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SYNCHRONOUS MULTIPLEX TELEGRAPHY.

No. 428,221. Patented May 20, 1890.

Fig. 1.

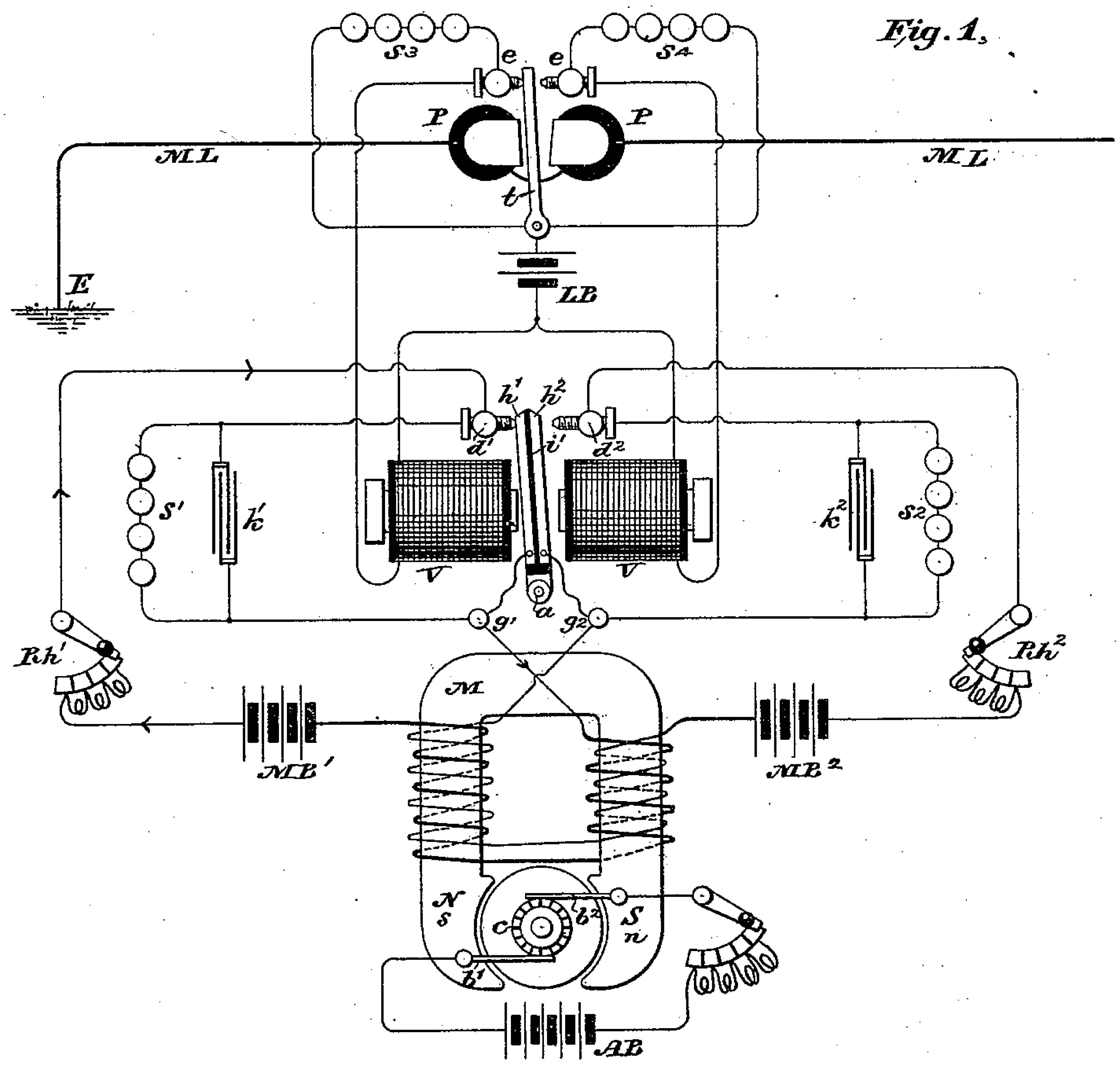
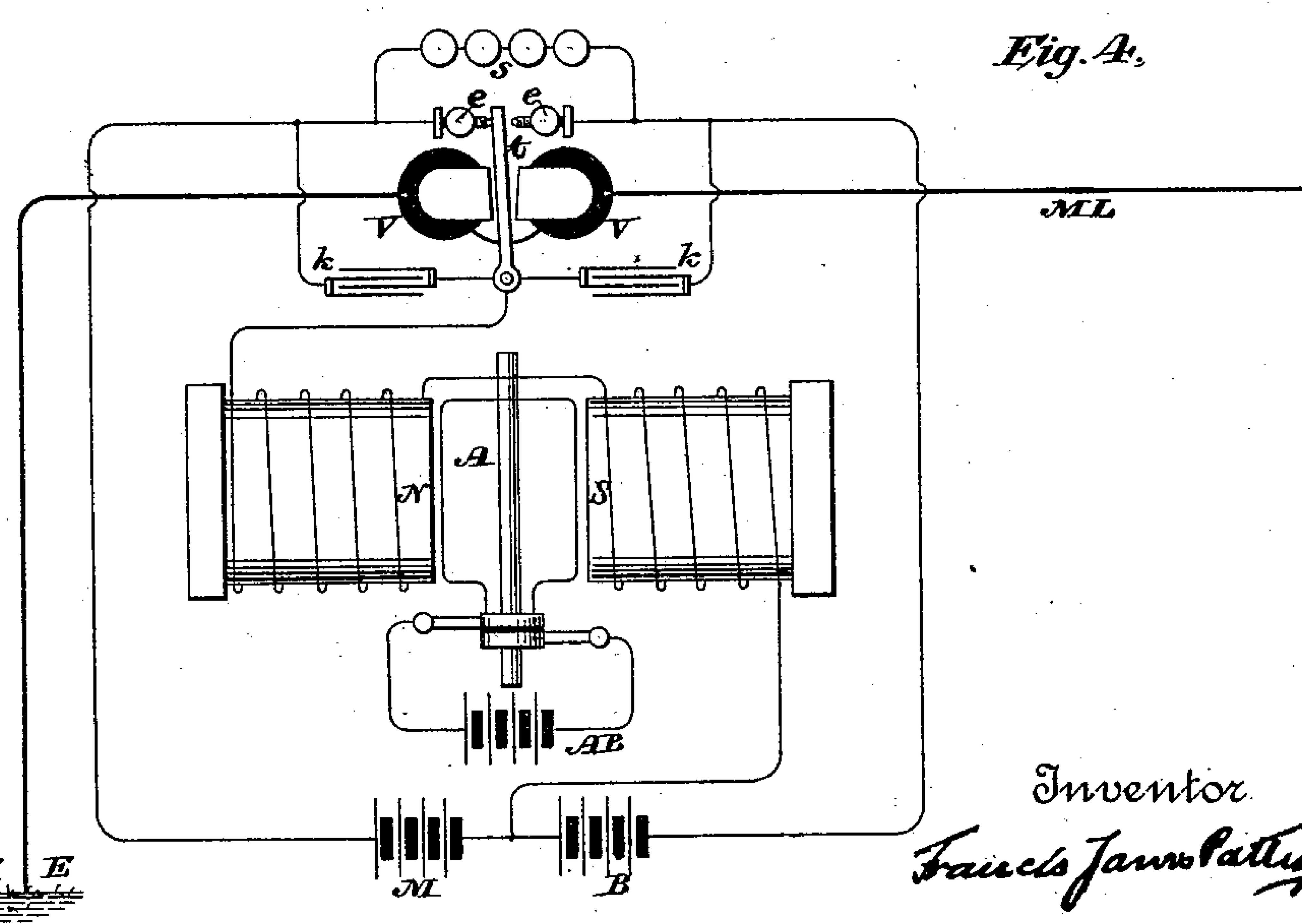


Fig. 4.



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SYNCHRONOUS MULTIPLEX TELEGRAPHY.

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Fig. 5.

