(No Model.) 4 Sheets—Sheet 1.

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SYNCHRONOUS TELEGRAPH.

No. 463,852. Patented Nov. 24, 1891.

Fig. 1,

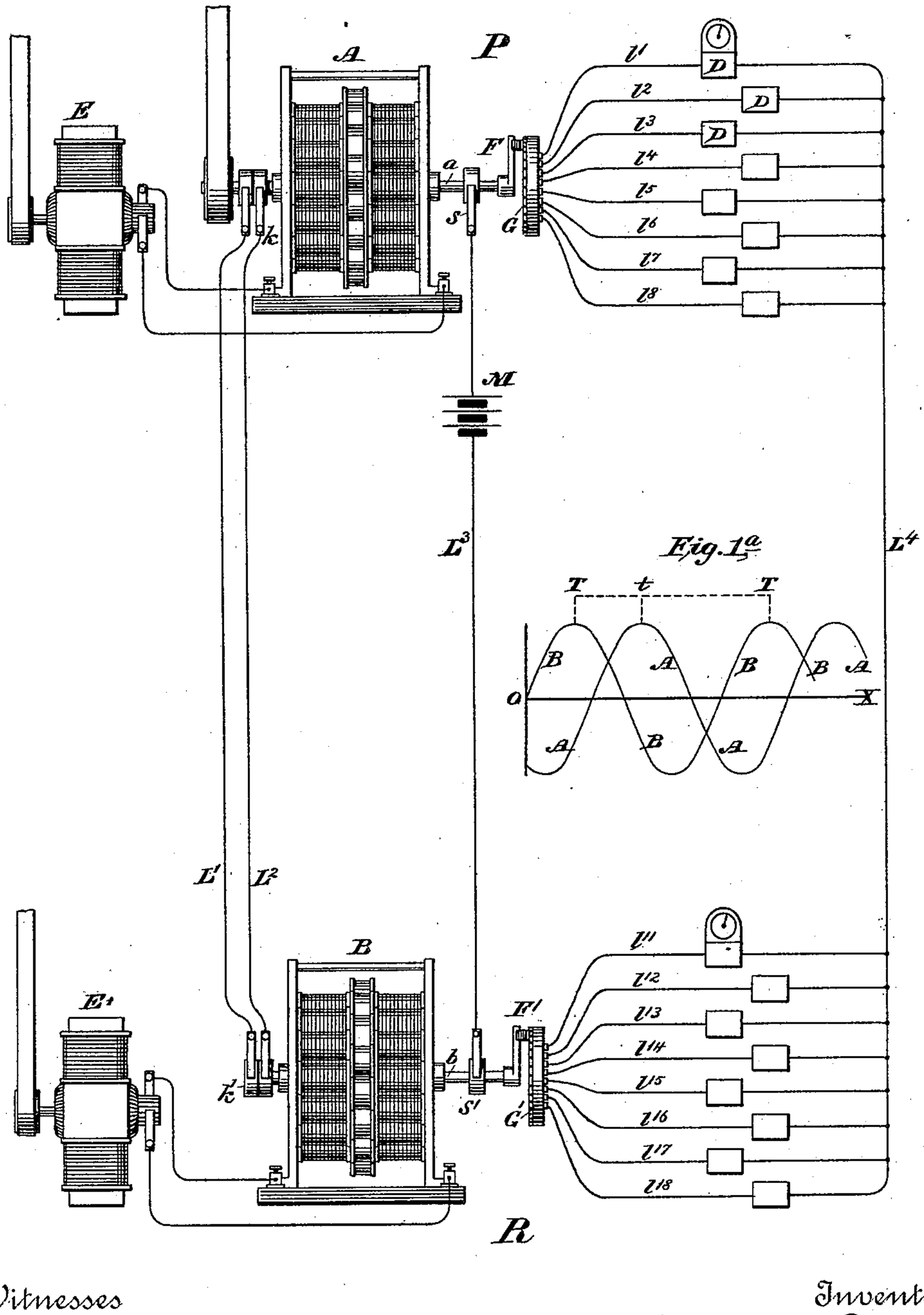

