NOTE.—*The application for a Patent has become void.*

This print shows the Specification as it became open to public inspection under Section 91 (3) (a) of the Acts.

PATENT SPECIFICATION

Convention Date (France): Oct. 17, 1929. **371,330**

Application Date (in United Kingdom): Oct. 17, 1930. No. 31,212/30.

Complete not Accepted.

COMPLETE SPECIFICATION.

Improvements in Electro Magnets which may be Associated with Electrical Contacts or otherwise, Applicable more particularly to Electric Clocks.

We, SOCIETE ANONYME DES ETABLISSEMENTS LEON HATOT, of 12, rue du Faubourg St. Honore, Paris, France, a French company, do hereby declare the nature of this invention and in what manner the same is to be performed, we declare that what we claim is:—

The present invention relates to improvements in electro magnets (which may be associated with electrical contacts or other wise) and to their application to independent or receiving electric clocks and watches, which may or may not be provided with bells and chimes and to various other apparatus such as bells, tremblers, electric flashers, polarised relays, accumulator chargers, synchronous motors, rotary motors without contact, the motors of loud speakers, pick-ups, etc.

In the electric clock industry, telegraphy, radio telegraphy and telephony, use is made in numerous pieces of apparatus of electro magnets having an alternating movement, which are employed in particular for actuating the hands, for winding up springs, for operating electric contacts, etc.

The qualities required of the electromagnets are generally as follows:—

1) Good electrical efficiency and low passive resistances, the latter being caused principally by the magnetic sticking and attraction, the inertia of the parts to be moved and the mechanical friction.

2) A simple construction and low cost price.

3) Small weight and small overall size of the electro magnet and low consumption, chiefly for portable time-keeping instruments, such as motor car watches, small clocks, etc., and for the time receivers mounted at the centre of translucent dials.

4) In most applications a good electrical efficiency must be obtained, with a very small supply voltage.

This last property is particularly desirable for electrical watches and small clocks which have to operate by means of a battery of small size having a long life.

For the battery to have a long life (for example for it to last more than two years) it is found in practice that it is advisable for given overall dimensions to employ a battery having a single element (1.5 volts) rather than batteries with three elements (4.5 volts) like the usual pocket lamp batteries. For one and the same output in watt hours with a very slow rate of discharge the duration is increased.

Calculation and experience show that polarised electro magnets give better results for employing the energy of the battery considered than the ordinary soft iron electro magnets. However, the polarised electro magnet systems employed up to the present time are massive, heavy and costly. Moreover, they comprise strong magnets which give rise to considerable friction and magnetic sticking. This also gives rise to the fact that the design of the forms of their constituent parts does not permit a uniformity in the thicknesses of the air gaps to be obtained easily, and that in practice relatively large differences exist which produce a lack of balance of the magnetic forces and considerably reduce the efficiency particularly when it is a question of producing a relatively very low mechanical force, as is the case in the applications considered.

The present invention relates in the first place to the very small polarised electro magnets adapted to be mounted in the cases of large watches, such as motor car clocks.

The features of construction and the shapes of the constituent parts permit all the members to be collected in a very small

[*Price* 1/-]

space and materials of the highest quality to be employed more advantageously in order to obtain a very high electrical power in proportion to the weight of the apparatus.

In order to obtain this last result the existing state of the art shows that it is of interest to employ:

1) A cobalt steel magnet the form of which is such that the ratio between the length and the other dimensions is preferably smaller than in the ordinary horse-shoe magnets.

2) For the iron members magnetised by the coil made from silicon sheets or from electrolytic iron or from any other material presenting a high permeability and a very low hysterisis (particularly certain iron nickel alloys when the field is weak.)

3. A copper coil of high conductivity with turns of as short as possible a length arranged to hold the maximum volume of copper.

4. Air gaps of large surface and small thickness permitting the reluctance of the deformable magnetic circuits to be varied within very large limits according to a predetermined law depending upon the applications.

The magnetic products considered above are very costly and in addition they are only found in certain advantageous commercial forms (in particular cylindrical rods and thin sheets).

The invention permits these materials to be utilised under the most favourable conditions and it also relates to various devices and uses of these systems associated with special electric contacts.

The subject matter of the invention is set forth in the following description of various forms of construction which are illustrated by way of example in the accompanying drawing.

In this drawing:

Figures 1 and 1a show the arrangement of an electro magnet provided with certain of the improvements forming the subject of the invention.

Figures 2, 2a and 2b show constructional modifications of the members.

Figures 3, 4, 5 and 6 shows various forms of the pole pieces permitting different properties to be obtained.

Figures 7 and 7a show an electro magnet which, during its displacements, actuates a special electrical contact having a rapid make-and-break and adapted to serve for numerous applications.

Figures 8 and 9 illustrate the operation of the contact of the apparatus shown in Figures 7 and 7a.

Figure 10 shows an arrangement which is more particularly applicable to watches which are wound electrically.

Figures 11, 11a and 11b show diagrammatically an arrangement applicable to a receiving clock movement which has to be mounted behind and at the centre of translucent illuminated dials and to form a shadow mark of the smallest possible diameter.

Figures 12, 13 and 14 show various modifications in the arrangement of the magnet or magnets which comprise the electro magnets forming the subject of the invention.

Figures 15, and 15a show an arrangement more particularly applicable to very powerful receiving clocks.

Figures 16, 16a and 16b show an arrangement which is particularly suitable for receiving clocks of very small diameter.

Figures 17, 17a and 17b show a constructional modification of an electro magnet by means of armatures and windings made of sheet metal laminations.

Figures 18, 18a and 18b show a modification of an electro magnet presenting the advantage that it can be constructed of very small size and and occupy only a very small space on the side of a watch case.

Figures 19, 19a and 19b show a constructional modification of the moving coil established by means of cut out and folded pieces of sheet metal.

Figures 20 and 20a and also Figures 21 and 21a, 22 and 22a, 23, 23a and 23b show a constructional modification of the electro magnets comprising certain of the improvements forming the subject of the invention.

Figures 24, 24a and 24b show an arrangement applicable to the pick-ups employed in phonographic reproducing machines.

Figure 25 shows an arrangement more particularly applicable to rotary motors without a commutator, operating by means of alternating current from the mains.

Figures 26 and 26a show a form of construction of the transmission of the movement.

Figures 27 and 28 show modifications of this transmission.

Figure 1 shows the main parts of an electro magnet constructed according to the invention. This electro magnet is formed by a magnet of cobalt steel, a moving coil the core N of which is made of electrolytic iron or metal of suitable properties having a high permeability and a very low hysterisis (pure iron or annealed Swedish iron may also be employed).

The coil is provided with pole masses

B_1 and B_2 which are made of sheet silicon or alloys of similar properties, that is to say having a very low hysterisis and a high permeability like the core N.

It is to be noted that the pole pieces B_1 and B_2 of the coil are formed by parts cut out from the thin sheet and then curved. The shapes to which they are cut out and the profile of curvature are determined according to the use, so that the reluctance of the magnetic circuit will vary according to a determined law as a function of the angular displacement of the coil of the electro magnet.

The magnetic and electro magnetic attraction during the passage of the current is exerted between the pole pieces B_1 and B_2 of the coil and four fixed pole pieces P_1, P_2, P_3, P_4 strongly magnetised by means of the members E_1 and E_2 made of soft sheet steel closing the magnetic circuit.

Preferably the fixed poles P_1, P_2, P_3, P_4 will be cylindrical in shape. The shape of the parts E_1 and E_2 made of thin sheet cut out and bent to shape permits any costly work of machining of the parts P_1, P_2, P_3, P_4 to be avoided, and as these parts E_1, E_2 have a certain elasticity they press strongly on the magnet and the latter does not need to be constructed with great accuracy. Moreover, the arrangement adopted permits a fairly large free space to be left between the parts E_1 and E_2, and the coil for mounting very flexible connections of small diameter can be formed of a large number of fine wires.

The insulation of the coil is obtained by means of washers made of thin sheets of insulating material (mica or vaseline-coated paper) which are supported by the massive iron members of the coil.

Two main arrangements may be adopted for the axis of the moving coil:

1. The arrangement shown in Figure 1 in which the axis passes through the core, the winding being made in two parts.

2. The arrangement shown in Figure 2. In this case the winding is not interrupted and there are two pivots of small length fixed respectively on two brass U-shaped supporting rods H_1 and H_2 which are screwed on the pole pieces B_1 and B_2.

The magnetic force of attraction which is exerted between the pole pieces P_1, P_2, P_3, P_4 and B_1 and B_2 varies in general with the position of the coil according to the variation in thickness and in width of the air gap. By suitably choosing the proportions of the pole pieces, the arrangement can be made so that under the influence of the magnet the coil will be in indifferent equilibrium for a sufficiently large movement to either side of the position shown in Figure 1 or 2. The arrangement may also be made such that the coil tends to be returned towards a predetermined position and a certain law obtained for the variation of the returning couple as a function of the angle of rotation of the coil.

For example, if the shapes and proportions indicated in Figures 3, 4, 5 and 6 are adopted, the following results are obtained: (it is to be noted that the air gap is constant and small but that the same results could have been obtained by adopting pole pieces B_1 and B_2 curved according to eccentric shapes so as to make the air gap vary according to the positions of the coil):

With the proportions shown in Figure 3, the coil tends to place itself in the position shown in this figure. If a continuous or undulating current is passed through the coil, the latter becomes inclined towards the left or towards the right depending upon the direction of the current. When the current is broken, the coil returns into the position shown in Figure 3.

