No. 778,021. PATENTED DEC. 20, 1904.

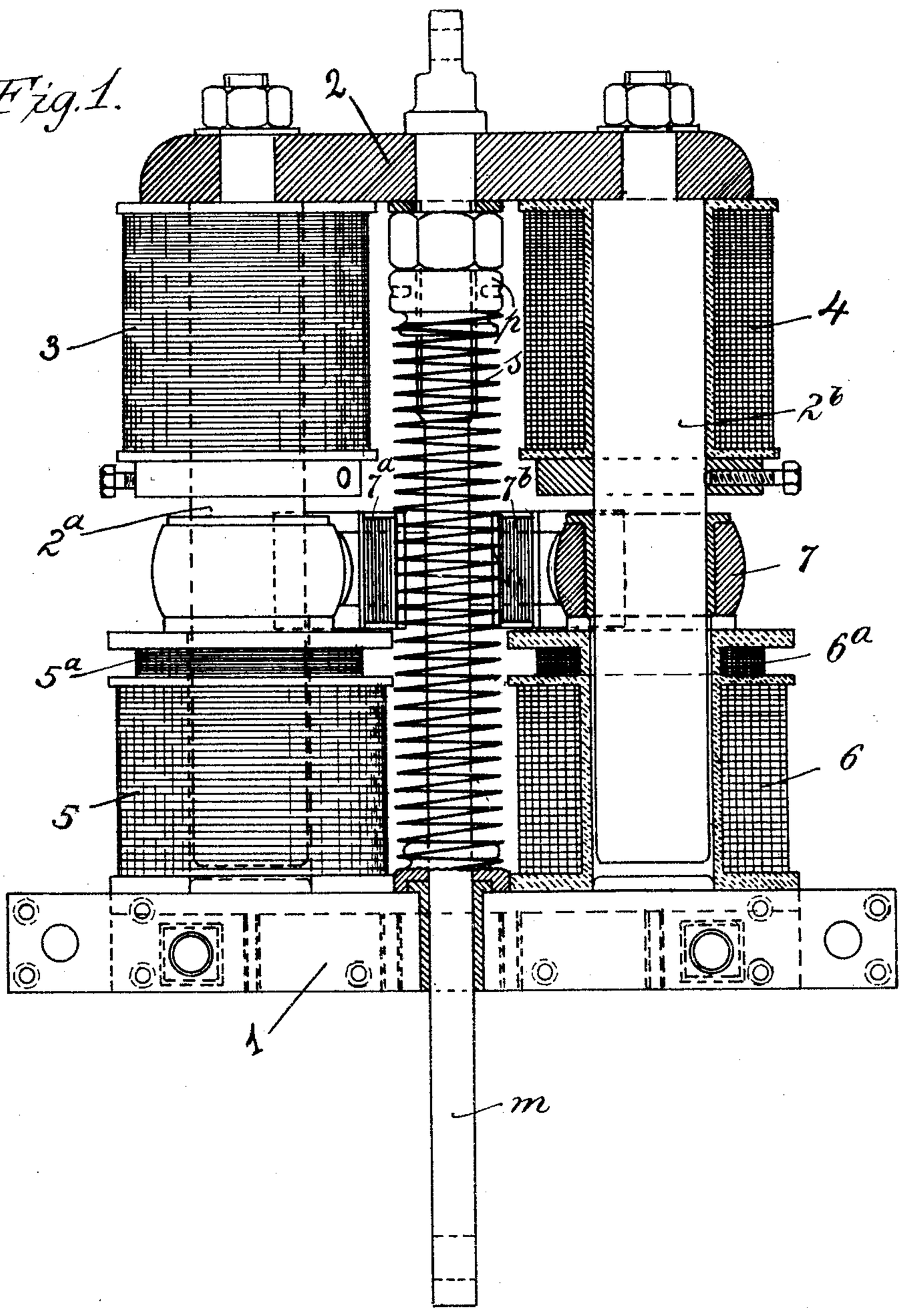
J. FEINGOLD.

ELECTROMAGNETIC APPARATUS FOR OPERATING RECIPROCATING MECHANISMS.

APPLICATION FILED JUNE 21, 1904.

NO MODEL. 5 SHEETS—SHEET 1.

Fig. 1.



