Feb. 13, 1951 J. B. POWERS 2,541,937

GATE OPERATING MOTOR

Filed Aug. 22, 1949 2 Sheets-Sheet 1

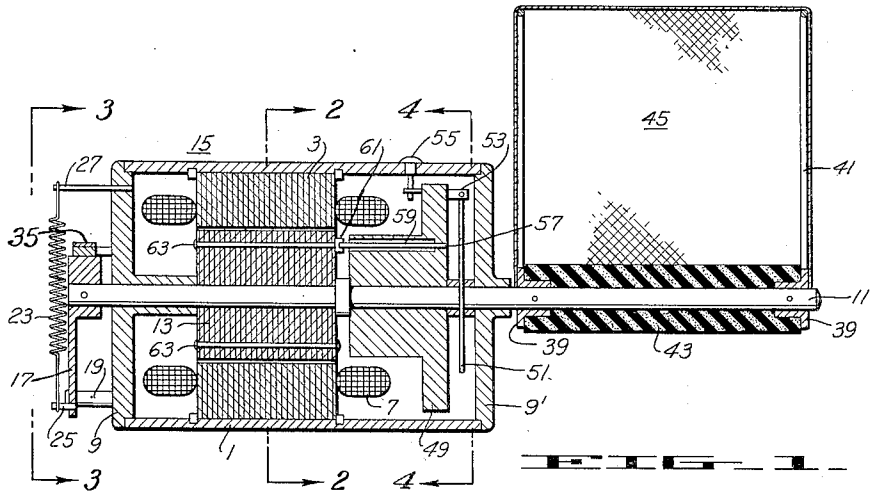


FIG. 1.

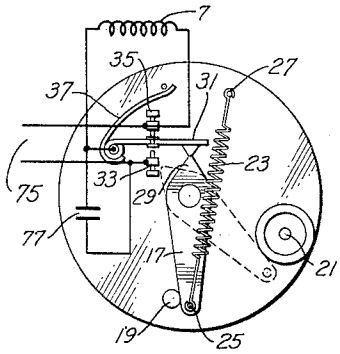


FIG. 3.

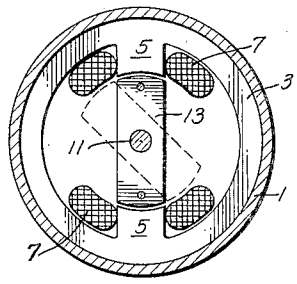


FIG. 2.

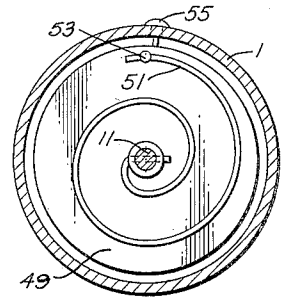


FIG. 4.

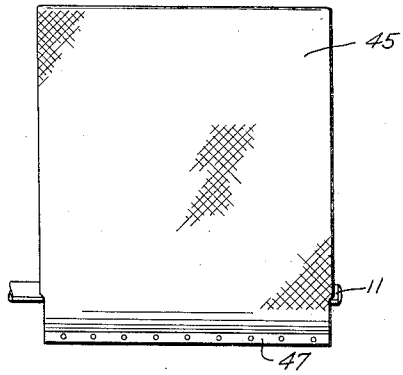


FIG. 6.

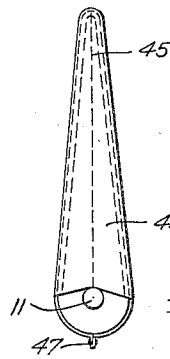


FIG. 5.