With the proportions shown in Figure 4, the position indicated for the coil is a position of unstable equilibrium. The coil tends to overturn towards the left or towards the right under the influence of the magnetic attraction. This coil can be made to pass from one extreme position to the other by passing a current of suitable direction, which current must however exceed a given limiting value below which the coil is not detached.

In the case shown in Figure 5, the coil is in indifferent equilibrium over a relatively large angle. When the coil is in the extreme left hand position, it can be brought to the right by means of a very small force.

For the purpose, it is necessary, within the whole extent of the displacement considered, for the magnetic attraction between B_1 and P_1 to form a couple exactly balancing that produced by the attraction between B_1 and P_2.

The form in which the parts B_1 and B_2 are cut out permits this result to be obtained. This arrangement corresponds to a very great sensitiveness of the coil, which is moved by a very weak current strengthening the magnetic attraction with one of the poles and reducing the attraction exerted by the other pole.

In the case shown in Figure 6, the unsymmetrical outline permits the result to be obtained that, when the current is zero, the coil tends to return of its own accord into the extreme right hand position. Naturally by employing a profile very similar to that shown in Figure 5,

this return force may be made to be constant and very weak (just sufficient to overcome the friction of the pivots).

The electro magnet which has been described above can be actuated either with emissions alternating in direction or with unidirectional emissions, the return being obtained by means of a spring or by the action of the magnetic forces, as described above. In order to obtain a good electrical efficiency with a fairly large movement of the coil, it will be advantageous to approach towards the arrangement shown in Figure 5.

The advantages of the above described modes of construction are the following:

1) Depending upon the application considered, the most favourable law can easily be obtained for the magnetic force as a function of the displacement while avoiding any complicated and delicate machining. In fact, the devices B_1 and B_2 are simple pieces of sheet material cut out and curved. In this way any costly turning and milling which presents inaccuracies on account of the wear of the tools is avoided.

The air gaps can be reduced because it is possible to obtain a perfect centering, particularly with the arrangement shown in Figures 2 and 2a, because the centering only depends upon the cut out and bent members H_1 and H_2. It is known in fact that the method of machining by cutting out and pressing permits considerable series of strictly identical and interchangeable parts to be obtained by means of operations which can be carried out by unskilled workers.

The proportions of the moving coil indicated in Figures 1 and 2 must also be noted, as these proportions contribute in improving the electrical efficiency. The coil is chosen relatively long (it is more than twice as long as the diameter of the outer turns). This condition favours the reduction of the losses by the Joule effect, because it is advantageous to reduce the length and consequently the resistance of each turn and to increase the lever arm of the electro magnetic force exerted between the pole pieces.

In describing various particular applications of the above electro magnets, in the following some modifications of the forms and positions of the permanent magnet will be shown, which are applicable according to the position available. Use may also be made in certain cases of a number of magnets while preserving the proportions of the coil which are recognised above as being most favourable.

Figures 19, 19a and 19b show a constructional modification of the moving coil in which the latter is formed of pieces of sheet material cut out and folded forming both the core and the pole masses. These arrangements also permit a large surface of air gap to be obtained and a core of small section so as to reduce the length and consequently the resistance of each turn.

In Figures 17, 17a and 17b is shown a mode of construction of the poles and of the moving coil by means of a stack of cut out laminations (like the field magnets and armatures in dynamos of usual construction).

This construction is particularly suitable in the case when the current employed is an undulating current obtained from the imperfect rectification of an alternating current (for example by means of Cuproxide rectifiers).

Figures 18, 18a and 18b show a modified form of construction in which the winding of the coil is concentric with its axis of oscillation. This arrangement permits a core to be obtained of great length and low inertia.

The electro magnets which are described hereinafter can be applied advantageously to the construction of a polarised receiver clock. The hands will always be controlled by an anchor or by a pawl mechanism.

The emissions of current may be obtained by a master clock actuating a reversing switch, or a two-way switch sending alternating successive emissions from two batteries into the circuit of the receivers.

The electro magnet of the receiver clock may also be actuated by a unidirectional current, the return to the initial position being produced by a spring, a counter weight or a magnetic attraction, as explained above with reference to Figure 6.

Figures 11—16 show diagrammatically some arrangements applicable to various types of time piece receivers. The pawl devices and wheels of these mechanisms shown in the figures are of existing type employed in clock construction, and without giving any detailed description of the known members the present description will be confined to an indication of the new improvements which these mechanisms comprise.

It is to be noted in the first place that in all these systems it has been sought to join all the members in a cylindrical casing of small length and of the smallest possible diameter, having the axis of the hands for its centre. This arrangement is particularly interesting when the mechanism is mounted behind and at the centre of a translucent dial illuminated

from the back. The result is also obtained that the shadow mark due to the time movement is very small and does not prevent the time from being read.

In Figure 11 the pivot axis O O^1 of the hands passes axially through the casing. For a given overall size it has been sought to increase as much as possible the length of the coil and the diameter of the ratchet wheel 1 driven by the reciprocating movement of the coil. For this purpose the coil has a length approaching the radius of the casing. Moreover, it actuates through a pin 2 and a forked lever 3 another pivot O_2 more distant from the centre O than the pivot O^1 of the coil. The pawls are pivotally mounted on the pivot O_2 and in this way a larger ratchet wheel can be mounted than if the pawls were pivoted directly on the pivot axis O^1 of the moving coil.

In Figure 15, the coil is arranged with respect to the casing in such a way that its length is greater than the radius of the casing. Two cobalt magnets 4 and 5 are employed which are arranged as shown in the figure.

The coil receiving the alternating emissions every half second can actuate the pivot 6 of a central second hand making one turn per minute in addition to the two usual hands. The profile view shows the manner in which the wheels are concentrated in the casing, which is of very small dimensions with respect to the coil.

In Figure 16 the moving coil pivots freely on the pivot of the large hand 7 itself. The handle 10 actuating the hand which moves every half minute is actuated by a pin 8 engaging in a notch in the handle. In this way the dimensions of the casing may be reduced to a minimum while having a coil and a magnet of maximum dimensions in the space available.

An electric switch or reverser operating when the coil has almost reached the end of its movement may also be associated with the electro magnets forming the subject of the invention. This switch may be a rocking switch, with mercury contacts or dry contacts.

Such an arrangement in particular permits a motor having a maintained alternating movement to be constructed which is adapted to be fitted to electric bells, to the selectors of automatic telephone lines, the flashing devices and other systems for intermittently lighting and extinguishing an electric lamp, etc. The frequency of the movement may be redued by any known methods such as by an increase in the inertia of the oscillating moving system, or by the addition of a brake retarding the movement in one direction (dashpot, or clockwork mechanism). In this way small alternating motors may be constructed which operate by means of a battery and actuate a pivot or cams through a pawl device or by other means, with the object of constructing toys, moving advertisement systems, time switches and various servo motors.

A trembler bell mechanism constructed with this polarised electro magnet presents the advantage of consuming much less current and working with a much smaller voltage than the existing electric bells having a soft iron armature. Consequently, they are particularly suitable for electric alarm clocks operating by means of a small battery situated in the casing or by means of the small battery actuating the time movement.

The polarised electro magnet described above may also be employed with advantage in the Rollin system striking clock and in similar apparatus. It may also be employed to maintain strokes spaced apart, associated with a releasing and stopping device by the movement of a counting wheel or of a rack cooperating with a worm screw of the hours.

It may also be applied to the systems of clocks and watches which have to be wound up comprising a wheel the speed of which is rendered uniform by an escapement and a balance wheel, and which is actuated by a spring or a driving weight wound up periodically.

In all the winding-up systems provided with a soft iron electro magnet (whether it is a question of a plate electro magnet or of an electro magnet with a plunger or of a laminated armature movable about an axis) these driving members may be replaced by a polarised electro magnet constructed according to the invention. This electro magnet is thus applicable:

1) To systems of the type comprising a ratchet wheel which pushes the pawl which is returned from time to time backwards by means of the electro magnet. In this case the movement of the pawl may be tied to the movement of the moving coil of the electro magnet. This will actuate an electric switch under conditions such that when the return movement commences slowly, the current will be broken and will be cut off; then at the end of this movement and during the commencement of the rapid power stroke, the contact will be closed.

Various electrical contact devices which are public property are known which fulfil these conditions.

The new polarised electro magnet may also be applied to systems of electric clocks which are public property which

operate on the following principles:

1. Systems in which the electrical contact is established periodically between a member rigid with the electro magnet and the pawl arm, which make the ratchet wheel turn, the passage of the current having the effect of actuating the electro magnet which lifts the pawl arm which separates by inertia, thus permitting the circuit to be broken and the electro magnet to be returned to its initial position.

2. Systems comprising a main spring motor maintaining the movement of the moving parts and another spring cooperating with a pawl, a ratchet wheel and the electro magnet for actuating the shaft of the main spring when the couple of the first spring becomes smaller than the couple produced by the second spring, the electro magnet being adapted to be actuated a number of times in succession and operating like a vibrating electric bell mechanism.