Fig. 1a

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Fig. 2,

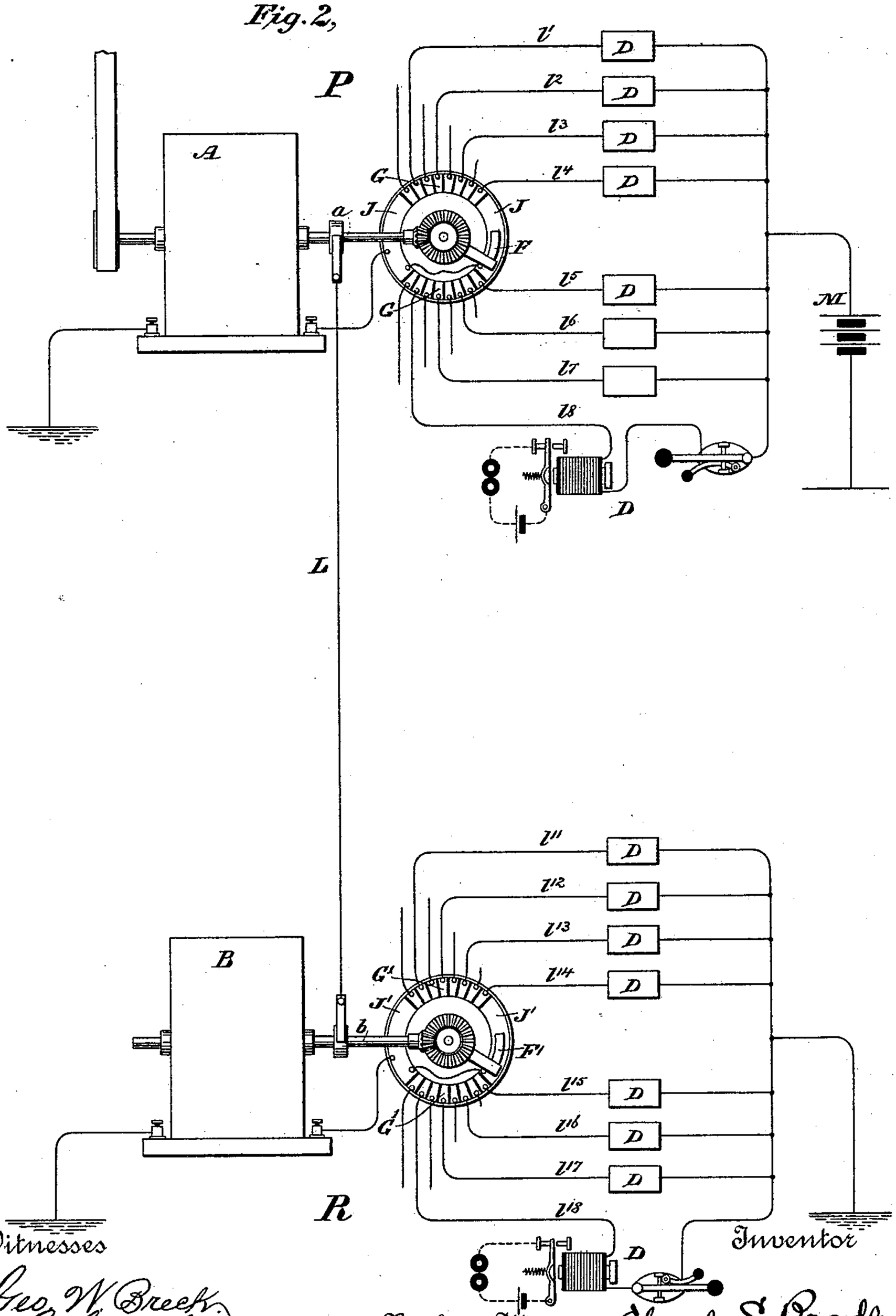

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Fig. 3.

