July 17, 1934. B. LAZICH ET AL 1,966,965

ELECTRICAL RELAY

Filed Jan. 14, 1930 4 Sheets-Sheet 1

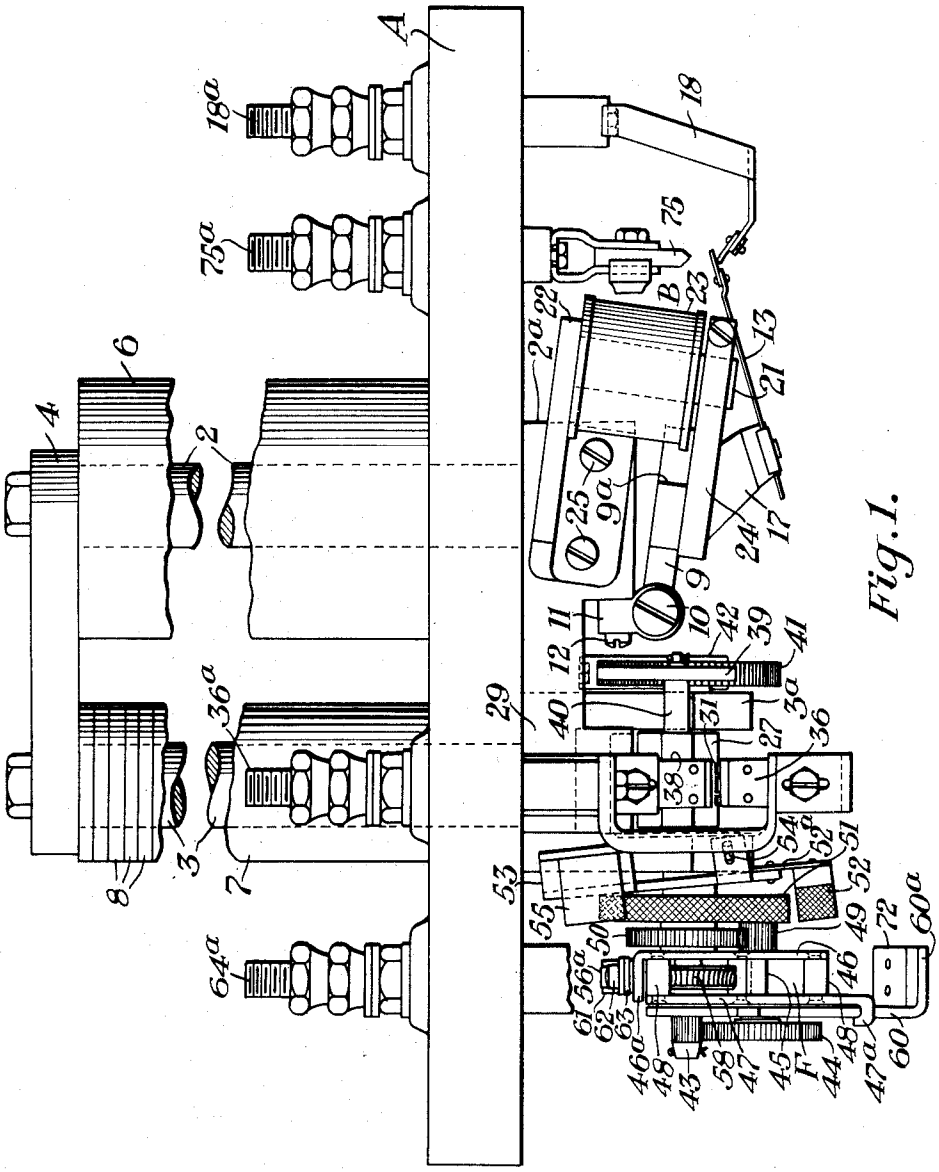


Fig. 1.

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Filed Jan. 14, 1930 4 Sheets-Sheet 2

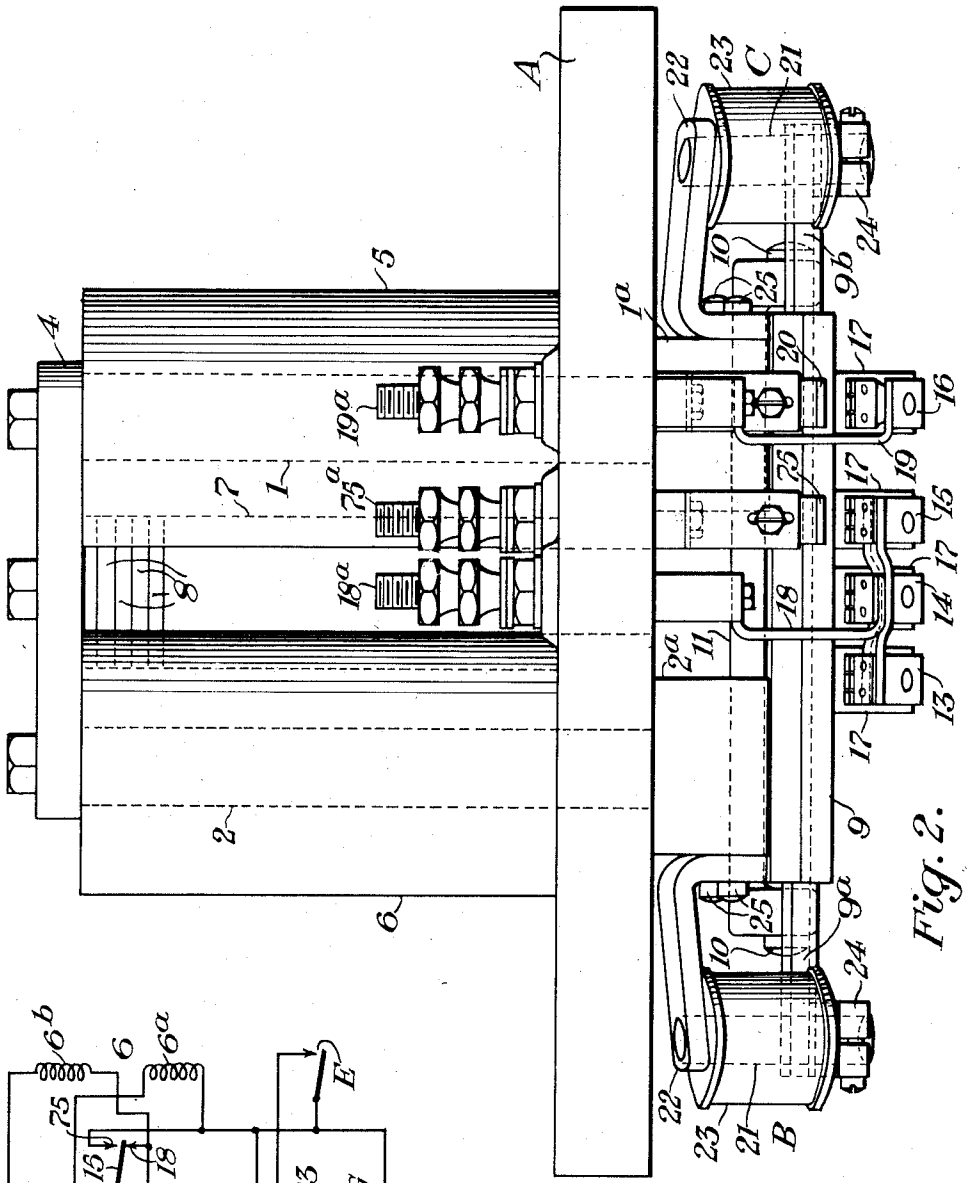


Fig. 2.