3. Direct reaction systems in which an electro magnet exerts an impulse on the balance wheel either periodically or when the amplitude falls below a given value.

4. Indirect reaction systems in which the electro magnet periodically lifts an impelling member acting on the balance wheel or upon the suspension plates of the balance wheel etc.

5. Known systems of electric clocks in which the balance wheel is provided with an ellipse engaging in a fork as in anchor escapements, the said fork being rigid with the coil of the polarised electro magnet and moving at each passage of the balance through the position of equilibrium so as to give an impulse to the balance wheel.

6. Systems adapted to strike the hours and half hours for clocks designed to have a striking device giving spaced-out strokes, which maintains itself and is started and stopped by means of a counter wheel or chaperon or a rack cooperating with a cam or worm screw rigid with the hour hand.

Figures 7 to 9 show a new form of construction of a switch which may be associated very advantageously with the electro magnet forming the subject of the invention in order to solve the various problems relating to electric clocks.

Naturally this type of contact may be applied in all other systems of polarised or non polarised electro magnets.

The contact operates between the conducting pin 11 rigid with movable part of the electro magnet and a movable member 12 which is half conducting and half insulating and which moves suddenly at the end of each displacement in a given direction.

The chief original feature of this system is that the movable member 12 oscillates with very small mechanical friction and that the desired displacement is obtained without the use of coil springs or impulse springs solely by means of the varying magnetic attraction which is exerted between the member 12 formed of a magnetic metal and two magnetised pole pieces. These pieces may be magnetised by the magnet of the polarised relay itself or by a special magnet (on the drawing the posts P_1 and P_2).

Figure 7 shows the contact member F mounted, the axis provided with fine pivots. The member is provided with fibre and gold linings between which moves the platinised pin rigid with the moving coil.

The member 12 is made of iron; it is balanced for the action of gravity and has the shape shown in the drawing, in which it will be noted that the edges X_1, Y_1, Z_1, X_2, Y_2 (Figure 8) have the shape of eccentric circular arcs arranged near the cylindrical posts P_1 and P_2 which are strongly magnetised.

It follows that the member 2, acted upon by the magnetic attraction of the posts P_1 and P_2 is in unstable equilibrium. It tends to swing first to one side and then to the other.

Consequently if the member 12 is in the extreme left hand position (Figure 8) and if the coil and the platinised pin 11 move in the direction *f* (under the action of a spring for example), the contact is first made between the pin and the insulating member. At the end of the travel of the coil the fork 12 moves suddenly and the contact is made between the pin 11 and the gold lining. The direction of the current should be chosen so that the coil will be displaced in the opposite direction to *f* and the contact remain established at the commencement between the pin and the gold, but so that at the end of the travel the contact will be broken suddenly. The coil then returns in the direction *f* and so on.

In order to utilise these members, the circuit shown in Figure 7a may be employed.

The coil is connected in series with a battery or any other source of current and the switch described above. Sparking may be avoided by a condenser or a resistance without self inductance shunting the contact. But these members are not indispensible because the operation is obtained with a very weak current and the self inductance of the apparatus is very small. Such an arrangement permits a rapid alternating movement automatically maintained to be obtained if the coil is simply

returned in the direction F_1 by a spring or any other means.

Moreover an ordinary watch or clock mechanism may be electrified by replacing the barrel spring by a spring acting upon an arm provided with a pawl and making a ratchet wheel rigid with the wheel system turn.

The pawl arm will be made rigid with the moving coil and under the action of the spring it will move in the direction f_1 with a slow movement rendered uniform by the escapement and the balance wheel of the clockwork mechanism. After having continued its movement for a certain time, the fork will establish the electrical contact and the pawl arm will suddenly return backwards. At the end of the stroke the contact will be suddenly broken and the pawl will continue to make the ratchet wheel turn until the contact again closes and so on.

The advantage of the above described contact resides in the fact that it is easy to construct and operates with very small mechanical friction so that there is no danger of jamming. The force necessary for the displacement of the fork is small and constant and it introduces no disturbances in the working of the time keeping mechanism; this is not the case in systems in which the mechanical friction is high.

Figure 10 shows a constructional modification of the contact shown in Figure 7. In this case the coil is provided with a pin 11_1 which has no electrical function. The member 12 is replaced by a small distributor which is partly conducting and partly insulating, upon which rubs a brush *b*.

In the application to the winding of watches it is of advantage to avoid placing the spiral balance wheel and the escapement in a strong magnetic field; this result is obtained with the arrangements shown in Figure 10 and in Figure 18, by mounting the electro magnet on the side of the casing opposite the delicate members of the watch and by insulating the latter magnetically by means of a screen *t* made of very permeable soft iron having no hysterisis.

The electrical contact described above and the similar systems of operation may be employed with the electro magnet constructed according to the invention for obtaining remote control by means of a switch or reverser, which is adapted to close rapidly but break slowly, the switch of the receiver electro magnet causing the circuit to be broken rapidly as soon as the desired movement is obtained.

For example, this result will be obtained by dividing the core of the electro magnet into two sections having a common point and connected to the control switch by three electric leads in such a way that for the two positions of the switch there correspond also two positions of the electro magnet.

In order that the current will be broken automatically as soon as the desired movement is completed, a switch will be arranged to be operated by the coil at each end of travel; this switch will be controlled in a similar manner to the device described with reference to Figure 7 with this difference that the fork will be entirely conducting and that it will return alternately into contact with two parallel and insulated pins rigid with the moving coil, connected respectively to the two sections of the winding. According to its position, this switch will close the circuit of one section or the other. The directions of the connections will be established in order to obtain the following operation:

A current will be sent into one of the circuits by means of the control switch (which may be adapted to break the circuit slowly) and the coil will move and will actuate its switch so as to break the circuit considered immediately and become placed on the other circuit.

The other circuit may then be closed by means of the control switch and the second section of the coil will then receive the current and will be displaced. At the end of the movement it will break the control current and will place the switch in the position permitting the following transmission to be received in the first circuit and so on.

The control switch may be formed by a pin mounted upon an arm given a movement of rotation and successively touching two contact springs; preferably electrical contacts will be adopted which are adapted to close suddenly. The rotary arm may turn slowly and in spite of this the transmissions are very short because the break is made on the switch as soon as the desired movement is obtained.

By way of applications of this system the following may be mentioned:

1. The distribution of time by means of receivers automatically cutting off the current as soon as the movement of the hand has been made.

2. The construction of clocks with or without striking mechanisms which are wound up by polarised electro magnets.

For the latter system the control switch will be mounted on one of the moving parts of the wheel system and the shaft of the barrel will be made to turn by the coil of the electro magnet by means of a ratchet and a pawl mechanism, so that

the shaft of the barrel turns on an average by the same amount which the spring unwinds in a continuous movement. The apparatus thus constructed may serve as a master clock (the movement of the two switches may in fact serve in addition for actuating time receivers provided with electro magnets similar to that which provides the winding up).

Naturally various changes may be made in the construction of the electro magnets and in the contacts while remaining within the scope of the invention.

In particular Figure 10 shows a modification.

In the place of the electro magnets shown in Figure 1 or 2, use may be made of only one half of the moving coil, that is to say it will be possible to have only two air gaps, as shown in Figure 20.

It is also to be noted that instead of the winding being mounted on the moving part, it may be situated on two coils wound respectively on two cores terminating at one pole of the magnet, as shown in Figure 21. This system approaches the well known arrangement of relays employed at the present time in the polarised bell mechanisms of telephones, but the invention may be applied thereto as regards the contacts and the arrangements and applications of the invention, and also the forms of the pole pieces and the means employed for obtaining a predetermined law of the magnetic force as a function of the angular displacement.

Figures 23, 23a and 23b shows a modified form of construction, characterised by the feature that the cores of the coils are arranged parallel to the axis of the movable armature of the electro magnet.

It is to be noted that in the electro magnet system associated with a switch shown in Figure 7 or Figure 10, the circuit may be caused to break when the speed reached by the coil is a maximum. Moreover, by adopting a suitable form for the pole pieces the variation of the flux of the magnet passing through the coil may be made to be a maximum at this moment. Under these conditions the induced counter electro motive force opposing the voltage applied to the coil is then a maximum and the factors entering into play may be determined so as to make this counter electro motive force approach or be equal to the supply voltage. In this case the current is already annulled when the circuit is broken mechanically and the break is made without sparks and without deterioration of the contact pieces.

It will be found to be advantageous to fulfil this condition or to approach it in applications relating to electric clocks, thus permitting the condensers to be dispensed with and the construction of the electric contacts to be simplified. This property may in addition find other applications as means for suppressing the sparks at contact.

The coil may be fed with continuous current supplied by batteries, accumulators or by current from the mains. It may also be fed with alternating current from the mains, the voltage of which will be reduced by a transformer and with current rectified by a valve or by a cuproxide rectifier. In this arrangement a small plug accumulator may be provided in order to supply the electro magnet in the event of the failure of the line current.