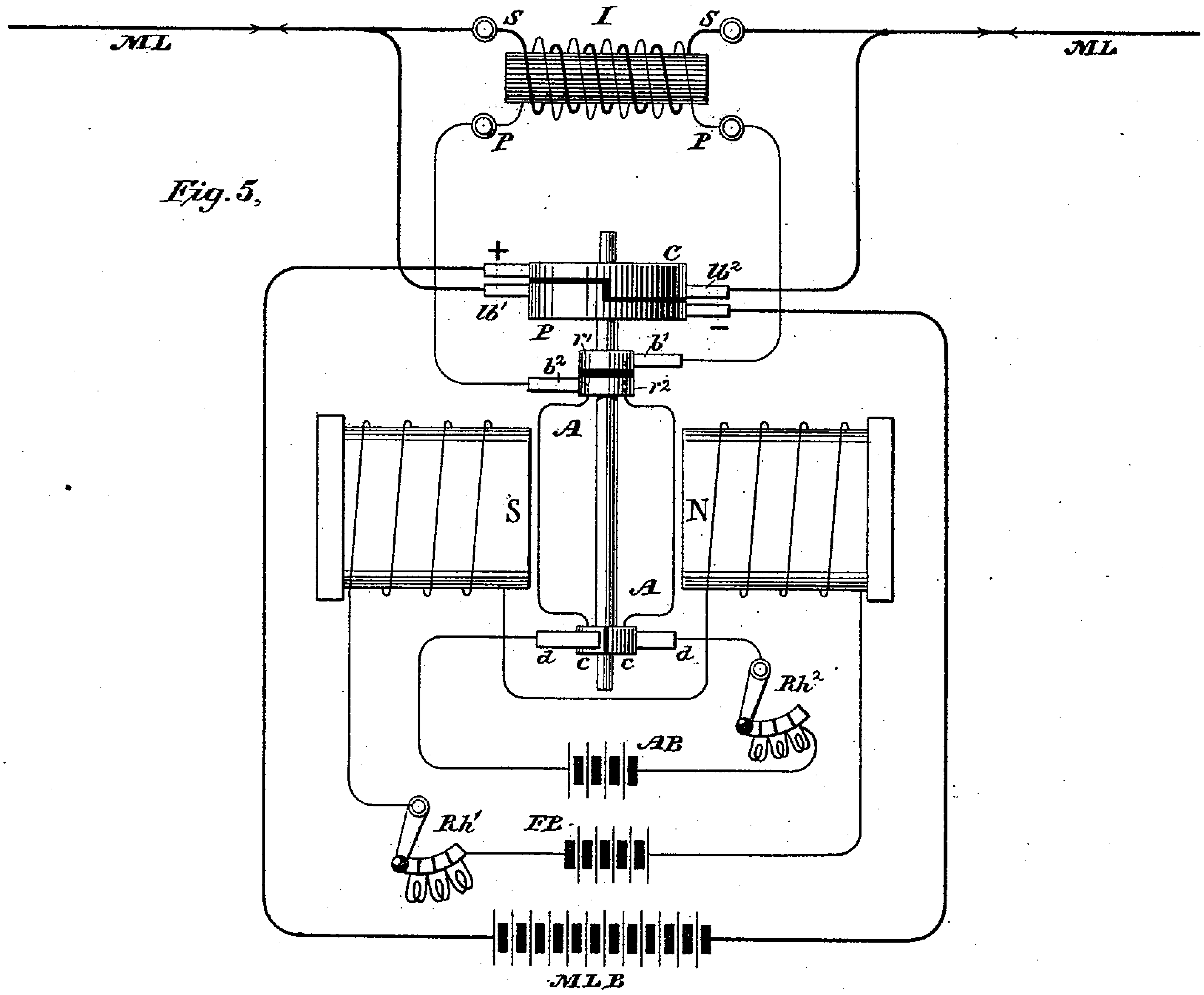


Fig. 2.

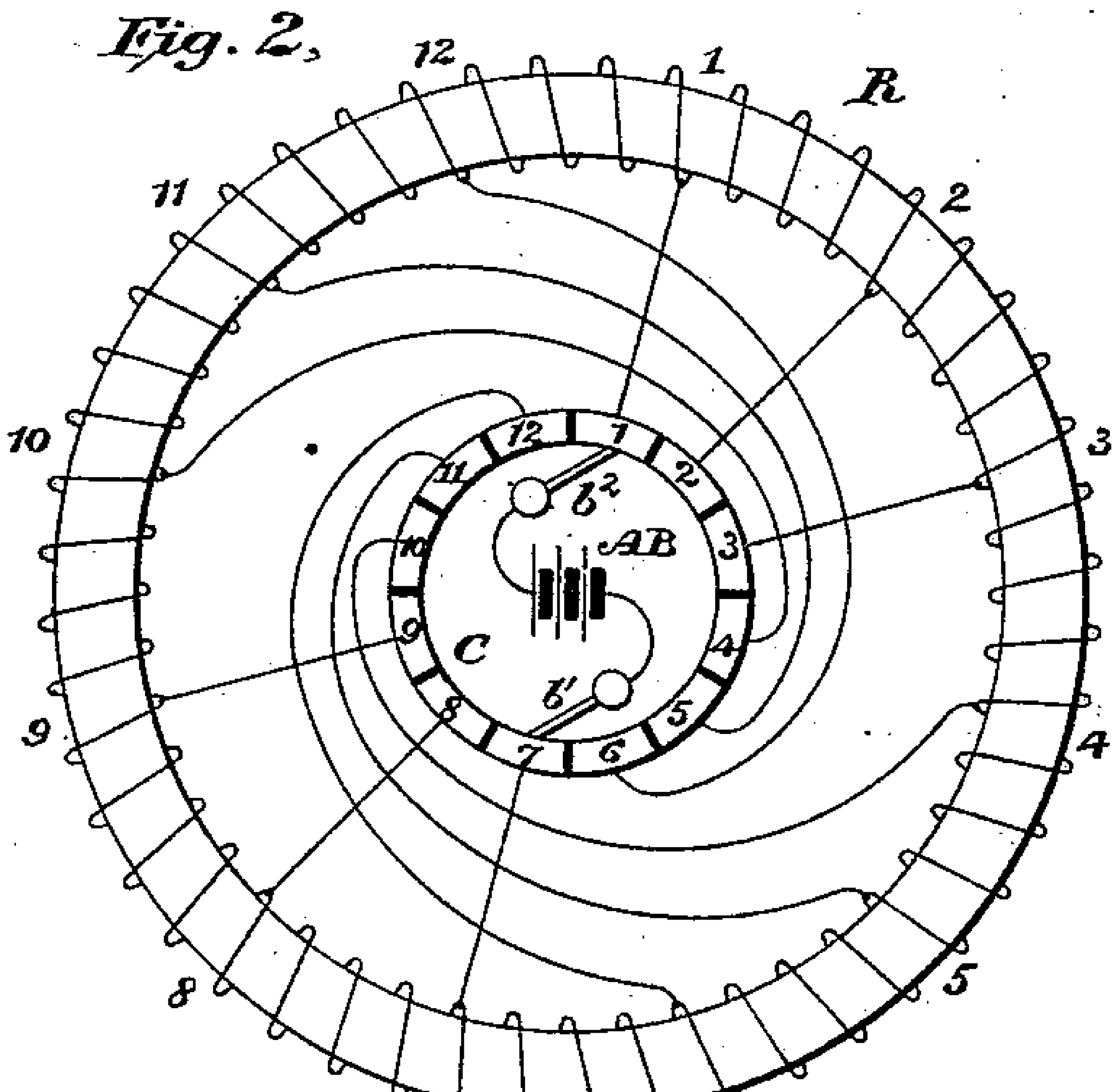
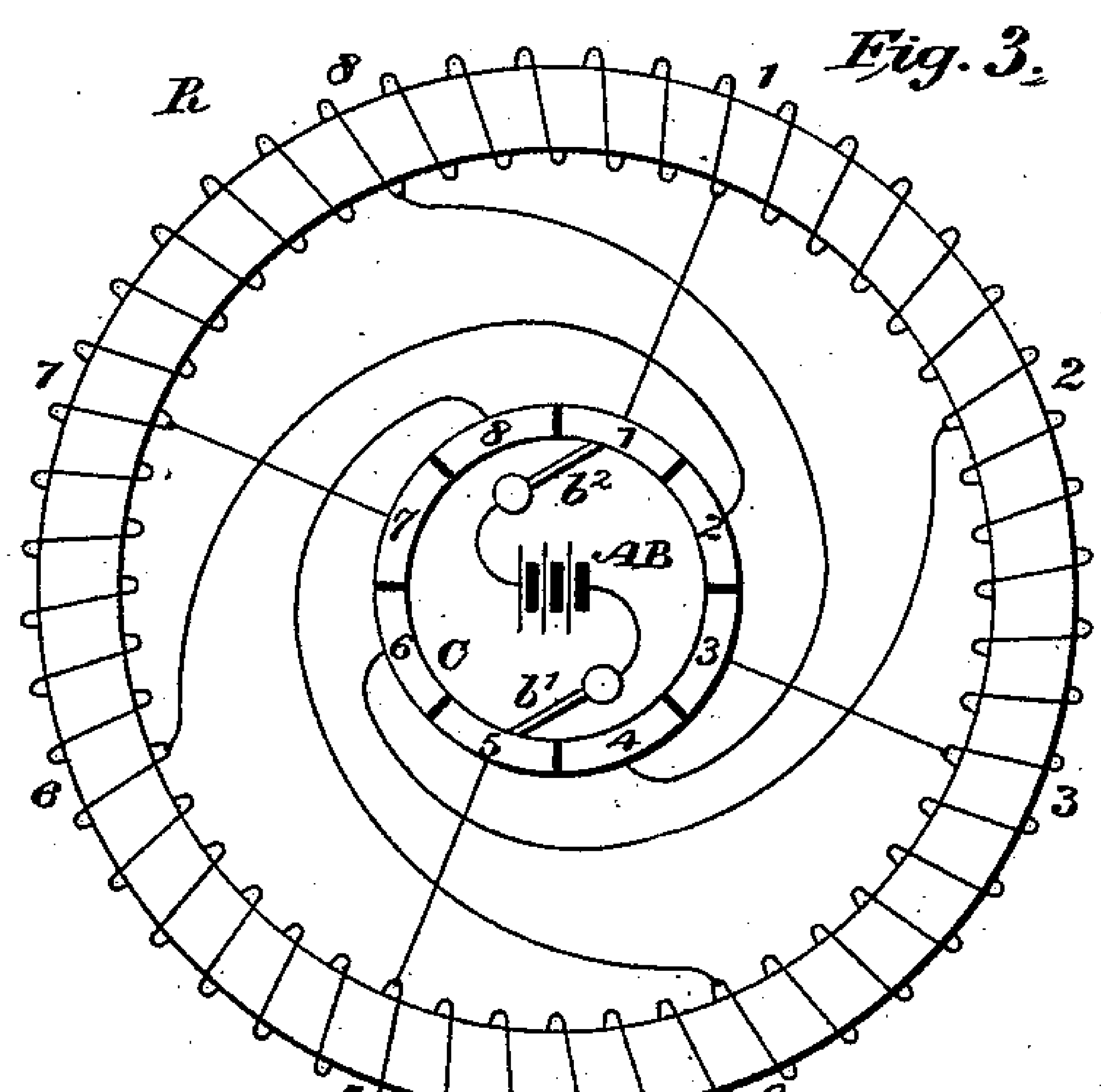


