PATENT SPECIFICATION

421,348

Application Date: July 21, 1933. No. 20615/33.

Complete Specification Accepted: Dec. 19, 1934.

COMPLETE SPECIFICATION

Improvements in Clockwork Movements

I, JEAN DELVINIOTTI, a French citizen, of 12, Rue Reynouard, Paris, France, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described

Figures 9, 10, 11 and 12 show other embodiments of the contacts arrangement;

Figures 13 and 14 show a watch movement according to the present invention

CORRECTION OF CLERICAL ERRORS

SPECIFICATION No. 421,348

The following corrections are in accordance with the Decision of the Assistant Comptroller, acting for the Comptroller-General, dated the eighth day of May, 1935:-

Page 1, line 1, and at the end of the Specification, *after* "JEAN" *insert* "THEODORE"

Page 1, line 2, *for* "Reynouard" *read* "Raynouard"

THE PATENT OFFICE,
27th May, 1935.

... having a metallic core. The balance and the coils are so disposed with respect to one another that, in the position of equilibrium of the balance, the contact or contacts that produce the closing of the energising circuit is, or are, open. In that way, although the iron mass of the balance closes, in its position of equilibrium, the magnetic circuit of the coils, no magnetic force is produced since the residual magnetism is negligible for practical purposes.

Preferred embodiments of my invention will be hereinafter described, with reference to the accompanying drawings, given merely by way of example, and in which:—

Figures 1 and 2 show a time-piece clockwork movement according to the present invention, in elevational view and in plan view respectively;

Figures 3, 4, 5, 6 and 7 show the contacts in several positions of the operation of the device, and the corresponding positions of the balance;

Figure 8 shows a driving system in plan view and in sectional view;

coils 13 and 13a provided with soft iron cores 12 and 12a disposed in the same plane as the balance, so that in the position of equilibrium of the balance, the coils are symmetrically disposed with reference to the mass of iron 25 of the balance (Figure 2).

On the other hand, in that position of equilibrium, the contact or contacts are opened and the impulses, which maintain the motion of the balance, take place, either symmetrically or not, in one or both directions, before the position of equilibrium.

To this effect, the balance carries two pallets 19a, 19b, provided on a sleeve 19, which is fixed to, and disposed coaxially with, the balance, and is electrically connected with the clockwork. Said pallets are intended to come into contact with the end 17a of an arm 17 carried by a pillar 16 insulated from the supporting plate of the clockwork. These two pallets are inclined, as shown in the lower parts of Figures 3, 4, 5, 6 and 7, which represent developments of piece 19 with its pallets and the end 17a of arm 17 in five different positions of the balance re-

[*Price* 1/-]

Price 4s 6d

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Improvements in Clockwork Movements

I, JEAN DELVINIOTTI, a French citizen, of 12, Rue Reynouard, Paris, France, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention concerns a clockwork movement of the type comprising a circular, balance and electric means for maintaining the motion thereof.

The object of the present invention is to provide an electric clockwork movement of small volume and of simple construction adapted to be used for timekeepers of small size (which will hereafter be referred to as "watches," or "timepieces," without giving any limitative meaning to these words) and which can be applied to all kinds of timepieces, from very small to very big clocks.

The clockwork movement according to the present invention comprises a driving balance, of small thickness, made of a non-magnetic material and carrying a mass of a magnetic metal, for instance soft iron, and two stationary coils, also of small thickness, having a metallic core. The balance and the coils are so disposed with respect to one another that, in the position of equilibrium of the balance, the contact or contacts that produce the closing of the energising circuit is, or are, open. In that way, although the iron mass of the balance closes, in its position of equilibrium, the magnetic circuit of the coils, no magnetic force is produced since the residual magnetism is negligible for practical purposes.

Preferred embodiments of my invention will be hereinafter described, with reference to the accompanying drawings, given merely by way of example, and in which:—

Figures 1 and 2 show a time-piece clockwork movement according to the present invention, in elevational view and in plan view respectively;

Figures 3, 4, 5, 6 and 7 show the contacts in several positions of the operation of the device, and the corresponding positions of the balance;

Figure 8 shows a driving system in plan view and in sectional view;

Figures 9, 10, 11 and 12 show other embodiments of the contacts arrangement;

Figures 13 and 14 show a watch movement according to the present invention, in elevational and in sectional view respectively;

Figures 15, 16 and 17 are diagrammatical views illustrating the operation of the device of Figures 13 and 14;

Figures 18 and 19 show still other embodiments of the contacts arrangement;

Figures 20, 21, 22 and 23 show various embodiments of systems in which the drive and the contacts form a single device;

Figure 24 shows another embodiment of the clockwork movement, including two balances.

According to the embodiment of my invention shown in Figures 1 and 2, the device for maintaining the motion comprises, as above explained, a circular balance 2 carrying a soft iron armature 25, the ends of which are at the periphery of the balance and subtend at the centre of the latter angle of about 60°, and two coils 13 and 13a provided with soft iron cores 12 and 12a disposed in the same plane as the balance, so that in the position of equilibrium of the balance, the coils are symmetrically disposed with reference to the mass of iron 25 of the balance (Figure 2).

On the other hand, in that position of equilibrium, the contact or contacts are opened and the impulses, which maintain the motion of the balance, take place, either symmetrically or not, in one or both directions, before the position of equilibrium.

To this effect, the balance carries two pallets 19a, 19b, provided on a sleeve 19, which is fixed to, and disposed coaxially with, the balance, and is electrically connected with the clockwork. Said pallets are intended to come into contact with the end 17a of an arm 17 carried by a pillar 16 insulated from the supporting plate of the clockwork. These two pallets are inclined, as shown in the lower parts of Figures 3, 4, 5, 6 and 7, which represent developments of piece 19 with its pallets and the end 17a of arm 17 in five different positions of the balance respectively.

On the other hand, arm 17 carries a flexible bade 18, the end of which is provided with a contact 18a for closing the energizing circuit through its contact with stud 20 carried by a pillar 21 insulated from the supporting plate of the clockwork.

Thus, referring, for instance, to Figure 3, it will be seen that contact 19a, 17a is made; balance 2, under the action of its inertia, moves in the direction of the arrow, the energizing circuit not being still closed. In the course of that displacement, pallet 19a made of a suitable metal, raises arm 17 through its extremity made of a suitable metal, so as to bring it into the position shown in Figure 4. Flexible blade 18, which is integral with arm 17, also moves in an upward direction and contacts 18a-20, made of a suitable metal, are brought together. Balance 2 then moves in the direction of the arrow of Figure 4, its mass of iron being acted upon by the electro-magnetic force of the two coils 13, 13a, the energising circuit being closed as follows: negative terminal of the source of current, mass of the clockwork, 19, 19a, 17a, 17, 18, 18a, 20, coils 13 and 13a, positive terminal of the source of current, or the reverse.