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Feb. 13, 1951 J. B. POWERS 2,541,937

GATE OPERATING MOTOR

Filed Aug. 22, 1949 2 Sheets-Sheet 2

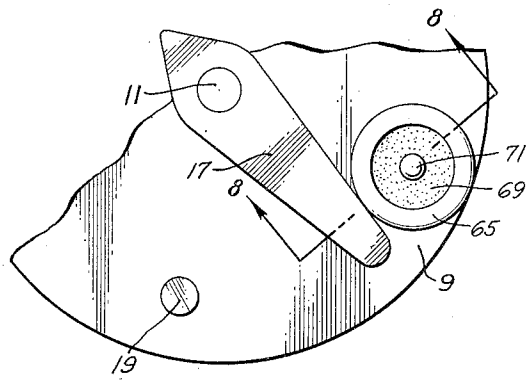


FIG. 7

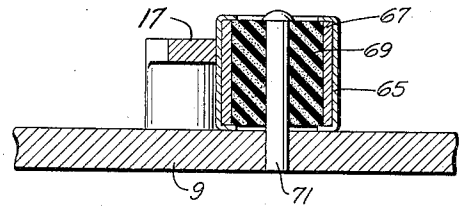


FIG. 8

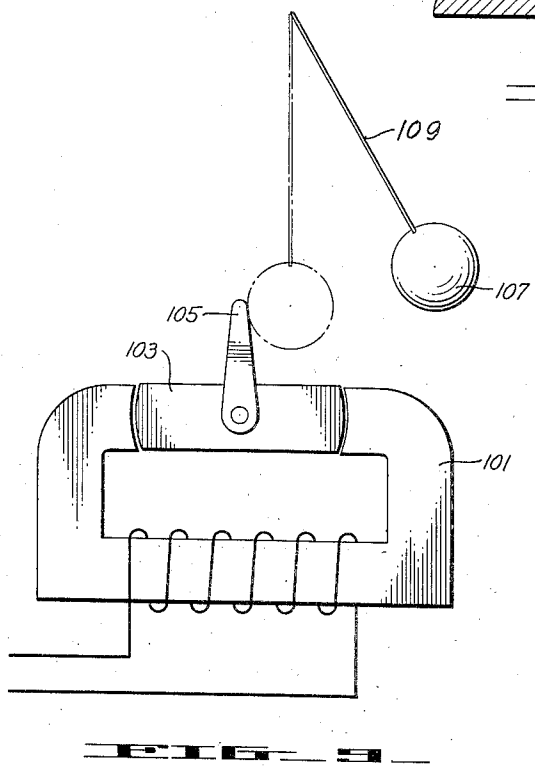


FIG. 9

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2,541,937

GATE OPERATING MOTOR

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Application August 22, 1949, Serial No. 111,720

11 Claims. (Cl. 172—126)

1

This invention relates to electromagnetic motors of a type which will move a mechanical element very rapidly through a limited displacement, hold it in the new position for a short but definite time, and then return it with equal rapidity to its original condition. Such motors are required for various operations, among the most important being in connection with electronic sorting operations of various kinds. In such operations articles of the same general class which differ in some physical characteristic such as diameter, weight, or color are classified within limited ranges of the characteristic by which they differ. In order to accomplish this sorting the objects to be classified are moved successively past some type of discriminating means which is sensitive to the characteristic in question, the movement being sometimes by gravity, sometimes by conveyor of one or another kind. The discriminator actuates mechanisms for directing the variously classified articles into different channels depending upon their classification as determined by the discriminating means.

Guidance of the articles selected to their proper channels requires some sort of a deflecting or gating mechanism. The number of units which may be sorted in any given time is directly dependent upon how rapidly such gating mechanisms may be made to work. Since one of the principal values of electronic sorting mechanisms is the extreme speed with which the electronic portion of the equipment may be made to act it is at once apparent that the limiting factor in connection with any such device is the response time of the motor which operates the gating mechanism. One obvious method of decreasing the response time is by giving the whole mechanism as low an effective mass or inertia as possible. When this factor has been decreased to the limit the next step in decreasing the response time is to increase the actuating force to as large a value as is feasible. With ordinary types of motor there is a limit to this, however, since even moving systems with low inertia are not without momentum when given a relatively high velocity, and when a gate of the character mentioned is opened or closed very rapidly it is difficult to absorb the energy which has been imparted to it, and there is consequently a strong tendency to recoil at the end of either its opening or closing motion.

