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3,153,131

SWITCH FOR LARGE CURRENTS WITH ONE CONTACT PLASTICALLY
DEFORMABLE IN PROPORTION TO CURRENT VALUE

Filed Aug. 17, 1959

2 Sheets-Sheet 1

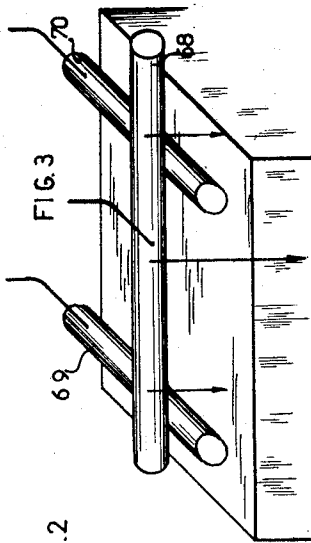


FIG. 2

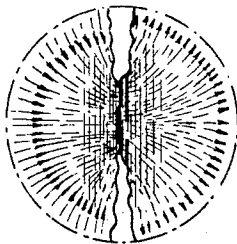


FIG. 1

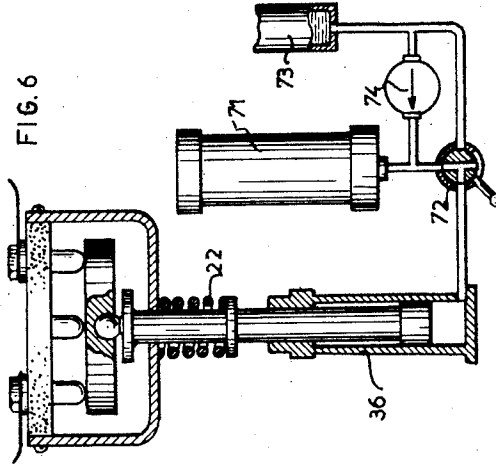
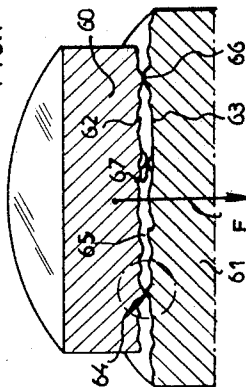


