

Nov. 10, 1953

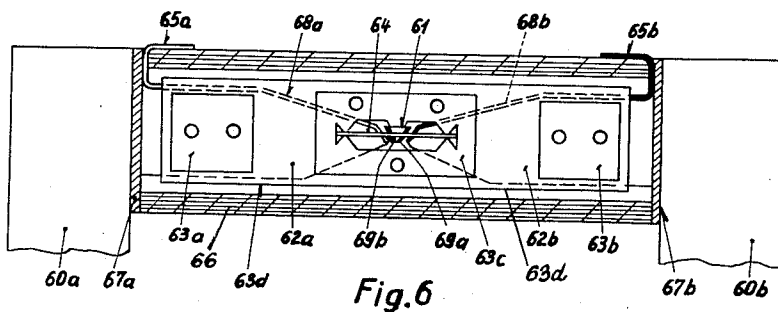
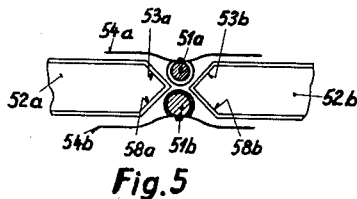
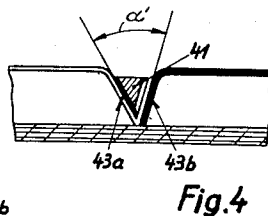
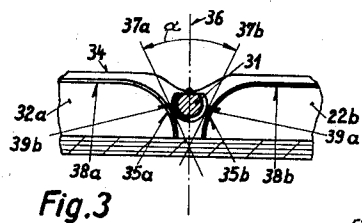
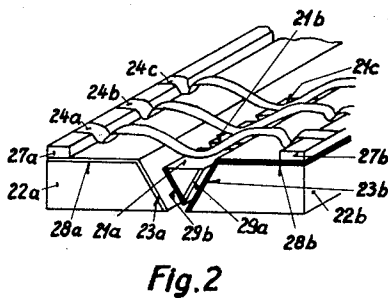
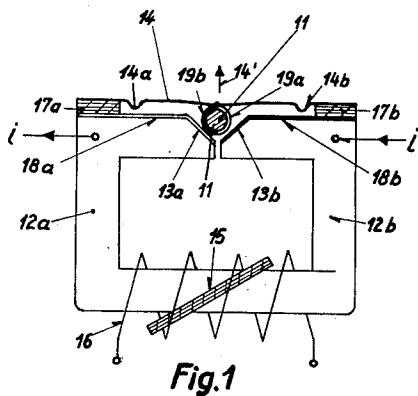
E. WETTSTEIN

2,658,971

ELECTRIC CONTACT DEVICE

Filed Sept. 16, 1949

2 Sheets-Sheet 1



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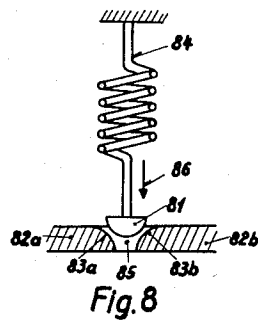
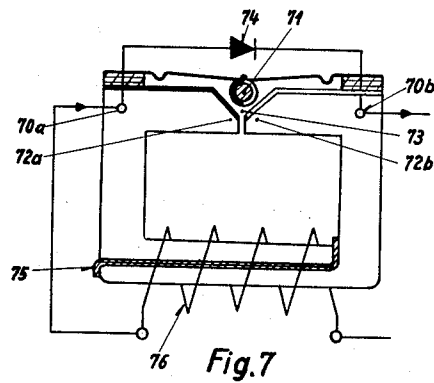
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,658,971

ELECTRIC CONTACT DEVICE

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September 17, 1948

15 Claims. (Cl. 200—87)

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My invention relates to electric contact devices in which a controllable switching force acts in opposition to a biasing force to cause a relative switching movement between mutually engageable contact members.

It is an object of my invention to provide contact devices that afford operating at an extremely high switching speed and under high contact pressure, yet are less subject to disturbing or detrimental effects of contact bouncing than contactors of the known designs when an attempt is made to operate them under such speed or pressure conditions.

Another object of the invention is to devise electromagnetic contactors capable of safely performing a complete circuit breaking or making operation within a small fraction of a cycle period of alternating current of customary frequency, for instance, of 50 or 60 cps.