Fig. 3.



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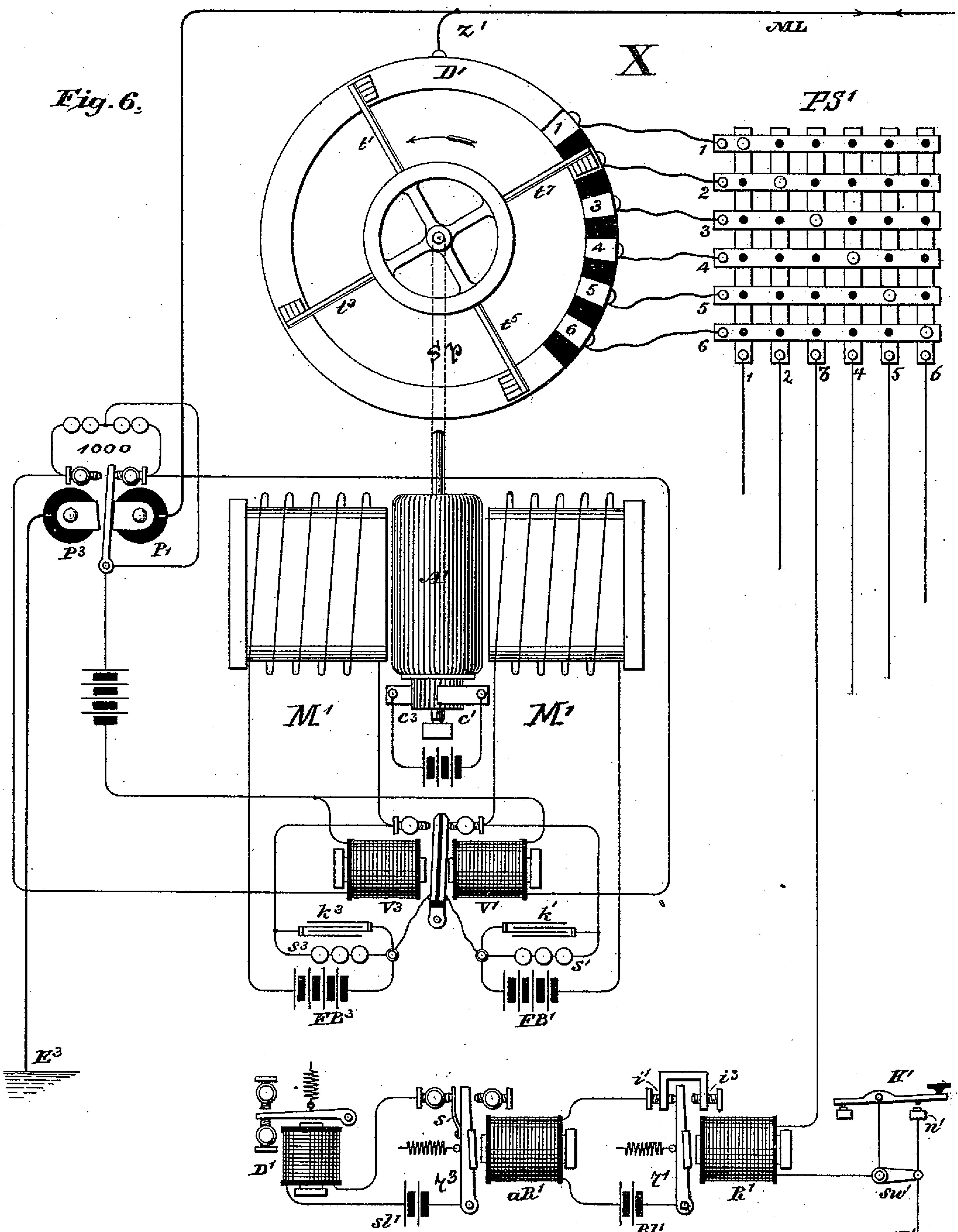
SYNCHRONOUS MULTIPLEX TELEGRAPHY.

No. 428,221. Patented May 20, 1890.

Fig. 6.



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(No Model.)

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SYNCHRONOUS MULTIPLEX TELEGRAPHY.