FIG. 5

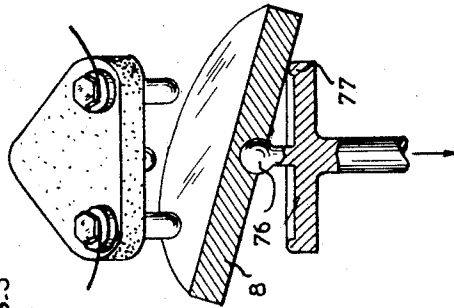


FIG. 6

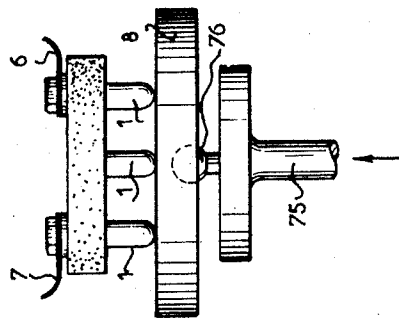


FIG. 7

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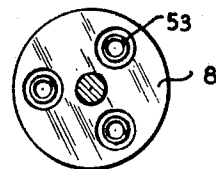
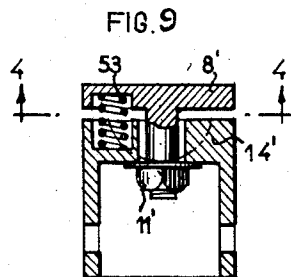
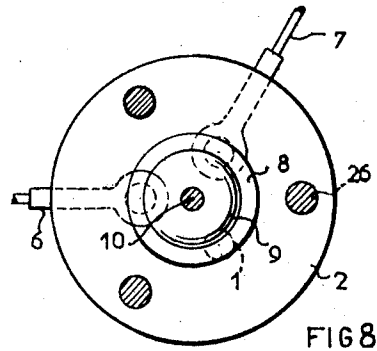
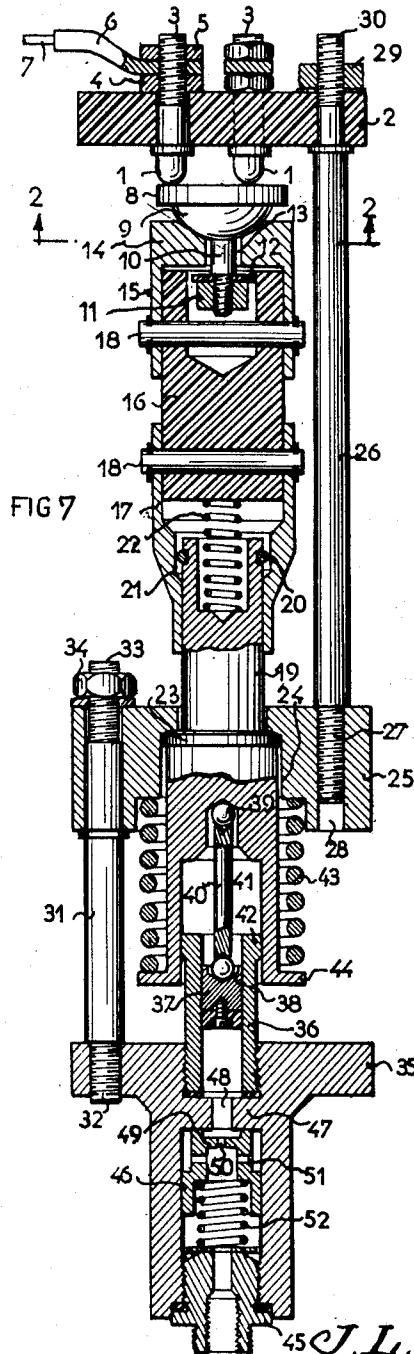
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2 Sheets-Sheet 2



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3,153,131

SWITCH FOR LARGE CURRENTS WITH ONE CONTACT PLASTICALLY DEFORMABLE IN PROPORTION TO CURRENT VALUE

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9 Claims. (Cl. 200—170)

The invention relates to make-and-break switches, the function of which is to complete or cut off electric circuits and, more particularly, circuits normally carrying a strong current (e.g., of several hundreds of amperes or more).

As known, good contacts are particularly essential when the current is strong, since the heat developed in the contact areas may become dangerous, as the current strength increases.

In low-current switches the control means provided for establishing the contact are always superabundant, so that there is usually no difficulty at the point of view of the heating, most of the prior solutions being therefore satisfactory.

The problem becomes critical only for high strength currents.

According to the conventional art, when contacts intended to control currents of high strength are to be established, one tries to design contact members provided with coinciding geometrical surfaces having an area proportional to the steady currents strength. Now the applicant has observed that when two plane bodies are brought into contact with each other under negligible pressure, they effectively bear on one another through three points only, whatever may be the accuracy of the machining, so that the overall effective metal-on-metal area is merely equal to the minute sum of the "areas" of these three points, which sum remains constant, whatever may be the size of the physical surfaces, as long as the contact pressure is not increased.

This is why the said pressure is usually increased so as to provide other contact points upon deformation of the three first ones.

In these conditions, it is clear that neither the overall effective metal-on-metal contact area nor the pressure to be adopted can possibly be predetermined.

Last but not least, the contact surface thus obtained undergoes deformations with time so that, whatever may be the initial superabundant pressure adopted, it is quite impossible to be sure that after a number of operations the contact will not become poor, which could cause deterioration of the apparatus, to say nothing of more severe incidents.

Independently of such risks, the requirement for a superabundant pressure and the machining servitudes, which increase with the size of the contact surfaces to be designed, make the known devices very expensive, in particular when they are intended to control high voltage networks.

The applicant has started from a diametrically opposed concept. He has shown that it was possible to use quasi-punctual contacts by voluntarily designing one of the contact members so that it offers at most three points, by giving to said points a sufficient plasticity and to the other contact member a sufficient hardness to obtain, when said members are pressed against each other, under deformation of the points, a well defined metal-on-metal contact surface not liable to undergo variations in duty, with the only condition that the pressure required to avoid excessive heating be accurately determined.

The applicant has established and practically checked that if a perfect contact is obtained between two contact

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members designed as mentioned above for a current of a given strength, under a pressure contact of a given value, it suffices, to maintain perfect contact for a stronger current, to give to the contact pressure a value proportional to the square of the current strength.

