(No Model.) 5 Sheets—Sheet 1.

S. D. FIELD.

VIBRATORY MULTIPLEX TELEGRAPHY.

No. 395,556. Patented Jan. 1, 1889.

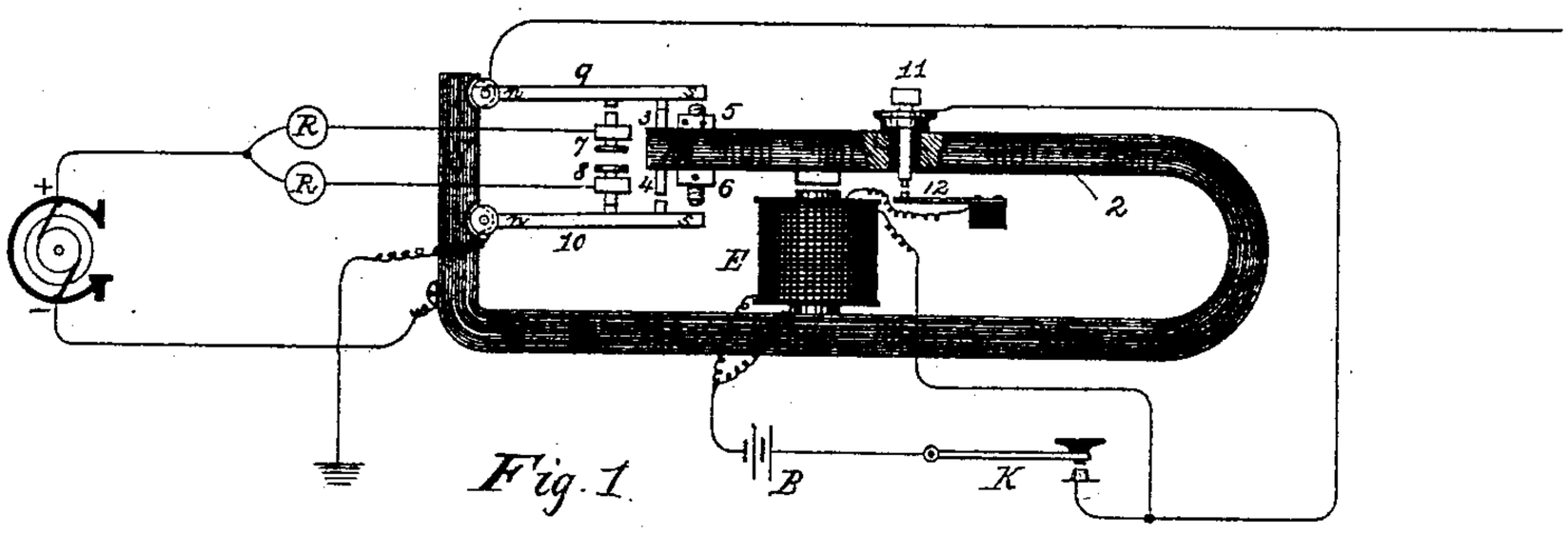


Fig. 1.

Fig. 2.

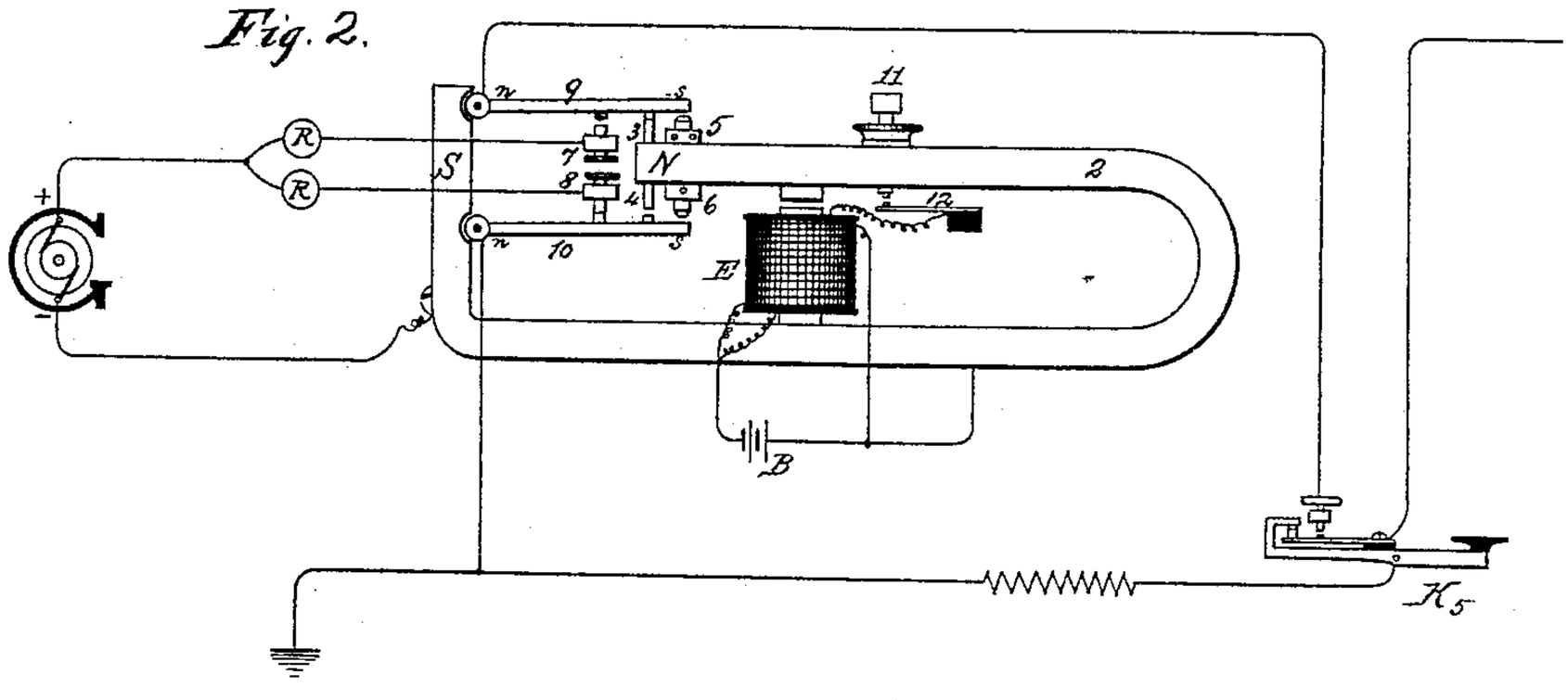
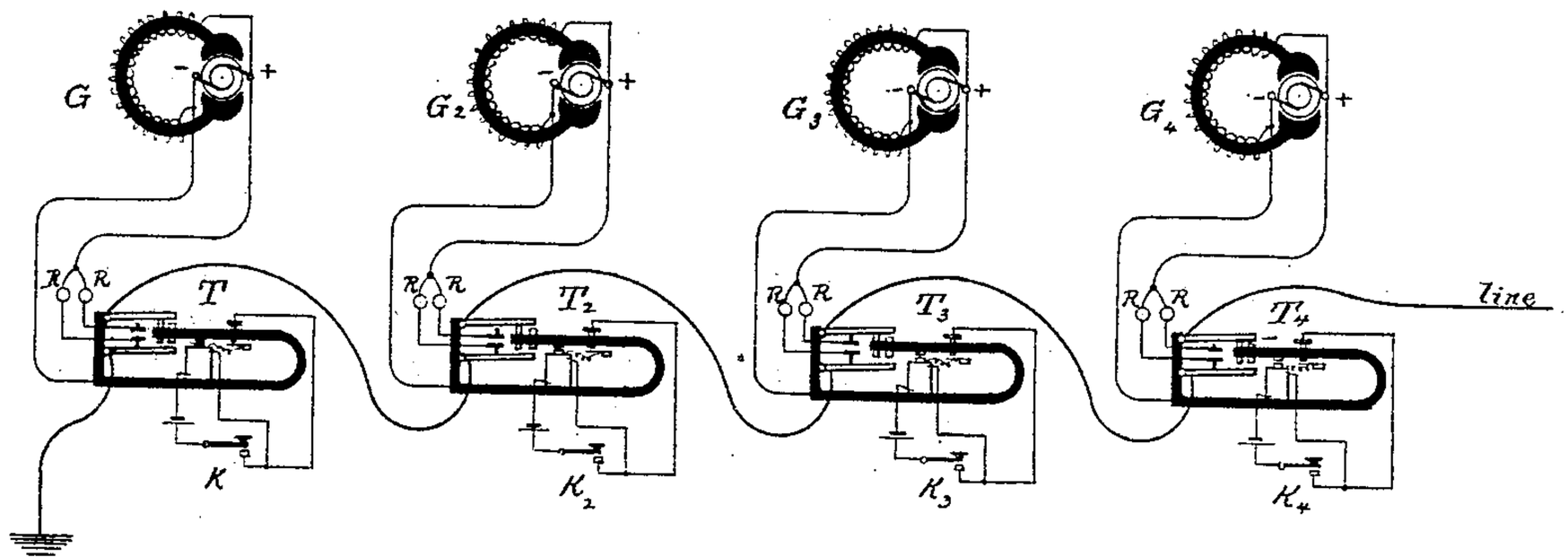