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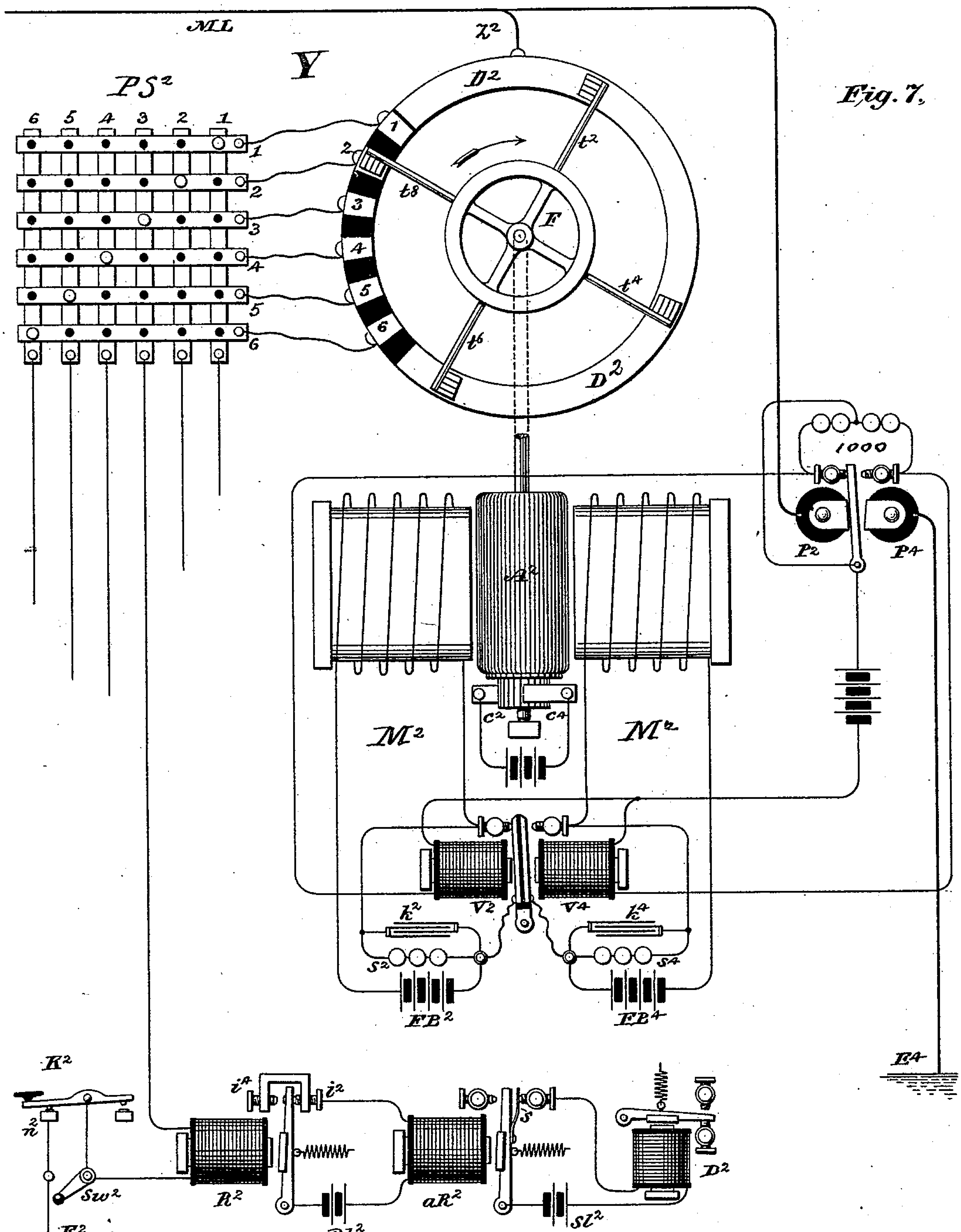
Fig. 7.



Witnesses

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SYNCHRONOUS MULTIPLEX TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 428,221, dated May 20, 1890.

Application filed January 10, 1890. Serial No. 336,576. (No model.)

To all whom it may concern:

Be it known that I, FRANCIS JARVIS PATTEN, a citizen of the United States, residing in New York, county of New York, and State of New York, have made a new and useful Invention in Telegraphic Systems, of which the following is a specification.

My invention relates particularly to that class of telegraphic systems known as "multiplex," in which a number of messages may be simultaneously transmitted on the same line-wire. Among systems of this character some, as duplex and quadruplex, are operated by the application of different strengths and polarities of current to the signaling-instruments, and others contain at different stations distributing apparatus, as "sunflowers," technically called, over which trailers are kept in synchronous rotation at different stations by electrically-controlled step-by-step devices, which give to each of a series of local receiving-instruments the use of a line-current for a small increment of time during which such apparatus is at work.

My invention belongs generically to the synchronous multiplex type embodying a novel system of synchronism by which the distributing apparatus at the different stations is kept in unison, and an independent system of signaling between the stations.

It consists, further, in a system in which progressive circuit-closers are maintained in synchronism by electric motors having independent field-magnet and armature circuits, one of which circuits in each motor is controlled by a line-current changed periodically by reversal or interruption or otherwise at periods corresponding to some part of the armature revolution, and the other circuit is excited by a current which produces in that circuit a suitable polarity, either constant or periodically reversed, as may be required to maintain a continuous and uniform movement of the apparatus.

The invention also consists in determining the rate of change in the controlling line-current for synchronizing the motors by the revolutions of a controlling-motor, which sets the pace for the other motors of the system, and the other motors are so constructed in respect to winding and connections that they may be made to go at the same pace as this controlling-motor or any fraction of its speed, as required. Thus the controlling-motor may be run very fast and all the others very slow, but all the driven machines alike in speed and in unison with each other.

The invention also consists in a novel system of circuits and connections of apparatus such that the synchronism remains uninterrupted, notwithstanding the frequent and repeated interruptions of the signaling-current incident to numerous simultaneous transmissions over the same wire.

The devices by which electric motors can be so connected in a system of telegraphic circuits as to render their operation at a distance continuous and reliable constitutes an important feature of the general synchronizing system, to which claim will be made in this application.

My invention embodies also other features, which will be hereinafter fully described in the specification, and definitely indicated in the appended claims.

In the accompanying drawings, Figures 1 and 4 represent the system of circuits, apparatus, and connections which I have devised for maintaining the continuous and uniform motion of an electric motor driven through the agency of a controlling line-circuit. Figs. 2 and 3 show a peculiar system of armature-connections. Fig. 5 shows the operative circuits and parts of an independent controlling-motor of peculiar form and construction, by which the line currents are periodically reversed and the movement of the machines at distant stations is controlled. Figs. 6 and 7 show diagrammatically two distant stations connected by a single line, and from which, at each end, radiate the connections to several local stations, the complete sending and receiving apparatus for one such local being shown at each end, one represented as sending and the other as receiving.

As the armature construction shown in Figs. 2 and 3 is novel, it will be first explained.

Any form of continuously-wound armature may be taken, as a Gramme ring or drum, and the ordinary connections to the commutator severed. They are then reconnected as follows:

Referring to Fig. 3, point 1 of the ring to segment 1 of the commutator; as before, point 2 to the opposite segment 6; point 3 to point 3, as before; and point 4 to the diametrically-opposite segment 8, and so on around the ring, all odd-numbered points connected to corresponding segments of the collector, as in a Gramme ring or drum-armature, and all even-numbered ones connected oppositely or reversedly, as shown in Fig. 3, or the ring winding may be connected in groups alternately direct and reverse, as shown in Fig. 2, segments 1 2 3 to points 1 2 3, and segments 4 5 6 to the opposite points 10 11 12, &c. In either case the identity and character of the drum-armature or Gramme ring is destroyed, as it will no longer perform any of its ordinary functions if placed in a constant magnetic field, the result of this system being that it will not rotate as before, but will vibrate back and forth under the action of the field, if given a current of one direction in the usual way, as indicated by the battery-connections and brushes shown in Figs. 2 and 3, the reason being that as the ring revolves its magnetism is constantly reversed by operation of the constantly-recurring reversed connections; but if this armature be placed in a field that is periodically reversed, then this form of armature will turn and the armature must turn at just such a rate that its reversals coincide exactly in time with those of the field. Now, giving the armature and field separate exciting-circuits and controlling all the field-circuits of any number of distant motors by a single controlling line-circuit having periodic reversals, while the armatures have independent separate sources of energy, then all the machines will revolve synchronously, for the reason that all the field polarities of the machines are reversed at the same instant of time and all the armatures are likewise reversed by the peculiar connections described, and thus are forced to move at such a rate that changes of polarity in the fields and armatures must occur at the same instant in each machine.

