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S. D. FIELD.

TELEGRAPHY.

No. 503,590. Patented Aug. 22, 1893.

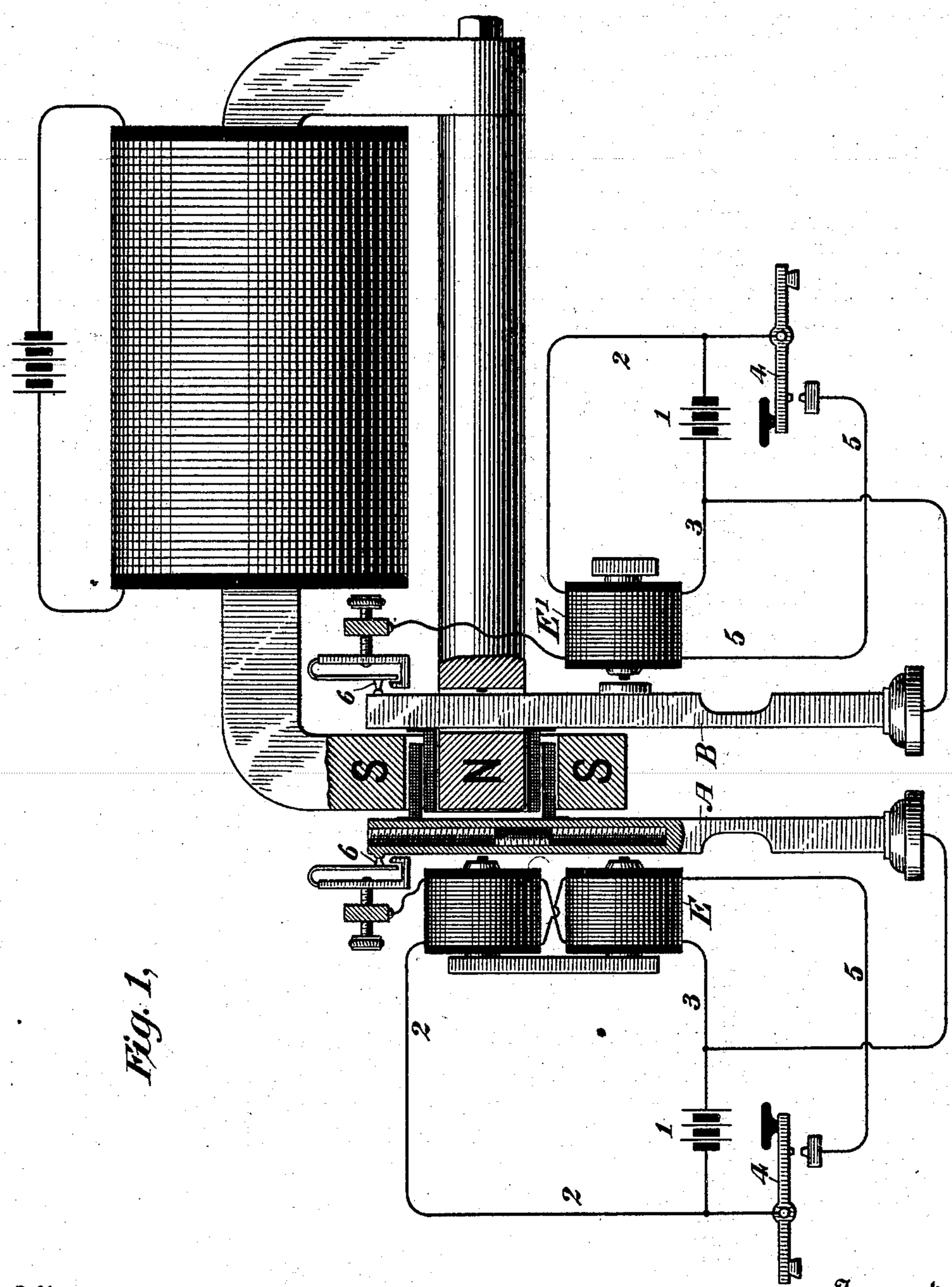

Fig. 1,

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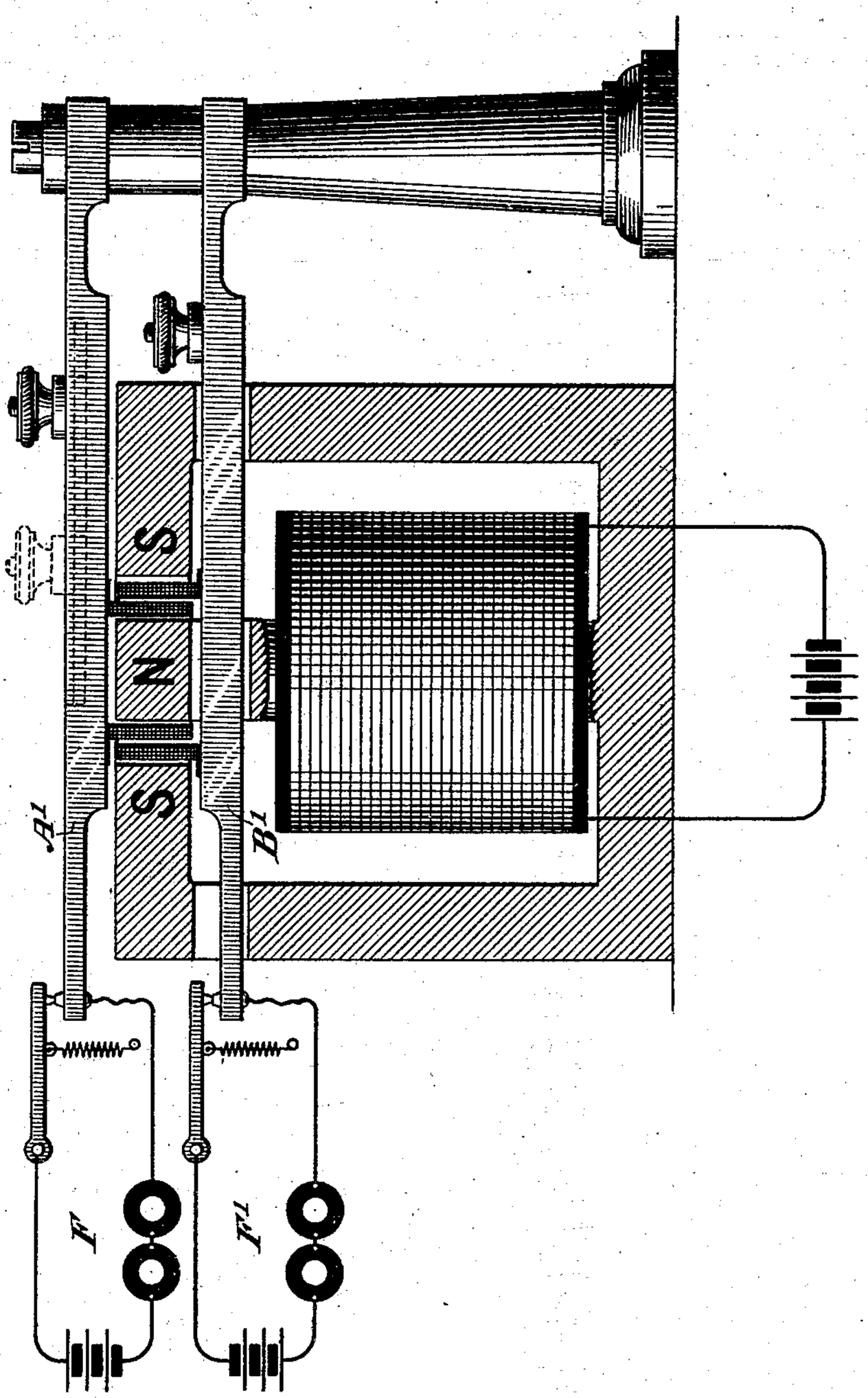
S. D. FIELD.

TELEGRAPHY.

No. 503,590. Patented Aug. 22, 1893.

Fig. 2,



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S. D. FIELD.

TELEGRAPHY.

No. 503,590. Patented Aug. 22, 1893.