Fig. 3.



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5 Sheets—Sheet 2.

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VIBRATORY MULTIPLEX TELEGRAPHY.

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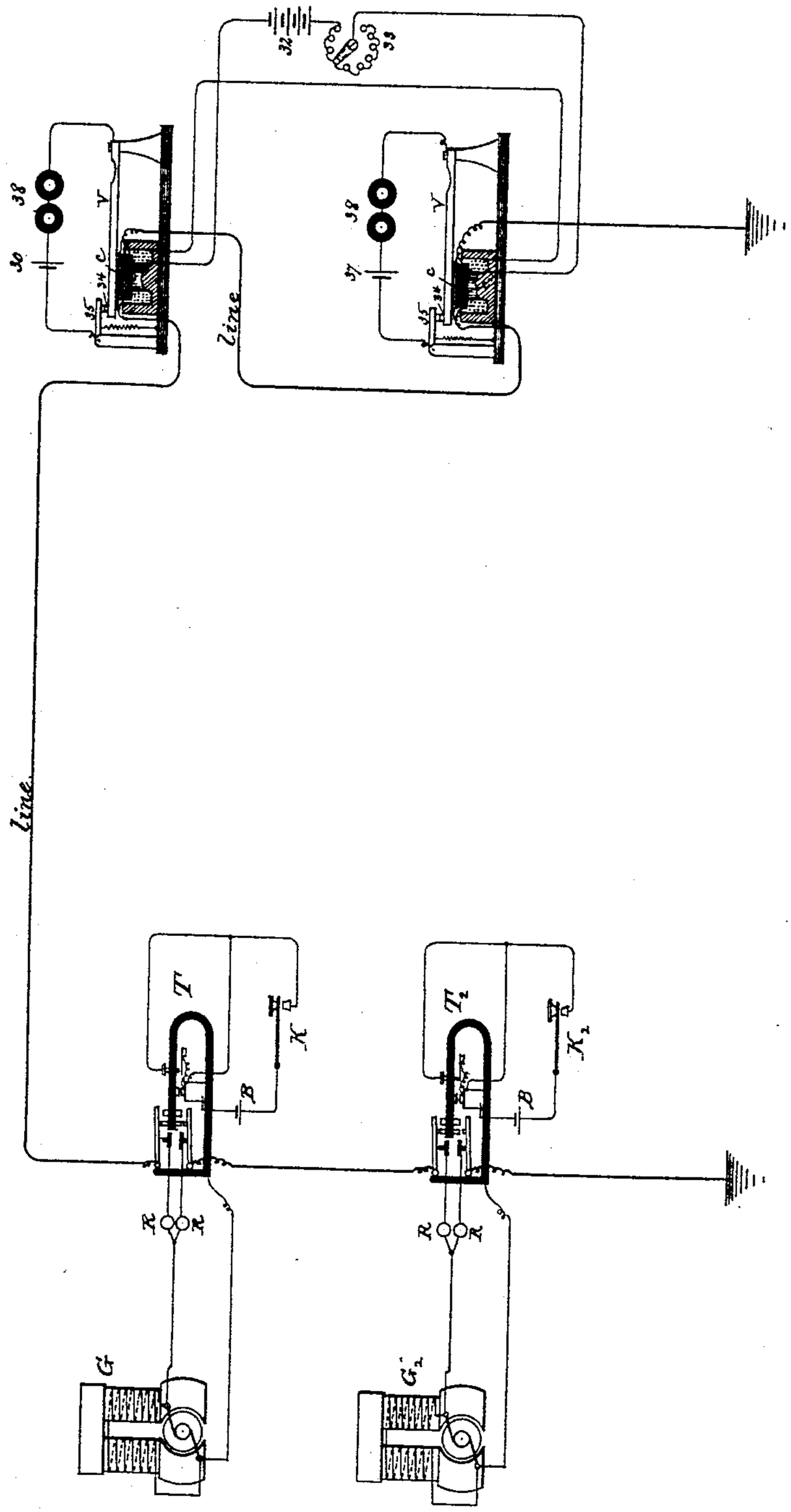

Fig. 4.

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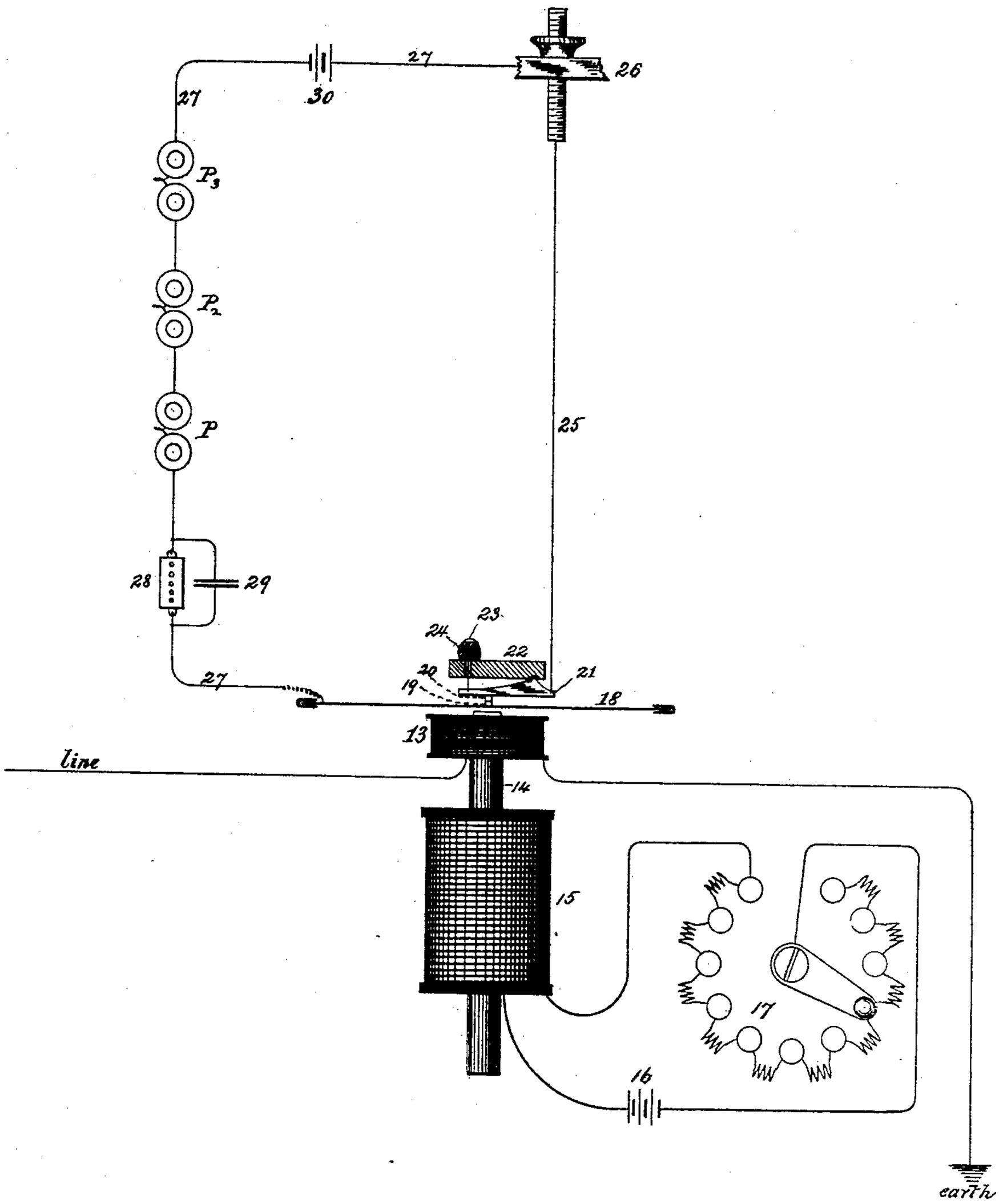
VIBRATORY MULTIPLEX TELEGRAPHY.