So far as the synchronizing system is concerned, it remains to show how all the field-circuits of different motors at distant stations are caused to reverse polarity at the same instant of time. In general terms, a controlling line-circuit is supplied with periodically-reversed currents or interrupted currents, which at the distant stations operate polarized or other suitable relays, and these by their vibrations reverse the direction of current in the field-circuits. Such is the general statement of the operation; but a very particular system of devices and circuits is necessary to the certain and effective performance of the steps described. This combination of circuits and devices is shown in Figs. 1, 6, and 7, to which reference will soon be made; but in order first to show the necessity of the complete system of devices and circuits used it will be necessary to refer first to Fig. 4, which, though an operative system of circuits, is not as effectual for the purposes required as the one hereinafter described, but serves to illustrate the defects which are remedied by the system of connections and devices shown in Fig. 1, which represents a very essential part of any sychronizing system in which electric motors having independent armature and field circuits are maintained in continued motion through the agency of a controlling line-circuit, and the distinctive features of this combination will be claimed in this application.

In Fig. 4 M L is a main-line wire grounded at E. It traverses a polarized relay V V, and as the line is supplied from a suitable source with currents that are periodically reversed the tongue of this polarized relay is maintained in constant vibration. The fixed point of this vibrating tongue is connected to one end of the field-circuit N S of an ordinary electric motor and the other end of this circuit is connected to the middle point of the split battery M B, while the extreme poles of this battery are connected to the contact-stops *e e* of the relay. Evidently, therefore, as the relay-tongue vibrates back and forth the current in the field-circuit of the motor will be reversed at each vibration of the relay-tongue, and if the two-pole armature A be supplied with a continuous current, as shown, from the source A B the motor-armature will turn, making one-half a revolution at each change of field polarity. A liquid-condenser *s* and plate-condensers *k k* may be placed as a shunt around the points *e e*. Now while this is an operative system of circuits it is not as effectual as that shown in Fig. 1.

The reasons are as follows: In the first place the main-line current is very slight on a line of any length, and the action of the polarized relay is necessarily very weak and cannot be made strong. The result is that the slightest spark at the points *e e* will soon bring the machine to rest by causing the relay-tongue to "stick," there not being force enough in its magnet to pull it away. The condenser devices shown will be ineffectual to prevent this spark, for the following reason: When the tongue of the relay is on one side, as shown, then one-half the battery M B—the left-hand half—is in action at the moment of breaking. However, when the tongue is in the middle the electro-motive force of the entire battery is suddenly brought into action to drive a current across the interval *e e* through the metal of the tongue. Besides this double electro-motive force suddenly brought into play, the displacement of the relay-tongue from the point *e* breaks the circuit of the field N S, and the magnetic reaction thus brought about still further tends to intensify the spark. These objectionable features render a different arrangement of circuits necessary for the best results.

The system shown in Fig. 1 is a characteristic feature of my synchronizing system. It constitutes an assemblage of devices and circuits which entirely obviate the difficulties met, and by its means such a system may be made continuously and reliably operative without care or attention.

In Fig. 1 the main line M L includes the polarized relay P P in circuit, as before; but this relay does not actuate the motor directly and is not connected to the motor-circuits directly. This polarized relay has the fixed point of its tongue connected to one pole of a local battery L B, the other terminal of which is carried to the right and left hand halves of the local "vibrator" V V, the other terminals of the coils of this vibrator being carried to the contact-stops *e e* of the polar relay, so that when the relay-tongue is on one side one coil of the vibrator is actuated, and its armature is drawn to that side, and when the relay-tongue reverses the vibrator-armature also reverses, so that the vibrator-armature follows the oscillations of the polarized relay-tongue. The vibrator, being actuated by a local circuit, can be given considerable strength without producing too great a spark at the points *e e*, and it is found that the vibrator can be given a pull of several pounds without causing such a spark at *e e* as could not be overcome by a few cups of liquid-condenser s^3 and s^4 shunted around the points, as shown. In this arrangement the liquid-condensers s^3 and s^4 suffice to completely eliminate the spark at the relay-points *e e*, so that the relay can be relied upon to keep its pace with line-currents so slight as to be scarcely measureable.

Now, the vibrator V V, which follows the relay, has a double armature, as shown, being provided with two conducting parts h' and h^2, connected to the two binding-posts g' and g^2 by flexible connections. These parts are separated from each other and from the pivot *a* by the insulating substance i'. (Shown in black.) The motor M has also a characteristic feature. It is provided with two independent field-circuits wound parallel and together throughout upon the field-cores. To avoid confusion one is shown in light lines in the fields; but they are alike in all respects, and are connected to separate and independent sources of energy M B' and M B^2, and the field is excited equally and oppositely by either one or the other of these two batteries, according to which field-circuit is used. Thus there are two separate field-circuits corresponding, respectively, to the two contact-points d' and d^2 of the vibrator, and the two sides h' and h^2 of the vibrator-armature, and when one circuit is in action the other is idle. In the position shown, with armature over to the left, the field is excited by the dark-line field-circuit producing the polarities N and S, the circuit being from the battery M B' to the left through the adjustable rheostat R h' to contact-point d', down left-side armature h' to the binding-post g' into right-hand half of field, winding (dark circuit) thence to left-hand half and back to the battery M B'. The armature of the machine is independently excited, as before, by the battery A B.

The field-circuits may be wound oppositely or their terminals may be connected to the batteries M B' and M B^2 reversed in such a way that one field-circuit will produce the poles N and S in the field and the other the poles *s* and *n*. In this system, it will be seen, the split field-battery M B of Fig. 4 has been replaced by two independent batteries and circuits M B' and M B^2 in Fig. 4, and the double electro-motive force due to both cannot operate to force a spark across the contact-points d' d^2. Notwithstanding this and the heavy pull given to the local vibrator the spark at d' and d^2 may still bring the machine to a stop if left without further control, and to prevent this the plate-condenser k' and liquid-condenser s' are shunted in parallel to one field-circuit between the points d' and g' and on the other circuit the plate and liquid condensers k^2 and s^2 are similarly placed. Neither of these devices will effectively do the work alone at this point, owing probably to the strong reaction of the field-magnet circuits of the motor at the instant of rupture of the field-circuit.

Such are the devices and circuits necessary to the maintenance of a continuous uninterrupted movement of electric motors at distant stations through the agency of a controlling line-circuit, and the required conditions are secured by simultaneous but independent reversals of polarity in the field and armature necessary to a uniform and synchronous movement.

Referring now to Figs. 6, 5, and 7, which should be placed as a single chart in the order named, I have presented the complete multiplex system, showing the synchronizing devices complete, distributers, switches, and the necessary signaling-instruments for the two stations, one complete set of the latter at each station X and Y being shown, these stations being represented as the two extremities of a single main-line circuit M L, connecting the two points, a single set of sending and receiving instruments being shown at each end, one set at Y sending, the other receiving. The remaining sets of sending and receiving apparatus at each end, being identical in form and connections with those shown, are omitted to avoid confusion of the drawings. The system is shown for a sextuplex; but evidently the number is limited by practical considerations only and any multiplex may be assumed.

Beginning now with a general description of the complete system as operated between two stations X in Fig. 6, and Y in Fig. 7, I find these stations connected by a single main-line wire M L, M L extending from X to Y and placed to earth at two points E' and E^2 at X, and E^2 and E^4 at Y, one such earth-connection going to the sending and receiving apparatus at each station through the segments of the circular distributers, the other earth-connection being a high-resistance shunt, through which the signaling-current cannot pass.

At some intermediate point between the stations X and Y, or, if need be, at one of the stations, and carrying devices that are included in the main-line circuit, as shown at Fig. 5, is an electric motor, which acts as an independent regulator and controller of the entire system. (See my patent, No. 392,930, page 2, line 130, *et sequiter;* also claim 4.) This machine, as shown at Fig. 5, is an electric motor of simple form, but with its armature A A and field-coils N S in separate independent circuits. The armature is energized by the source A B or armature-battery, through the adjustable resistance R h^2, brushes *d d*, and commutator-segments *c c*. The field of this machine has a separate source of energy or field-battery F B and rheostat R *h'*. By operation of these separate circuits with adjustable resistances in each the speed of the machine is under perfect control, and as this machine controls the speed of the main-line-distributing machines at X and Y it is important to have it thus controllable in speed, and a separate circuit-machine is necessary for this.