When balance 2 is in its position of equilibrium (Figure 5), contact 17a is released from pallet 19a and arm 17 on coming back to its original position, in turn moves contacts 18a and 20 away from each other (Figure 6).

As balance 2 further moves under the action of its inertia, as shown in Figure 7, contact 17a is brought against the back of pallet 19b and the inclined plane of said pallet moves in a downward direction arm 17 and flexible blade 18, which subsequently assume a position symmetrical with that shown in Figure 3, so that the contact is made at 17a-19b instead of 17a-19a.

That position make is possible to have, on the return motion of the balance, the same operation, but now in the reverse order. as that above described.

It follows from the preceding explanations that the closing of the electric circuit takes place through contacts 18a-20, and that the opening is produced through contacts 17a-19a or 17a-19b according to the direction of the motion of the balance.

Another system of contact may advantageously be utilized (Figures 18 and 19).

This system works in both directions, the operation being similar to that illustrated in Figures 3 to 7.

Blade 17 (Figure 18) is maintained between two blades 17b and 17c. Contact stud 20 is mounted on a movable lever 20a, urged by a coiled spring 20b, or through any other elastic means, against its stop 20c. The whole is insulated from the mass and is connected to one of the coils.

In this embodiment, the contact with stud 20 is produced through part 17a, the part 18a of Figures 3, 4, 5, 6 and 7 being done away with in this case.

The operation will readily be understood as it is similar to that described with reference to Figures 3 to 7 inclusive, the pallet 19a, or 19b, raising part 17a, against contact stud 20.

In the embodiment of Figure 19, which is slightly different from that of Figure 18, blades 17, 17b and 17c have been replaced by a jointed system. Blade 17 is carried by a sleeve 17c pivoting about an axis 17f; said sleeve carries a coiled spring 17g, which has its outer end fixed at 17h.

The whole of said contact 17 is connected to the mass of the clockwork.

The balance may also be kept moving, in another manner, through a system of contacts 18a-20, several embodiments of which are diagrammatically shown in Figures 9, 10, 11 and 12, the closing and the opening of the electric circuit taking place through the same contacts 18a-20. Thus, referring, for instance, to Figures 9, 10, 11 and 12, it will be seen that the electric circuits are different, but that the contact is made between stud 20 and the end 18a of flexible blade 18.

Under the action of pallets 19a and 19b, which, in this case, act merely as cams, arm 17 moves as in the system above described, and the mechanical and magnetic actions take place in the same manner as in the case of Figures 3 to 7 inclusive.

In the embodiment of Figure 9, flexible arm 71 is supported by a pillar 16 insulated from the mass of the apparatus and connected with two coils 13 and 13a; Sleeve 19 that carries pallets 19a and 19b is insulated from the mass of the apparatus and stud 20 is connected with said mass.

The electric circuit is the following: negative terminal, stud 20, 18a, 18, 17, 16, coils 13 and 13a, positive terminal, or the reverse.

In the embodiment of Figure 10, flexible arm 17 is supported by a pillar 16 connected to the mass of the apparatus, sleeve 19 itself is connected to the mass and stud 20 is insulated from the mass and connected with coils 13 and 13a.

The electric circuit in this case is as follows: negative terminal of the source of current, 16, 17, 18, 18a, 20, 13a, positive terminal, or the reverse.

In the embodiment of Figure 11, flexible arm 17 is supported by a pillar 16 insulated from the mass of the apparatus and connected with coils 13 and 13a (which themselves are connected with the positive terminal); sleeve 19 is insulated from the mass; stud 20 is also insulated from the mass, but it is connected to the negative terminal of the source of current.

The electric circuit is the following: negative terminal of the source of current, 20, 18a, 18, 17, 16, coils 13 and 13a and positive terminal of said source, or the reverse.

In Figure 12, the flexible arm 17 is supported by a column 16 insulated from the mass and connected to a coil 13, itself connected to the positive terminal of the source of current. The sleeve 19 is insulated from the mass, as also is the stud 20 which is connected to the coil 13*a* which itself is connected to the negative terminal of the source of current.

The electric circuit is the following: negative, coil 13a, 20, 18a, 18, 17, 16, coil 13 and positive, or conversely.

In order better to understand the motion in the case of a timepiece according to the present invention, the embodiment of Figures 1 and 2 will be more specifically described. The clockwork movement comprises a main supporting plate 1, made of a moulded insulating material or any metallic material and provided with supports for balance 2 and driving wheel 4.

Balance 2 is mounted on a spindle 10, pivoted at one end on a bent part of plate 1 and at the other end in a member 22. Said spindle 10 of balance 2 carries, besides its coiled spring 24, a sleeve 19 provided with pallets 19a and 19b, which play the part of breaking contacts (case of Figures 3, 4, 5, 6, 7, 15, 16, 17) or of cams (case of Figures 9. 10, 11, 12, 18, 19) according to the arrangement that is utilized. Said spindle 10 further carries the means for driving ratchet wheel 4, according to the showing of Figure 8. Said means will be hereinafter specifically described.

Another embodiment of my invention, which is more particularly applicable to watches, but which could also quite well be adapted to timepieces as in the preceding examples is shown in Figures 13 and 14. It comprises a circular balance 3 provided with an armature of soft iron 5, and two coils 6 and 6a, placed in the same plane as the balance, in such manner that in the position of equilibrium of the balance with reference to the coils armature 5 is symmetrically placed.

On the other hand. in said position of equilibrium the contacts are open and the impulses that serve to keep the balance in motion take place symmetrically or not, in one or in both directions, before the position of equilibrium.

For this purpose, the balance spindle 15 is provided with two pallets 8 and 8a made of a suitable metal, adapted to come into contact with the end 7a, made of a suitable metal, of a flexible blade carried by the main supporting plate of the watch and electrically insulated therefrom.

Said two pallets are inclined, as shown in Figures 15, 16 and 17, which represent the development of pallets 8 and 8a and the end 7a of blade 7, in three different positions of the balance.

Thus, taking, for instance, the position of Figure 15 it will be seen that contact 7a-8a is closed and that the balance moves in the direction of the arrow, its mass of iron being subjected to the action of the two coils 6-6a. The electric circuit is the following: negative terminal of the source of current, coils 6 and 6a, contact 7a, contact 8a, and positive terminal of the source of current, or the reverse. During that displacement, contact 7a, carried by blade 7, moves upwardly under the action of pallet 8a, pallets 8 and 8a, carried by the balance having inclined surfaces.

When balance 3 arrives at its position of equilibrium (Figure 16) the electric circuit is opened, contact 7a being released, and flexible blade 7 comes back to its original position.

As the balance further moves under the action of its inertia, as shown in Figure 17, in the direction of the arrow, contact 7a is brought against the back of pallet 8, which is covered with a layer of an insulating material 17. The inclined disposition of said pallet causes the end 7a of blade 7 to move in a downward direction and to escape from pallet 8, so as to come back to its original position. During the return motion of the balance, blade 7 is given the same displacements, but now in the reverse order.