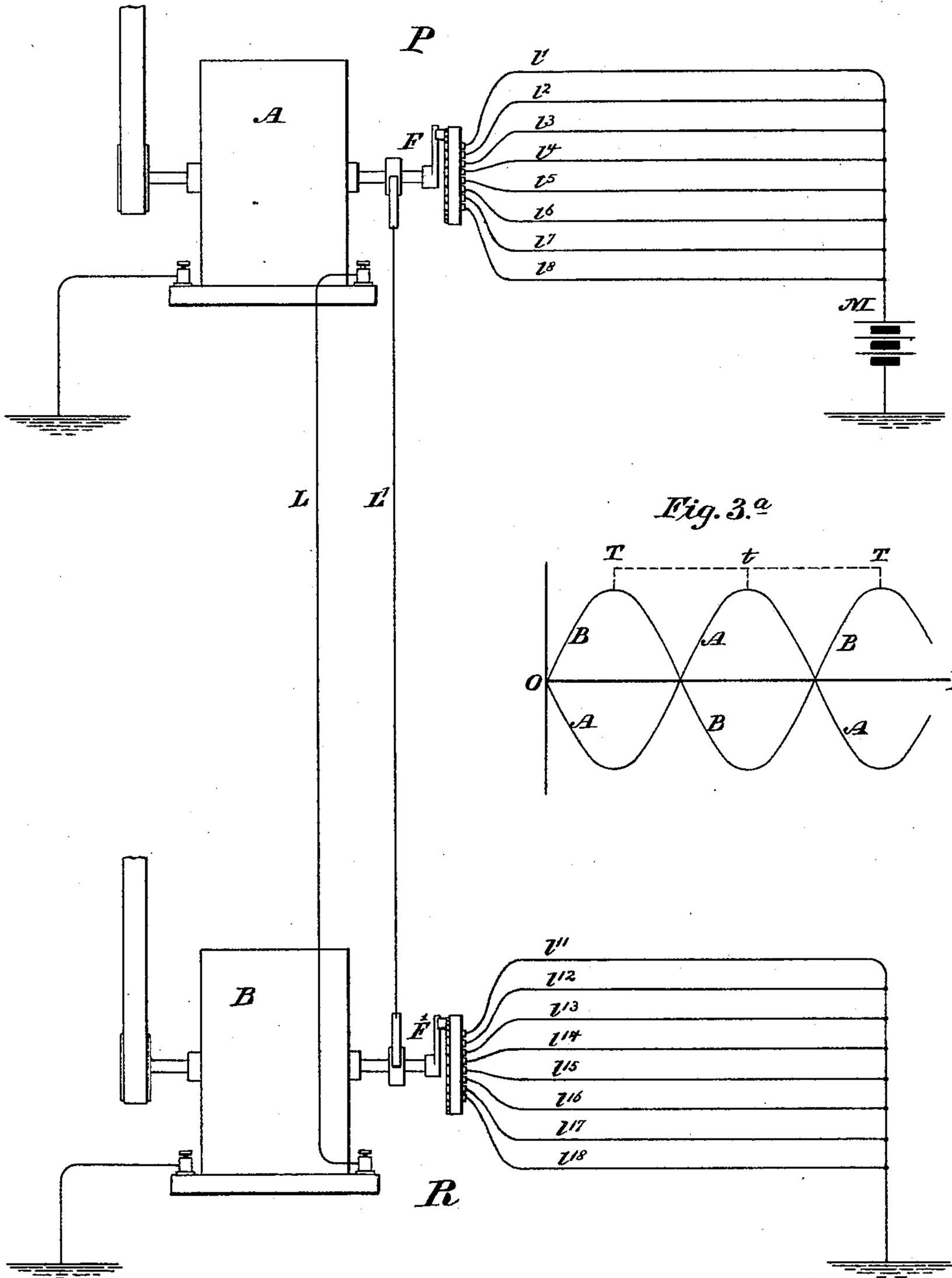

Fig. 3.a

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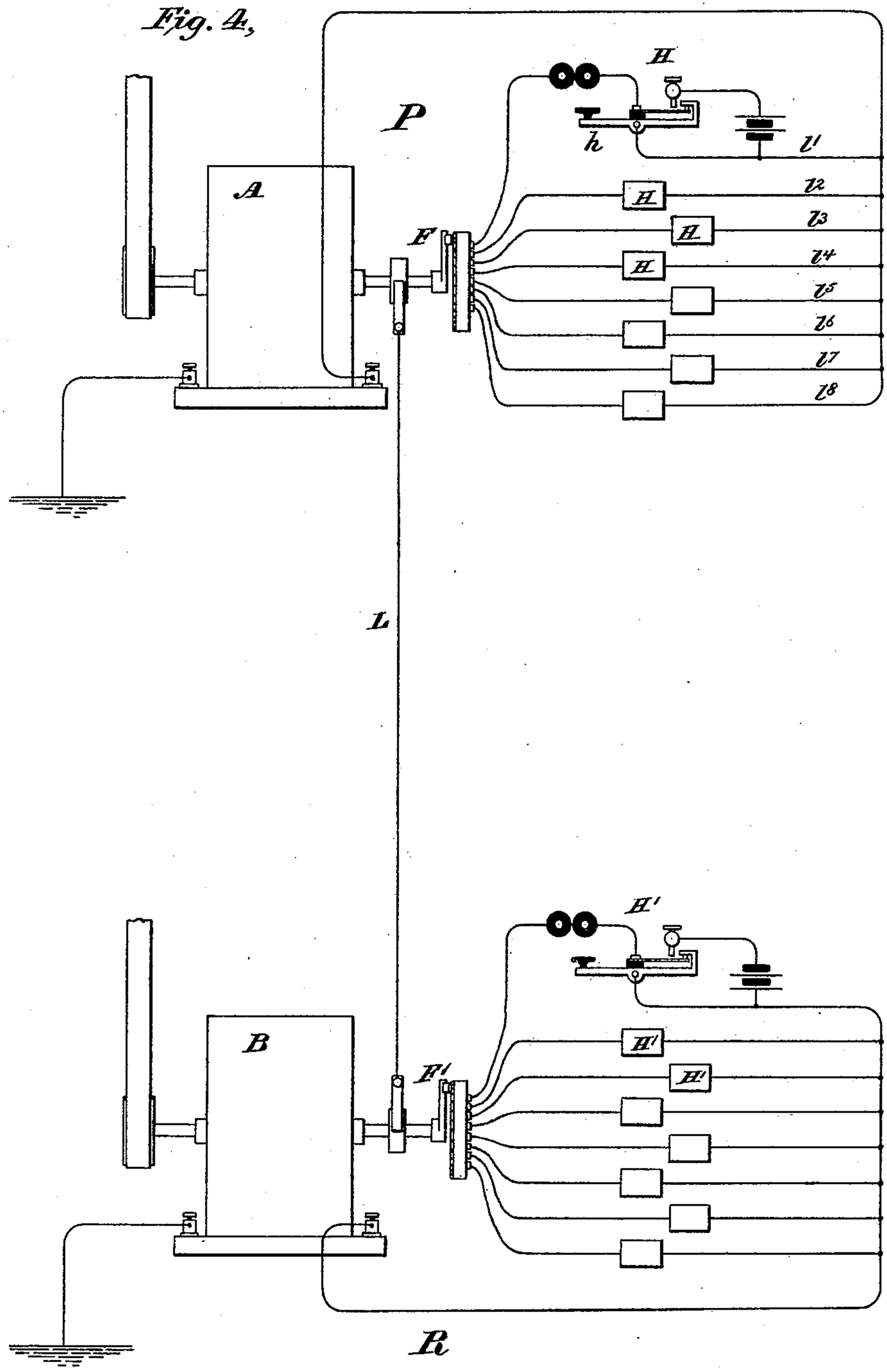
Fig. 4,



Witnesses

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UNITED STATES PATENT OFFICE.

CHARLES S. BRADLEY, OF YONKERS, NEW YORK.

SYNCHRONOUS TELEGRAPH.

SPECIFICATION forming part of Letters Patent No. 463,852, dated November 24, 1891.

Application filed January 28, 1887. Serial No. 225,764. (No model.)