The machine shown in Fig. 5 has two principal functions. First, it reverses periodically and at regular intervals a main-line current used for signaling and derived from one source, (shown as a main-line battery at M L B,) which produces a low-tension current. It also reverses a current derived from the source A B, and also reversed periodically in the primary or inducing circuit of the induction-coil I. The secondary or induced circuit S S is connected, as shown in Fig. 5, as a shunt to the main line M L. This device, therefore, produces a high-tension current also periodically reversed on the main line, and the connections are such that the directions of these high and low tension-reversed currents, which are simultaneously reversed on the line, always have the same direction or polarity at the same time.

The main-line signaling-current emanating from the source M L B is periodically reversed by operation of the revolving pole-changer P C, carried upon the spindle of the motor. This pole-changer consists of two rings with overlapping semicircular projections, and on these projections the line-brushes *l b'* and *l* b^2 bear, while on the upper and lower continuous rings bear the two brushes that are connected to the terminals of the main-line battery M L B. Thus at every half-revolution of the pole-changer P C the signaling-current from the main-line battery M L B is reversed, and these reversals occur accurately at every half-revolution of the motor-armature A A. In this manner the motor shown in Fig. 5 periodically reverses the main-line signaling-current, which, it has been stated, is a comparatively low-tension current. The armature-circuit A A of this motor is not of itself a closed circuit, but is closed through an external loop, (see my patents, Nos. 392,930, of November 13, 1888; 397,817, February 12, 1889, and 397,489, February 5, 1889,) which includes in circuit the primary P P of the induction-coil I, connected through the brushes *b'* and b^2, bearing on rings *r'* and r^2, to the armature-circuit A A of the motor, and as this armature receives its current from the battery A B in reverse direction at each half-revolution through the two-part commutator *c c* and brushes *d d* bearing thereon, so therefore at each half-revolution of the armature the main-line current from the battery M L B and the current in the primary P P of the induction-coil I are simultaneously reversed by reason of the fact that the break in the middle part of the pole-changer P C and the slit in the commutator *c c* are on the same axial line. Furthermore, it will be observed that as the current in the armature-circuit A A from the battery A B is affected and varied in strength by the counter electro-motive force of the armature itself while turning, so the current in the primary P P of the induction-coil will not only be reversed at each half-revolution, but there will be in this primary a true alternating current reversed at each half-revolution of the armature A A, and so generating in the secondary S S of this induction-coil a true alternating current of high electro-motive force, and varying in accordance with the law of sines as the armature-coil A A moves from one position to another. This device therefore operates to produce in the main-line circuit a continuously and uniformly alternating current of high electro-motive force, while the pole-changer P C sends from the signaling-line battery M L B a correspondingly-reversed current of low electro-motive force, but reversed at the same time by separate devices operated by the same machine. The separate reversed currents traverse the entire line-circuit and operate to produce the same identical effects at both the distant stations X and Y. Their operation at one end will therefore suffice for a description of both. At both ends there is a high-resistance path to earth that can only be traversed by the high-tension current, and there is a low-resistance-path for signaling, which can be traversed by both; but the instruments for sending and receiving in the low-tension path are so wound as not to be susceptible to the action of the high-tension current. The high-tension current is designed to maintain the synchronism and is to be kept operative at all times through its own path independently of any interruptions of the signaling-current, and the continuous motion of the machines is thus secured independently of any breaks or interruptions of the low-tension signaling-current, the devices for the use of which will not respond to reversals of the high-tension current.

Assuming now the machine at Fig. 5 in motion, reversing periodically the synchronizing and signaling currents and passing to station X, Fig. 6, we find the main line M L divides at the point z', one branch going to earth at E^3 through the synchronizing-relay P' P^3 of one thousand ohms resistance, and the other branch to earth at E' through the distributer D', trailer-arms t' t^7, one of the segments 1 2 3 4 5 6 of the distributer, thence through the pin-switch P S' and branch circuit to the particular receiving and sending instrument R' and key K', momentarily thrown in connection by the trailer, and so to earth at E', at which point all the sending and receiving apparatus at X is placed to earth. The receiving-relay R' being a comparatively low-resistance relay, is not affected by the high-tension currents designed to operate the synchronizing-relay P' P^3.

The operation of the synchronizing apparatus is as follows, (see, also, former patents, Nos. 395,508, 395,509, and 395,510, all of January 1, 1889:) The high-tension reversed currents sent out periodically and continuously from the induction-coil at Fig. 5 traverse the high-tension polarized relays P' P^3 at X and P^2 P^4 at Y, and maintain the tongues of these polarized relays in constant and uniform vibration, and as they vibrate back and forth they operate through the local devices and circuits shown in Fig. 6, and in further detail in Fig. 1, and previously explained, to periodically and simultaneously reverse the polarities of the motor-fields M' at X and M M^2 at Y, and the armatures of these machines are connected to their separate sources of energy in the manner shown in Figs. 2 or 3 and previously explained, so that the two machines can only move by coincident reversals of polarity in field and armature circuits at the two ends of line. This particular form of armature-connection and its method of operation, differing, as it does, materially from a Gramme ring or drum-armature winding in the principle of its operation, is patented to me in Nos. 410,987 and 410,988, of September 10, 1889; and I desire now to claim the specific system of circuits, which effects their mutual adaptation as the co-operative parts of a general system through the agency of the devices and local connections shown, which combine these different patented devices, so as to produce an operative system for multiplex telegraphy.

So far as the synchronizing system is concerned this comprises at some point in the line-circuit the regulating-motor shown at Fig. 5, with its revolving pole-changer reversing periodically a low-tension signaling-current, and simultaneously through the suitable independent co-operating parts, the high-tension synchronizing-current, then at sending and receiving stations two earth-connections in line with instruments in each adapted to respond to the respective currents. The high-tension synchronizing-relays are adapted to respond to the high-tension current and actuate the local vibrators which carry the heavy local field-currents.

The double-circuit field, with the double-circuit vibrators and their co-operating plate and liquid condensers placed, as shown, in multiple arc around the sparking-points, and in general the system of using entirely separate and independent circuits in every synchronizing part, are all special features of this organization which insure the operation of the synchronizing system and prevent burning out of the parts and stopping of the machines. Among these I lay special stress and importance upon, first, the double field winding of the motors, each designed and connected through the vibrators to operate separately and independently in turn, and, secondly, the double local vibrator system which renders the double-field circuit system possible.

The general features and operative parts of the telegraph system proper will now be explained.

The two machines at stations X and Y being supposed in continuous motion and carrying the revolving trailing arms t' t^5 at X and t^4 t^6, &c., at Y in uniform and in synchronous movement over the surfaces of the distributers D' and D^2 at these stations, and making successive and simultaneous contacts with the corresponding insulated segments 1 2 3 4 5 6 at the two stations in rotation, and through which the different sending and receiving devices are placed successively in circuit, I have then, with the exception of the necessary sending and receiving apparatus, all the required conditions for multiplex telegraphy. The sending and receiving apparatus will now be explained and its method of operation shown first with reference to the distributers D' at X and D^2 at Y. These devices are made different from the usual form. Instead of being divided into segments all around the circle, only a fourth part of the entire circumference is subdivided. It is usual in such apparatus to divide the entire circumference into segments; but as the distributer is the main feature of cost in such a system as is here described, it is important to reduce the divided portion, and, on the plan here shown, a half, a quarter, an eighth, or any subdivision of the distributer, may be cut into segments and serve the same purpose as if the entire circumference were cut up in the usual way. This will be understood by reference to the drawings, Fig. 6, in which a quarter-segment of the distributer is divided into segments, the other three-fourths being left intact. The uncut part is connected to the main line, as shown at D' z', and the spindle S p is provided with four arms t' t^3 t^5 t^7, all carrying brushes that sweep over the subdivided and the solid part of the distributer continuously, and each brush in electrical contact with both these parts in turn. From this it results that there are always three brushes connected to the main line M.L through the solid part of the distributer, while the fourth brush, passing over the divided quadrant, always connects the line to the particular local branch which is at the time receiving the line-current. Thus for a sextuplex arrangement the divided quadrant would be cut into twelve segments, six of them (shown black) being insulating-segments, the other six, numbered 1 to 6, inclusive, being shown white, each of these being the connecting-point to one of the six branch circuits.