Witnesses.
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John Lotka

Inventor:
Joseph Feingold
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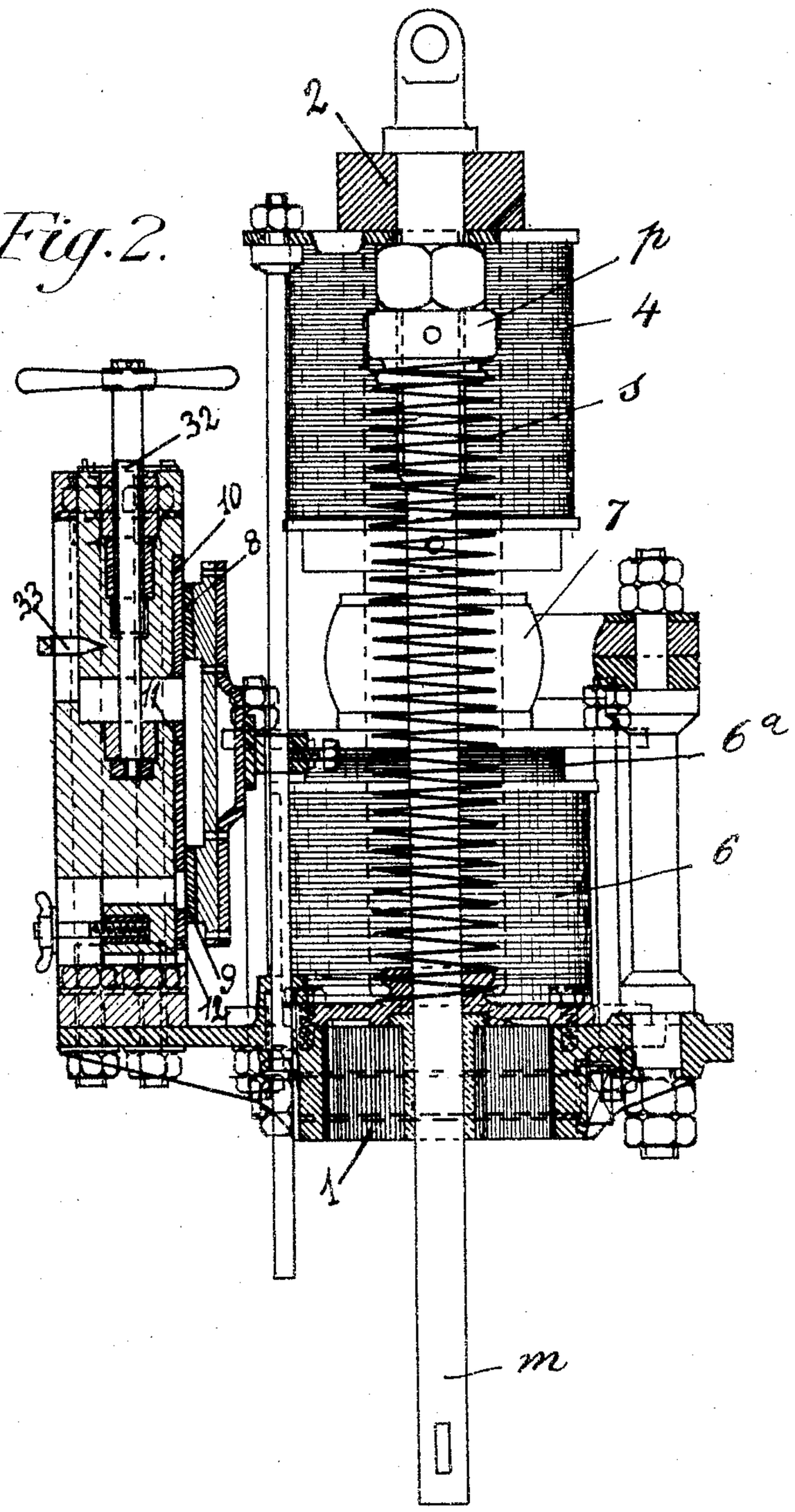
NO MODEL. 5 SHEETS—SHEET 2.

Fig. 2.



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NO MODEL. 5 SHEETS—SHEET 3.

Fig. 4.

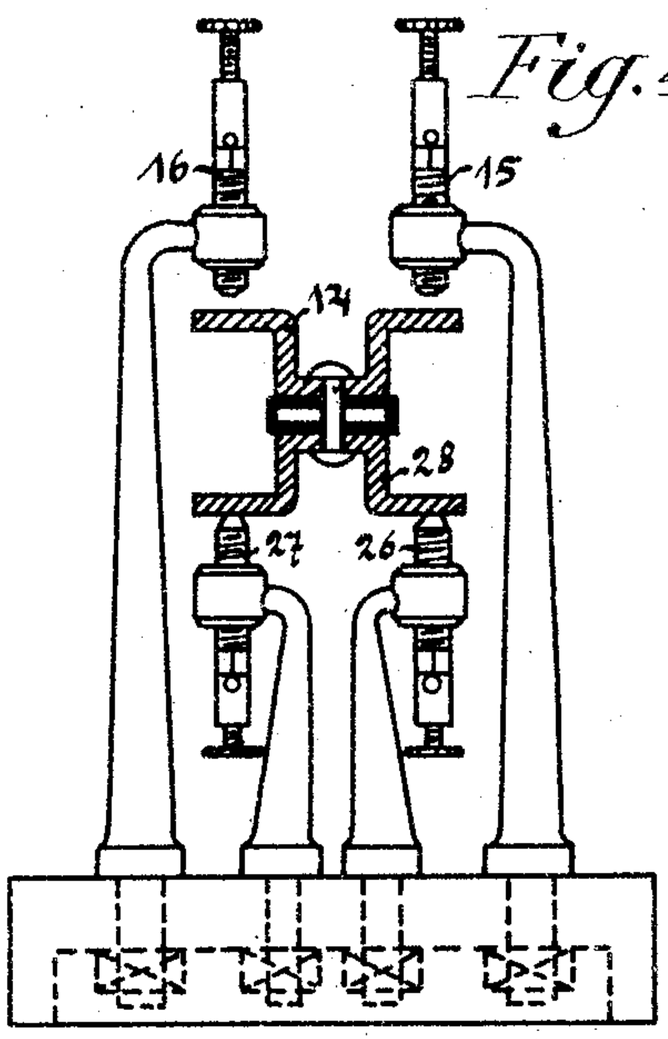


Fig. 3.