To all whom it may concern:

Be it known that I, CHARLES S. BRADLEY, of Yonkers, in the county of Westchester and State of New York, have invented certain new and useful Improvements in Synchronous Telegraphs, of which the following is a specification.

My invention relates to telegraphic or other systems which depend for their operation upon the synchronous movement by electrical means of two or more circuit-controlling instruments situated at different stations; and the invention relates particularly to multiplex, printing, fac-simile, and autographic telegraphs.

The object of the invention is to improve such systems and apparatus by making them more positive and generally reliable in their action and operative for longer distances and heavier work.

In the accompanying drawings, which illustrate my invention, Figure 1 is a diagram representing an organization of apparatus according to my invention. Fig. 1ª represents graphically the electrical conditions in the circuit in Fig. 1. Fig. 2 is a diagram representing a modification of my invention organized as a multiplex-telegraph system and in which only a single line-wire is necessary. Fig. 3 is a diagram representing a modification of my system in which the two machines which maintain the synchronous movement are both electrical generators or dynamo-electric machines in contradistinction to one or both of them being electric motors. Fig. 3ª represents the electrical conditions in the circuit in Fig. 3. Fig. 4 is a diagram representing a modification of my system in which the machines for producing the synchronism are in series with the telegraphic apparatus proper operated thereby.

In Fig. 1, A represents an alternating-current dynamo-electric machine—that is, an electric generator of any suitable form constructed to produce successive electric currents or pulsations of alternately positive and negative polarity and preferably of equal potential and duration. For example, the well-known Siemens or Alteneck, Gordon, and Ferranti-Thompson alternating dynamos are well adapted to my purpose; but I do not wish to confine myself to any particular form of alternating-current machine, since there are many forms which will serve sufficiently well.

In the drawings I have represented the field-magnets of the dynamo A as connected to and fed by a separate "exciter" E or small auxiliary direct-current dynamo, which arrangement is usually adopted; but, if desired, any of the well-known "self-exciting" alternating dynamos may be employed, as the machine A, in which case a separate exciter is not required. The armature of the dynamo A, located at the first station P, is electrically connected by line-wires L' and L^2 with the armature of a second alternating-current machine B, located at the other station R, which machine may be exactly like the machine A. Electrical connection is made to the revolving armatures of the two machines A and B by suitable continuous metallic rings *k* and *k'*, placed upon the respective armature-shafts *a* and *b*, and brushes in contact with said rings in the usual manner. The field-magnets of the machine B may be fed by a separate exciter E', as represented. This second machine is to be driven as a motor by the generator A. Mounted upon and revolving with the shaft *a* of the dynamo A is a brush or finger F, which sweeps over and makes contact with a series of insulated contact-points G, arranged in a circle. The finger F is electrically connected to the line-wire L^3 by a suitable contact ring and brush S, and the line-wire L^3 is connected in a like manner at the other end to a similar finger F', mounted upon and revolving with the shaft *b* of the motor B. The finger F' sweeps over a similar and corresponding series of contact-points G', arranged in a circle. Respectively connected with the contact-points G, at the station P, are a number of branch circuits $l' l^2$, &c., the other ends of which are connected to and united at the line-wire L^4. Similarly the contact-points G' at the other station R are respectively connected to a number of branch circuits $l^{11} l^{12}$, &c., which also connect with the line-wire L^4. In the branch circuits $l' l^2$, &c., and $l^{11} l^{12} l^{13}$, &c., are placed suitable

telegraphic or other apparatus or instruments which it is desired to operate. For example, the common "dial-telegraph," as represented in Fig. 1, or the ordinary Morse instruments represented in Fig. 2, or other transmitting and receiving apparatus, may be put in these branch circuits. A battery M or other suitable source of current is placed in the main circuit, as represented.