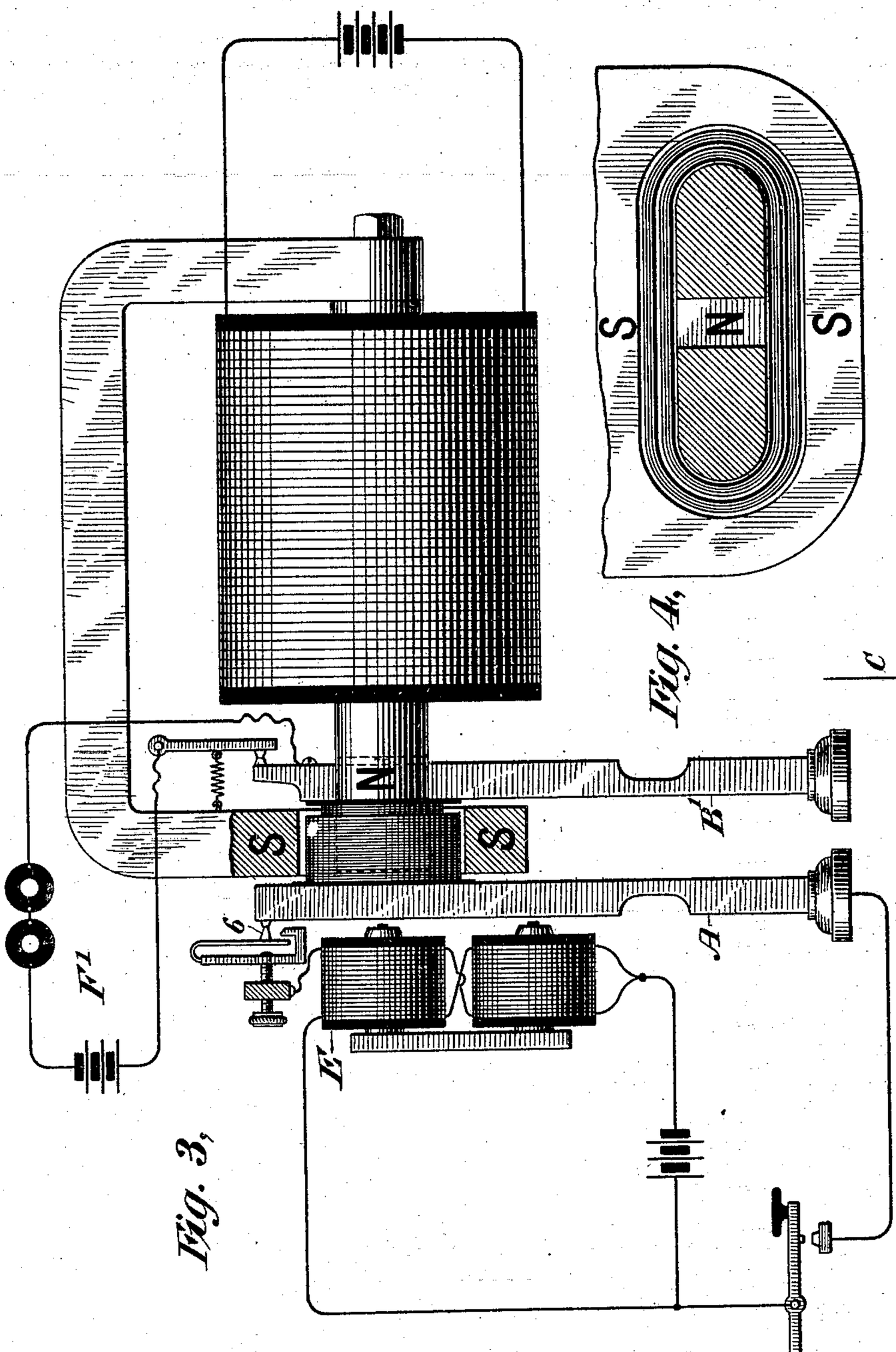

Fig. 3,

Fig. 4,

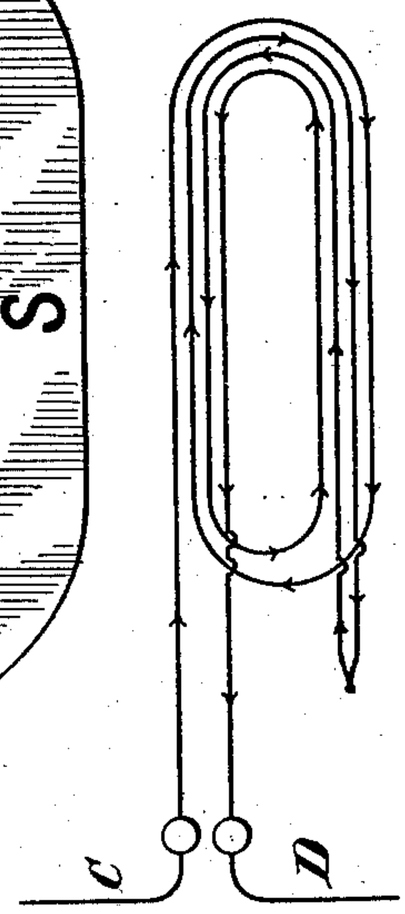

Fig. 5,

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S. D. FIELD.

TELEGRAPHY.

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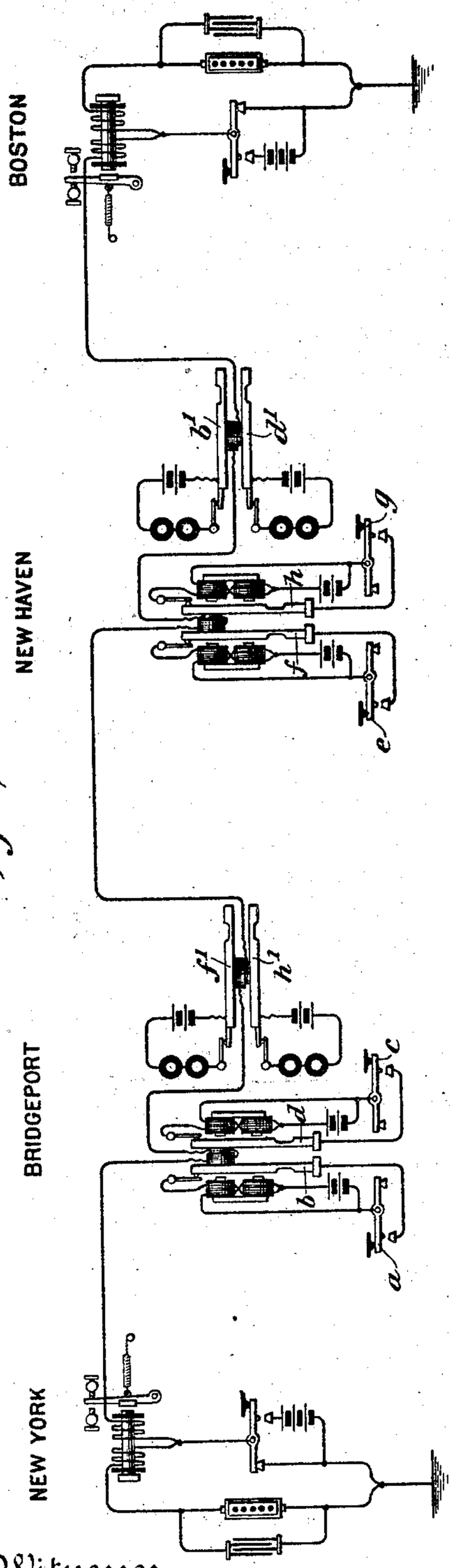

Fig. 6.

