FIELD.

VIBRATORY TELEGRAPHY.

No. 491,163. Patented Feb. 7, 1893.

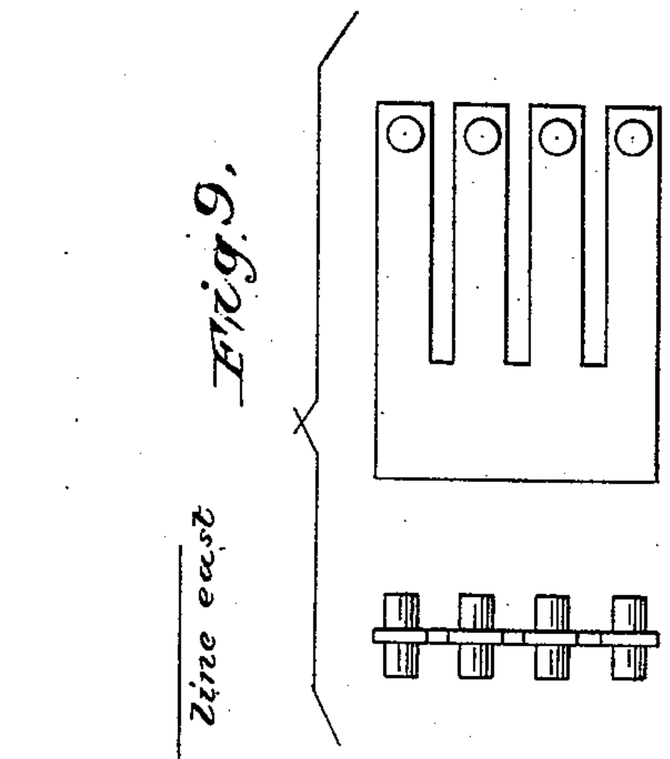

Fig. 9.

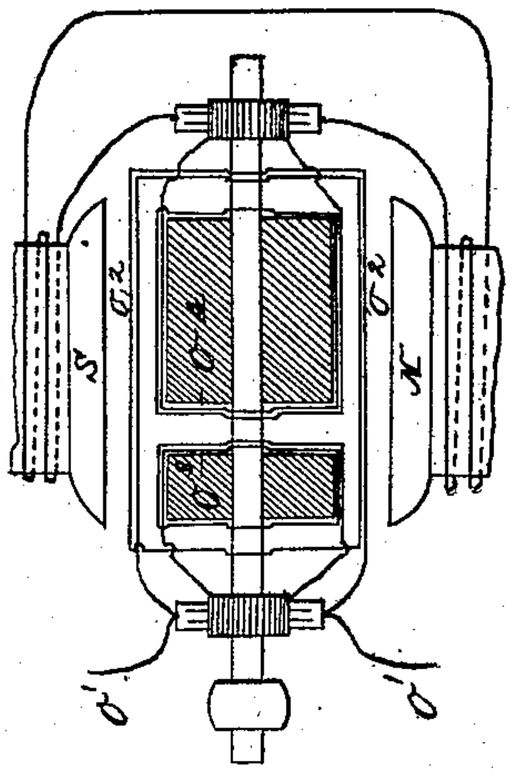

Fig. 10.