The operation of the apparatus above described is as follows: The armature of the dynamo A is caused to revolve by mechanically connecting it to a steam-engine or other suitable source of power, the field-magnets being excited by the small dynamo E. The alternating current thus generated in the dynamo A is conveyed to the motor B by the line-wires L' L^2, the field-magnets of which second machine B are excited by the small dynamo E'. If now the armature of the motor B be caused to revolve by extraneous means and brought up to the same speed as the dynamo A, so that the rate of alternations of current of the machine B agree exactly with those of the machine A, (the two machines being assumed to be of precisely similar construction,) then the machine B will fall into step, so to speak, with the machine A, and the two will continue to revolve exactly synchronously after having been once brought into unison, even though the speed of the machine A varies, provided, of course, the variation is not very sudden. Another method of getting the machines into synchronism is to start the dynamo A slowly and turn the motor B by hand until its speed agrees with that of the dynamo. Then increase the speed of the dynamo gradually, so that the motor will follow it until the desired speed is reached. The speeds must be brought to agree closely before the synchronizing effect asserts itself; but after it is established both machines—dynamo as well as motor—will strongly resist any tendency to throw them out of synchronism. In fact the whole power an alternating-current motor is capable of developing will be exerted to overcome any force tending to prevent it from revolving synchronously with the dynamo which actuates it. The proper electrical conditions under which the two machines A and B will run synchronously in the system represented in Fig. 1 are such that the alternations or waves of electro-motive force in the dynamo A are more than a quarter of a period and less than a half-period behind those of the motor B. These conditions are indicated graphically in Fig. 1^a, in which the abscissæ represent time and the ordinates electro-motive force. The curves AAA and BBB represent the alternations of electro-motive force in the dynamo A and the motor B, respectively. Calling the distance TT a "period," being equal to the total length of one alternation or wave, it will be observed that the curve A is a distance T*t*, which is greater than a quarter and less than a half period behind the curve B, depending upon the amount of work the motor is doing. When the motor is running perfectly free, it is theoretically half a period ahead of the dynamo. The counter-alternations of the motor just neutralize the direct alternations of the dynamo and no current flows. Of course practically friction pulls the motor back slightly, and when it performs work it drops back still more. If the load is increased until the motor is only a quarter-period ahead of the dynamo, the limit is reached, and further increase of load will stop the motor entirely. The synchronous movement of the respective shafts *a* and *b* of the two machines A and B being obtained and maintained, as above described, the brushes or distributers F and F', respectively mounted upon said shafts, will also move synchronously and will make connection with corresponding contact-points of the series G and the series G' at exactly the same instant. Thus each of the branch circuits, l^3 for example, at one station P will be placed in direct and exclusive connection for an instant with the corresponding branch circuit l^{13} at the other station R once during each revolution of the distributers F and F', and the telegraphic or other apparatus located in each of these branch circuits is placed in direct and exclusive communication with the corresponding apparatus at the other station. The number of circuits that can be operated in this way will depend upon the purpose for which they are used. For example, if the apparatus D, located in each branch circuit, is a simple dial-telegraph, there may be, say, fifty branch circuits at each end of the line, and the dynamo A should be run at about three hundred or four hundred turns per minute. This gives three hundred or four hundred contacts or electrical impulses per minute to each of the branch circuits and the apparatus located thereon, or five or six impulses per second, which is about the proper speed to operate a dial-telegraph rapidly. A speed of three hundred or four hundred turns per minute is a comparatively slow one for the dynamo A, and I therefore prefer to run it at a higher speed—say ten hundred or fifteen hundred turns per minute—and connect the shaft *a* to the distributer F by suitable gearing, as represented in Fig. 2, so that the speed of the latter will be the speed desired. If Morse telegraphic apparatus is used in the branch circuits, we require from ten to thirty impulses per second, and the distributer F should therefore revolve ten to thirty times per second, or six hundred to eighteen hundred turns per minute, in which case it can be attached directly to the shaft and the dynamo A driven at the same speed.

In order that the positions of the brushes F and F' shall agree sufficiently closely, it is desirable that the number of alternations of current per revolution, which determine the

synchronism and consequently the number of pole-pieces in the dynamo as well as in the motor, shall be as great or greater than the number of branch circuits at each station.