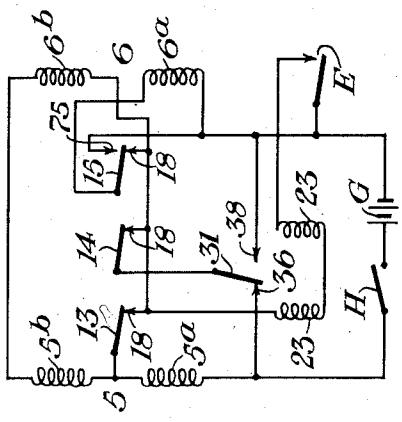


Fig. 9.

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ELECTRICAL RELAY

Filed Jan. 14, 1930 4 Sheets-Sheet 3

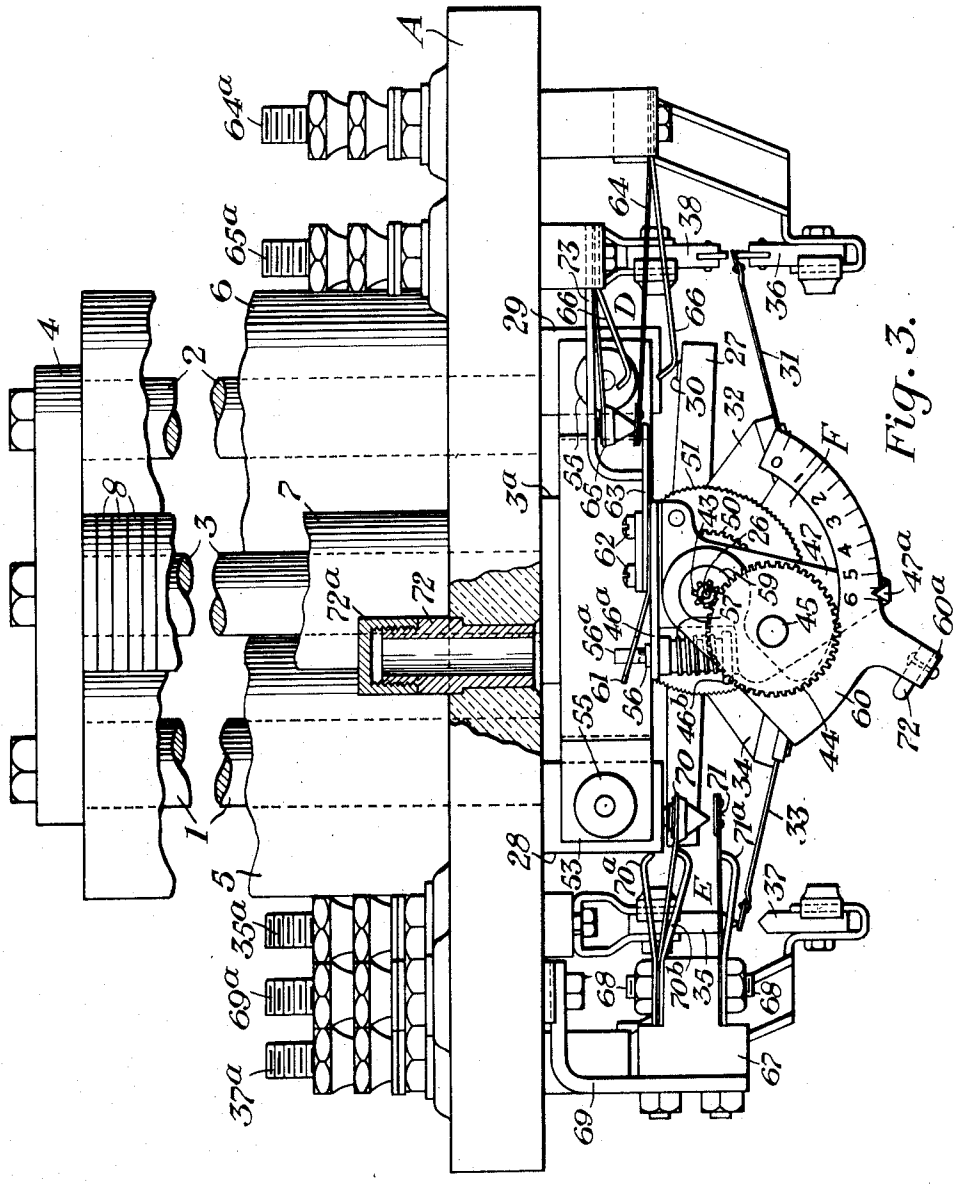


Fig. 3.

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ELECTRICAL RELAY

Filed Jan. 14, 1930 4 Sheets-Sheet 4

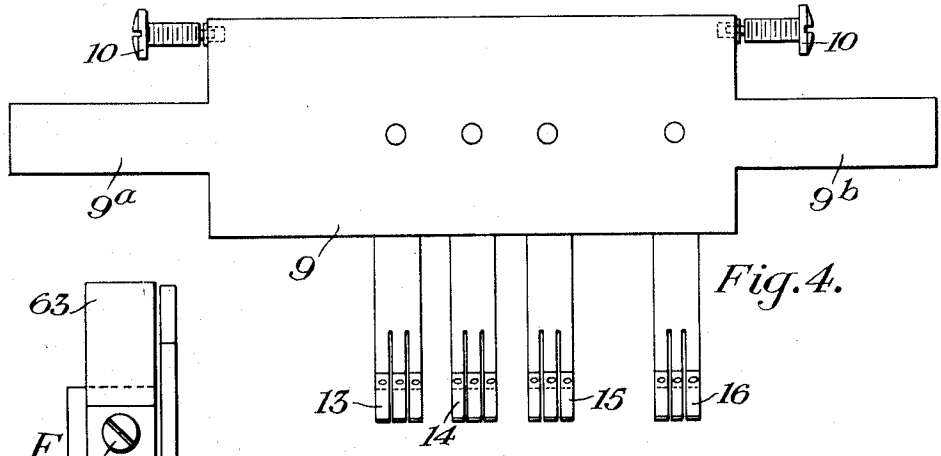


Fig. 4.