Most types of sorting mechanisms for classifying objects into more than two simple categories require a plurality of gates arranged in succession, so that the article to be selected will pass

2

into the first channel wherein the gate is open. One such sorting mechanism is shown in my copending U. S. patent application Serial No. 111,719, filed August 22, 1949. In that application I show a plurality of gates arranged in a triangular or "gable" form, with one gate at the top which moves to direct the selected objects down one or the other side of the gable in accordance as it is on one side or the other of the median characteristic according to which selection is being made, and with other gates disposed down the two sides of the gables which open in succession from bottom to top as the critical characteristic increases. In the device as there described the articles to be sorted fall through the device by gravity.

Passage through a device of this kind under the action of gravity is relatively rapid, but the rate of passage does set a limit to the number of articles which can be handled in unit time. Unless elaborate delay mechanisms are used, such as are not ordinarily economically justified, only one article can be passing through the equipment at any one time. A small but finite time is required for the discriminating mechanism to pass its signal to the gates and for the gates to respond. The last gate in the series must be closed and ready for reactuation before the next article is selected. In one embodiment of the invention of the prior application referred to the time required for the objects to be sorted to pass between the discriminating mechanisms and the final gate is approximately one-tenth of a second. The first gate must be positioned and ready to make a selection in a very small fraction of this time, but as soon as its selection is made it can start to return to its "normal" position, and it does no harm if a major portion of the one-tenth second interval is occupied by this return. The lower gates in the series do not have to open so rapidly, but once their selection has been made and the object selected has either been passed by them or deflected by them the more rapidly they close, the sooner a new selection can be made.

The most satisfactory type of motor to operate a gate of this character is one wherein the gate is opened by electromagnetic action and closed by spring or equivalent device as soon as the motor is deenergized. A rotary armature within an electromagnetic field provided with reentrant pole is a logical form for such a motor to take. Assuming that the same amount of energy is used to open the gate in each case and, similarly, to close it, the speed with which the opening and

closing operations take place depends upon the portion of the opening or closing portion of the cycle within which the energy is applied. If the motors for all gates have the same types of field coils and the same average air gaps, so that the total flux when in the fully activated position is the same, a pole piece shaped so that the maximum rate-of-change of flux occurs at the start of the operation will give maximum speed of opening. By shaping the pole pieces variously as between the different gates, and by careful adjustment of spring tensions and moments for closing the gates it is possible with such types of motors to get satisfactory operation, since, at least to a limited extent, an arrangement which will give quick opening will give slow closure and vice versa. With motors of this type it is advantageous, too, to accentuate this tendency, since it gives each gate the maximum time to recover from any recoil effects before it is again actuated.

As will be appreciated from the above description, to set a group of gates in the manner described is a matter of considerable delicacy, which degenerates, in the last analysis, to a cut-and-try operation. A gating system will be equally effective, however, were the gates to be opened and closed at maximum speed, irrespective of their position in the series, if this can be done without incurring recoil phenomena which will effectively vitiate the whole operation.

The broad purpose of the present invention is to provide a motor which will accomplish such maximum speed operations in both directions and, furthermore, which will do this without causing the gates to bounce or recoil. Other objects, contributory to this purpose, are to provide a motor of the character described having maximum initial acceleration, and therefore a maximum velocity of operation; to provide a motor having means for absorbing, practically instantaneously, the energy imparted to its moving system during the operation, storing such energy for a predetermined period, and returning the energy in reverse direction to the moving system after a predetermined time so that closure also will take place at maximum velocity; further, to provide means of absorbing the energy of closure without bounce or recoil.