The modified form of my system shown in Fig. 2 differs from that just described in being adapted to be operated by a single line-wire, as represented. The dynamo A and motor B may be precisely similar to those already described; but for the sake of simplicity I have omitted the separate exciting-machines and assumed them to be autoexcitant. The line-wire L is connected at one end by a suitable contact ring and brush to the distributer F and at the other end in a similar manner to the distributer F′. The distributers F and F′ are mechanically connected to the shafts *a* and *b*, respectively, by suitable gearing, so as to give the proper relative speed in case it is desired to revolve the dynamo faster than the distributer, or vice versa. A portion of the circle swept over by the distributer F is devoted to maintaining the synchronism of the apparatus, and one or more contact-points J J are therefore connected to one terminal of the dynamo A, the other terminal of which is connected to the ground. A portion G of the contact-points are respectively connected to branch circuits l' l^2, &c., in which are located telegraphic or other apparatus. For the purpose of illustration I have represented a set of Morse instruments in one of these circuits l^8 and indicated them in the case of the other branch circuits. A precisely-similar arrangement of circuits is made at the other end of the line. The operation of this system is similar to that already described, the only difference being that the circuit is employed only a portion of the time to maintain the synchronism and portion of the time for telegraphic transmission. I have represented in the drawings that one-half of the time is given to the synchronism and is divided into two portions of a quarter each; but it is obvious that a greater or less portion of the time may be devoted to maintaining the synchronism and that it may be divided up in any desired manner. While the circuit is being employed for telegraphic transmission and there is no current flowing from the dynamo to the motor the latter runs by its own momentum, and during the short time it is out of circuit, ordinarily a small fraction of a revolution, it will not change its speed appreciably.

A modified form of my system shown in Fig. 3 differs from those already shown and described, in the fact that I employ two alternating-current dynamos instead of a dynamo and motor to maintain the desired synchronism—that is, both the machines A and B are alternating dynamos or electric generators—and I have therefore represented them both as being driven by power by means of suitable belting. The machine A is connected with the machine B by line-wire L, and the circuit, after passing through the machine, is grounded at the two ends, or may be brought back by another line, forming a metallic circuit, as desired. For the sake of simplicity of description I have shown another line L′ for the telegraphic transmission. The arrangements of the distributers F and F′, the branch circuits, &c., may be precisely similar to those already described.

In operating the above-described system the two generators A and B are respectively connected to suitable sources of power adapted to drive them as nearly as possible at the same speed. When once brought into unison, the machines will strongly tend to run synchronously and in such a manner with respect to each other that their alternations are half a period apart and directly oppose and neutralize each other, as represented graphically in Fig. 3ª, the maximum positive potentials and the maximum negative potentials of both machines occurring simultaneously. The only work the two machines A and B have to do when they are running synchronously is to supply the loss from leakage and induction along the line and overcome friction and the resistance of the air, whereas if the machines get the least bit out of synchronism the alternations will tend to augment instead of neutralize each other, and the machines will have to maintain a current in the circuit and will require a great deal more power to drive them. Hence slight differences in the speeds of the two sources of power will be taken up by the elasticity and slip of the belts, &c.; but in order that the machines A and B may be as free as possible from liability of being forced out of agreement with each other I prefer to employ as sources of power special engines or electric motors of just sufficient power to properly drive the machines A and B when they are in synchronism, but not of sufficient excess of power to overcome the decided increase in mechanical resistance which occurs when it is attempted to throw them out of synchronism. In this way the sources of power and machines will adapt themselves to each other and settle down into a natural gait, as it were, and, excepting accidents, it will require much more power to destroy the synchronism than to maintain it. The unison being thus secured, the utilization of this system for transmission may be the same as already described, suitable receiving and transmitting apparatus being placed in the branch circuits l' l^2 and l^{11} l^{12}, &c., for this purpose.

