(No Model.)

4 Sheets—Sheet 1.

W. B. COOPER.

PYROMAGNETIC GENERATOR AND MOTOR.

No. 422,295.

Patented Feb. 25, 1890.

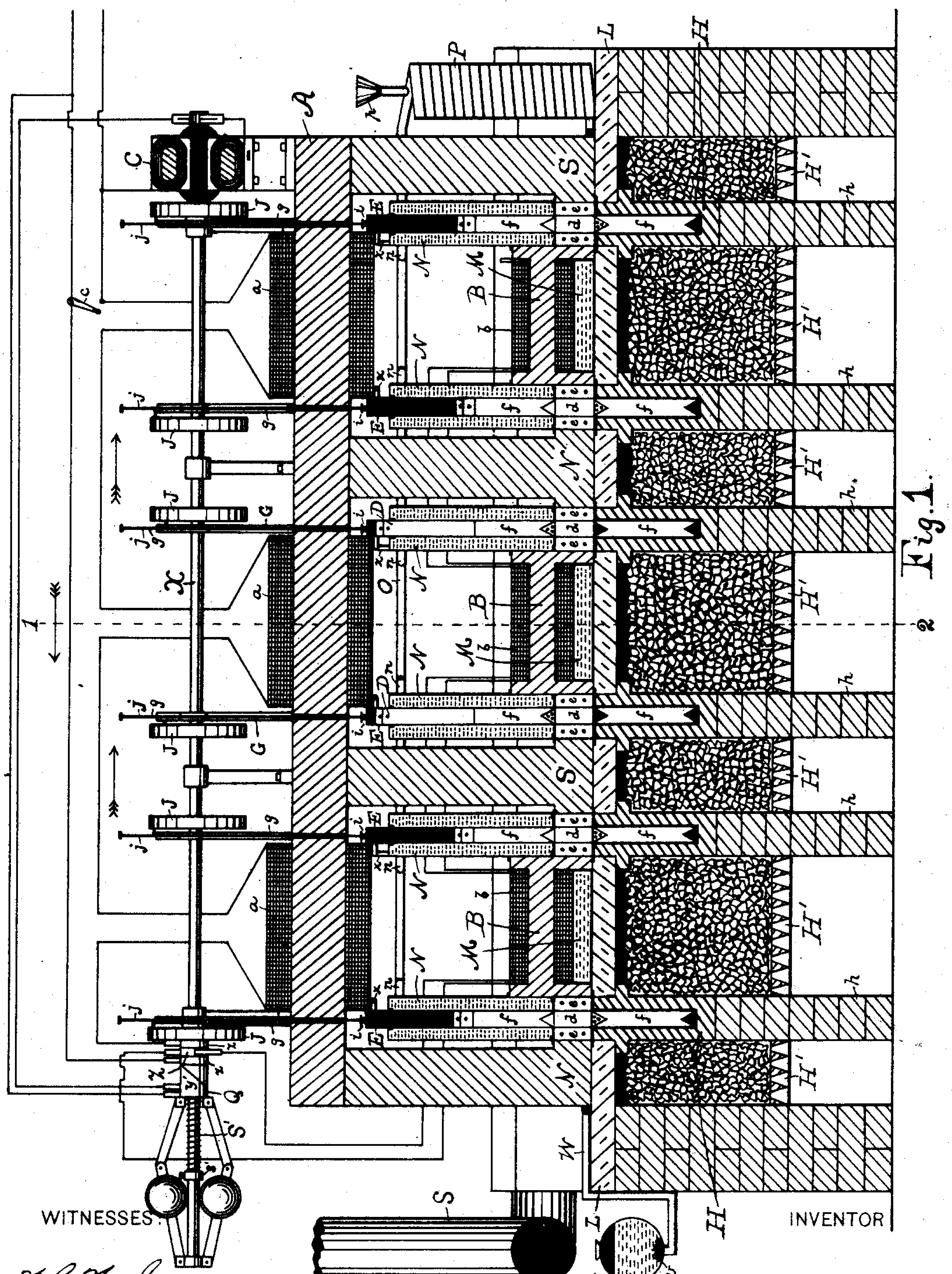

Fig. 1.

WITNESSES

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Fig. 4.

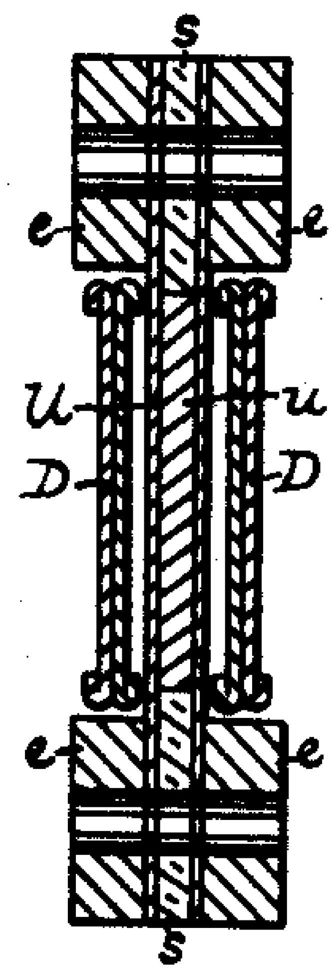

Fig. 5.

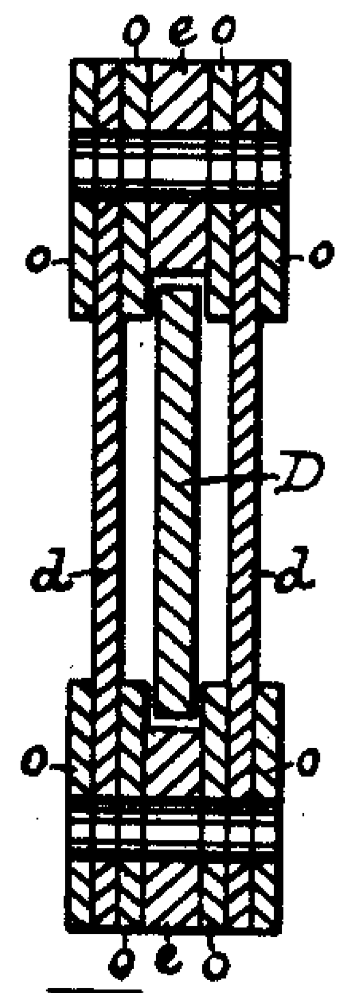

Fig. 6.

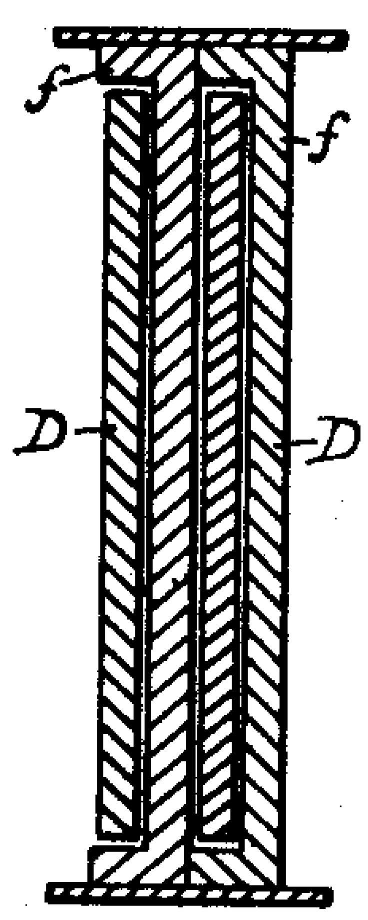

Fig. 7.

Fig. 8.