According to a feature of my invention, I provide one of the mutually engageable contact members at its contact surface with a recess which is open and flaring toward the other contact member and is at least partially occupied by the latter when the members are in circuit-closing position. I further give the movable contact member or members two degrees of freedom, namely an essentially translatory main or switching movement and another movement transverse to the direction of the switching movement. The recess may have various designs. For instance, it may have the shape of a wedge, funnel, cylinder or sphere; and the appertaining other contact member may have a triangular, trapezoidal, part-circular or other arcuate cross section for instance.

According to another feature of the invention, I provide the mutually engageable surfaces, or only the recessed surface, with an elastically deformable surface layer (contact spring) to permit some limited expansion of the flaring recess due to the elasticity of the layer.

These and other objects and features of the invention will be apparent from the following description of the embodiments exemplified by the drawing in which:

Figure 1 shows schematically, by a lateral view, the basic design of an electromagnetic contact device according to the invention,

Figure 2 shows a partial and perspective view of the contact elements of another device equipped with a plurality of movable contact members to cooperate with a common stationary contact member,

Figures 3, 4 and 5 show respective part-section-

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tional views of three further modifications of the contact members of devices according to the invention,

Figure 6 is a partial and part-sectional view of another electromagnetic contact device of a cartridge-type design,

Figure 7 shows diagrammatically a device according to the invention designed for operation as a rectifier unit, and

Figure 8 is a part-sectional view of a further embodiment showing funnel-shaped contact members.

The electromagnetic contact device shown in Figure 1, has a magnetizable armature 11 of circular cross section. The appertaining field structure is composed of two parts 12a and 12b which are rigidly interconnected but are electrically separated from each other by an insulating body 15. The field structure has an air gap bordered by pole faces 13a and 13b which are shaped to form a flaring or wedge shaped recess. The armature 11 is attached, for instance by riveting, to a leaf spring 14. Spring 14 has indented or loop portions at 14a and 14b to be resilient not only in the switching direction indicated by an arrow 14' but also perpendicularly to that direction. Hence, the armature 11, suspended and biased by the spring, is capable of movement toward and away from the field structure and can also move laterally from one toward the other pole face of the structure, both movements being subject to the biasing force of the spring. The ends of spring 14 are rigidly secured to the field structure but electrically separated therefrom by bodies 17a and 17b of insulating material. An energizing coil 16 is mounted on the field structure.

The two parts 12a and 12b of the field structure are equipped with respective terminals so that the pole faces 13a and 13b serve as the stationary contact members of the contactor, while the armature 11 operates as a movable contact bridge for closing a circuit for the current *i* between the two parts 12a and 12b. Armature 11 is normally biased to the illustrated, open position. When coil 16 is energized, the armature 11 is magnetically pulled against its spring bias into the wedge shaped recess between the pole faces 13a and 13b until the armature is in contact with both faces and closes the circuit for the current *i* to be controlled. The switching movement of armature 11 from open to closed position is essentially translatory, but, as mentioned, the armature is also capable of limited movement transverse to the switching direction. Such lateral movements may occur especially be-

tween the moment of first engagement with one of the pole faces and the moment of completed seating of the armature on both pole faces.

Since the magnetic pole recesses of field structure and armature function also as electric contact surfaces, it is desirable to secure a satisfactory current passage by coating these surfaces, at least at the places of contact, with a layer of good conducting material. The thickness of such coatings should be as small as possible, preferably at most .2 mm. Such contact coatings are indicated at the places 18a and 18b of the pole faces and adjacent surface areas of the field structure. Similar coatings are provided at 19a and 19b, on the armature.

Contactors for unidirectional current, i. e. for constant or variable direct current, that are either equipped with spark quenching devices or in which the occurrence of arcs is prevented by other means such as by limitation of the voltage or current to be switched, may be subject to deterioration at the contacts due to the gradual transfer of minute particles of contact material from the anodic to the cathodic contact surface. To prevent such disturbances, the contact surfaces of devices according to the invention may be placed in a protective gas and the cathodic contact surfaces (for instance, the surfaces 18a and 19a in Fig. 1) are preferably coated with silver while the anodic contact surfaces (18b and 19b in Fig. 1) are coated with copper. Especially favorable results from the viewpoint of reduced contact bouncing are obtained by making at least one of the coatings elastically resilient in the direction of the magnetic pull. Such a resiliency, however, should be limited to a resilient travel of at most 0.1 mm. The surface layer of the armature is preferably so designed that it encloses the armature at least partially and its arrangement should be such that the magnetic flux traverses the layer in a substantially perpendicular direction in order to prevent unduly increasing the reluctance of the magnetic circuit. The surface layers (contact springs) 18a and 18b on pole faces 13a and 13b of the field structure 12a, 12b consist preferably of thin metal sheets or foils and are fastened together with the insulating bodies 17a and 17b.