The arrangement shown thus provides for four contacts of each branch circuit to the main line during one revolution, each brush in turn acting as a connecter from the main line to the branches connected to the different conducting-segments. Thus during each quarter-revolution of the machine one of the four branches t' t^3 t^5 t^7 will pass over the conducting-segment No. 3 of the subdivided quadrant and so connect the branch circuit No. 3 and included instruments to line and earth at E′, and similarly at station Y, to line at that station and earth E^2, thus momentarily completing the circuit for that branch.

The machines being supposed in synchronous rotation at the two stations X and Y, each branch circuit will receive in turn a series of intermittent impulses as the trailers sweep over the connecting-segments, and as the pole-changer at P C, Fig. 5, is continually reversing the line-current these intermittent impulses received in the branches at each station will be alternately positive and negative in rapid succession. To respond to such a series of rapidly-recurring effects, the receiving apparatus must be so constructed as to respond quickly and remain in one position while the key is closed, no matter how many interrupted impulses may be required to indicate a single dot with the Morse key, and to remain in the open position however long the key may remain open, and it is also desirable to contrive such apparatus for sending and receiving by means of the ordinary key used for simplex telegraphy, ordinary relays and senders indicating dots and dashes clearly in response to the ordinary manipulation of the key at the other extremity of the line. In the system I describe this is effected in a novel manner.

Referring to Fig. 6 again, the branch circuit No. 3 includes the neutral receiving-relay R′ when this instrument is connected direct to earth at E′ through the switches *sw′*. The same branch to earth will include the key K′ in circuit through point n', when this switch is open and the key is closed on its front contact, as shown at the sending-station Y, where the key is represented in the sending position and the switch sw^2 is open. These relays R′ at X and R^2 at Y therefore receive a series of rapid intermittent impulses, and when made sufficiently delicate to respond to these currents of short duration rapidly repeated five to ten times during a single dot of the key. The relay-armature r', Fig. 6, and tongue are maintained in constant vibration while the key at the sending end is closed.

Such action will not cause a sounder to respond to the motions of the key without some special device arranged to distinguish between the periods of time when the relay-armature is in vibration and when it is not. This is effected in the system shown by the operation of a single intermediate instrument. (Shown in Fig. 6 at *a* R′ and called an "auxiliary" relay.) It is a local instrument and works the sounder D′ in response to the action of the main-line relay.

Its operation is as follows: The auxiliary relay is operated by a local circuit energized by the local battery R l', which includes coils of the auxiliary relay in circuit. One extremity of the source R l' is connected to the fixed point of the armature r' of the receiving-relay R′, and the other extremity, passing through the auxiliary relay, is connected to both the front and back contact-points i^3 and i' of the receiving-relay R′. Thus if the receiving-relay armature is vibrating back and forth the auxiliary relay *a* R′ receives an impulse whenever the armature r' of the receiving-relay R′ strikes either the front contact i^3 or the back contact i', from which it follows that the armature r^3 of the auxiliary relay *a* R′ must make two vibrations to each single vibration of the receiving-relay armature r'. The armature of the receiving-relay R′ is maintained in rapid vibration, so rapid that it is impossible for the auxiliary relay-armature to follow at double speed, and from this relation of the two relays it results that so long as the receiving-relay proper R′ is maintained in vibration by the key, the circuit being closed, the auxiliary relay, being unable to follow, remains against its back stop, where it is held by the spring. Instantly, however, that the main-line receiving-relay ceases vibrating, or is allowed to come to rest by opening the key at Y, the tongue and armature, resting firmly against one of the contact-points, causes the auxiliary relay to draw its armature against the action of the spring firmly against its front stop, which action, it will be seen, opens the sounder-circuit, and the sounder-armature flies up or opens. If the key is again closed at Y, then the armature of the receiving-relay begins vibrating under the action of the intermittent impulses sent to line. The armature of the auxiliary relay, being unable to follow, is instantly drawn by the spring against its back contact, the sounder-circuit is closed, and the sounder remains closed as long as the armature of the main-line relay is kept in vibration by a closed key at the other end of the line. Such is the general system used for sending ordinary Morse signals composed of dots and dashes by intermittent impulses of current sent to line and causing an ordinary sounder to respond clearly and sharply to such signals.

There are many modifications of the system shown, which need not be described in detail here; but the general principle of arrangement is the same in all, which consists, mainly, of an auxiliary local relay so connected that its armature remains against one stop while the main-line relay is in vibration (either back or front) and against the other when the line is open. In the system shown Y is sending to X, line-switch to earth E^2 at Y is open, so that the line is opened and closed by the operator at Y by opening and closing his key. Line-switch *sw'* at X is closed, thus putting the branch at X permanently to earth at E', the main-line relay being included in the branch circuit to earth at each station.

It will be seen that in the position indicated the main-line relays R' at X and R^2 at Y will receive an impulse of current from the line every time that one of the trailer-arms strikes the segment No. 3 at each end, and so connecting these branches and their included relays simultaneously to line and earth at E' and E^2. Such an impulse is received by the relays four times during each revolution a second of the machine, so that five revolutions a second of the machine at three hundred a minute (a fair working speed for a steady movement) gives the receiving-relays twenty impulses a second. Maintained in vibration at this rate, or higher, the auxiliary relay-armatures cannot follow. I therefore find the following conditions at the two ends of the line: at X line closed to earth through switch *sw'*; at Y line closed by depressed key K^2; at both stations main-line relays vibrating back and forth; at both stations auxiliary relays released, as they cannot follow at double speed, and both drawn by their springs against the back contact - closing the sounder - circuits at both stations, and sounders at both stations closed down. Opening the key at Y reverses all these conditions at both stations, main-line relays cease vibrating, the armatures of the auxiliary relays are instantly drawn up, sounder-circuits opened, and the sounder-armatures fly up. Ordinary Morse transmission is thus maintained in all the local circuits, of which one is shown complete, with an ordinary single-acting key, an ordinary main-line relay of sensitive construction, and a single local instrument or auxiliary relay, the function of which is to translate the action of the main-line receiving-relay into the ordinary dots and dashes of the Morse code. From the connection shown it is evident that the operator at X can at any time stop or interrupt the distant sending-operator at Y, simply "breaking" in the ordinary way by opening his line-switch *sw'*.

It is thus seen that in the system I have devised and here explained the different operators at the two extremities of the line work precisely as if each had the entire use of an independent line to himself, sending ordinary Morse signals, which are also read at the sending end, received on ordinary Morse instruments at both ends, and facilities for "breaking in," as in straight-line work or "simplex telegraphy."

An examination of the circuits will show that the auxiliary-relay tongue rests on its back contact when the sounder is down or closed. Thus the sounder follows the motion of the key up and down; but this motion in the relay is reversed.

As some operators prefer to read by the relay it is sometimes important to have the relay also follow the motion of the key in the ordinary way, and this can be readily effected by placing the sounder in a shunt to the sounder-circuit, which arrangement will be shown in another application.

