Sept. 4, 1928. 1,683,450

W. P. CROCKETT

ELECTROMAGNETIC DEVICE

Filed Dec. 26, 1924 2 Sheets-Sheet 1

Fig. 1.

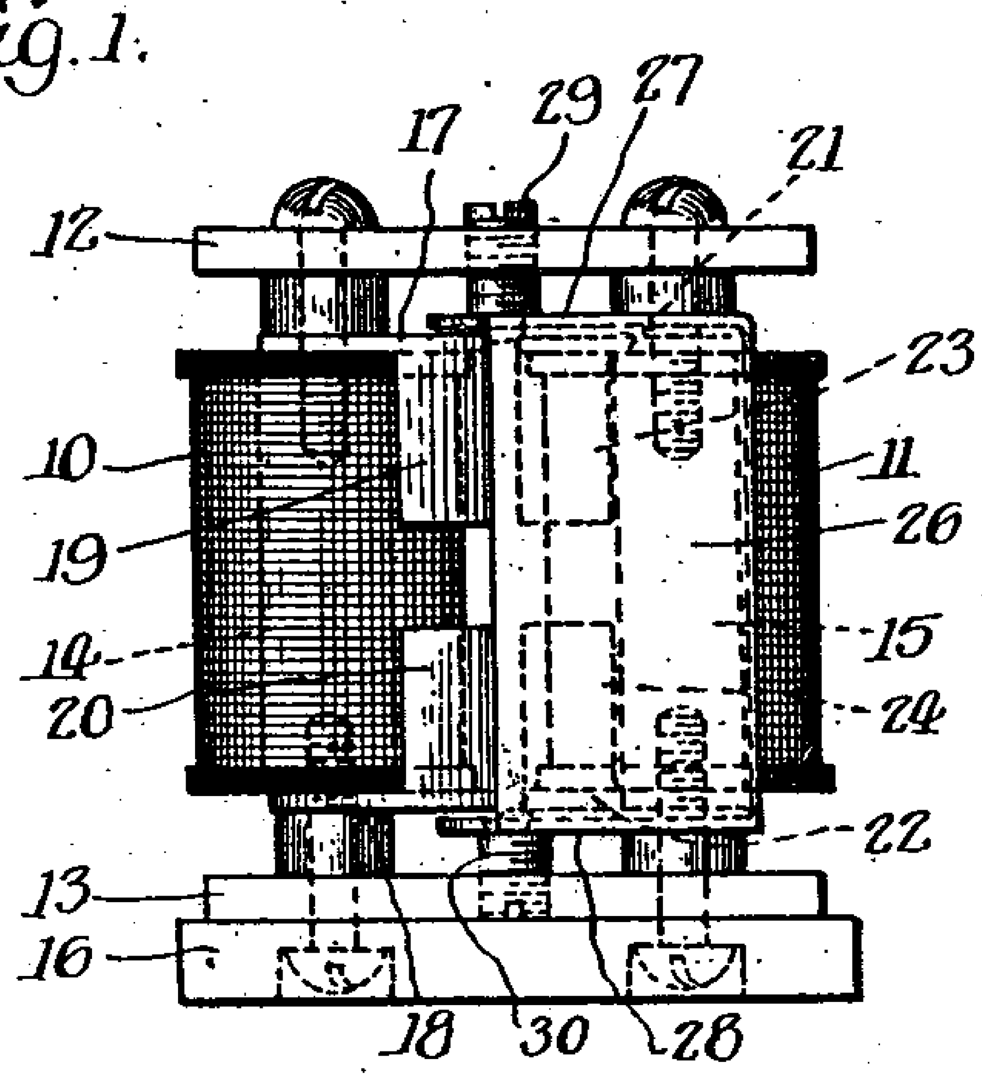


Fig. 2.

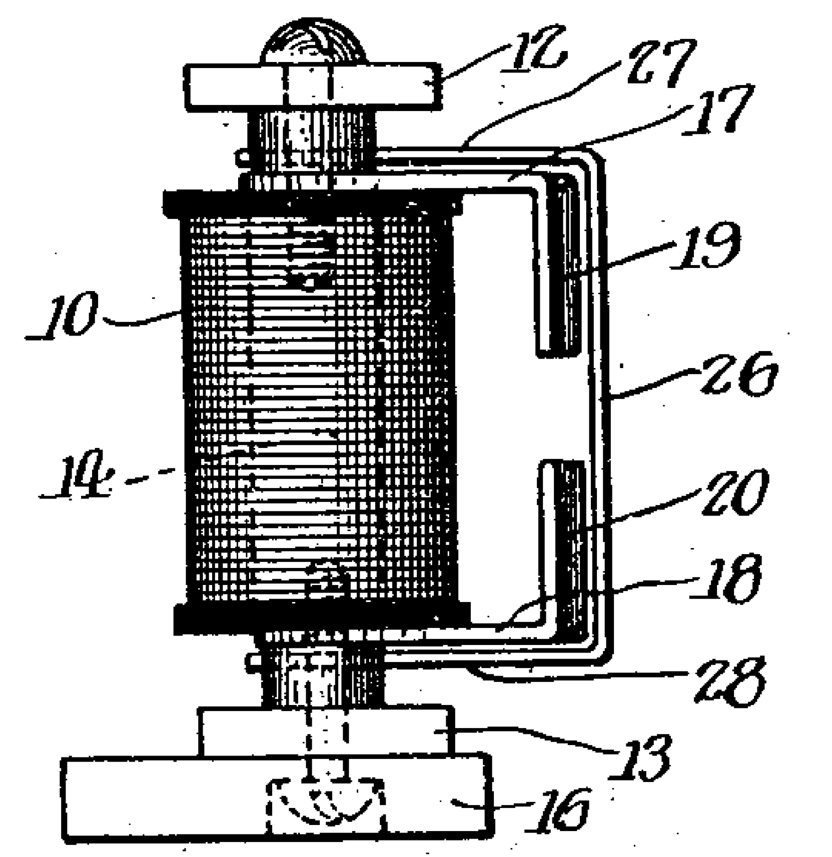


Fig. 3.