Fig. 2 shows only some of the contact elements, including the armatures and field poles, of a multiple electromagnetic contact device whose remaining field structure and control coil may be similar to the corresponding parts of the embodiment shown in Fig. 1. According to Fig. 2, several independently movable armatures are provided, such as those denoted by 21a, 21b, 21c. These armatures are individually mounted on respective springs 24a, 24b, 24c, and are insulated at 27a, 27b from the two pole pieces 22a and 22b of the field structure. The armatures of this embodiment have a triangular cross section. The magnetic pole faces 23a and 24b of the field structure are covered by surface layers or contact springs 23a and 28b, and the armatures are surfaced at 29a and 29b, substantially as described with reference to Fig. 1.

A multiple contactor according to Fig. 2 permits making the various springs 24a, 24b, etc., or/and the various air gaps different from one another so that the armatures close the respective electric circuits in a desired sequence, or operate in response to different respective magnitudes of the control current applied to the energizing coil of the field structure. These ex-

pedients aid in reducing the occurrence or detrimental effects of contact bouncing.

Fig. 3 shows an especially favorable design of the wedge shaped recess between the pole faces of the stationary field structure, the non-illustrated portion of the device being, for instance, similar to the corresponding portion of the embodiment of Fig. 1. It has been found that bouncing of the armature 31 (Fig. 3) when it hits against the pole faces of the pole pieces 32a, 32b can be greatly reduced or virtually eliminated if the pole face pair of the field structure is given a mirror-symmetrical shape and if the armature 31 is designed and mounted so as to have two degrees of freedom, i. e., is movable in the direction of the plane 36 of symmetry of the pole faces and perpendicularly to that plane. It is further advantageous to shape the pole faces in such a manner that an angle α not larger than 120° will exist between the two tangential planes 37a and 37b extending through two successive points of contact 35a and 35b between armature 31 and the respective pole faces. Numeral 34 denotes the spring to which the armature 31 is attached, while numerals 33a and 33b, 39a and 39b denote thin metal sheets of electric contact material on the pole and armature faces for the purpose described with reference to the embodiments of Fig. 1.

As is apparent from the above-described embodiments, the design of switching devices according to the invention is generally such that the two air gaps between the armature and the two respective pole faces of the field structure vary equally while the armature is moving under magnetic pull. However, an improved suppression of bouncing tendencies can be obtained by a design of the kind shown in Figure 4.

In the modification of the contact members according to Fig. 4, the armature 41 is in slidable engagement with one pole face 43a of the field structure so that only the one air gap between armature 41 and pole face 43b changes its width during the armature movement. The friction between armature 41 and pole face 43a prevents or dampens any bouncing tendencies. Such a design is fully taken advantage of if the pole surfaces 43a and 43b of the field structure are shaped so that the tangential planes through two successive points of contact between the armature and the respective pole faces include an angle α of at most 90° . Of course, with plane pole surfaces as shown in Fig. 4, the angle α is equal to the angle between the two pole faces 43a and 43b. If the angle α were larger than 90° , the impact of the armature upon pole face 43b would cause a repulsive force tending to reflect the armature out of the recess.

In the modification according to Fig. 5 the pole pieces 52a and 52b are knife edge shaped and face each other, thus forming between each other two wedge shaped recesses at both sides respectively of the pole pieces. An armature 51a is disposed in one recess, and a second armature 51b is disposed in the other. The two armatures 51a and 51b can be given different shapes or designs. For instance, in the illustrated embodiment the armature 51a is lighter in weight and is attached to a spring 54a weaker than the spring 54b which holds the heavier armature 51b. As a result, the lighter and more easily movable armature 51a responds to a lower magnitude of energizing current, while the heavier armature 51b engages the appertaining pole faces 58a and 58b at a later moment of an

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increasing energizing current, the armature 51b being designed to carry a larger magnetic flux and also a larger electric current. The pole faces 53a, 53b and 58a, 58b, as well as the armature 51a and 51b are preferably covered by layers of contact material as previously described.