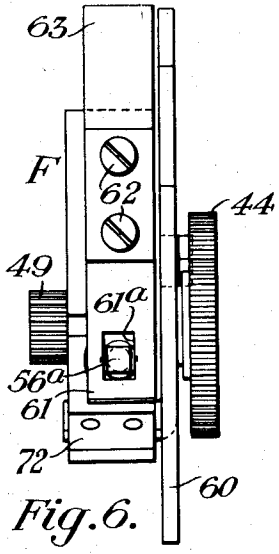


Fig. 6.

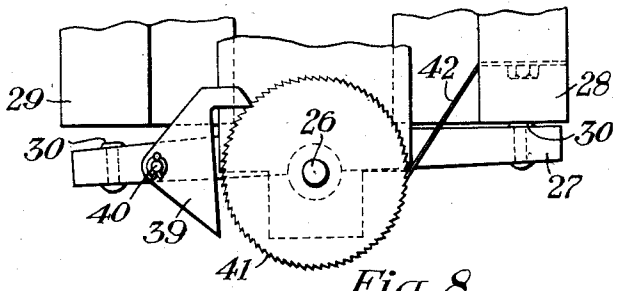


Fig. 8.

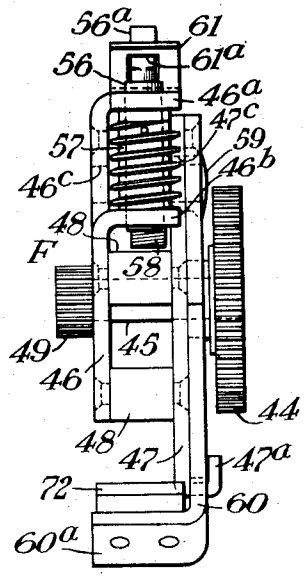


Fig. 5.

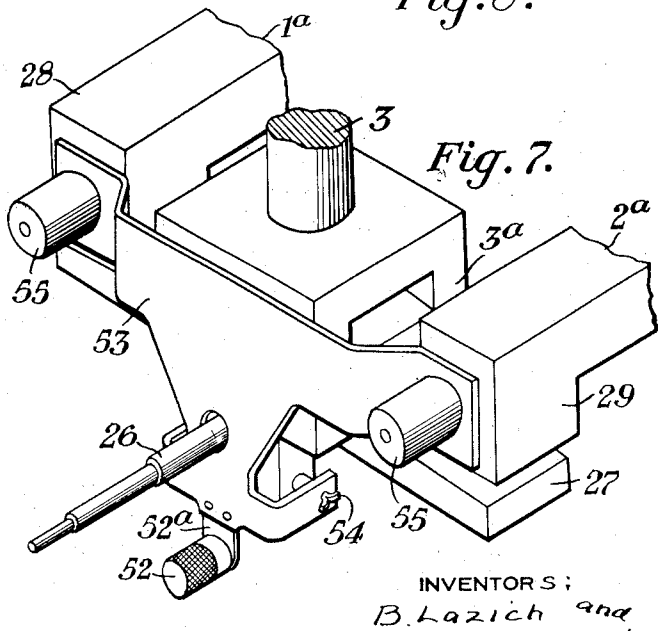


Fig. 7.

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1,966,965

UNITED STATES PATENT OFFICE

1,966,965

ELECTRICAL RELAY

Branko Lazich and Harry E. Ashworth, Pittsburgh, Pa., assignors to The Union Switch & Signal Company, Swissvale, Pa., a corporation of Pennsylvania

Application January 14, 1930, Serial No. 420,736

25 Claims. (Cl. 200—97)

Our invention relates to electrical relays, and particularly to relays of the type comprising a winding and a contact which is operated at the expiration of a time interval of predetermined length and of comparatively long duration after said winding becomes energized.

One object of our invention is to provide a relay of the type described in which the length of the time interval which elapses between the energization of its winding and the operation of its contact may be adjusted to any desired value.

Another object of our invention is to provide a relay of the type described which is so constructed as to provide maximum reliability of operation.

We will describe one form of relay embodying our invention, and will then point out the novel features thereof in claims.

In the accompanying drawings, Fig. 1 is a view, showing in side elevation, one form of relay embodying our invention, with certain of the parts omitted to illustrate the construction. Fig. 2 is a front view of the relay illustrated in Fig. 1. Fig. 3 is a rear view of the relay illustrated in Figs. 1 and 2. Fig. 4 is a top plan view of the neutral armature for the relay illustrated in Figs. 1, 2 and 3. Fig. 5 is a view showing, on a somewhat larger scale, the contact arm F for the relay illustrated in Figs. 1, 2 and 3, as it appears when viewed from the left in Fig. 3. Fig. 6 is a top plan view, drawn to the same scale as Fig. 5, of the contact arm for the relay illustrated in Figs. 1, 2 and 3. Fig. 7 is a fragmental view showing in isometric projection the magnetic clutch and drive shaft 26 forming a part of the relay illustrated in Figs. 1, 2 and 3. Fig. 8 is a detail view showing the pawl and ratchet mechanism for rotating the drive shaft 26 in response to oscillation of the auxiliary armature 27, as it appears when viewed from the right in Fig. 1. Fig. 9 is a diagrammatic view showing one circuit arrangement which may be used with the relay shown in Figs. 1, 2 and 3.

Similar reference characters refer to similar parts in each of the several views.

Referring first to Figs. 1, 2 and 3, the relay comprises a top plate A of suitable insulating material, such as porcelain or hard rubber, which serves as a support for all of the operating parts of the relay. Mounted on the top plate A are three magnetizable cores 1, 2 and 3, the upper ends of which are connected together by a back strap 4, and the lower ends of which terminate, on the under side of the top plate A, in enlarged pole pieces 1^a, 2^a, and 3^a, respectively. The core 1 is provided with a coil 5 and the core 2 is provided with a coil 6, each of which coils consists of two separate windings as will be explained more fully hereinafter. The core 3 is provided with a plurality of closed conductors. As here shown, these conductors comprise a sleeve 7 of suitable material such as copper, and a plurality of washers 8, also of suitable material such as copper.