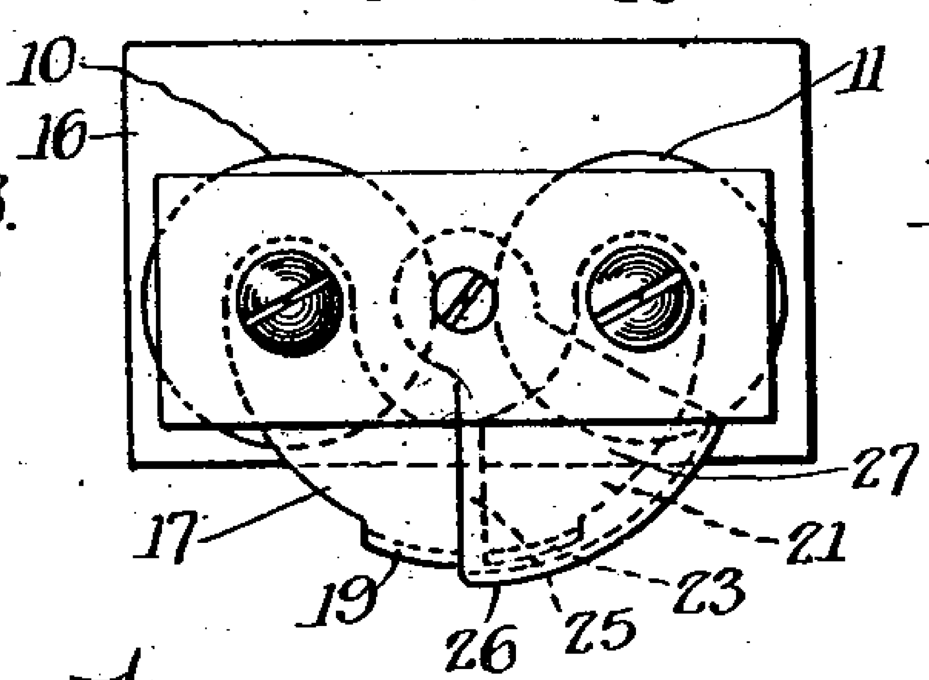


Fig. 4.

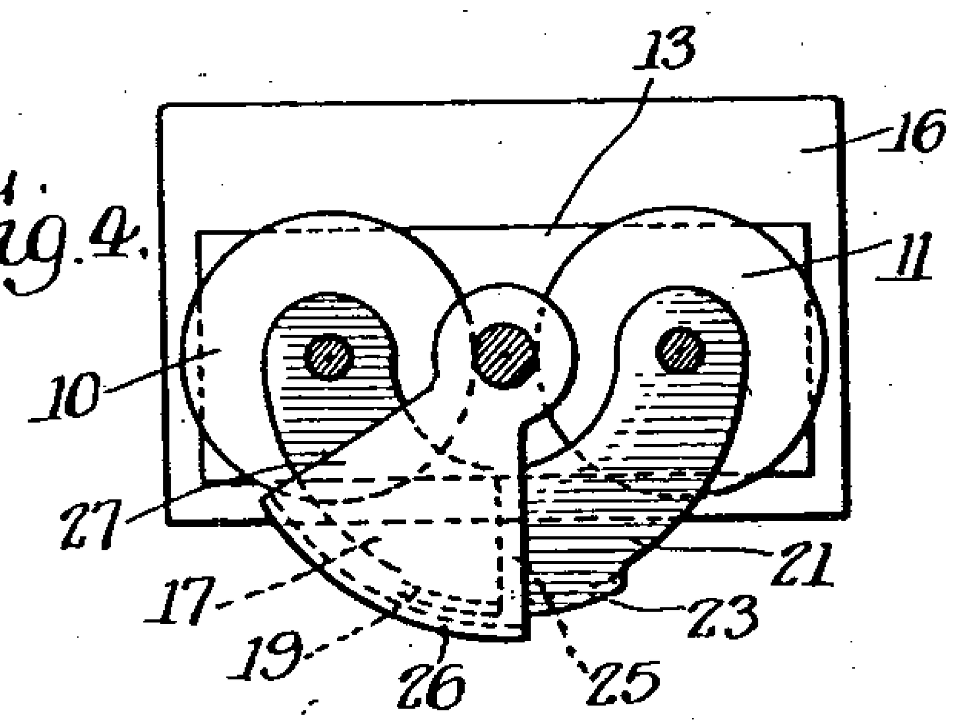


Fig. 5.

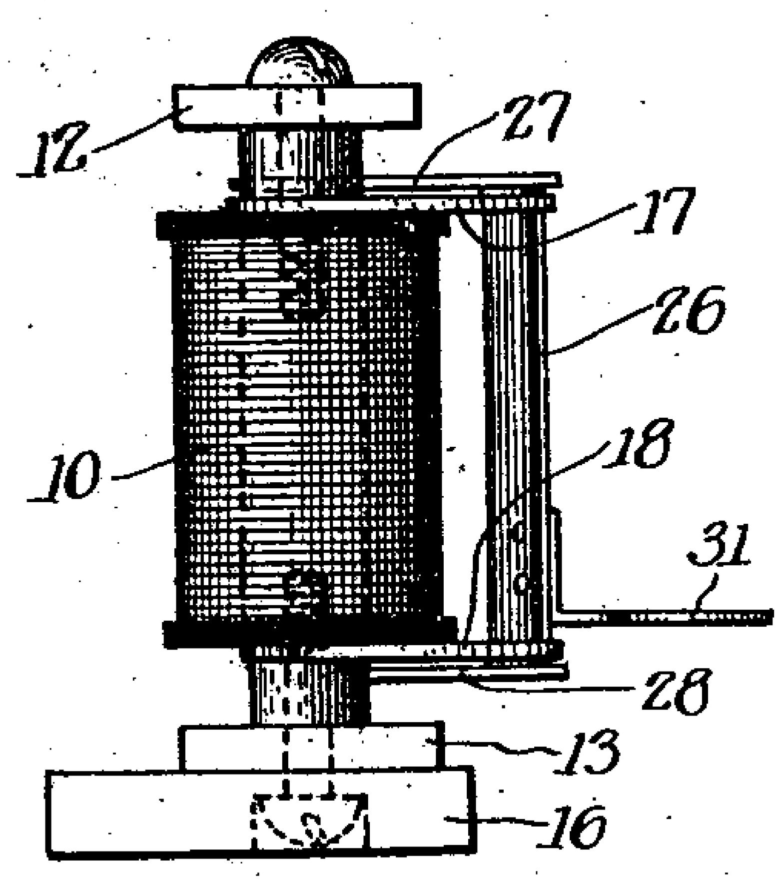


Fig. 6.

