Sept. 10, 1929. N. L. PILLION 1,728,135

ELECTROMAGNETIC STEPPING MECHANISM

Filed July 16, 1926

Fig. 1.

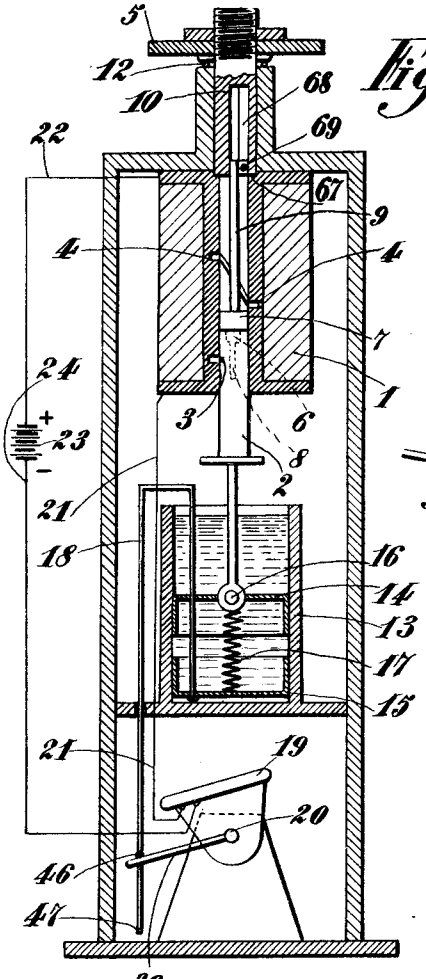


Fig. 2

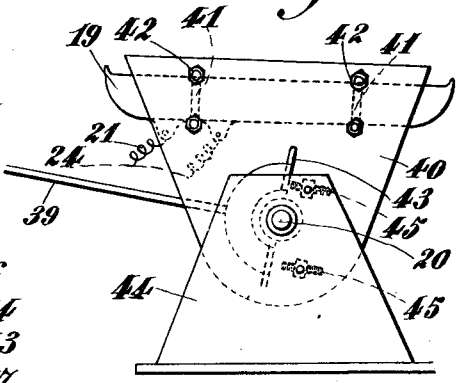


Fig. 4

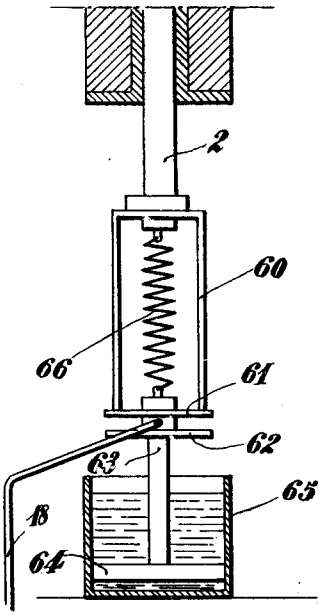
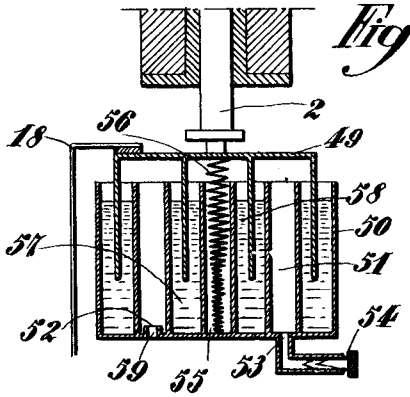


Fig. 3



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UNITED STATES PATENT OFFICE.

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ELECTROMAGNETIC STEPPING MECHANISM.

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In the case of certain electro-magnetic devices, the core moves laterally during the magnetic attraction and it has been attempted to transform this movement into a horizontal rotary movement, but up to the present it has not been possible to obtain positive results.

The invention, therefore, relates to improvements in this type of electro-magnetic devices, the purpose of which is to transform the lateral movement of the core, during its rising movement, into an intermittent horizontal rotary movement. Such a device may, for example, be applied to the step by step drive of a drum which controls the successive passage of a series of panels, objects or images before the eye of the observer.