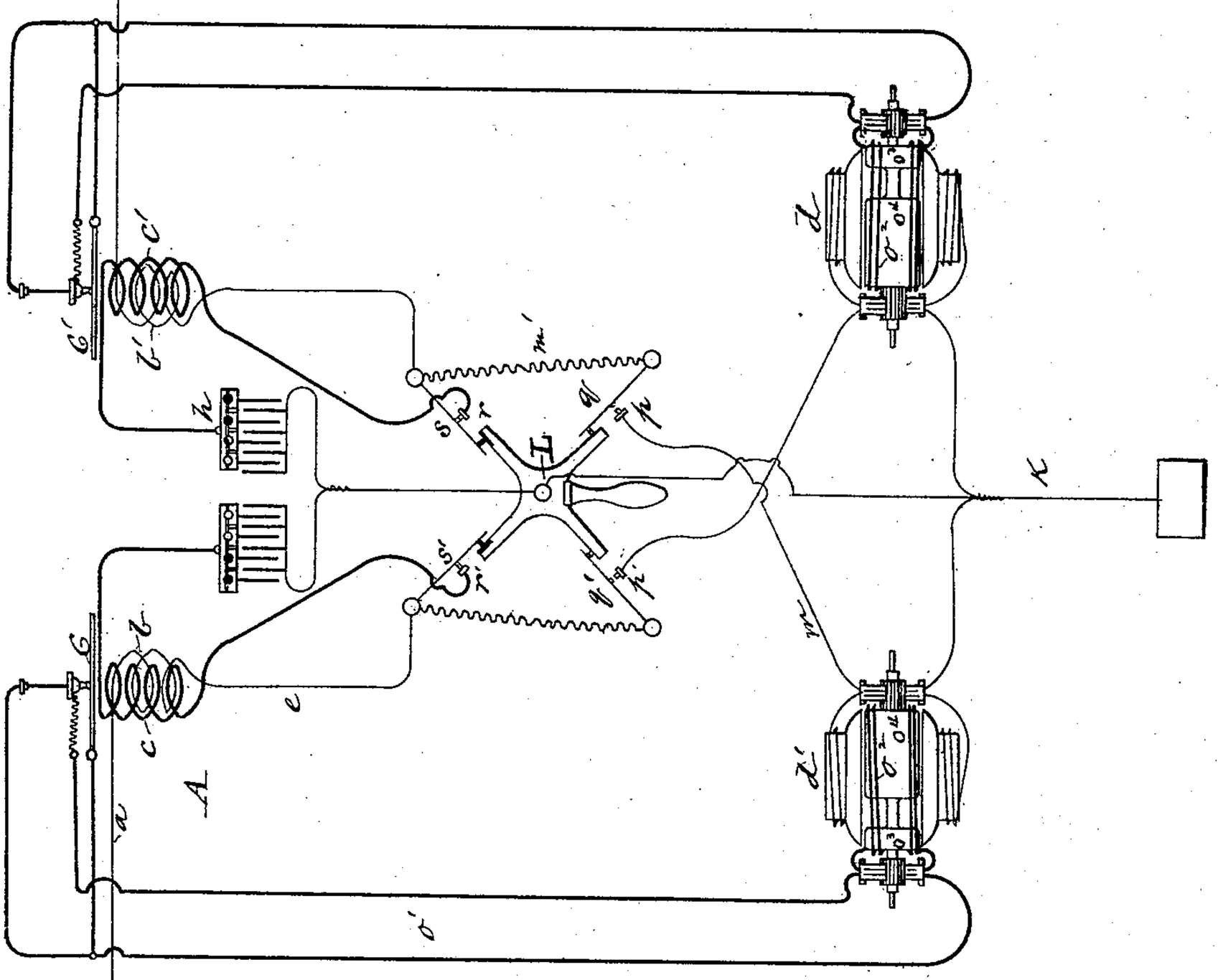

Fig. 1.

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S. D. FIELD.

VIBRATORY TELEGRAPHY.