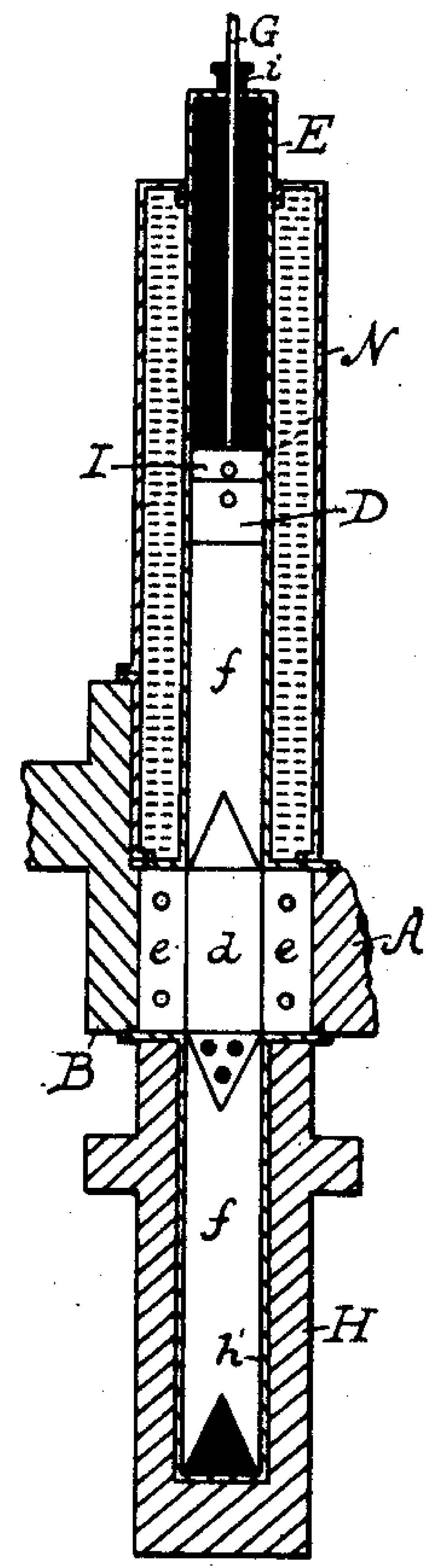

Fig. 9.

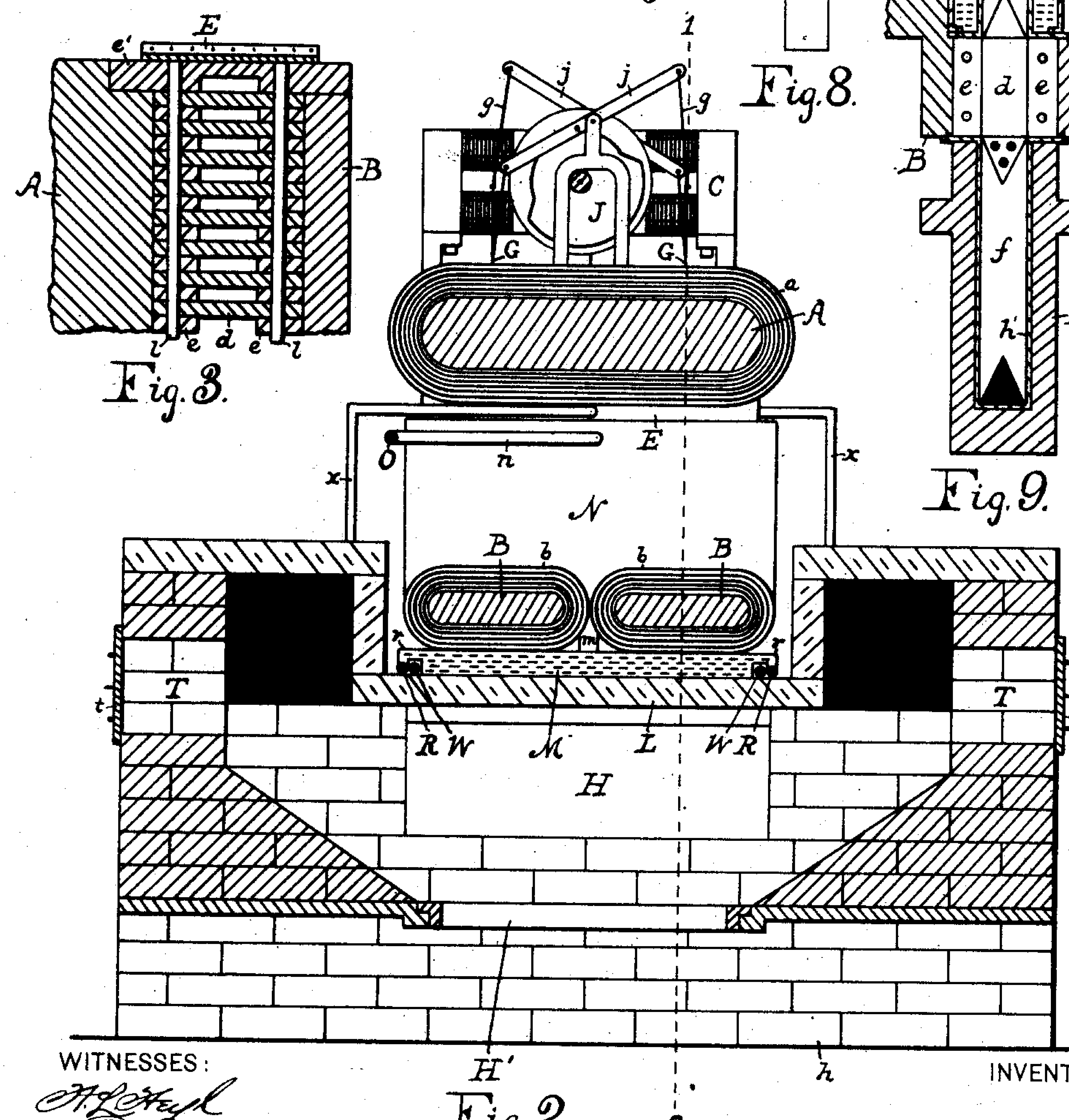

Fig. 3.

Fig. 2.

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(No Model.)

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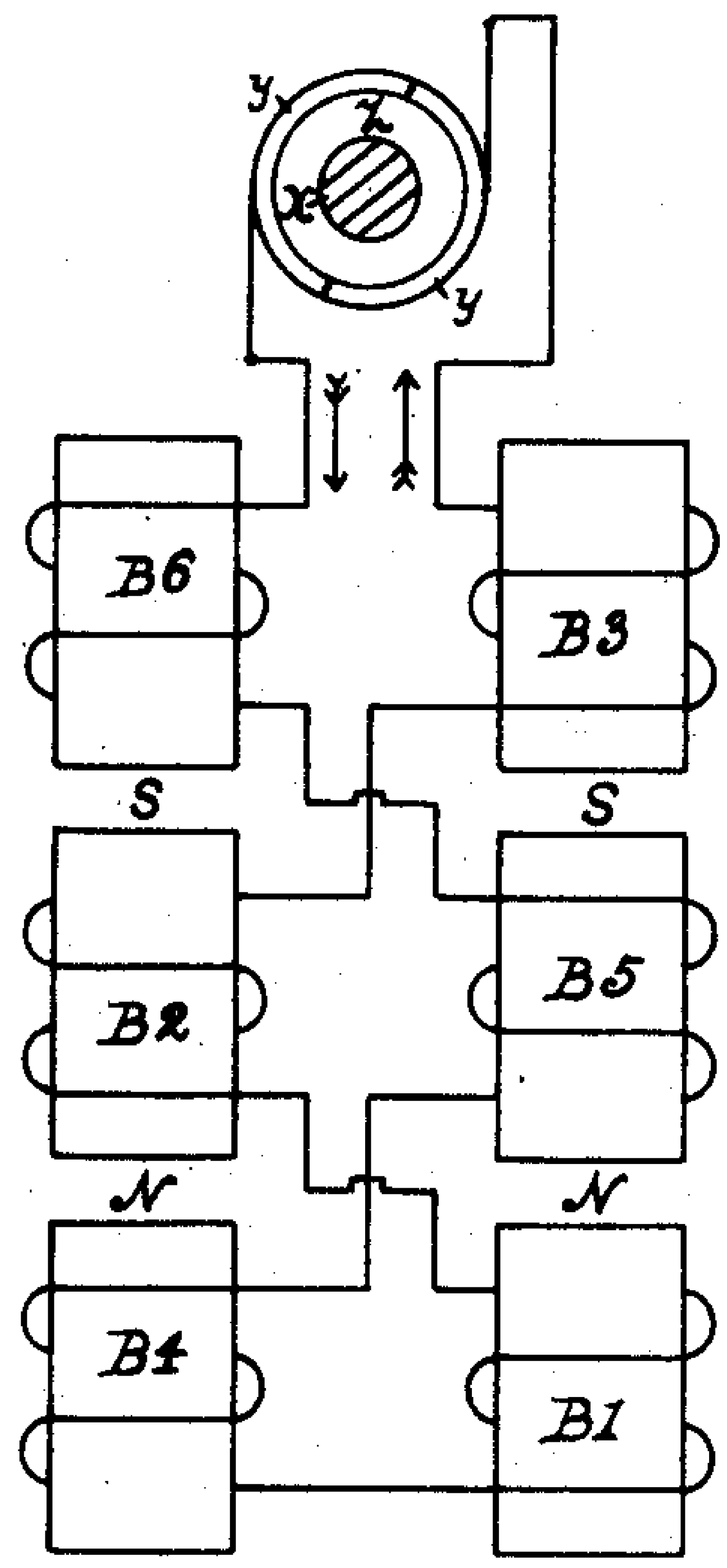

Fig.10.

