May 10, 1949. H. MAERZ 2,469,834

ELECTRIC CLOCK MOTOR AND SYSTEM

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Fig. 1.

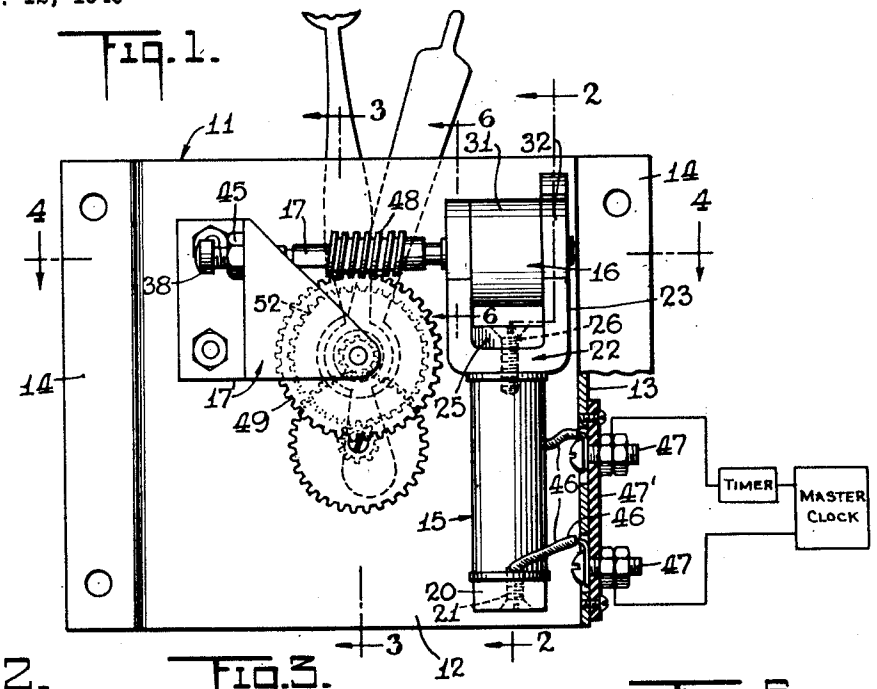


Fig. 2.

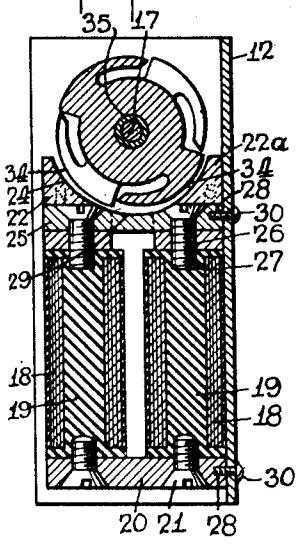


Fig. 3.

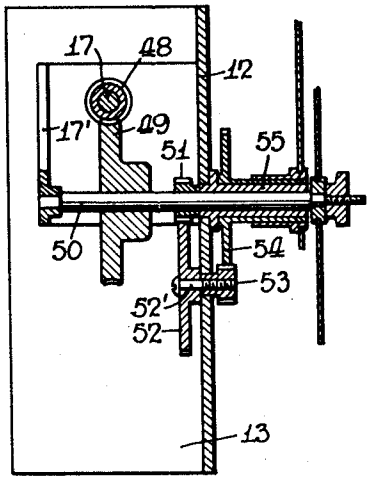


Fig. 5.

