No. 636,520. Patented Nov. 7, 1899.

E. GRAY.

TRANSMISSION OF SOUND AND DEVICE FOR CARRYING SAME INTO EFFECT.

(Application filed June 23, 1899.)

(No Model.) 4 Sheets—Sheet 1.

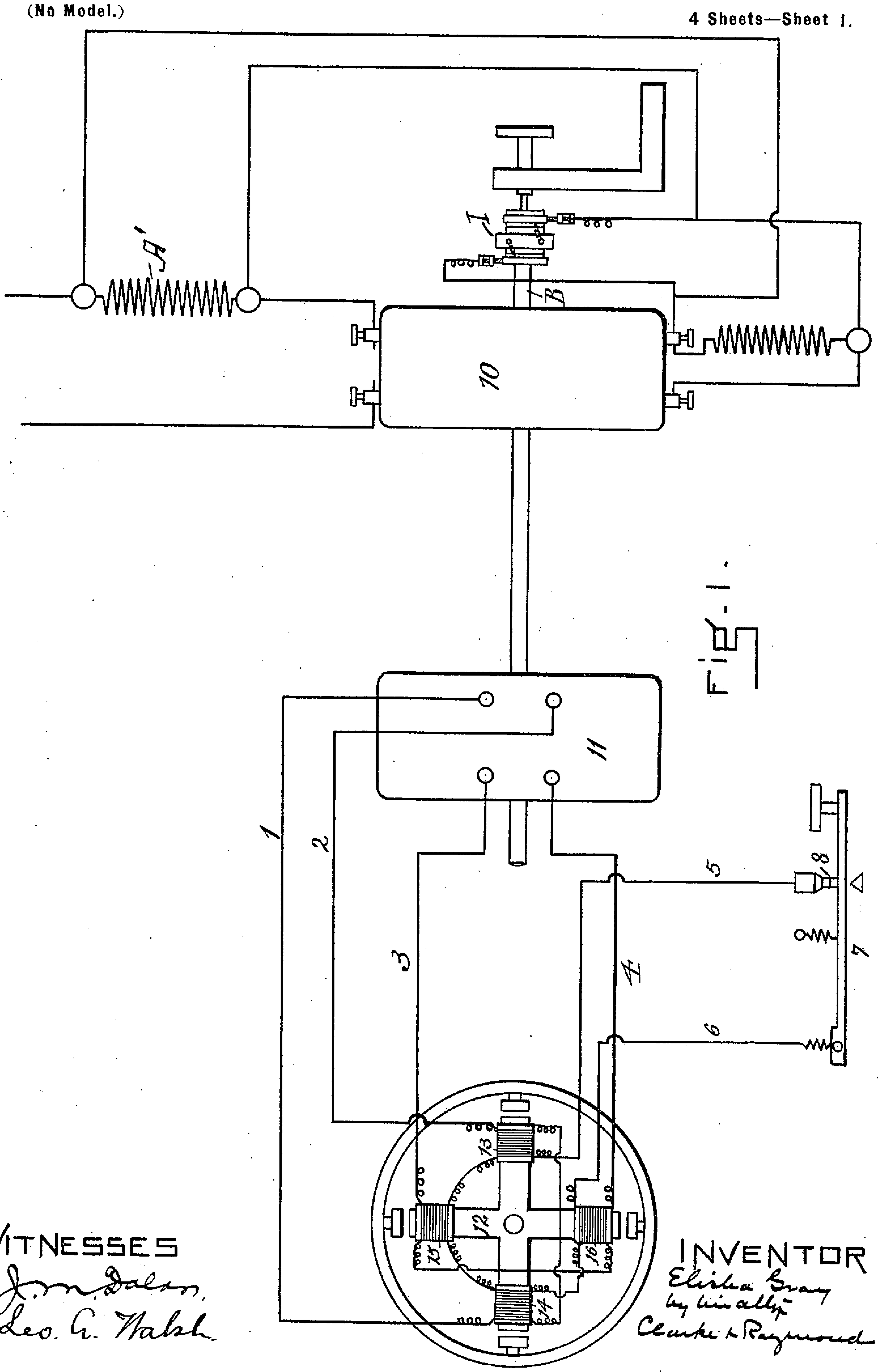

Fig. 1.