A neutral armature 9 is pivotally supported for swinging motion toward or away from the pole pieces 1^a and 2^a on two pivot pins 10 threaded through the downwardly extending lugs of a non-magnetizable bracket 11 which is fastened to the sides of the pole pieces 1^a and 2^a by means of screws 12, as best seen in Fig. 1. The opposite ends of the armature 9 are provided with extensions 9^a and 9^b (see Fig. 4) which extensions cooperate with two auxiliary electromagnets B and C, respectively. These electromagnets are similar and, in the form here shown, and best illustrated in Figs. 1 and 2, each comprises a magnetizable core 21 extending downwardly from a magnetizable arm 22, and provided with a winding 23 and an elongated pole piece 24. The arm 22 of the electromagnet B is attached to the side of the pole piece 2^a by means of screws 25, and the arm 22 of electromagnet C is similarly attached to the side of the pole piece 1^a. The parts of the electromagnets B and C are so arranged that when neutral armature 9 is swung away from the pole pieces 1^a and 2^a, to its lower position in which it is illustrated in the drawings, the upper side of the pole piece 24 of electromagnet B will be parallel to, and will engage the underside of the extension 9^a of armature 9, and the upper side of pole piece 24 of electromagnet C will be parallel to, and will engage the underside of the extension 9^b of armature 9. The function of the electromagnets B and C will be explained in detail hereinafter.

A plurality of contact fingers, here shown as four in number, and designated 13, 14, 15, and 16, are attached to the under side of the armature 9 by means of insulating supports 17. When armature 9 is swung away from the pole pieces 1^a and 2^a, as shown in the drawings, the contact fingers 13, 14, and 15 each engage a back contact 18 to close contacts 13—18, 14—18, and 15—18, while the contact finger 16 engages a back contact 19 to close a contact 16—19. When armature 9 is swung towards the pole pieces 1^a and 2^a, however, the contacts 13—18, 14—18, 15—18, and 16—19 are all opened, and the contact finger 15 then engages a front contact 75 to close a con-

tact 15—75, while the contact finger 16 engages a front contact 20 to close a contact 16—20. The front contact 75 and the back contacts 18 and 19 are attached to terminal posts 75^a, 18^a and 19^a respectively, mounted on the top plate A, as shown in Figs. 1 and 2, while the front contact 20 is attached to a similar terminal post which is not shown in the drawings, but which is also mounted on top plate A.

As best seen in Figs. 1, 7 and 8, pole piece 3^a of core 3 is bifurcated, and pivotally supported at its centre on a drive shaft 26 journaled in the bifurcations of pole piece 3^a, is an auxiliary armature 27. The pole pieces 1^a and 2^a have integral extensions 28 and 29, respectively, the pole faces of which overlie the armature 27 at its opposite ends. The armature 27 is arranged to swing toward one or the other of these pole faces, non-magnetizable stops 30 (Fig. 8), being attached to the armature to prevent the armature from coming into actual contact with the pole faces.

The auxiliary armature 27 is provided at one end with a contact finger 31 (Fig. 3) which is attached to the underside of the armature by means of an insulating support 32 and, at the other end, with a similar contact finger 33 which is similarly attached to the armature by means of an insulating support 34. When the armature 27 is swung toward the pole face of extension 28 of pole piece 1^a, as shown in the drawings, the contact finger 33 engages a fixed contact 35 fastened to a terminal post 35^a, mounted on the top plate A, to close a normal contact 33—35, and the contact finger 31 engages a fixed contact 36 attached to a terminal post 36^a, also mounted on the top plate A, to close a normal contact 31—36. When armature 27 is swung toward the pole face of extension 29 of pole piece 2^a, however, the contact finger 33 then engages a fixed contact 37 to close a reverse contact 33—37, and the contact finger 31 engages a fixed contact 38 to close a reverse contact 31—38. The fixed contact 37 is attached to a terminal post 37^a mounted on the top plate A, and the fixed contact 38 is attached to a similar terminal post also mounted on top plate A, but not shown in the drawings. While we have shown only two contact fingers attached to the armature 27 for simplicity in illustrating our invention, it is understood that additional contact fingers may be attached to this armature when desired.

As will be explained more fully hereinafter, the auxiliary armature 27 may at times be made to oscillate. When this armature is oscillating, the motion of the armature in one direction is transmitted to the drive shaft 26 by means of a pawl and ratchet mechanism (Figs. 1, 3, and 8), the pawl 39 being carried by a stud 40 projecting from the side of the armature 27, and the ratchet wheel 41 being secured to one end of the drive shaft 26. The pawl 39 is normally held in engagement with the ratchet wheel 41 by gravity. Rotation of the drive shaft 26 in the direction opposite from that imparted to the drive shaft by the pawl and ratchet mechanism is prevented by a dog 42 of suitable resilient material secured to the underside of the extension 28 of the pole piece 1^a, and arranged to successively engage the teeth of the ratchet wheel 41 as the wheel is rotated by the dog.

Mounted on the opposite end of the drive shaft 26 from the ratchet wheel 41 is a contact arm designated in general by the reference character F. As here shown, the contact arm F comprises two parallel plates 46 and 47 secured together by spacing studs 48, as best seen in Figs. 1 and 5. The plate 46 is provided with two integral spaced lugs 46^a and 46^b, and secured to a short shaft 56 which is journaled in these lugs is a worm 57. The worm 57 meshes with a worm wheel 58, the hub 59 of which extends through, and is journaled in, a hole 47^c in the plate 47. Attached to the outer end of the hub 59 is a segment 60 which holds the worm wheel in place. The upper end 56^a of the shaft 56 is made rectangular in shape to enable the shaft to be turned by a wrench or other suitable tool, and it will be apparent that when this shaft is turned, the worm 57 rotates the worm wheel 58, thereby changing the position of the segment 60 with respect to the plates 46 and 47. The segment 60 is provided with a scale, as best seen in Fig. 3, and the plate 47 has formed on its lower end a pointer 47^a which moves along this scale as the position of the segment with respect to the plates 46 and 47 is varied. The reason for varying the relative position of the segment 60 and the plates 46 and 47 will be explained in detail hereinafter.

When the segment 60 has been adjusted to a predetermined position with respect to the plates 46 and 47, it is desirable to hold the segment in this position and, for this purpose, we provide a locking member, here shown as a strip 61 of flexible material, such as phosphor bronze. One end of the strip 61 is fastened to the lug 46^a by means of screws 62, and the other end of the strip is bent upwardly, and is provided with a rectangular slot 61^a which is just wide enough to receive the upper end 56^a of the short shaft 56 when the sides of the rectangular end 56^a are parallel to the sides of the slot 61^a. With the parts of the arm F locked in this manner, when it is desired to change the position of the segment 60 with respect to the plates 47 and 48, the inclined end of the strip 61 is depressed as by the tool which is utilized for turning the shaft 56 until this end is below the rectangular end 56^a of the shaft 56, whereupon the shaft 56 may be rotated until the segment 60 occupies the desired position. It will be apparent that as soon as the tool is removed from the shaft, the free end of the strip 61 will automatically return to its inclined locking position provided the shaft occupies a position in which the sides of the end 56^a are parallel to the sides of the slot 61^a.