The theory established by the applicant is the following: When two metal members are pressed against each other with a predetermined force there is obtained a metal-on-metal actual contact area proportional to said force and reversely proportional to the hardness of the softer metal.

When an electric current is to pass through the said effective contact area, the maximum value of the current is determined by the heating resulting from the comparatively narrow size of the area, maximum heating being determined in turn by the nature of the metal and that of the ambient medium.

Moreover, the amount of heat brought to said contact area due to the current obviously has to be evacuated through the mass of the contact members so that it is a function of the thermal conductivity of the metals. In the case of a steady current, it is thus possible to determine a temperature equilibrium corresponding to the maximum heating.

For the same temperature difference between the contact area and the ambient medium, the amount of heat Q_1 evacuated from the said contact area, increases as the square root of the surface of said area, i.e., as the square root of the force pressing the contact members against each other:

$$Q_1 = a\sqrt{F}$$

F being the said force and a a constant depending on the nature of the metals used (hardness, electric and thermal conductivity, etc.).

On the other hand, the amount of heat Q_2 developed upon flowing of a current of a given strength decreases as the root square of the contact pressure and increases as the square of the current strength, which may be written:

$$Q_2 = b \times \frac{I^2}{\sqrt{F}}$$

I being the current strength, and b a constant depending on the nature of the metals used (hardness, electric and thermal conductivity, etc.).

Since both amounts of heat are necessarily equal ($Q_1 = Q_2$) the following formula may be written:

$$a\sqrt{F} = b \times \frac{I^2}{\sqrt{F}}$$

and hence,

$$I^2 = \frac{a}{b} \times F$$

and, assuming that

$$\frac{b}{a} = \frac{I}{K}$$

$$I^2 = \frac{I}{K} \times F$$

or:

$$F = K.I^2 \quad (I)$$

Thus, it may be seen that the contact pressure has to be proportional to the square of the steady current strength.

To show that this theory may easily be embodied in industrial applications, the applicant has computed the values of the forces to be used for high current strength (e.g., of about 1000 A.), he has found that the force required was only about 50 kg., which result is in con-

tradistinction with the values to be expected by extrapolation of the usual superabundant contacts for low currents, which extrapolation would lead to pressures of several tenths of tons.

During tests effected with contacts constituted by simple cylindrical wires arranged in cross-like fashion, and hence contacting each other in one single point, as described in detail hereunder, the applicant has obtained the following results (wire diameter: 1 mm.; current strength: 20 A.; contact heating: negligible).

Nature of the metals:	Contact force, g.
Copper/copper	20
Copper/hard bronze	20
Hard bronze/hard bronze	400
Chromium - plated copper/chromium plated copper	Impossible
Oxidized copper/oxidized copper	20

It may be easily seen in the above table, that if one of the metals is sufficiently plastic, the required contact force is very small (20 g.).

Thus, for 1 A., it suffices to use a contact force (see Formula I) 400 times smaller (20²), i.e.,

$$\frac{20}{20^2} = 0.05$$

and for 1000 A.: $0.05 \times 10^6 \text{ g.} = 50 \text{ kg.}$

It may be seen moreover that only one of the two contacts has to offer high thermal conductivity.

It is to be noted that for asserting in advance and maintaining with time a predetermined metal-on-metal contact obtained by deformation, it is indispensable that the number of contact points provided be not greater than three. This results from the well-known geometrical law according to which two points determine a line and three points a plane.

It is to be noted furthermore that if the same overall area of effective contact is to be reproduced indefinitely, it is the contact member provided with points which is to be deformed, and not the other member in which the said points could form recesses, which would impair the reproduction of the same contact conditions.

An object of the invention is therefore to provide a make-and-break switch, wherein one of the contact members is provided with at most three contact points, made of a comparatively soft and plastic material such as copper, while the other contact member offers a comparatively hard contact surface, such as hard bronze, on which the said points will become blunted, means being provided to press said contact members against each other with a force proportional to the square of the current strength to be controlled.

Another object of the invention is to design the said points in the shape of rods substantially normal to the contact surface in circuit-making position and whose diameter is so chosen that the above mentioned contact force, while being capable of making the points blunt, is not liable to cause a permanent deformation of the main portions of said rod, the contact pressure means being therefore so designed as to exert on the contact but a force limited to a predetermined maximum value, the said force thus being comprised within two predetermined limit values, one of which depends on the current strength to be controlled, while the other one is chosen according to the mechanical resistance of the contact points.