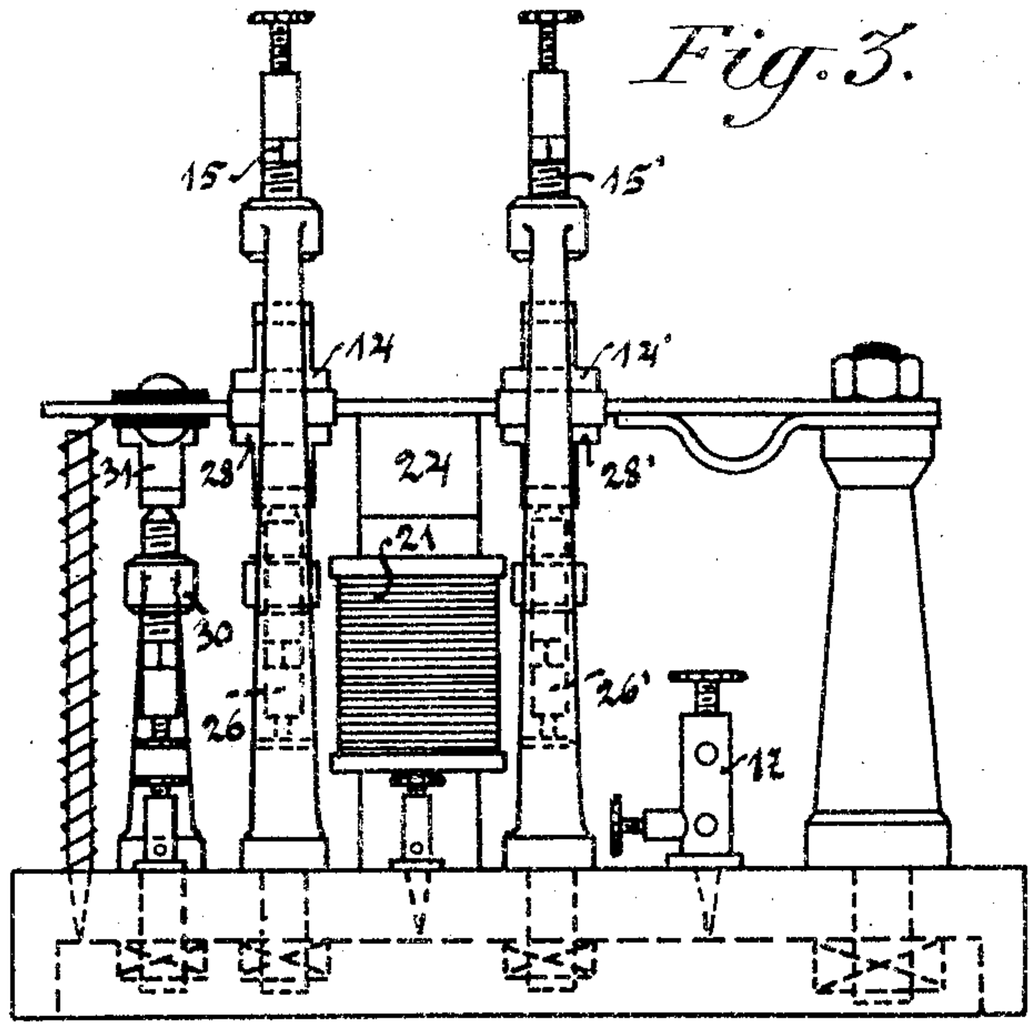
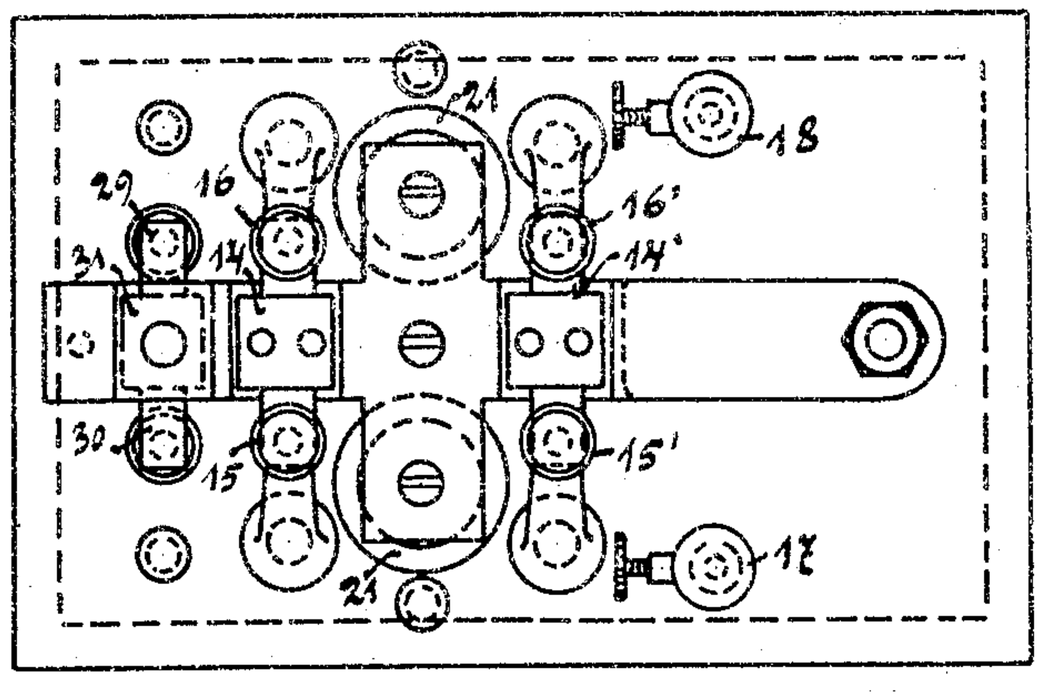


Fig. 5.