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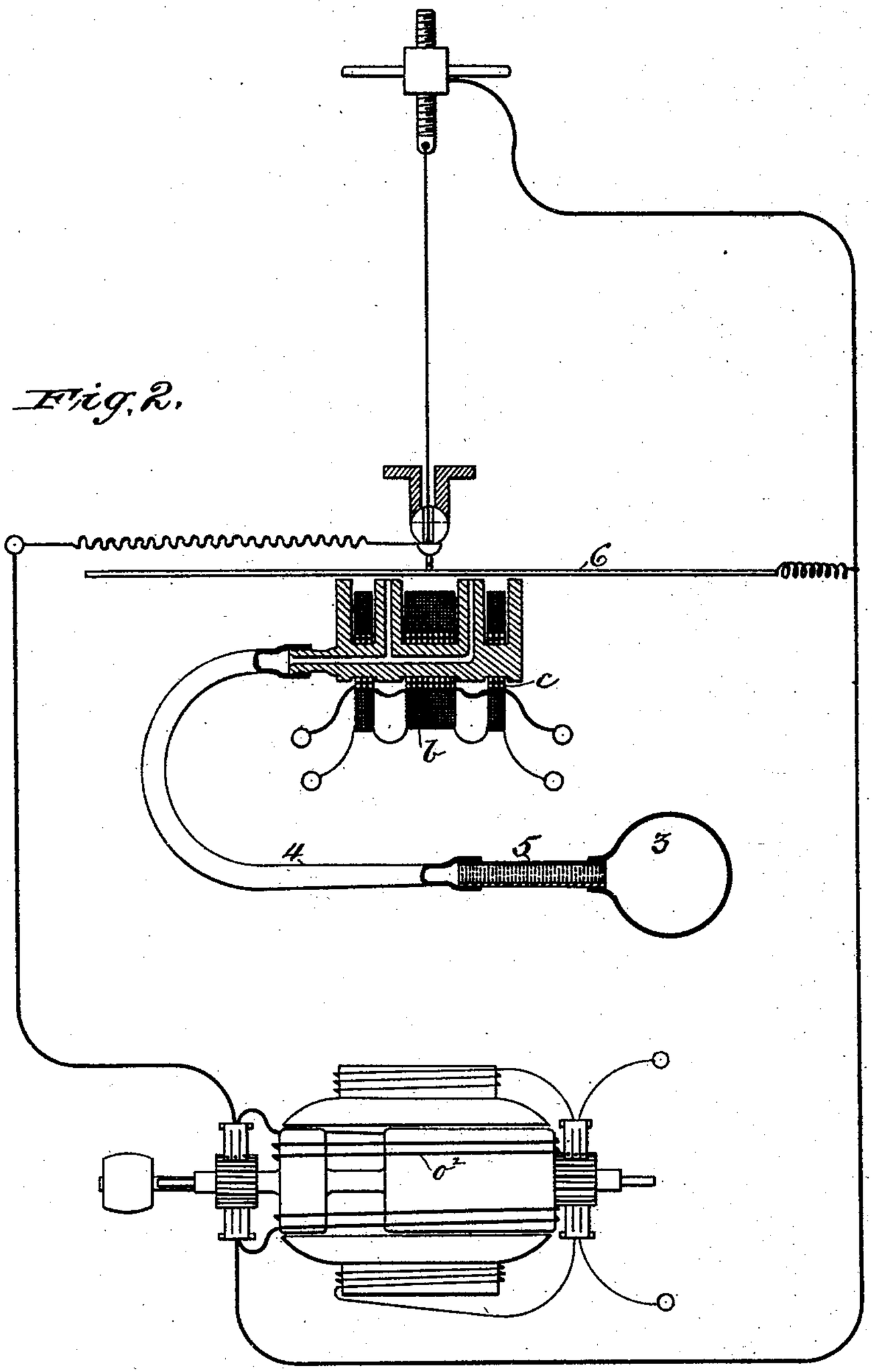
Fig. 2.



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(No Model.) 3 Sheets—Sheet 3.

S. D. FIELD.

VIBRATORY TELEGRAPHY.

No. 491,163. Patented Feb. 7, 1893.

Fig. 3.