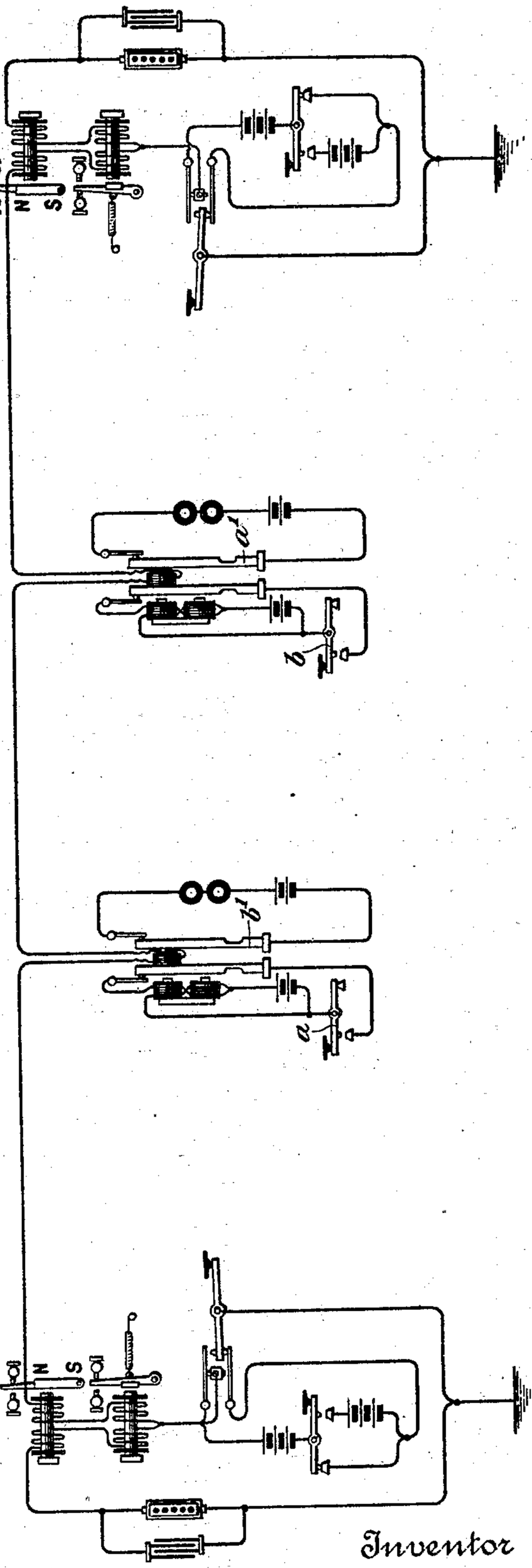

Fig. 7.

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S. D. FIELD.

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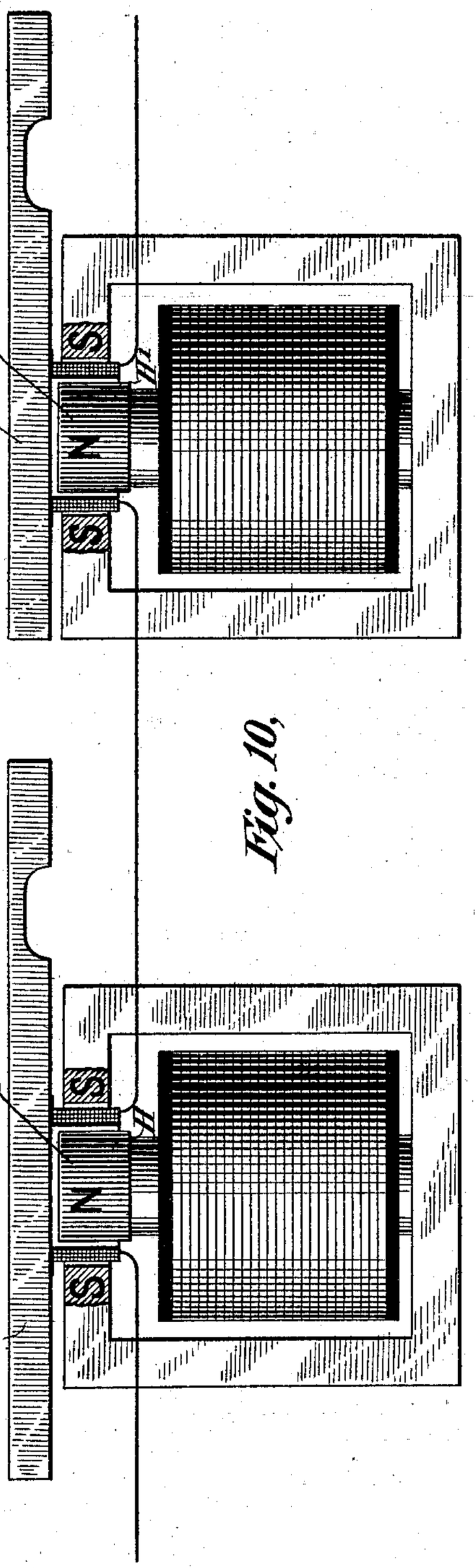


Fig. 10,

Fig. 9,

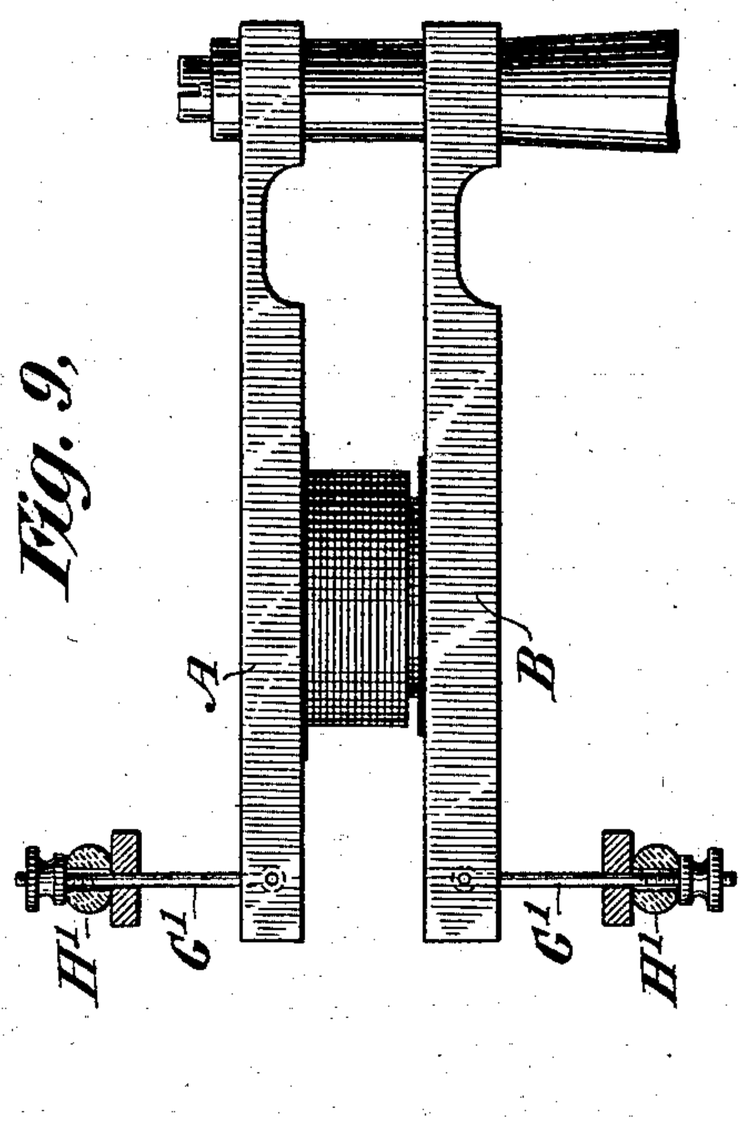
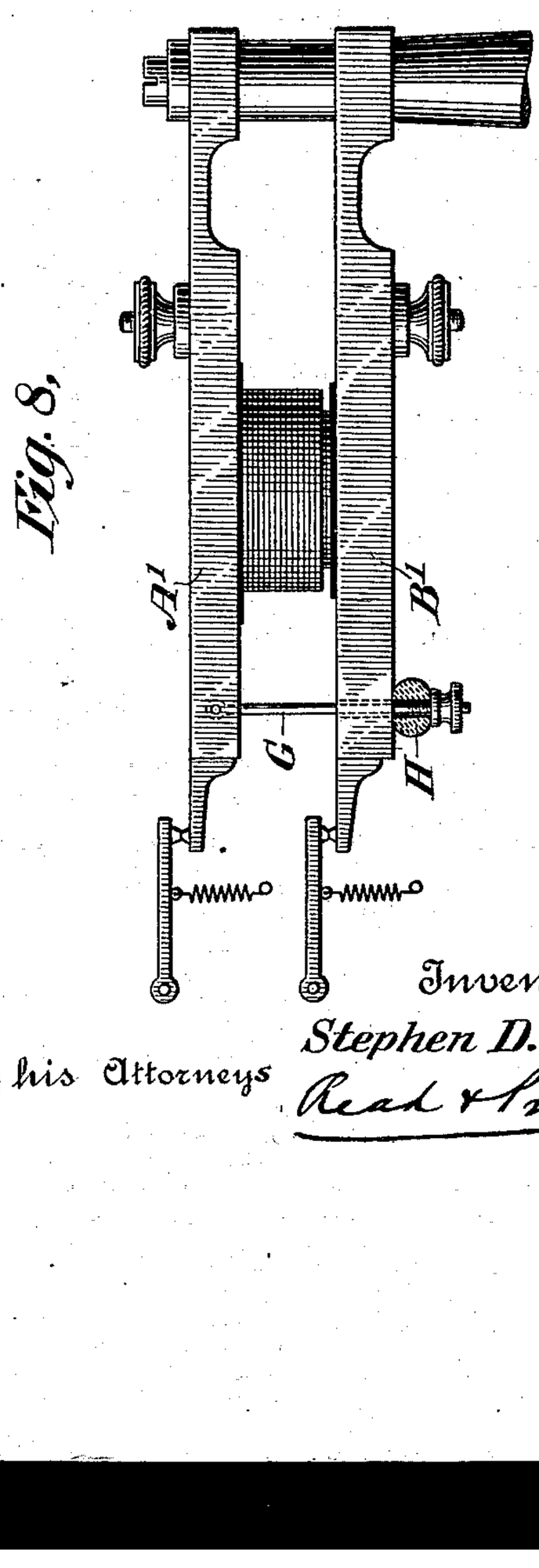