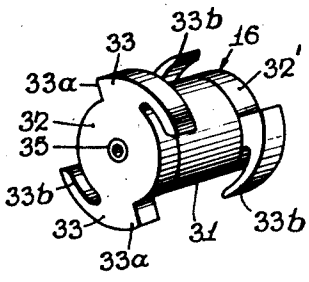
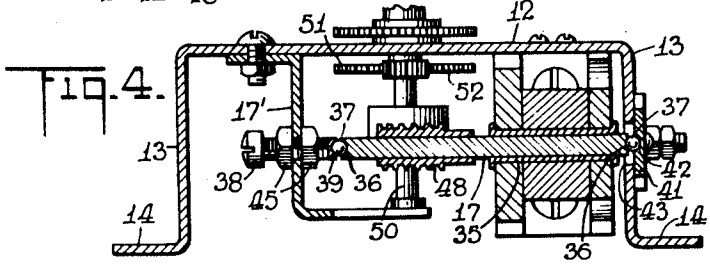


Fig. 4.



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FIG. 6.

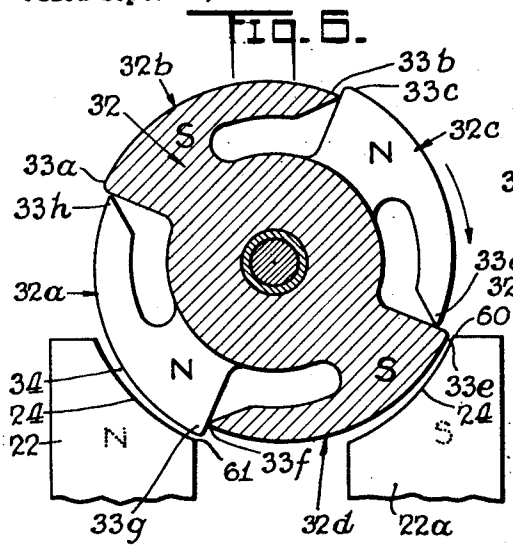


FIG. 7.

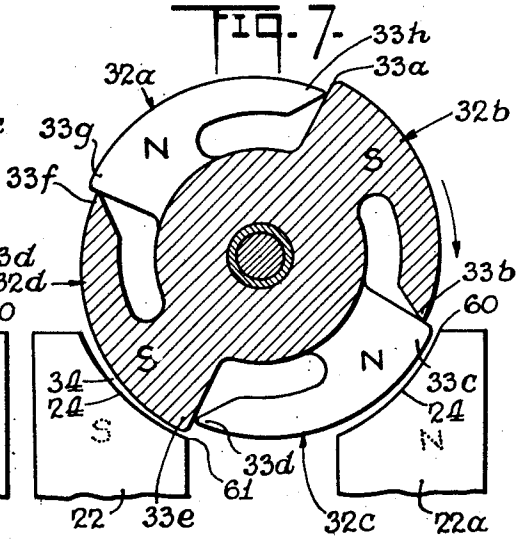


FIG. 8.

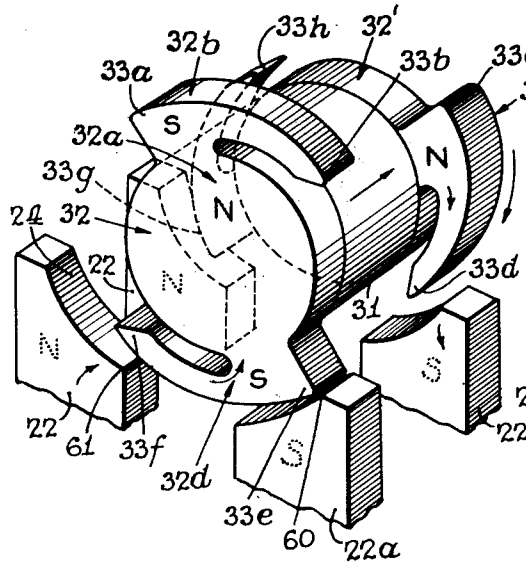
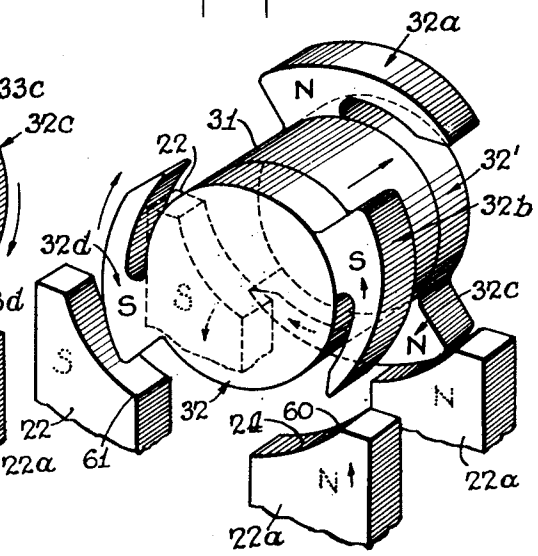