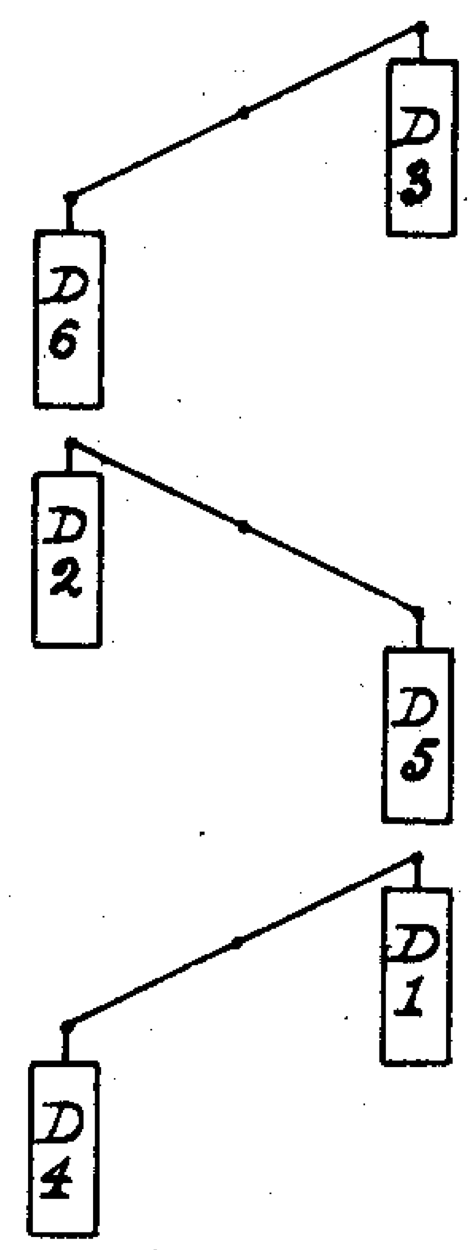

Fig.11.

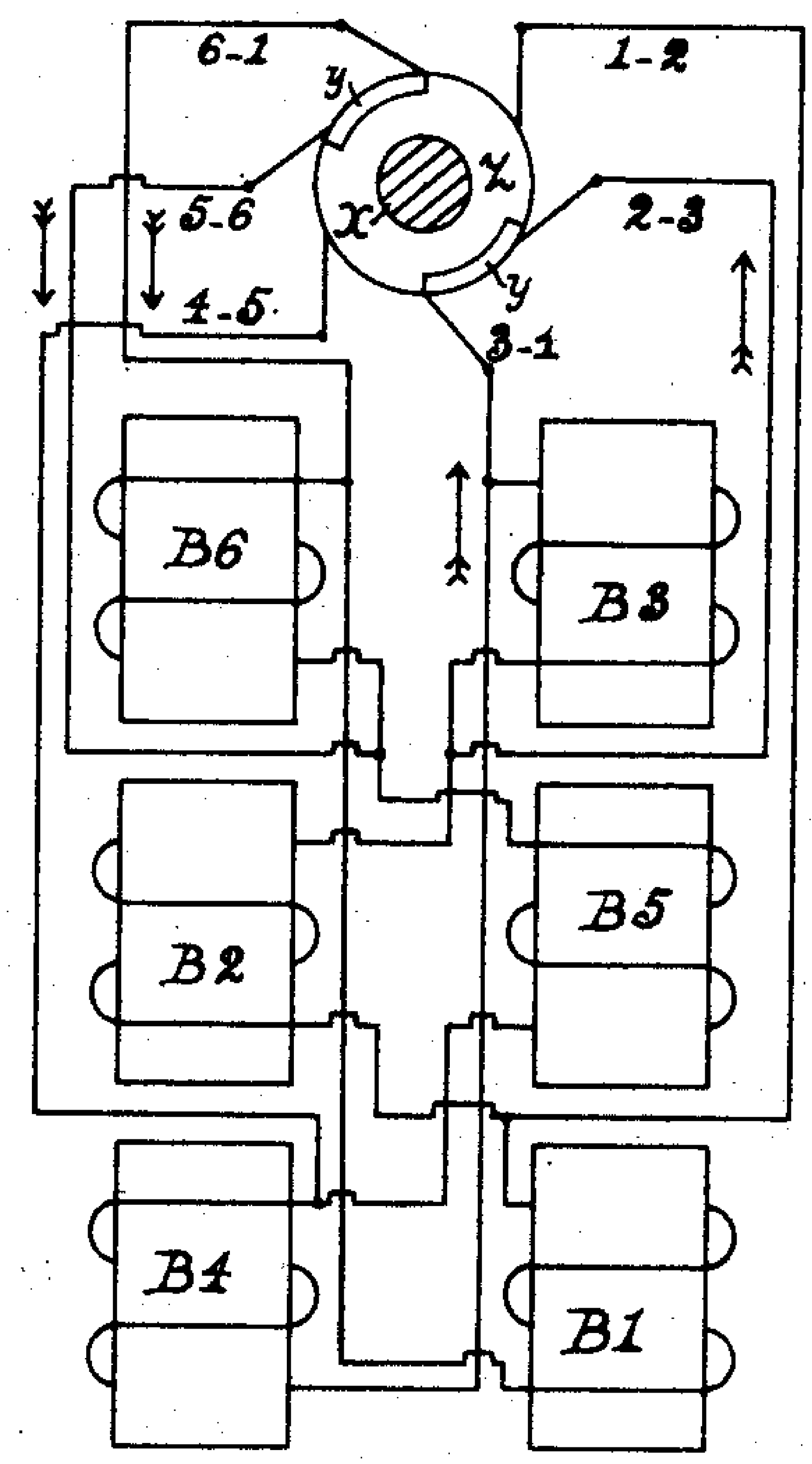

Fig.12.