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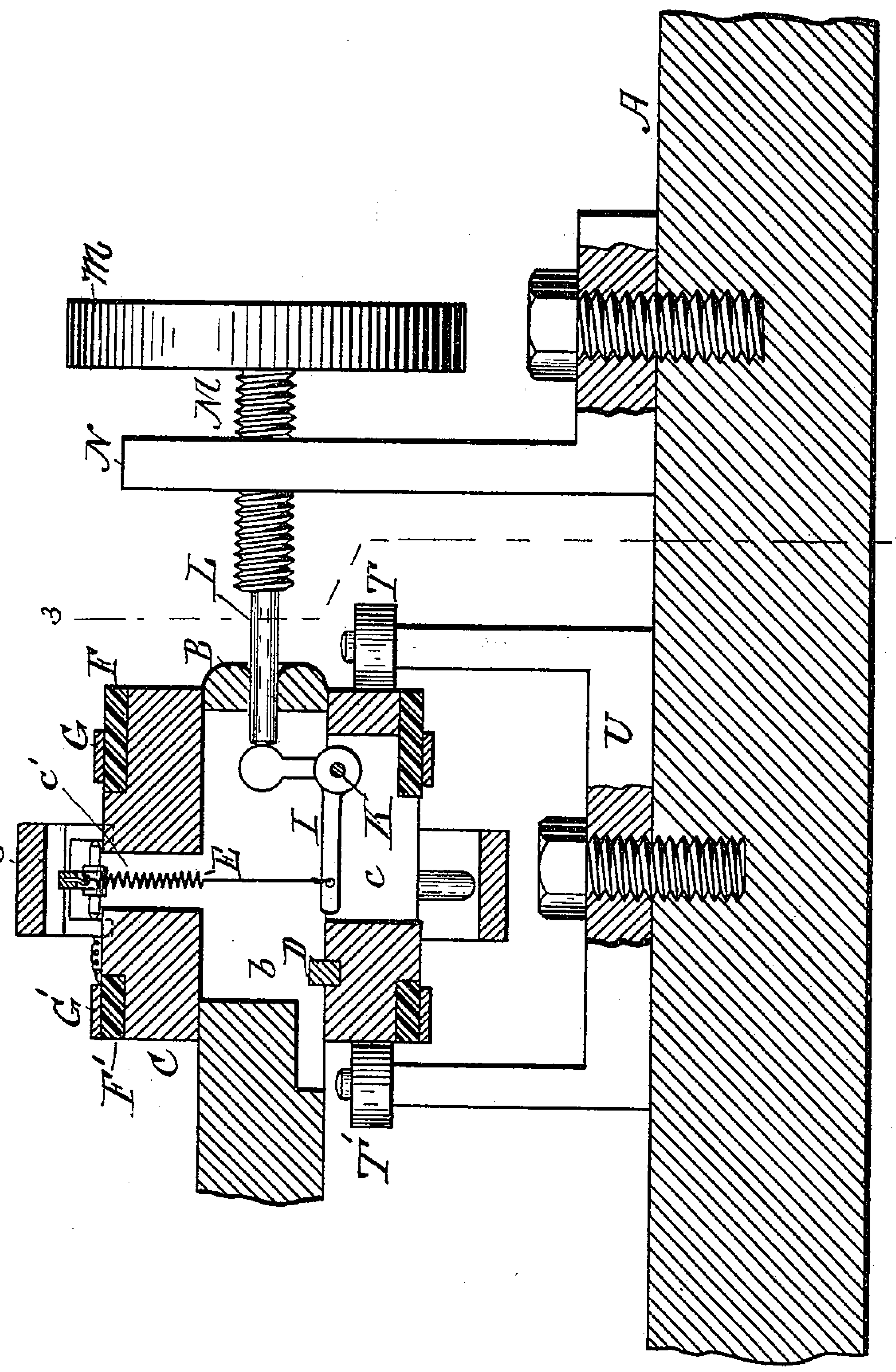

Fig. 2.