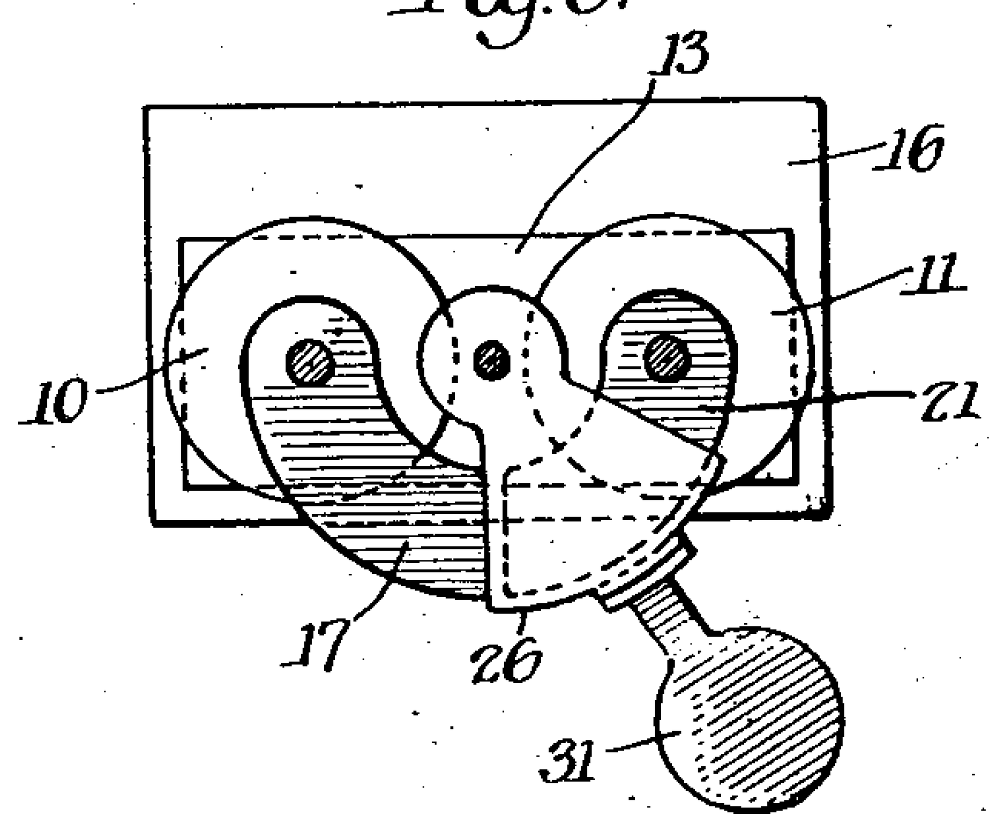


Fig. 7.

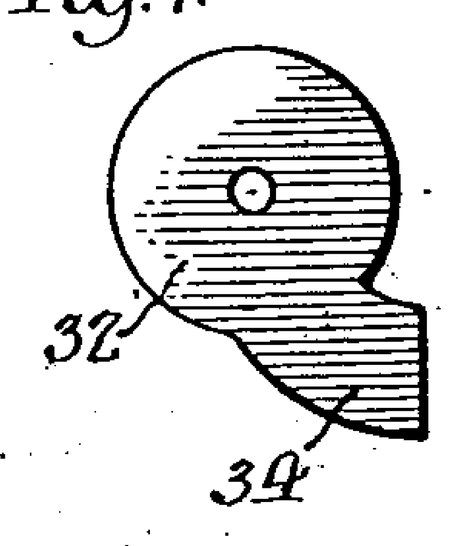
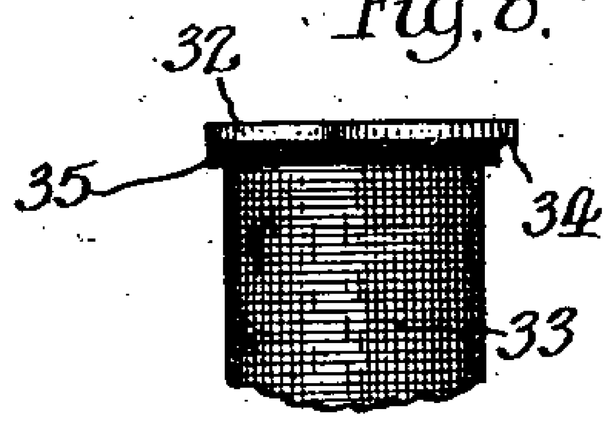


Fig. 8.



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Sept. 4, 1928. **1,683,450**

W. P. CROCKETT

ELECTROMAGNETIC DEVICE

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Fig. 9.

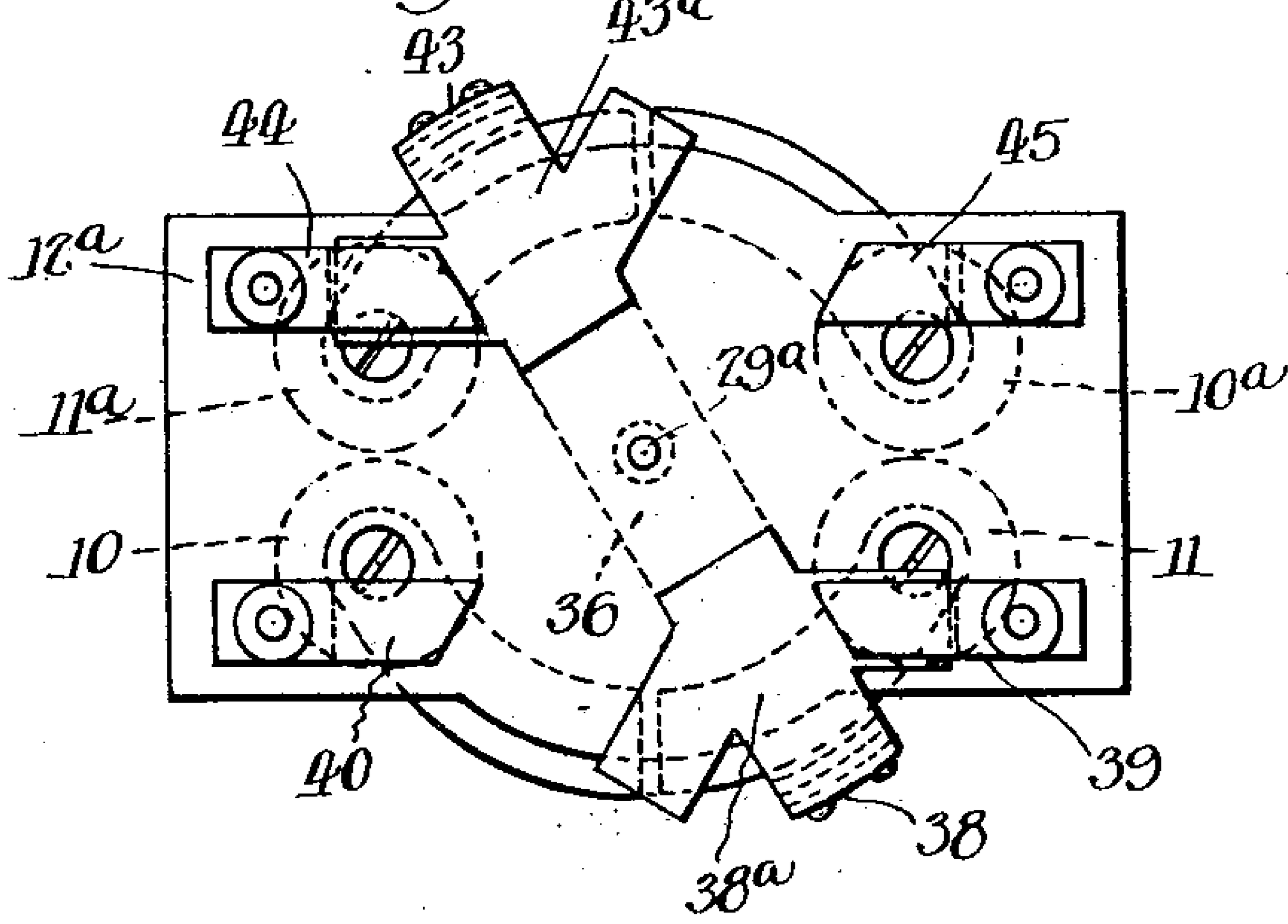


Fig. 10.