FIG. 9.



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ELECTRIC CLOCK MOTOR AND SYSTEM

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Application September 12, 1946, Serial No. 696,591

4 Claims. (Cl. 172—275)

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This invention relates to intermittent motors which, though of more general utility, are especially useful for driving secondary clocks.

As conducive to a clear understanding of the invention, it is noted that in a system in which a number of clocks are actuated from a master clock that sends out impulses at predetermined time intervals, it is desirable that the secondary clock motors be small and efficient in operation with the consumption of a minimum of current, so that a system incorporating a considerable number of secondary clocks may be operated without the need for heavy and expensive wiring.

In a system such as the one above described, the periodic impulses from the master clock will effect step-by-step rotation of the secondary clock hands and for accuracy it is important both that each step should be a uniform fraction of the sixty-minute period and that only properly timed impulses from the master clock should cause the step-by-step rotation.

Unless some means is provided to limit the movement of the clock hands, the inertia of the clock motor armature during each impulse from the master clock might drive the hands of the secondary clock through an interval greater than that intended. Where it is attempted to limit the movement of the clock hands by ratchets or oher mechanical means, the clock will require additional parts that add to the bulk and cost, that are subject to wear and will be noisy in operation.

It is accordingly among the objects of this invention to provide an intermittent electric clock motor driven solely by periodic electric impulses controlled from the master clock to advance at each impulse through a uniform predetermined fraction of the sixty-minute period, which clock motor is silent in operation, neat, compact and sturdy in construction of but few simple moving parts that are easy to assemble, which is not likely to get out of order, which draws but little current, is not subject to disturbance from inductive impulses due to other apparatus on the same circuit, nor does itself cause such disturbances, is efficient in operation, not subject to undue wear and is devoid of auxiliary parts such as ratchets, pawls, springs or stops.

In the accompanying drawings in which are shown one or more of various possible embodiments of the several features of the invention,

Fig. 1 is a rear elevation of the secondary clock, diagrammatically showing a master clock and timer connected thereto,

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Fig. 2 is a longitudinal sectional view taken along line 2—2 of Fig. 1,

Fig. 3 is a longitudinal sectional view taken along line 3—3 of Fig. 1,

Fig. 4 is a transverse sectional view taken along line 4—4 of Fig. 1,

Fig. 5 is a perspective view of the rotor of the clock motor,

Fig. 6 is a fragmentary transverse sectional view of the motor on a larger scale, taken on line 6—6 of Fig. 1,

Fig. 7 is a view similar to Fig. 6 with the armature rotated 90 degrees,

Fig. 8 is a fragmentary perspective view of the motor substantially in the position shown in Fig. 6, and

Fig. 9 is a view similar to Fig. 8 with the armature rotated 90 degrees to substantially the position shown in Fig. 7.

Referring now to the drawings, the clock comprises a housing 11, which in the embodiment shown has a front panel 12 illustratively rectangular in shape and sides 13 with flanges 14 thereon for mounting purposes, but which may be of any other suitable shape.