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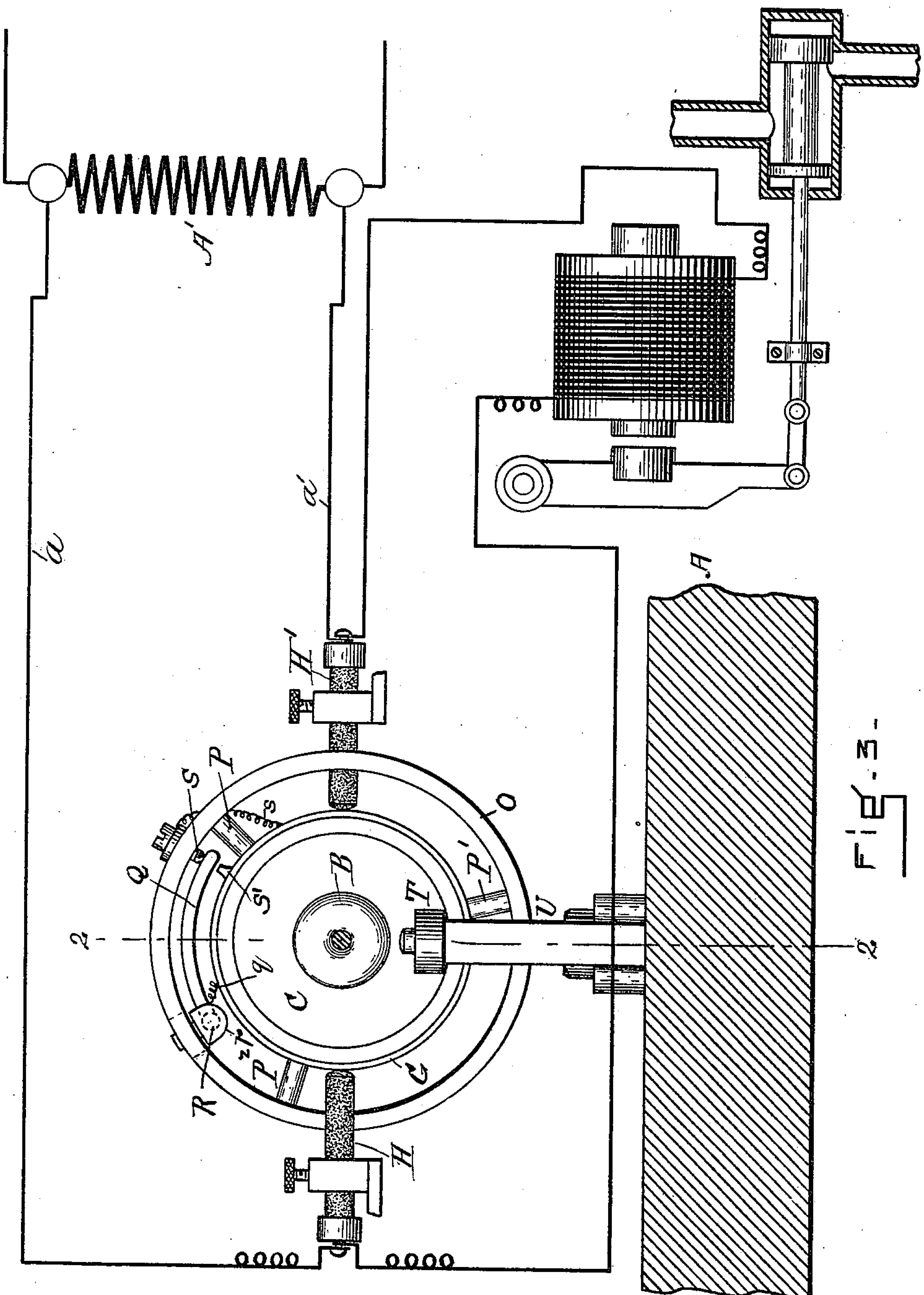

FIG. 3.

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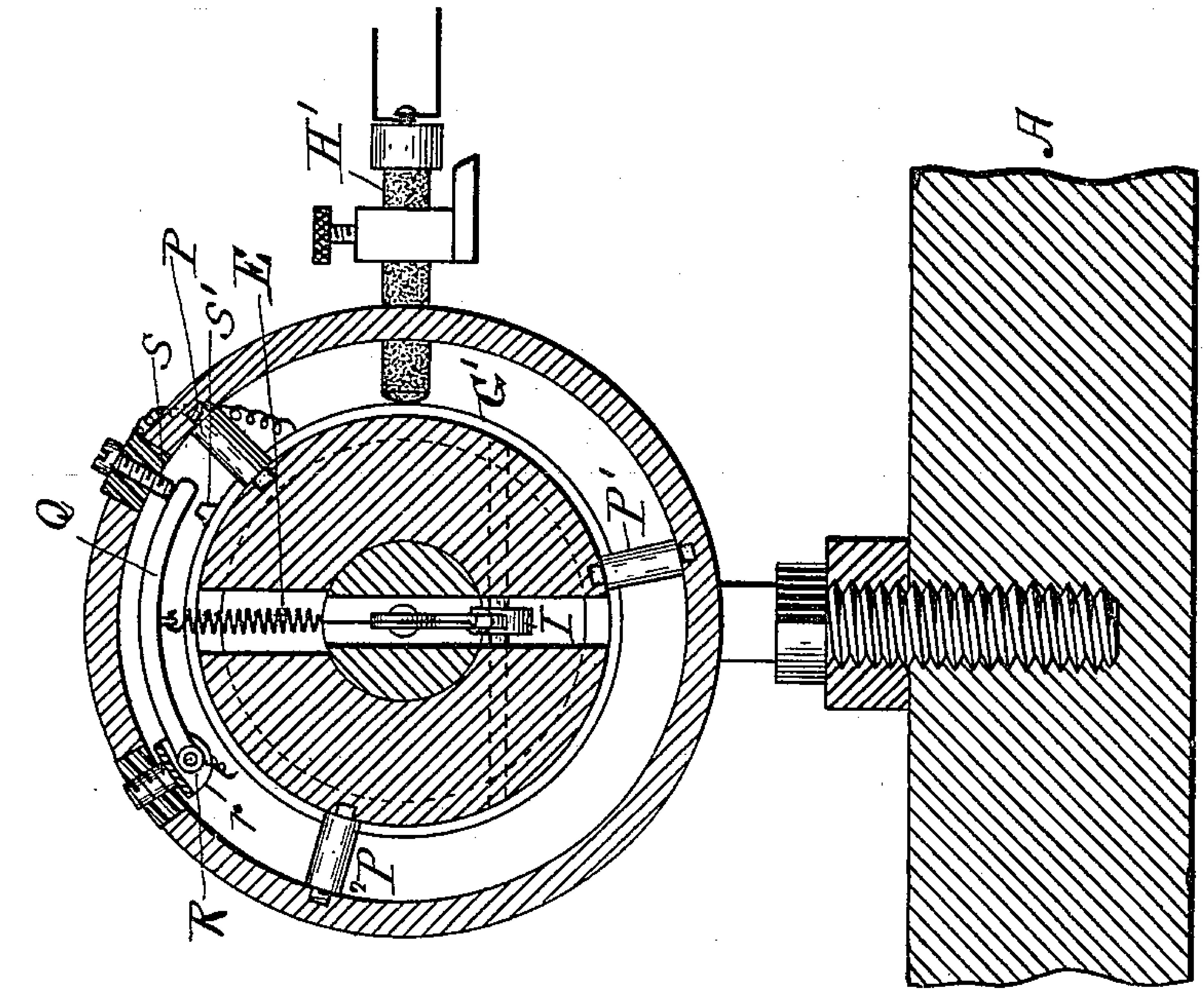