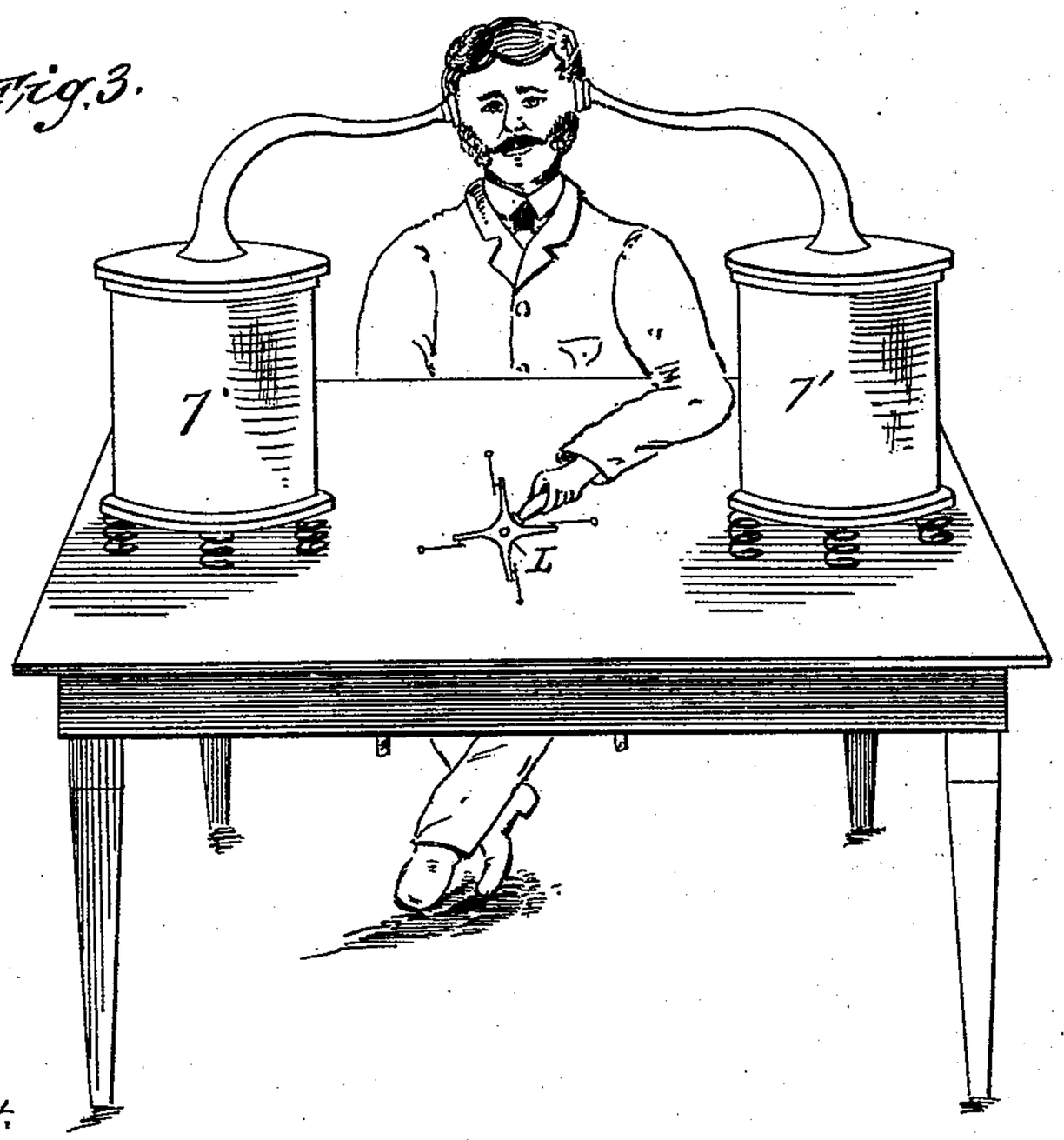


Fig. 4.

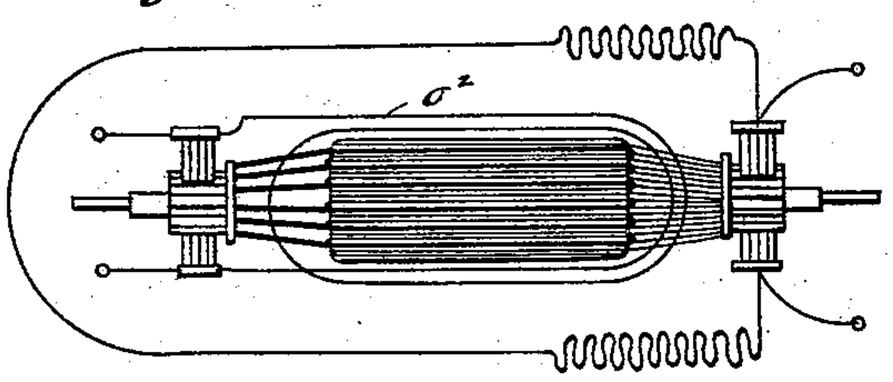


Fig. 5

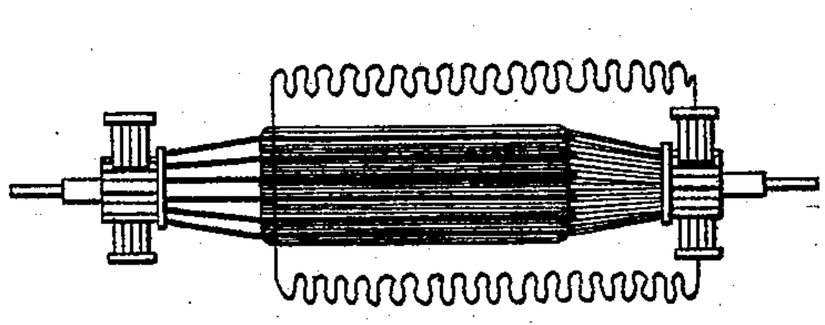


Fig. 6.

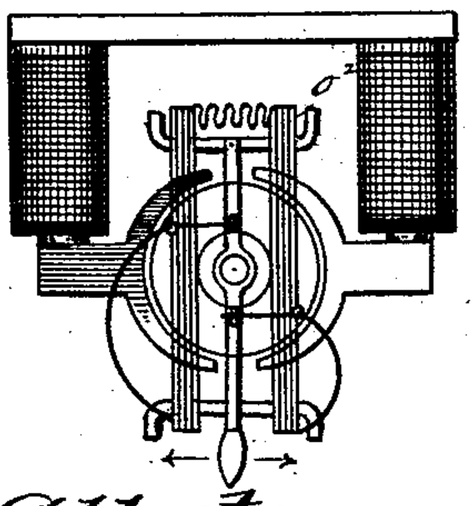


Fig. 7.