Considered broadly my invention comprises an electromagnet which is provided with a movable armature which is preferably spring-held in a position where it will be subject to maximum torque upon excitation of the electromagnet, the moving system which is to be activated by the motor being connected mechanically with the armature. Connected to the armature is an impact member which is so placed as to contact a complementary member just prior to the desired position of maximum displacement of the armature; e. g., just prior to the point at which a sorting gate is fully opened. The complementary impact member is attached to a mass which is oscillatorily mounted and which is effectively equal to the effective mass of the armature and moving system applied at the point of impact; in other words, if both armature and mass are pivotally mounted, as will customarily be the case, the moments of inertia of the armature and moving system and that of the mass should be substantially equal. The impact members are so positioned as to contact when the oscillatorily mounted mass is substantially in its neutral position, and, preferably, at least one of the impacting members has some degree of resilience. With this arrangement as much energy as may be desired may be imparted to the armature and moving system when the magnet is excited. The armature may be accelerated throughout its permitted movement up to the point where the impact members come into contact. At this instant substantially all of the energy stored in the moving system will be transferred to the oscillatory mass, by virtue of the principle of conservation of momentum, and the mass will start upon a half-cycle of oscillation the duration of which will be substantially independent of the velocity imparted to it by the impact. At the end of this half-cycle of oscillation the two impacting members will again come in contact, and the energy stored in the oscillatory mass will be retransferred to the armature and moving system in the opposite direction, so that the reverse operation will start at practically the same velocity with which the direct operation ceased, the interval between the opening and closing operations being strictly under control and being one-half period of the oscillatory system, which can be any combination of mass and restoring force such as a pendulum, a balance wheel, or any other of the many well-known types of mechanical oscillator.

The invention will be better understood by reference to the following description of a preferred embodiment of the invention, taken in connection with the accompanying drawings wherein:

Fig. 1 is an axial sectional view of a sorting gate and motor therefor embodying this invention;

Fig. 2 is a transverse section of the motor, the plane of section being indicated by the line 2—2 in Fig. 1;

Fig. 3 is an end view of the motor of Fig. 1, the direction of view being from left to right in the diagram of Fig. 1;

Fig. 4 is a partial sectional view taken on the line 4—4 of Fig. 1, and showing the oscillatory mass and its restoring spring, the elements lying behind the plane of the wheel being omitted from the showing to avoid confusion;

Fig. 5 is an end elevation of a preferred form of sorting gate;

Fig. 6 is a side elevation of the gate shown in Fig. 5;

Figs. 7 and 8 are detailed views of a preferred form of stop for absorbing the energy of the moving system upon the closure of the gate; and

Fig. 9 is a schematic diagram of a different form of the invention, using a gravity-actuated pendulum as the oscillatory mass.

Considering now in detail the preferred form of the invention illustrated in Figures 1 through 6, it comprises a cylindrical casing 1 surrounding a group of laminations 3 which comprise the frame of an electromagnet having a pair of re-entrant poles 5. Each of the poles is surrounded by an exciting coil 7 in a well-known manner. The casing 1 is closed by a pair of end bells 9 and 9' which support an axial shaft 11 to which are secured a laminated armature 13, the gate or other device to be actuated by the motor, generally designated by the reference character 15, and a spring lever 17.

Coacting with the lever 17 are a pair of limit stops 19 and 21 which define the "open" and "closed" conditions of the gate. The limit stop 19 can be a simple pin. The stop 21 is provided with damping or energy-absorbing means and will be described in further detail later.

An off-center spring 23, secured to pins 25 and 27 on the lever arm 17 and the end bell 9

respectively serves to hold the gate normally in the "closed" position. As shown in the drawing this spring is so arranged that movement from closed to open positions increases its extension only slightly, while at the same time this motion greatly decreases the lever arm upon which the spring acts and thus decreases the closing moment when the gate is in the open position. The end 29 of the lever arm is formed as a cam which actuates a contact arm 31 an instant before the gate is fully opened, transferring the arm from a contact 33 to a second contact 35. A leaf-spring 37 serves to hold the contact arm normally against the contact 33.

The armature 13 being fixed to the shaft, the lever arm and stops of course define its positions in both the open and closed conditions of the gate 15. The solid lines in Figures 2 and 3 indicate the "gate open" positions of armature and spring arm respectively, the dotted lines showing the "gate closed" positions. As shown in Figure 2, the ends of poles 5 are arcuate and concentric with the arcuate ends of the armature, poles and armatures being separated by very small air gaps when the motor is in the gate-open position. In the gate-closed position, when the motor is awaiting activation, the armature is preferably just entering the space between the pole pieces, so that as it starts to move the rate-of-change of the flux through it is a maximum. This gives maximum acceleration at the start of its movement and insures that the motion will be accomplished in minimum time.