The following pieces of apparatus may be mentioned as other examples of the application of the invention, but it is understood that this list does not limit the number of applications provided for.—

The electro magnet associated with the switch shown in Figure 7 or 10 or with any other switch having a similar operation, forms a motor having a reciprocating movement which can drive a wheel through a pawl mechanism or any other means for transforming the reciprocating motion into a continuous movement. By way of a simple contact for maintaining the reciprocating movement of the electro magnet, use may be made of a simple blade contact like that in vibrating electric bells. Use may also be made of the modified forms of contact already employed in the induction coil for lighting the motor and for maintaining vibrating blades and tuning forks. The reciprocating motor thus constructed and operating by means of undulated or intermittent undirectional direct current is particularly suitable in all applications which require a small power and a slow and uniform speed (for example phonograph motors).

In particular, in all systems for winding up clocks with or without a striking mechanism which operates by means of a small rotary electric motor, the electro magnet having a reciprocating movement converted into a continuous rotation, according to the invention, may be employed in the place of this electric motor.

When alternating current is available such as a current of 40—60 periods per second distributed by the mains, all electric contact may be done away with, the coil making a reciprocating movement of the same frequency as the current which passes through it.

This arrangement, which may for example rotate a shaft, is thus applicable to all the winding devices previously provided and arranged for actuation by a

motor with a rotating field. It is also applicable to the system of electric time transmission by alternating current the frequency of which is rendered perfectly uniform by the central factory. In this case the oscillating coil must actuate a ratchet wheel to the extent of one tooth per period.

In this last application the polarised electro magnet presents the advantage of starting of its own accord very easily and of giving a very high power for a very small volume; in addition to permitting the hands to be controlled, this arrangement permits driving springs or weights to be wound up which are adapted to serve as safety devices in the event of a failure of the current or for actuating hour striking mechanisms, chimes, various sound warning devices, time releases and switches, etc.

In this application a relatively slow speed is obtained directly by actuating a ratchet wheel having a large number of teeth; this is not so with the rotating field motors at present employed, which turn at a speed equal to the frequency of the alternating current.

In order to obtain the operation of the coil as a motor having a synchronous alternating movement under very favourable conditions, and with a practically constant amplitude of oscillation, it is advantageous to employ the methods patented by the Etablissements Leon Hatot for the electro magnetic synchronisation of pendulums. In particular, forms of poles will be adopted and a spring will be associated with the coil if necessary in such a way that when the current is zero the coil will already form an oscillating system the natural period of which will be a little longer than that of the alternating current for the oscillations of small amplitude and a little shorter for amplitudes greater than the working value to be obtained. Synchronous working will then be produced in the manner described in the patents of the Societe des Etablissments Hatot mentioned above.

Such a device differs from the systems comprising sustained vibrating blades in that the movable pole pieces move in front of fixed pole pieces and that on this account there can be no sound producing impact between these parts. Consequently a silent operation can be obtained. Moreover the law of magnetic attraction may be chosen so that the synchronising force does not disturb the natural period.

If it is proposed to obtain a continuous rotation of a shaft, use may be made, instead of a pawl mechanism, of a silent drive such as the one which is based upon a free drive in one direction and a wedging action in the reverse direction (for example rollers with cams having eccentric teeth as in certain free wheel mechanisms employed in bicycles and in magneto-operated pocket lamps).

Practical experience has shown that with an electro magnet constructed as indicated in Figure 1, and supplied with alternating current at about 50 periods per second, the amplitude of oscillation is relatively high (greater than 5°). This arrangement is consequently very suitable for the construction of rectifiers for recharging accumulators provided with robust contacts which are easy to adjust.

Figure 25 shows a motor with an oscillating coil which rotates the toothed wheel R in one direction only by means of the pinions Z mounted upon the arms *b*. When the coil turns in the direction f_1 it causes the pinions to jam and these pinions become rigid with the wheel R. In the reverse direction the pinions turn freely and there is no transmission of movement.

Figures 26 and 26a show a modification in which the pinions are replaced by suitable eccentric cams acting upon an uncut wheel R.

In Figure 27 the discontinuous drive operates through a clutch controlled by the alternating current which serves for oscillating the coil which makes the shaft O_1 oscillate. For this purpose the clutch is controlled by a vibrating cam L and the coil E supplied if necessary through a condenser in order that the phase difference between the movement of the clutch and that of the oscillating coil will have a suitable value.

Figure 28 shows another mode of transmission by means of a wire and pulley. A phonic wheel may permit the speed to be rendered uniform so that the whole arrangement possesses the properties of a self-starting synchronous motor.

The stability of the synchronous oscillations of the coil and the uniformity of the amplitude may be obtained as indicated in Figure 25 by two stops M_1 and M_2 against which a rubber lined member rigid with the coil strikes.

The improvements forming the subject of the invention are immediately applicable to electric bells with a striker, or chimes, controlled by unidirectional or alternating periodic current, like the telephone bells actuated by magnetos. They enable the dimensions of such apparatus to be considerably reduced for the same useful mechanical power.

Finally it will be understood that the special properties of the systems which

have been described with reference to their use as powerful motors also permits them to be employed as a generator of magneto electric current.

By way of example, Figures 24, 24a and 24b illustrate diagrammatically the application of the invention to a pick up adapted to generate an alternating current when the moving coil at O is given a reciprocating angular movement by means of a needle *a* rigid with its shaft and the end *p* of which is made to follow a sinuous path by means of a phonograph disc. In such an application it is sought to obtain directly the strongest possible current and on the other hand, in order to obtain a good phonographic reproduction it is necessary to establish a certain law between the induced current and the displacement of the needle transmitted to the coil.

It has been shown above that the invention permits this result to be obtained easily by suitably choosing the form of the pole pieces. It will be found of greater advantage to reduce the weight of the movable carriage and to increase the ratio between the distances O B and O *p*. The coil may be wound directly upon a piece of sheet cut out and folded, as shown in Figure 24a so that it will not yield even if it is thin.

The same device may obviously serve as a loud speaker motor by sending a telephone current into the coil and by using the displacements of the coil in order to obtain sound vibrations. In this case it is necessary to provide damping members, as shown in the figure. Instead of pivoting, the coil may be wound on a vibrating blade.

In these last described applications, in view of the fact that the angular displacement of the coil is very small, it is of interest to be able to regulate with precision the relative positions of the pole pieces between which the magnetic attractions are exerted.

Figure 24b shows an arrangement which is particularly suitable for use in the case when the displacement of B is very small. The pole P_1 and the pole P_2 may be made to turn in such a manner as to increase or reduce the reluctances of the by-passed portions of the magnetic flux passing from the poles P_1 and P_2 to the pole piece B.

Referring to Figures 3, 4, 5 and 6 and the corresponding applications, it is seen that this regulation quite well permits the relation between the instantaneous induced electro motive force and the angular displacement to be determined as desired.

The above described improvements are applicable to the resonance oscillating relay obtained by associating the coil with a spring arrangement which gives it a clearly defined natural period which can only be slightly modified by the periodic current received by the coil.

The coil of the electro magnet occupying the mean position when the current is zero and the two extreme positions for the currents of opposite direction, enables direction indicators for motor cars to be constructed by arranging an arrow or other warning device, to be controlled by a switch. A continuous alternating movement of this arrow can in addition be obtained by a switch controlled by the coil. This switch may be constructed as described above with reference to the arrangements for winding up watches.

All the devices described may be modified while remaining within the scope of the invention, by replacing the fixed permanent magnets by fixed coils on the one hand and the moving coil by one or more movable permanent magnets on the other hand.

In order to obtain the properties described in the specification by means of such arrangements, it will be sufficient not to change the forms of the adjacent pole masses between which the magnetic attractions and repulses are effected. In this way the same law of variation of the reluctance of the air gaps as a function of the angle of rotation will be preserved and the electro magnetic actions will be the same.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A polarised electro magnet formed by a coil provided with pole masses composed of sheets cut out to a certain shape and then bent to a certain profile moving with respect to a magnetic field preferably produced by one or more permanent magnets and a plurality of iron posts arranged parallel to the axis of the coil and connected magnetically to the poles of the magnet by sheet members cut out and bent in such a way as to possess a certain amount of elasticity and to leave on each side of the coil a sufficiently large free space to hold the flexible connections leading the current to the coil.

2. A polarised electro magnet according to claim 1, characterised by the feature that the coil is relatively very long with respect to its diameter (length more than three times the diameter) and that the cobalt steel magnet is of relatively short length with respect to its other dimensions.

3. A polarised electro magnet as claimed in claims 1 and 2, in which two cobalt steel magnets are arranged round the coil and at a small distance and form a protecting casing the internal volume of which is almost wholly occupied by the coil.

4. A polarised electro magnet as claimed in claim 1, wherein the sheet material pole pieces of the coil are held by $2p$ sheet brass supporting rods cut out and bent to a U-shape and provided with short pivots by means of which the coil is pivotally mounted, the coil being placed between the supporting rods.

5. A polarised electro magnet as claimed in claim 1, wherein the forms of the pole pieces permit the coil placed in the magnetic field to be in stable, unstable or indifferent equilibrium or very slightly drawn in a given direction.

6. A polarised electro magnet according to the preceding claims and associated with an electrical contact controlled by the displacements of the coil so as to obtain a maintained reciprocating movement, and the application of this system to all previously known apparatus comprising electro magnets which make a to and fro movement.