In the embodiment illustrated in Fig. 6 two pole pieces 62a, 62b and the appertaining armature 61 with its biasing spring 64 are built together into a structural unit of cartridge-like design. The pole pieces 62a and 62b consist preferably of laminated or otherwise subdivided ferromagnetic material of especially low losses, for instance, of total losses below 1 watt/kg. at an induction of 10,000 Gauss and a frequency of 50 cps. The pole pieces are held together by plates 63a, 63b and a connecting plate 63c, an insulating plate 63d being interposed. The pole faces of pole pieces 62a and 62b are surfaced with a layer 68a or 68b of good conducting material consisting, for instance, of silver and copper, respectively. These layers consist of metal sheets and they form also the terminals 65a, 65b for supplying the current to be controlled by the cartridge type switching unit. The armature 61 is coated with contact material at 69a and 69b and is attached to the spring 64 which is mounted in knife edge type recesses of the plate 63c. The pole pieces, the armature with the appertaining spring and the plates are enclosed within a tubular housing 66 of insulating, for instance, ceramic material. The ends of the housing are sealed by thin cover plates 67a, 67b of ferromagnetic material which are firmly connected with the pole pieces 62a, 62b soldered to the housing. Numerals 60a and 60b denote the respective legs of a field structure which may otherwise be designed in accordance with Fig. 1. However, the energizing winding (not illustrated) may be disposed around the housing 66 instead of, or in addition to, being mounted on the leg or base portion of the field structure. When the energizing coil is sufficiently excited to make the pole pieces attract the armature into contact closing position, the current flows, for instance, from terminal 65a through the contact sheet 68a of pole shoe 62a through the armature 61 and the contact sheet of 68b of pole shoe 62b to the terminal 65b of the switching cartridge.

In the magneto-mechanical rectifying unit illustrated in Fig. 7, an alternating current i , to be rectified by periodic and synchronized switching, flows through the energizing coil 76 and thence through a terminal 70a and a valve unit 74 to the terminal 70b. The contact portion of the device, comprising the spring suspended armature 71 and the pole pieces 72a, 72b of the magnetic field structure is electrically connected in parallel relation to the valve element 74. The field structure is subdivided by insulation 75 and is otherwise designed and operative substantially as described in conjunction with the other embodiments. The valve unit 74 is conductive only at low instantaneous values of current, while the contact members of the electromagnetic switching device are rated to carry the current during the predominant portion of the conductive half-wave periods. The device operates as follows: Assume that the alternating current i is just passing through the zero value at the beginning of a conductive period of valve 74. Then the current will initially flow through the valve 74 while the armature 71 is still in the illustrated open position. The valve current energizes the coil 76. When the instantaneous value of the current reaches a

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sufficient magnitude, still relatively far ahead of the current maximum, the field structure is sufficiently magnetized to rapidly attract the armature 71 into the wedge shaped recess 73 and into contact engagement with the pole pieces 72a, 72b so that the valve 74 is short-circuited. From now on the current i flows directly from terminal 70a through armature 71 to terminal 70b. After passing through the maximum value and declining to lower instantaneous values, the current will reach a magnitude shortly ahead of the next zero passage at which the energization of coil 76 becomes again insufficient to hold the armature 71 against its spring bias. The armature drops off, and the current again flows through the valve 74. At the subsequent zero passage the current stops flowing and the unit remains non-conductive during the next half-wave period. It will be noted that the contact closes and opens at movements in which the valve is effective across the contact gap. As a result such a rectifying device operates without arcing or sparking.

In the modification of the magnetic and electric contact elements shown in Fig. 8, a stationary contact member 82a, 82b has a funnel-shaped recess 85. The other contact member 81 is semi-spherical and is attached to a spring 84 which permits the contact member 81 to move not only in the switching direction denoted by the arrow 86 but also within a plane transverse to that direction. If the switching member 81 is attracted, for instance, by a magnetic field system (not illustrated) it may, for instance, first touch the surface portion 83a of the funnel-shaped recess 85 before the reflective force of the impact causes it to move laterally into contact engagement with the surface portion 83a. It will be understood that in the modification of Fig. 8 the two portions 82a and 82b of the stationary contact member may form an integral conductive body so that the current to be controlled is supplied through contact member 81 which closes the circuit whenever it engages any point of the funnel surface. It is then necessary to provide a separate field structure underneath the magnetizable contact member 81 for pulling this contact member into the circuit closing position. However, the two portions 82a and 82b of the stationary contact member may also be insulated from each other and may be made of magnetic material to form part of a field structure as described in conjunction with preceding embodiments.