Fig. 8,



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S. D. FIELD.

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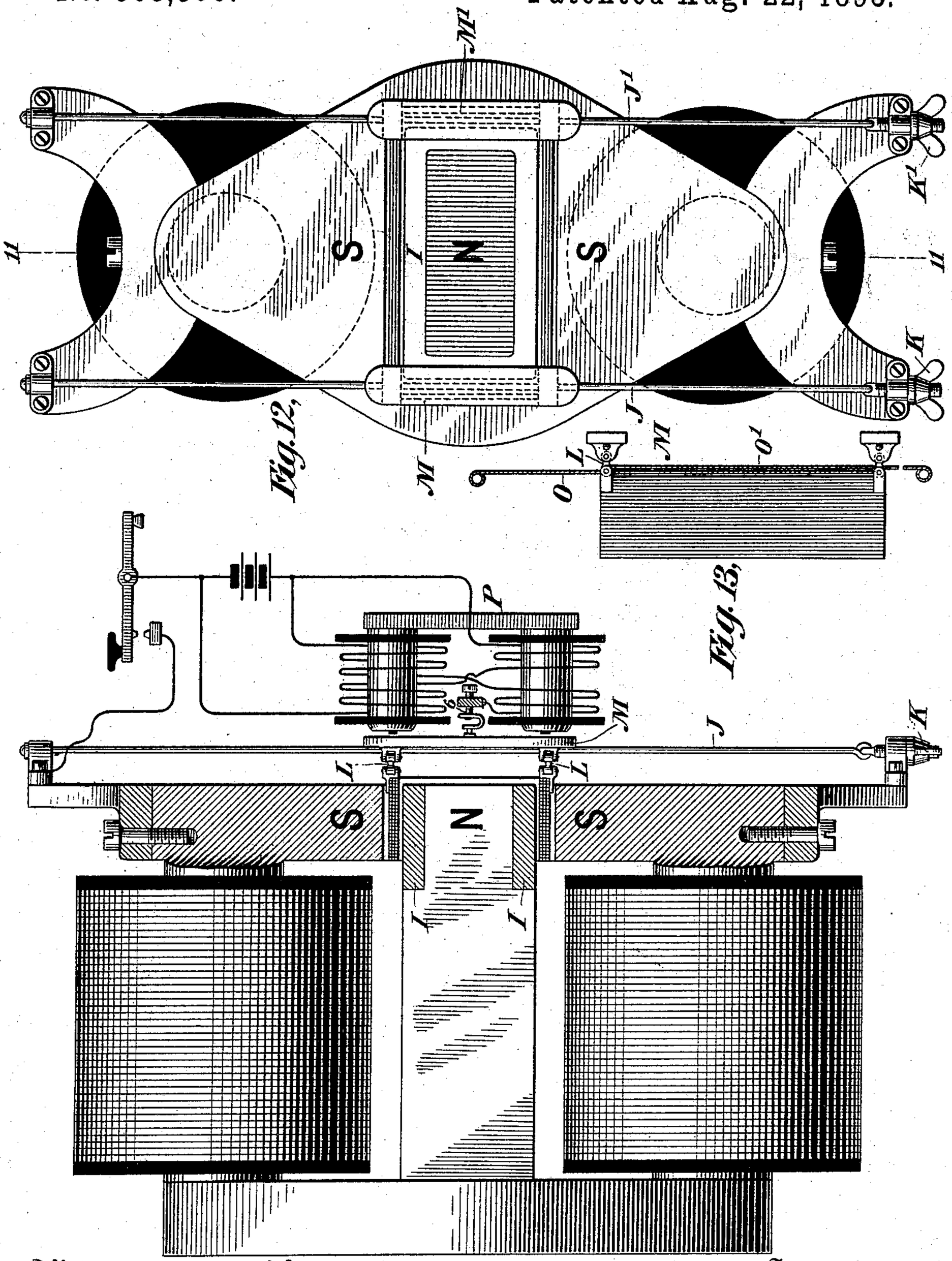

Fig. 12,

Fig. 13,

Fig. 11,

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S. D. FIELD.

TELEGRAPHY.

No. 503,590. Patented Aug. 22, 1893.

Fig. 15.