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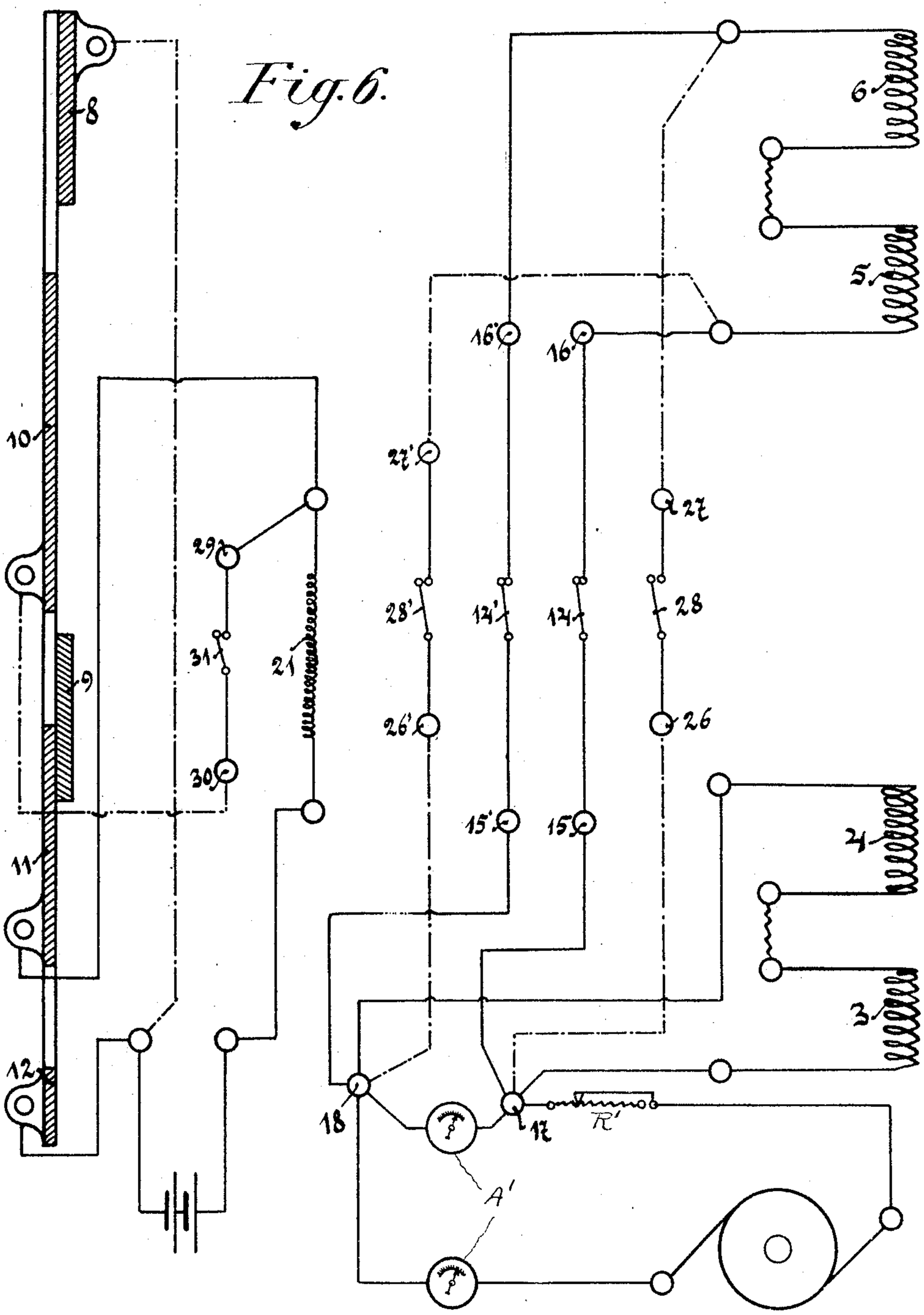
NO MODEL. 5 SHEETS—SHEET 4.

Fig. 6.