Fig. 5.

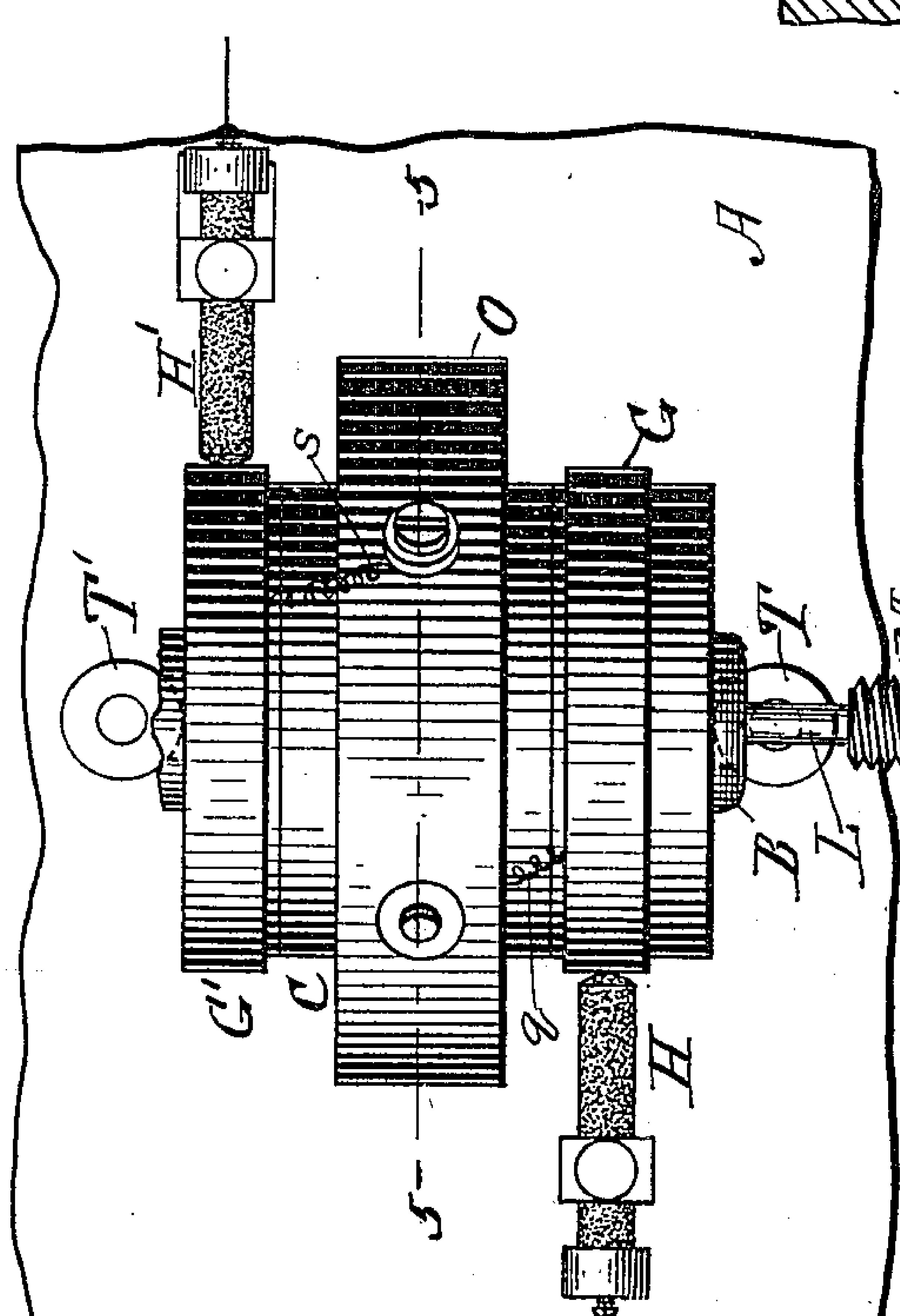

Fig. 4.