The invention consists in mounting freely, in the coil and in the prolongation of the core of the electro-magnet, which core is given an upward helicoidal movement through the intermediary of a pin moving in a helicoidal groove, a magnetic member of the same diameter as the core and suitably guided relative thereto as well as relative to an upper plate to which it is connected in such a manner as to entrain it in its rotary movement, but not in its upward movement, the said member being connected by magnetization to the core of the electro magnet as long as current passes through the coil, but is released therefrom when the circuit is broken, and the core falls under the action of gravity.

The invention also consists in providing braking means for the purpose of retarding the rising movement of the core during the passage of the current through the coil and for prolonging the excitation current in the coil, so as to prevent any slipping of the magnetic member upon the core, and to permit of a stoppage of the partial rotary movement as soon as the current ceases to pass without this movement being able to continue under the action of centrifugal force.

The invention also consists in providing a device for regulating the duration of fall of the core when the coil is no longer excited, so as to obtain a predetermined periodicity in the operation of the apparatus.

According to one form of execution of the invention, the braking device consists of two pistons connected together by a spring and moving in a chamber containing a viscous fluid, the upper piston being connected to the core of the electro-magnet by a swivel-joint, and the lower piston having a driving arm adapted to actuate a mercury-switch.

According to another form of execution of the invention, the braking device is constituted by a piston moving in a viscous mass, the rod of this piston being connected by a spring to the core of the electro-magnet, this core carrying a stirrup or yoke adapted to bear upon a washer connected to the piston-rod and said rod carrying the driving arm for the mercury-switch.

When the periods of functioning of the device are to be regulated with greater precision, the braking device comprises a pneumatic bell carried by the core of the electro-magnet and moving in a vessel containing a fluid mass such as mercury, the said bell carrying the driving arm for the mercury switch and being connected to the bottom of the vessel by a spring, an orifice for the admission of air and an adjustable air outlet orifice being provided beneath the bell.

The invention also consists in a switch containing mercury in vacuum, constituted by an oscillating tube containing mercury and connected to the source of electric energy, the axis of oscillation of the said tube being connected to a lever adapted to be actuated by the driving arm carried by the braking device.

Certain forms of execution of the invention have been shown but merely by way of example in the accompanying drawings:

In these drawings, Fig. 1 is a vertical sec-

tion of the electro-magnetic actuating device according to the invention.

Fig. 2 is a view on a larger scale of the mercury switch to be seen in Fig. 1.

Fig. 3 shows a modified form of construction of the braking device, particularly advantageous when it is desired to obtain a strictly constant periodicity of the functioning of the electro-magnetic actuating device.

Fig. 4 shows another modified form of construction of the braking device.

The electro-magnetic driving device comprises a coil 1 (Fig. 1) which acts by magnetic attraction upon a soft iron core 2, provided with a pin 3 which can move during the magnetic attraction in a helicoidal groove 4 formed upon the inner wall of the coil. The arrangement of this pin and of the groove could be reversed without any disadvantage. In this way a helicoidal rotary movement is produced and can be transmitted to any desired member in the form of a horizontal rotation, for example to a plate 5 connected to the core 2. But it is evident that, as soon as the core 2 falls, owing to cutting off of the current in the coil, it will effect the rotary helicoidal movement in the opposite direction, while the plate which is connected thereto will itself effect a horizontal rotation opposite to the former.

The device forming the subject of the present invention relates to means for preventing the plate from moving rearwardly when the magnetic attraction ceases, so as thereby to enable it to be possible to obtain an intermittent horizontal rotary movement in the same direction, which renders it possible to utilize this electro-magnetic driving device for the advancing movement or the step by step rotation of panels or images used for purposes of publicity or others.