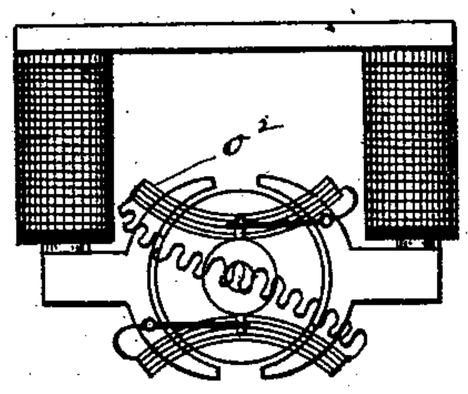
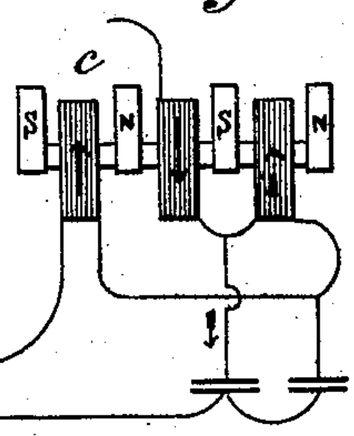


Fig. 8.



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UNITED STATES PATENT OFFICE.

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VIBRATORY TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 491,163, dated February 7, 1893.

Application filed January 7, 1892. Serial No. 417,249. (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 Vibratory 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.

The object of this invention is first to establish direct inter-communication of intelligence between two or more distant stations by means of electrical vibrations or undulations to a greater distance than has heretofore been possible, and second, to increase indefinitely the distance limit of inter-communication by providing means by which the vibrations or undulations which communicate the intelligence may be faithfully repeated from one electric circuit to another. When electric vibrations or undulations of a very rapid character are transmitted over an electric circuit it is found in practice that a distance limit over which reliable communication is possible is soon reached. This is especially the case in transmission of speech and in such systems of multiplex telegraphy as utilize a great number of vibrations or undulations on the line at the same time. My present invention is designed to increase indefinitely the distance limit of such communication. The result may be accomplished by rendering the receiving apparatus more sensitive; by providing transmitting apparatus which will produce greater fluctuations of the transmitting current; or by using relays to throw upon the distant section of the line electrical vibrations or undulations of greater electro-motive-force but of the same character as those received by the relays. In carrying my invention into practice all of these provisions may be adopted.

The invention comprises an improved receiver of great sensitiveness to electrical vibrations, such receiver being capable of use as a receiver in a simple circuit or as a relay for repeating vibrations into other circuits.

It comprises also an improved means of raising the tension of a current so as to give the same a high electro-motive-force and render it capable of overcoming a great line resistance, said means comprising an armature of an electric generator wound with independent circuits, one of which is connected to line, and the other of which is connected to current varying devices in the local circuit. More specifically considered the means for raising the tension comprises a dynamo electric machine provided with carbon brushes on its commutator and provided with two circuits, one of which is operated by the undulations the tension of which is to be raised, and the other of which is connected to line circuit.

The invention also comprises means for preventing the absorption of vibrations of great frequency or short period, to produce upon the receiving instrument a reaction which is a faithful reproduction of the action of the transmitting instrument upon the line.

The invention also comprises various other features of novelty which will be hereinafter more fully described in the specification and definitely indicated in the appended claims.

In the accompanying drawings which illustrate the invention, Figure 1 illustrates a system embodying my invention, showing in detail the apparatus at a station where the vibrations or undulations are repeated from one line circuit to another; Fig. 2 is an enlarged view of the dynamo and relay or receiving instrument; Fig. 3 is a perspective view of a repeating apparatus showing the method of isolating the same from interfering vibrations; Figs. 4, 5, 6 and 7 show different modes of arranging the circuits of the dynamo electric machine by which the tension of the current is raised at a transmitting or repeating station; Fig. 8 is a detail view showing a mode of preventing the absorption of undulations of very rapid frequency in their passage through the coils of the receiving or transmitting magnet; Fig. 9 illustrates the brush used on the dynamo electric machines of the system; Fig. 10 shows the arrangement of circuits on the generator.