The clock motor comprises an intermittently energizable electromagnet 15, and an armature or rotor 16 therefor mounted on a shaft 17. The electromagnet comprises a pair of parallel solenoid coils 18 each having a soft iron magnetic core 19 connected by a soft iron bar 20 affixed to each of the iron cores at one end thereof by a screw 21. Affixed to the respective free ends of the iron cores 19 by a non-magnetic bar 25 are substantially U-shaped soft iron pole pieces 22 and 22^a, each having a pair of arms 23. The non-magnetic bar 25 rests upon and bridges between pole pieces 22 and 22^a, is positioned between the arms 23 thereof, and is affixed to the iron cores by screws 26 which pass through bar 25 and pole pieces 22 and 22^a, respectively, into threaded holes 27 in each of the iron cores. The pole pieces each have an arcuate cavity 24 in opposing faces thereof which, together with depression 29 at the mid-point of bar 25 form the cradle for the armature or rotor 16.

Bars 20 and 25 have threaded holes 28 at one end thereof and are affixed against the inner face of front panel 12 by screws 30, thereby holding the electromagnet in place with the length of the solenoid coils parallel to both front panel 12 and the sides 13 of the housing. The two free leads 46 from the solenoid coils are affixed to terminal posts 47 mounted on terminal strip 47' at the side 13 of the housing.

The armature or rotor 16 which is cradled between the pole pieces 22 and 22a comprises a central sleeve or core 31 of "Alnico" or other permanently magnetized material. Affixed to the sleeve or core 31 at each end thereof are end pieces 32 and 32' of magnetic material, each having a plurality of pole shoes that are integral parts thereof. The pole pieces are so spaced, as shown in Figs. 6 and 7, that the peripheral length of each pole shoe is slightly less than the distance between the upper end 60 of pole piece 22a and the lower end 61 of pole piece 22.

The sleeve or core 31 of the armature and the end pieces 32 and 32' are held together by a hollow rivet 35 which passes through the core and the end pieces. The end pieces are so displaced on the core that each of the pole shoes of one end piece is midway between consecutive pole shoes of the other end piece. Inasmuch as each end piece, in the embodiment shown herein, has two pole shoes, the pole shoes of one will be displaced 90 degrees with respect to those of the other.

As shown in Figs. 6 and 7, the heels 33a and 33e of pole shoes 32b and 32d and the heels 33c and 33g of pole shoes 32c and 32a are diametrically opposed. Each shoe has a leading toe 33b, 33d, 33f and 33h which all point in the same peripheral direction. Preferably, as shown in the embodiment herein, the periphery of each of said shoes is curved so that the radial distance from the axis of the rotor to the heel is greater than the radial distance to the tip of the toe. However, the periphery of each of the pole shoes may be concentric with the axis of the armature and the cavity in each of the faces of the pole pieces may flare, or the cavity in the face of the pole piece may flare and the periphery of the pole shoe may be as shown in the preferred embodiment.

When any portion of a pole shoe is adjacent the arcuate face 24 of a pole piece, the curvature of the adjacent faces of the pole piece and the pole shoe is such that a substantially wedge shaped air gap 34 is formed for the purpose hereinafter set forth.

The armature is secured by force fit on shaft 17, the latter passing through the hollow rivet in the armature. Shaft 17 has ball seats 36 at each end thereof in which rest anti-friction balls 37 and is supported at one end by adjusting screw 38 which has a ball seat 39 at one end thereof engaging corresponding anti-friction ball 37. The adjusting screw is supported by a bracket 17' perpendicularly affixed to the inner face of front panel 12. The other end of the shaft is supported by a bearing in the side 13 of the housing which comprises a plate 41 having a ball seat 42 therein in which rests the other anti-friction ball 37, said plate being superposed over opening 43 in side 13. Lateral adjustment of shaft 17 to loosen or tighten the anti-friction bearings at each end thereof is achieved by adjusting lock nuts 45 on adjusting screw 38.

Shaft 17 is parallel to front panel 12 of the housing and the armature is of such axial length that each end piece thereof is aligned with the arms of opposing pole pieces, as shown in Fig. 1.