No. 395,556. Patented Jan. 1, 1889.

Fig. 5.



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VIBRATORY MULTIPLEX TELEGRAPHY.

No. 395,556. Patented Jan. 1, 1889.

Fig. 6.

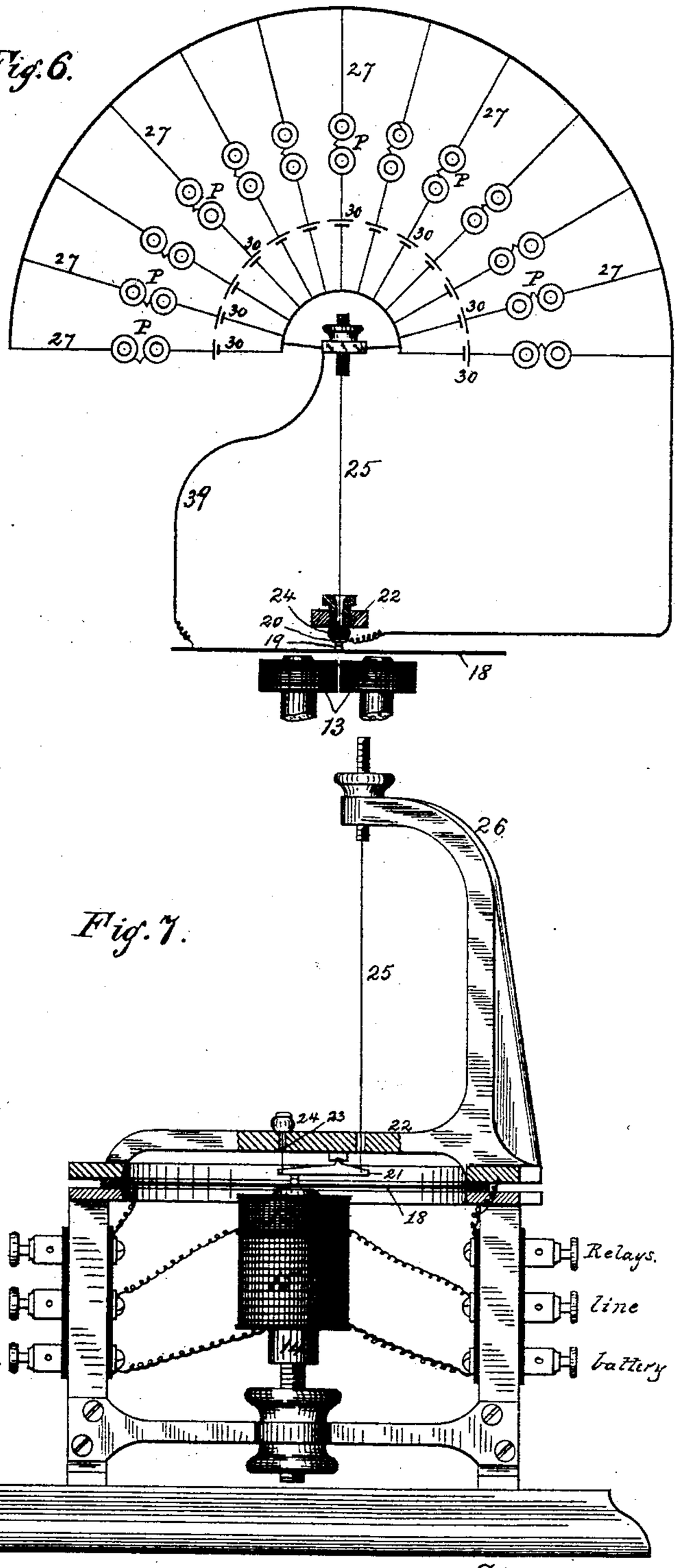

Fig. 7.

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VIBRATORY MULTIPLEX TELEGRAPHY.

No. 395,556. Patented Jan. 1, 1889.

Fig. 8.