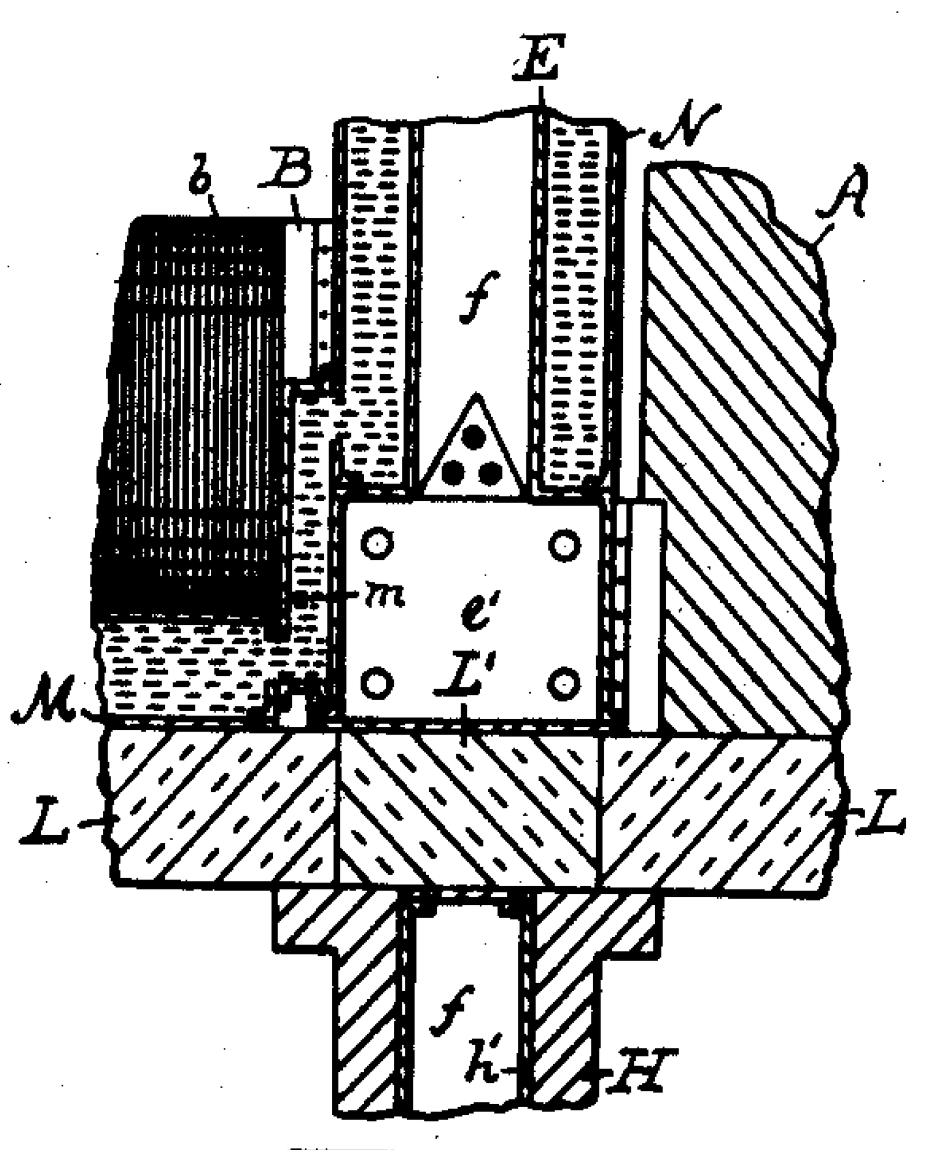

Fig.13.

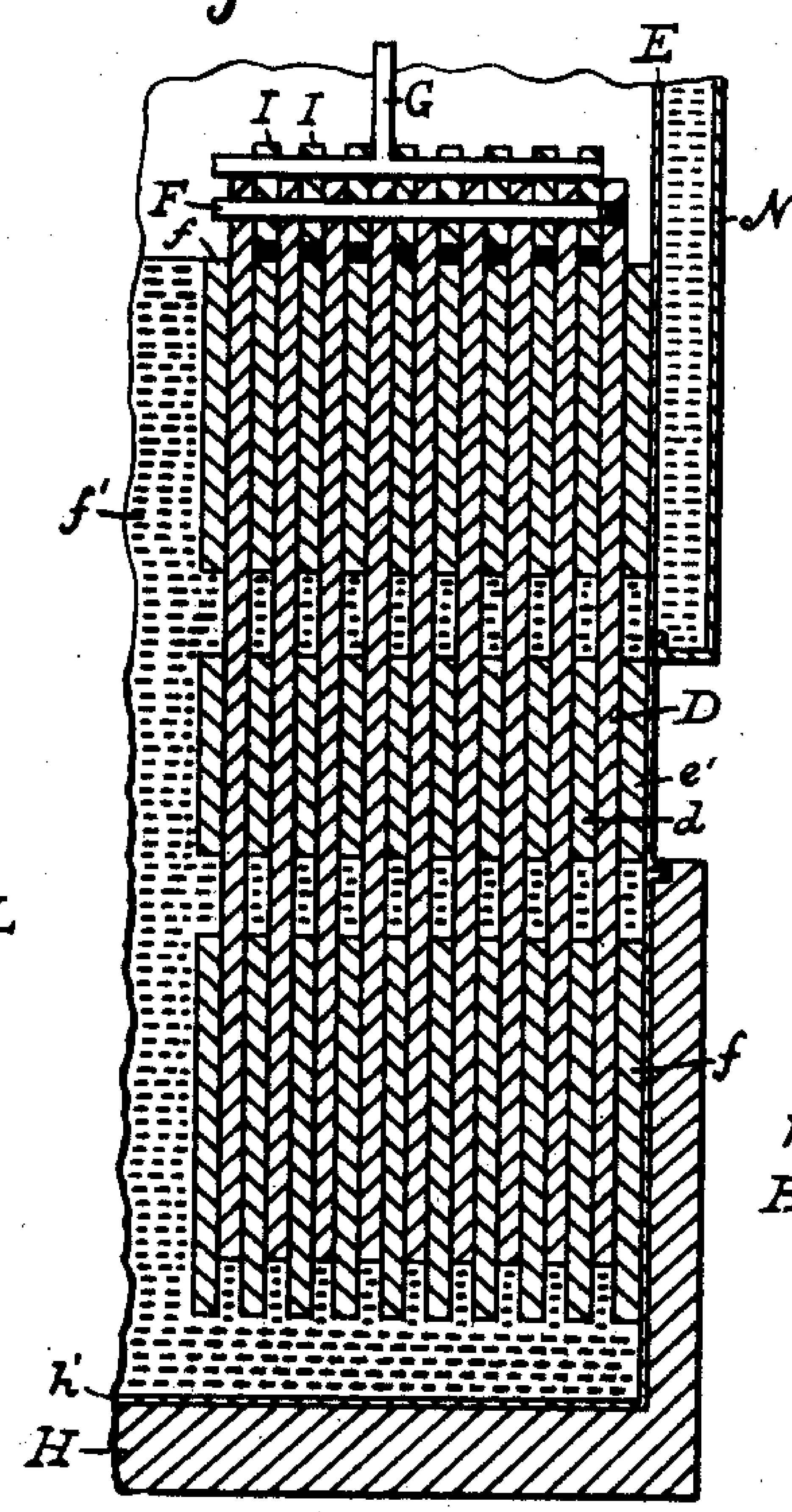

Fig.14.

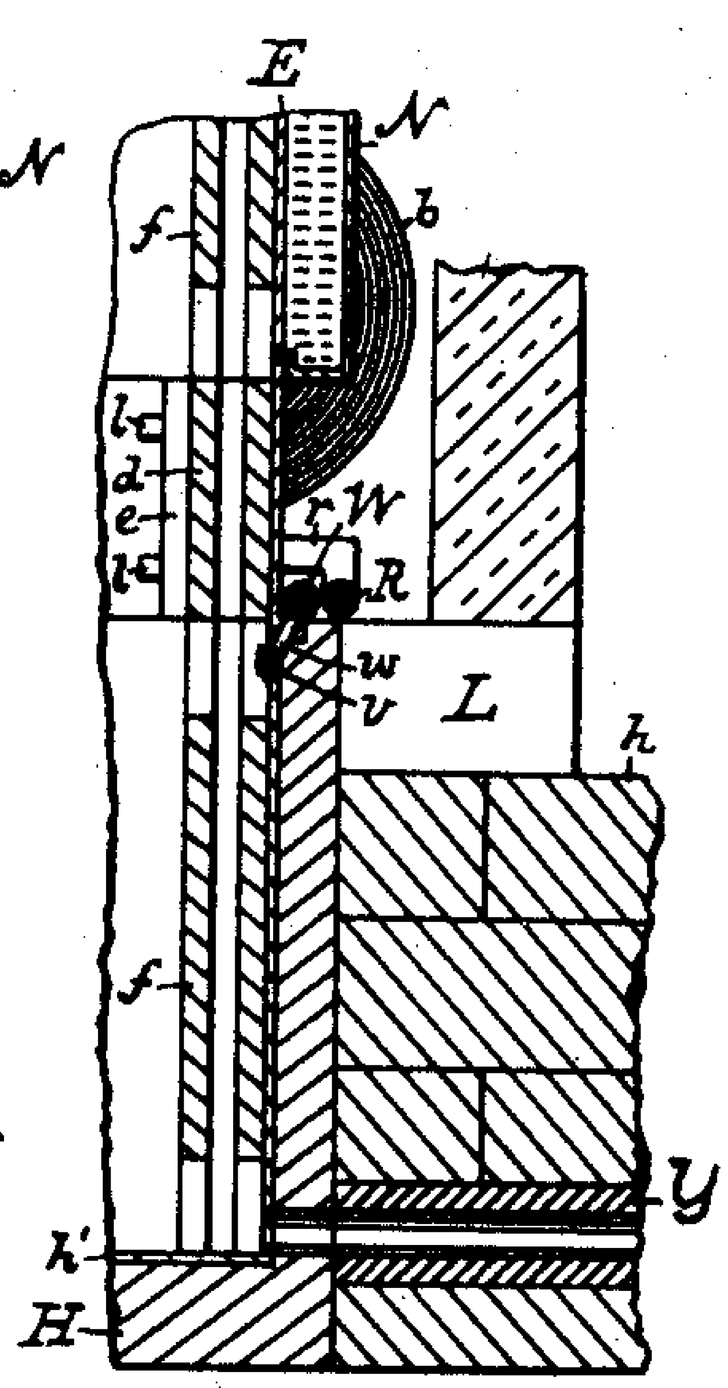

Fig.15.