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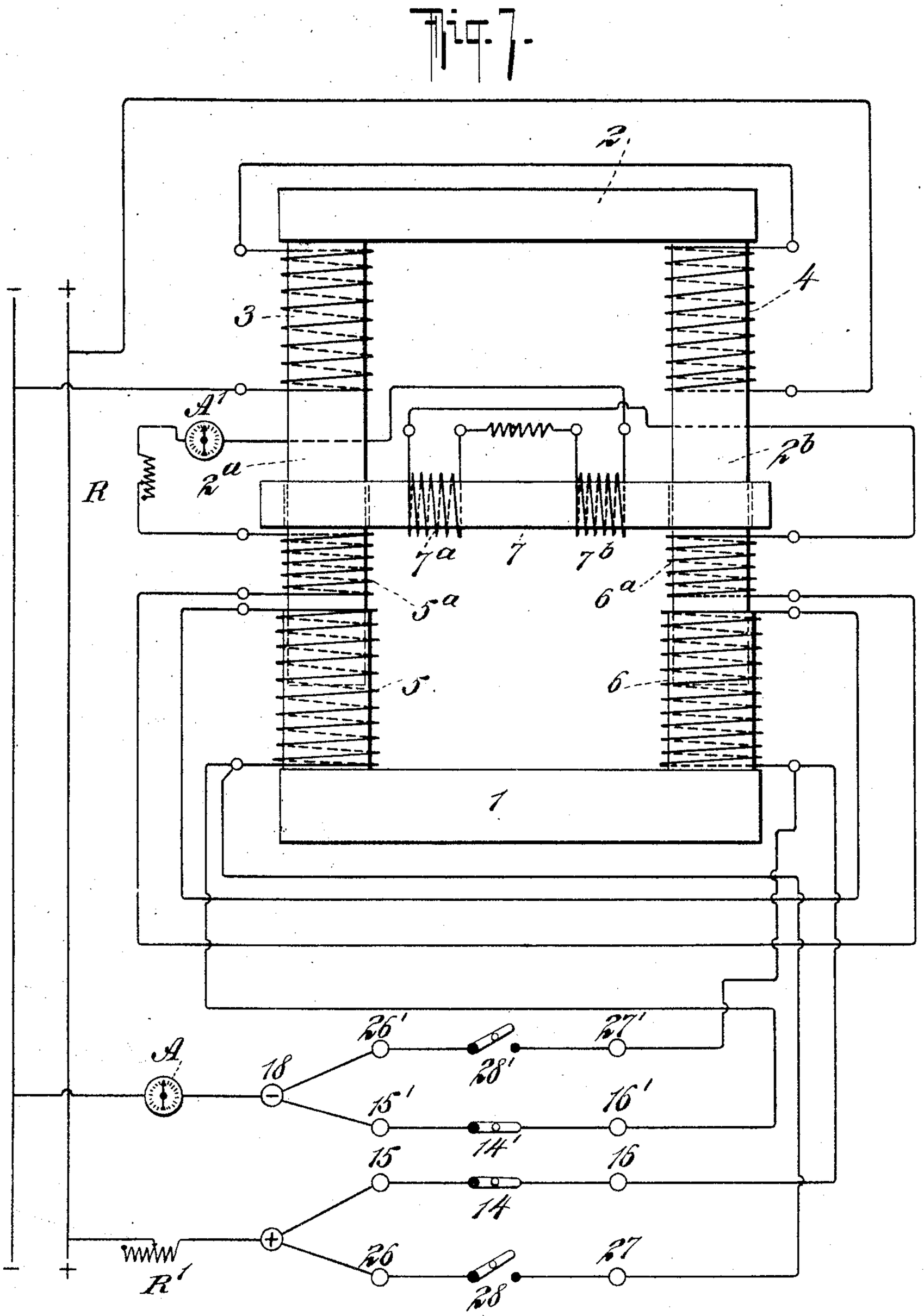
NO MODEL. 5 SHEETS—SHEET 5.

Fig. 7.



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No. 778,021. Patented December 20, 1904.

UNITED STATES PATENT OFFICE.

JOSEPH FEINGOLD, OF FRANKFORT-ON-THE-MAIN, GERMANY.

ELECTROMAGNETIC APPARATUS FOR OPERATING RECIPROCATING MECHANISMS.

SPECIFICATION forming part of Letters Patent No. 778,021, dated December 20, 1904.

Application filed June 21, 1904. Serial No. 213,476.

To all whom it may concern:

Be it known that I, JOSEPH FEINGOLD, electrical engineer, residing at 15 Bettinastrasse, Frankfort-on-the-Main, Germany, have invented new and useful Improvements in Electromagnetic Apparatus for Operating Reciprocating Mechanisms, of which the following is a specification.

This invention has for its object an electromagnetic apparatus for driving hammers, punching machinery, pumps, and generally for all kinds of working machines having a rectilinear to-and-fro working motion.

The driving apparatus constructed according to my invention consists of several coils, of which some are fixed on the framing of the machine and have the electric current flowing through them alternately in opposite directions, while the others are fixed to the reciprocating part of the working machine and have current flowing through them always in one and the same direction, whereby an alternate attraction and repulsion of the two sets of coils is effected according to the direction in which the current is made to flow through the fixed coils. The movable coils are provided with long iron cores, which enter the fixed coils, so that these cores afford a good conduction for the magnetic lines of force.

In order to prevent during the repulsion of the two sets of spools the magnetic lines of force from being closed through an air-gap, which would cause a considerable reduction of the magnetic field in the upper coils, through which the continuous current flows in one and the same direction, there is arranged between the fixed and movable coils an iron transverse piece, through which the cores pass. On this transverse piece are two wire coils, connected in series, which on the interposition of a regulating resistance are connected in series with two auxiliary coils that are mounted on the fixed coils, so that by means of the same the magnetic resistance of the transverse piece can be varied at will. For reversing the current flowing through the fixed coils a switch is employed, which is preferably energized from a separate source, such switch being operated by means of adjustable sliding contacts connected with the reciprocating part of the working machine.

The electromagnetic driving apparatus is shown on the accompanying drawings, in which—

Figure 1 shows a front elevation, partly in section, of the electromagnetic driving apparatus which can readily be fitted to a pump, hammer, punching-machine, or the like. Fig. 2 shows a vertical section of the apparatus at right angles to Fig. 1. Figs. 3, 4, and 5 show, respectively in front view, side view, and plan, a construction of the switch. Fig. 6 shows a diagram of some of the electric leads and connections, and Fig. 7 is a diagram illustrating the electrical connections of the circuits in which the magnet-coils are included.

The electromagnetic driving apparatus consists, as shown in Figs. 1 and 2, of two double-armed electromagnets 1 and 2, the cores 2^a and 2^b of the upper electromagnets 2 being made to enter the coils of the lower ones. The upper electromagnet 2 carries a middle rod *m*, which is connected at top or at bottom with the machine to be driven. If the said machine has only a small stroke—such, for instance, as a pump—the connection is effected directly; but if it has a greater stroke—as, for instance, a punching-machine—a lever transmission is introduced into the connection.