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UNITED STATES PATENT OFFICE.

ELISHA GRAY, OF HIGHLAND PARK, ILLINOIS.

TRANSMISSION OF SOUND AND DEVICE FOR CARRYING SAME INTO EFFECT.

SPECIFICATION forming part of Letters Patent No. 636,520, dated November 7, 1899.

Application filed June 23, 1899. Serial No. 721,672. (No model.)

To all whom it may concern:

Be it known that I, ELISHA GRAY, a citizen of the United States, residing at Highland Park, in the county of Lake and State of Illinois, have invented certain new and useful Improvements in the Transmission of Sound and in Devices for Carrying the Same into Effect, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming a part of this specification, in explaining its nature.

My invention is an improvement upon that of Gray and Mundy, described in their allowed application, filed April 17, 1899, Serial No. 713,037, and the patent on which will issue simultaneously herewith. The invention of said application describes a method of ringing bells electrically by means of a direct-acting intermittent electric pulsating current the pulsations of which are originated and controlled by the vibrations of a tuned reed.

My present invention is an improvement in the art; and it consists in ringing a bell electrically by the direct action of a pulsating current the pulsations of which are originated and governed by an alternating dynamo.

My invention further comprises means for practising the art and for governing or regulating the speed of the dynamo, whereby it is enabled to produce electric pulsations in accord with the fundamental vibration rate of the bell. This latter portion of the invention is also useful for other purposes, as will hereinafter appear.

The dynamo which I prefer to employ belongs to the class known as "two-phase" machines and does not differ, essentially, in construction from any of the well-known forms. The connections between the dynamo and the bell-magnets are so made that the pulsations from one phase will actuate one set of magnets placed diametrically opposite to each other in the bell, while the other phase is connected with the second set of magnets, placed in the bell diametrically opposite to and at right angles with the first set. The pole-pieces of each phase of the dynamo are preferably so arranged that the interval of no current between any two pulsations in the same phase is not less in time than the length of a pulsation; but it may be of greater length. The two phases of the machine are so related to each other that a pulsation in one phase occurs at the moment of no current in the other phase, and this alternately energizes each pair or set of magnets, so that while one set or pair is pulling upon the bell the other set or pair is deënergized. The advantages of ringing a bell by this method lie chiefly in the fact that any desired amount of electrical power for energizing the magnets can be used and that there are no electrical contacts to be looked after.

The alternating dynamo may be driven by any source of power that can be so regulated in respect to speed as will furnish the required rate of electrical vibrations per second necessary to correspond with the rate of vibration of the bell in producing its dominant tone. Heretofore, so far as I am aware, there has been no means for regulating the speed of the motor or the speed of the dynamo with sufficient exactness to produce in a bell a sustained tone of its dominant note. The governor hereinafter described has obviated this difficulty and permits the dynamo to be run from any source of power.

I will now describe the invention in connection with the drawings, wherein—

Figure 1 is a diagrammatic view of a motor-dynamo and the connections of the dynamo with the bell-magnets and bell. Fig. 2 is a view in vertical section upon the dotted line 2 2 of Fig. 3, showing the construction and application of the governor. Fig. 3 is an end view, enlarged, of the governor, showing also an electrical resistance-coil and a balanced steam-valve controlled by the governor through the medium of an electromagnet. Fig. 4 is a plan view, enlarged, of the governor, showing brushes, to which reference will hereinafter be made. Fig. 5 is a view in vertical cross-section, enlarged, upon the line 5 5 of Fig. 4.

Like letters and numerals of reference refer to like parts in the different figures of the drawings.

In the drawings, 10, Fig. 1, is a conventional motor which is mounted upon the shaft B. 11 is a two-phase alternating dynamo mounted upon the said shaft B and rotated by the motor. 12 is the bell. It is represented in Fig. 1 with its mouth exposed, so that its two pairs of magnets 13 and 14 and 15 and 16 and their connections may be readily observed. The wires 1 2 connect one phase of the dynamo 11 with the pair of magnets 13 and 14 in the series. Likewise the wires 3 4 pass from the other phase of the dynamo 11 through the other pair of magnets 15 and 16 in the series. Inasmuch as these three parts of the system—namely, the motor, alternating dynamo, and the bell, with its magnets—are either well-known separately or have heretofore been separately described, it is unnecessary to here describe them more fully in detail. There is also mounted upon the shaft B of the motor 10 a regulator or governor I, the specific construction of which will be hereinafter described, and the object of which is to regulate the speed of the motor, and thus regulate the speed of the dynamo, and to automatically govern or control the speed of both after it has been once set or adjusted to the speed which it is desired to obtain. Its purpose is to govern the speed of the alternating dynamo so perfectly and continuously that it will communicate to the pairs of bell-ringing magnets in alternate order electric pulsations which shall be in accord with the rate of the vibration of the bell in producing its dominant tone, and the tone of the bell itself acts as the means whereby the governor is primarily adjusted or set to produce the speed of the dynamo necessary for causing these pulsations.