As can be seen in Fig. 1, the upper face of the core 2 is recessed so as to receive a head 6 formed upon the lower face of a piece of soft iron 7, said soft iron piece having the same diameter as the core 2 and constituting a prolongation of this latter. The head 6 is provided upon its lower face with a copper guide rod 8 which can move in a corresponding hole in the core 2. Upon its upper face the soft iron member 7 is provided with a rod 9 having a tenon 67 which can move in a vertical groove 68 formed in the support 10 of the plate 5; a ball 69 mounted in the tenon 67 facilitates its rising and falling movements. This tenon 67 could moreover be replaced by any other similar part and, for example, by a roll carried by the rod 9. The plate 5 is fitted with a ball bearing 12.

When the coil is excited, the plate 5 is entrained, by the core during its rising movement, in a horizontal rotary motion. If the magnetic member 7 were not disconnected from the core 2 when this latter falls back under its own weight after cutting off the current, the plate 5 would accomplish at this moment a horizontal rotation in a direction contrary to the first, but this cannot take place, since the magnetic member 7 when falling, is not entrained by the core 2. The plate 5 therefore stops and does not continue its horizontal rotation in the same direction until the coil is again excited.

Beneath the coil 1 there is arranged a braking device comprising a vessel 13 filled with a viscous liquid, such as glycerine, in which are fitted two independent pistons 14 and 15 which can move vertically; the first of these pistons is connected, on the one hand, to the core 2, by the intermediary of a swivel joint 16 and on the other hand to a piston 15 by a spring 17. The piston 15 has an arm 18 the purpose of which is to actuate the mercury switch 19 which will be described below. These pistons 14 and 15 are drilled with suitable orifices so as to facilitate their movements in the mass of glycerine.

The mercury switch is constituted by a vacuum tube 19 (see Fig. 2) containing mercury and provided with two terminals for the conductors 21 and 24, this tube being fixed by means of yokes 41 and nuts 42 upon an oscillating plate 40. This plate is mounted upon a shaft 20 carried by a bracket 44 and is connected to a bar 43 upon which the actuating lever 39 is fixed, the said bar 43 bearing in one or the other of its extreme positions against adjustable abutments 45. The lever 18 of the braking device also carries two abutments 46 and 47 which are adapted to actuate the lever 39 of the switch at the ends of the stroke of the pistons 14 and 15 (and consequently at the ends of the stroke of the core 2). The switch is connected, on the one hand, to the coil 1 by the conductor 21, and, on the other hand, by the conductor 22 to one of the poles of the source of energy 23, the other pole of which is connected to the coil 1.

Supposing that the coil 1 is not excited, the core 2 has fallen into its lowest position as shown in Fig. 1, the rod 18 of the braking device is at its lowest position and has acted by means of its abutment 46 upon the lever 39 thereby causing the mercury tube 19 to swing towards the left; in this position of the tube 19 contact is established and as the circuit through the source of energy 23 is closed, the coil 1 is excited and attracts the core 2. This latter during its rising movement pushes the magnetic member 7 upwards and, by magnetization entrains it in its helicoidal movement of rotation, this magnetic member communicating to the shaft 10 a horizontal rotary movement owing to the engagement of the tenon 67 on the rod 9 in the groove 68. The plate

5 will therefore be entrained in this movement until the abutment 47 acts upon the switch 19 so as to swing it and thus to interrupt the current.

During the helicoidal rising movement of the core 2, the piston 14 rises, entrained by this core in its rising movement, but not in its rotary movement owing to the swivel joint 16, and its rising movement is opposed by the viscous mass which it is forced to pass through, so that the helicoidal ascending movement of the core takes place sufficiently slowly for the movement of the plate 5 to take place with great regularity and so that when the core stops, the plate can not continue its movement under the action of inertia. Shortly after it commences its movement, the piston 14 entrained, through the intermediary of the spring 17, the second piston 15 so that the driving arm 18 is raised in its turn. When the core 2 has arrived at the end of its stroke, owing to its abutting against the coil 1, the excitation current will be slightly prolonged under the action of the spring which, as it resumes its state of normal compression will raise the piston 15 a little more while the piston 14 is immobilized. During this movement of the piston 15, the abutment 47 of the arm 18 comes into action upon the lever 39 and the switch 19 will swing towards the right so as to interrupt the current. At this moment the coil 1 no longer acts upon the core 2 and this latter will fall back under its own weight thereby detaching itself from the magnetic member 7 and will effect a rotary motion in the opposite direction to the first rotary motion, the said motion will be retarded by the difficulty experienced by the pistons 14 and 15 to pass through the viscous mass of the vessel 13; as the contact of the core 2 with the magnetic member 7 is broken, this latter can only fall freely but without being entrained and consequently, without communicating any rotary movement of the plate 5.