The specific construction of the clockwork movement the operation of which has just been described, will be better understood from Figures 13 and 14. The watch comprises a main supporting plate 1 provided with the same supports as in the case of ordinary watches having a mechanical movement which maintains the mechanism of movable parts 16. In Figure 13 I have only shown their position by dotted lines. in order not to confuse the drawing. Balance 3 is mounted on a spindle 15, pivoted between plate 1 and member 2 (Figure 14) the spindle 15 of the balance carries, besides its coiled spring, pallets 8 and 8a, playing the part of contacts (Figures 15, 16, 17). Said spindle further carries the means for driving the wheelwork (Figure 8).

All the devices for keeping the balance in motion that have been above described as working in both directions can work in only one direction by doing away with one of the two pallets, such as 19a, 19b, 8a or 8b.

The driving device by which the balance drives the train to the hands is shown in Figure 8 and comprises a box 11 provided with a small pawl 26 pivoted on a screw 29 on the box and carrying a stud 9. Said pawl 26 is brought back into its normal position by a small spring 27. Wheel 4 is driven by stud 9 in only one direction of the oscillations of the balance. Pawl 26 is pivoted in such manner that it allows stud 9 to pass over the teeth of the ratchet wheel during the return motion of the balance. A pawl 28 serves to maintain ratchet wheel 4 against retrograde movement. Ratchet wheels 4 being thus driven, the spindle of said wheel carries an endless screw 5 (Figure 1) or a pinion (Figure 13) according to the needs of the reducing gear, which is of the usual arrangement.

All the contacting means that have just been described could, of course, be employed with a driving system different from the one described with reference to Figure 8. For instance, it would be possible to utilise a driving system of the type of metronome escapements, but with an inversed working.

The system of contact in one or both directions above-described (Figures 3, 4, 5, 6, 7, 9, 10, 11, 12, 15, 16, 17, 18, 19) and the driving system of Figure 8 have independent functions, but the present invention also comprises watches and timepieces in which the contacting device and the driving device make a single unit. Figure 20 shows such an arrangement.

According to the embodiment of Figure 20, contact is produced for only one direction of the motion. For this purpose, the pawl 26 must be keyed on the shaft 10 of the balance 2 in such a position that stud 9 of said pawl will be ready to engage ratchet wheel 4 (Figures 8 and 20) to impart the movement to said wheel when the iron mass 25 of balance 2 is in the position of Figure 3, with respect to the iron core of coils 13 and 13a.

Under the action of stud 9 ratchet wheel 4 rotates in the direction of the arrow (Figure 20) and in turn lifts a stop blade 28, which carries at its end 28a a contact made of a suitable material. Said contact 28a then closes the electric circuit through its co-operation with contact 29a carried by a pivoting arm 29 which is applied by coiled spring 31 against stud 30.

The whole of parts 29 and 30 is insulated from the mass of the apparatus and is connected to one of the two coils 13 or 13a.

When balance 2 is in the position of Figure 6, pawl 28 has come back to its place in the interval between two adjacent teeth of ratchet wheel 4 (Figure 20) and the circuit is opened, lever 29, which carries contact 29a being stopped by stud 30.

I have shown in Figure 21 another system in which the driving device and the contacting device are combined. This system works with impulses being given with only one direction of the oscillations, and establishes the magentic circuit through a mechanism comprising two lever pivoted at 35a and 36a (Figure 21).

The axis 10 of the balance carries on a small disc a rigid stud 37. The latter moves in the direction of the arrow and is brought into contact with a small blade 38 riveted at its end 38a to a lever 35. Consequently, lever 35 is lowered and it causes its contact piece 39 to co-operate with contact 40 mounted in a piece 40a insulated on lever 36 and thus to close the circuit.

As stud 37 further moves in the direction of the arrow, it escapes from small blade 38, and lever 35 is then brought back into contact with stop 43 by its coiled spring 41, while lever 36 is brought back into contact with its stop 44 by its coiled spring 42, as shown by Figure 21.

The balance in turn brings back stud 37 to its original position, said stud indicated by 37a meeting, in the course of this movement, the underneath of blade 38, which, being very flexible, is lifted by the stud without actuating its lever 35.

In order that the device may operate properly, stud 37 must be keyed on the spindle of the balance in such manner that being in its operative position as shown in Figure 21, the iron 25 of balance 2 is in the position of Figure 3 with respect to the iron elements of coils 13 and 13a.

The wheel 4 can be rotated by a pawl 45 placed at one of the ends of levers 35 or 36 (Figure 21). By way of example, in Figure 21, pawl 45 has been placed at one end of lever 36.

The system shown in Figure 22 functions by an impulse in one direction only.

The spindle 10 of the balance carries a pin 37 fixed on a small plate. The said pin moves in the direction of the arrow and ecounters the end of the blade 35. On that account, it drives the blade 35 which, by its movement in the direction of the arrow, leads the end 39 of the blade 36 to the insulated contact 40 and thereby closes the circuit.

The pin 37, continuing its movement in the direction of the arrow, liberates the end of the blade 35, which reassumes its position of rest. The blade 36, integral with the blade 35, thereby has its end 39 separated from the insulated contact pin 40.

In its turn, the balance wheel returns the pin 37, which encounters the end of the blade 35 and drives the latter, but this time in the direction opposite to the arrow. In this operation, the contact 39 moves away from the insulated contact 40 and causes this return to be without impulse.

The system shown in Figure 23 operates with an impulse in one direction only.

The spindle 10 of the balance carries a pin 37 fixed on a small plate. The latter moving in the direction of the arrow encouters the end of the blade 35.

The end of the blade 35, driven by the pin 37 in the direction of the arrow, thereby encounters the contact pin 40, mounted on the end of the lever 36 pivoted at 36a urged by the spring 42 against the abutment 44, the whole of which is insulated. The circuit is thus made.

The pin 37, continuing its movement in the direction of the arrow, escapes from the blade 35; at this moment the blade 35, maintained by the counter blades 35a and 35b, reassumes its position of rest. In assuming this position of rest, the blade 35 leaves the contact pin 40, which is kept away by the abutment 44 holding the lever 36. The circuit is thereby broken.

On its return, the balance returns the pin 37 in the direction opposite to the arrow, encounters the end of the flexible blade 35 and raises it in order to pass. In this return operation, the end of the blade 35 moves away from the contact pin 40 and causes this return to be without impulse.

According to the embodiment of Figures 1 and 2 the electro-magnet consists of two coils 13 and 13a, having iron cores 12 and 12a respectively and provided with suitable windings. Iron cores 12 and 12a are connected together by a yoke 30, also made of iron, which also serves to fix the electro magnet to the main supporting plate 1.

The cores of coils 13 and 13a, yoke 30 and the armature 25 of the balance can be made at will, wholly or partly, of pieces of soft iron, as stated in the above description, or of permanent magnets.