For the same purpose of insuring maximum speed of action the structure of the gate itself is made as light as possible. In the present gate, where the device is intended for sorting fruit, the gate must be of a material which will not bruise the fruit when the gate is struck by the latter. The gate is accordingly secured to the shaft by two small pulley-like bushings 39, the flanges whereof are grooved. Two ends of a pair of triangular wire frames 41 are brazed into these grooves. A cylinder, preferably of sponge rubber, 43, of about the same diameter as the outer flanges of the bushings 39 is fitted over the shaft between the bushings, and over the whole there is placed a jacket 45 of cloth, fastened at the sides by a seam 45' and secured at the bottom either by sewing or by rivets, as is indicated by the reference characters 47.

As thus far described the motor does not depart greatly from conventional types. Its unique action depends upon the equipment next to be described. This comprises a balance wheel or flywheel 49, which in this case is journalled upon the shaft 11 so that the balance wheel and the remainder of the moving system can have independent motions. Connection between the balance wheel and the shaft is made by a spring 51, which, at one end, passes through the shaft as indicated by Figure 4. Its other or outer end is secured to a stud 53 adjacent the periphery of the wheel. This stud may extend through the balance wheel and form, in conjunction with a pin 55 passing through the casing 1, a stop which limits the motion of the balance wheel.

The balance wheel is also provided with an impact pin 57, preferably made of stiff spring wire, which extends from the outer face of the balance wheel toward the armature through a hole 59 and which engages the large head 61 of one of the rivets 63 which hold the laminations of the armature together.

The spring 51 is a formed spiral approximately

as shown in the figure when it is completely unstressed. It is secured to the shaft in such position that it will be in its relaxed or unstressed condition substantially at the point where the impact members 59 and 61 are in contact. A spring of the type mentioned, corresponding generally to the type used as the hairspring of a watch, exerts approximately equal stress when rotated by equal angles in either direction from its neutral position; i. e., whether the coils of the spring are opened or closed. The stops 53 and 55 are positioned so that the balance wheel cannot follow the armature and shaft into the gate-closed position; i. e., the positioning of the parts is such that the spring 51 is stressed when the gate is closed so as to hold the stops 53 and 55 together, and, further, so that the impact members 59 and 61 contact just before the gate is in the fully opened position.

The mass, or, more properly, the moment of inertia of the balance wheel about the shaft is important. This is so computed that it is as nearly as possible equal to the combined moment of inertia of the entire system comprising the gate, the armature, the shaft and the spring lever 17. It may be pertinent to note that in spite of the light construction of the gate the moment of inertia of the outer third of the gate structure is about the same as that of all of the rest of the system combined.

As a result of the structure which has been described, when the gate is in the closed position, held there by the tension of the spring 23, the stops 53 and 55 constraining the balance wheel are in contact and held there by the spring 51, the action of the latter tending to oppose that of the spring 23. The latter should be, at this point, stressed just sufficiently definitely to overcome the tension of spring 51 and hold the gate closed.

When the motor is excited the armature 13 flips rapidly into the position indicated by the solid lines in Figure 2. Just before it reaches this position the impact members 59 and 61 engage and the momentum of the moving system is almost instantaneously transferred to the balance wheel, spring 51 being unstressed at the instant of contact. The resilience of impact member 59 should be just sufficient to make the impact perfectly elastic, and prevent peening of the members 61 and 59 by the force of the blow. If this is done and the parts are properly proportioned the moving system will be brought to rest just as the spring arm 17 comes in contact with the stop pin 19, all the energy of the system having been transferred to the balance wheel.

The balance wheel starts to rotate at substantially the same angular velocity as that which the armature had just before the impact, the spring 51 being increasingly stressed as rotation of the wheel continues. The stress on the spring decelerates the balance wheel, and eventually reverses its direction of rotation. As long as it is stressed it tends to hold the spring arm 17 against the stop 19 against the relatively small moment of the spring 23 when the arm is in this position. The balance wheel accordingly attains substantially the same velocity, (although in the opposite direction) as was imparted to it by the armature, and at approximately the point at which its excursion started the impact members 59 and 61 again engage, the wheel transferring its momentum back to the remainder of the moving system and coming to rest, practically without jar, against the stop 55 and the gate starting

its closing movement with maximum velocity, having been knocked shut by the balance wheel. In its closing the gate is given some slight additional acceleration by the spring 23.