As soon as the core 2 and, consequently, the pistons 14 and 15 have moved down sufficiently for the abutment 46 to act again upon the switch 19, this latter will swing towards the left, the circuit will again be closed and the excitation of the coil will cause the rising movement of the core 2 so that the plate 5 will again be given a rotary movement.

The braking device could also be constructed in the manner shown in Fig. 4. In this example, the core 2 carries at its base a yoke 60 which normally rests freely upon a washer 61 which is connected, as is also another washer 62, to the rod 63 of a piston 64. This latter moves in a cylinder 65 containing a viscous liquid such as glycerine. The core 2 is connected by a spring 66 to the rod of the piston 63 and this latter has fixed thereto a driving arm 18 for the mercury switch. By means of this device, the current is prolonged after the core has reached its highest position, owing to the spring 66 which continues to raise the piston 64 until the arm 18 has acted upon the switch 19 so as to interrupt the current. At this moment, the core 2 acts abruptly through its yoke 60 upon the washer 61, so as to cause the piston 64 to descend, but the descent of this latter is retarded by the resistance offered by the mass of glycerine, and continues until the piston 64 has reached the position in which the arm 18 acts upon the switch 19 so as to cause it to swing and to close the circuit again, thereby causing another rotation of the plate 5. It will be seen that in this manner intermittent rotary movement is obtained for the plate 5, this movement being always in the same direction, thus rendering it possible to use this device for causing the step by step rotation of a drum.

In certain cases, such as in the case where the device is used for actuating a drum on which are disposed ordinary images or a text for publicity, the regulation of the periodicity can be obtained sufficiently approximately with the braking devices which have been described above, but this is not the case when it is desired that the images shall succeed each other at strictly equal intervals of time, as would be the case, for example, where an image is required to pass before the eye of the spectator every minute. It will be possible to obtain this precision in the functioning of the apparatus, and consequently to extend the field of its applications, by substituting the braking device shown in Fig. 3 for the one which has been described. In this example, the bell 49 is carried by the core 2 so as to be entrained in its rising movement but not in its rotary movement and plunger into a vessel 50 containing liquid, preferably mercury.

The annular chamber 51 is formed in the vessel 50 and opens at its upper portion beneath the bell 49 and it is provided with an admission opening 59, closed by a flap valve 52, and with a discharge opening 53 which can be adjusted by means of a needle valve 54. In the central portion of the vessel there is also formed a cylindrical chamber 55 in which can move a spring 56 fixed on the one hand to the bell 49 and on the other hand to the bottom of the vessel 50, this spring being preferably conical so as to create a progressive resistance to the rise and fall of the bell. The annular space 57 comprised between the cylindrical chamber 55 and the annular chamber 51 preferably contains the same liquid (in this case mercury) as the rest of the vessel, and the bell is provided with a wall 58 which can move in this annular space 57. The bell 49 carries the

driving arm 18 which acts upon the oscillating mercury switch 19. This pneumatic bell evidently gives a regularity of running which is moreover adjustable and which is almost absolute both as regards the rise and fall of the core.