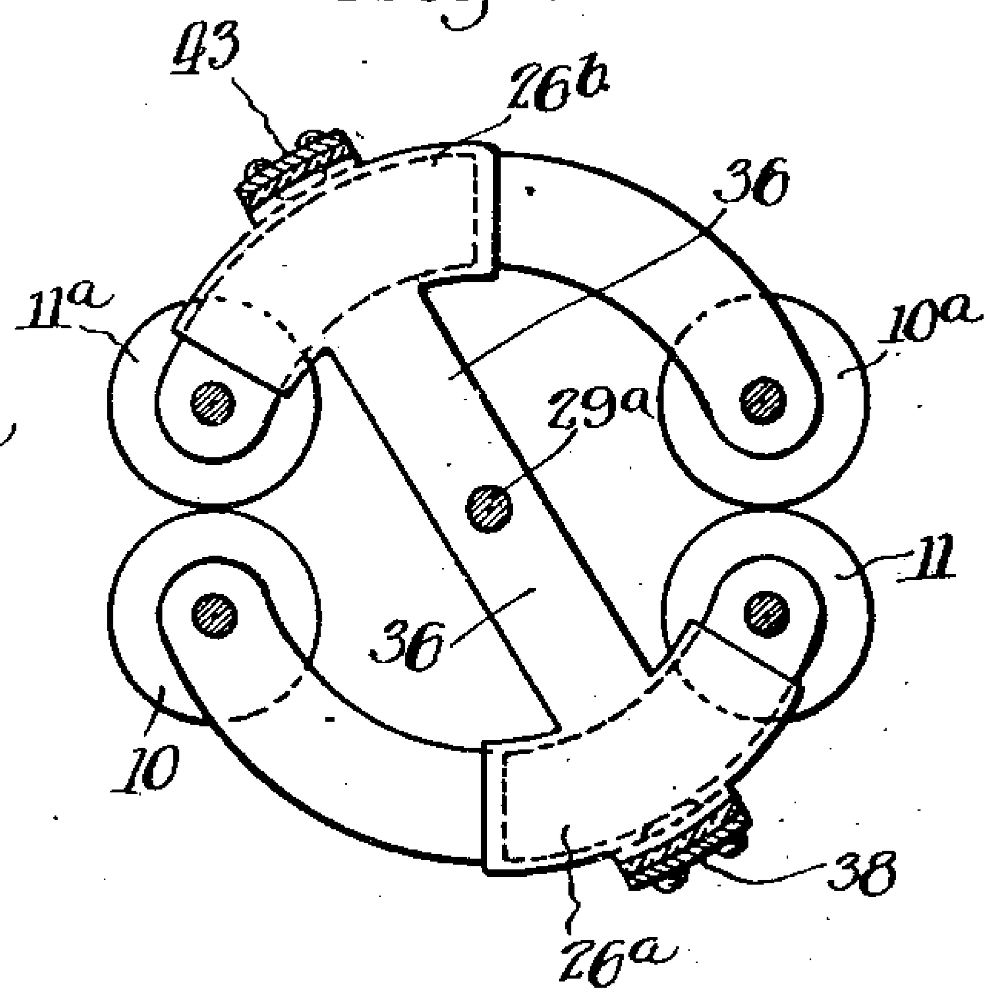


Fig. 11.

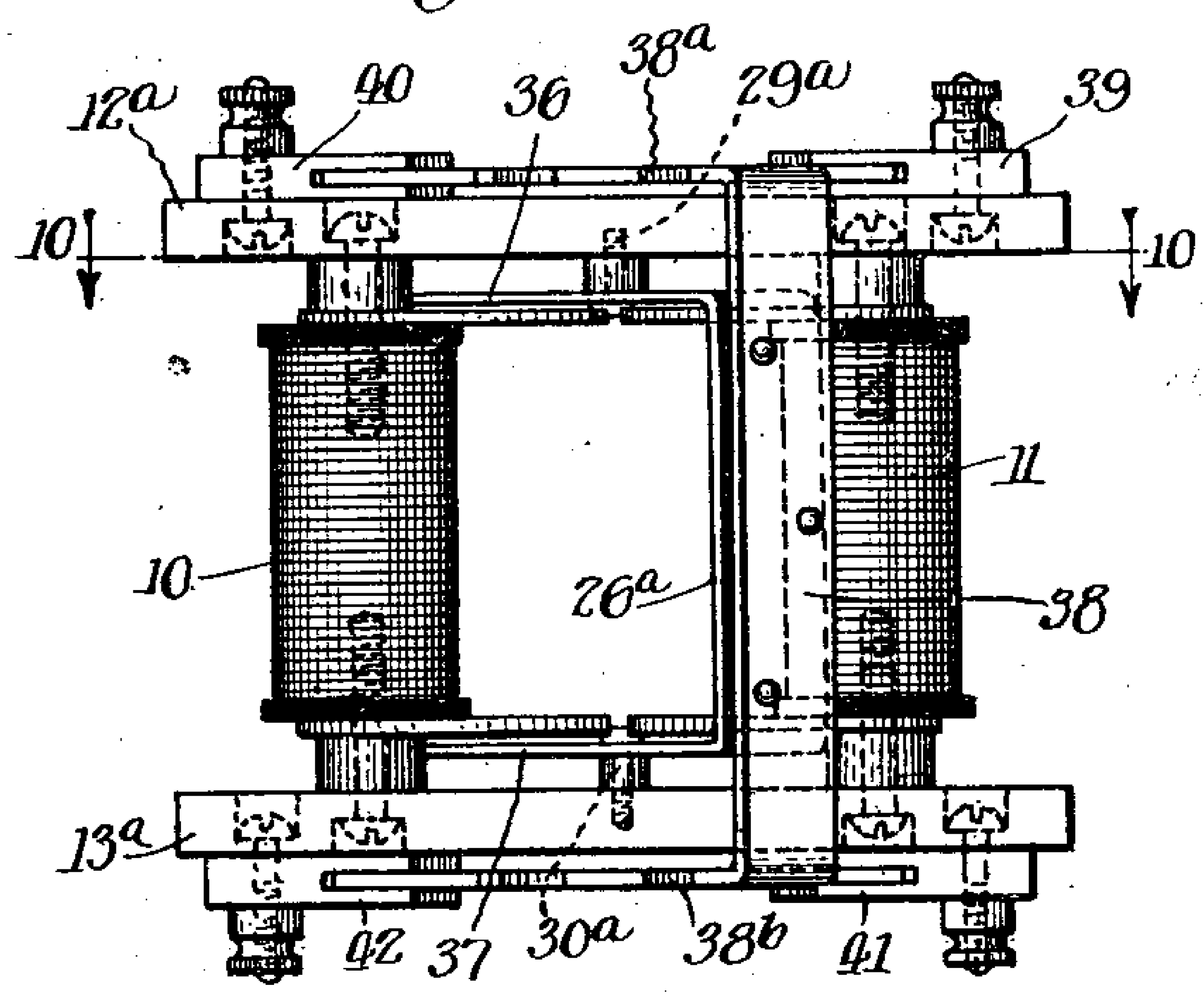


Fig. 12.