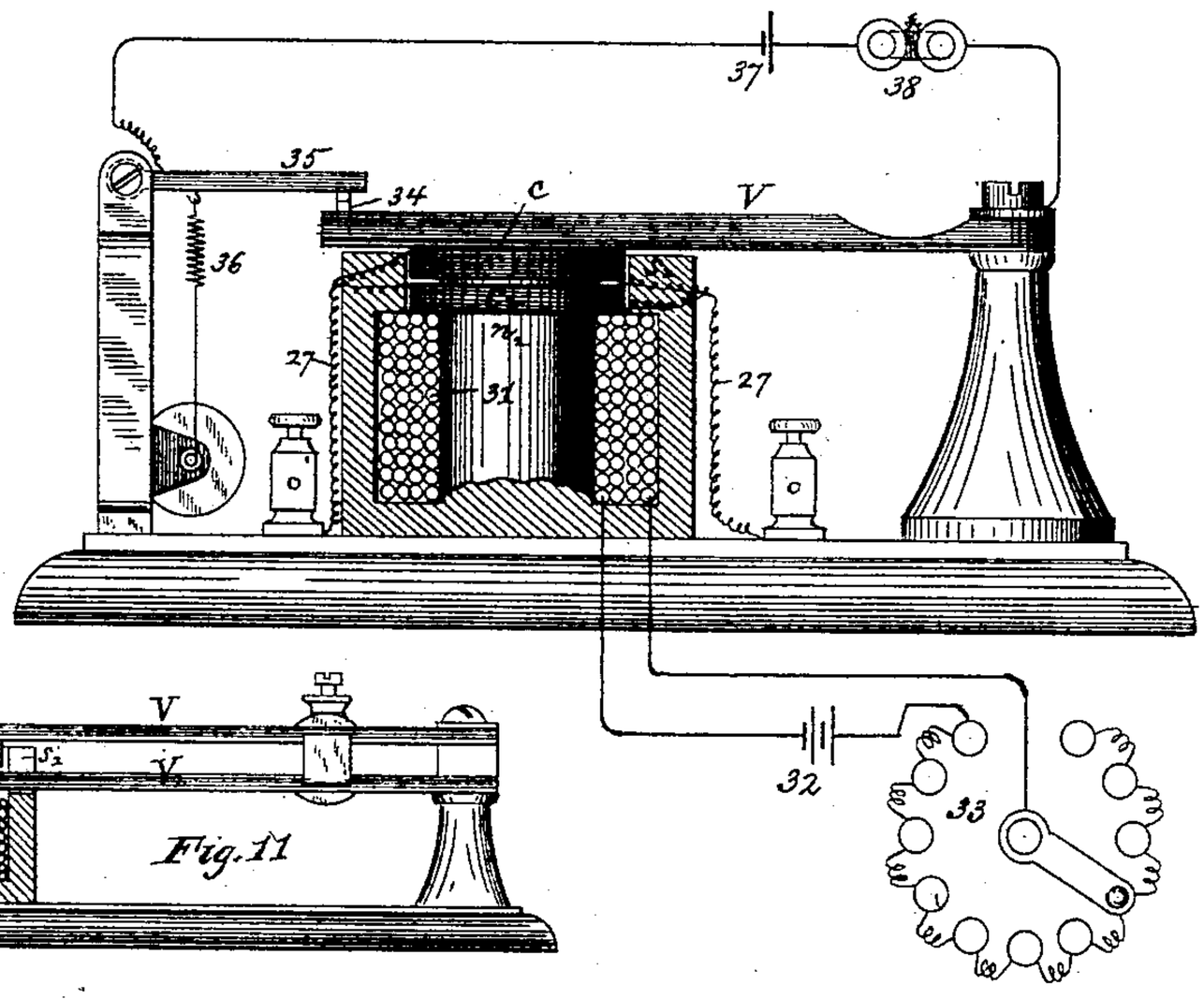
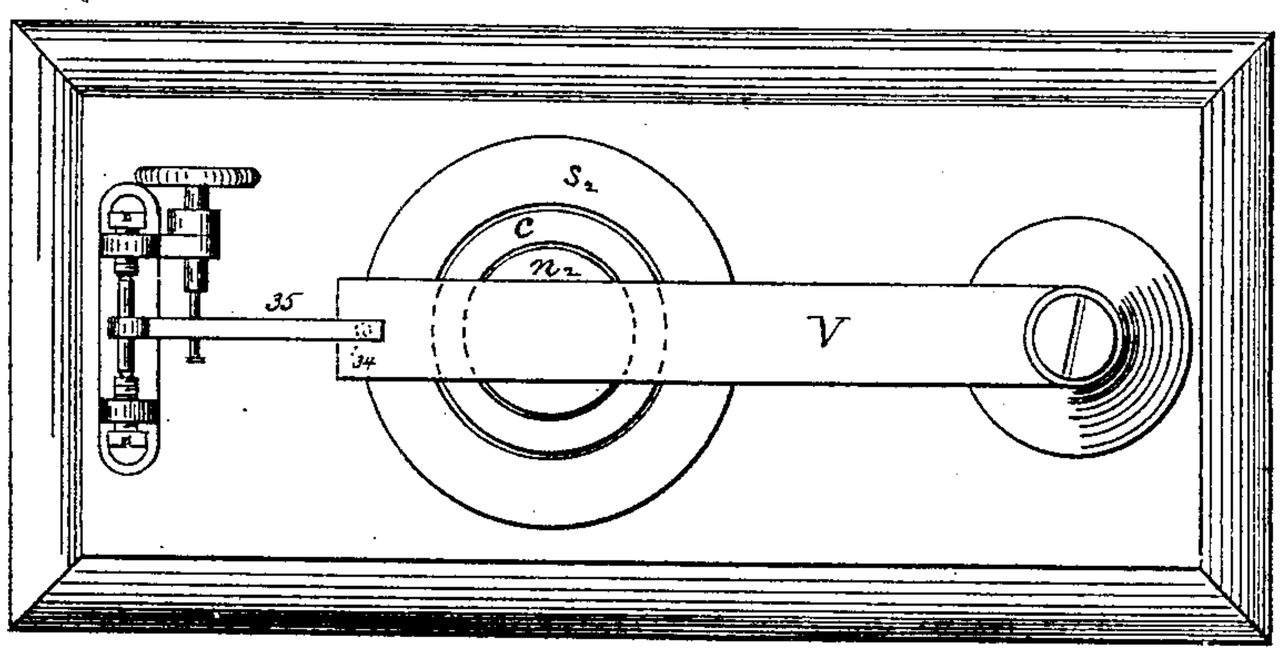


Fig. 11

Fig. 9.



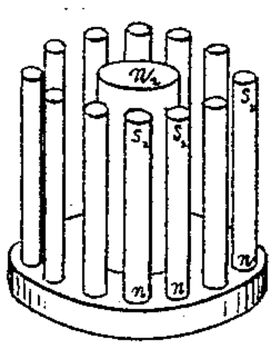
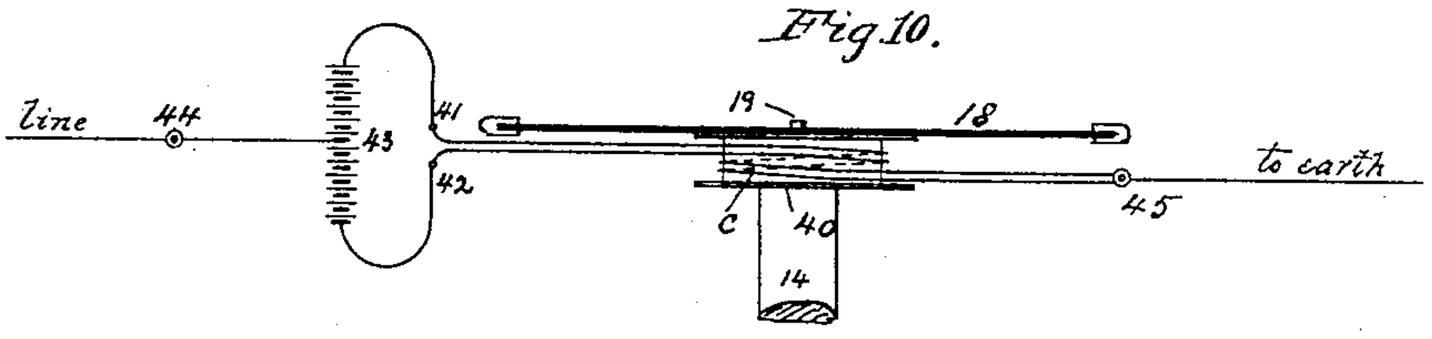


Fig. 13.

Fig. 10.



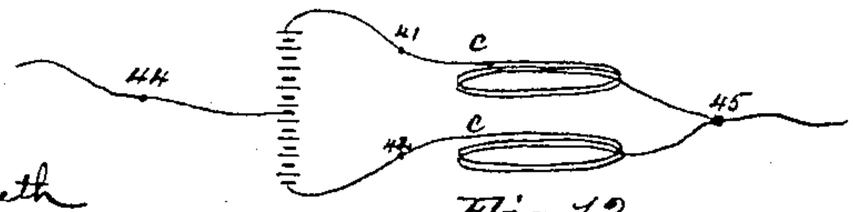


Fig. 12.

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UNITED STATES PATENT OFFICE.

STEPHEN DUDLEY FIELD, OF STOCKBRIDGE, MASSACHUSETTS.

VIBRATORY MULTIPLEX TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 395,556, dated January 1, 1889.

Application filed June 13, 1888. Serial No. 276,994. (No model.)