It will be seen from the above that the time that the gate remains open is equal to one-half period of the balance wheel and spring 51 considered as a mechanical oscillatory system. The length of this half period can be controlled by adjusting the stiffness of the spring 51, the effective mass of the balance wheel having been dictated by the fact that its moment of inertia must be equal to that of the parts rigidly mounted to the shaft 11.

The strength of the spring 23 is dictated by that of spring 51, being just strong enough, when applied through its maximum lever arm with the gate fully closed, to overcome the moment applied by spring 51.

Since the gate is traveling at high velocity at the instant of closure means are provided for absorbing its energy to prevent its recoil. Such energy-absorbing means are embodied in the stop 21. The latter comprises an annulus 65, preferably of hardened steel, the mass of which is equal to the equivalent mass of the rotating system referred to the point of impact with the arm 17. In order to attain this mass with reasonable size the annulus 65 may be loaded by means of an inner ring 67 of lead or other heavy material. The remainder of the annulus is filled with a semi-resilient material having a high internal hysteresis, such as the synthetic rubber sponge 69. The whole stop is secured to the end plate 9 by a stud 71. With this arrangement the energy of the rotating system is transferred to the loaded annulus 65 upon the impact, but instead of being returned to the moving system as in the case of the balance wheel the energy is dissipated both by friction between the annulus and the end plate 9 and by the mechanical hysteresis of the synthetic sponge rubber.

It may be noted here that the stop 21 is not necessarily mounted in the position shown. If the arrangement of the remainder of the structure permits the stop may be placed where it will be engaged by the gate itself. If this be done good design dictates that it be located where it will engage the center of percussion of one of the members 41. Since the lever arm with respect to the rotating system will be longer in the latter case than it will be if the stop is located at the position shown and the effective mass of the rotating system will therefore be smaller when referred to this point of impact, the mass of the annulus 65 will, in this case, also be smaller, and loading with lead may be unnecessary.

Thus far nothing has been said of the electrical system for operating the motor, and it should be evident that the latter will perform its function with many different types of exciting circuit. The particular embodiment of this invention which has been here described in detail was originally designed for use with a sorting circuit of the type described in my copending U. S. patent application Serial No. 111,718, filed August 22, 1949. That particular circuit is not necessary, however, for successful operation of the device here claimed, all that is required being some means of supplying an actuating pulse of sufficiently long duration to accomplish the opening of the gate. Figure 3 shows, schematically, connections to a circuit 75 through which such a pulse may be supplied. One side of the circuit connects to contact 33, and then (when the gate is in closed position) through contact arm 31 to one end of the magnet winding 7. The other end of this winding connects to contact 35 and the other lead 75. A condenser 77 is shunted across the contact arm 31 and contact 33.

The contact 33 is so adjusted that its connection with the contact arm 31 is broken at substantially the same instant that the impact members 59 and 61 engage. The inductance of the electromagnet is considerable, and current therefore tends to continue to flow, this current being supplied by condenser 77 up to the instant when contact 35 makes connection with arm 31 shorting the magnet coil. This inductive current serves to hold the armature in the gate-open position during the very short interval when the spring 51 is unstressed, but it has died out completely by the time the balance wheel makes its return oscillation so that there is no magnetic force tending to hold the gates open when the instant for its closure arrives. When this instant does occur the balance wheel is traveling so rapidly and the moment of spring 23 is so small, due to its short lever arm in this position, that no material acceleration of the moving system takes place in the very short period between the time when spring 51 is sufficiently relaxed so that spring 23 could overcome its tension and the instant of impact between the elements 59 and 61.