7. A device as claimed in claim 6, wherein the electrical contact controlled by the coil comprises a fork-shaped iron member which is half conducting and half insulating, and is subjected to the magnetic attraction of two magnetised posts, a conducting pin rigid with the coil being mounted between the arms of this fork, the diameter of the pin being smaller than the width of the fork and the iron member being so shaped that it tends to reverse suddenly to the left and to the right when it is displaced by the pin, which is given a to and fro motion, this switch being connected in the circuit of the coil and the latter being drawn in a direction such that the contact is broken during the greater part of the movements in this direction and closed in the movements in the reverse direction.

8. A modified form of the device claimed in claim 7, wherein the coil is provided with a driving pin which performs no electrical function, actuating at the ends of its travel a small rotary distributor which is half conducting and half insulating upon which a brush is carried.

9. A device as claimed in claims 7 and 8, for use in winding electric clocks and watches, wherein the coil actuates the wheels by a pawl and a driving spring (or a weight) and returns backwards suddenly from time to time when the electrical contact closes.

10. The application of the device claimed in claims 7 and 8 to receivers which themselves cause the current to be cut off as soon as the desired movement is effected.

11. A device as claimed in claim 9 applied to electric motors wherein the coil surrounded by the magnets occupies a very small space in the casing of the watch on the side opposite the balance wheel and the spiral, these members being moreover insulated magnetically by means of a screen made of very permeable iron free from hysterisis.

12. An electro magnet according to claim 1 and/or according to one or more of claims 2 to 11, for use in the constructions of polarised receivers of small size, characterised by the feature that the coil indirectly controls the pawls or the anchor which drives the ratchet through the medium of an auxiliary lever permitting a ratchet wheel of large diameter to be mounted and coils to be employed having their axes parallel to that of the hands and of relatively great length (of length equal to or greater than the radius of the casing).

13. A polarised electro magnet according to any of the preceding claims, wherein the coil has its axis at the centre of the casing of the receiver and oscillates freely upon the axis of the large hand.

14. A polarised electro magnet according to the preceding claims, wherein the magnet is formed by means of laminated sheet pole masses.

15. A polarised electro magnet according to the preceding claims, comprising a coil provided with a single pole piece.

16. A polarised electro magnet according to the preceding claims, wherein the electro magnet comprises a moving part in the form of the iron members forming the coil claimed in claim 1 and the following claims, but different from these arrangements in that the moving part comprises no winding, the winding being distributed over the fixed posts forming the pole masses of the magnet.

17. A polarised electro magnet according to one or more of the preceding claims, for use in an electric pick-up, characterised by the feature that the radius of the end of the hand is much smaller than the radius of the magnetic forces and that the pole piece of the coil moves in front of four magnetised posts of such form that the relative position of the pole pieces can be adjusted by the rotation of the posts.

18. A polarised electro magnet according to claim 17, employed for maintaining the operation of vibrating tuning

forks, etc. and for wireless loud speaker motors.

19. A polarised electro magnet as claimed in claim 1, employed in oscillating motors operating with alternating current and the oscillating coil of which is adapted to produce the continuous rotation of a shaft.

20. A polarised electro magnet as claimed in claim 19, wherein the driven shaft turns through an angle strictly proportional to the number of oscillations, the speed being if necessary rendered uniform by a phonic wheel.

21. A polarised electro magnet as claimed in claim 19, wherein the transmission of the movement takes place through a silent mechanism based on a device which makes the shafts rigid with each other for one direction of displacement only of the coil.

22. A polarised electro magnet as claimed in claim 21, wherein use is made of a clutch controlled periodically by the alternating current actuating the oscillating coil.

23. A polarised electro magnet as claimed in claim 19, wherein use is made of the method of synchronous control forming the subject of the patents in the name of Societe des Etablissements Leon Hatot, consisting in employing an oscillating system having small amplitudes at a period a little longer than that of the alternating current and having large amplitudes at a shorter period, this effect being obtainable in particular by the form of the pole pieces or by abutments preferably made of rubber or felt.

24. The use of the polarised electro magnet according to the preceding claims, associated with springs for constructing resonance relays.

25. The improved polarised electro magnet, substantially as described and as illustrated in the accompanying drawings.

Dated this 17th day of October, 1930.

MARKS & CLERK.

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Fig 1

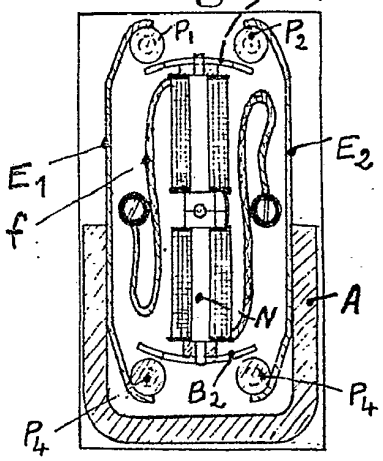
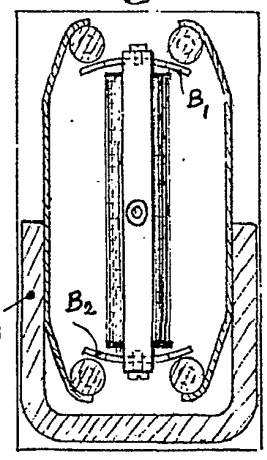


Fig.2



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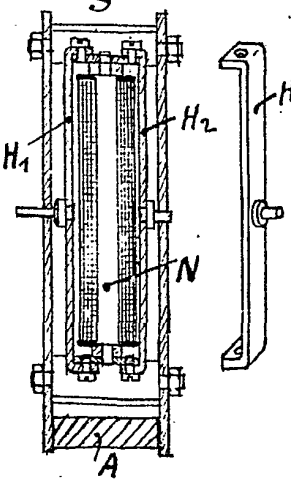

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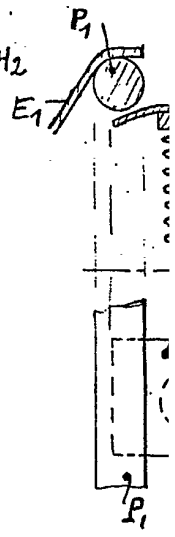
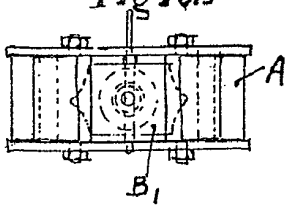


Fig 1bis



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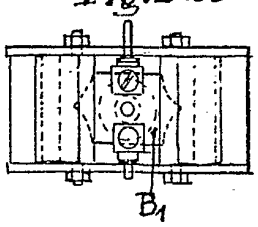


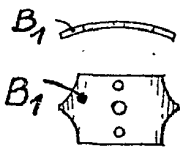


Fig. 1

Fig.7

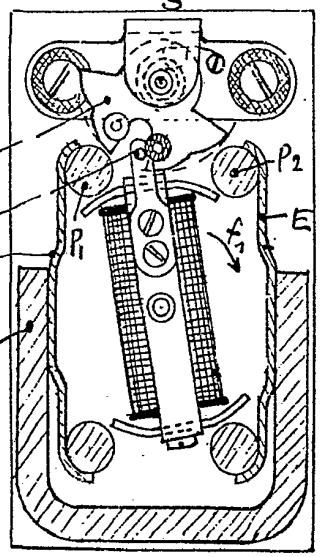
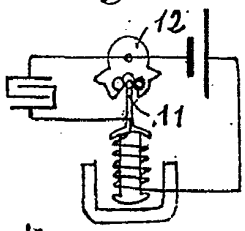


Fig. 7 bis



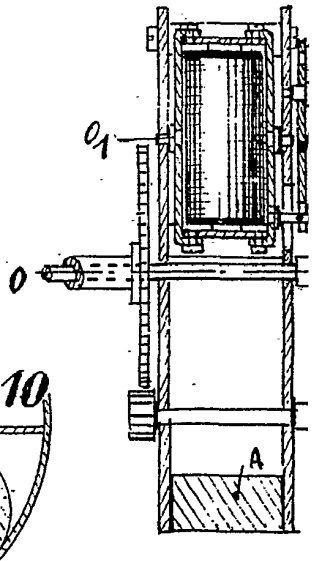


Fig.10

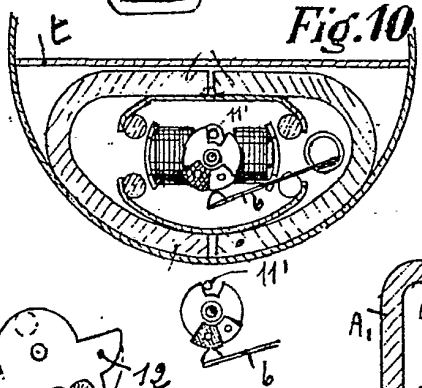


Fig.12

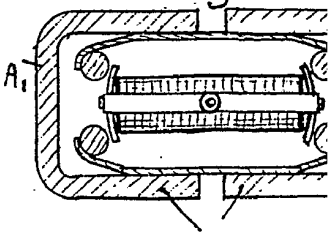


Fig. 8

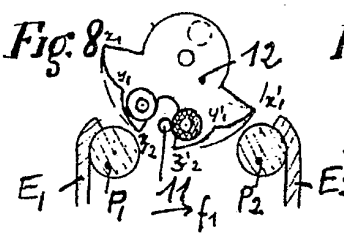


Fig.9

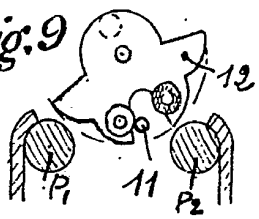
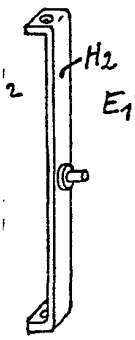