Heretofore all centrifugal governors, whether the object was to open and close an electric circuit or to move a steam or other valve, were constructed with the view of moving some intermediate mechanism or device, and this fact made it necessary to give the centrifugal arm or arms of such governors considerable weight, and this weight made it necessary to overcome considerable inertia every time either the load or initial power driving the motor was changed. This inertia in turn made any change necessarily slow, so that the motor would have to change its speed for a perceptible time before the governor would act. This would cause a series of fluctuations from fast to slow whenever the supply or load changed and would not govern closely enough to produce a continuous tone of any definite pitch. I have overcome that difficulty by using a very light centrifugal lever, so light that the factor inertia may be ignored. The electric current passes directly through this lever, and any movement, even one one-thousandth of an inch, will bring into action a power that either checks or accelerates the speed of the motor. This lever is regulated to operate a motor at any desired speed by a device that increases or decreases the tension of the light spiral spring that is attached directly to the lever, and this renders it unnecessary for the lever to overcome any inertia or friction outside of itself.

The governor will now be described in detail and especially in connection with Figs. 2, 3, 4, and 5 of the drawings.

A, Fig. 2, is a base upon which is mounted certain parts of the governor.

C is a metal sleeve or ring which is mounted upon the shaft B and preferably in a manner to freely slide a limited distance longitudinally upon it. This ring is revolved with the shaft B, with which it is connected by a spline D, fastened to the sleeve and fitted to a slot or groove in the shaft B in a manner to allow the sleeve to have the sliding or end motion upon the shaft above referred to, or, as will be more usually the case, so that the shaft B can slide back and forth with respect to the sleeve. The shaft has a slot *b*, which is cut entirely through it and is of any desired width. The sleeve C is also provided with a slot *c* in extension of the said shaft-slot *b*. The sleeve also has on the opposite side of the shaft a radial hole *c'* large enough to contain the adjusting-spring E. It will be noticed that the slots in the shaft and sleeve are kept in line with each other by the spline D.

F F' are rings of vulcanite, rubber, or other insulating substance secured to the sleeve C and revolving therewith.

G G' are metal rings that are forced tightly upon the insulating-rings F F' and are insulated thereby from the sleeve C and with which the electrical brushes H H' (see Figs. 3 and 4) maintain a contact.

I (see Fig. 2) is an angular lever pivoted at K to the metal sleeve and one arm of which is contained in the slot *b* of the shaft.

L is an adjusting spindle or device which is carried by a stationary bracket or post N, mounted upon the base A, and which has a threaded section M screwing in a nut in the post or bracket and by means of which it is provided with an endwise movement. It is adapted to be turned by the wheel *m*, and its threaded section M has an extension L into a hole in the end of the shaft B, and its inner end is in contact with one arm of the lever I. The pin is loose in the shaft-hole and does not revolve with the shaft. A metal ring O surrounds the sleeve C and is held in concentric relation thereto by means of the supports or connections P P' P^2. To the inner side of this ring a lever Q (see Fig. 5) is pivoted at its end R to the lever-holder *r*, which is insulated from the ring O. The lever is represented as having the form of an arc. It is connected by the spring E, previously referred to, with the lever I, and it is adapted to move between the contact-point S, carried by the ring O, but insulated from it, and which point may be radially adjustable in and out with respect to the ring and the point S', which is mounted upon the sleeve C.

The tension of the spring E is adjusted or regulated by means of the adjusting spindle or device L, which is adapted to be turned to set the spring while the machine is in operation and which causes the pin or spindle L to move the lever in one direction or to permit it to be moved in the reverse direction, thus causing its end to which the spring is attached to be moved out or in, thus varying the tension of the spring by increasing or decreasing its length.

The lever Q has electrical connection by means of a wire q with the insulated ring G and the brush H. The contact-point S is electrically connected with the insulated ring G′ and the brush H′ by the wire s, which connects the contact-point with the insulated ring G.

When endwise movement resides in the shaft B rather than in the governor, the governor may be held as against endwise movement by the rolls T T′, which are carried at the ends of the yoke U, firmly secured to the base A.

It will be seen that the part called the "lever" Q is moved outward or in one direction by centrifugal force of the governor and inward by the weighing and balancing spring, which is constantly exerting a draft upon it, and that the lever thus becomes a circuit maker and breaker. The circuit may be established at the end of its outward movement of the lever, as above described, or, if desired, at the end of its inward movement, and when it is required to be especially sensitive it is desirable that the lever be made very light and relatively long, that its actuating-spring be also very light, and that its contact-point be at or near its moving end.