To all whom it may concern:

Be it known that I, STEPHEN DUDLEY FIELD, a citizen of the United States, residing at Stockbridge, in the county of Berkshire and State of Massachusetts, have invented certain new and useful Improvements in Vibratory 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 the transmission of electric signals for the various purposes to which it may be adapted, and may be termed generally a "vibratory multiplex-telegraph apparatus," by the use of which simultaneous transmission of any number of independent sets of signals may be effected over a telegraphic circuit by means of current impulses whose intervals are variously timed for transmission by special instruments, and which are at the receiving end of the circuit analyzed for reproduction by an inharmonic receiving instrument or repeater and the different sets of signals selectively passed to their own particular local receiving and sounding apparatus.

The objects of the present invention are manifold: first, I aim at the application to vibratory multiplex-telegraph apparatus of a dynamo-electric generator, or, rather, a series of such generators, having very low resistance and having practically no magnetic drag, and therefore no retarding influence on the instruments at the distant end of the line; secondly, I propose to so improve the devices controlling the transmission-contacts that there will be absolutely no variation of resistance arising from the continual opening and closing of these contacts under the conditions of great speed of vibration and there will be practically a total absence of sparking.

A further object is to have the vibratory transmitting-instruments normally inactive, but at the same time so sensitively responsive to the operations of the transmitting-keys that at all times during the momentary depressions of the said keys and the closing of the specific transmitting-circuit belonging to such key the vibratory transmitter will take up and uniformly maintain its exact predetermined rate of vibration, and such exact rate of vibration will throw into the main circuit alternating impulses of current in exact and particular accordance therewith without any discordance or want of uniformity, so that the signals due to any particular transmitting-instrument will be sent over the line with the utmost sharpness and definition.

A further object of the invention is to provide at the distant end a repeating apparatus entirely inharmonic in its character and adapted to respond accurately to all the varying impulses or vibrations of current passing over the line, and to sort these out and repeat them in their proper order and relations into a number of local receiving apparatus actuating sounders or registers, or other devices, as may be found best adapted under the particular circumstances of use in any given case.

A further object is to so construct and organize such an inharmonic receiver that its operations will all be dependent either upon a single coil or helix in the main circuit, so that the magnetic drag will be reduced to an inappreciable minimum, or upon a combination of coils working either in multiple arc or series one with the other in such manner as to entirely eliminate the magnetic drag, while at the same time it can be successfully used as a repeating device for actuating a large number of independent contacts in the local circuits of separate tone-receivers for the selection and reception of a great number of sets of transmitted impulses.

A further object is the provision of suitable means of eliminating the spark due to the extra currents from the magnetic coils of such tone-receivers.

To these and other ends my invention consists in the construction, organization, and arrangement of apparatus and devices, substantially as hereinafter more fully described and claimed.

In the accompanying drawings, which form part of this specification, Figure 1 is a diagrammatic representation of one of my improved tone-transmitters and the controlling-key adapted to send the vibrations corresponding to it into the line. Fig. 2 is a modification of the same. Fig. 3 is a diagram illustrating in a general manner the application of the appropriate features of my invention

to a complete apparatus for the transmission of signals. Fig. 4 is a diagram showing a pair of transmitting apparatus connected to a distant receiving apparatus through a single line. Fig. 5 is a diagram illustrating the operation of the inharmonic receiving or repeating apparatus. Fig. 6 is a similar diagram of a modified arrangement of the inharmonic repeating apparatus. Fig. 7 is an elevation of the repeater alone in one of its practical forms. Fig. 8 is a sectional elevation and diagram of circuits of a practical form of what I term a "tone-receiver" and "relay." Fig. 9 is a plan view of the same without its circuits. Fig. 10 is a modification of the receiving-instrument, in which the magnetic drag is entirely eliminated. Fig. 11 is a modification of the apparatus shown at Fig. 8, showing a tuned fork with the coils reacting to produce greater sensibility. Fig. 12 is a diagram more clearly showing the arrangement of circuits of Fig. 10. Fig. 13 shows a permanent magnet for the field of the receiving-coil.

Referring to Fig. 3, I use a series of simple shunt-wound dynamo-electric generators, G G^2 G^3 G^4, whose shunt and armature circuits are so proportioned relatively to each other that the same or substantially the same inductive effect is obtained in both the shunt and the armature circuit. The effect of this equalizing of the inductive effect is such that a current from an outside source traversing a given generator will have a tendency to build up the shunt or increase its magnetizing effect, while it will, on the other hand, have a tendency to take from or decrease the magnetizing effect of the armature, or vice versa. The extra currents produced in the coils of the shunt-field will thus be of opposite character to the extra currents produced in the armature, and these two will therefore neutralize each other with respect to the production of any retarding effect in the circuit—that is to say, if the armature shows a tendency to retard the current the shunt will have an opposing tendency to accelerate the current, and therefore this extra current effect will be annihilated.

Hitherto in the transmission of vibratory currents the various transmitter-contacts have been adjusted by springs. Such an arrangement in very high speed vibrations has a strong tendency to the most utter irregularity of action by reason of the momentum of the contact-lever giving it a tendency to fly away from its contact at the moment of extreme phase of vibration. This tendency has given rise to an inevitable fluttering or jarring of the contact-points, which has the effect of causing a great momentary rise of resistance at such point of contact, which, being in the circuit at the moment, must necessarily produce a corresponding diminution of the strength of current flowing in the circuit, which in turn must necessarily cause great irregularity and want of uniformity in the action of the receiving-instruments at the distant end of the line. By my invention I overcome this very serious defect and obstacle to successful operation by substituting, either wholly or in part, for the springs the attractive power of a permanent magnet so arranged that, while drawing the contact-levers tightly toward their stops or giving them the proper normal tendency, it offers no resistance to the vibration of the transmitter itself, except at the actual instant of breaking its hold, and this occurs at a moment when no bad effect can follow either at the transmitter or at the distant receiver.

One construction available for the foregoing purpose is illustrated at Fig. 1, where 2 represents a U-shaped permanent magnet having one pole, N, extended and turned over so as to confront the other pole, S. On the pole N, I mount the two contacts 3 4, and back of these on the same pole I mount the adjustable soft-iron projections 5 and 6, the adjustment being secured by a tightening-nut. On suitable supports I arrange the adjustable contacts 7 and 8, which are both connected to one pole of the generator G, having interposed in each of the connecting-lines the safety-resistance R, as shown. Pivoted to the pole S of the magnet or vibrator 2, not in direct contact therewith, but close enough to be inductively polarized to a sufficient extent, are the two soft-iron contact-levers 9 and 10, with platinum contacts corresponding to the parts 3, 4, 7, and 8. The permanent magnetism of the pole N, acting through the soft-iron projections 5 and 6, and the induced magnetism (indicated by the letters *n* and *s*,) cause the two levers 9 and 10 to be mutually pressed toward the pole N and into firm contact with such other contacts as are at the moment in their path. The figure shows the normal condition when the magnet 2 is at rest.