On the rod *m* is mounted a spring *s*, which is compressed on the attraction of the coils and on the repulsion expands again, whereby the transmission of force is rendered more regular. By means of a screw-nut *p* the tension of the spring can be varied at will so as to correspond with the magnetic action.

To the upper parts of the cores 2^a and 2^b are fixed the coils 3 and 4, through which a continuous current flows continuously in the same direction, while the fixed coils 5 and 6 have current flowing through them alternately in opposite directions by means of the switch, so that between the fixed and movable coils attraction and repulsion alternately take place, whereby a reciprocating motion of the working part of the machine is effected. Between the two sets of coils the cores pass through an iron transverse piece 7, which has

a lining of brass or other non-magnetic material and which carries two inducing-coils 7^a and 7^b, that are connected in series with the auxiliary coils 5^a and 6^a and with an adjustable resistance R, as shown in Fig. 7. When attraction takes place between the electromagnets 1 and 2, the magnetic lines of force have a closed path through the cores and the two yoke-pieces. They will, however, not have a tendency to close through the transverse piece 7, inasmuch as its resistance is comparatively great in consequence of the non-magnetic lining and also because the upper coils or the lower coils exercise, so to speak, a sucking action on the lines of force.

When after reversing the current a repulsion takes place between the fixed and movable coils, the lines of force are compelled to close through the transverse piece 7, as its resistance is considerably less than that of the surrounding atmosphere. The lines of force, therefore, also in this case find a path closed by means of iron. It can hardly be assumed that also during the attraction period a practically considerable portion of the lines of force will pass through the transverse piece 7. Such only takes place during the repulsion period. During the attraction period, as above mentioned, a reciprocal suction action is exerted by the lower and upper coil pairs, as there are here two sources of magneto-motoric force in juxtaposition which assist each other's action, thus forming a magnetic circle and opposing all strewing of the lines of force. When the end of the stroke is nearly reached, so that the cores are drawn into the lower coils, if an interruption of the current in the latter is effected and immediately afterward a reversal thereof the two magneto-motoric sources of power will then operate in contrary direction. The lines of force, so to speak, impinge upon each other and endeavor to compensate each other, so as to weaken the field, and as according to the known magnetic law a magnetic circle is always where the path for the lines of force is most favorable—that is to say, where the field is strongest—a repulsion will take place which is greatest during the first instant.

The sudden considerable weakening of the field acts in a different manner upon the upper and lower electromagnets. During the attraction the gradually-increasing flow of lines of force produces in the lower coils an electromotoric force which acts against the terminal pressure. If now the latter is reversed, the number of lines of force is reduced and the electromotive force changes its direction. At the same time, however, the current has reversed its direction, so that the electromotive force now produced again operates contrary to the terminal pressure. With the upper coils the case is different. Here the current flows continuously in one and the same direction.

If the transverse piece be left out of consideration, then during the attraction there would be produced in these coils by the increase of the lines of force an electromotive force which acts counter to the terminal pressure. If now the lower circuit be interrupted and the current reversed, the field in the upper coils vanishes suddenly to a great extent, the electromotive counter force changes its direction, but not the current, and thus the electromotive force is added to the terminal pressure, and the great pressure difference which is then produced at the outer terminals and the coils must naturally produce a current which the winding cannot stand. It is therefore necessary, as shown, to take care that during the compensation action of the two halves of the magnetic circuit there shall not occur any great variation in the magnetic field of the upper coils, and this is effected by the transverse piece 7. The lines of force finding a resistance in the reaction of the lower coils at the ends of the cores find a convenient path through the transverse piece, where they close to a great extent, the remaining portion issuing from the ends of the cores and closing through the air. By this means it is rendered possible to prevent considerable fluctuations in the magnetic condition, as also in the electric condition, of the upper coils through which a constant continuous current flows. These variations will be the smaller the greater is the proportion of the total magnetic field produced by the upper coils as compared with that of the lower coils—that is to say, the greater the proportion is between the number of ampere-turns of the former to those of the latter and, furthermore, the greater the number of turns is of the upper coils and the greater its ohmic resistance is, or, in other words, the smaller the wire section and the smaller the current is which passes through the wire, for with a large number of wire turns a small increase of current is sufficient to effect a considerable increase of the number of lines of force, and in a large resistance considerable differences of pressure are not objectionable.

It is not necessary to greatly excite the lower coils. The energizing is sufficient if it leads the lines of force away from the transverse piece during the attraction period, in particular at the commencement thereof. These coils have, therefore, few windings of thick wire and conduct a considerable current. They constitute the inductive part proper and must therefore only have a small ohmic resistance and correspond to the armature of an electromotor, the upper coils representing the field-magnets. The magnetic deviation during the repulsion period must, however, not become too great in order that the repulsive action may not be diminished too much. The correct size and power of conduction of the magnetic deviation can, how-

ever, not be determined for a hammer, a punching-machine, &c. It rather depends upon the currents that are employed, as also upon the speed and whether strong or weak pressures or concussions are to be produced. For this purpose there are arranged upon the transverse piece 7 the coils 7^a and 7^b, which, together with the regulating resistance R, are connected in series with the auxiliary coils 5^a and 6^a in a separate independent circuit. This has a double purpose—namely, during the attraction period to drive the lines of force out of the piece 7, therefore to weaken the field thereof, and during the repulsion period to assist the deviation of the lines of force into the transverse piece 7, so as to strengthen the field thereof. Both objects can be attained by so connecting the auxiliary coils 5^a and 6^a with the coils of the transverse piece that the electromotive forces produced therein by the regular increase and decrease of the flow of magnetic lines of force are always opposed to each other. With a suitable proportion of the number of windings the electromotive force of the auxiliary coils 5^a and 6^a will overbalance that of the coils 7^a and 7^b. By varying the interpolated regulating resistance R the auxiliary current can be regulated at will.