Fig.3



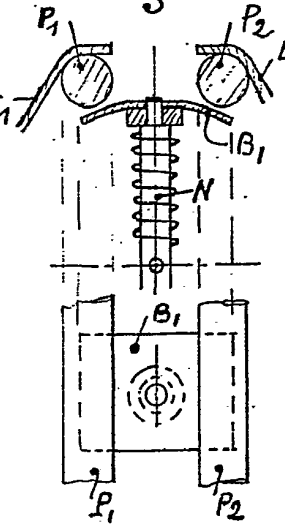


Fig.4

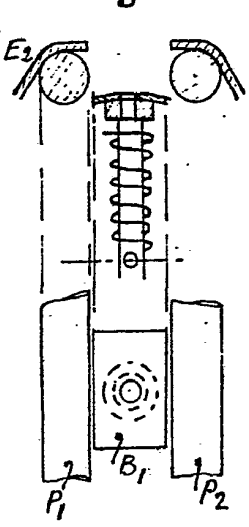


Fig.5

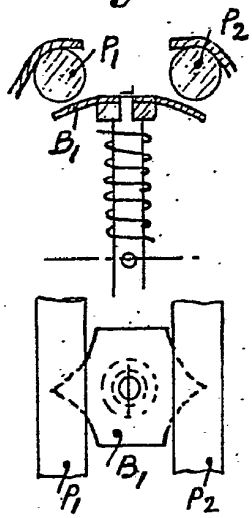


Fig.6

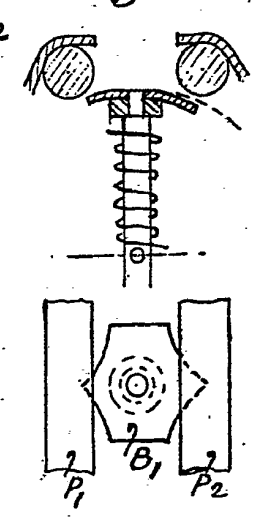


Fig. 11

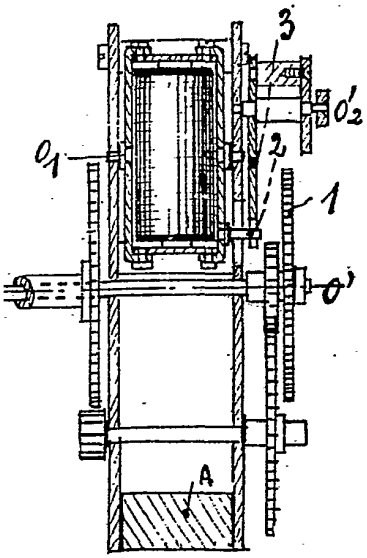


Fig. 11 bis

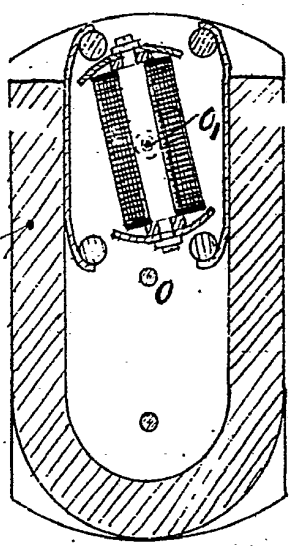
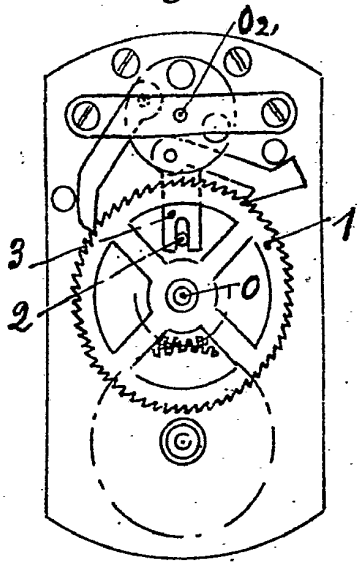


Fig. 11 ter



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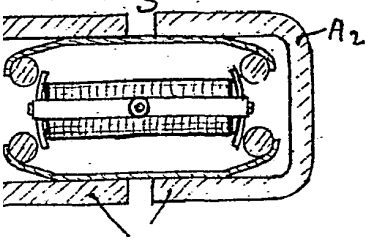

Fig.13

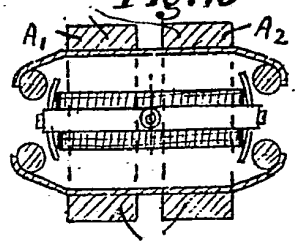

Fig.14

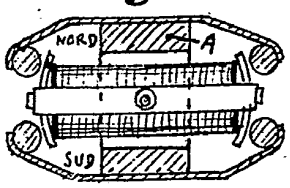

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Fig 1

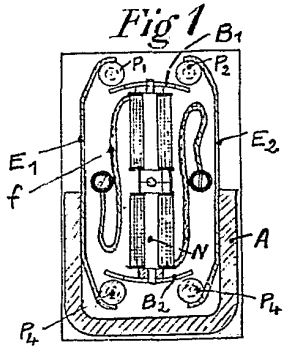
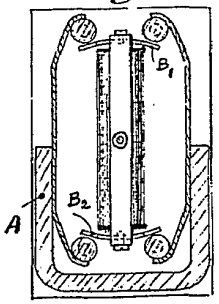


Fig.2



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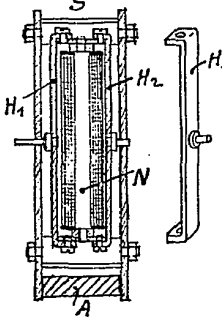
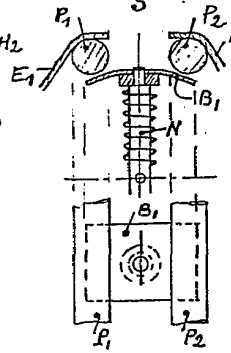


Fig.3



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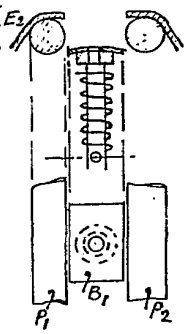

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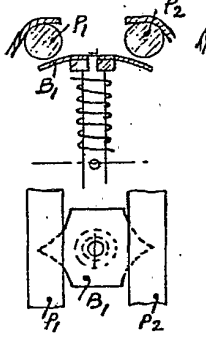

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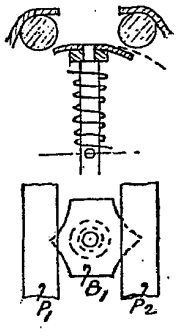
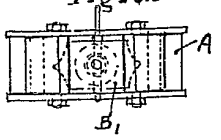


Fig 1bis



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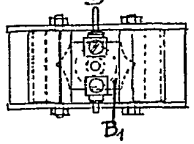


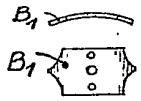
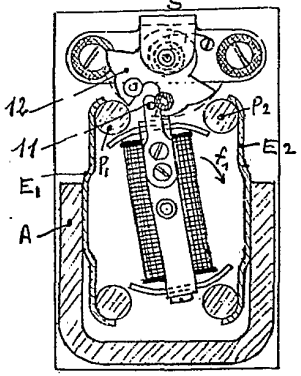


Fig.7



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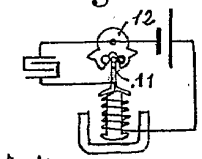


Fig.10

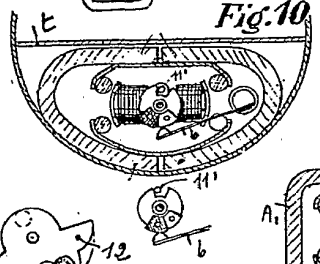
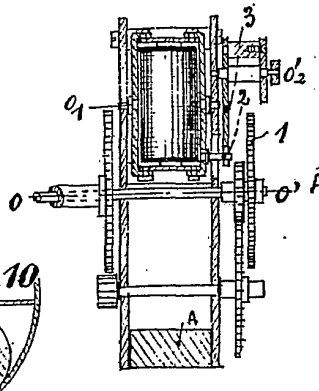


Fig.11



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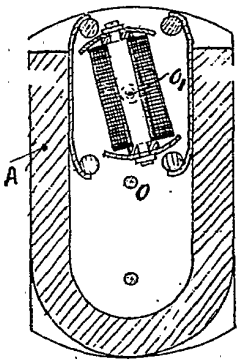
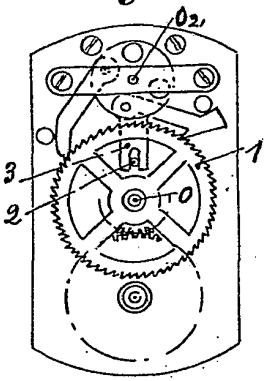


Fig.11 ter



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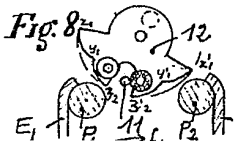