The generator-circuits are as follows: One terminal of the generator is always in connection with the contacts 7 and 8, and the other terminal of the generator is constantly connected to vibrating magnet 2. In the position shown at Fig. 1 contact 3 is closed on lever 9, while lever 10 is closed on contact 8. Lever 9 is permanently connected to the line, while lever 10 is connected to the ground or to the next tone-transmitter, while both the levers 9 and 10 are insulated from magnet 2. By this construction when the parts are in the positions shown the positive pole of generator G is connected to earth, while its negative pole is connected through magnet 2, contact 3, and lever 9 to the line. When the magnet 2 is caused to move into its opposite position of vibration, the positive pole of the generator is connected by contact 7 with lever 9 and the main line, while the negative terminal is connected through the vibrating magnet 2, contact 4, and lever 10 with the ground or the next tone-transmitter, thus reversing the direction of current on the line. During these movements back and forth of the pole N there is no fluttering of contacts or change of re-

sistances therein, as the magnetic attraction exerted between the pole N and the soft-iron contact-levers 9 and 10 is always maintained uniformly, and disturbances due to inertia cannot take place. Consequently the operations of the contact-levers 9 and 10 will be such as to make the current impulses sharp and distinct no matter what may be the rate of vibration of the particular tone-transmitter. In order to effect a perfectly-uniform rate and amplitude of vibration of the fork or magnet 2, I attach to its stationary leg an electro-magnet, E, arranged to have its core facing in close proximity to the other leg of the magnet 2, or a soft-iron armature attached thereto. At a suitable location on the upper leg of the vibrating magnet 2, I place an adjustable insulated contact, 11, and below this a corresponding contact, 12. I wind the electro-magnet E with two conductors differentially disposed or connected, as shown, and connect one pole of the local battery B with the differential winding in such manner that when the battery-circuit is closed through both windings their combined inductive effect upon the core will be nothing. The remaining end of one of these windings runs to the contact 12, while the remaining end of the other winding goes to the anvil of the key K, the key K itself being connected with the other terminal of battery B. Another connection is made between the anvil of the key and the adjustable contact 11. Thus constructed, when the key K is depressed so as to touch its anvil the effect is to close one of the differential circuits on magnet E, and, energizing its core, instantly attract the opposite pole of the vibrating magnet 2; but the instant this occurs contact is closed between 11 and 12, which immediately has the effect of neutralizing the magnet E, and the pole N is now not attracted. In other words, the closing of the key K instantly sets up the full rate and amplitude of the vibrations which correspond to the fundamental tone of the vibrating magnet 2, and consequently in exact accordance with the periods of make on the part of the key K there will be sent into the line or main circuit a series of alternating impulses of current whose period of alternation exactly corresponds with the fundamental of the magnet 2. When the key K is open, no such vibrations are produced, but, instead, a continuous current in a single direction traverses the line from the generator G.

Referring now to Fig. 3, it will be readily understood that the various tone-transmitters T T^2 T^3 T^4 are constructed to have different fundamental rates of vibrations, and as each one directly controls the current from its own special generator G G^2 G^3 G^4 they will all act independently of each other, and each one by the operation of its own key will impress on the main line its own distinctive series of vibrations of current, and each series will correspond in character or rate with the fundamental tone of one of the transmitters, T.

During the periods in which a given transmitter is either not under operation, or, when in operation, not sending vibrations into the main line, the generator of such transmitter will of course be generating current, and such current will traverse the line continuously without vibration or any other change. It will be observed that all the generators and the transmitters are in series with one another in the main circuit, the ground or earth not being reached until the whole series has been included in the circuit. I am enabled to make this arrangement because of the total absence of retarding effects or other sources of confusion of signals hereinbefore noted, and also from the fact that the only resistances in the entire system, as illustrated in Figs. 3 and 4, are the resistance of the sensitive coil of the repeating-instrument, the line itself, the transmitter-contacts, which, as stated, are exceedingly low, the safety-resistances R, and the resistances of the generators G, (which of themselves, on account of the low external resistance, will be very low,) and the general result of all this is the advantage of being able to use a very low electro-motive force from each of the generators and the consequent ability to construct the latter of very small dimensions. For the average length of working-circuit I propose to use generators each having an electro-motive force of about twenty volts.

In the event of a possible sluggishness of the vibrating magnet 2 of Fig. 1 at the moment of closing the key K, I propose to use a modification which is shown in Fig. 2, in which the magnet 2 will be maintained in continuous vibration at its fundamental rate, and these vibrations will be sent to line by means of the key K^5. The electro-magnet E has its contacts operated automatically by the battery B being permanently in the energizing-circuit, as illustrated, and the transmitting-key K^5 sends the vibratory impulses of current to line only when depressed.

As I propose to transmit a large number of different tones or sets of vibrations, it becomes necessary to provide at the distant or receiving end of the circuit an apparatus capable of separating these different tone impulses and delivering each kind to its respective translating devices, such as tone-relays actuating local sounders or other equivalent devices. For this purpose I have devised what I term an "inharmonic repeater." Briefly, this device consists in a diaphragm which is capable of responding to all sorts of current variations, and is actuated by the electro-magnetic changes taking place in a coil or coils which are included in the main line and control the vibration of the diaphragm. The complete receiving apparatus in one arrangement of circuits is shown diagrammatically at Fig. 5, where the line or main circuit enters a coil, 13, which is mounted upon an iron core, 14, which I prefer to magnetize by means of a separate coil, 15, included in a local circuit with a battery, 16,

and adjustable rheostat 17, which serves to adjust the conditions to suit the requirements. After leaving the coil 13 the line goes to earth, (when working in one direction only. When working in both directions it goes to the transmitting-keys as in ordinary duplex mechanism.) Directly opposite the core 14 at the end which carries the coil 13, I mount a diaphragm, 18, which is so arranged as to be free to vibrate in accordance with the varying attractions of core 14, due to the vibratory impulses of current traversing the main line from the transmitters at the distant station. On the rear of the diaphragm I arrange a contact, 19, facing a contact, 20, which is placed on a lever, 21, mounted to vibrate on knife-edges on the support 22, which latter is independent of the diaphragm 18. At one end the lever 21 is supported by a thin wire, 23, having a riveted head or other means of engaging with a soft-rubber spring, 24, which, like the diaphragm, will not take up any particular tone to the exclusion of others, but will be in that sense inharmonic. The other end of lever 21 has attached to it a long thin wire, 25, which can be to good advantage composed of German silver, and I term this a "thermic wire." I make it of German silver because of its relatively high resistance and consequent tendency to heat with the passage of current, and I make it very thin in order to have it part with the heat with the utmost possible rapidity, in order that the wire will expand and contract in prompt accordance with the vibrations of current communicated to it.

The thermic wire 25 is supported at its opposite end by bracket 26, which is suitably attached to the frame carrying the diaphragm 18, and is preferably arranged to have its tension adjustable in a suitable manner. A circuit, 27, is arranged between the diaphragm and the other end of the thermic wire, as shown at Fig. 5, and this circuit includes a resistance, 28, shunted by condenser 29, and the local circuit then passes through the various tone-relays P P^2 P^3, &c., and a battery, 30, is also included in this circuit.

Each of the tone-relays P is constructed as shown at Figs. 8 and 9, where I give the preferred form. A tubular magnet, n^2 s^2, is constructed, having the energizing-coil 31, with battery 32 and adjustable rheostat 33, in a local circuit, by which means the intensity of the annular field of force between the poles n^2 s^2 may be suitably adjusted. On a suitable support I fix a vibrating tongue, V, which for each of the tone-relays will be tuned to vibrate at a different rate, and will therefore take up only its own rate of vibration. The tongue V stands in close proximity to the annular polar field of the magnet n^2 s^2 and has attached to it the annular coil c, and in the polar field of the said magnet I fix the corresponding annular coil, c^2, so that the two annular coils will face each other, one being fixed and the other movable, since it is attached to the vibrating tongue V. The two coils c c^2 are differentially connected into the circuit 27 of the repeating apparatus and the various pairs of such coils are in series, as in Fig. 5, so that the current from the relaying-battery 30 will pass through all of the said pairs of coils and the impulses of current, according to their rate, will be responded to only by the tongues V which correspond to such rates. Each tongue is provided with a back contact, 34, and the contact-lever 35 is normally drawn into contact by means of the spring 36, and the sounder-circuit is established between the tongue V on the one hand and the lever 35 on the other hand through a local battery, 37, and ordinary sounder, 38, so that each of the tone-relays is thus provided with its own independent sounder-circuit and battery therefor.