Briefly, it seems that the principle of the invention may be distinguished from the conventional art in the following manner:

Heretofore the general trend was to design perfect contact surfaces having an area proportional to the current strength and to press said surfaces on each other with pressures impossible to determine in advance.

According to the invention, however, the contact pres-

sures are accurately predetermined, specific materials are chosen for each contact member, only three contact "points" are provided and finally the arrangement is such that the overall effective metal-on-metal contact area be sufficient to avoid any objectionable heating and moreover be reproduced with the same value, whenever the circuit is made again after breaking.

Another object of the invention is to provide a make-and-break switch of the type described, wherein the above mentioned contact rods are made of copper, which material offers a very high electric and thermal conductivity, a suitable plasticity and a convenient resistance to permanent deformation under axial compression, the other contact member being preferably made of a metal such as stainless hard bronze, which material offers a sufficient electric conductivity, a great hardness, and a convenient resistance against corrosion.

The applicant has observed that it was sufficient to use copper only for one contact member, since the heat dispersion through the copper rods suffices to cool down the contact area formed by their blunted points.

Another object of the invention is to design one of the contact members in the shape of three separated rods, at least two of which constitute electric conductors, while the other contact member is constituted by a plate swivelling about a point located near its surface, the orientation freedom of said plate being so limited that the break distance be sufficient for each separated contact, whatever may be the orientation of the plate.

Owing to this arrangement, when the two contact members are applied against each other, the contact surface first reaches one of the points, whereupon it is tilted to bear also against the two other points.

Therefore, it will be easily understood that whatever may be the inaccuracy or misalignments between the two contact members a rigorous three-point contact will be established and it will be sufficient to exert between the switch members the above mentioned contact pressure in a direction which is not necessarily defined with accuracy to obtain an excellent electric contact between at least two of the points and the orientatable surface.

Thus it suffices to connect these two points respectively to two electric conductors for obtaining electric interconnection between these conductors, when the switch is closed through the other member. The invention thus offers the essential advantage of permitting manufacture of the switch by means of parts machined with usual tolerances without any adjustment on assembling.

A more specific object of the invention is to design the plate provided with the contact surface in the shape of a semi-spherical head at one end of a guiding rod, the other end of which is provided with abutment means, the said rod being engaged in a bore of the wall of the relevant contact member (which is preferably the movable one) the opening of said bore adjacent to the contact member being provided with a semi-spherical edge which cooperates with the above mentioned head, so as to form a knee-joint. This whole structure is machined with a sufficient clearance with respect to the said bore to float slightly therein, both along the guiding rod and in swivel fashion.

It is another object of the invention to design the control means provided for actuating the movable contact member in such a manner as to permit generating and sustaining the above defined contact forces. The said control means are furthermore preferably adapted to ensure very quick cut-off, e.g., with an acceleration of the movable contact member permitting its withdrawal away from the fixed contact member by one centimeter in a time of about $\frac{1}{1000}$ of a second.

According to a more specific object of the invention, to ensure both the required contact pressure and a very quick cut-off, the control system essentially comprises a hydraulic cylinder closing the switch and holding it in closed condition against the action of powerful elastic

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means, and circuit-breaking is obtained by exhausting the hydraulic cylinder at a sufficiently high rate to cause no dash-pot braking of the above mentioned elastic means, once the same has been released.

In a particularly simple, efficient and inexpensive embodiment, the circuit-making and breaking take place by a simple relative axial displacement, the movable contact member being fast with the piston rod of the hydraulic cylinder, while the fixed contact member comprises three points, whose active ends are located at the apices of an equilateral triangle the plane of which is substantially normal to the cylinder axis and having its centre on said axis.

It is another object of the invention to provide means for rendering the circuit-making stroke of the switch progressive, without slowing down its circuit-breaking stroke.

A more specific object of the invention is to use, for the purpose set forth in the preceding paragraph a kind of non-return valve interposed in the feeding and exhaust duct of the cylinder and which, as the latter is fed with pressure liquid compels the same to flow through a restriction while during exhaust the said valve is unseated by the liquid pressure and lets said liquid escape freely. Due to the high hydraulic pressure required to arm elastic means sufficiently strong to ensure the desired quick cut-out, stress-limiting means are preferably interposed between the hydraulic cylinder and the movable contact member, so that the contact pressure, while having a sufficient value to ensure a suitable electric contact, nevertheless be not capable of deteriorating the contact points.