It is to be observed that if during the attraction period lines of force should close through the transverse piece 7 this would only occur to a very limited extent at the expense of the operative lines of force passing through the ends of the cores, as the magnetic resistance here will be less, because the total iron section is larger, and more lines of force are produced if the cores and yoke-pieces are not already saturated.

The switch shown at Figs. 3, 4, and 5 for reversing the current of the fixed coils consists of a spring carrying the bridge-contacts 14 14′, 28 28′, and 31, insulated from each other and to which is also fixed the armature 24 of an electromagnet 21. If the electromagnet is without current, the contacts 14 14′ establish a connection between the binding-posts 15 16 and 15′ 16′, while on the attraction of the armature 24 the contacts 28 28′ establish connections between the binding-posts 26 27 and 26′ 27′. At the same time the contact-piece 31 also connects the terminals 29 and 30.

With a reciprocating part of the machine, such as the yoke 2, are connected two sliding contact-pieces 8 and 9, insulated from each other, which slide upon the insulated bars 10, 11, and 12, Figs. 2 and 6. The upper one of these bars, 10, is made vertically adjustable by means of a screw 32, and the position of the bar for the time being is indicated by an index 33. The lower bar can also be adjusted in height between certain limits. The bars 11 and 12 are connected to the circuit of a special source of current, such as a small battery, in which is also included the relay-coil 21. In a shunt to this circuit are included the bars 10 and 8, as also the binding-posts 29 and 30. From the diagrams Figs. 6 and 7 it will furthermore be seen that the movable coils 3 and 4 are included in the circuit of the dynamo, being connected with the terminals 17 and 18 of the dynamo-circuit, from which terminals are also branched two shunt-circuits, of which the one passes through the binding-posts 15 16, the fixed coils 5 6, and the binding-posts 16′ and 15′, while the other passes through 26 27, through coils 6 and 5 in opposite directions, and through the posts 27′ and 26′ back to the post 18. Fig. 7 also shows the auxiliary circuit, including in series the coils 7^a 7^b, the variable resistance R, and the coils 5^a and 6^a. A variable resistance R′ may also be provided in the circuit of the reversing-coils 5 and 6. Ampere-meters A A′, respectively, may be arranged in the circuit of the reversing-coils and in the auxiliary circuit containing the coils 7^a 7^b.

The action of the apparatus is as follows: When the upper electromagnet is in its highest position, the sliding contacts 8 and 9 assume the position shown at Fig. 6. Consequently no current passes through the electromagnet 21, and the binding-posts 15 16 and 15′ 16′ are connected through the bridge-contact 14 and 14′, while the other contacts, 28, 28′, and 31, are opened. The current then flows in the one direction through the coils 5 and 6, which are so wound that an attraction takes place between them and the movable coils 3 and 4. By this means the upper electromagnet is attracted, and the cores pass into the lower coils; contact 8 comes into engagement with bar 10, and then the contact-piece 9 bridges the gap between bars 11 and 12 and connects them electrically. By this means the battery-circuit is closed, the electromagnet 21 of the switch is excited, and the contacts 14 14′ are opened, while the contacts 28, 28′, and 31 are closed. The current then flows in the contrary direction through the fixed coils 5 and 6, and a repulsion of the coils takes place—that is to say, an upward motion of the upper electromagnets. The lower edge of the contact-piece 9 now passes away from the bar 12 again, and the current would be interrupted in electromagnet 21 unless a second connection of the battery with the electromagnet were made through the contact 31, owing to the fact that the contact 8 during the upward movement still remains in engagement with bar 10 for some time after contact 9 has left bar 12. The battery-current then flows through 8 10 30 31 29, through the coil 21, until the lower edge of the sliding contact 8 leaves the bar 10. The electromagnet 21 will then again be without current, and the switch will be reversed, whereupon the described action will be repeated. By adjusting the bar 10 lower by means of the screw 32 the repulsion period will be shortened, so that the stroke of the

working part will be shorter. The reverse will take place if the bar 10 were screwed upward. In order also to enable the upward stroke to be varied, the bar 12 is also made adjustable, so that the stroke becomes smaller if this be moved upward and greater if it be moved downward. The cores 2^a and 2^b engage in their highest position with the lower coils, and in their lowest position they approach closely, with only a slight air-space, the lower yoke-piece, which projects with corresponding cylindrical projections into the hollow of the coils thereon.

The advantages of this electromagnetic driving apparatus consists, first, in that the rectilinear motion is effected directly without being first converted from a rotary motion; secondly, in affording great convenience of working and manipulation, small amount of wear and tear, and simplicity of construction, in consequence of which the cost is greatly reduced. Furthermore, by the interpolation of resistance (such as R′) into the main circuit, as also by the variation of the resistance R in circuit with the coils 7^a 7^b of the transverse piece and the resistance-coils 5^a 6^a, the strength of the blow or of the pressure can be regulated at will. Also by means of the adjustable contact-bars the extent of the stroke can be adjusted to any requirements. Further advantages consist in that the electrical energy is continuously utilized and that all sparking is avoided.