In devices according to the invention the effects of contact bouncing are minimized because, when the moving contact member under the effect of the controlling force touches a point of the recessed contact surface, any bouncing will not reflect the moving contact member in the circuit-opening direction but will cause a reflective movement toward the opposite point or face of the recess. In this manner, a sequence of reflective lateral movements may occur, all tending to promote a proper seating of the mutually engaging contact. Indeed, by virtue of the above described elastic surfacing, it can be achieved that when the moving contact member is reflected from a first point of contact toward a second point of contact, both points within the flaring recess, the second contact is made before the first contact is interrupted. As also explained, it is further possible to virtually eliminate bouncing tendencies. It is an essential advantage that these results are achieved without requiring an increase in total mass, weight or size of the

armature or moving contact member thus facilitating an operation at extremely high switching speeds.

It is generally preferable to design the movable contact member (armature) as an elongated prism, cylinder or cylinder section and to arrange it so that the magnetic flux traverses the peripheral surface substantially perpendicularly. In order to obtain a switch member (armature) of minimum weight and hence a minimum switching period for a given amount of energizing ampere turns, it is advantageous to give the switching member a cross sectional area of at most 2 mm.². It is often advisable to design the ferromagnetic portion of this switching member as a compact body because the application of laminations is rather difficult and the eddy current losses are negligible with such small dimensions. While in the above described embodiments the biasing force for the armature is provided by springs, it is obvious that other biasing means are likewise applicable. For instance, the biasing force may consist in a magnetic pull obtained, for instance, by means of a permanent magnet which attracts the armature in the desired biasing direction. The insulation between the two magnet pole pieces is preferably designed so that its magnet reluctance is not more than one-fifth of the magnet reluctance of the working gap, i. e., of the total air gap between the armature and the pole faces. Such a low reluctance of the insulation can be readily achieved, for instance, with a design as illustrated at 75 in Fig. 7.

It will be obvious to those skilled in the art upon a study of this disclosure that devices according to the invention can be modified in various respects and may be embodied in designs other than those specifically described in this specification, without departing from the objects and essential features of my invention and within the scope of the claims annexed hereto.

I claim:

1. An electric contact device, comprising electric circuit means for the passage of current to be controlled, said circuit means including a stationary and magnetizable electric contact structure and a magnetizable electric contact member movable relative to said structure, said member having a circuit-closing position in which said member is in electric contact engagement with said structure and a circuit-opening position in which said member is disengaged from said structure, biasing spring means joined with said member and biasing said member to said circuit-opening position, said structure and said member forming together a magnetic system for moving when magnetized said member to said circuit-closing position, said structure having a recess diverging relative to said member and said member being seated in said recess when in said circuit-closing position, said spring means being resilient in at least two mutually intersecting directions and forming the sole mechanical support of said member when said member is in said circuit-opening position so that said member is capable of reflective movements across said recess when moving to said circuit-closing position.

2. An electric contact device, comprising a magnet field structure having two rigidly interconnected and mutually spaced pole pieces electrically insulated from each other and having respective electric terminals for connection to an electric circuit to be controlled, said pole pieces having respective pole faces forming together an air gap of divergent shape, a movable electri-

cally conductive magnet armature disposed in the field of said gap to be attracted to said structure when said structure is magnetized, said armature having a shape adapted to that of said gap and being bridgingly engageable with said two pole pieces when in attracted position to then electrically interconnect said terminals, biasing spring means connected with said armature for biasing it away from said pole pieces to circuit-opening position, said spring means forming the sole support of said armature in said circuit-opening position and being resilient in the pole-piece engaging direction of armature movement as well as transverse to said direction so that said armature is movable between said two positions and also in a direction across said gap.

3. A contact device for controlling an electric circuit, comprising a rigid stationary contact structure of magnetizable material having an outwardly-flaring and wedge-shaped recess and being elastically deformable at the surface of said recess, a wedge-shaped electric contact member of magnetizable material being movable relative to said structure between a circuit-closing position and a circuit-opening position, said member being seated in said recess when in said circuit-closing position, biasing spring means joined with said member and biasing it to one of said positions, said structure and said member forming together a magnet system for moving said member to said other position, said spring means being resilient in two mutually intersecting directions and forming the only mechanical support of said member when said member is in said circuit-opening position whereby said member has at least two freedoms of movement namely in the direction from one to the other of said positions and in a direction across said recess.