A clock gear train is driven from the shaft on which the armature is mounted and, as shown, comprises a worm 48 affixed to the shaft 17 and a worm gear 49 meshing with the worm 48 and mounted on a shaft 50 which bears at its ends in bracket 17' and front panel 12. Upon shaft 50 is keyed a pinion 51 meshing with a gear 52 which has a shaft 52' through plate 12. A pinion 53 rotatable with gear 52 meshes with gear 54 rigid with sleeve 55 encompassing shaft 50. The minute hand may be mounted on shaft 50 and the hour hand on sleeve 55.

The secondary clock motor is actuated by impulses from a master clock which is diagrammatically shown connected to the terminals 47 of the secondary clock in Fig. 1. A timer located at the master clock alternates the polarity of the impulses at the rate desired.

Operation

In the embodiment shown herein, the solenoid coils are connected in such a manner that the magnetic flux created by the coil current is in series in the cores of both coils. The two coils are preferably connected in series but may be connected in parallel to produce this result. The polarity of the current through the coils is periodically reversed by means of the timing mechanism located at the master clock. In usual practice, this reversal occurs twice a minute, each impulse lasting approximately one second. On each reversal of the polarity of the current, the armature will be rotated 90 degrees in the same direction as will be hereafter explained, the clock gear train thereby moving the clock hands one-half minute.

To illustrate the operation of the motor, when an impulse of current is applied to the electromagnet windings of the clock, the armature of which is in position shown in Figs. 6 and 8, the pole pieces will become of opposite polarity, for example, pole piece 22 a north pole and pole piece 22a a south pole. As the end pieces of the armature are permanently magnetized due to the influence of permanently magnetized core 31, end piece 32 always is a south pole and end piece 32' a north pole.

Accordingly, the pole piece 22, now a north pole, will exert a torque upon the armature by attracting the pole shoe 32d of the south end piece 32, since the toe 33f thereof is adjacent said pole piece. A similar attraction will be exerted at the same time by pole piece 22a, now a south pole, upon pole shoe 32c of the north end piece 32' of the armature.

Inasmuch as pole pieces 22 and 22a are at this time respectively of the same polarity as heels 33g and 33e that are respectively contiguous thereto, the resultant repulsion between the heels and the pole pieces will initially be in a radial direction and therefore will exert no torque. However, once the armature starts rotating as a result of the attraction of toes 33d and 33f by pole pieces 22a and 22, respectively, the repulsion of heels 33g and 33e by pole pieces 22 and 22a respectively will also aid in the turning of the armature.

As has been heretofore described, when a pole shoe and an arcuate face of the pole piece are adjacent, a substantially wedge shaped air gap 34 is formed. As the toe of the shoe rotates so that it is in juxtaposition with a pole piece, the gap between the two is widest at the tip of the toe and hence the flux transmission is least at that point. The flux transmission and hence the attraction is greatest at the point of the narrowest gap which will be when the heel of the pole shoe rotates into close juxtaposition to the pole piece. Consequently there will be a tendency for the pole shoe and hence the armature to rotate to the position of minimum air gap between the pole piece and pole shoe.

The magnetic flux will find a path of least re-

luctance from north pole piece 22 into south pole shoe 32d of end piece 32 which now is in close juxtaposition with pole piece 22, thence through core 31 of the armature into the north pole shoe 32c of end piece 32' which is now in close juxtaposition with south pole piece 22a and thence into the south pole piece 22a.

The clockwise rotation of the armature through a quadrant is thus initiated by the attraction by pole pieces for pole shoes of opposite polarity, which attraction is thereupon aided by the repulsion of pole shoes by pole pieces of like polarity, and the rotation is further aided by the wedge shape of the air gap between pole piece and pole shoe.