Referring to Figure 13, it will be seen that the electro-magnet consists of two coils 6 and 6a, having flat cores 4 and 4a respectively, which are connected by a yoke 13 made of soft iron, which also serves for the fixation of the electro-magnet to plate 1 through member 18.

In Figure 24 I have shown another embodiment particularly intended to be used in connection with big clocks, which comprises two balances 2 mounted on a common shaft 10 and having respectively each its couple of coils 13 and 13a fed through one or several contacts. Of course, the invention is not limited to the case of only two balances as in the embodiment of Figure 24.

While I have disclosed in the foregoing description what I deem to be practical and efficient embodiments of my invention, it should be well understood that I do not wish to be limited thereto, as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of my invention as comprehended within the scope of the appended claims.

HAVING NOW particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:—

1. An electrically-driven timekeeper, in which a circular balance of non-magnetic material carries a magnetic mass, characterised in that a contact which closes the electric circuit of a magnet for giving impulses to the balance, in one or in each direction of movement, is closed before the passage of the balance through its static position of equilibrium, but is opened on the passage through this position, the magnetic reluctance being the lowest in this position.

2. A timekeeper, as claimed in Claim 1, characterised in that the ends of the magnetic mass are at the periphery of the balance.

3. A timekeeper, as claimed in Claim 1, characterised in that a single shaft (for example 10, Figure 24) carries a plurality of balances (for example 2, 2a) each provided with an electro-magnet (for example 13).

4. A timekeeper according to Claims 1 and 2, characterised in that, spaced on the balance (for example 2) or its shaft (for example 10) are bevelled surfaces (for example 19a, 19b) which are inclined relatively to each other so as to form an inverted "V," and which are in alternate co-operation with a stationary resilient member (for example 17) for contact making, and alternately raise and lower the

said member (see for example Figures 1 to 6).

5. A timekeeper as claimed in Claim 4, characterised in that the resilient member (for example 17) has a resilient element (for example 18) co-operating with a stationary contact (for example 20).

6. A timekeeper, as claimed in Claims 1 to 3, characterised in that the closing of the circuit is effected through two sets of contacts (for example 17, 19 and 18, 20) (see for example Figures 1 to 6).

7. A timekeeper, as claimed in Claim 4, characterised in that the resilient contact element (for example 20a) mounted in a stationary manner, projects into the path of swing of the contact member (for example 17) influenced by the sloping surfaces (for example 19) (see for example Figures 18, 19).

8. A timekeeper, as claimed in Claim 4, characterised in that the sloping surfaces (for example 8, 8a) carry insulating coverings (for example 17, 17a) on the sides which face one another (see for example Figures 15 to 17).

9. A timekeeper, as claimed in Claims 1 and 2, characterised in that the contact member consists of a pawl (for example 28) which, in engagement with a toothed wheel (for example 4) driven in one direction by the balance (for example 2) comes into contact, on the progressive movement of the toothed wheel, with a spring contact (for example 31, 29, 28a) (see for example Figure 20).

10. A timekeeper as claimed in Claims 1 and 2, characterised in that an abutment (for example 37) of the balance is co-operative in one direction of movement with a resilient weight-influenced rocking lever (for example 35), and the latter is co-operative in one direction of movement for contact-making with a spring-loaded or weight-loaded lever (for example 36) (see for example Figure 21).

11. A timekeeper, as claimed in Claims 1, 2 and 8, characterised in that a lever (for example 36) carries a pawl (for example 45) on one end (see for example Figure 21).

12. A timekeeper, as claimed in Claim 5, characterised in that the stationary contact (for example 20a) is itself fixed to a spiral spring (for example 20b) to enable it to ensure a better contact.

13. The clockwork movement substantially as described or substantially as shown in the accompanying drawings.

Dated this 21st day of July, 1933.

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per Boult, Wade & Tennant,
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London, E.C.1,
Chartered Patent Agents.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1935.