The employment of two generators, by which the synchronism is maintained by the opposition and neutralizing of two currents, whereby little or no synchronizing current flows over the line, is a very favorable arrangement for my purposes, since it leaves the circuit practically free for telegraphic or other transmission. The modified form of my system represented in Fig. 4 is designed with

reference to this fact. In this system the dynamos A and B may be precisely similar to those in Fig. 3; but in this case only a single line-wire L is required, which is connected at its two ends with the distributers F and F′, respectively. From the distributer F the circuit leads through the branch circuits $l' l^2$, &c., and then through the dynamo A to the ground at the station P. The circuit follows a corresponding path at the other station R. Thus the dynamos A and B are directly in circuit with the telegraphic apparatus; but since the currents produced by the two machines neutralize or practically neutralize each other, they do not interfere with the telegraphic transmission, as already explained. The telegraphic apparatus H, which I have represented in this case, is arranged so as to maintain the continuity of the circuit all the time, a continuity-key *h* being used for the purpose; but it is obvious that any telegraphic apparatus may be used which keeps the circuit closed the greater part of the time or sufficiently to allow the generators A and B to keep each other in synchronism. In operating this system the dynamos are driven, as described in the case of Fig. 3, in such a manner that they run synchronously and their alternations oppose and practically neutralize each other. The telegraphic apparatus H H H, located in the branch circuits, may then be operated in the usual manner, the depression of the continuity-key *h* at the station P introducing a battery into the circuit and operating the corresponding relay at the other station R, but without interrupting the continuity of the circuit. It will be seen that in this system the alternations or pulsations of current produced by the synchronizing-machines are generated at both ends of the line, and therefore the difficulties due to the static capacity of the line will be reduced to one-half. Consequently I can in this way operate a line twice as long as if it were charged from one end alone, other things being equal. Moreover, the leakage along the line is also supplied from both ends instead of from only one end.

It is obvious that other receiving and transmitting apparatus—such, for example, as printing, autographic, and fac-simile telegraphs—may be operated according to my invention in a manner generically the same as the systems I have shown and described.

It is obvious that the alternating-machines which I employ need not be identical in form. For example, one may be constructed to give more alternations per revolution than the other, in which case they may revolve at different speeds when they are in electrical agreement, and they should therefore be connected to the distributers in such manner as to bring the latter to the same speed.

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

1. In a telegraphic system, the combination of two alternating-current machines located at different points, mutually reacting to maintain continuous synchronous movement, an electric connection between them, and telegraphic transmitters and receivers located at such points, the connecting-circuit of which passes through synchronously-driven mechanism controlled by said alternating-machines, substantially as described.

2. In an electrical synchronous system, synchronously-moving alternating-current machines located at different stations with circuit connections, in combination with circuit controlling and distributing switches mechanically connected to said alternating-current machines and caused to move synchronously thereby and to connect in circuit successively corresponding ones of a series of branch circuits located at each of said stations, substantially as described.

3. In a telegraphic system, the combination of two alternating-current generators located at different points, an electric connection between them, and telegraphic transmitters and receivers located at such points, the connecting-circuit of which passes through synchronously-operated mechanism controlled by said alternating generators, substantially as described.

4. In an electric-telegraph system, two or more synchronously-revolving alternating-current generators located at different stations with circuit connections, in combination with circuit-controllers mechanically connected to and moved synchronously by said generators, a series of branch circuits at each station, of which corresponding ones are successively connected to the main circuit at the same instant by said circuit-controllers, and telegraph transmitters and receivers placed in said branch circuits, substantially as described.

5. In a telegraphic system, the combination of two alternating-current generators located at different points, an electric connection between them, and telegraphic transmitters and receivers located at such points, the connecting-circuit of which passes through synchronously-operated mechanism controlled by said alternating generators, said generators being connected to the circuit in multiple arc with each other, whereby the alternations they produce when running normally oppose and practically neutralize one another and leave the circuit free for transmission, substantially as described.

6. In a telegraphic system, the combination of two alternating-current generators located at different points, the generators being connected to a circuit in multiple-arc relation for the purpose described, synchronously-actuated distributers operated by the generators, and telegraphic transmitters and receivers in branch circuits connected with line through such distributers, the line being

common to the telegraphic and synchronizing circuit.

7. In a telegraphic system, the combination of synchronously-actuated distributers located at two or more stations, telegraphic signaling apparatus in a series of branch circuits at said stations, synchronizing apparatus, and a line-wire common to both synchronizing and telegraphic circuits, the synchronizing-circuit being continuously closed except when a signal is being sent.

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