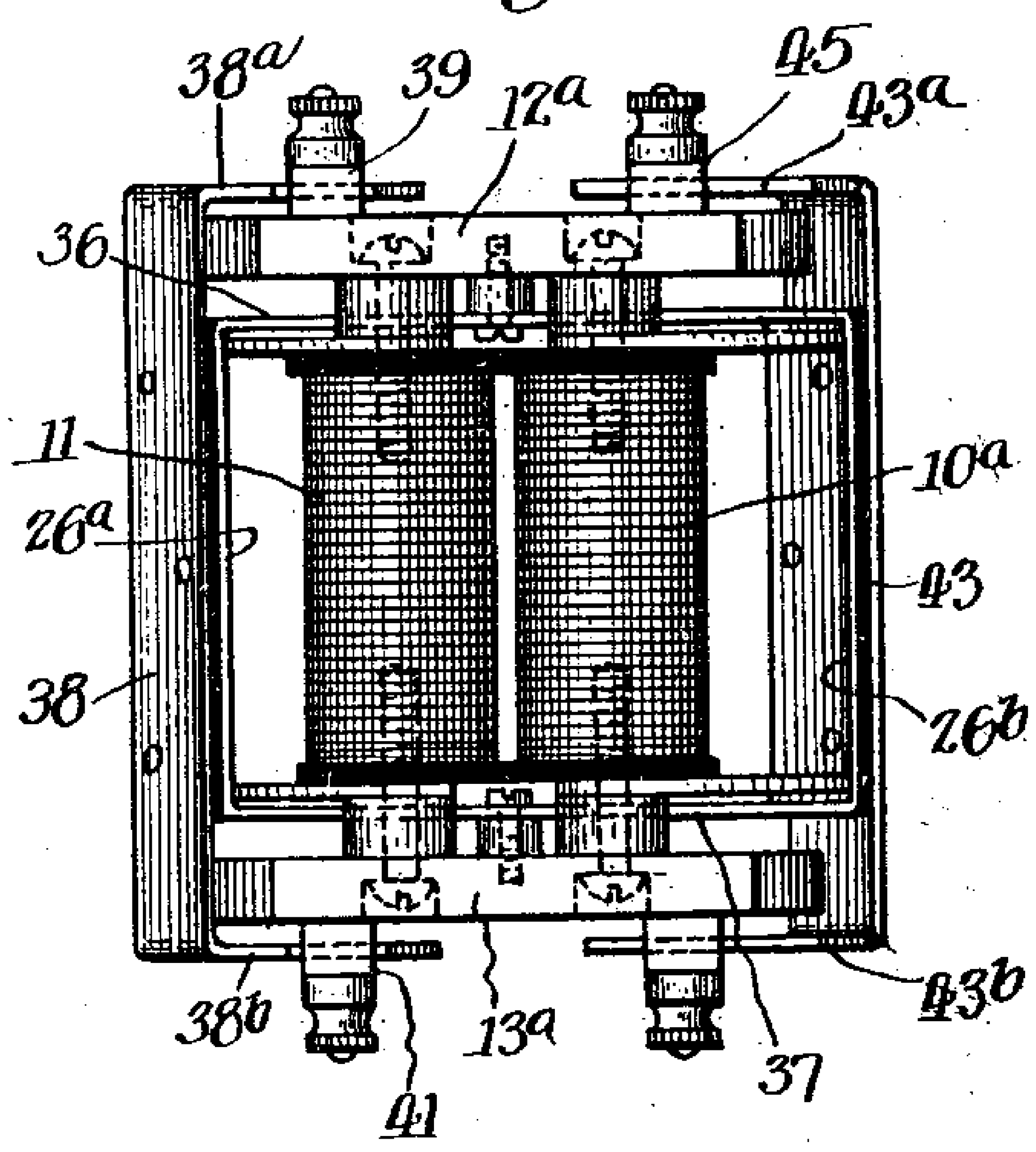
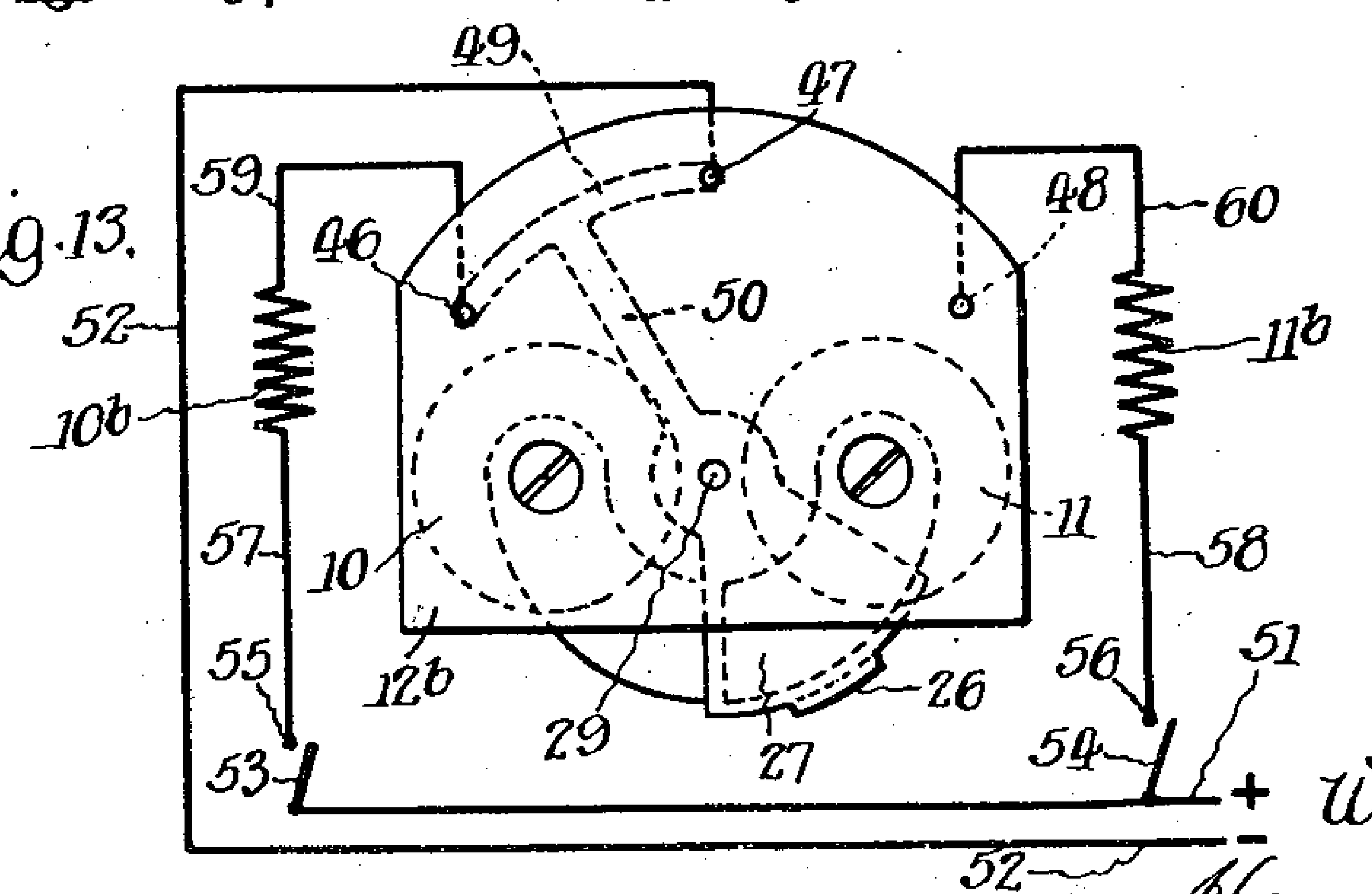


Fig. 13.