[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. I

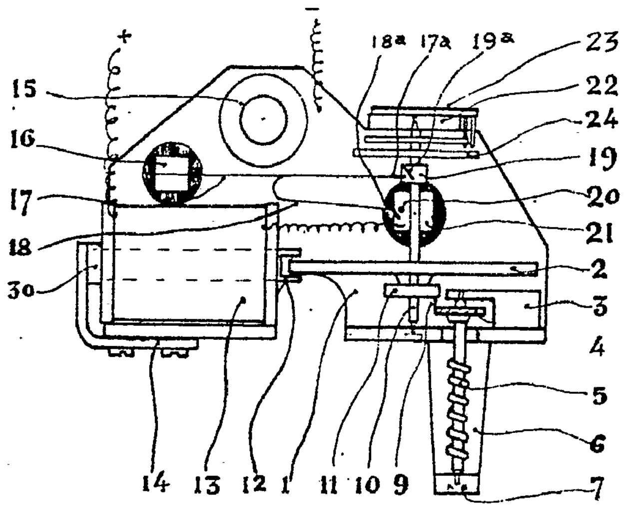


Fig. 2

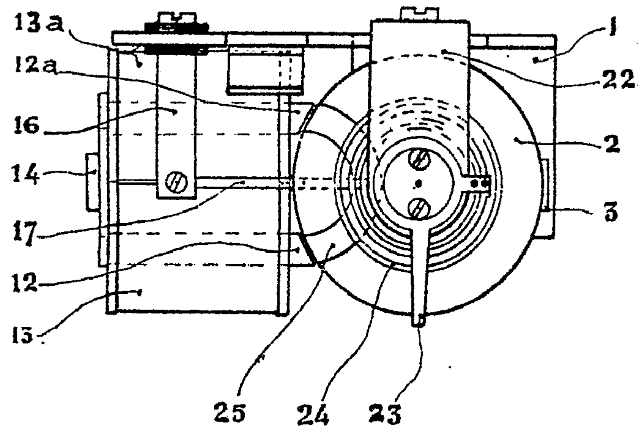


Fig. 7

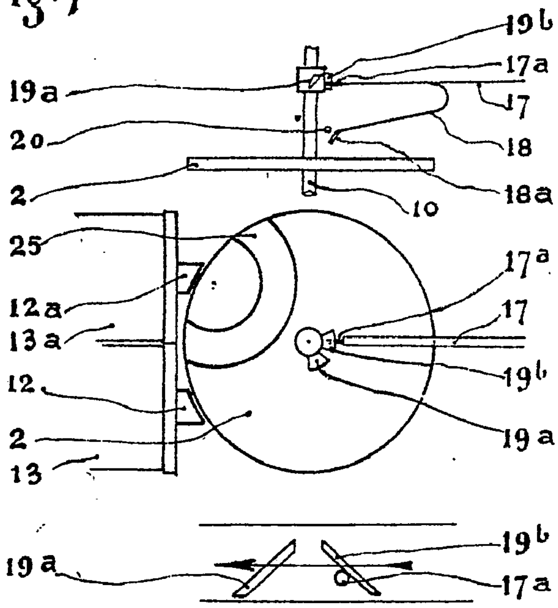


Fig. 3

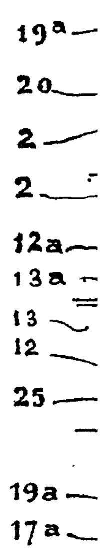


Fig. 5

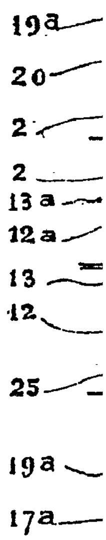


Fig. 3

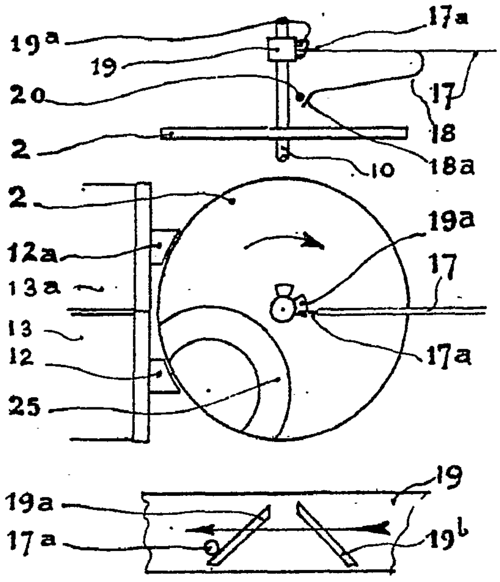


Fig. 4

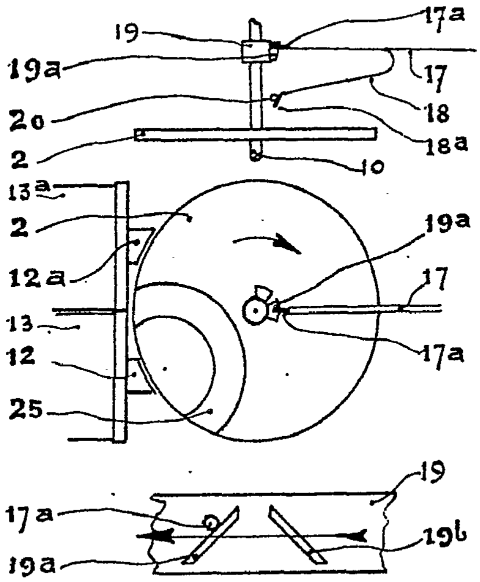


Fig. 5

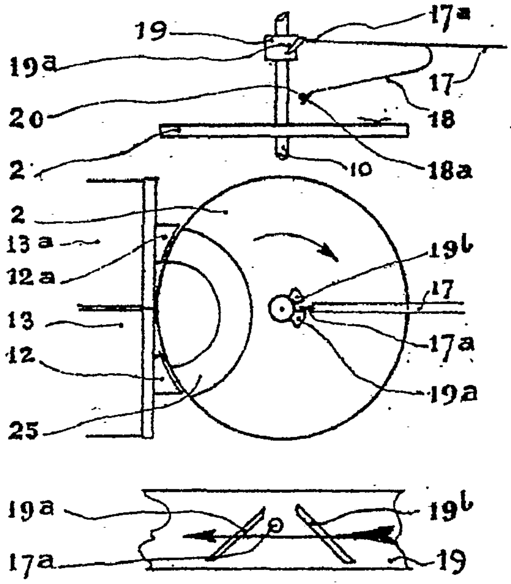
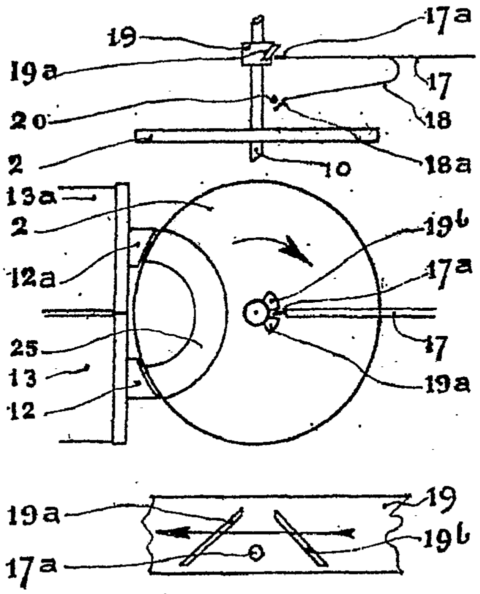


Fig. 6



Malby & Sons Photo-Lith.

Fig. 1

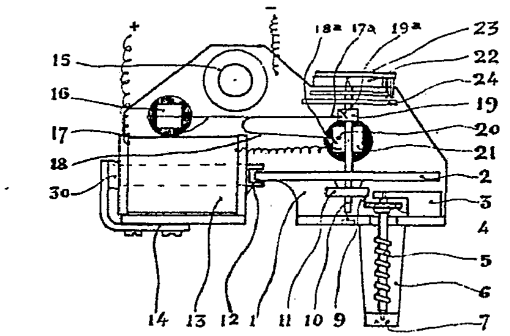


Fig. 2

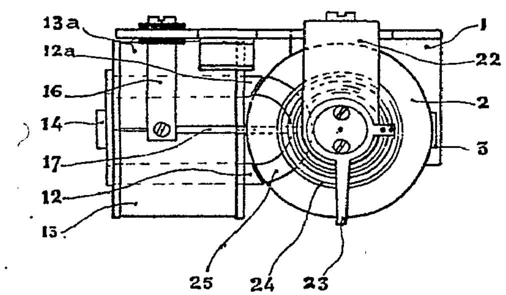


Fig. 3

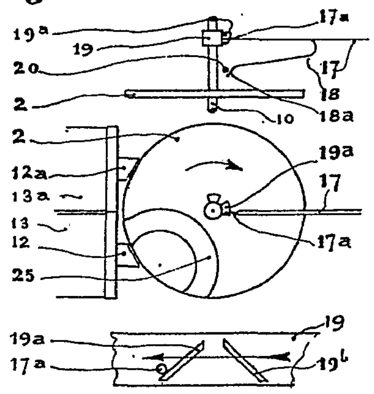
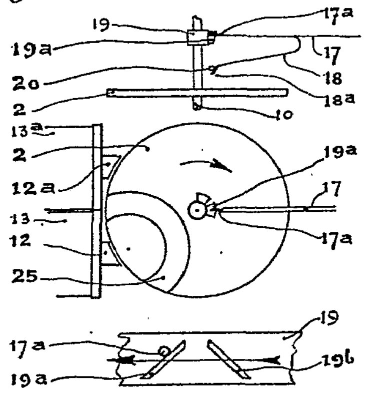