The drive shaft 26 extends through the hub 59 of the worm wheel 58 and through a hole 46^c in the plate 46 with sufficient clearance to permit the contact arm F to rotate about the drive shaft, and has attached to its outer end a pinion 43 which holds the contact arm F on the drive shaft. The pinion 43 meshes with a gear wheel 44 secured to one end of a countershaft 45. The countershaft 45 is journaled in suitable holes in the plates 46 and 47 of the arm F, and carries on its other end a pinion 49 which meshes with a gear wheel 50 mounted on a bushing loosely journaled on the drive shaft 26. The gear wheel 50 is attached to, or formed integral with, a clutch wheel 51 which, as here shown, is a knurled metal wheel, but which may, if desired, be constructed of any other suitable material, such for example, as cork, leather, or a condensation product of phenol. The clutch wheel 51 is at times engaged by a knurled stud 52 forming a part of a magnetic clutch which we will now describe.

This magnetic clutch, as best seen in Fig. 7, comprises a magnetizable member 53, pivotally supported on a pin 54 carried by a projection on one of the bifurcations of the pole piece 3^a, and arranged to be attracted toward the pole piece 3^a

and the extensions 28 and 29 of the pole pieces 1^a and 2^a, respectively, when either or both of the coils 5, and 6 are energized. The knurled stud 52 is attached to the lower end of the member 53 by means of a short strip 52^a, preferably of flexible material, and the parts are so arranged that when the magnetizable member 53 is attracted towards the pole piece 3^a and the extensions 28 and 29, the stud 52 will engage the clutch wheel 51 and prevent rotation of the gear wheel 50. Two counterweights 55, attached to the upper part of the magnetizable member 53, bias this member to a position in which the stud 52 is out of engagement with the clutch wheel 51.

The contact arm F is biased by gravity to a position in which an insulating strip 63 attached to the lug 46^a engages a stop 73 fastened to a terminal post 65^a mounted on the top plate A as best seen in Fig. 3. When the arm occupies this position, the strip 63 also engages a contact finger 64 and moves it into engagement with a contact finger 65 to close a contact D. The contact finger 65 is attached to the terminal post 65^a, while the contact finger 64 is attached to a similar terminal post 64^a also mounted on the top plate A. Suitable stops 66 are attached to the terminal posts 65^a and 64^a to limit the spacing between the contact fingers when the strip 63 is moved out of engagement with the contact finger 64.

The contact arm F also controls a contact E comprising two spaced contact fingers 70 and 71 attached by means of studs 68 to a block 67 of insulating material, which block, in turn, is fastened by means of a bracket 69 to a terminal post 69^a mounted on the top plate A. The contact finger 70 is provided with top and bottom stops 70^a and 70^b and the contact finger 71 is provided with a bottom stop 71^a. The contact E is arranged to be closed, in a manner which will be described in detail hereinafter, by an insulating piece 72 riveted to a lug 60^a formed on the segment 60 of the contact arm F.

Referring now to the wiring diagram for the relay shown in Fig. 9, the two windings of the coil 5 referred to hereinbefore are designated by the reference characters 5^a and 5^b, respectively, and the two windings of the coil 6 are designated by the reference characters 6^a and 6^b. Current is supplied to these windings and to the winding 23 of each of the auxiliary electromagnets B and C from a suitable source, such as a battery G, over a circuit controller H which may be operated in any suitable manner.

As shown in the drawings, circuit controller H is open so that windings 5^a and 5^b of coil 5, windings 6^a and 6^b of coil 6, and windings 23 of the electromagnets B and C are all de-energized. The neutral armature 9 is therefore swung away from pole pieces 1^a and 2^a so that contacts 13—18, 14—18, 15—18, and 16—19 are closed, while contacts 15—75 and 16—20 are open. Auxiliary armature 27 is swung toward extension 28 of pole piece 1^a, and normal contacts 33—35 and 31—36 are therefore closed and reverse contacts 33—37 and 31—38 are open. The contact arm F is held by gravity in its normal position, so that contact D is closed and contact E is open.

We will now assume that with the parts in the positions just described, circuit controller H becomes closed. Windings 5^a, 5^b, 6^b and 6^a are therefore connected in series with battery G over contact 15—18, but only winding 6^a becomes energized because windings 5^b and 6^b are short-circuited over a circuit which includes contact 13—18, and winding 5^a is short-circuited over a circuit which includes contacts 13—18, 14—18, and 31—36. As a result, auxiliary armature 27 is swung toward extension 29 of pole piece 2^a, and the magnetizable member 53 of the magnetic clutch is attracted to the pole piece 3^a and the extensions 28 and 29 of the pole pieces 1^a and 2^a. The neutral armature 9, however, is held away from the pole pieces 1^a and 2^a under these conditions because the windings 23 of the auxiliary electromagnets B and C are deenergized, and the reluctance of the path to the neutral armature through the magnetic structures of the auxiliary electromagnets B and C for the flux set up by the winding 6^a is lower than the reluctance of the path to the neutral armature through the air gaps between the pole pieces 1^a and 2^a and the neutral armature, and more flux therefore reaches the neutral armature through the magnetic structure of the auxiliary electromagnets than through the air gaps between the pole pieces 1^a and 2^a and the neutral armature. It follows that the tractive force exerted to lift the armature 9 toward pole pieces 1^a and 2^a is less than the combined force of gravity and the effect of the flux through the magnetic structures of electromagnets B and C. The contacts 13—18, 14—18, 15—18 and 16—19 controlled by the neutral armature therefore remain closed even though winding 6^a of coil 6 is now energized.