It will be necessary, however, in order to obtain such strict precision, that the air confined in the bell shall always be of the same composition and the same temperature. It is to be pointed out that in this device the mercury in the vessel 50 plays a double part; it facilitates the rising movement of the valve owing to the difference in its density from that of the metal of the bell, which latter is made of aluminium; and it retards the descending movement for the same reason. The air and the mercury therefore constitute agents of sufficient constancy to allow the obtention of chronometric movements of the electro-magnetic actuating device which has just been described. The result is that it would be possible to cause a partial rotation of the plate 5 at very regular intervals of time, for example, once a minute and to indicate by numbering the images, the duration of each passage of the image. In this way an electric clock could be obtained which would not need any clockwork mechanism. It would evidently be possible to make various modifications in detail in the devices which have just been described without thereby altering the spirit of the invention.

I claim:

1. An electromagnetic actuating device comprising an electric circuit, a coil in said circuit, a core adapted to be moved in said coil when the latter is energized, a rotary plate, means for rotating said plate, and means for electromagnetically coupling said core and said plate-rotating means, said coupling means being rendered inoperative when the current is cut off.

2. Electromagnetic actuating device comprising an electric circuit, a coil in said circuit wound on a spool having a helicoidal groove, a core in said spool and engaging said groove, a magnetizable member forming a prolongation of said core and loosely mounted thereon, a rod resting upon said magnetizable member and adapted to rotate a horizontal plate, said core, magnetizable member and rod being drivingly connected together by magnetization when current is passing through the coil, but when current is cut off, the core performs its descending rotary motion in the opposite direction without entraining the magnetizable member, rod or plate.

3. Electromagnetic actuating device comprising an electric circuit, a coil in said circuit wound on a spool having a helicoidal groove, a core in said spool and engaging said groove, a plate adapted to be rotated horizontally by the ascensional movement of said core in said groove, a rod actuated by said core and adapted to make and break the circuit at the lowest and highest positions of said core respectively.

4. Electromagnetic actuating device comprising an electric circuit, a coil in said circuit wound on a spool having a helicoidal groove, a core in said spool and engaging said groove, a plate adapted to be rotated horizontally by the ascensional movement of said core in said groove, a rod actuated by said core, said rod having abutments, a switch in said circuit, a lever adapted to be be oscillated by said abutments to move said switch to make or break the circuit.

5. Electromagnetic actuating device comprising an electric circuit, a coil in said circuit wound on a spool having a helicoidal groove, a core in said spool and engaging said groove, a plate adapted to be rotated by the ascensional movement of said core in said groove, a rod actuated by said core, said rod having abutments, a mercury switch in said circuit, an arm fixed to the axis of rotation of said switch and adapted to be engaged by one or other of said abutments according as the core is in one or other of its extreme positions.

6. Electromagnetic actuating device comprising an electric circuit, a coil in said circuit wound on a spool having a helicoidal groove, a core in said spool and engaging said groove, a plate adapted to be rotated horizontally by the ascensional movement of said core in said groove, and means connected to said core for retarding the ascensional movement of said core.

7. Electromagnetic actuating device comprising an electric circuit, a coil in said circuit wound on a spool having a helicoidal groove, a core in said spool and engaging said groove, a switch actuated by said core to control the circuit, a plate adapted to be rotated horizontally by the ascensional movement of said core in said groove, a vessel containing a viscous mass arranged beneath said core and a piston attached to said core and immersed in said viscous mass.

8. Electromagnetic actuating device comprising an electric circuit, a coil in said circuit wound on a spool having a helicoidal groove, a core in said spool and engaging said groove, a switch actuated by said core to control the circuit, a plate adapted to be rotated horizontally by the ascensional movement of said core in said groove, a vessel containing a viscous mass arranged beneath said core, a piston immersed in said viscous mass and a spring connecting said core and piston together.

9. Electromagnetic actuating device comprising an electric circuit, a coil in said circuit wound on a spool having a helicoidal groove, a core in said spool and engaging

said groove, a switch actuated by said core to control the circuit, a plate adapted to be rotated horizontally by the ascensional movement os said core in said groove, a vessel containing a viscous mass arranged beneath said core, a pair of pistons immersed in said viscous mass, one of said pistons being connected to the core, the second of said pistons being connected to the switch-operating device, and a spring connecting said pistons.

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