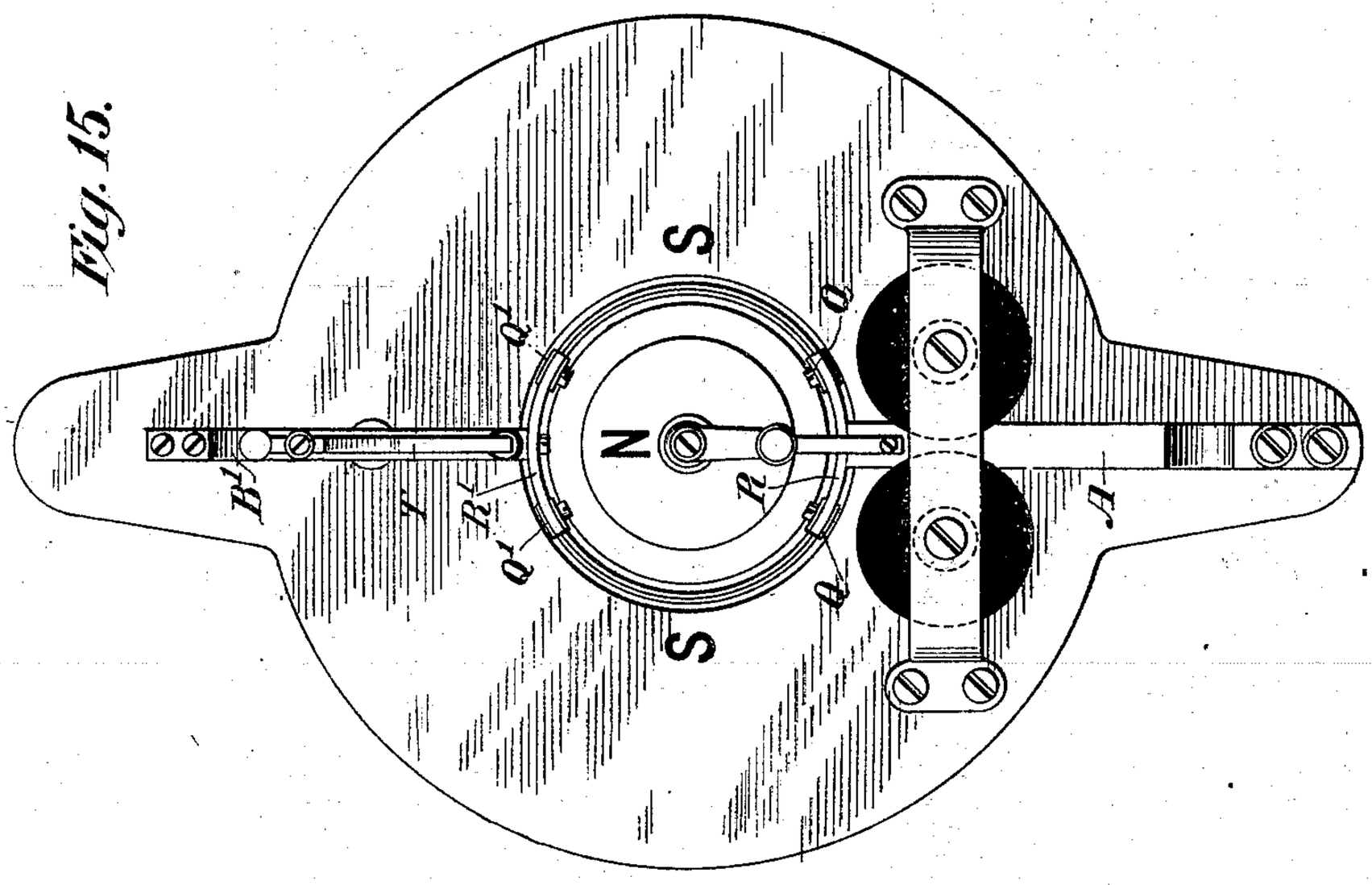
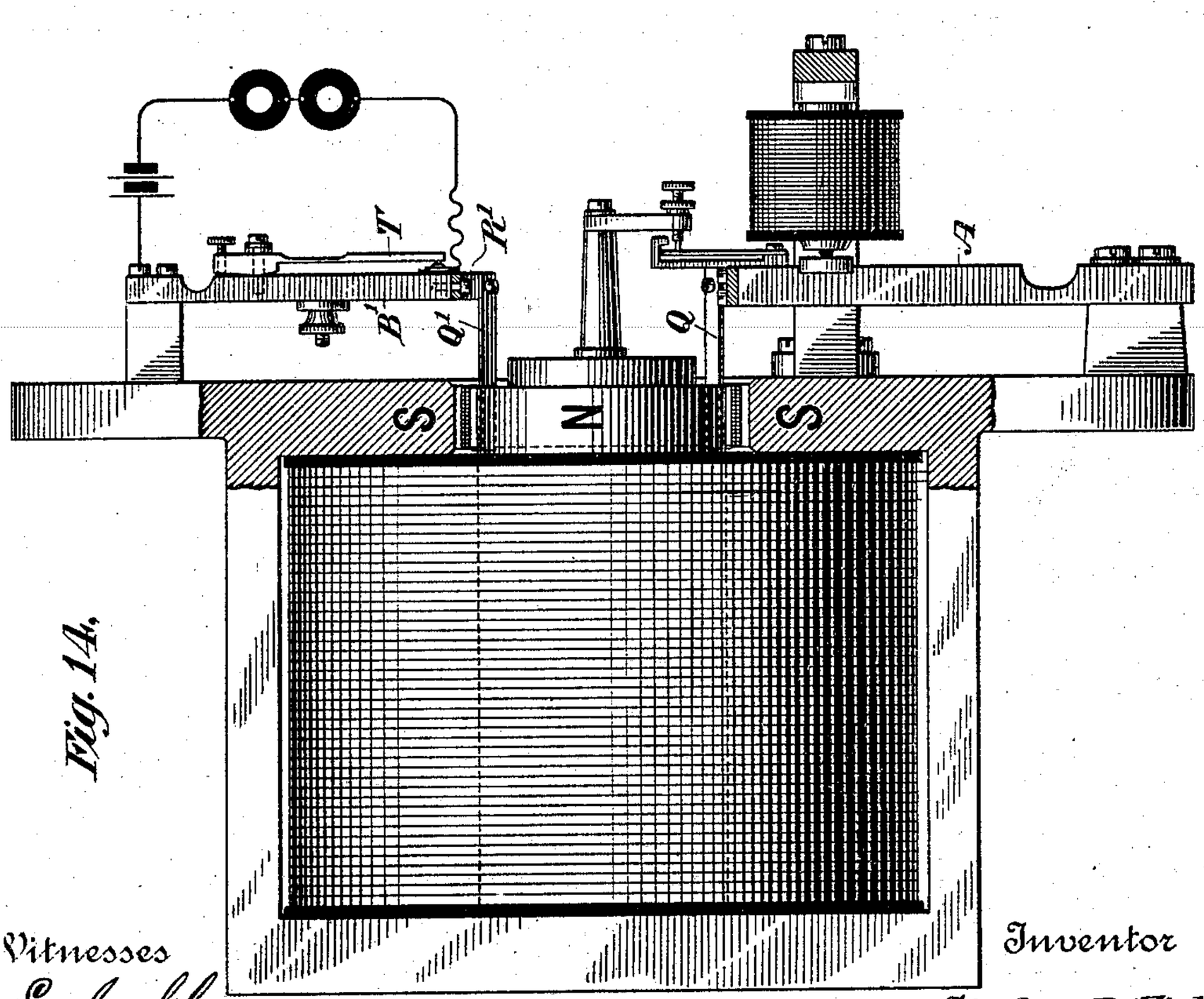


Fig. 14.



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UNITED STATES PATENT OFFICE.

STEPHEN DUDLEY FIELD, OF YONKERS, NEW YORK.

TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 503,590, dated August 22, 1893.

Application filed January 16, 1893. Serial No. 458,503. (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 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 telegraphy and has for its object to increase the signaling capacity of lines and to enable a single wire to accommodate a number of operators at terminal or intermediate stations. It may be tersely described as an improvement in multiplex telegraphy in the broadest interpretation of that term, the telegraphy being multiplex in character, whether the plurality of operators employed are stationed at terminal or intermediate stations.

The basic feature of my invention lies in the employment of transmitting and receiving instruments having practically no self-induction, and therefore offering no retardation to the transmission of currents.

My invention is applicable to existing systems, such as the duplex and quadruplex, to enlarge their capabilities. These systems as now employed are limited to intercommunication between two terminal stations, it having been found impracticable to interpose electro-magnetic devices in the circuits of these systems at intermediate stations, for the reason that the self-inductive effect of such devices exercises a halting or retarding effect upon passing signals and renders them unintelligible at the terminal stations. This self-inductive property of electro-magnetic apparatus has been one of the most serious limiting factors in telegraphy, and is especially serious in multiplex systems. An electro-magnet interposed in a circuit over which passes a fluctuating or interrupted current acts as a choke coil to shut off the flow of such current. The current in starting to flow creates a magnetic field, the creation of which generates a counter-electro-motive-force, opposing the flow of the current, the result of which operation in apparatus employing rapidly fluctuating or interrupted currents is to shut off the main portion of the current, permitting only a little to flow, and to retard the action of the responding instruments. In my system I employ what I may term chokeless coils; that is to say, coils which permit an instantaneous flow of the signaling currents in almost full strength, the coils being so placed and connected that they offer no magnetic retardation. Instruments constructed in accordance with my invention may therefore be interposed in signaling circuits at any desired points, and by arranging the system so that current impulses used by different corresponding operators will be created at different instants of time, signals may be exchanged between all the stations of the line simultaneously.