When the auxiliary armature 27 is swung towards extension 29 of pole piece 2^a, the normal contacts 31—36 and 33—35 controlled by this armature are opened, and the reverse contacts 31—38 and 33—37 become closed. Since contacts 14—18 and 15—18 are still closed, the closing of reverse contact 31—38 short circuits winding 6^a of coil 6, and the field set up by this winding commences to decay. Due, however, to the snubbing effect of the circuit for winding 6^a and to the sleeve 7 and washers 8 on the core 3, this decay is comparatively slow. The opening of the contact 31—36 meantime has allowed winding 5^a to become energized. The growth of the flux set up by this latter winding is comparatively slow, however, due to the sleeve 7 and washers 8 on core 3 but, after an interval of time, the torque exerted on armature 27 by this flux over-balances the torque exerted on armature 27 by the decaying flux in winding 6^a, and armature 27 then swings back toward extension 28 of pole piece 1^a. This motion first opens reverse contacts 31—38 and 33—37 and then closes normal contacts 31—36 and 33—35. The neutral armature 9 is still held away from the pole pieces 1^a and 2^a during this movement of the armature 27 for the reasons pointed out hereinbefore, so that contacts 13—18, 14—18, 15—18, and 16—19 controlled by the armature 9 are still closed, and winding 6^a therefore again becomes energized and winding 5^a again becomes short-circuited. The field of winding 6^a then slowly builds up and the field of winding 5^a slowly decays, this decay being retarded by the self-inductance of winding 5^a, and by sleeve 3, and the washers 8. It will therefore be clear that auxiliary armature 27 is positively swung to and fro as long as circuit controller H is closed and the winding 23 of the auxiliary electromagnets B and C remain deenergized, and it will also be clear that a considerable interval of time elapses between armature movements. It should be pointed out that this time interval is substantially independent of fluctuations of the electromotive force in the energy supply because the auxiliary armature is

acted upon by two opposing forces both of which increase or decrease as the electromotive force of the energy supply increases or decreases. This time interval, however, may be varied by varying the rate at which the flux in this core builds up or decays, this variation being effected, with the apparatus constructed in the manner here shown, by varying the number of washers 8 on core 3.

Each time auxiliary armature 27 is swung towards pole piece 29, drive shaft 26 is rotated through a small arc due to the pawl and ratchet mechanism described hereinbefore. This rotation of the drive shaft 26 is transmitted through the pinion 43 to the gear wheel 44 which, in turn, drives pinion 49. Since the magnetizable member 53 is now swung towards pole piece 3^a and the extensions 28 and 29 of the pole pieces 1^a and 2^a, gear wheel 50 is prevented from rotating by the engagement of knurled stud 52 with the clutch wheel 51, and it will be apparent, therefore, that the pinion 43, gear wheel 44, pinion 49, and gear wheel 50 constitute a planetary drive by means of which contact arm F is rotated around the drive shaft 26 as a pivot, the direction of such rotation being clockwise as seen in Fig. 3. As soon as the contact arm has been rotated through a small arc, the resultant movement of the insulted strip 63 permits contact finger 64 to move out of engagement with contact finger 65, thereby opening contact D; and, when the arm has been rotated through a sufficiently large arc, the insulating piece 72 attached to segment 60 engages contact finger 71 and moves it into engagement with contact finger 70, thereby closing contact E.

When contact E becomes closed, current from battery G is supplied to the windings 23 of the electromagnets B and C in series if contact 31—36 is closed, or if this contact is not closed, then on the next operation of armature 27 which closes this contact, the circuit for these windings including, in addition to contact E and contact 31—36, contact 14—18 and circuit controller H, as will be apparent from an inspection of Fig. 9. The windings 23 are connected in this circuit in such manner that the fluxes created in the cores 21 of the auxiliary electromagnets B and C by the current in these windings thread the cores 21 in the opposite direction from the flux which threads these cores due to current in either of the windings 5^a and 6^a, and the parts are so proportioned that the magnitude of the flux in the cores 21 due to the current in the windings 23 is sufficiently great that the flux which threads the armature 9 through the air gaps between the armature 9 and the pole pieces 1^a and 2^a under these conditions will exert a torque on the armature which causes the armature to swing toward the pole pieces 1^a and 2^a. Shortly after the armature 9 starts to swing toward the pole pieces 1^a and 2^a, contacts 14—18, 15—18, and 16—19 are opened, but contact 13—18 is adjusted to remain closed until the armature has moved a short distance beyond the point in its upward travel at which the contacts 14—18, 15—18, and 16—19 open. When contacts 14—18 and 15—13 are opened, winding 6^a which is normally energized when these contacts are closed and contact 31—36 is closed, becomes de-energized and, at the same time, the short circuit which is normally completed for winding 5^a at contact 14—18 when contact 31—36 is closed, is opened. Winding 5^a is then supplied with current in series with the windings 23 of the electromagnets B and C over contact 13—18 which, as pointed out hereinbefore, remains closed after contacts 14—18 and 15—18 are opened, and winding 5^a therefore becomes energized and supplies flux to the armature 9 in place of winding 6^a. The resistance of the windings 23 will usually be considerably less than the resistance of the winding 5^a, so that the magnitude of the flux which is supplied to armature 9 due to the current in winding 5^a under these conditions will be only slightly less than the magnitude of the flux which was supplied to the armature 9 due to current in winding 6^a, and it will be apparent, therefore, that the opening of contacts 14—18 and 15—18 has very little effect on the torque exerted on the armature tending to move the armature toward the pole pieces 1^a and 2^a. As soon as winding 6^a becomes de-energized and winding 5^a becomes energized in the manner just described, auxiliary armature 27 stops oscillating and this armature is then held in the position in which its normal contacts 31—36 and 33—35 are closed. When contact 13—18 opens, the short circuit which was previously closed for windings 5^b and 6^b at this contact, is opened, and the windings 5^a, 5^b, 6^b and 23 in series are then all supplied with current from battery G over contact E and circuit controller H, so that these windings are all energized. The windings 5^b and 6^b are preferably constructed to have a comparatively high resistance in order to limit to a low value the current supplied to the relay from battery G after these windings become energized. When armature 9 has completed its upward stroke contacts 15—75 and 16—20 become closed. As long as circuit controller H now remains closed the windings 5^a, 5^b, 6^b and 23 will continue to be energized because the magnetic clutch is held in the position in which the stud 52 engages the clutch wheel 51, so that the contact arm F is held in the position in which contact E is closed. It will be apparent, therefore, that after the neutral armature has once been attracted to the pole pieces 1^a and 2^a, this armature will be held in the position which it then occupies until circuit controller H is opened to de-energize the relay. When this is done, the neutral armature 9 drops away from the pole pieces 1^a and 2^a, thereby opening contacts 15—75 and 16—20, and closing contacts 13—18, 14—18, 15—18 and 16—19. Furthermore, the magnetic clutch drops away from the pole piece 3^a and the extensions 28 and 29 of the pole pieces 1^a and 2^a, respectively, thereby permitting the contact arm to return by gravity to its normal position. When the contact arm returns to its normal position, contact E is opened and contact D becomes closed. When contact D becomes closed, the parts of the relay are then restored to their normal positions in which they are illustrated in the drawings.

It will be noted in Fig. 9 that when armature 9 is picked up, winding 6^a is short-circuited by contact 15—75. As a result, when the relay becomes de-energized, the self-inductance of winding 6^a retards the decay of flux which threads the neutral armature, and hence causes the neutral armature to be slow-releasing. Under some conditions it may be desirable to cause the neutral armature to release more quickly upon the de-energization of the relay and, when this is the case, this contact may be omitted.