Fig. 4



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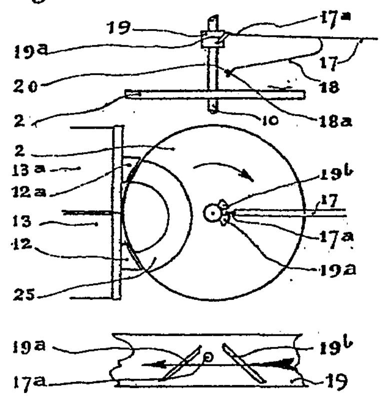

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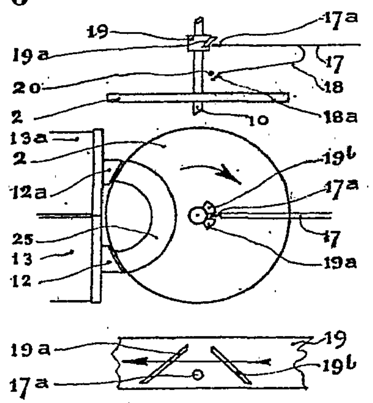

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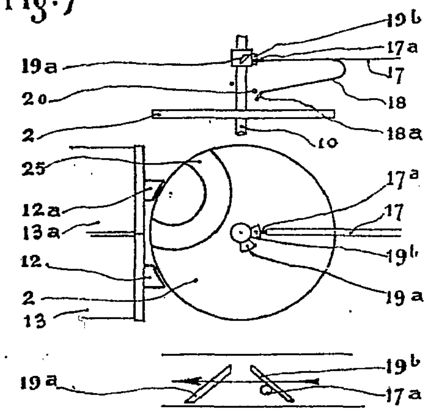

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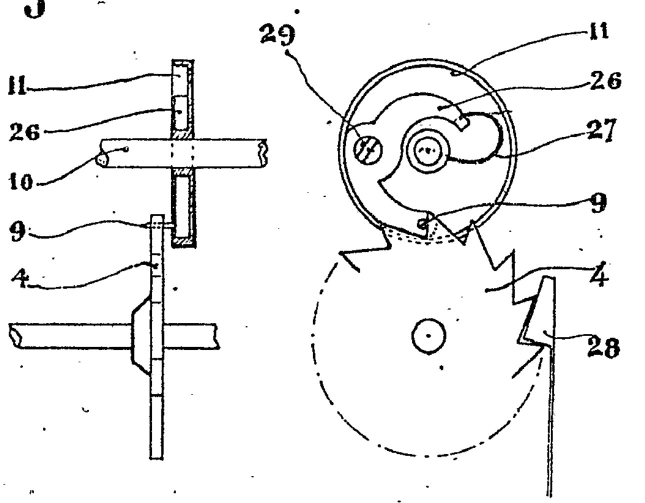

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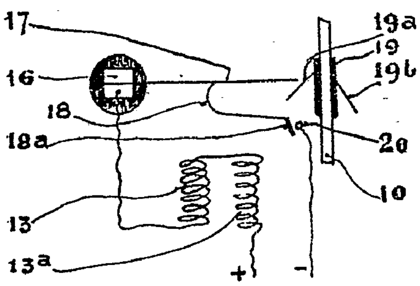

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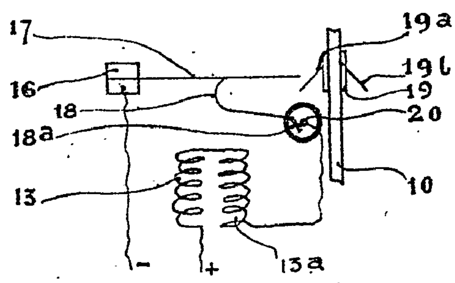

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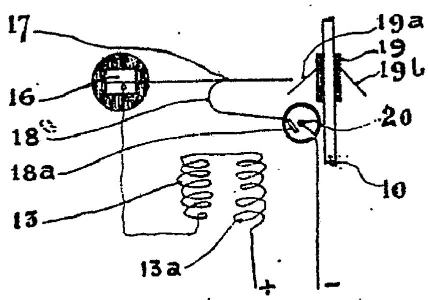

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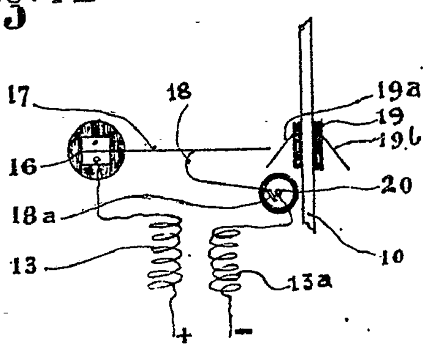

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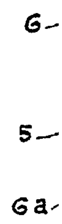
Fig



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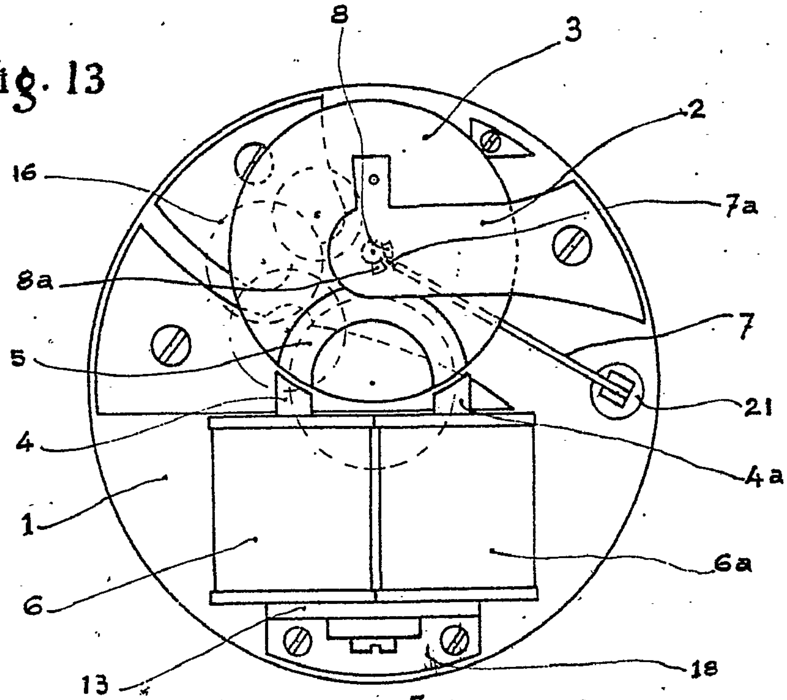

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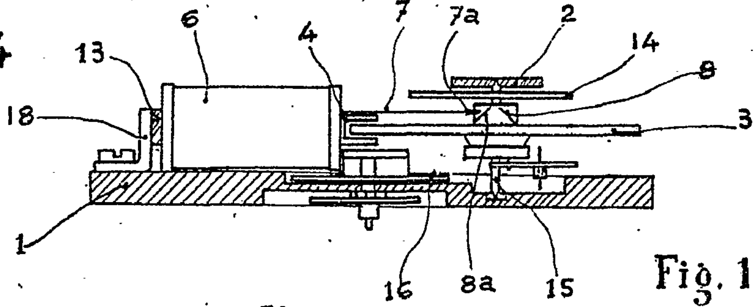