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Patented Sept. 4, 1928. **1,683,450**

UNITED STATES PATENT OFFICE.

WILLIAM P. CROCKETT, OF CHICAGO, ILLINOIS.

ELECTROMAGNETIC DEVICE.

Application filed December 26, 1924. Serial No. 758.021.

My invention relates to an improved construction of electromagnetic devices by which an armature may be given a large amount of movement under the action of the magnetic field produced by an electromagnet, the construction being such that the air gap or air gaps in the magnetic path are maintained of small extent throughout the entire range of movement of the armture.

More specifically, my invention consists in providing an electromagnet with pole ends of magnetic material which extend first laterally from the magnetic core of the magnet, and then parallel with the axis of the core to present an outer cylindrical surface, the parallel portions of the pole extensions, extending towards each other and having disposed outside of them an armature having a similar cylindrical formation on its inner surface and mounted coaxially with the cylindrical surfaces of the pole ends so that a small air gap is maintained between the armature and the pole ends. In this way I arrange the armature for movement outside of the pole extensions instead of between pole extensions, as has been common practice in the past, and in this way I am able, by properly proportioning the parts, to secure a much greater travel of the armature than is possible where the armature is arranged to move between the pole ends of electromagnets, assuming that the air gap in the latter case is of sufficiently small extent to anywhere nearly approach the small air gap I am able to use. By maintaining the air gaps in my construction of small length, I am able to produce a magnetic field of high density efficiently and in this way effectively produce a high degree of turning effort on the armature.

In carrying out my invention I prefer to employ two electromagnets of the kind referred to, constructed and disposed so that their cylindrical polar extensions are coaxial about an axis between the electromagnets, about which axis the armature is mounted with its cylindrical surface coaxial therewith. It is not essential that the axis of the armature shall be in the plane of the axes of the electromagnets, the particular location of the armature axis being determined by the degree of curvature it is desired that the cylindrical surfaces of the pole extensions and the armature shall have. The armature is constructed so that when acted upon by one of the magnets it is moved to a position for the production of a maximum turning effect on it by the action of the second electromagnet when the latter is energized and vice versa.

The armature may be employed for a wide variety of purposes, for example, it may itself constitute a visual signal, it may carry a visual signal of any desired kind, it may be employed to operate switching devices, and it may, in fact, be employed to actuate any devices requiring a considerable amount of movement and which it is desired to give alternate positions.

In some cases I find it advisable to produce a greater amount of turning effort on the armature system than is possible with one electromagnet acting as described, and in this event I may employ two pairs of electromagnets, each constructed as referred to and both pairs arranged to operate the same moving system of parts, it being understood that in this case two armatures are provided which are rigidly secured to the moving system, so that by energizing one magnet of each pair at the same time the turning effort of the two electromagnets becomes effective to rotate or turn the moving parts. This construction is valuable under some conditions for the operation of switching mechanism, particularly where large movement is desired and considerable effort is required to move the switch blades into engagement with the contacts and disengage them therefrom.

My invention will best be understood by reference to the accompanying drawings showing preferred embodiments thereof in which:

Figure 1 shows my device in simple form in front elevation.

Figure 2 is a side elevation of the device shown in Figure 1.

Figure 3 is a top view of the device shown in Figure 1 with the armature in a position corresponding to that shown in Figures 1 and 2.

Figure 4 is a view similar to Figure 3 showing the armature in its alternate position and with the top supporting bar removed.

Figure 5 shows in a view similar to Figure 2 a modified construction in which the pole ends are provided only with lateral extensions having edges concentric with the inner cylindrical surface of the armature and a target carried by the armature.

Figure 6 shows in a view similar to Figure 3 the device illustrated in Figure 5.

Figure 7 shows in plan view a modified form of combined magnet end and pole extension.

Figure 8 shows in front elevation a part of an electromagnet provided with the magnet end and pole extension construction shown in Figure 7.

Figure 9 shows in a view similar to Figure 3 a modified construction in which two pairs of electromagnets are employed and switching devices are arranged to be actuated by the armature of the device.

Figure 10 is a sectional view of the parts shown in Figure 9 taken along the line 10—10 in Figure 11.

Figure 11 is a front elevation of the parts shown in Figure 9.

Figure 12 is a side elevation of the parts shown in Figure 9, and,

Figure 13 is a diagrammatic view illustrating in top view a modified construction of my device and wiring connections by which the energizing circuit of either magnet may be opened automatically by the operation of the magnet energized to operate the armature.

Similar numerals refer to similar parts throughout the several views.

As shown in Figs. 1–4 inclusive, my device consists of two electromagnets 10 and 11 held in slightly separated condition by upper and lower retaining bars 12 and 13 of non-magnetic material secured to the cores 14 and 15 of said magnets respectively by screws as indicated, the lower screws also serving to secure the magnet assembly to a suitable mounting block 16. The core 14 has rigidly secured to its ends above and below the winding of the magnet, polar extensions 17 and 18 of magnetic material which, as indicated in Figures 3 and 4, are preferably provided with curved edges concentric about an axis preferably in a plane between the two electromagnets. At their outer ends, the extensions 17 and 18 have integral portions 19 and 20 extending from their outer curved edges towards each other and sufficiently separated at their adjacent ends to insure against the flow of an appreciable amount of magnetic flux between them. The outer surfaces of the extensions 19 and 20 are cylindrical about said axis which is preferably parallel with the axes of said electromagnets. The ends of the core 15 are provided with lateral extensions 21 and 22 similar to the extensions 17 and 18, and from the extensions 21 and 22, integral extensions 23 and 24 extend towards each other in a similar manner to the extensions 19 and 20. The extensions 21, 22, 23 and 24 differ from the extensions 17, 18, 19 and 20 only in that they are curved in a reverse direction, the outer surfaces of the extensions 23 and 24 being coaxial with the axis of the outer cylindrical surfaces of the extensions 19 and 20. The ends of the extensions 17 and 21 and the adjacent edges of the extensions 19 and 23 are separated by an air gap 25, the extensions 18 and 22 and the adjacent edges of the extensions 20 and 24 being similarly separated.