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(No Model.)

4 Sheets—Sheet 4.

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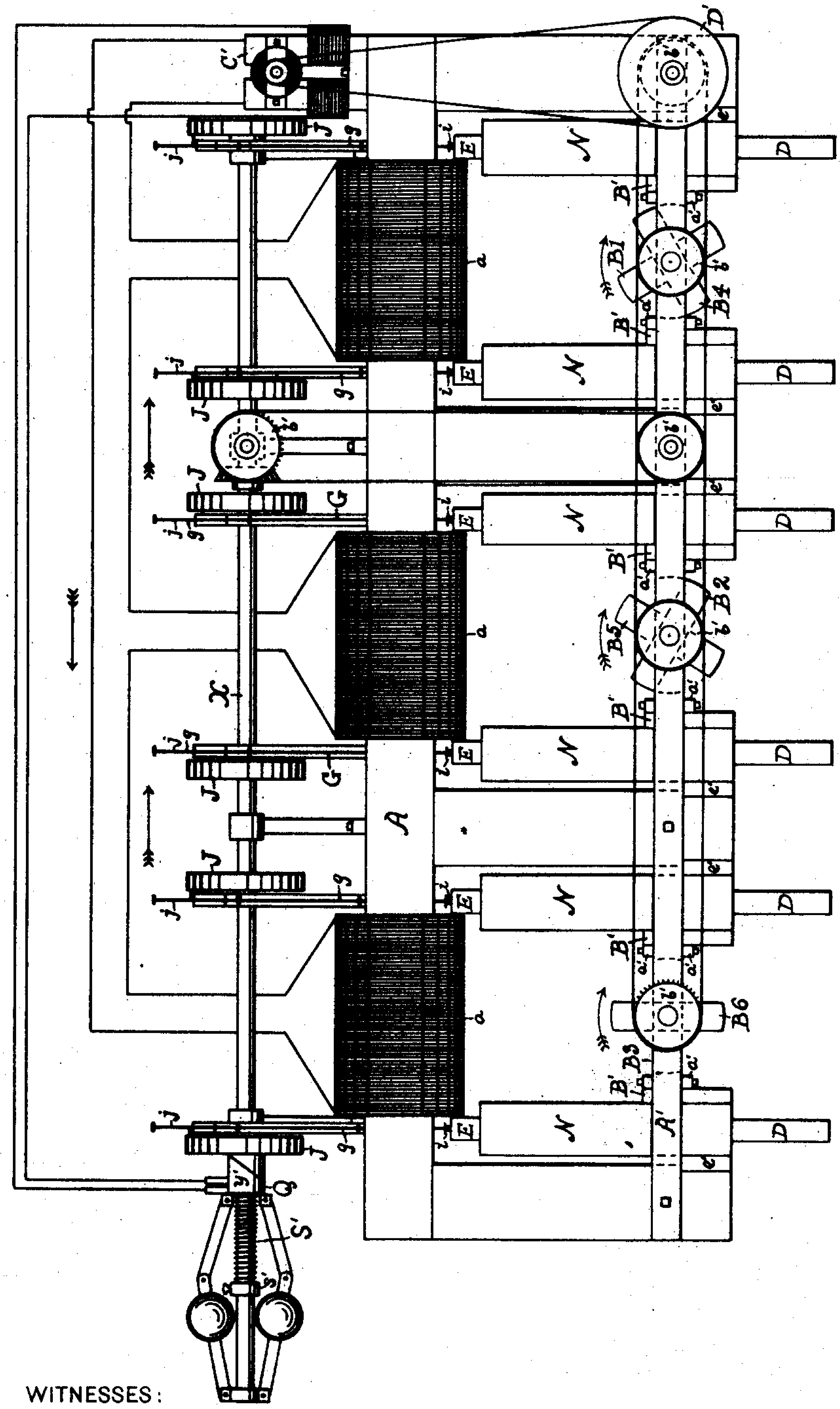

Fig. 16.

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UNITED STATES PATENT OFFICE.

WILLIAM BURR COOPER, OF PHILADELPHIA, PENNSYLVANIA.

PYROMAGNETIC GENERATOR AND MOTOR.

SPECIFICATION forming part of Letters Patent No. 422,295, dated February 25, 1890.

Application filed May 16, 1889. Serial No. 311,092. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM BURR COOPER, a citizen of the United States, residing in the city and county of Philadelphia, State of Pennsylvania, have invented an Improvement in Pyromagnetic Generators and Motors, of which the following is a specification.

The object of my invention is the application of the change of magnetic resistance of the magnetic metals which is caused by heat, and in order to apply this to the generation of electricity I use armatures surrounded by coils in which currents of electricity are induced, sections of laminated iron or other magnetic metal connecting the armatures to the poles of the field-magnet, and a means of alternately heating and cooling the laminated sections above and below the mean of the range of temperature in which the magnetic change occurs. This may be accomplished by introducing between the magnetic laminæ movable laminæ which are heated at one end to a high temperature, and moving them back and forth between the magnetic laminæ, both sets of laminæ being inclosed in a chamber containing a non-oxidizing atmosphere. Molten metal may also be used in conjunction with the movable laminæ.

By modifying the device so that the armatures can rotate, a motor may be constructed operating upon the same plan as the generator.

In the accompanying drawings the same letters refer to the same parts.

Figure 1 is a longitudinal section through the line 1 2, Fig. 2. Fig. 2 is a transverse section through the line 1 2, Fig. 1. Fig. 3 is a horizontal section of the magnetic laminæ, showing the means of connecting them to the armatures and the poles of the field-magnet. Fig. 4 is a vertical section of the composite laminæ; and Fig. 5, a horizontal section of the composite laminæ, also showing a method of constructing the movable laminæ. Fig. 6 is a horizontal section of the magnetic and movable laminæ, showing supplementary laminæ. Fig. 7 is a horizontal section of the movable and stationary laminæ. Fig. 8 is a stationary laminæ. Fig. 9 is a vertical section of one of the chambers, showing the inclosed laminæ. Fig. 10 shows the method of connecting the armature-coils and of commutating the current which is adopted in Fig. 1. Fig. 11 shows the position of the movable laminæ in Fig. 1. Fig. 12 shows a method of connecting the coils when a uniform current is desired. Fig. 13 is a vertical cross-section of a chamber, showing the portion between the armatures. Fig. 14 is a vertical section of the magnetic, movable, and stationary laminæ in a chamber containing molten metal. Fig. 15 is a vertical section of part of a chamber, showing one of the pipes by which the hydrocarbon is introduced and other details. Fig. 16 is a side view of the motor, the furnace and lower halves of the chambers being omitted.

A is the field-magnet, the alternate arms of which are of the same polarity, as shown by the letters N S, thus forming three separate magnetic fields in the device shown. It is energized by the coils *a a*.

B B are the armatures, which are magnetically connected to the poles of the magnet by sections composed of magnetic laminæ *d d*.

D D are the movable laminæ, which are composed of some non-magnetic material, or one which will become non-magnetic at the temperature to which they are exposed, and which will also sustain a high heat without fusing. Each set is suspended to a rod F, which passes through perforations in them, as shown in Fig. 14, and hangs in the interstices between the magnetic laminæ, being separated by the intervening laminæ I I, which are also preferably non-magnetic and project above the laminæ D D, the T-shaped rod G passing through perforations in them. The movable laminæ are perforated, as shown, to reduce the conduction of heat to the cool portion.