In carrying out my invention I utilize a principle first disclosed in Letters Patent issued to me on November 13, 1888, No. 393,914, and January 1, 1889, No. 395,556, wherein is described a receiving instrument embodying coreless coils floating in an intense magnetic field and nested and coupled together so as to offer a minimum counter-electro-motive-force to currents conveying signals. In my present invention I utilize this principle in both transmitting and receiving instruments and mount the several coils upon independent reeds or other vibratory agents, each having its own rate, which corresponds to that of a similar reed or similar reeds at other stations. Two reeds having different rates of vibration have their affixed coils free to vibrate in the same magnetic field, the two coils being coupled together and to line so that passing currents, whether generated by the movement of the coil for transmission, or creating motion of the coil for receiving, will circulate in opposite directions in adjacent portions of the two co-operating coils, thus facilitating the passage of current by reason of their mutual induction instead of hampering it as is the case with ordinary electro-magnetic apparatus.

My invention resides in the transmitting and receiving apparatus, and in a combination of the two, whether the combination comprises a joint outfit for a single station or a separate outfit for different stations. As a transmitter it comprises chokeless coils independently governed and moving at different rates of vibration in the same magnetic field.

It also comprises such coils coupled so as to assist one another by mutual induction. It also comprises a combined transmitter and receiver, or two receivers having these relationships. It also comprises a system embodying two or more stations provided with signaling outfits of this character. It also comprises a system capable of duplex or quadruplex functions at terminal stations and having interposed in the same circuit instruments of the character above referred to so that a plant may have its capacity largely increased without reduction of efficiency. It also comprises novel apparatus for vibrating the signaling coils. It comprises also other features which will be particularly hereinafter described, and the novelty of which will be definitely indicated in the appended claims.

In the accompanying drawings which illustrate the invention, Figure 1 is a side elevation partially in diagram and partially in section of a transmitting instrument, suitable for two independent operators, embodying a part of my invention. Fig. 2 is a similar view of a corresponding receiving instrument. Fig. 3 is a similar view of a combined transmitting and receiving instrument. Fig. 4 is a detail view of the magnetic field in which the coils shown in Fig. 3 are placed. Fig. 5 is a diagram showing the manner of coupling the coils so that the passage of currents is assisted by mutual induction. Fig. 6 is a diagrammatic view of a duplex system of telegraphy, having apparatus constructed in accordance with my invention interposed at intermediate stations between the termini. Fig. 7 is a diagrammatic view of a quadruplex system similarly equipped. Fig. 8 is a side elevation of a portion of a double receiving instrument suitable for the use of two operators. Fig. 9 is a side elevation of a corresponding transmitting instrument. Fig. 10 is a side elevation of two co-operating transmitting instruments in which the coils are placed in different magnetic fields, and the self-induction is eliminated by providing a closed electric circuit in which the counter-electric energy can act, thus relieving the line. Fig. 11 is a side elevation partially in section of a modified form of instrument from that shown in Figs. 1, &c., in which tuned strings or cords are used as vibratory agents in lieu of the reeds shown in the other figures. This instrument may be used either as a single or double transmitter or receiver. Fig. 12 is a front elevation with parts removed to better show the construction of the instrument shown in Fig. 11. Fig. 13 is a detail view of the instruments shown in Figs. 11 and 12, showing a mode of mounting the coils so as to prevent lateral movement in the narrow magnetic field in which the core is supported; and Figs. 14 and 15 are a side elevation and a top plan view respectively of a modification of the type of instrument shown in Figs. 1, 2, &c.

Referring first to Fig. 1, I have shown an electro-magnet, one pole of which, S, is provided with an aperture into which the other pole, N, projects, an annular space being left between the two in which are two coils affixed to two reeds A, B, having independent rates of vibration, the rates being adjustable in any suitable manner, as, for example, as indicated, by drilling a hole longitudinally of the reed and fitting therein a screw plug co-operating with a thread formed in the aperture, by the adjustment of which longitudinally of the reed its rate of vibration may be varied. The annular space between the poles N and S is made as narrow as compatible with an efficient vibration of the coils, and the latter may be superposed or nested as indicated in the drawings, or may be placed side by side, the former method being preferably adopted, as the effects of mutual induction are better applied, as will be hereinafter more fully described. I have found that in such a system the vibration of the coils under the influence of the reed sets up in the wire of which they are composed electric currents, which, although the coils may be of quite low resistance, as, for example, about twenty-four ohms each, will give rise to currents of a voltage sufficient to be commercially valuable upon circuits of great length. Two coils are connected in series with relation to a line, but in such a manner that the current flows through them in opposite directions in the immediate adjacent wires, so that the effect of mutual induction between the currents developed in the two coils will be to assist one another and to eliminate the retardation due to self-induction.

The manner of arranging the wires of the two coils is illustrated in Fig. 5, where, by following the direction of the arrows, it will be seen that the currents flowing in adjoining convolutions circulate in reverse directions, and yet the two coils are connected in series relation with the line wires C and D and throw their currents in series relation upon such wires. This arrangement may be practically carried out by winding the two coils in reverse directions, connecting one pair of terminals together, and the other pair of terminals to the two sides of the line. The two reeds will be given different rates of vibration, as, for example, the reed A may have one hundred vibrations per second, and the reed B one hundred and fifty vibrations per second. Local apparatus is provided for maintaining either or both of the reeds in continuous operation so long as a key controlled by the transmitting operator is actuated. Under these circumstances when a key is depressed the reed is thrown into vibration, an electromotive-force is developed in the corresponding coil which throws current upon line corresponding in frequency to the rate of the reed to which the coil is attached. When both keys are simultaneously depressed each coil develops its own current and both sets of waves pass to line. It will thus be seen that

the apparatus now being described is in effect a compound dynamo-electric machine capable of developing two sets of impulses, either or both of which may be actuated by two operators whom the instrument will accommodate.

For rendering the instrument instantly responsive to the operator's key I have provided for each reed a magnet, as indicated at E, E′, which, so long as the apparatus is quiescent is energized by a local circuit including the battery 1, wires 2 and 3, and one set of convolutions on the magnet. Each of the magnets E, E′ is differentially wound, that is to say, is provided with duplex coils, one set of which is included in the circuit 1, 2, 3 above noted, and the other set of which includes the battery, key 4, wire 5, and a circuit-breaking contact 6 completed by the reed when drawn up to the magnet. Under these circumstances, so long as the key is open, as indicated in the drawings, but one of the differential circuits will be active and the magnets E, E′ will be energized, holding the contacts closed at 6, and rendering the differential circuit 1, 4, 5, 6, complete at all points except the key, so that when the operator depresses the key this circuit is completed, rendering the magnet neutral and permitting the reed to instantly bound away from the condition of strain in which it was held by the magnet, thus opening one differential circuit at the point 6 and again rendering the normally closed circuit active. Under these conditions the apparatus becomes instantly responsive to a depression of the operator's key and the circuit-breaking function of the contacts at 6 maintains a continuous vibration of the reeds in accordance with their particular rates so long as the keys are closed. This construction embodies a feature of great practical importance in providing the operator with a transmitting apparatus which will instantly respond to the operation of his key, and one in which there is no delay of transmission by reason of inertia of the current generating apparatus. The reed being held in a condition of mechanical strain is ready instantly to respond to the least weakening of the magnetic field which holds it in the condition of strain, and the generation of current by the coil carried by the reed begins instantly upon the depression of the signaling key.

In Fig. 2 is shown a compound receiver which may be used to serve two receiving operators and is the complement in point of construction to the apparatus described in Fig. 1. In this instrument I have two reeds A′, B′ whose rates of vibration correspond to those of two transmitting reeds located at other stations and to which are affixed coils similarly arranged to those described in connection with Fig. 1 and connected in series relation in the line circuit. The rates of vibration of the reeds may be rendered adjustable, either in the manner indicated in Fig. 1, or as shown in Fig. 2, by a slide or weight longitudinally adjustable of the reed. The coils are supported in an intense annular magnetic field produced similarly to that shown in Fig. 1, though the magnet may be modified structurally. As shown it comprises a tubular magnet, one pole of which, N, is surrounded by the walls of an annular opening formed in the other pole, S, one reed being supported above both poles and the other passing through slots formed in the poles. Each reed carries a contact co-operating with another contact attached to a spring actuated lever and normally closing a local circuit F, F′ including a local battery and sounder. The reeds A′ or B′ will be silent except at such times as a transmitting reed having a corresponding rate is in operation, when it will be thrown into vibration, and by varying or opening the contacts of its local circuit will operate the sounder and reproduce the signal thrown upon line by the transmitting operator.