Other objects and advantages of the invention will be hereinafter described with reference to the accompanying drawings, given merely by way of example.

In these drawings:

FIG. 1 shows, at an exaggerated scale, actual contact between two solid bodies.

FIG. 2 is an enlarged view of one of the contact points of FIG. 1, illustrating restriction phenomena acting on the electric and thermal flows.

FIG. 3 shows the testing device which has been used by the applicant to check his theory.

FIG. 4 is an elevational view of the contact members of a switch according to the invention, shown in circuit-making position.

FIG. 5 shows the same device as FIG. 4, but with the contacts in circuit-breaking position.

FIG. 6 diagrammatically shows a switch according to the invention with a hydraulic control.

FIG. 7 is a longitudinal axial sectional view of a construction of the switch according to the invention.

FIG. 8 is a partly sectional view along line 2—2 of FIG. 7.

FIG. 9 shows an alternative construction of the orientable contact, and,

FIG. 10 is a sectional view along line 4—4 of FIG. 9.

In FIG. 1, to illustrate the fact that it is no use trying to establish wide contact surfaces to accommodate strong current there are shown two plane bodies 60 and 61 bearing on each other under the action of a weak force F such as for example the weight of the body 60. The irregularities of the respective contact surfaces 62 and 63 have been strongly exaggerated to show that, whatever may be the machining accuracy, as long as the parts undergo no deformation they bear on each other on three points only, as shown respectively at 64, 65 and 66. However, the action of the force F causes a minute deformation of the theoretical contact points, as shown in the drawing, which provides an overall metal-on-metal contact area of very small value, equal to the sum of the three areas resulting from the deformation of the three points 64, 65, 66 respectively. According to the conventional art, one tries to increase this metal-on-metal contact surface by reducing as much as possible the irregularities of the surfaces 62 and 63 by a careful machin-

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ing and by increasing the force F to a sufficient extent to create other points and hence other minute contact areas, under deformation of the parts 60 and 61. It may be easily seen in FIG. 1 that the establishment of the additional contact points can only take place at random since, for example, if the outline of the surface were, as shown in FIG. 1, by sufficiently deforming the two parts, there would be obtained initially a fourth contact point, e.g., as at 67 between those two points of the surfaces 62 and 63 which were the nearest when only three contact points were provided, and so on. Now the exact shape of the outline depends on a number of factors such as the machining accuracy, the cleanliness of the surfaces, etc., so that, even with a superabundant force F , it is impossible to predetermine the initial contact conditions and so that the slightest deformation of the contact members immediately modifies the contact conditions for the next circuit-making operation.

It may be seen in FIG. 2, wherein a contact point has been shown with a force diagram indicating in an arbitrary way that maximum heating prevails in the immediate vicinity of the contact surface S . It may be seen also in this figure that, in the near vicinity of the said contact surface, the irregular outlines extend very near each other, which may give rise to sparking, heat exchanges, etc., all phenomena which are uncontrollable in the conventional art.

The applicant has succeeded in controlling positively the mechanical electric and thermal conditions prevailing in the contact surfaces and hence, not only in determining with accuracy the conditions of the initial contact, but also in maintaining these conditions during practically the whole life of the contact members. For this purpose, the applicant voluntarily separates the outlines of the contact members, except for the effective contact areas; in other words, he limits the contact surfaces substantially to quasi-punctual areas by providing at most the maximum number of contact points obtainable between two bodies, viz. three.

The applicant has further shown that, to limit heating to a reasonable value and hence to ensure flowing of the desired current strength in the required conditions, it was sufficient to provide a comparatively weak and well-defined contact force, as explained in the preamble. To determine experimentally the pressure values, the applicant has used the testing device shown in FIG. 3 which comprises a cylindrical conductor 68 bearing in cross-like fashion on two other cylindrical conductors 69 and 70 and he succeeded in establishing that with comparatively weak forces it was perfectly possible to accommodate comparatively high current strength, provided that at least one of the metals is sufficiently plastic which happens to be the case of copper.

The results of these tests have been given in the preamble so that it is not necessary to describe them again.

Now, whenever the switch is closed, the previously established metal-on-metal contact areas have to be safely reproduced.