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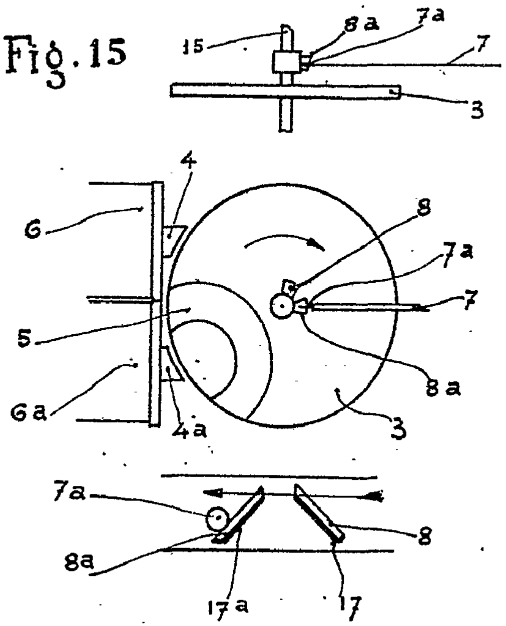

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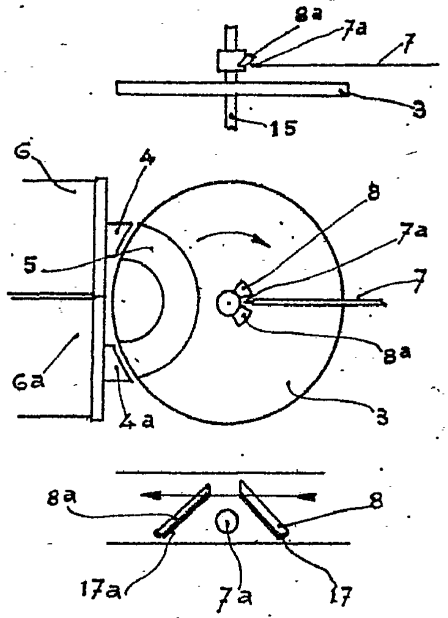

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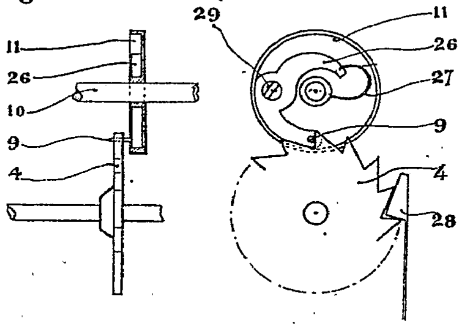

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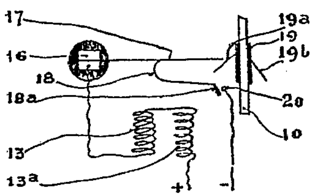

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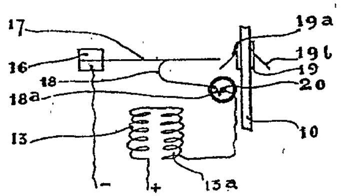

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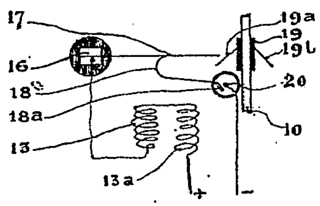

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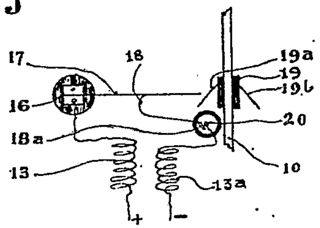

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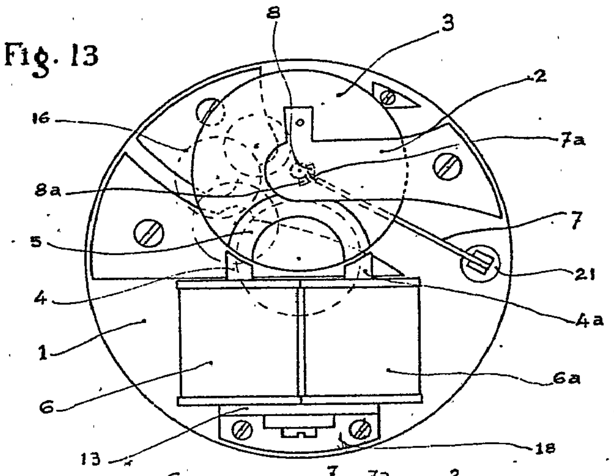

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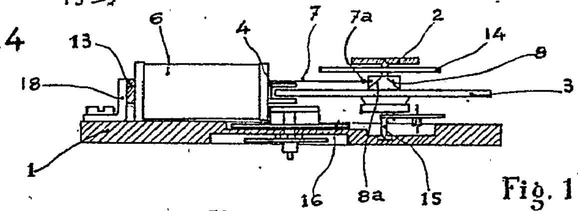

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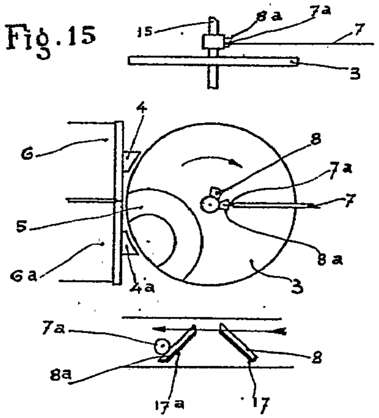

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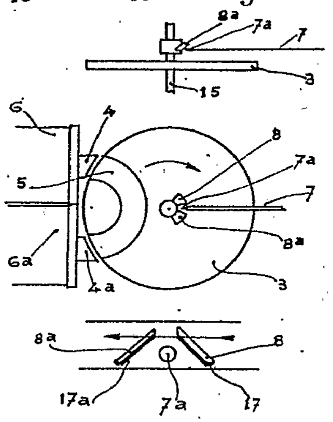

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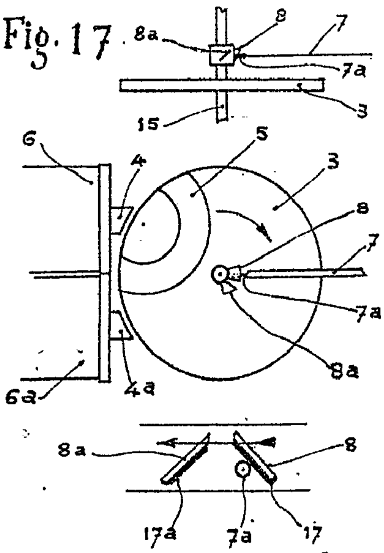