The same instrument may embody both the features of transmitter and receiver as illustrated in Fig. 3. In this case one of the reeds, as A, co-operates with an attracting magnet E and a transmitting outfit similar in character to that described in connection with the instrument shown at A in Fig. 1, and the other reed, B′, having a different rate of vibration from the reed A co-operates with a local circuit F′ in the same manner as reed B′ described in connection with Fig. 2. Two coils carried by the reeds A, B′ may be arranged in the same manner with relation to the magnetic field as the coils described in the preceding figures, and are connected in series relation with the line. Such an organization may provide a single operator with both transmitting and receiving outfit. The coil mounted upon the receiving reed B′ is quiescent except at such times as there is passing upon line impulses having a frequency corresponding to the rate of vibration of its reed, when it will be thrown into operation and reproduce the transmitted signal. The cores of the electro-magnets are preferably laminated so as to increase the effectiveness and sensitiveness of the apparatus. The annular opening in which the coils are supported and the corresponding shape of the coils may be made of any convenient shape. As illustrated in Fig. 4, it is somewhat elliptical in shape. A line equipped with apparatus as hereinbefore described has removed from it the most serious obstacle to multiplex transmission.

Additional instruments inserted in the circuit do not materially affect the clearness of transmission, so that the limitation imposed by static effects which may be provided for in other ways not necessary to consider here, becomes the chief controlling factor of the line's capacity.

It will be noted that a circuit equipped with the apparatus hereinbefore described may be completely closed at all times during transmission, and the signaling currents are induced currents propagated over the line

without in any way disturbing its conductive integrity or interposing apparatus causing retardation of transmission. The ohmic resistance of the apparatus corresponding to a single operator is so trivial as to be negligible.

When the apparatus is interposed in a duplex or quadruplex system the reeds employed are preferably of such rigidity that the currents utilized for duplex or quadruplex transmission can have but little effect upon them, and yet when currents are passed through their attached coils in unison with the beat or pitch to which they have been tuned or adjusted, they will be promptly caused to vibrate. In some cases, however, it may be desirable to avoid the bias given a reed when the apparatus is used in one of these systems by the duplex or quadruplex currents. The strain of this bias upon the reeds will have approximately the same effect as if a spring were attached thereto rendering it sluggish to the influence of impulses to which it has been tuned. This defect may be overcome by coupling the reeds together by means of an inharmonious or neutral spring, which, by opposing or releasing strain compensates for any bias exercised by outside currents passing through the coils. I have found a rubber sphere to be admirably adapted for this purpose, and have shown an organization in Figs. 8 and 9 adapted to counteract the tendency just noticed, the former figure showing two receiving reeds coupled together by a link G passing through a perforation formed in a rubber sphere H and provided with an adjusting nut by which the tension may be varied. This sphere being inharmonious in its action will permit the reeds to respond to impulses corresponding to their rates, acting simply as a stiffener and yet will oppose a tendency to separation by any influence exerted by a direct current.

In Fig. 9 each of two reeds forming a double transmitting outfit is shown as provided with a separate rubber sphere for counteracting the bias referred to. When the reeds are associated in other relationships such as for example one acting as a transmitter and the other as a receiver the inharmonious spring will be arranged in such a way as to oppose the bias which the line current will tend to give them.

While the manner of eliminating the coil retardation which I have described is the one I prefer to use, there are other ways in which its effect may be mitigated and which may be used in conjunction with the plan hereinbefore described or as an independent means of rendering the coils chokeless. For example, in Fig. 10 I have shown a system of two instruments, one of which may be the transmitter and the other the receiver, the coils being coupled in series relation to the line and mounted so as to vibrate in independent magnetic fields. Over the core of the electro-magnet creating the magnetic field is placed a copper or other good conductive ring I, I′ which acts as a closed secondary circuit and reduces the counter-electro-motive-force of the coils. An impulse passing through one of these coils will develop secondary currents in the copper ring which flowing in an opposite direction to those in the coils will facilitate their passage.

In Figs. 11, 12, and 13 I have shown a transmitting and receiving instrument or both in which tuned strings or cords are used as the harmonic vibrator instead of the reeds illustrated in the figures hereinbefore described. A single coil in this case may be used both for transmitting and receiving or may act as a double transmitter or receiver. The coil floats or is suspended in an intense magnetic field formed by the pole-pieces N, S, of an electro-magnet; over the former which is preferably laminated may be placed a conductive ring I similarly to the ring described in Fig. 10, and the ring may be formed of iron so as to form a path for the lines of force traversing the field as well as to form a conductor for the secondary currents developed. The coil is pivotally supported by means of toggles L, L upon armatures M, M′ mounted upon cords J, J′, the tension or tone of which may be adjusted by means of wing nuts K, K′. In operative relation to the armature M is an electro-magnet P differentially wound and connected with an operator's transmitting circuit in a manner similar to the apparatus described in connection with Fig. 1. If the apparatus is a double transmitter two such electro-magnets will be provided, one for each harmonic vibrator, and each will be coupled in such a differential transmitting circuit, and when the keys are depressed the strings will be thrown into instantaneous vibration by means of the make and break at the contact 6, which is the counterpart of the contact 6 described in Fig. 1. The harmonic vibrators J, J′ now become the counterparts of the reeds described in Fig. 1 and each end of the coil is vibrated independently of the other end in accordance with the rate to which its controlling string has been tuned. In order to prevent lateral deflection of the coil and impingement against the walls of the magnetic field, cords O, O′ may have one pair of ends affixed to the corners of the coil the other ends of the cords being fastened to posts or studs mounted upon any suitable portion of the frame work of the apparatus. This organization is shown in Fig. 13 and has been omitted from Figs. 11 and 12 in order to avoid obscurity.

When the apparatus is to act as a double receiver the magnets P and their arms will of course be omitted, the arms upon which the toggles are mounted being secured to the strings in any suitable way. By using such a magnet on one armature, M, and omitting it from the other the apparatus becomes a combined transmitter and receiver.

The instrument when in operation is controlled by two sets of impulses, one corre-

sponding to each of the strings J, J′, and the motion of the coil will be a resultant motion due to these two sets of impulses. When the instrument is acting as a receiver this resultant motion will be resolved by the strings themselves into such components as will throw the strings into vibration according to their own particular rates. When both cords are acting as transmitters the attached coil will take a resultant motion which will throw upon line currents of exactly the value necessary to their reproduction in the corresponding instruments at some other station. When one of the strings acts as a receiving agent it should be provided with a tremulous contact controlling a sounder circuit in a manner similar to the receiving reeds hereinbefore described.

If desired nested coils may be used independently and fixedly attached to separate vibrating strings. The strings will preferably be formed of metal or if made of other material measures should be adopted to provide for the circuit breaking operation at the contact 6 when the apparatus is acting as a transmitter. If simply the transmitting side of the coil is in action but one of the strings will be vibrated and the coil will be given a simple vibratory movement corresponding to the tone of the string.

Figs. 14 and 15 show a modified form of construction of the combined transmitting and receiving reed instrument. The operation of the apparatus is similar in function to that described in Fig. 3. A single coil however is used and is supported at opposite ends so as to partake of a compound movement when both the transmitter and receiver are in operation, similar to the coil described in Fig. 11. Each side of the coil is pendulously supported upon two elastic arms Q, Q, Q′, Q′, bent at their inner extremities so as to embrace the coil, and supported at their outer extremities upon a yoke piece R, R′ secured to the ends of the transmitting and receiving reeds. The transmitting reed has a cooperating magnet and circuit connections similar to those described in connection with Fig. 1, and the receiving reed B′ carries a spring contact T controlling a local circuit including the receiving sounder.