For this purpose, as mentioned in the preamble, it is necessary and sufficient that the contact points be made of a comparatively plastic metal such as copper, the other contact member being made, on the contrary, of a comparatively hard metal such as hard bronze. If the second contact member were also made of a soft metal such as copper predetermined initial conditions of contact could be obtained, as shown by the results of the above mentioned tests (of the value obtained for the copper/copper contact) but the said second contact member would undergo, under the action of the points, a hollow deformation so that at the next closing of the switch it would be impossible, except if an extreme accuracy of the parts were provided (which would imply a high cost), to re-establish the same contact conditions.

It will be noted moreover that the oxide tending to be formed on circuit-breaking is expelled away from the

contact area due to the high unitary pressure exerted on the geometrical contact surface. Furthermore, it is also possible, since the contact surface, according to the invention, is made of a hard metal, to use a stainless alloy such as stainless hard bronze, which seems moreover to confer corrosion resisting properties to the contact surfaces of the copper points during the very operation of the switch.

As explained in the preamble, the contact pressure provided is not prohibitive and it will be seen, in the simple embodiment of the invention described hereunder, that said pressure may be obtained, for example, by means of a simple stress-limiting spring, the control of the movable contact displacements being ensured conveniently by means of a hydraulic plant capable both of compressing said spring and ensuring said displacements at a suitable speed.

In FIGS. 4 and 5 is shown in circuit-breaking and circuit-making positions, respectively, a particularly simple and efficient construction of the contact members of a switch according to the invention. In this construction, the switch contact member comprises three rods 1, two of which only are connected to electric conductors 6 and 7, and the movable contact member comprises a plate 8, swivelling mounted at 76, on a movable structure 75 carrying abutments 77 which, as shown in FIG. 5, limit the possible tilting of the plate 8 about the swivel-joint 76, so that as the contact members are taken away from each other for circuit-breaking purpose, the plate 8 be stopped, for example in the position shown in FIG. 5, at a sufficient distance from the point 1.

In FIG. 6, there is shown at 22 a circuit-breaking spring which is compressed, when the switch is to be closed, by a cylinder 36 which is fed with pressure liquid from an air-and-oil accumulator 71, the feeding and the exhaust of said cylinder being controlled by a distributor 72. In 73 is shown the oil reservoir and in 74 a pump adapted to keep the accumulator 71 under pressure.

In the constructive embodiment shown in FIGS. 7 to 10 the orientatable contact is constituted by a plate 8 rigid with a semi-spherical portion 9 provided with a shank 10, the free end of which is threaded and carries a retaining head constituted by a nut 11 clamping a washer 12. This whole assembly is slightly floating in an axial bore 13, the outer edge of which has a spherical shape, said bore being provided in the bottom 14 of a cylindrical dish 15 in which is threaded one end of an insulating member 16, the other end of which is mounted in a sleeve 17.

In the example shown, the centre of the semi-spherical portion 9 is located on the active surface of the contact plate 8, at the centre of the same. The insulating member 16 is fixedly secured in the dish 15 and sleeve 17 by means of gudgeon pins 18. The sleeve 17 is slidably mounted on a rod 19, the axial displacement of the rod 19 towards the outside of the sleeve 17 being limited by means of a piano wire 20 cooperating with an inner annular shoulder 21 of the sleeve 17. A stress-limiting compression spring 22 is interposed between the insulating part 16 and an axial housing provided in the associated end of the rod 19.

The above described assembly constitutes a movable contact structure of variable length which tends to be held extended by the stress-limiting spring 22. This structure is slidably mounted in turn through the bead 23 of the rod 19 in a bore 24 of a fixed part 25. The insulating plate 2 which carries the contact points, is connected to the part 25 through tie-bolts 26 screwed at 27 in holes 28 of the fixed part 25 and secured, by means of nuts 29 cooperating with threaded ends 30, on the insulating plate. A similar arrangement comprising tie-bolts 31, threads 32 and 33 and nuts 34 connects the fixed part 25 to a fixed base 35. In this base is also secured the casing 36 of a hydraulic cylinder whose piston 37 is connected, for pushing action only to the

rod 19 through two balls 38, 39, between which is interposed a substantially axial pushing-rod 40, the ball 38 bearing in a housing provided in the relevant face of the piston 37, while the ball 39 rests in an axial recess 41 of the rod 19. The latter is slidably mounted on a bead 42 of the casing 36 which co-operates with the above mentioned bead 23 to ensure axial guiding of the said rod in two materially distant zones.