Inasmuch as the armature is permanently magnetized, when the current is off, pole pieces 22, 22a, cores 19 and iron bar 20 form a closed circuit with respect to the magnetized armature. The armature will rotate in its bearings until it reaches a point of equilibrium which will be at a point of maximum flux transmission between the pole shoe and the pole piece. Since the pole shoes are identical, as are the pole pieces, the point of equilibrium will be the same at each reversal of current. Accordingly, although there is a slight overrunning of the armature due to its inertia when acted on by the electromagnets, the armature will automatically settle back into place so that each movement thereof is exactly 90 degrees.

The armature having been brought to the position shown in Fig. 7, at the next impulse from the master clock of reversed polarity, the pole piece 22 that was formerly a north pole will now be a south pole and vice versa, as shown in Figs. 7 and 9 and at this time, the south and north toes 33b and 33d of the pole shoes 32b and 32c are in close proximity to the now north and south pole pieces respectively, and the north and south heels 33c and 33e are in close proximity to the now north and south pole pieces. The impulse will cause the armature to rotate 90 degrees in the same direction as before, as previously described, and the magnetic flux will find a path of least reluctance as shown in Fig. 9, from north pole piece 22a into the south pole shoe 32b, through core 31 of the armature into the north pole shoe 32c and into south pole piece 22. We can, therefore, see that as the magnetic fluxes find paths of minimum reluctance through the armature always in the same axial direction from the south end of the core to the north end thereof, this tends to maintain rather than oppose the magnetism of the armature.

In the embodiment shown herein, each end piece has two pole shoes. The peripheral length of each pole shoe is approximately equal to 360 degrees divided by the number of pole shoes on both end pieces. As the end pieces are so displaced on the core that each of the pole shoes of one end piece is midway between consecutive pole shoes of the other end piece, and as each reversal of the polarity of the current rotates the armature 90 degrees, it is therefore apparent that by increasing the number of pole shoes on the armature end pieces, the armature would be rotated a lesser number of degrees corresponding to the increased number of pole shoes at each impulse from the master clock. For example, by having four pole shoes on each end piece, the armature would rotate 45 degrees at each reversal of the polarity of the current.

As the step-by-step movement of the armature causes the step-by-step movement of the clock train and clock hands, the latter will move an exact subdivision of 60 minutes at each impulse. In the embodiment shown, an impulse is received from the master clock every 30 seconds which will cause the secondary clock hands to move one-half minute at each impulse. By varying the rate of the impulses from the master clock, the speed of the secondary clock could also be varied, and by increasing the number of pole shoes, the distance the hands of the second clock travels at each impulse could be reduced.

The reversal of polarity is essential to cause the step-by-step rotation of the clock. This feature ensures that possible vibration of the switch contacts in the master clock causing two impulses of the same polarity to be transmitted almost simultaneously will not cause two movements of the armature. In the event that static charges on the line should cause an impulse to reach the secondary clock that would cause the armature to rotate before the properly timed impulse from the master clock, the subsequent properly timed impulse would have no effect since it necessarily would be of the same polarity as the static charge. For example, if a positive impulse from the master clock had just caused a rotation of the armature of the secondary clock, and the static discharge was positive, since a negative impulse would be needed to rotate the armature, the static discharge would have no effect. However, if the static discharge was negative, it would move the armature. Since the next impulse from the master clock would also be negative, the armature would not rotate until the next positive impulse was received from the master clock.

The armature 16, having a relatively large mass will not respond to short duration inductive impulses caused by other apparatus in the clock circuit. Consequently such inductive impulse will not result in the fortuitous rotation of the armature which would cause an erroneous time indication. The magnetic circuit of the clock system has a relatively large air gap 34 between the armature pole shoes and the pole pieces and consequently the variations in magnetic flux are not so marked as to disturb other apparatus in the same circuit.