It will be observed that the diaphragm 18 is absolutely untrammeled in its movement, since no obstacle lies in its range of vibration which can in even the slightest degree act as a damper to its movement. It thus differs essentially from all such apparatus as require the movement of the diaphragm to expend part or all of its inertia in imparting motion to contact springs or levers or in effecting changes of resistance between two or more local-circuit contacts. Such mechanical work I throw upon the local battery and thermic wire, and I use the diaphragm only to control the local circuit in the manner described, and as this does not require the expenditure of any energy whatever on the part of the diaphragm the latter is obviously totally unrestricted in the movements impressed upon it by the arriving vibratory current impulses.

Thus constructed the operation will be as follows: All the different kinds of current impulses coming over the line will pass through the diaphragm-coil 13, and will therefore throw the diaphragm 18 into vibration in exact correspondence with said impulses in accordance with well-known principles. When the diaphragm is attracted, it breaks the local circuit 27 at the contacts 19 and 20, and this immediately causes the thermic wire 25 to contract. Contact 20, being attached to the lever 21, which is pivoted on knife-edges and held in place by the strain of the soft-rubber inharmonious spring 24, obeys the motion given to it by the thermic wire, which is obviously in exact correspondence with the motion of the diaphragm, since it is governed thereby. A continuance of the vibrations on the main line through coil 13 obviously acts, through the interposition of diaphragm 18, to cause a motion of the latter and the resultant breaking and making of the contacts 19 and 20 such that the latter respond to any and all vibratory influences of the main-line currents, and therefore the vibrations of the transmitters at the distant end are transferred into the circuit 27, which contains the above-mentioned tone-relays P P^2, &c. The self-adjusting contact arrangements just described will

have their adjustment so arranged as to always break on the attracted movement of the diaphragm and close immediately upon the reversed motion of the same. The office of the resistance 28 and the shunted condenser 29 is to eliminate the retarding effects due to the extra currents of the instruments in the circuit 27, and thereby to eliminate the spark at the contacts 19 and 20.

It will thus be seen that by the employment of a single coil, 13, for the purpose of receiving and causing the transfer and analysis of the various pulsations of current flowing on the main line I have only to contend with the small magnetic drag of a single coil, and this will be so slight in the general result that its influence may be neglected. By winding this coil 13 differentially the system may be duplexed in a manner well known in the art, and therefore not necessary to specifically describe herein. It is evident that by the foregoing arrangement all retarding effects or counter-electro-motive forces of magnetic coils are practically eliminated from the main circuit, and that in the independent local relay-circuit 27, I have only to contend against the retarding effects or counter electro-motive forces due to the mechanical movement of the armatures of the tone-relays. The two substantially equal coils c c^2 are in the same magnetic field and are connected in such manner that the current will circulate in opposite directions in the two. The result of this arrangement is that the extra current produced in each coil will be of opposite sign, (as already described in connection with the shunt-generators G,) and therefore there will be no counter electro-motive force to the arriving signals; hence when both coils are motionless there is no drag in their circuit, and signals passing which are not in harmony with a particular tone-relay will experience no retardation beyond that due to mere resistance. When, however, the movable coil c on the tongue V vibrates, a slight counter electro-motive force is set up in the circuit 27. This, however, is in strict proportion to the work done, and as it is always accompanied by corresponding increase of power, due to the sequence of vibration from the corresponding transmitter, the effect is altogether harmonious. In event of a comparatively short main line it is practicable to dispense with the repeating devices, and in that case the various tone-relays may be connected directly into the main circuit, as clearly illustrated by Fig. 4.

As a modification of the arrangement shown at Fig. 5, the thermic wire 25 may be so arranged as to be shunted by a circuit of low resistance, 39, and the various relay-circuits 27, with their respective tone-relays P P^2, &c., and their respective batteries 30, will all be arranged in multiple arc, as shown at Fig. 6. In this modification the thermic wire 25 is differently arranged. The contact is made with the diaphragm directly through the interposed soft-rubber spring 24, which now is placed under the support 22, and its tension or strain acts to press the contact 20 against the contact 19 of the diaphragm. In the condition of no motion of the diaphragm, as shown in the figure, the thermic wire 25 is shunted by the low-resistance wire 37 through contacts 19 and 20. When, now, the diaphragm is attracted, this low-resistance circuit is broken and the local current passes through the thermic wire alone, which instantly expands and restores the contact between 19 and 20 on the attempt of the diaphragm to come backwardly, and the motion and the varying effects are repeated with the same results as in the form shown at Fig. 5. In this multiple-arc arrangement and shunted thermic wire I do not need to use the shunted condenser, as there is no actual break of the local circuit, but simply a change in its resistance.

Instead of providing a separate battery, 32, and adjustable rheostat 33 for each of the tone-relays, obviously a number of the latter may be connected in circuit with a single polarizing-battery and adjusting-rheostat, because the various disturbing elements or weakened currents which might take place on the line under any contingency would affect all the tone-relays alike, and therefore the common adjustment required would be the same for each of the tone-relays. Obviously the annular polar field for the location of the coils c c^2 may be obtained by the use of a permanent magnet instead of an electro-magnet, as indicated by Fig. 13.

Heretofore tuned bars and strings have been actuated by magnetic attraction and repulsion as a source of motion for vibration-receivers in harmonic telegraphy; but the attempt to use them has developed certain objections which prove very serious. There has been an excessive magnetic drag due to the electro-magnets heretofore used, and the tongues or strings once put in motion have had a tendency to prolong the vibration after the actuating impulse of current has ceased, and such continued vibration would of course prolong the signal, to the resulting mutilation thereof. In my arrangement, however, the coils, being closed on themselves and one of them vibrating in a most intense magnetic field, will experience a dampening effect, due to the current set up by cutting the lines of force while vibrating in a field independently maintained, and must therefore come to rest with great rapidity, and consequently the signals rendered will be sharp and distinct.

For some purposes of repeating the tone relay or repeater illustrated in Fig. 5 may be constructed with a diaphragm carrying the coil c, instead of having the latter attached to a vibrating tongue. This modification is illustrated by Fig. 10, which also embodies the construction of a receiving-instrument which

will have absolutely no magnetic drag and will act perfectly as a repeater. In this case the diaphragm 18 has attached to it a bobbin, 40, on which are two coils wound side by side, the ends of both said coils being joined together and their beginning ends (marked 41 and 42) being left open for connection, as will be explained. These coils are arranged to stand in an intense magnetic field similarly to the instrument shown at Fig. 8, except that the two coils, or, more properly, the double coil, will be in this case attached to the lower side of the diaphragm 18. Polarization of the said coils is obtained by means of a battery, 43, to whose outer terminals the wires 41 and 42 are respectively attached. The line-terminal 44 is connected directly to the middle of the battery 43, and the other line-terminal, 45, or ground is connected to the joined ends of the coil *c*, as indicated in the figure. It will be observed that the battery 43, acting by itself, will have no effect whatever upon the exterior polarization so long as no impulses of current are traversing the line, because the current of said battery simply flows around one of the conductors of coil *c* in one direction and comes back to the other pole of the battery through the twin conductor of the same coil by reason of the junction of the two wires at the terminal 45. An impulse of a given direction now coming over the line will take either path 41 or path 42 to reach point 45, and, according to the direction, will increase the current flowing in either one or the other of the twin coils *c*, thus disturbing the balance and producing motion of the diaphragm in accordance with the direction of the current impulse which preponderates.