I use the same magnetic arrangement for transmitting, repeating or receiving the electric vibrations or undulations. In order to obtain the necessary delicacy of armature movement to respond to extremely weak vibrations I arrange the diaphragm or other inharmonious armature so closely in proximity

to the poles of an electro-magnet that under ordinary circumstances the attraction incident to the polarization of the magnet would cause it to come into contact with the poles. Such contact if permissible in receiving instruments such as telephones would render a faithful receiving of the line undulations impossible. To guard against such contact I provide an air spring or cushion between the diaphragm and the magnet poles. This may be practically carried out in an efficient manner by boring a hole through the core of the magnet or magnets and causing a stream of compressed air to pass through this hole and impinge upon the diaphragm. The air provides a separating medium of extreme mobility and holds the armature away from the face of the magnet without in any way hampering its sensitiveness, so that I am enabled to use a diaphragm of extreme mobility and at the same time have it under an intense magnetic stress by mounting it close to the magnet poles. The air thus acts as a spring or inharmonic elastic cushion for the diaphragm opposing the normal strain due to magnetic attraction and permits me to use an exceedingly thin and mobile diaphragm. The loss of magnetic substance is compensated for by a multiplicity of polar faces which by their distribution over the diaphragm afford a sufficient path for the lines of force. The air may be compressed by any well known mechanical method. To guard against pulsations or outside vibrations being carried through the compressed air to the armature I arrange between the reservoir for compressed air and the tube leading to the magnet a separator consisting of a tube filled with wire gauze partitions; or layers of sponge or other deadening substance may be substituted. This structure is illustrated in detail in Fig. 2, where 3 represents a compressed air reservoir in which the air may be compressed by any suitable mechanism, and 4 represents a flexible tube which may have thick walls of rubber or felt, between which is inserted a separator 5 containing a number of transverse wire gauze partitions which will permit the transmission of the compressed air but will deaden any vibrations tending to pass from the air reservoir to the tube 4. The electro-magnet as shown is multipolar in character, its core being perforated for the transmission of the compressed air which impinges upon a diaphragm 6 and holds the latter out of contact with the cores. The magnet and its operative parts are preferably inclosed in a vessel as 7, 7′, see Fig. 3, by which the diaphragm is protected from outside vibrations. The diaphragm reacts upon a local circuit connected with or forming a shunt to the armature of a dynamo electric machine so that variations in resistance of this circuit created by the vibrations of the diaphragm will weaken or strengthen the current flowing through the armature coil and thus change the potential of the current thrown upon line by the dynamo.

The specific organization of apparatus by which the changes in resistance of the shunt circuit are caused by the diaphragm is similar in character to apparatus described in Letters Patent heretofore issued to me and numbered 433,120, dated July 29, 1890. It comprises a back stop carrying a contact co-operating with a contact on the diaphragm, the back stop being elastically mounted on some inharmonious substance, as, for example, soft rubber. The diaphragm contacts are in circuit of the dynamo shunt and in a shunt around the contacts is placed a German silver wire under tension. When the resistance through the contacts varies more or less current is shunted through the German silver wire which is of such tenuity that the variations in temperature developed by such changes in current strength will cause it to expand or contract and follow or recede from the diaphragm with great rapidity and reproduce in the shunt circuit the faintest vibrations which are impressed upon the diaphragm by the electro-magnet. At the transmitting or repeating station I employ for the purpose of raising the tension of the line current an apparatus in which there is a condition of magnetic stress and in which there are two circuits of low and high potential respectively. This result may be obtained by various devices, as, for example, by a polarized core upon which are wound low and high voltage coils, but the best device I have yet discovered is a shunt wound dynamo electric machine in which carbon brushes of a type invented by Mr. Rudolf Eickemeyer are used; this type of brush is illustrated in Fig. 9 in plan and side elevation, and comprises a series of independent springs carrying sticks of arc light carbon. The local circuit influenced directly by the vibrations or undulations is in shunt relation to one of the dynamo circuits and an independent high voltage circuit is carried from such dynamo to the outgoing line. I have discovered that the carbon brushes of the pattern referred to run so noiselessly upon the commutator that when carrying current no fret or tear is noticeable in the most delicate mechanism included in the circuit. These brushes consist of a series of carbon pencils carried by independent springs and bearing in a line upon the commutator. Their efficiency in such a system as this probably results from the fact that a perfect contact is maintained and no sparking occurs. The shunt dynamo has several very important advantages to a signaling system and especially such a signaling system as involves the transmission of speech. At uniform speed absolutely uniform currents are obtainable and there is thorough absence of inductive retardation in the passage of rapid electrical vibrations, which cannot be said of ordinary electro-magnets.