It will be understood that the tension of the spring may be varied while the holder is in operation, and this I consider to be an important part of the invention in that I am enabled to balance the pressure or draft of the spring to the centrifugal force of the lever while the motor is in operation and to thus accurately set the lever so that it will operate when any desired rate of rotation is obtained and at which rate it will continue to operate.

While I have described the circuit maker and breaker as a lever, I would say that any other device adapted to be moved by centrifugal force in one direction and by an adjustable spring or balancing means adapted to be set or adjusted while the mechanism is rotating, and which device is adapted to make or break an electric circuit, may be employed.

Having described the construction of the governing apparatus, I will now explain its operation when used to govern the speed of an electric motor, reference being had to so much of Fig. 3 as represents a resistance-coil.

It is well known that the speed of an electric motor will be increased, especially when it is carrying a light load, by introducing a resistance in the field-circuit; also, that the speed of the motor will be decreased, other things being equal, by introducing a resistance in the circuit running from the source of power to the motor. For the purposes of illustration let us consider the first-named method—to wit, the introduction of a resistance in the field-circuit.

Referring again to Fig. 3, one end of the resistance-coil A′ is connected with the brush H by a wire a. The other end is connected with the brush H′ by a wire a', and the lever Q when in contact with the contact-point S will complete a circuit through the brushes and lever between one end of the resistance-coil and the other, cutting it entirely out of the field-circuit. Supposing, for instance, that when the resistance-coil is thus cut out of the field-circuit the speed of the motor is at the rate of seventeen hundred revolutions per minute, and that when the resistance-coil is in the field-circuit the speed of the motor will be at the rate of two thousand five hundred revolutions per minute, and supposing it is desired to obtain and maintain in the motor a rate of two thousand one hundred revolutions per minute, which with an alternator of ten poles would give three hundred and fifty pulsations per second, the number required to ring a bell whose dominant tone is about F♯ above middle C, the operation of regulating the motor to obtain the required speed or rate of rotation would be as follows: As heretofore described, the governor revolves with the shaft B, carried by the spline D, and every change in the rate of rotation of the motor, however slight, will produce a change in the centrifugal force which is acting upon the lever Q, and the problem is to cause the tension upon the spring E to exactly balance the centrifugal force which is exerted upon the said lever when the shaft of the motor revolves at the rate of two thousand one hundred revolutions per minute, as the lever theoretically would then be sustained in an intermediate position between the points S S′ and held in such position by the equal balancing of the two opposing forces acting upon it—one the centrifugal due to the rotation of the lever, and the other in the nature of a centripetal due to the draft upon the lever by the spring—the lever thus acting much as a scale-beam acts in weighing anything. This balancing of the two forces to obtain the rate of revolution required is readily secured by turning the adjusting-screw back or forth to change the weight of the spring and until the desired rate of rotation is secured. If the screw-spindle is moved inward with respect to the shaft its speed is increased, as this movement increases the tension or weight upon the centrifugal circuit-maker and requires that a greater centrifugal force be attained before the circuit can be established. If the spindle is moved outward with respect to the shaft, (or in the reverse direction,) the tension upon the spring is decreased and the centrifugal circuit-maker will operate at a lower centrifugal force. The adjusting-spindle may have any desired fineness of adjustment imparted to it which may be required, even to the extent of operating it by a micrometer or a worm-gear. The rate of rotation to be attained may be ascertained by any speed-indicator, and in the invention herein described the bell itself furnishes such an indicator, the sounding of its dominant tone showing that the governor has been set to obtain the desired rate of rotation of the motor.

When the proper balance between the two forces acting upon the circuit maker or breaker is secured to produce the rate of rotation in the motor of two thousand one hundred per minute, any tendency of the motor to rotate at a higher rate is immediately checked by the lever coming into contact with the point S, thus cutting out the resistance from the field-circuit. This check to the power is immediately felt, and the lever then drops away from its contact-point, and by so doing again introduces the resistance into the field. This causes the lever to vibrate rapidly on and off the point S. Other things being equal, the lighter the centrifugal lever the more sensitive it will be to changes of rotary speed.

In practice it has been found that a lever of an inch and a quarter long by an eighth of an inch in diameter is sensitive enough to govern an alternating dynamo sufficiently to give to a bell a sustained tone whose pitch requires three hundred and fifty vibrations per second. By reducing the weight of the mechanism and increasing the delicacy of adjustment a motor may be governed with sufficient accuracy to give a sustained tone whose pitch requires one thousand or more vibrations per second. Instead of cutting in and out a resistance placed in the circuit of the field of a motor the resistance may be placed in the feed-wire running to the motor, and thus regulate the speed of the motor by causing changes in the flow of current to the motor which shall correspond to the changes in the load. Where it is practicable, however, the first-described method is preferred.