The armature 26 consisting of a cylindrical wall of magnetic material, is supported adjacent the outer surfaces of the extensions 19, 20, 23 and 24 by integral bent ends 27 and 28 having bearings at their inner ends engaged by bearing screws 29 and 30 located in the mounting bars 12 and 13 respectively, coaxially with the common connections of the outer cylindrical surfaces of the extensions 19, 20, 23 and 24 and the inner cylindrical surface of the armature 26. The radius of the inner surface of the armature 26 is slightly greater than the radius of the outer surfaces of the extensions 19, 20, 23 and 24, the difference being only enough to provide positive mechanical clearance between the parts when the armature is turned on its supporting screws 29 and 30. This clearance is purposely made smaller than the length of the air gap 25. It will be also observed that the ends 27 and 28 of the armature are adjacent the upper surfaces of the upper polar extensions 17 and 21 and the lower surfaces of the lower polar extension 18 and 22 respectively, only sufficient clearance being provided to insure the parts against mechanical engagement. It will be noted that the bearing screws 29 and 30 afford a convenient means for accurately positioning the armature relatively to the upper and lower polar extensions, to maintain the end clearances referred to.

For the construction illustrated in Figures 1–4 inclusive, the armature is free to swing until one or the other of its edges engages the corresponding heads of the electro-magnets, as the case may be. Obviously any other desired relation may be secured by differently proportioning the armature, and motion of the armature in either direction may be limited in any desired manner.

With the construction illustrated in Figures 1–4 inclusive, the annular extent of the armature is such that when it is in either of its extreme positions of movement, completely enclosing the corresponding cylindrical polar extensions, the outer edge of the armature is substantially in the plane of the edges of the other polar extensions so that the air gap 25 is just enclosed by the armature. Assuming the position of the armature shown in Figure 3, when the electromagnet 10 is energized, the shortest path for the magnetic flux is from the outer edges of the extensions 19 and 20 to the adjacent edge of the armature 26, the armature itself forming the entire return path for the flux, excepting for the small amount of separation between the armature and the extensions 19 and 20 resulting from the construction above described. This condition primarily produces a magnetic flux of high density through the edges of the polar extensions referred to and the adjacent edge of the armature. In fact this density is so high as to completely saturate the extensions and armature at their edges, and as a result a considerable amount of the magnetic flux is required to take a longer path through the air from the extensions 19 and 20 to the edge of the armature, than is represented by the mechanical separation of said extensions from the armature. As a result, a high degree of turning effort is exerted on the armature, which at once begins to move towards the position indicated in Figure 4. The magnetic condition first described is modified somewhat as the armature begins to overlap the extensions 19 and 20, but action of the same nature continues for further movement of the armature and for this reason the armature continues to move in the same direction until it reaches the position indicated in Figure 4. The polar extensions 19 and 20 are desirable where a large amount of turning effort is required at the beginning of the movement of the armature. When the armature has about half completed its movement towards the position shown in Figure 4, a turning effort is still exerted on the armature by the flux from the extensions 17 and 18 through the armature adjacent the air gap 25, so that the condition of lowest reluctance to magnetic flux is not established until the armature has reached the position indicated in Figure 4. A similar condition is created when it is desired to move the armature from the position indicated in Figure 4 to the position indicated in Figure 3 by energizing the magnet 11. The magnetic action described is aided by making the armature relatively thin.

From the above it will appear that I provide means for positively moving an armature through a distance greatly in excess of the air gap and that this motion may be in a first direction due to the energization of one electromagnet and in an opposite direction due to the energization of a second electromagnet.

The oscillating movement of the armature referred to, may be employed to operate any desired instrumentalities. If desired the cylindrical surface of the armature itself, or either of its ends may form a visible indication expressing either one of two conditions as desired, for which the magnets 10 and 11 will be respectively energized.

The construction shown in Figures 5 and 6 is the same as that above described with the exception that the polar extensions 19, 20, 23 and 24 are omitted and the polar extensions 17, 18, 21 and 22 alone are employed, also that in this case the armature 26 has secured thereto in any suitable manner, for example by riveting, a target or signal 31, which may be given either one of two positions by movement of the armature, in substantially the manner above described. In this case, electromagnetic action takes place between the curved edges of the extensions 17 and 18 and the adjacent inner cylindrical surface of the armature 26 in substantially the same manner as above described.

It will be understood that the portion 26 of the armature illustrated in Figures 5 and 6, to which the indicator 31 is attached, may be straight and flat and not cylindrical or curved, and that this portion 26 may be made integral with the parts 27 and 28 of the armature or may be attached thereto in any suitable manner.

In Figures 7 and 8 I illustrate a simplified detail of construction by which the head 32 of the magnet 33 is of magnetic material formed integrally with the polar extension 34, the extension 34 corresponding to the similar extension 17 used in the complete structure illustrated in Figures 1–6 inclusive and the extensions being of the kind shown in Figures 5 and 6 inclusive. In this case the head 32 is of course insulated from the winding of the magnet 33 by suitable material as shown at 35.

In the construction shown in Figures 9–12 inclusive, the electromagnetic system consists of two pairs of magnets 10, 11 and 10^a, 11^a, each pair being of a construction similar to that described above in connection with Figures 1–4 inclusive. The two pairs of magnets are secured together by top and bottom plates 12^a and 13^a, respectively, of insulating material which hold the circular edges of the polar extensions co-axial about the bearings 29^a and 30^a used to support the armature structure. In this case, the armature consists of two parts 26^a, 26^b, each formed in the manner described in connection with Figs. 1–4 inclusive, the two armatures being joined at their ends by cross bars 36 and 37 holding the armatures co-axially about the axis of the bearings 29^a and 30^a. The armature 26^a has secured thereto and insulated therefrom, a switch blade 38 which is extended above and below the mounting plates 12^a and 13^a respectively and provided above and below said plates with bent ends 38^a and 38^b extending substantially parallel with the mounting plates 12^a and 13^a respectively. The mounting plate 12^a carries a switch contact 39 preferably of the jaw type for engagement by the bent end 38^a when the armature system is in the position indicated in Figures 9–12 inclusive, and said mounting plate also carries a second switch contact 40 for engagement with the bend 38^a when the armature is in its alternate position due to the energization of the magnets 10 and 10^a. The mounting plate 13^a has secured to its lower face a switch contact 41 for engagement by the bent end 38^b at the same time the contact 39 is engaged, and a second similar contact 42 for engagement by the bent end 38^b at the same time that the contact 40 is engaged. In this way, either the contacts 39 and 41 or the contacts 40 and 42 may be connected by the switch blade 38 depending on the position of the armature system.

The armature 26^b has secured thereto and insulated therefrom, a switch blade 43 similar to the switch blade 38 and having similar end extensions 43^a and 43^b for engaging contacts 44 and 45 carried by the mounting plate 12^a and similar contacts carried by the mounting plate 13^a, as a result of which the switch blade 43 connects the contact 44 with the similar lower contact at the same time that the contacts 39 and 41 are connected by the switch blade 38, and that the switch blade 43 connects the contact 45 with the similar lower contact at the same time that the contacts 40 and 42 are connected by the switch blade 38. Convenient connection may be made with the several switch contacts by the binding screws indicated.

The switch construction described may be used as a double pole, double throw switch, or for any purpose where it is desired to alternately connect two out of four pairs of contacts. Thus my electromagnetic system may conveniently be employed to operate switching devices of the type just described or similar switching mechanism having other arrangements of contacts, as desired.