The circuits upon the dynamo may be variously arranged, as illustrated in Figs. 1, 2, 4, 5, 6 and 7. In Figs. 1 and 2 the armature is provided with two independent cores, one of which is wound with a low resistance coil O^3, and the other of which is wound with a high tension coil O^4. In shunt relation to the low resistance armature is a separate circuit O^2, the coils of which are fixed and surround both the other armature circuits and will influence both of them. Any fluctuation of resistance in the local circuit therefore produced by the movements of the transmitting or repeating diaphragm not only varies the magnetism of the low resistance and thereby reacts on the high resistance circuit but also acts directly on the high resistance circuit. The latter is therefore affected both by the direct action upon its core of the shunt circuit O^2 and by the increased output of the machine developed by the increased excitation of the low tension armature.

The field-magnet of the machine may bo excited by a shunt from the high tension circuit as illustrated.

In Fig. 4 is shown a system of winding in which the two armature circuits of the generator are wound upon the same core but deliver their currents to separate sets of brushes. Surrounding the common core is the coil o^2 analogous in all respects to the coil o^2 of the machine illustrated in Figs. 1 and 2.

In Fig. 5 the auxiliary exciting coil o^2 is omitted and the low resistance armature coil alone is relied upon to vary the output of the machine.

In Figs. 6 and 7 the coil o^2 is capable of angular adjustment with relation to the armature poles or diameter of commutation of the low potential armature so that its inductive effect upon the armature may be varied. The preferable mode of mounting it is as shown to have it surround the armature and mounted upon a fixed part of the dynamo frame so as to be capable of partial rotation.

It is well known that rapid electrical vibrations experience a damping effect when caused to pass through a wire coiled parallel to itself, the effect being greatly magnified when the coil surrounds a core of iron as is the case in electro-magnets. The more minute the periodicity of the vibrations the more damaging the effect of a given length of coiled wire. In some forms of apparatus where the coils of wire are of sufficient length to give a strong magnetizing effect to long impulses in a series of pulsations of variable length, any short impulses in the series will be completely damped or wiped out so as to have no effect upon the cores around which they should circulate. This defect may be largely overcome by arranging a battery of small magnets in series, each of a size to accommodate the most minute impulses employed. The line currents after passing the first magnet find a return through a condenser provided between the coil or magnet and the one next in series, a more prolonged impulse serving to fill this condenser and energize the next magnet of the series and so on through the set. To adapt this arrangement to my improved receiver I proceed as in Fig. 8 where the current first passes through the center coil thence through the one to the right and finally that of the left finding partial circuit in transit *via* the condenser shown.

Having thus described the several parts of my system, I will now describe their arrangement for co-operation in the transmitting or repeating of electrical vibrations or undulations.

In Fig. 1 is represented a station in which two lines terminate. Both lines are normally grounded through a coil of a receiving magnet and an improved button switch. The dynamos used in the system are continuously in action at a constant speed. If the line west is in action current will pass from line wire *a* by way of coil *b* and wire *e* to switch L and ground by wire *k*. Any fluctuations in the current on line causes variation at the points of contact in the relaying diaphragm and varies the resistance of local circuit *o'*. The operator at the repeating station upon hearing a signal proceed from the western instrument will throw the switch L to the left, thus providing for a repeating of the vibrations transmitted over the western line to the eastern line. Every change of load in the local circuit *o'* developed by the movements of the diaphragm of the instrument at A will react upon the dynamo. As shown in the diagram an independent dynamo is provided for each circuit. It is obvious however that as but a single machine is connected to either circuit at the same time one machine might be made to answer the purpose. The switch being thrown to the left to connect the western line to the eastern line cuts into action the dynamo *d'*, closing a circuit for its high tension armature coil through wires *k m* contacts *p q* wire *m'* coil *b'* and line. An artificial circuit is closed by way of circuit *k m p q m' s r* coil *c'* adjustable condenser *h* and wire *k* to earth. The auxiliary coil *c'* and the artificial circuit just traced are for the purpose of deadening the effect of the current on the home instrument. Should the attendant note any irregularity in the signal going out on the eastern side he will understand that the person at the distant end of the eastern line desires to break, when a reversal of his switch will give the eastern operator the command of the circuit. When the switch is in midway position both dynamos *d* and *d'* are detached and both relays are operated by currents circulating through both of their coils in series and finding earth through their attached condensers. The four arms of the switch and the four pairs of co-operating contact points permit of either dynamo being thrown upon the real and artificial lines corresponding to either the line east or the line west by a single movement, and in the nor-

mal condition of the apparatus both lines east and west can call the intermediate operator but are disconnected from each other. Normally the inductive devices, in this case the dynamo electric machines, are on open circuit; as soon, however, as the switch L is turned the lines east and west will be thrown into communicating relationship. The dynamo raises the low electro-motive-force of the incoming currents to a high limit and will repeat faithfully fluctuations or undulations of the calling or speaking circuit. The armature being in a condition of magnetic stress the faintest fluctuation of resistance in circuit *o'* will be transferred with magnified strength to the outgoing line. At a terminal station the transfer switch L will of course not be needed. The equipment of such a station might be the ordinary equipment for throwing signals upon the line whether the impulses accompanying such signals be intermittent, pulsatory or undulatory in character. If a tension raising device such as the dynamo I have described be used the local circuit will be connected with the current varying devices and the high tension circuit with the line.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:—

1. The combination of a local circuit including signal transmitting devices, a line circuit, and low and high tension coils connected to the respective circuits, said coils being in inductive relation to the magnetic system of a continuously operating dynamo electric machine.