I would say that the governor may be used for other purposes than for automatically controlling the action of an alternating dynamo in bell-ringing, as herein specified, and I do not wish to be understood as limiting this part of the invention to such use. In Fig. 3 I have represented one of its other uses, in that it is there shown as used to govern a steam-engine. When so employed, it will be desirable to use a balanced valve in the steam-supply pipe, which shall be set to admit to the engine the requisite amount of steam necessary for causing a definite number of revolutions per minute of the engine, and any diminution or excess of such revolutions will cause the governor to actuate the valve in one direction or the other through the medium of a magnet which is energized or deënergized and which operates, through a pivoted armature-lever, the valve connected with the moving end of said armature-lever. This illustration is used simply for the purpose of showing the range of the invention, and I would say that it may be applied to regulate water-power, compressed-air motors, and in fact all forms of motor depending on a source of power-supply that is irregular. It will govern equally well in cases where the source of supply is regular and the load or work done is inconstant, or where the load is constant and the supply irregular, or both may be irregular, assuming, of course, that the source of power never falls below the point which would give the required speed.

I have shown the governor as mounted upon the motor-shaft; but of course it is not necessary that it should be so mounted so long as it is rotated from it.

In Fig. 1 I have shown a method of signaling or operating the bell without checking the flow of pulsations from either of the circuits running from the alternator to the bell-magnets. Wire 5 passes from point 8, which connects with key 7, to secondary coils wound upon magnets 13 15 14 16 and are connected together in series terminating in wire 6, which connects with key 7. If key 7 is in contact with the point 8, then this secondary circuit is closed, and when pulsations are sent into the primary coils from the alternator 11 secondary impulses will be induced in all of the secondary coils simultaneously—that is to say, whenever an impulse passes through one set of primary coils the secondary impulse will pass through all four of the coils, and thus cause a pull upon the bell in two directions at right angles to each other simultaneously. While this does not stop entirely the ringing of the bell, it so interferes with it as to cause it to ring with much less energy during the time the secondary circuit (represented by wires 5 and 6) is closed. If key 7 is now depressed, the secondary circuit will be broken and the bell will be free to ring in accord with the primary impulses. If the key is depressed and elevated to practice the Morse code or in any other prearranged or arbitrary order, signals may be transmitted through the air or water of the character desired. There are other ways in which this same effect may be obtained, and I do not wish to be understood as confining myself to the one described.

I prefer to arrange the circuit maker or breaker Q in line with the direction of rotation rather than crosswise it and with its pivotal point in advance, as by so doing it is subjected to the least friction, and therefore responds most readily to very slight variations in centrifugal force.

Having thus fully described my invention, I claim and desire to secure by Letters Patent of the United States—

1. A bell, magnets in pairs to produce magnetic lines of force to act upon the bell, a multiphase alternating generator the phases of which are connected with alternate pairs of magnets.

2. The combination of the bell, two pairs of magnets diametrically arranged with respect to the bell, and a multiphase alternating dynamo the phases of which are connected with said magnets in pair series and alternating order.

3. A bell, magnets and means for energizing them to provide pulsating lines of force of the rate of vibration of the dominant tone of the bell, actuated in alternate order, and secondary coils on the magnets in series, connected with the wires 5 and 6 and a key for making and breaking the secondary circuit.

4. A bell, combined with a multiphase generator for directly producing pulsating lines of force to engender in the bell vibrations of the dominant tones of the said bell, and means for governing the speed of the said generator, whereby its pulsations may be set and maintained in accord with the vibrations of the dominant tones of the said bell.

5. In a device for governing electrically the application or use of power, a light rotary centrifugal circuit maker and breaker itself adapted to be adjusted while in operation and to make or break a controlling-circuit through itself upon the development of a predetermined rate of rotation or power.

6. In a device for governing electrically the application or use of power, a rotary circuit maker and breaker adapted to be actuated by centrifugal force in one direction and by a balancing or weighing spring or device in a reverse direction, and which forms a part of a controlling-circuit and means for balancing or setting said spring or balancing device during the operation of the machine.

7. In a governor for automatically regulating the rate of rotation of a motor or dynamo a light circuit maker and breaker in the form of an arm or lever pivoted at one end to an insulated rotary support and connected with a brush H, a rotary insulated contact-point carried by said rotary support and connected with the brush H′, a spring attached to said lever or arm for moving or drawing it from said contact-point, a spring-tension regulator comprising a device like a lever to which the spring is attached, and which rotates therewith, and means which do not rotate with said lever for adjusting it and the spring while they are rotating.

8. In a governor for automatically regulating the rate of rotation of a motor or dynamo, two insulated metal conducting-rings mounted thereon, a ring mounted upon said sleeve to be rotated therewith, an insulated holder and an insulated contact-point carried by said ring, one of which is connected with the metal conducting-ring G′ and the other with the metal conducting-ring G, a light arm or lever pivoted at its forward end to said holder and extending backward therefrom in line with said contact-point, and forming a circuit maker or breaker, a lever mounted upon the sleeve, a spring connecting said circuit maker and breaker with one arm of said lever, and an adjusting non-rotating pin or spindle against which another arm of said lever bears, and which pin or spindle is endwise movable without being rotated to adjust the tension of said spring, and the brushes H, H′.

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