As a modification of the receiving apparatus illustrated by Figs. 8 and 9, I may use that shown by Fig. 11, wherein the tubular field-magnet n^2 s^2 is used; but its poles are slotted out to receive one of the tongues of a vibrating fork composed of two tongues, V V^2, attached to a suitable support and having an adjusting-clamp for the purpose of tuning the respective instruments to their proper rate of vibration. The leg V of the fork in this instrument occupies the same relative position as the tongue V in Fig. 8 and has attached to it the annular helix *c*, as in said figure. The leg V^2 stands directly under the leg V and in the slot in the upper portion of the field-magnet n^2 s^2, and this leg on its upper surface has attached to it a second annular coil or helix, c^2, the relations being such that one of the annular coils plays inside the other, and the two coils are joined in parallel or series into the circuit in such manner as to be cumulative in their action. Thus, when an impulse comes tending to draw the coil *c* and its leg V downwardly, the same impulse will act to move the coil c^2 and its leg V^2 upwardly, so that the vibration which is the resultant of these two motions will be strong and sharp. In this case the respective contacts of the local-sounder circuit may be attached to the free ends of the legs V V^2, as shown, and for convenience of circuiting, the legs V V^2 may be insulated from each other in any suitable manner.

I claim as my invention—

1. In a vibratory multiplex-telegraph system, two or more dynamo-electric generators having their armatures in series with each other and their fields each in plain shunt to its own armature, in combination with a group of pole-changing transmitting-keys, each adapted to change the polarity of its own generator with respect to the general circuit without opening the latter.

2. In a vibratory multiplex-telegraph system, a group of dynamo-electric generators in series, a corresponding group of vibratory pole-changers provided with vibrating mechanism and respectively adapted to change the polarity of their generators with respect to the general circuit at different rates of vibration, and a group of keys adapted to control the operation of the vibrating mechanism of said pole-changers.

3. In a multiplex-telegraph system, a pole-changing transmitter having two magnetic contact-levers and a vibrating magnet interposed between them adapted to exert an attractive effect on said levers, in combination with suitable pole-changing contacts on said levers and magnet, whereby springs may be dispensed with and their disturbing effects prevented.

4. In a multiplex-telegraph system, a pole-changing transmitter having iron contact-levers inductively polarized at their pivoted ends and a vibrating magnet-pole between their free ends, in combination with suitable pole-changing contacts on said levers and magnet, the polarity of said free ends and said interposed magnet-pole being of opposite sign, so as to produce mutual attraction of the levers toward said interposed magnet-pole, substantially as described.

5. In a vibratory telegraph system, a pole-changing transmitter composed of a U-magnet having suitable contact devices, an electro-magnet interposed between the legs of said magnet, and a local battery and key in circuit locally with said electro-magnet, whereby the operation of the key in the local circuit starts the U-magnet in vibration or stops it, according to position.

6. In a vibratory telegraph system, a pole-changing transmitter comprising, with suitable circuiting devices, a vibrator whose vibrations are controlled by intermittent magnetic attractions, in combination with an electro-magnet in circuit locally with a local battery and a key adapted to send the local current through said magnet, and thus control the vibrator, substantially as described.

7. In a vibratory telegraph system, a pole-changing transmitter comprising, with suitable circuiting devices, a tuned fork having

between its legs an electro-magnet energized by a local battery and having a neutralizing-coil in addition to its energizing-coil, and contacts suitably arranged, the whole so constructed and adapted for operation that when said electro-magnet is energized it attracts said fork, and thereby closes the circuit of the neutralizing-coil and the attraction thereupon ceases, and thus the fork is automatically vibrated.

8. A relay or repeater for vibratory current impulses, consisting of a coil in the main line, a diaphragm arranged for free and unobstructed vibration responsively to said vibratory current impulses and located within inductive range of said coil, a local circuit having automatically-adjustable contacts actuated by said diaphragm, but depending for adjustment on devices in the local circuit, and receiving devices in said local circuit.

9. In a vibratory multiplex-telegraph system, a combined tone receiving and distributing apparatus comprising a coil in the main line, a vibratory diaphragm of inductive material arranged for free and unobstructed vibration responsively to all current changes in said coil, a local circuit having adjustable contacts actuated by said diaphragm, but dependent for adjustment on devices in the local circuit, one or more relays in said local circuit, and local sounders controlled by the relays.

10. In a vibratory multiplex-telegraph system, the receiving apparatus comprisng the following elements in combination: first, a coil or helix in the main line, and within inductive range thereof a vibratory diaphragm capable of responding to the changes of current in the line; second, a single pair of back contacts controlled by said diaphragm and included in a local circuit containing tone-relays, and, third, a group of tone-relays in the local circuit respectively adapted to vibrate at rates corresponding to those of the various transmitting-instruments, said diaphragm being adapted to operate its back contacts in accordance with the impulses on the main line, and said relays being adapted to selectively respond to the local current impulses thus set up.

11. A repeater or relay composed of an electro-magnetic coil, a vibrating diaphragm responsive to current changes in said coil and having back contacts, one moved by the diaphragm and the other controlled by a thermic wire or rod adapted to expansion and contraction by the presence or absence of current therein, and a local circuit including said contacts and thermic wire or rod and one or more receiving-instruments.

12. A vibratory or harmonic repeater or relay comprising, with a diaphragm and its actuating coil or coils, a wire controlling the back or local contacts and in the local circuit and adapted to be momentarily expanded by the local currents, substantially as described.

13. In a repeater or relay wherein the line-currents effect the vibration of a diaphragm, the combination therewith of a thermic wire in a local circuit containing a battery and contact devices for said local circuit controlled by the thermic wire, but actuated by the diaphragm, and mechanical connections between said thermic wire and contact device.

14. In a repeater or relay wherein the line-currents effect movement of one member of the relay, the combination, with such member, of a thermic wire in a local circuit containing a battery and contact devices for said local circuit controlled by the thermic wire, but actuated by said movable member, and mechanical connections between said thermic wire and contact device.

15. In a vibrating telegraph system, a tone-receiver comprising a tuned vibrating tongue or fork having suitably-arranged sounder-contacts and carrying an actuating annular helix fixed to said tongue and located in an annular field of force, whereby said helix sets the tongue vibrating in response to the current impulses sent through it.

16. In a vibratory telegraph system, a tone-receiver comprising a tuned vibrating fork having an actuating annular helix fixed to it, in combination with a tubular field-magnet for polarizing the field in which said helix moves.

17. In a vibratory telegraph system, a tone-receiver comprising a tuned vibrating fork having an actuating annular helix fixed to it in an annular field of force and a second annular helix stationary in the same field, both said helices being included in a common circuit, and one helix movable in said field.

18. In a vibrating telegraph system, a tone receiver composed of two similar reeds, each carrying an annular helix, the two helices being in circuit together and arranged one inside the other in the same field of force.

19. In a vibratory telegraph system, a tone-receiver composed of two similar reeds, each carrying an annular helix, the two helices being in circuit together in the same field of force and the reeds being adjustable as to pitch.

20. In a vibratory telegraph system, a combined tone-receiver and relay composed of two similar reeds of the same pitch, each carrying an actuating-helix, both helices being in circuit together in the same field of force and each reed provided with one of a pair of contacts for the local circuit.

21. In a vibratory telegraph system, a group of two or more tone-receivers of different pitch in the local circuit of a general repeating-instrument adapted to respond to and analyze the line-currents and repeat them into the local circuit, in combination with a local battery and sounders, one for each tone-receiver.

22. A receiving-instrument for alternating current impulses, consisting of a vibratory dia-

phragm and a pair of coils wound side by side and controlling said diaphragm, both coils being at one end connected to earth and at the other to the terminals of a battery to which the main line is connected at an intermediate point, whereby magnetic lag in such instrument is eliminated.

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

STEPHEN DUDLEY FIELD.

Witnesses:
JAMES H. PANDERSON,
LAURENCE RYAN.