It will thus be seen by an examination of the system that the machines are maintained in continuous motion by an uninterrupted superposed high-tension current that cannot affect the telegraph-instruments, and the signaling is accomplished by interrupting a line-current of low tension, which finds its way to earth through the sending and receiving instruments, maintaining the latter in vibration when their circuits are closed, but not affecting the high-resistance synchronizing-relays when they are open. The system as a whole, therefore, comprises the following co-operative parts: A line-circuit between stations connected between its earth terminals to a main-line battery through a revolving pole-changer, which rapidly and periodically reverses this main-line current uniformly; also, to a source of high electro-motive force, producing a high-tension superposed current, also reversed by the same agency, and therefore simultaneously with the former; a controlling-motor for driving the pole-changer, reversing the line-currents, and setting the pace for the synchronizing-motors at distant stations; at distant stations synchronizing-motors of the description shown formerly patented to me; a number of low-resistance circuits from line to earth through distributing - segments and trailers driven by the synchronizing-motors, including signaling devices; an independent shunt-circuit to earth around the distributers at each station and having high-tension polarized relays in circuit designed to respond to the reversals of the high-tension superposed synchronizing-current, but not permitting the passage to earth of the low-tension signaling-current through this shunt; vibrators connected in local circuits at the stations and driven or maintained in vibration by the high-tension polarized relay-connections from vibrators to the machine, or synchronizing-motor circuits for reversing currents in one or both the machine-circuits, as may be required in the several kinds of machines patented to me (or others;) a system of liquid-condensers around the relay-points; a system of plate and liquid condensers and system of connecting-circuits to the machine-circuits, whereby the motors can be maintained in uninterrupted motion; a system of sending and receiving instruments in each of the branch circuits at each station, designed, as shown, for telegraphic transmission in ordinary Morse characters by means of the intermittent pulsations of the reversed-line currents, which is constantly maintained, and, in general, the system of maintaining motors in uniform synchronous movement by a high-tension superposed line-current constantly reversed and a simultaneously-reversed low-tension current by the interruption of which ordinary telegraphic transmission is maintained in a multiplex system.

Having thus described my invention, what I claim, and desire to procure by Letters Patent of the United States, is—

1. In a system of synchronous multiplex telegraphy, a pair of distributers with transmitting and receiving apparatus, in combination with a pole-changer and a signaling-battery located in the main line and at a point between two stations, substantially as described.

2. In a system of synchronous multiplex telegraphy, a pair of distributers controlled by electrically-driven motors, transmitting and receiving apparatus for each distributer, and a main-line signaling-battery located in the main line joining the distributers and at a point between two stations, in combination with a pole-changer adapted to reverse the direction of said battery continuously, substantially as described.

3. In a system of synchronous multiplex telegraphy, a pair of distributers, motors for driving said distributers, synchronizing mechanism for keeping said motors in synchronism, a main-line signaling-battery, a pole-changer for reversing the direction of said battery continuously, a motor for driving said pole-changer, an inductive device controlled also by said motor for influencing or controlling the synchronizing devices at each distributer, substantially as described.

4. In a system of synchronous multiplex telegraphy, a motor located at a point on the main line between any two stations, in combination with a main-line battery and pole-changing device, and connections between said motor and battery, whereby currents of reverse polarity are successively set up in opposite directions, substantially as described.

5. In a system of synchronous multiplex telegraphy, an electric motor located at a point between two stations of a single main line, a main-line battery, a pole-changer, and a secondary-current-generating device, with connections between said motor, battery, and secondary-current device whereby signaling-currents and regulating-currents are sent over the line conjointly, substantially as described.

6. In a system of synchronous multiplex telegraphy, a main-line battery, a pole-changer, and a secondary-current-generating device, all located in a single main line and at a point between two stations, substantially as described.

7. In a system of synchronous multiplex telegraphy, a secondary-current-generating device located in the main line between the distributers, in combination with means at each distributer for regulating their synchronism, substantially as described.

8. In a system of synchronous multiplex telegraphy, a main-line battery and a secondary-current-generating device located in the main line between two stations, in combination with a single device for causing said battery and secondary-current-generating device to rapidly reverse the polarity of the currents sent to line, the alternating currents from the two devices differing in tension, substantially as described.

9. In a system of synchronous multiplex telegraphy, a main line connected directly at each end to the current-distributers, in combination with synchronizing devices located in branches permanently running to earth around the distributers, substantially as described.

10. In a system of synchronous multiplex telegraphy, a main line connected at each end directly to a distributer and including in its circuit a main-line battery and a pole-changer intermediate the distributers, with synchronizing mechanism located in branches earthed around the distributers, substantially as described.

11. In a system of synchronous multiplex telegraphy, a current-distributer or analogous device propelled by an electric motor the armature whereof is magnetized by a continuous current, in combination with a polar relay P, located in the main line, and a regulating-motor adapted to control a secondary-current-generating device located directly in the main line, with local-circuit connections between said polar relay and the field-coils of the first-named motor and those of the armature-coil of the second motor, and the secondary-current-generating device, whereby absolute synchronism is maintained, substantially as described.

12. In a system of synchronous multiplex telegraphy, a synchronizing-relay located in the main line, in combination with a distributer-motor having its field-circuit connected to an energizing-battery through the relay-armature and front and back stops thereof, with a spark-preventing device located in a shunt around the contacts, substantially as described.

13. In a system of synchronous multiplex telegraphy, a synchronizing-relay controlling a local-battery circuit, which includes electromagnetic means for controlling the speed of a distributer-motor, in combination with a spark-preventing device arranged in a shunt around the relay-contacts, substantially as described.

14. In a system of synchronous multiplex telegraphy, a synchronizing-relay having a local circuit adapted to control an electro-magnetic device, which in turn has local-circuit connections through independent batteries, and the field-magnet of a synchronizing-motor having its armature in a separate circuit, substantially as described.

15. In a system of synchronous multiplex telegraphy, a synchronizing-relay adapted to control a local circuit through a magnetic device, a pair of local batteries having independent connections through the armature of the electro-magnetic device, and the field-magnet of a distributer-motor, with anti-sparking devices in shunts around the contacts of the relay and the electro-magnetic device, substantially as described.

16. A distributer for use in synchronous multiplex telegraphy or analogous electrical-current-distributing systems, consisting of a circular distributing-ring having insulated segments in a sector thereof, the remaining portion being connected to line, in combination with two or more distributing-brushes which bear successively on the unbroken portion of the ring and the insulated segments, substantially as described.

17. In a system of synchronous multiplex telegraphy, a distributer-ring connected directly to the main line, in combination with a series of insulated contacting segments occupying a part only of the same distributer-ring, and two or more brushes adapted to connect the unbroken part of the ring with the segments in succession, substantially as described.

18. A telegraphic receiving-instrument consisting of a main-line relay having front and back contacts for its armature, both electrically connected through a single circuit to a local battery, and an auxiliary relay and its own armature, in combination with a sounder located in a second local-battery circuit, including the armature and one contact-stop of the secondary relay, substantially as described.

19. A telegraphic receiving-relay adapted to respond to rapidly-recurring impulses of electricity, in combination with an auxiliary relay connected through a single local circuit with the armature-lever and front and back contact-stops of the first-named relay, and adapted to respond only on a definite cessation of the main-line impulses, substantially as described.

20. A telegraphic receiving-relay adapted to respond to rapidly-recurring impulses of electricity, and an auxiliary relay connected through a single local circuit with the armature and front and back contact-stops of the first-named relay, and adapted to respond only on a definite cessation of the main-line impulses, in combination with a local sounder in a local circuit controlled by the auxiliary relay, substantially as described.

21. In a system of synchronous multiplex telegraphy, the combination of the following elements: two or more current-distributers driven by electrical motors, a pole-changer, and a main-line battery located between two stations, a secondary-current-generating device, synchronizing-relays at each distributer, and connections, as described, whereby current impulses differing in tension are sent continuously over the line, the distributers synchronized, and multiplex transmitting and receiving apparatus adapted to send and receive independent or simultaneous signals, substantially as described.

22. In a system of synchronous multiplex telegraphic apparatus, current-distributers located in a single main line, but connected directly thereto, synchronizing-relays, one for each distributer, located each in a shunt around the distributer, a device located in the main line having electrical connections for setting up two sets of current-impulses over the line, one of which controls the synchronizing-relays and the other the signals, electric driving-motors, one for each distributer, controlled by the synchronizing-relays, independent earth-circuits for the signaling and synchronizing devices, and signaling and receiving instruments, all connected and adapted, substantially as described, for the multiplex transmission of telegraphic messages.

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Witnesses:
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