The time interval which elapses between the energization of the relay and the closing of contact E depends upon the rate at which armature 27 oscillates, upon the gear ratios of the planetary drive for the contact arm F, and upon the length of the arc through which the contact arm F must rotate from its normal position before in-

sulating piece 72 closes contact E. The rate at which armature 27 oscillates may be varied by varying the proportioning of the parts, and by varying the number of washers 8 on core 3, as pointed out hereinbefore; the gear ratios of the planetary drive may be varied by replacing the gear wheels with other gear wheels having the desired ratio, as will be readily understood; and the length of the arc through which the contact arm F has to move from its normal position in order to close contact E may be varied by varying the relative position of the segment 60 with respect to the plates 46 and 47 in the manner which has also been previously described. It will be apparent, therefore, that the time interval which elapses between the energization of the relay and the closing of contact E may be adjusted to any desired value.

For any given gear ratio and proportioning of the parts the time interval required for the operation of the relay may be indicated by the position of the pointer 47ª on the scale which is provided on segment 60 by suitably calibrating this scale so that the graduations on this scale correspond to the correct time intervals.

It is desirable that adjustments in the length of the time interval which elapses between the energization of the relay and the closing of contact E due to changes in the position of the segment 60 with respect to the plates 46 and 47 of the contact arm F may be made from the top of the relay and, for this purpose, we provide a bushing 72 which is mounted in the top plate A in such manner that the bushing is directly above the vertical shaft 56 when the contact arm occupies its normal position, as shown in Fig. 3. The upper end of this bushing is threaded to receive a nut 72ª, by means of which the top of the bushing may be closed. With the parts constructed in this manner, when it is desired to change the position of the segment 60 with respect to the plates 46 and 47 of the arm F, the nut 72ª is removed from the top of the bushing, and the shaft 56 is turned by a suitable tool inserted through the bushing 72.

The contact D serves as a check to indicate that the contact arm F has returned to its normal position when the relay becomes de-energized. This contact may be used to control any suitable form of indicating apparatus in any suitable manner.

The normal contact 33—35 and reverse contact 33—37 controlled by the auxiliary armature 27, and the contacts 16—19 and 16—20 controlled by the neutral armature may be utilized to control any desired circuits in any suitable manner forming no part of our present invention and therefore not shown in the drawings.

From the foregoing, it will be apparent that we have provided a time element relay in which a definite time interval of adjustable length and of comparatively long duration may be made to elapse between the energization of the relay and the closing of contact E.

One advantage of a relay embodying our invention is that, since the contacts 13—18, 14—18 and 15—18 are included in the circuits over which current is supplied to the windings of the relay before contact E becomes closed, the neutral armature is positively prevented from picking up until this contact becomes closed. For, if, due, for example, to vibration or to some fault in the magnetic structure of the auxiliary electromagnets B and C, or to excessive voltage supplied to either or both of the windings 5ª and 6ª, the neutral armature starts to move toward the pole pieces 1ª and 2ª before contact E becomes closed, then, as soon as the motion of the armature starts, the contacts 14—18 and 15—18 open and de-energize the winding 5ª or 6ª which is then energized, so that the armature 9 immediately returns to its lower position.

Another advantage of a relay embodying our invention is that due to the construction and arrangement of the parts a high degree of accuracy in the time required for the operation of contact E is obtained.

Still another advantage of a relay embodying our invention is that the relay is constructed with a minimum of parts arranged to provide maximum reliability of operation.

Although we have herein shown and described only one form of relay embodying our invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of our invention.

Having thus described our invention, what we claim is:

1. A relay comprising an electromagnet, a first member which is oscillated when said electromagnet becomes energized, a second member controlled by said electromagnet, a contact, and means controlled by said second member and responsive to oscillation of said first member for operating said contact.

2. A relay comprising an electromagnet, a first member which is oscillated when said electromagnet becomes energized, a second member controlled by said electromagnet, a contact, and means controlled by said second member and responsive to a predetermined number of oscillations of said first member for operating said contact.

3. A relay comprising an electromagnet, a first member which is oscillated when said electromagnet becomes energized, a second member controlled by said electromagnet, a contact, and means controlled by said second member and responsive to a predetermined number of uninterrupted oscillations of said first member for operating said contact.

4. A relay comprising an electromagnet, a first member which is oscillated when said electromagnet becomes energized, a second member controlled by said electromagnet, a contact, and means controlled by said second member and responsive to oscillation of said first member for operating said contact at the expiration of a predetermined time interval after said electromagnet becomes energized.

5. In combination, an oscillatable armature, an electromagnet for oscillating said armature, a magnetic clutch controlled by said electromagnet, a contact, and means controlled by said clutch and responsive to oscillation of said armature for operating said contact.

6. In combination, an oscillatable armature, an electromagnet for oscillating said armature, a magnetic clutch controlled by said electromagnet, a contact, and means controlled by said clutch and responsive to oscillation of said armature for operating said contact at the expiration of a predetermined time interval after said electromagnet becomes energized.

7. A relay comprising an oscillatable armature, an electromagnet for oscillating said armature, a magnetic clutch controlled by said electromagnet, a rotatable contact arm biased to one position, means controlled by said clutch for ro-

tating said arm through a small arc in one direction for each oscillation of said armature, and a contact arranged to be operated by said arm when said arm has been rotated in said one direction through a predetermined angular distance from said one position.

8. In combination, an electromagnet, a first armature arranged to oscillate in response to energization of said electromagnet, a contact, means responsive to a predetermined number of oscillations of said first armature to operate said contact, a second armature, and means controlled by said contact for at times placing the second armature under the control of said electromagnet.

9. In combination, an electromagnet, a first armature arranged to oscillate in response to energization of said electromagnet, a contact, means responsive to a predetermined number of uninterrupted oscillations of said first armature to operate said contact, a second armature, and means controlled by said contact for at times placing the second armature under the control of said electromagnet.

10. In combination, an electromagnet, a first armature arranged to oscillate in response to energization of said electromagnet, a contact, means responsive to a predetermined number of oscillations of said first armature to operate said contact, a second armature controlled at times by said electromagnet, and means for preventing operation of said second armature by said electromagnet unless said contact is operated.

11. In combination, an electromagnet, a first armature arranged to oscillate in response to energization of said electromagnet, a contact, means responsive to oscillation of said first armature for operating said contact at the expiration of a predetermined time interval after said electromagnet becomes energized, a second armature, and means controlled by said contact for at times placing the second armature under the control of said electromagnet.