In the construction shown diagrammatically in Figure 13, an electromagnetic system is indicated similar to that shown and described in connection with Figures 1–4 inclusive. In this case, however, the mounting plate 12^b is extended somewhat to support three electric contacts 46, 47 and 48 in the path of a switch blade 49 carried by an arm 50 connected with the upper end member 27 of the armature 26. The switch blade 49 is of a sufficient length to connect the contacts 46 and 47 for the position of the armature 26 shown in Figure 13, and to connect the contacts 47 and 48 for the alternate position of said armature. In this view the windings of the electromagnets 10 and 11 are indicated diagrammatically at 10^b and 11^b. The circuit connections of the device are as follows: 51 and 52 are supply conductors for receiving suitable electric energy from any source (not shown), to operate the magnets 10 and 11. The conductor 52 is connected with the contact 47. The conductor 51 is connected with the pivotal point of switches 53 and 54, the contacts 55 and 56 of which are connected by wires 57 and 58 with the windings 10^b and 11^b, the other terminals of which are connected by wires 59 and 60 with the contacts 46 and 48 respectively. As a result of the connections described when the switch 53 is closed, current flows through the winding 10^b, the magnet 10 is energized and the armature 26 is moved towards the magnet 10. This moves the switch blade 49 from engagement with the contact 46 and into engagement with the contact 48, thus interrupting the energizing circuit of the magnet 10 so that current flow is interrupted by the operation of the device whether the switch 53 is at once moved to its open position or not. Similarly, if, after the operation described, the switch 54 is closed, the magnet 11 is energized by current flow through its winding 11^b and the armature is moved back to the position indicated in Figure 13, moving the switch blade 49 from engagement with the contact 48 and into engagement with the contact 46, thus interrupting the energizing circuit of the magnet 11 even though the switch 54 may remain in its closed position until the operation of the device has been completed. The switches 53 and 54 should normally, of course, be in their open position, which may be provided for by any suitable means well known to the art.

While I have shown my invention in the particular embodiments above described, it will be understood that I do not limit myself to these exact constructions, as I may employ equivalents known to the art at the time of the filing of this application without departing from the scope of the appended claims.

What I claim is:

1. In an electromagnetic device, the combination of a pair of electromagnets, bars of non-magnetic material securing said electromagnets together in substantially parallel relation, pole pieces having curved outer edges and substantially parallel adjacent edges at each end of said electromagnets separated by a substantial air gap, polar extensions from the pole pieces of each electromagnet extending towards each other and having cylindrical outer surfaces, the cylindrical surfaces of said extensions being coaxial, and an armature pivotally supported by said bars for oscillation about the common axis of said cylindrical surfaces, said armature comprising a body portion having a cylindrical inner surface separated from said cylindrical surfaces of said polar extensions by a small air gap and laterally extending ends for engaging its pivotal supports.

2. In an electromagnetic device, the combination of a pair of electromagnets, bars of non-magnetic material securing said electromagnets together in substantially parallel relation, pole pieces having curved outer edges and substantially parallel adjacent edges at each end of said electromagnets separated by a substantial air gap, polar extensions from the pole pieces of each electromagnet extending towards each other and having cylindrical outer surfaces, the cylindrical surfaces of said extensions being coaxial, an armature pivotally supported by

said bars for oscillation about the common axis of said cylindrical surfaces, said armature comprising a body portion having a cylindrical inner surface separated from said cylindrical surfaces of said polar extensions by a small air gap and laterally extending ends for engaging its pivotal supports, and devices for limiting movement of said armature in each direction, the body portion of said armature being so proportioned that for either of its positions of extreme movement the edges of said extensions next to be energized to attract it are substantially in the plane of its adjacent edge.

3. In an electromagnetic device, the combination of a pair of electromagnets, bars of non-magnetic material securing said electromagnets together in substantially parallel relation, pole pieces having curved outer edges and substantially parallel adjacent edges at each end of said electromagnets separated by a substantial air gap, said curved edges being coaxial, and an armature pivotally supported by said bars for oscillation about the common axis of said coaxial edges, said armature comprising a body portion having a cylindrical inner surface separated from said coaxial edges by a small air gap and laterally extending ends for engaging its pivotal supports.

4. In an electromagnetic device, the combination of a pair of electromagnets, bars of non-magnetic material securing said electromagnets together in substantially parallel relation, pole pieces having curved outer edges and substantially parallel adjacent edges at each end of said electromagnets separated by a substantial air gap, said curved edges being coaxial, an armature pivotally supported by said bars for oscillation about the common axis of said coaxial edges, said armature comprising a body portion having a cylindrical inner surface separated from said coaxial edges by a small air gap and laterally extending ends for engaging its pivotal supports, and devices for limiting movement of said armature in each direction, the body portion of said armature being so proportioned that for either of its positions of extreme movement the edges of said pole pieces next to be energized to attract it are substantially in the plane of its adjacent edge.

5. In an electromagnetic device, the combination of an electromagnet, pole pieces having curved outer edges, polar extensions from the pole pieces extending towards each other and having cylindrical outer surfaces, said cylindrical extensions being coaxial, and an armature pivotally supported for oscillation about the common axis of said cylindrical surfaces, said armature comprising a body portion having a cylindrical surface separated from said cylindrical surfaces of said polar extensions by a small air gap and laterally extending ends for engaging its pivotal supports.

6. In an electromagnetic device, the combination of an electromagnet, pole pieces having curved outer edges, said curved edges being coaxial, and an armature pivotally supported for oscillation about the common axis of said coaxial edges, said armature comprising a body portion having a cylindrical inner surface separated from said coaxial edges by a small air gap and laterally extending ends for engaging the pivotal supports.

7. In an electromagnetic device, the combination of a single coil electromagnet having polar extensions from both its ends provided with curved surfaces, an armature having a similarly curved operating surface presented to said polar curved surfaces and separated therefrom by small air gaps, a pivotal support for said armature mounting it for oscillatory movement maintaining said air gaps substantially constant, and a second similar electromagnet having similar polar extensions similarly related to said armature operating surface for effecting reverse movement of said armature.

8. In an electromagnetic device, the combination of a single coil electromagnet having polar extensions from both its ends provided with curved surfaces, an armature having a similarly curved operating surface presented to said polar curved surfaces and separated therefrom by small air gaps, a pivotal support for said armature mounting it for oscillatory movement maintaining said air gaps substantially constant, said curved surfaces being cylindrical and coaxial with said pivotal support, and a second similar electromagnet having similar polar extensions similarly related to said armature operating for effecting reverse movement of said armature.

9. In an electromagnetic device, the combination of an electromagnet, pole pieces having curved outer edges, polar extensions from the pole pieces extending towards each other and having cylindrical outer surfaces, said cylindrical extensions being coaxial, and an armature pivotally supported for oscillation about the common axis of said cylindrical surfaces, said armature comprising a body portion having a cylindrical inner surface separated from said cylindrical surfaces of said polar extensions by a small air gap and laterally extending ends for engaging its pivotal supports, the body portion of said armature being relatively thin magnetic material decreasing the total reluctance of the magnetic path for movement of said armature.

In witness whereof, I hereunto subscribe my name this 24th day of December, A. D. 1924.

WILLIAM P. CROCKETT.