It will be readily understood that the switch shown in Figs. 4, 5, and 6 being operated electrically may be placed at a considerable distance from the machine proper, if desired. Thus the comparatively delicate mechanism of the switch may be located where it will not be disturbed by jars and vibrations such as occur in the neighborhood of rapidly-moving machinery. The switch may also be located in a room relatively free from dust and in a place where sparking will not be dangerous. The sliding contact-pieces 8 9, which are connected directly with the reciprocating magnet-cores, carry only the relatively weak battery-current, so that there is little danger from sparking and slight liability of untimely contact in consequence of vibrations. The result of the adjustment of bars 10 and 12 is thus much more reliable than if said bars were in the high-tension circuit of the working coils.

If alternating current is used, the iron parts of the electromagnets must consist of insulated laminæ. With continuous current the lower transverse piece also requires to be built up of insulated laminæ.

What I claim, and desire to secure by Letters Patent, is the following:

1. In an electromagnetic driving apparatus for hammers, punching-machines, pumps and the like the combination of movable double-cored electromagnet-coils connected with the reciprocating part of the machine and excited by a continuous current with fixed double-armed electromagnet-coils excited by an alternately-reversed current substantially as described.

2. In an electromagnetic driving apparatus for hammers, punching-machines, pumps and the like the combination of movable double-cored electromagnets connected with the reciprocating part of the machine and excited by a continuous current with fixed double-armed electromagnets excited by a current alternately reversed by a switch substantially as described.

3. In an electromagnetic driving apparatus for hammers, punching-machines, pumps and the like the combination of movable electromagnet-coils provided with cores passing into the fixed electromagnet-coils with a transverse iron bar connecting the cores, substantially as described.

4. In an electromagnetic driving apparatus for hammers, punching-machines, pumps and the like the combination of movable electromagnet-coils provided with cores passing into the fixed electromagnet-coils with a transverse iron bar connecting the cores and having holes lined with non-magnetic material substantially as described.

5. In an electromagnetic driving apparatus for hammers, punching-machines, pumps and the like the combination of movable electromagnet-coils provided with cores passing into the fixed electromagnet-coils with a transverse iron bar having holes lined with non-magnetic material and wound with inducing-coils included in the circuit of a regulatable resistance, substantially as described.

6. In an electromagnetic driving apparatus for hammers, punching-machines, pumps and the like the combination of movable electromagnet-coils provided with cores passing into the fixed electromagnet-coils with a transverse iron bar having holes lined with non-magnetic material and wound with inducing-coils included in the circuit of a regulatable resistance and of auxiliary coils surrounding the cores, substantially as described.

7. In an electromagnetic driving apparatus for hammers, punching-machines, pumps, and the like, the combination of a fixed coil, a reciprocating coil, a switch for periodically reversing the current in one of said coils so as to produce motion by alternate attraction and repulsion, a circuit closer or controller operated by the movement of the reciprocating coil, and electrical connections from said controller to said switch to operate the switch electrically by the movement of the said controller.

8. In an electromagnetic driving apparatus for hammers, punching-machines, pumps and the like an automatic current-controller for the electromagnet of the switch consisting of two sliding contact-pieces connected with the

movable coils of the apparatus and three contact-bars, one of which is adjustable according to the desired stroke of the apparatus, substantially as described.

9. In an electromagnetic driving apparatus for working machines with reciprocating motion, a set of electromagnet-coils fixed to the reciprocating part of the machine and receiving reciprocating motion by magnetic attraction and repulsion, a set of fixed electromagnet-coils elongated iron cores carried by the reciprocating coils and penetrating into the fixed coils, means for supplying a continuous electric current to the reciprocating coils, means for supplying an alternately-reversed continuous current to the fixed coils, a transverse iron bar, interposed between the movable and fixed coils and having holes preferably lined with non-magnetic material, through which pass the extended cores of the movable coils, sliding contacts moving with the reciprocating part of the machine, adjustable contact-bars and a fixed contact-bar with which the movable contacts alternately make contact, a switch, an electrical circuit comprising said switch, said contacts and a source of current, so as to operate said switch by the reciprocating motion of said sliding contacts, and means for establishing a connection between the switch and the fixed electromagnet-coils for causing the currents in the fixed electromagnet-coils to be reversed each time that the said switch is operated by the motion of the sliding contacts, substantially as described.

10. In an electromagnetic driving apparatus for hammers, punching-machines, pumps, and the like, the combination of double-cored movable electromagnets connected with the reciprocating part of the machine, fixed double-cored electromagnets, in operative relation to said movable electromagnets, and means for periodically reversing the current in one set of electromagnets so as to produce a reciprocating motion by alternate attraction and repulsion.

11. In an electromagnetic driving apparatus for hammers, punching-machines, pumps, and the like, the combination of a movable electromagnet, a fixed electromagnet, means for periodically reversing the current in one of said magnets, a bar of magnetic material through which the core of the movable magnet passes, an inducing-coil on said bar and a variable resistance in circuit with said inducing-coil.

12. In an electromagnetic driving apparatus for hammers, punching-machines, pumps, and the like, the combination of a movable electromagnet, a fixed electromagnet, means for periodically reversing the current in one of said magnets, a bar of magnetic material through which the core of the movable magnet passes, an inducing-coil on said bar, an auxiliary coil surrounding said core and a variable resistance in circuit with said inducing-coil and with said auxiliary coil.

In testimony that I claim the foregoing as my invention I have signed my name, in presence of two witnesses, this 8th day of June, 1904.

JOSEPH FEINGOLD.

Witnesses:
ROBERT BÜHL,
JEAN GRUND.