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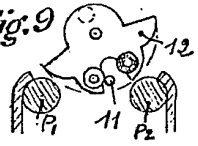

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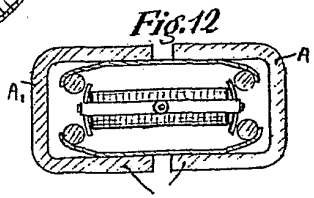

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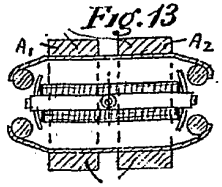

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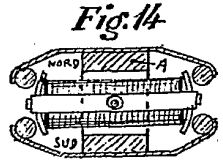

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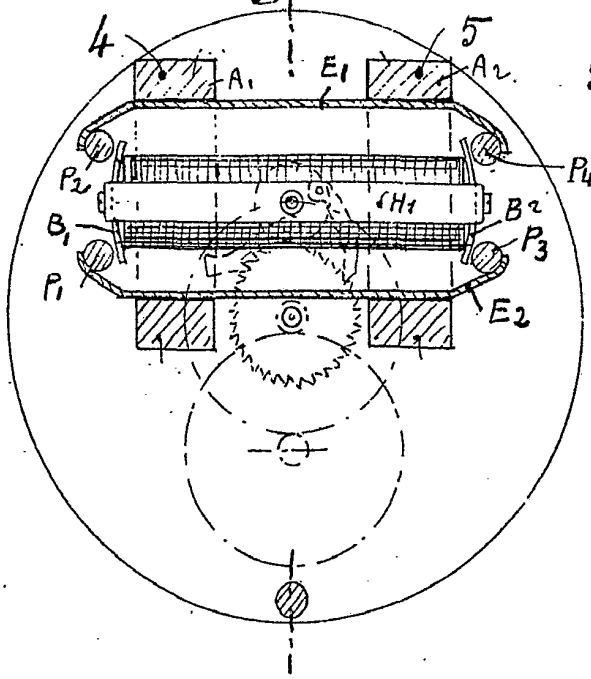

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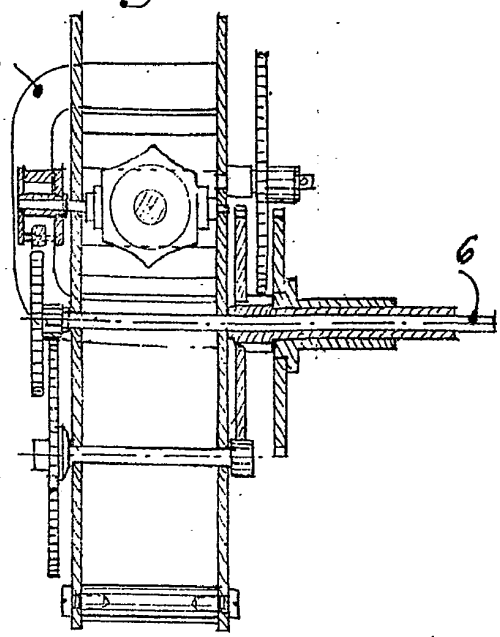

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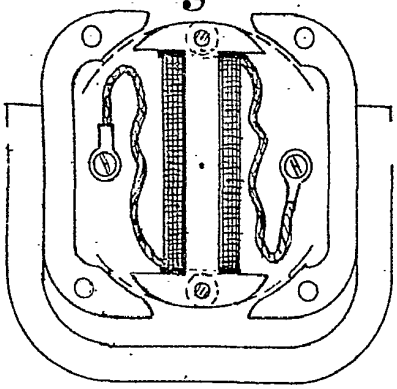

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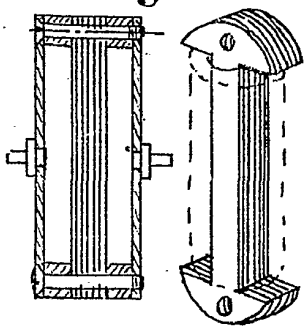

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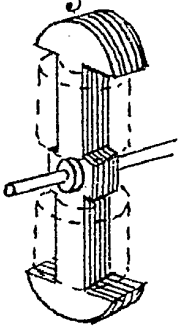

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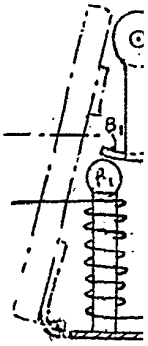

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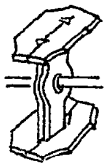

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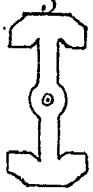

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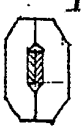

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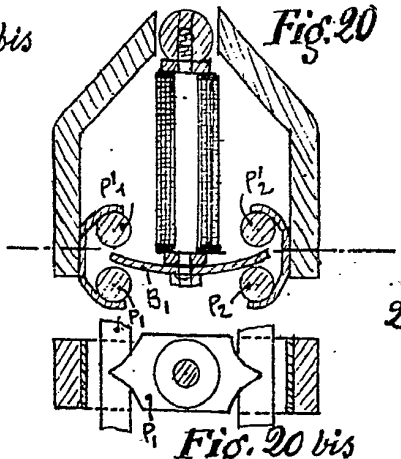

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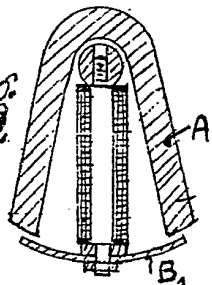

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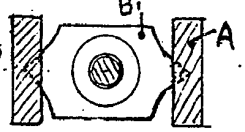

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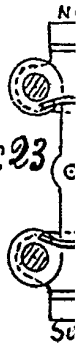

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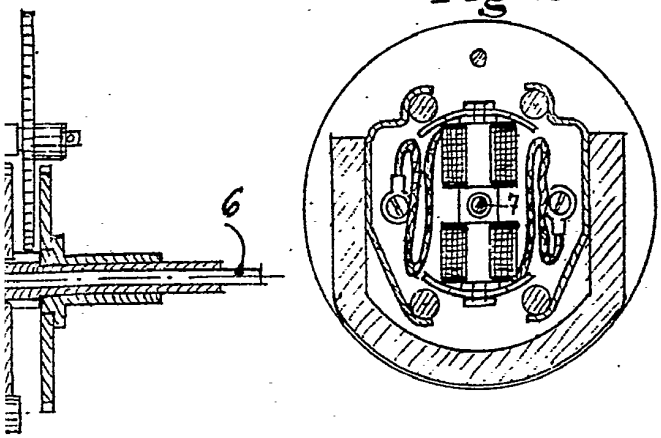

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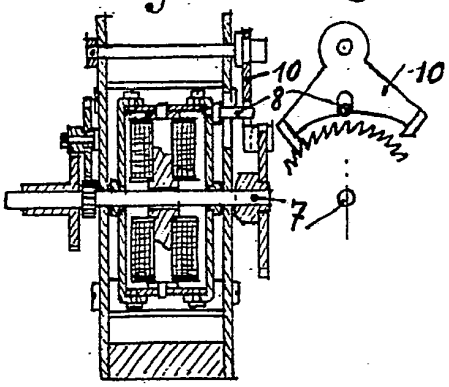

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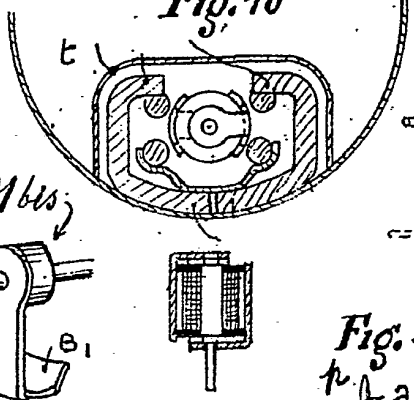
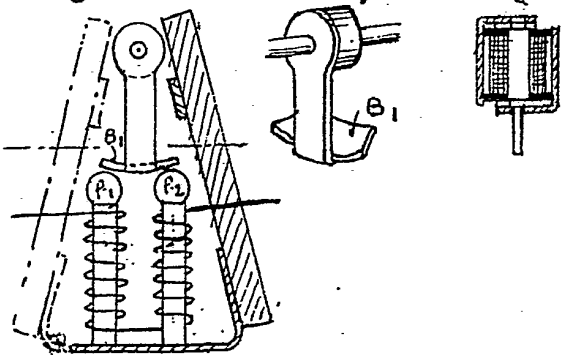


Fig. 18 bis

Fig. 18 ter

Fig. 21 Fig. 21 bis



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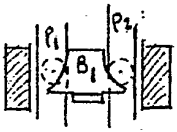

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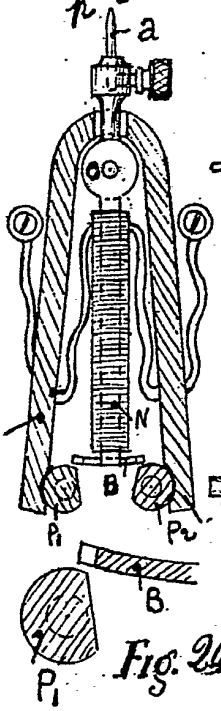