This arrangement, together with the thrust connection ensured without any guiding by the balls 38, 39 and the pushing-rod 40, permits transmitting the required forces in a generally axial direction without any risk of jamming of the slidable assembly, even under slight misalignment. The strong spring provided to ensure circuit-breaking is shown at 43. The said spring is interposed between a flange 44 of rod 19 and the fixed part 25. It continuously urges the rod 19 towards the piston 37, which justifies the previously described arrangement according to which the said rod and piston are connected positively only for pushing action.

The fixed part 35 is provided with a series of bores of various diameters. At the lower end (in FIG. 7) of the part 35, one of these bores is innerly threaded and a threaded union 45 is screwed therein. The threaded union 45 establishes a communication between the pressure liquid source and the cylinder 36, on the one hand, and between the said cylinder and an exhaust circuit, on the other hand, through suitable ducts (not shown).

Exhaust is triggered when the circuit is to be broken, to release the spring 43 so that the latter can impart to the movable contact member a very high acceleration. Exhaust is, for example, ensured by means of a quick exhausting device.

Finally, there is shown at 46 a kind of non-return valve constituted by a small sleeve sliding in one of the bores of the part 35 and terminated at its end opposed to the union 45 by a partition 47 provided with a third bore 48 leading to the cylinder 36. The small sleeve 46 itself comprises a partition 49 provided with a calibrated orifice 50, while a cylindrical portion of its wall, having a diameter smaller than that which is sliding in the bore of the part 35, is also provided with radial ports 51 disposed between the partition 49 and the guided end of the sleeve near the union 45. A weak spring 52 tends to maintain continuously the sleeve 46 against the wall 47, position in which the cylinder 36 communicates with the union 45 only through the calibrated orifice 50, while if the sleeve 46 is taken away from this position against the action of the spring 52, said communication takes place not only through the orifice 50, but also through the ports 51.

In the alternative construction shown in FIG. 9, the movable contact member does not comprise any physical knee-joint and the contact plate 8' is continuously urged outwardly by means of three springs 53 tending to press the head 11' against the partition 14' of the movable contact member, but capable of yielding selectively as the switch is closed to permit the required orientation of the plate 8'.

There is thus obtained a transverse freedom under deformation of the springs 53 so that the desired swivel effect is obtained without any friction.

The device operates as follows:

As pressure liquid is admitted through the union 45, the said liquid enters the cylinder 36, the feeding rate being limited by the calibrated orifice 50. The piston 37 is displaced by this liquid and pushes the rod 19 through the balls 38 and 39 and the pushing-rod 40 under compression of the spring 43. The contact plate 8 first comes into contact, for example, with one single point 1; as the movable contact member is further displaced, owing to its orientation freedom, the plate 8 then tilts around that point 1, without leaving the same, and comes for example into contact with a second point 1; finally, it becomes tilted around the contact line thus

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determined by the two first points 1, until it is also brought into contact with the third and last point 1. Then the displacement of the movable contact structure is stopped while the rod 19 further moves on, under the action of the pressure liquid and penetrates into the sleeve 17 under compression of the stress-limiting spring 22. At last, the rod 19 is stopped in turn by the bead 23 abutting against the fixed part 25. There is thus established an excellent three-point electric contact between the ends of the three points 1 and the conducting plate 8, under a predetermined pressure equally distributed among the three points and corresponding to the strength of the spring 22 which is calibrated as defined in the preamble. The device according to the invention thus permits, not only obtaining an excellent electric contact under pressure, but also keeping the said pressure constant even if the pressure source undergoes certain fluctuations. Moreover, the compression stroke of the spring 22 permits automatically taking up the wear of the contact points. This contact is maintained as long as the hydraulic pressure prevailing in the cylinder 36 overcomes the strength of the powerful spring 43. If now the cylinder 36 is exhausted, for example by means of the above cited quick exhausting device, the piston 37 is released and the spring 43 is made free of quickly displacing the rod 19 in the direction tending to remove it away from the fixed contact structure. The spring 22 expands, the rod 19 begins to enter the sleeve 17, the insulating member 16 and the dish 14; finally, the latter comes into contact with the head 11 and suddenly separates the points 1 from the contact plate 8 which is slightly tilted until it bears on suitable abutments such as 77, FIG. 5, see above. It is to be noted that the liquid, which, during exhaust, tends to flow out of the cylinder 36 unseats the small sleeve 46 from the wall 47 under compression of the weak spring 52, so that the liquid can flow out, not only through the orifice 50, but also through the ports 51, i.e., at a sufficient rate to avoid any dash-pot braking of the piston 37.