As many changes could be made in the above construction, and many apparently widely different embodiments of this invention could be made without departing from the scope of the claims, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. An intermittent motor comprising an electromagnetic stator and a rotor, the stator comprising two soft iron pole pieces having an arcuate cavity in opposing faces thereof, a magnetic core connected to each of said pole pieces, an energizing winding about each of said cores, said windings being connected so that the magnetic flux created by the energization of the windings is in series in the cores of both windings, the rotor of said motor comprising a magnetized core having a plurality of curved magnetic pole shoes at each end thereof angularly equidistant from each other, the toes of said pole shoes all pointing in the same peripheral direction the curvature of the faces of the pole pieces

and the peripheries of the pole shoes being such that when adjacent to each other a substantially wedge shaped air gap will be formed, the pole shoes at the ends of the core being so disposed that each of the pole shoes at one end of the core is midway between consecutive pole shoes at the other end of the core, whereby when said core windings are intermittently energized by impulses alternately reversed in polarity, the rotor will revolve at each impulse one-half the arcuate distance between the pole shoes at one end of said magnetized core.

2. An intermittent motor comprising a stator and a rotor, the stator comprising two parallel soft iron pole pieces having an arcuate cavity in opposing faces thereof, a magnetic core connected to each of said pole pieces, an energizing winding about each of said magnetic cores, said windings being connected so that the magnetic flux created by the energization of the windings is in series in the cores of both windings, the rotor of said motor comprising two parallel magnetic end pieces, each of said end pieces having a plurality of pole shoes angularly equidistant from each other, each of said pole shoes having a heel portion and a toe portion, the toes of said pole shoes all pointing in the same peripheral direction, the periphery of each of said pole shoes being curved so that the radial distance from the axis of the rotor is greater to the heel portion than to the toe portion, a magnetized core connecting said end pieces, said end pieces and said core being mounted for rotation between said pole pieces, the end pieces being so displaced with respect to each other that each of the pole shoes of one end piece is midway between consecutive pole shoes of the other end piece, whereby when said core windings are intermittently energized by impulses alternately reversed in polarity, the rotor will revolve at each impulse one-half the arcuate distance between the pole shoes at one end of said magnetized core.

3. An electric clock comprising an intermittent motor comprising a housing, a stator and a rotor mounted in said housing, the stator comprising two parallel pole pieces having an arcuate cavity in opposing faces thereof, a magnetic core connected to each of said pole pieces, an energizing winding about each of said magnetic cores, said windings being connected so that the magnetic flux created by the energization of the windings is in series in the cores of both windings, the rotor of said motor comprising two parallel magnetic end pieces, each of said end pieces having a plurality of pole shoes angularly equidistant from each other, each of said pole shoes having a heel and a toe portion, the toes of said pole shoes all pointing in the same peripheral direction, the periphery of each of the pole shoes being curved so that the radial distance from the axis of the rotor is greater to the heel portion than to the toe portion, whereby when said pole pieces and said pole shoes are adjacent to each other a substantially wedge shaped air gap will be formed, the peripheral length of each of the pole shoes being approximately equal to 360 degrees divided by the number of pole shoes on both end pieces, said pole pieces being so spaced that the peripheral length of each pole shoe is slightly less than the distance between the upper end of one pole piece and the lower end of the other pole piece, a magnetized core connecting said end pieces, said rotor being mounted for rotation between said pole pieces, said end pieces being so displaced with respect to each other that each of the pole shoes of one end piece is midway between consecutive pole shoes of the other end piece.

4. As an article of manufacture, a rotor for an electric motor comprising two parallel magnetic end pieces, each of said end pieces having a plurality of pole shoes angularly equidistant from each other, each of said pole shoes having a heel and a toe portion, the toes of said pole shoes all pointing in the same peripheral direction, the periphery of each of the pole shoes being curved so that the radial distance from the axis of the rotor is greater to the heel portion than to the toe portion, the peripheral length of each pole shoe being approximately equal to 360 degrees divided by the number of pole shoes on both end pieces, a magnetized core connecting said end pieces and a rivet passing through said end pieces and said core holding said end pieces and said core together, with the end pieces being so displaced with respect to each other that each of the pole shoes of one end piece is midway between consecutive pole shoes of the other end piece.

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