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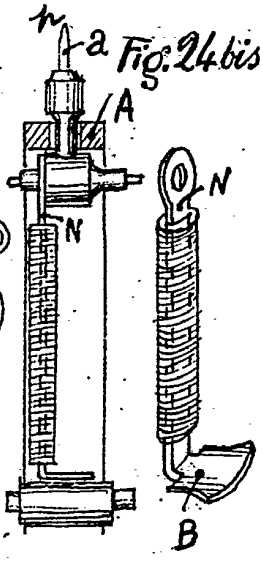


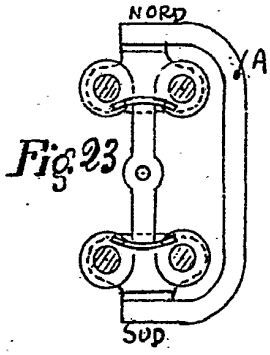
Fig. 24 ter

A

B1

A

Fig. 23



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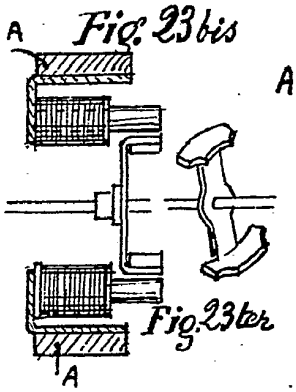

Fig. 23 ter

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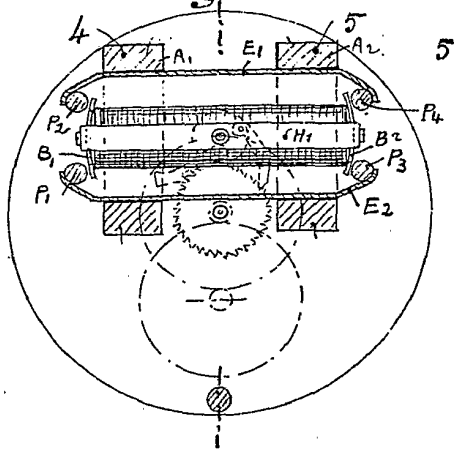
Fig. 15



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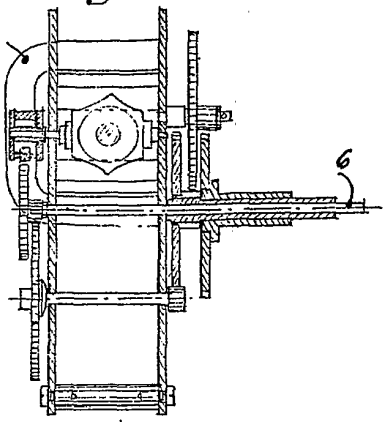

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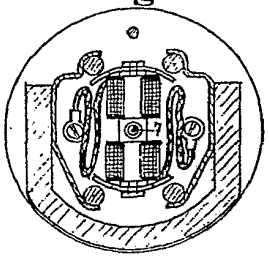

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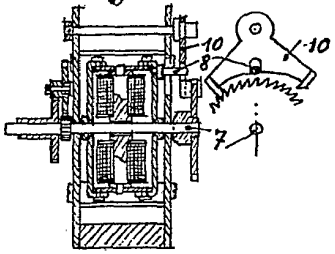

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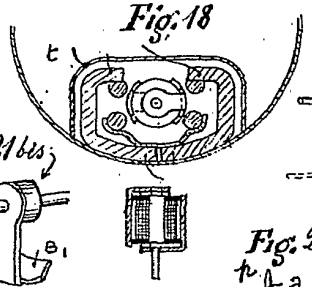
Fig. 18



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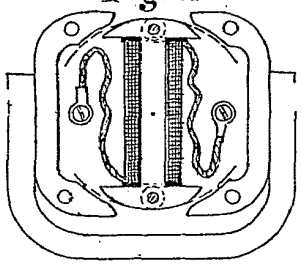

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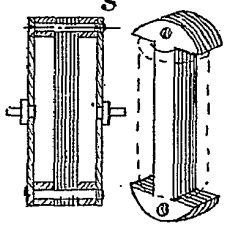

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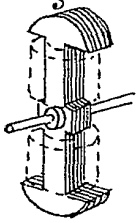

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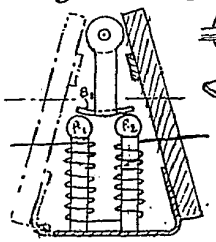

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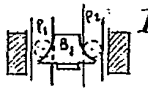

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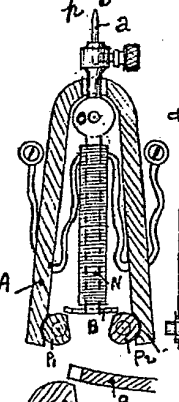

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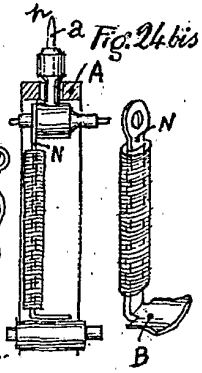

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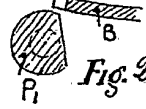

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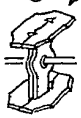

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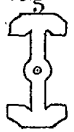

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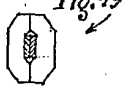

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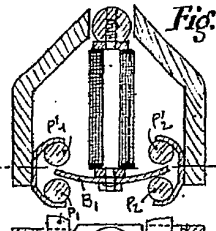

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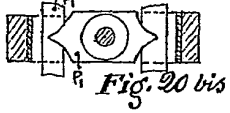

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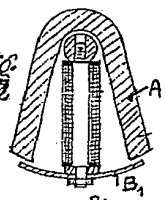

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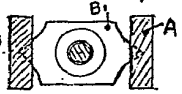

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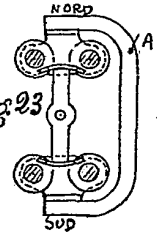

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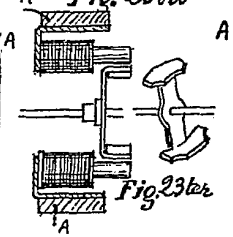

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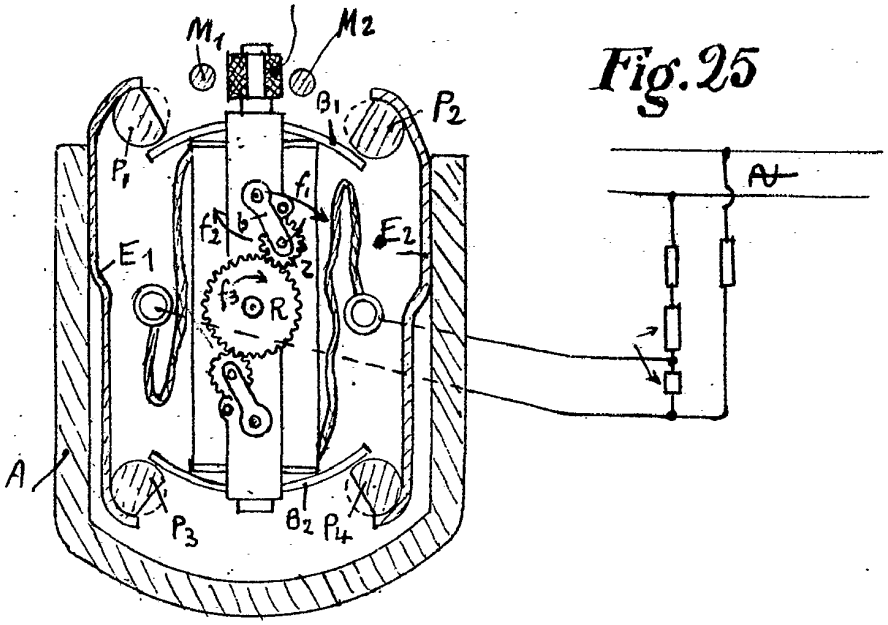
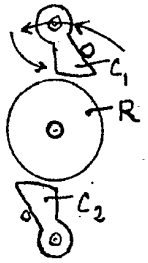


Fig. 25

Fig. 26



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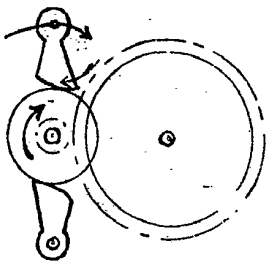

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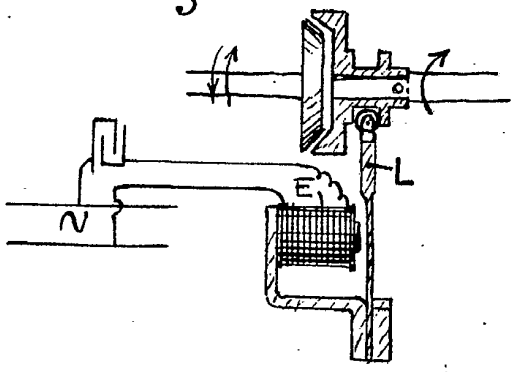

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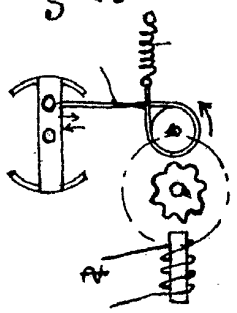

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