2. In a signal or intelligence transmitting system a local circuit containing resistance varying devices, a dynamo electric machine having such circuit in shunt relation to a low resistance armature coil, and an auxiliary high tension armature coil connected to line.

3. The combination with a signaling system, of a dynamo electric generator having its armature adapted to be connected to line, and a shunt to an armature polarizing coil including a local circuit containing signal transmitting devices.

4. The combination of a local circuit, a line circuit, and a dynamo electric machine having its armature discharging through carbon brushes into said circuits, the local circuit being in shunt relation to one pair of brushes, said dynamo electric machine being in continuous operation during transmission.

5. The combination of a local circuit, a line circuit, and a dynamo electric machine having its armature discharging into said circuits through carbon brushes having multiple and independently movable carbon contacts, the local circuit being in shunt relation to one pair of brushes, said dynamo electric machine being in continuous operation during transmission.

6. The combination of a dynamo electric machine having independent high and low potential windings on its armature and independent pairs of brushes for the two windings, a local and line circuit connected to the respective windings, the local circuit containing current varying devices, and a coil electrically connected to the local circuit, said coil being in inductive relation to the high potential circuit.

7. The combination of a dynamo electric machine having independent high and low potential windings on its armature, local and line circuits connected to the respective windings, the local circuit containing signal transmitting devices and being in shunt relation to a coil inductively related to both armature windings.

8. The combination of a dynamo electric machine, independent high and low potential windings, a line circuit connected therewith a local circuit including signal transmitting devices and a regulating coil connected with the local circuits surrounding the armature and fixed relatively to the line of commutation.

9. The combination of a dynamo electric machine, having independent high and low potential windings, a line circuit connected with the high potential circuit, signaling transmitting devices connected with the low potential circuit; and a coil controlled by the signal transmitting devices for varying the output, said coil surrounding the armature and being angularly adjustable with relation to the line of commutation.

10. A transmitting or receiving instrument for electric vibrations or undulations comprising an electro-magnet and an armature therefor controlled by a gaseous retractile agency.

11. A transmitting or receiving instrument for electric vibrations or undulations comprising an electro-magnet and an armature therefor held retracted by the pressure of a gaseous current.

12. A transmitting or receiving instrument for electric vibrations or undulations comprising an electro-magnet, and a diaphragm or other inharmonious armature therefor, said diaphragm being held in a retracted position by a current of air.

13. In a signaling system a relaying or repeating station at which the lines from the terminal stations are normally grounded, transmitting or receiving instruments at the relay station in communication with each line, each instrument being surrounded by a vibration damping material for the purpose described, and provided with externally projecting mouth or ear pieces, whereby an operator may communicate with both lines, means for reinforcing vibrations or undulations from either line, and a switch controlled by the operator for placing this reinforcing agency in operative relation to either line.

14. A transmitting or receiving instrument provided with a vibratory armature, an electro-magnet, and a retractile agency consisting of a stream of compressed air, means for iso-

lating the armature from disturbing local vibration, and means for excluding vibration through the stream of air.

15. A transmitting or receiving instrument for signaling systems operated by electric vibrations or undulations of varying frequency, having sectional coils, each section having an independent return path, adjacent sections being reversely wound, separate magnetic circuits being provided for each section.

16. An electro-magnet for responding to electric vibations of varying character, having a series of coil sections in series successive sections being reversely wound, a common core, a pole piece at both ends of each section, and an armature acted upon by all of the pole pieces.

17. An electro-magnet having connected at one or more intermediate points of its convolutions, one or more condensers, said condenser being connected with a return path from the electro-magnet, whereby impulses of different character may pass more freely.

18. A transmitting or receiving instrument having a number of coil sections and one or more condensers connected in shunt relation to the line and the several coil sections.

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

STEPHEN DUDLEY FIELD.

Witnesses:
HENRY OSTERHELD,
RUDOLF EICKEMEYER, Jr.