While the invention has been described with particular reference to a preferred embodiment, it is not intended to limit the scope of the invention to the embodiment illustrated, nor otherwise than the terms of the subjoined claims.

In particular, the three points 1 could be disposed at the apices of any kind of triangle, the assembly is not necessarily coaxial and the relative displacement between the contact members may be ensured by motions other than a translation; finally, it is also possible to provide one or two points 1 only, however the construction described and shown offers the advantage of being extremely simple and the swivel system permits leaving to the movable contact member any angular freedom around the axis of the system, which radically suppresses any problem of guiding, friction, etc. The hydraulic control which has been shown in the drawings is purely illustrative. It is obvious that it could be replaced at will by any hydraulic system capable of supplying the required contact pressure, the hydraulic control shown in the drawings being however particularly well adapted to axial translation control of a movable contact member without any jamming, in spite of the fact that no accurate alignment has to be provided between the various parts.

What I claim is:

1. A switch for large currents in which the area of the contact surfaces, when the switch is closed, is dependent on the pressure between the surfaces and in which the predetermined pressure for different values of current is proportional to the square of the current strength, said switch comprising two relatively movable contact members, one of said members having a hard metal contact surface and the other member terminating in no more than three softer plastically deformable metal contacts,

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the metals of the contact members being electrically highly conductive and at least one of the said metals being highly thermally conductive, control means for pressing the contacts against the contact surface with the minimum amount of force proportional to the square of the current and sufficient to deform the contacts without penetration of the surface to form contact surface areas of such extent as to conduct away all of the heat developed by the current flowing therethrough.

2. A switch according to claim 1, wherein said contacts are of copper.

3. A switch according to claim 2, wherein said contact surface comprise a plate having a face of stainless hard bronze.

4. A switch according to claim 1, wherein said contacts are provided by three elongated tapered rods each having a diameter of such dimension as to resist permanent deformation of the body thereof in response to said force, an insulating support to which said rods are fixedly secured, at least two of said rods being connected to electrical conductors, the other contact member having a flat surface and being unconnected to any electrical conductor, and means movably supporting said contact surface member for universal adjustment relative to the contacts for contact engagement of the surface with all of said contacts.

5. A switch according to claim 1, wherein the control means includes hydraulic cylinder means for applying a force, force-responsive means for relatively pressing the contacts against the contact surface, and a resilient stress-limiting member between the force-applying means and the force-responsive means.

6. A switch according to claim 1, wherein said member having a hard metal contact surface comprises a circular plate, and means supporting the plate for free rotatable movement about an axis substantially normal to the surface and passing through the plate and for universal swivelling movement about a point adjacent to the surface.

7. A switch according to claim 1 in which the member having a hard metal contact surface comprises a circular plate, a fixed wall having a recess therein and a bore extending through the wall and recess, the surface of the plate opposite said contacts and the wall of the recess being shaped to provide universal swivelling movement and rotation of the contact member within the recess when seated therein, a rod extending from the opposite surface of the plate and freely through the bore, to limit swivelling movement of the plate.

8. A switch according to claim 1 in which the member having a hard metal contact surface comprises a circular plate, a fixed wall having a bore therethrough, a rod extending from the surface of the plate opposite said contacts and passing freely through the bore, and at least three resilient members angularly spaced about the axis of the bore and interposed between the wall and the plate member to bias the plate to a position in which its contact surface is normal to the axis of the bore.

9. A high capacity circuit breaker comprising at least one elongated contact member of soft copper presenting a generally convex contact end, a flat contact member of hard bronze presenting its flat surface toward said elongated contact member to be contacted thereby to close an electric circuit, said flat contact member of hard bronze being stationary and said elongated contact member of soft copper being movable axially into and out of engagement with said flat contact member of hard bronze, means to press said elongated contact member against said flat contact member with a predetermined pressure in the range of 20 grams for a current flow of 20 amperes, the predetermined pressure being adjustable whereby the pressure between the contacts may be adjusted in accordance with the ratio that the pressure varies with the square of the amperes flowing through the contacts.

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