12. In combination, an electromagnet, a drive shaft, an armature mounted to oscillate on said drive shaft in response to energization of said electromagnet, means for rotating said drive shaft in response to oscillation of said armature, a magnetic clutch which is operated when said electromagnet becomes energized, a contact, and means controlled by said clutch and responsive to rotation of said drive shaft for operating said contact at the expiration of a predetermined time interval after said electromagnet becomes energized.

13. In combination, an electromagnet, a drive shaft, an armature mounted to oscillate on said drive shaft in response to energization of said electromagnet, means for rotating said drive shaft in response to oscillation of said armature, a magnetic clutch which is operated when said electromagnet becomes energized, a contact arm pivoted on said drive shaft and biased to one position, means controlled by said clutch for rotating said contact arm from said one position in response to rotation of said drive shaft, and a contact controlled by said contact arm.

14. In combination, an electromagnet, a drive shaft, an armature mounted to oscillate on said drive shaft in response to energization of said electromagnet, means for rotating said drive shaft in response to oscillation of said armature, a magnetic clutch which is operated when said electromagnet becomes energized, a contact arm pivoted on said drive shaft and biased to one position, means controlled by said clutch for rotating said contact arm from said one position in response to rotation of said drive shaft, and a contact arranged to be operated by said arm when said arm is rotated through a predetermined angular distance from said one position.

15. In combination, an electromagnet, a drive shaft, an armature mounted to oscillate on said drive shaft in response to energization of said electromagnet, means for rotating said drive shaft in response to oscillation of said armature, a magnetic clutch which is operated when said electromagnet becomes energized, a contact arm pivoted on said drive shaft and biased to one position, means controlled by said clutch for rotating said contact arm from said one position in response to rotation of said drive shaft, a first contact arranged to be closed when and only when said arm occupies said one position, and a second contact arranged to be operated by said arm when said arm has been rotated from said one position through a predetermined angular distance.

16. In combination, an electromagnet, a drive shaft, an armature mounted to oscillate on said drive shaft in response to energization of said electromagnet, means for rotating said drive shaft in response to oscillation of said armature, a magnetic clutch which is operated when said electromagnet becomes energized, a contact arm pivoted on said drive shaft and biased to one position, means controlled by said clutch for rotating said contact arm from said one position in response to rotation of said drive shaft, a contact arranged to be operated by said arm when said arm has been rotated from said one position through a predetermined angular distance, and means for varying the distance through which said arm must be rotated to operate said contact.

17. In combination, an oscillatable armature, an electromagnet for oscillating said armature, a drive shaft, means for rotating said drive shaft in one direction in response to oscillation of said armature, a contact arm mounted on said drive shaft, a magnetic clutch controlled by said electromagnet, means controlled by said clutch for at times rotating said contact arm in response to rotation of said drive shaft, and a contact controlled by said contact arm.

18. In combination, an oscillatable armature, an electromagnet for oscillating said armature, a drive shaft, means for rotating said drive shaft in one direction in response to oscillation of said armature, a gear wheel journaled on said drive shaft, a clutch wheel secured to said gear wheel, a magnetic clutch controlled by said electromagnet and arranged to engage said clutch wheel when said electromagnet is energized to prevent rotation of said gear wheel, a contact arm pivoted on said drive shaft and provided with means for rotating said arm in response to rotation of said shaft when rotation of said gear wheel is prevented by said clutch, and a contact controlled by said contact arm.

19. In combination, an oscillatable armature, an electromagnet for oscillating said armature, a drive shaft, means for rotating said drive shaft in one direction in response to oscillation of said armature, a gear wheel journaled on said drive shaft, a clutch wheel secured to said gear wheel, a magnetic clutch controlled by said electromagnet and arranged to engage said clutch wheel when said electromagnet is energized to prevent

rotation of said gear wheel, a pinion secured to said drive shaft, a contact arm journaled on said drive shaft and having a planetary drive which includes said pinion and said gear wheel for rotating said contact arm about said shaft as a pivot when rotation of said gear wheel is prevented by said clutch, and a contact controlled by said contact arm.

20. In combination, an oscillatable armature, an electromagnet for oscillating said armature, a drive shaft, means for rotating said drive shaft in one direction in response to oscillation of said armature, a first gear wheel journaled on said drive shaft, a clutch wheel secured to said first gear wheel, a magnetic clutch controlled by said electromagnet and arranged to engage said clutch wheel when said electromagnet is energized to prevent rotation of said first gear wheel, a first pinion secured to said drive shaft, a contact arm journaled on said drive shaft, a countershaft journaled in said contact arm, a second gear wheel attached to said countershaft and meshing with said first pinion, a second pinion attached to said countershaft and meshing with said first gear wheel, and a contact controlled by said contact arm.

21. In combination, an electromagnet, a drive shaft, an armature mounted to oscillate on said drive shaft in response to energization of said electromagnet, means for rotating said drive shaft in response to oscillation of said armature, a fixed contact, and an adjustable contact arm pivoted on said drive shaft and arranged to be rotated in response to rotation of said drive shaft for operating said contact.

22. In combination, a drive shaft, an oscillatable armature pivoted on said drive shaft, an electromagnet for at times oscillating said armature, means for rotating said drive shaft through a small arc in one direction each time said armature is oscillated; a contact arm comprising a frame made up of two parallel plates connected together by spacing studs, said plates being provided with holes which receive said drive shaft, a first pinion on said drive shaft, a countershaft journaled in said frame, a first gear wheel secured to said countershaft and meshing with said first pinion, a second gear wheel journaled on said drive shaft, a second pinion secured to said countershaft and meshing with said second gear wheel, means for preventing said second gear wheel from rotating when said electromagnet is energized, and a contact operated by said contact arm.

23. In a relay, in combination, a top plate, an adjustable contact arm secured to the underside of said top plate, and a bushing mounted in said top plate and provided with a hole for receiving a tool by means of which adjustments of said contact arm may be made from the upper side of said top plate.

24. In combination, an oscillatable armature, an electromagnet for at times oscillating said armature, a drive shaft, means for rotating said drive shaft through a small arc in one direction for each oscillation of said armature, a contact arm pivoted on said drive shaft and biased to one position, means for at times rotating said arm from said one position in response to rotation of said drive shaft, and a contact arranged to be operated when and only when said arm occupies said one position.

25. In combination, an oscillatable armature, an electromagnet for at times oscillating said armature, a drive shaft, means for rotating said drive shaft through a small arc in one direction for each oscillation of said armature, a contact arm pivoted on said drive shaft and biased to one position, a fixed stop, an insulating piece secured to said arm and arranged to engage said stop when said arm occupies said one position, means controlled by said electromagnet and said shaft for at times rotating said arm from said one position, and a contact which is closed by said insulating piece when and only when said arm occupies said one position.

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