4. A contact device for controlling an electric circuit, comprising an electromagnetic field structure having pole means and being adapted for connection to the circuit to be controlled, an armature member forming a magnetic circuit together with said field structure and being electrically engageable with said pole means to close said electric circuit, biasing spring means attached to said armature to normally hold said armature away from said pole means, said pole means having a recess flaring toward said armature and having an elastically deformable and electrically conductive surface element disposed at said recess to be contacted by said armature when said armature is in engagement with said pole means, said spring means being resilient in two mutually intersecting directions and forming the sole support of said armature when said armature is disengaged from said pole means, whereby said armature is movable relative to said pole means in the pole-means engaging direction and also in a direction across said recess so as to be capable of repetitive reflective movements across said recess during circuit-closing performance.

5. In a device according to claim 4, said armature being compact and rigid throughout and consisting of a main body of magnetizable material and of a surface layer of electrically highly conductive material engageable by said surface element of said pole means, said surface layer and said surface element having each a thickness of at most .2 mm.

6. In a device according to claim 4, said surface element being elastically deformable in the di-

rection of the magnetic pull and having a resilient travel of at most 0.1 mm.

7. An electric contact device, comprising a magnetizable and electrically conductive armature, spring means connected with said armature for biasing said armature toward a given position, an electromagnetic field structure forming a magnetic circuit with said armature for moving said armature to another position, said field structure having two rigidly interconnected pole pieces of rigid material insulated from each other and having respective pole faces forming together an air gap flaring toward said armature, two elastically deformable surface elements disposed on said respective pole faces in face-to-face relation thereto so as to leave in said air gap a flaring recess which is expansible only due to deformation of said surface elements, electric terminals adapted for connection to an electric circuit to be controlled and electrically joined with said respective surface elements, said spring means being resilient in two mutually perpendicular directions and forming the sole support of said armature when said armature is in said given position, said armature being in electric bridging engagement with both said elements when in said other position and being movable in a direction between said two positions and also in a direction across said gap.

8. In a device according to claim 2, said gap and said armature having matching wedge shapes respectively and each of them having two angularly interrelated plane contact surfaces, said pole-piece engaging direction of armature movement extending substantially parallel to one of said contact surfaces of said pole pieces.

9. In a device according to claim 2, said gap and said armature having matching wedge shapes respectively and each of them having two angularly interrelated plane contact surfaces, one of said contact surfaces of said armature and the adjacent contact surface of said gap being in slidable engagement with each other during circuit closing armature movement.

10. In a device according to claim 2, said gap having two opposingly inclined surfaces, the planes tangential to said respective recess surfaces at successive points of reflective impact engagement with said armature being inclined toward each other at an angle of at most 90°.

11. In a device according to claim 2, said gap having two mirror-symmetrical surfaces of curved shape, said surfaces having at any two corresponding points of contact engagement with said armature two respective tangential planes inclined toward each other at an angle of at most 120°.

12. In a switching device according to claim 4, said spring means consisting essentially of an elongated leaf spring extending substantially parallel to said direction across said recess and having both ends stationarily attached to said structure, said armature being attached to said spring at the center portion of said spring to subject said spring to bending when moving in said pole-means engaging direction, and said spring having curved portions between said armature and said respective ends so as to be also yieldable longitudinally.

13. A switching device, comprising stationary contact means having two mutually insulated portions spaced from each other to form an air gap, said portions having respective wedge-shaped surfaces tapering toward each other at said gap whereby said gap forms two outwardly flaring recesses at opposite sides respectively of said contact means, two movable contact members disposed opposite said respective recesses, spring means connected with said members to bias said members away from said recesses, said members being individually movable in the direction toward said respective recesses and into electrical bridging engagement with said two surfaces, and said spring means allowing said contact members to individually move in a direction across said respective recesses.

14. In a contact device according to claim 2, said armature consisting of a compact body of substantially prismatic shape and having across said gap a cross sectional area of at most 2 mm.².

15. An electric contact device, comprising a magnet field structure having two rigidly interconnected and mutually spaced pole pieces electrically insulated from each other and having respective electric terminals for connection to an electric circuit to be controlled, said pole pieces having respective pole faces forming together an air-gap of divergent shape, a movable electrically conductive magnet armature disposed in the field of said gap to be attracted to said structure when said structure is magnetized, said armature having a shape adapted to that of said gap and being bridgingly engageable with said two pole pieces when in attracted position to then electrically interconnect said terminals, a leaf spring having respective ends insulatedly mounted on said pole pieces and extending substantially parallel to the spacing direction of said pole pieces, said leaf spring having its center connected with said armature for biasing said armature away from said pole pieces and forming the sole support of said armature when said armature is away from said pole pieces.

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