In the particular application for which this motor was first designed it was desired that the gate should remain open for a period of about one-tenth second. It has been found that such a period can be very accurately achieved, and that by varying the spring 51 the open period can be varied almost at will, both through periods of a third this length or less through periods up to several times as great. Compensatory adjustments must also be made in the strength of spring 23, but such adjustments have no direct effect upon the time which the gate remains open or upon the time required for its change from the open to the closed position but, instead, relate solely to holding the gate closed during intervals of inactivation and to prevent premature closing through the application of unnecessary force in the brief interval between the time when spring 51 is nearly relaxed and the time when the impact members 59 and 61 engage.

It should be apparent that the mechanical form in which this invention is embodied can be altered very widely without departing from the principles here disclosed. Almost any type of mechanical oscillatory system can be used instead of the balance wheel, one of the simplest being a gravity-operated pendulum as is shown diagrammatically in Figure 9. In this case the electromagnet 101 is shown as provided with a rotary armature 103, and in the fully actuated or attracted position the impact member 105 contacts, directly, the bob 107 of a pendulum 109. The latter is so suspended that it hangs vertically, i. e., in its neutral position, at the instant before impact. The time of operation of such a device would depend upon the length of the pendulum stem. Such a device would be bulky and clumsy in comparison with the one shown in detail, and it is illustrated merely to indicate that the principles of this invention can be incorporated in forms quite different from those of the preferred type of the device. For such applications as this a centrally pivoted rotary armature is to be preferred because of its high initial acceleration and the consequent speed with which it acts, instead of pendulums of either the gravity

or the torsional type such as the balance wheel which is preferred. Because of this general applicability of principle the forms fully shown are not to be considered as limiting, but as illustrative merely.

I claim:

1. A motor for opening and closing sorting gates or like functions comprising an electromagnet, a moving system including an armature for said magnet and means for normally holding said armature in position for movement by excitation of said magnet, a mass mounted for oscillatory movement adjacent said armature, and mutually engaging impact members mounted on said mass and said armature respectively, said members being positioned to engage at a point where said armature is approaching the limit of movement by said magnet and said mass is approximately in its neutral position, said moving system and said mass having substantially the same effective inertia whereby the major portion of the momentum of said moving system is transferred to said mass at the limit of its motion and is returned to said moving system in opposite sense after one-half oscillation of said mass.

2. A motor in accordance with claim 1 wherein at least one of said impact members is resilient.

3. A motor in accordance with claim 1 wherein said mass is a spring restrained balance wheel.

4. A motor in accordance with claim 1 including a rotatably mounted shaft for said moving system and armature, and wherein said mass is a spring restrained balance wheel mounted on said shaft.

5. A motor in accordance with claim 1 wherein said means for normally holding said armature in position for actuation by said magnet comprises an off-center spring positioned to exert minimum moment when said armature is in fully attracted position and maximum moment when in inactivated position.

6. A motor in accordance with claim 1 including means for shorting said electromagnet when said armature is in fully attracted position.

7. A motor of the class described comprising a reentrant-pole electromagnet, an axial shaft through said magnet, an armature fixed to said shaft, a balance wheel mounted for rotation on said shaft, mutually engaging impact members on said armature and balance wheel, resilient means for holding said armature out of alinement with the poles of said magnet when said motor is inactive, a spring connecting said balance wheel and shaft, said spring being substantially relaxed when said impact members are engaged, and a stop positioned to limit the motion of said balance wheel to prevent engagement of said impact members until said armature is substantially in alinement with said poles.

8. A motor in accordance with claim 7 including a pair of stops positioned to limit the movement of said armature in its actuated and unactuated positions.

9. A motor in accordance with claim 7 including a pair of stops positioned to limit the movement of said armature in its actuated and unactuated positions, said last mentioned stop including energy-absorbing means for preventing recoil.

10. A motor in accordance with claim 7 including switching means actuated by said armature when substantially in actuated position for shorting said electromagnet.

11. A motor in accordance with claim 7 including a pair of stops positioned to limit the movement of said armature in its actuated and unactuated positions, said last mentioned stop comprising an annular mass, a stud for supporting said mass, and a semi-resilient material of high mechanical hysteresis interposed between and secured to said mass and stud.

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The following references are of record in the file of this patent:

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