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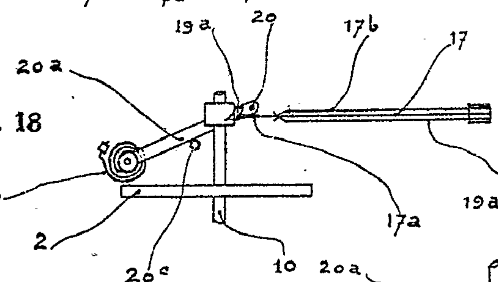

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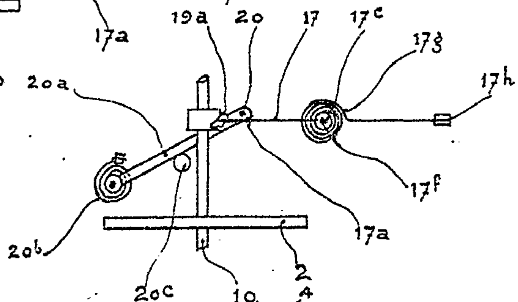

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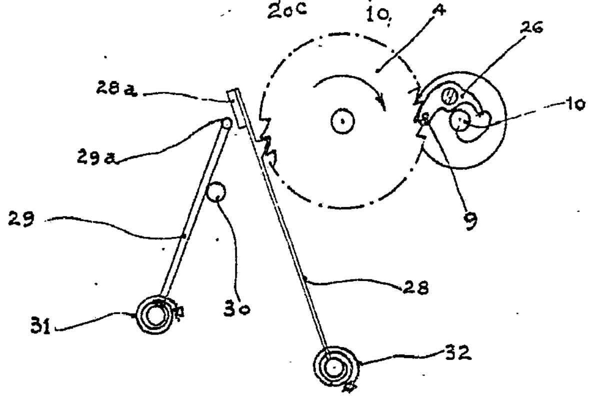

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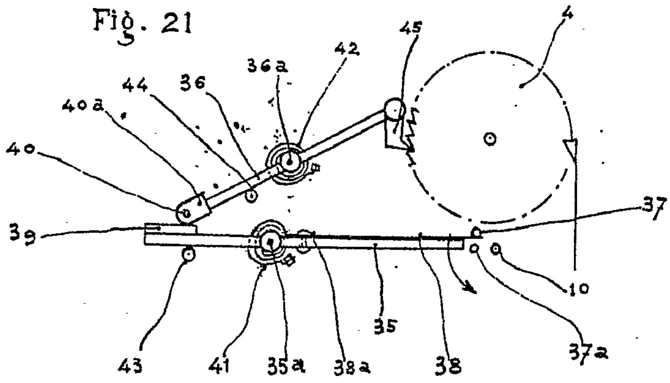

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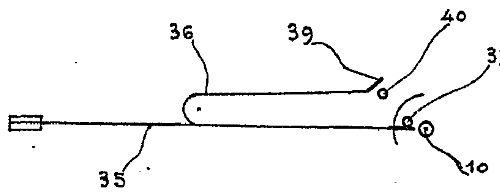

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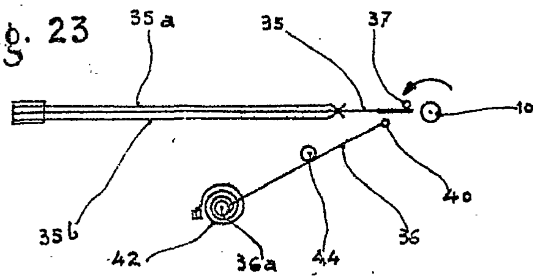

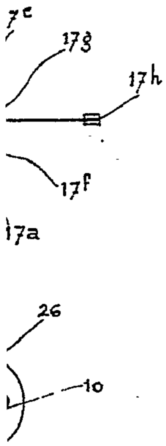

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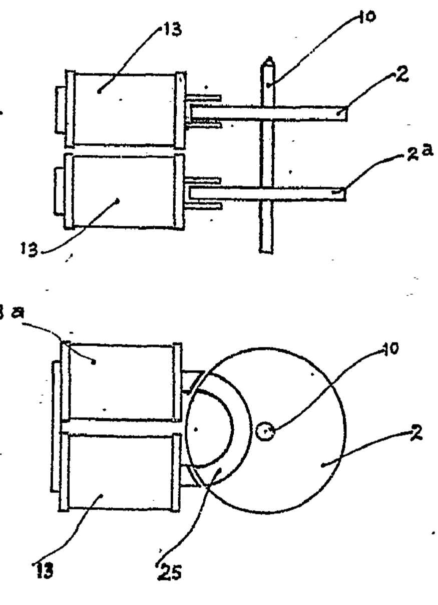
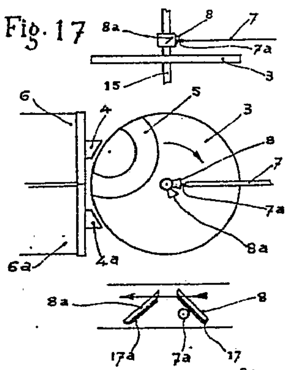


[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 17



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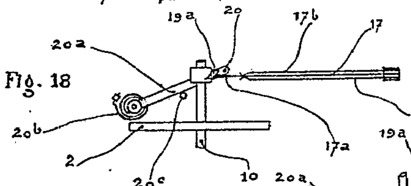

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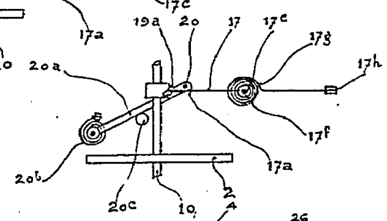

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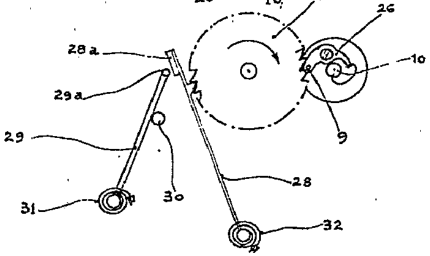

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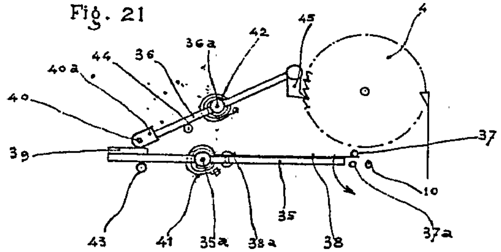

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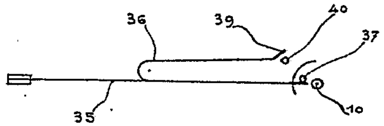

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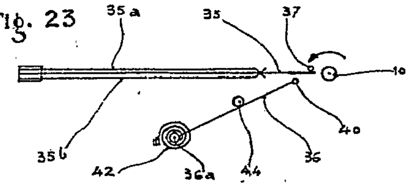

Fig. 24