H H are chambers of some refractory material, preferably the mixture of graphite and clay used for crucibles, and should be glazed to render them impervious. They rest upon the partitions *h h*, which may be made of bricks of the same material.

E E are chambers of some non-magnetic metal, preferably copper, secured to the armatures and poles of the field-magnet by screws. They have stuffing-boxes *i i*, through which the rods G G pass. The rods G G are attached by connecting-rods g g to the levers j j, which are operated by the disks J J in the manner described farther on, the core of the field-magnet being perforated to allow the rods to pass through it, and also to provide them with a bearing.

It will be seen that the chambers H H and the chambers E E completely inclose both the magnetic and movable laminæ, being separated by the laminated portions of the armatures, and if the chambers H H are heated and the movable laminæ are raised and lowered, when they are raised the heated portion is interposed between the magnetic laminæ which are heated, and when they are lowered the cool portion is interposed and they are cooled, and by a proper adjustment of the motion and temperature of the movable laminæ the temperature of the magnetic laminæ may be caused to fluctuate, so as to alternately revive and destroy their power of transmitting the magnetic force to the armatures B B, and thus generate currents in the coils b b, with which they are surrounded.

L L are slabs of fire-brick resting upon the chambers H H and forming the top of the furnace-chamber. Between the partitions h h are the grates H′ H′, thus forming seven fire-chambers in the apparatus shown.

In order to maintain as great a difference of temperature between the different portions of the movable laminæ as possible, stationary laminæ f f are introduced into the chambers H H and E E. These may be formed of strips of sheet metal bent at their edges and placed in the chambers in the manner shown in Fig. 7. Those in the chambers E E are made of some non-magnetic metal, preferably copper, and as they would conduct the heat from the magnetic laminæ they are notched in the manner shown, which will prevent them coming into contact with the magnetic laminæ except at two points. The stationary laminæ in the chambers H H are also notched at the bottom to permit the circulation of the contents. They may be made of iron, as they are kept at a temperature above that at which they are magnetic.

As will be seen in Fig. 2, there are two armatures in each magnetic field and two sets of movable laminæ for each armature, one set being balanced by another, so that when one set is lowered into the chamber H the other will be raised into the chamber E, the two sets of laminæ operating each armature being simultaneously raised when those of its mate are lowered. Two armatures in adjoining magnetic fields might be operated in the same manner.

It will be seen that by adopting the plan of inclosing the movable laminæ belonging to adjoining armatures in the same chamber or in communicating chambers the vertical displacement of the contents which would take place in a single chamber, and would tend to produce uniformity of temperature of the chambers, is replaced by a lateral displacement as the opposite sets of movable laminæ are simultaneously raised and lowered.

The movable laminæ may be made of the alloy of nickel and copper used for coinage, the composition being one part of nickel to three parts of copper, and steel containing twelve per cent. of manganese is adapted to the purpose. The portion which is heated may, however, be made of iron, and the remainder of some non-magnetic metal, to which it may be joined by riveting or welding. Some non-volatile metal having a sufficiently low fusing-point—as tin, lead, or an alloy of them—may be used in conjunction with the movable laminæ to afford a medium for the transfer of heat between them and the stationary and magnetic laminæ, as shown in Fig. 14, the molten metal f' filling the interstices between the laminæ. By this arrangement the advantages of complete contact are secured, together with a high thermal capacity and a low thermal resistance of the heating and cooling medium and protection from oxidation.

The metal used must be one which is fusible at the temperature of the chambers E E, and which will not volatilize at the temperature of the chambers H H.

The molten metal may be prevented from alloying with the heated laminæ by oxidizing their surface or by coating them with a silicate which does not fuse at the temperature to which they are exposed.

Between the armatures and the slabs L L are water-jackets M M, which are connected by the pipes m m with the water-jackets N N, surrounding the chambers E E. These are connected by the branch pipes n n to the pipe O, which is connected to the cooling-coil P, from which the water is returned to the water-jackets by the pipes R R, having the branches r r. This system is filled by the funnel p. By placing the coil P at a higher level than the jackets it may be used to condense the vapor of the volatile liquid used in the jackets, which will cause them to be maintained at the temperature at which the liquid boils, and this may be varied by using a liquid with a low boiling-point, as benzine, or one with a high one, as turpentine.

An alloy of bismuth, eight parts; lead, six parts, and tin, three parts, fuses below the boiling-point of water, so that with that water could be used as the cooling agent in the jackets, and if it were kept under pressure it could be used with an alloy having a higher fusing-point than the above.

For temperatures above the boiling-points of available liquids air may be used as the cooling medium, and may be drawn through the jackets by connecting the pipe O with the furnace-chamber. The molten metal may be protected from oxidation by covering it with rosin; or the vapor of a hydrocarbon may be introduced above the molten metal in the manner described farther on.

S is the pipe leading to the chimney, which is connected by branches to the elevated portions of the furnace-chamber on each side, through which the escaping gases can travel the whole length of the furnace-chamber above the fuel, as seen in Fig. 2. The fuel is introduced by the openings T T, which are closed by the doors *t t*.

The magnetic laminæ *d d*, forming the magnetic sections, are separated from each other by the intervening magnetic laminæ *e e*, and are connected by rods *l l*, passing through them, being held in place by non-magnetic end pieces *e' e'*, as shown in Fig. 3.

The chambers H H have linings *h' h'*, consisting of interior chambers, which are preferably of wrought-iron. These chambers are secured to the armatures and the poles of the field-magnet in the same manner as the chambers E E, some of the cements used for heated iron being applied to render the joints tight.

If the end pieces *e' e'* are of the proper thickness, the chambers *h' h'* will be prevented from forming magnetic connections at the ends, and the method of preventing connections being formed by the chambers between the armatures is shown in Fig. 13, in which it will be seen that the slab of fire-brick L intervenes between the chambers *h'* and E, so that the temperature of all that part of the chamber *h'* will be above the point at which it is magnetic.

The chambers *h' h'* may be prevented from alloying with the molten metal by lining them with some refractory material.

As the conditions tend to produce an objectionable gradation of temperature in the magnetic laminæ unless they are thicker than is desirable, composite laminæ may be used, consisting of magnetic laminæ having interposed non-magnetic laminæ, which are preferably made of some metal having a low thermal resistance, as copper, which will convey the heat from the hot to the cooler portion. The interposed laminæ are not made as wide as the magnetic laminæ, as they would conduct heat to the armatures and poles of the magnet. The composite laminæ may be constructed in the manner shown in Figs. 4 and 5, a piece of sheet-iron U being folded over a copper plate *u*, the remaining space being preferably filled with asbestus *s*.

As heat is transmitted more rapidly by contact between a hot and cold body than by radiation, the magnetic laminæ will be unevenly heated when no molten metal is introduced between them and the movable laminæ, as uniform contact is practically impossible. I therefore propose to exclude transverse sections of the magnetic laminæ from contact with the movable laminæ. This may be accomplished by introducing between the magnetic laminæ *d d* and the intervening laminæ *e e* supplementary magnetic laminæ *o o*, as shown in Fig. 6, or by making the movable laminæ duplex and turning their edges over in the manner shown in Fig. 5. It will be seen that the central portion of the magnetic laminæ will be heated and cooled solely by radiation. This plan is also applicable when molten metal is used in conjunction with the movable laminæ and the thermal resistance of the movable laminæ is lower than that of the molten metal.

The terms "magnetic laminæ" and "stationary laminæ" when applied to the aggregate are designed to comprehend any body having parallel perforations, and "movable laminæ" to refer to any solid body which is adapted to move in the perforations.

As it is practically impossible to entirely exclude air from the chambers in which the laminæ are inclosed, powdered charcoal or lamp-black may be introduced, which, when heated, will combine with any oxygen that may leak in, and thus protect the laminæ from oxidation when molten metal is not used. It may be introduced by unscrewing the stuffing-boxes. A better method of protecting the laminæ, however, is the introduction into the chambers of the vapor of some volatile hydrocarbon. To accomplish this automatically, a liquid hydrocarbon—as petroleum or one of its derivatives—may be used and introduced into the chambers by means of capillary attraction, the volatilization causing a continuous supply, upon the principle of a lamp.