Transmitting and receiving apparatus involving the principles hereinbefore described may be used at two terminal stations and at intermediate stations if required. When used at intermediate stations the entire apparatus at all such intermediate stations will of course be in series relation to the line. Two or more outfits at the terminal stations may be connected in series or multiple relation to the line. If the latter, provisions should be adopted to prevent short circuits. A line embodying a number of such instruments simultaneously operating would contain a mass of unintelligible impulses until each set of impulses was picked out by the several instruments adapted to respond to some component factor of the aggregate.

In Fig. 6 I have shown an organization in which apparatus constructed in accordance with my invention is interposed between the termini of a duplex system at two or more intermediate stations. In such a system two operators may exchange signals, for example, between New York and Boston, while simultaneously two or more operators are intercommunicating with each other between Bridgeport and New Haven. For example, suppose an operator at Bridgeport desired to communicate with an operator at New Haven, while two operators at New York and Boston were exchanging signals. By depressing key *a* the operator at Bridgeport sets his reed into operation, creating upon the line vibrations or undulations synchronous in period with the vibrations of reed *b*. At New Haven is a receiving reed *b′* which corresponds in rate to the transmitting reed *b*, and when thrown into vibration will open its sounder or recording circuit and reproduce the signal transmitted by the depression of the key *a*. These undulations have no effect upon the operation of the duplex instruments at New York and Boston. The vibrations are of such rapidity that ordinary electromagnetic apparatus will not respond to them. On the other hand the only effect of the currents used by the operators at New York and Boston will be to give a slight bias to the vibrating reeds at Bridgeport and New Haven which if annoying may be counteracted in the manner hereinbefore described. Simultaneously with the operation of the key *a* another operator at Bridgeport may be manipulating a key *c* which will throw into operation a transmitting reed *d* and develop impulses which will traverse the line and throw into operation a corresponding reed *d′* at New Haven. Similarly at New Haven are two transmitting outfits *e*, *g* which have transmitting reeds *f* and *h*, to which reeds *f′*, *h′* at Bridgeport will respond. Assume that reed *b* has been set to a vibratory rate of twenty periods per second; reed *d* to thirty per second; reed *f* at fifty per second; and reed *h* at seventy per second. We now have four transmitting reeds operating at different rates and controlled by separate keys, two being located at Bridgeport and two at New Haven. Suppose that receiving instrument *b′* be set at twenty vibrations per second; *d′* at thirty; *f′* at fifty; and *h′* at seventy. If the key *e* be depressed reed *f* will be operated at fifty per second, and reed *f′* will correspond thereto. If both *e* and *g* be depressed *f* and *h* will throw waves at the rates of fifty and seventy upon line, which will be picked out of the receivers *f′* and *h′* and reproduced at Bridgeport. Similarly if the keys *a* and *c* at Bridgeport be simultaneously operated reeds *b* and *d* will throw upon line impulses at the rate of twenty and thirty per second respectively,

producing a composite set of electric undulations which will be resolved or analyzed by the receiving instruments *b' d'* at New Haven. These instruments might be located at as many stations as may require service, the rates of vibration of the sets of corresponding reeds being given sufficiently wide margins to prevent interference with one another. The adjustability in the rate of the reeds of the several stations enables the operator to adjust his reed to counteract irregularities due to climatic effects or to change the tone of his reed so as to bring it into synchronism with the reed corresponding to the station he may desire to communicate with.

In Fig. 7 a single transmitting and receiving outfit is shown as interposed at two intermediate stations in a quadruplex system. The only tendency of the variation in strength or reversal of currents used for the quadruplex signaling will be as hereinbefore described to give a bias to the apparatus, which, if found objectionable, may be counteracted in the way described. The polar and neutral relays at the terminal stations may perform their functions independent of the harmonic system in operation at the intermediate stations.

In the system shown in Fig. 7 the transmitting outfit *a*, at say Bridgeport, will be adjusted in rate of vibration to the receiving outfit *a'* at New Haven, and the transmitting outfit *b* at New Haven will be similarly adjusted with reference to the receiving outfit *b'* at Bridgeport.

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

1. A transmitting generator for a signaling system containing a chokeless coil supported in a magnetic field, a harmonic vibrator for vibrating the coil across the lines of force of said field said vibrator being normally strained, and a key and controlling magnet for instantly releasing the strain, whereby vibrations are instantly sent to line upon operation of the key.

2. A transmitting generator for a signaling system comprising nested coils supported in a common magnetic field and mounted so as to vibrate harmonically in opposite directions.

3. A harmonic signaling instrument comprising two coils attached to harmonic vibrators of different rates and supported in a magnetic field and interconnected so as to assist each other by mutual induction.

4. A harmonic signaling instrument comprising nested coils supported in a common magnetic field and attached to harmonic vibrators of different rates.

5. A transmitting generator comprising nested coils supported in a common magnetic field and attached to vibrators of different rates and independent means for actuating the several coils.

6. A signaling instrument comprising two coils connected in series and reversely wound in the same magnetic field, said coils being attached to harmonic vibrators of adjustable rates adapted to vibrate them across the field.

7. A signaling instrument for a harmonic telegraph system comprising two connected nested coils supported in the same magnetic field and attached to two harmonic adjustable vibrators having different rates.

8. A transmitting instrument for a harmonic telegraph system comprising a normally strained harmonic vibrator, a coil of wire in a magnetic field attached to said vibrator, a key for releasing the strain, and an electro-magnet and local connections for maintaining the vibrator in operation so long as the key is held closed.

9. A transmitting instrument for a harmonic telegraph system comprising a coil supported in a magnetic field, said coil being attached to a harmonic vibrator, an electro-magnet provided with a normally closed circuit for holding said vibrator in a state of stress, a key and circuit connections for releasing the vibrator and maintaining it in operation when the key is actuated.

10. A transmitting instrument for a harmonic telegraph system comprising a coil supported in a magnetic field, said coil being attached to a harmonic vibrator, a magnet for normally holding the vibrator in a state of stress, and a key for closing a local circuit and releasing the vibrator, and circuit connections including an electro-magnet and interrupter to maintain the vibrator in action while the key is in signaling position.

11. A transmitting instrument for a harmonic telegraph system comprising a generating coil supported in a magnetic field, said coil being attached to a harmonic vibrator, a charged electro-magnet for normally holding the vibrator in a state of stress, a differential winding on said electro-magnet including a signaling key and an interrupter for opening the differential circuit at each vibration of the vibrator.

12. A combined transmitting and receiving instrument for a harmonic signaling system comprising two coils supported in a common magnetic field and attached to harmonic vibrators of different rates.

13. A combined transmitting and receiving instrument for a harmonic signaling system comprising two coils supported in the same magnetic field, one serving as a transmitting agent and the other as a receiving agent, said coils being attached to two harmonic vibrators having different rates.

14. A harmonic telegraph system comprising three or more stations connected in series relation by a continuously closed circuit, chokeless transmitting and receiving instruments at the several stations comprising harmonic vibrators and generating coils for originating electric vibrations, and similar vibrators and receiving coils, the instruments at the several stations having different rates of

vibration and their coils being wound to eliminate self-inductive drag.

15. A harmonic telegraph system containing a series of stations connected by a continuously closed circuit, and inductionless or chokeless signal transmitting and receiving instruments at different stations cooperating with harmonic vibrators of adjustable rates of vibration.

16. In a balanced telegraphic circuit such as a duplex or quadruplex, the combination with the terminal stations provided with balanced signaling apparatus, of one or more intermediate stations included in the main circuit provided with chokeless signaling apparatus comprising harmonic vibrators for originating line impulses and harmonic vibrators for receiving line impulses, the several vibrators at different stations being tuned to different rates.

17. A multiplex telegraph system comprising a series of stations at two of which is balanced signaling apparatus, and a series of chokeless harmonic signal transmitting and receiving instruments included in the same circuit comprising harmonic vibrators for originating line impulses and harmonic vibrators for receiving line impulses, the several vibrators at different stations being tuned to different rates.

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

STEPHEN DUDLEY FIELD.

Witnesses:

R. EICKEMEYER, Jr.,

HENRY OSTERHELD.