The pipes W W, having the branches *w w* entering the chambers H H, as shown in Fig. 15, contain a wick *v*, which may be made of asbestus, and are connected with the reservoir V, which is at a lower level than the ends of the wick in the branch pipes *w w*. When the chambers H H are heated, the oil is volatilized, and the volatile products may be conducted into the furnace-chamber by the pipes *x x*, the supply being controlled by the size of the wick.

The reservoir V may be placed at any desired distance from the apparatus, and in order that refilling may not be neglected some one of the electric alarms for indicating the level of liquids should be connected with it.

As hydrocarbon vapors decompose when heated and deposit soot, which would in time interfere with the action of the movable laminæ, the earthenware pipes Y Y are built into the brick-work, as shown in Fig. 15, through which a rod may be inserted from the outside to remove the accumulations of soot which collect at the bottoms of the chambers. The outer ends of these pipes are securely closed by plugs, which may be made of asbestus.

By connecting the pipes *x x* with a condensing-coil the condensable portion of the products escaping from the chambers E E may be returned to the reservoir V.

As iron combines with carbon if it is subjected to the action of a carbonizing atmosphere at a high temperature, and as its magnetic resistance is thereby increased, the magnetic laminæ may be protected by plating them with some metal which will not alloy with them at the temperature to which they are exposed, as copper or nickel.

The movable laminæ are operated by means of the disks J J, which are rotated by the shaft X, and have grooves in them in which run small pulleys, which are attached to the levers *j j*, to which the movable laminæ are suspended, as shown in Figs. 1 and 2. The shaft is driven by some suitable power, an electromotor being shown, which it will be seen is placed in a derived circuit.

The armature-coils are wound in the manner indicated, and are connected in series in the order 3 2 1 4 5 6, as shown in Fig. 10, and the disks J J are adjusted so that the movable laminæ of armatures 1 2 3 will be simultaneously raised and those of 4 5 6 depressed, as shown in Fig. 11, the point of observation being the electromotor in Fig. 1. As the currents generated in the coils of armatures the laminæ of which are being heated are in the opposite direction from those generated in the coils of armatures the laminæ of which are being cooled, there will be alternate currents produced having the electro-motive force of all the armatures, and where a variable current is admissible these alternate currents may be converted into a direct current by a commutator Z, having two semi-peripheral segments *y y*, each connected to a collecting-ring *z*, as shown in Fig. 1, the commutator being so placed in relation to the disks that the collectors which form the terminals of the circuit will pass from one segment to the other at the moment that the movable laminæ are shifted.

Where it is desired to use an alternating current, the field-magnet may be energized by a derived circuit, in which the commutator is placed. It is also evident that any number of armatures may be coupled in independent circuits.

By coupling the armature-coils in the manner shown both sides of the field-magnet are kept in use and the field-magnetism used to the best advantage.

Where uniformity of current is essential, the arrangement shown in Fig. 12 may be adopted. In this case the coils are all connected in series in the order of their numbers in a closed circuit, the commutator having two opposite segments *y y*, connected to collecting-rings, as shown in Fig. 1, and as many collectors as there are armatures, which rest upon the face of the commutator at equidistant points, as shown, each of the collectors being connected to a portion of the closed circuit between the armatures, so that as the commutator is rotated the segments will maintain a connection between sucessive armatures at opposite points of the closed circuit, and the disks are so arranged that the movable laminæ are operated successively just at the moment when the segments of the commutator connect with the circuit at a point beyond the armature to which they belong, and as the movable laminæ are shifted twice in a revolution of the shaft it will be seen that the movable laminæ belonging to one-half of the armatures will be continually depressed and those belonging to the other half will be elevated, and that the opposing currents which are generated in the opposite portions of the circuit will escape together by the connections with the commutator. In the present position of the movable laminæ, which is shown in Fig. 11, the magnetic laminæ of armatures 4 5 6 are being cooled and those of 1 2 3 are being heated, and just as the movable laminæ belonging to armature 6 are depressed and those of 3 elevated the segments of the commutator are connected to the closed circuit between the armatures 6 and 1 and 3 and 4. By this arrangement a lower electro-motive force is attained than in the preceding, as the armatures act in two parallel series.

The maximum efficiency of the generator will be secured by the adjustment of the relation between the temperature of the hot and cool portions of the movable laminæ, for as the different portions are alternately interposed between the magnetic laminæ for equal intervals the mean of the range of fluctuation of temperature of the magnetic laminæ will be the mean of the difference of temperature of the different portions of the movable laminæ. This should therefore correspond to the mean of the range of temperature in which the magnetic change occurs; but as the field-magnet and the armatures conduct the heat from the magnetic laminæ the mean of the difference of temperature of the hot and cool portions of the movable laminæ should be above that of the range in which the magnetic change occurs. This difference between the two means must necessarily be greater as the thickness of the magnetic laminæ is increased.

Assuming that the mean of the range of temperature in which the magnetic change occurs in iron is about 700° centigrade, then if the cool portions of the movable laminæ are exposed to a temperature of 50° the hot portions should be exposed to a temperature of over 1,350°, and if the cool portions are exposed to a temperature of 200° a temperature somewhat above 1,200° would be proper for the hot portions. It is therefore evident that if the means of transmitting heat to the movable laminæ is the same in the upper and lower portions of the chambers it would be necessary to expose the cool portions to a temperature not below 200° if the hot portions were not exposed to a higher temperature than 1,200°.

The above remarks are based upon the assumption that the thermal resistance and the product of the specific heat multiplied by the specific weight are the same for the metals of which the hot and cool portions of the movable laminæ are made, as a metal having a high thermal resistance or a low capacity for heat would have to be subjected to a higher temperature to effect the same results than one having the opposite qualities.

Experiment has shown that a great change in the magnetic resistance of iron is produced by a change of 50° of temperature within the critical range, and it is clear that the greatest efficiency will be attained when the heat and time which are expended to effect the change of temperature produce the maximum change of magnetic resistance. This can only be determined by results; but it is this which I design to render available.

Nickel may be used for the magnetic laminæ; but while its magnetic resistance is greater than that of iron the range of temperature in which the magnetic change occurs is much lower, and from what has been said it will be seen that it would not be as well adapted to the purpose as iron. It may, however, be found advantageous to alloy nickel with the iron used for the magnetic laminæ, as it causes the magnetic change to occur at a lower temperature. When the proportion of nickel is fifty per cent., the critical temperature at which the magnetic change occurs is about half-way between the critical temperatures of the two metals.

The temperature of the different portions of the movable laminæ being dependent upon the temperatures of the upper and lower portions of the chambers in which they operate, it may be regulated by the thermal resistance of the walls of the chambers, that being dependent upon their thickness and the material of which they are constructed. It is evident that as the thickness of the magnetic laminæ is increased the time required to produce a given change of temperature will be greater, and therefore the hot and cool portions of the movable laminæ must be interposed between them for a greater interval, and there will be a certain rate of alternation which will produce the requisite change of temperature in magnetic laminæ of a given thickness. I therefore propose to control the motion of the movable laminæ by some suitable governing device. This may be accomplished by a governor controlling the current to the motor C. This consists of the ordinary centrifugal governor (shown in Fig. 1) connected to a movable commutator Q, having a **V**-shaped conducting portion y', upon which two collectors connected to terminals of the motor-circuit rest. When the governor is rotated, the commutator is moved so that the current is interrupted for a greater or less period during each revolution, the interval depending upon the speed of rotation, and by adjusting the pressure of the spring S′ by the movable sleeve s' the speed may be regulated.

The apparatus is started in the following manner: A fire is built in the furnace-chamber, and when a suitable temperature has been attained a storage-battery or other generator of electricity is connected in the external circuit and the movable laminæ are operated by the electromotor until the magnetic laminæ have reached the normal temperature, the switch c being closed, so as to shunt out the field-magnet and the armatures. This is then opened, and the magnet being excited by the current from the battery the armatures will generate a current and the battery may be disconnected.

The temperature applied to the chambers H H when the apparatus is in full operation may be sufficient to fuse the linings h' h' if the abstraction of heat from the interior by the motion of the movable laminæ is discontinued. To avoid this and also the risk of fusing the movable laminæ, the current is shunted through a suitable resistance when it is necessary to suspend the operation of translating devices, and after the external circuit has been closed it is not opened until the temperature of the laminæ has been so reduced that the current is insufficient to operate them.

The generator may be transformed into a motor by dividing each of the armatures B into three parts, the central portion being placed on a shaft, as shown in Fig. 16, and the fixed portions B′ B′ acting as pole-pieces, each pair of armatures being placed at right angles to each other upon the same shaft, and the shafts being connected by chain gearing and sprocket-wheels b' b', so as to maintain their relative positions, which are preferably such that alternately-opposite armatures will come into operation successively, the order in which the armatures reach the pole-pieces being indicated by their numbers in Fig. 12, and the positions of the movable laminæ when the armatures are in the positions shown in Fig. 16 are shown in Fig. 11, and the order in which they are operated is that of their numbers. The movable laminæ are connected to the armatures by sprocket and bevel gearing, as shown, the grooves in the disks J J being so arranged that the movable laminæ will be shifted four times in each revolution of the shaft X when geared in the manner shown in the drawings. If grooved, as shown in Fig. 2, the speed of the shaft must be doubled. The armature-shafts have their bearings in non-magnetic bar A′, which is bolted to the field-magnet, and to which are bolted the non-magnetic bars a' a', which extend to another bar A′ on the other side of the magnet, and thus retain the pole-pieces in position.

To secure clearness in the drawings, the correct proportions of the armatures and pole-pieces have not been adhered to, as they should be double the thickness shown, so that their faces will form arcs of one-sixth of the circumference of the circle described by the armatures.

The field-magnet may be energized by a current from a dynamo C′, run by the motor, as shown. The pulley D′, being double, may run another belt, by which power is transmitted to machinery. When the proper temperature has been attained, the belt connecting with the dynamo C′ is moved by hand, and this excites the field-magnet, and also causes the movable laminæ to attain the proper temperature, and the apparatus will then move automatically. The speed may be regulated by placing the field-magnet of the dynamo C′ in a derived circuit, which is controlled by the governor, as shown.

It is manifest that the extent to which the pole-pieces are solid or interstitial is a mere matter of detail, and that there would be no departure from my invention if they were wholly interstitial, as the essential feature is the interposition of immovable and interstitial magnetic sections between the poles of the field-magnet and a rotating armature, which are heated and cooled, so as to alternately revive and destroy their magnetic power.

I claim as my invention—

1. In a pyromagnetic generator, an interstitial armature and a coil in a magnetic field, and a means of passing a heating and cooling medium through the interstices.

2. In a pyromagnetic generator, an armature surrounded by a coil and connected to each pole of the field-magnet by an interstitial magnetic section, and a means of passing a heating and cooling medium through the interstices.

3. In a pyromagnetic generator, an armature surrounded by a coil and connected to each pole of the field-magnet by a magnetic laminæ, and a means of passing a heating and cooling medium between the laminæ.

4. In a pyromagnetic generator, an armature having an elongated cross-section surrounded by a coil and connected to each pole of the field-magnet by magnetic laminæ placed transversely, and a means of passing a heating and cooling medium between the laminæ.

5. In a pyromagnetic generator, magnetic laminæ and a coil in a magnetic field, movable laminæ adapted to move back and forth between the magnetic laminæ, and a means of heating part of each of the movable laminæ.

6. In a pyromagnetic generator, magnetic laminæ and a coil in a magnetic field, movable laminæ adapted to move back and forth between the magnetic laminæ, transverse sections of the magnetic laminæ being excluded from contact with the movable laminæ, and a means of heating part of each of the movable laminæ.

7. In a pyromagnetic generator, magnetic laminæ and a coil in a magnetic field, movable laminæ adapted to move back and forth between the magnetic laminæ, inclosed in a chamber, and a means of heating part of the chamber.

8. In a pyromagnetic generator, two sets of magnetic laminæ and two coils in a magnetic field, two sets of movable laminæ adapted to move back and forth between the magnetic laminæ, both sets of movable laminæ being inclosed in the same chamber, and a means of heating parts of the chamber.

9. In a pyromagnetic generator, magnetic laminæ, and a coil in a magnetic field, movable laminæ adapted to move back and forth between the magnetic laminæ at fixed intervals, and a means of heating part of each of the movable laminæ.

10. In a pyromagnetic generator, two sets of magnetic laminæ and two coils in a magnetic field, two sets of movable laminæ adapted to move simultaneously back and forth between the magnetic laminæ in opposite directions, and a means of heating part of each of the movable laminæ.

11. In a pyromagnetic generator, a multiplex field-magnet having mutual poles and a plurality of magnetic fields, an armature in each magnetic field surrounded by a coil and connected to each pole of the magnet by an interstitial magnetic section, and a means of passing a heating and cooling medium through the interstices.

12. In a pyromagnetic generator, a multiplex field-magnet having mutual poles and a plurality of magnetic fields, a plurality of armatures in each magnetic field, each surrounded by a coil and connected to each pole of the magnet by an interstitial magnetic section, and a means of passing a heating and cooling medium through the interstices.

13. In a pyromagnetic generator, a multiplex field-magnet having mutual poles and a plurality of magnetic fields, a plurality of armatures in each magnetic field, each surrounded by a coil and connected to each pole of the magnet by an interstitial magnetic section, and a means of passing a heating and cooling medium simultaneously or successively through the interstitial sections of armatures located in relatively different portions of adjoining magnetic fields.

14. In a pyromagnetic generator, magnetic laminæ and a coil in a magnetic field, movable laminæ adapted to move back and forth between the magnetic laminæ, inclosed in a chamber containing stationary laminæ, and a means of heating part of the chamber.

15. In a pyromagnetic generator, magnetic laminæ and a coil in a magnetic field, movable laminæ adapted to move back and forth between the magnetic laminæ, inclosed in a chamber containing a fusible metal, and a means of heating part of the chamber.

16. In a pyromagnetic generator, magnetic laminæ and a coil in a magnetic field, movable laminæ adapted to move back and forth between the magnetic laminæ, inclosed in a chamber containing stationary laminæ and a fusible metal, and a means of heating part of the chamber.

17. In a pyromagnetic generator or motor, a chamber inclosing the interstitial magnetic portions connected to an oil-reservoir by a pipe containing a wick which terminates in

the oil and is adapted to convey it to the chamber by capillary attraction.

18. In a pyromagnetic generator or motor, composite laminæ which consist of magnetic laminæ having interposed non-magnetic laminæ.

19. In a device for generating electricity or producing power, a multiplex field-magnet having mutual poles and a plurality of magnetic fields, each field having its respective energizing-coil and armature.

WILLIAM BURR COOPER.

Witnesses:
H. L. HEYL,
ALFRED RIGLING.

Corrections in Letters Patent No. 422,295.

It is hereby certified that in Letters Patent No. 422,295, granted February 25, 1890, upon the application of William Burr Cooper, of Philadelphia, Pennsylvania, for an improvement in "Pyromagnetic Generators and Motors," errors appear in the printed specification requiring correction, as follows: In lines 48–49, page 1, the words "a stationary" should be stricken out and the words *one of the movable* inserted; in lines 52–53, same page, the word "commutating" should read *commuting;* in line 56, same page, the word "uniform" should be stricken out and the word *constant* inserted; in line 15, page 2, the word *then* should be inserted before the word "heated," and the words *upper and lower portions of the* should be inserted before the word "chambers" in line 67, same page; in line 49, page 4, the word "uniformity" should be stricken out and the words *greater constancy* inserted; in line 14, page 5, the word *co-adjustment* should be inserted after the word "this;" in line 118, same page, the word *the* should be inserted before the word "non-magnetic;" in line 35, page 6, the letter "a" before the word "magnetic" should be stricken out; and in line 71, same page, the word "parts" should read *part;* and that the Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed, countersigned, and sealed this 25th day of March, A. D. 1890.

CYRUS BUSSEY,

[SEAL.]

Assistant Secretary of the Interior.

Countersigned:

C. E. MITCHELL,

Commissioner of Patents.