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SWITCH DEVICE

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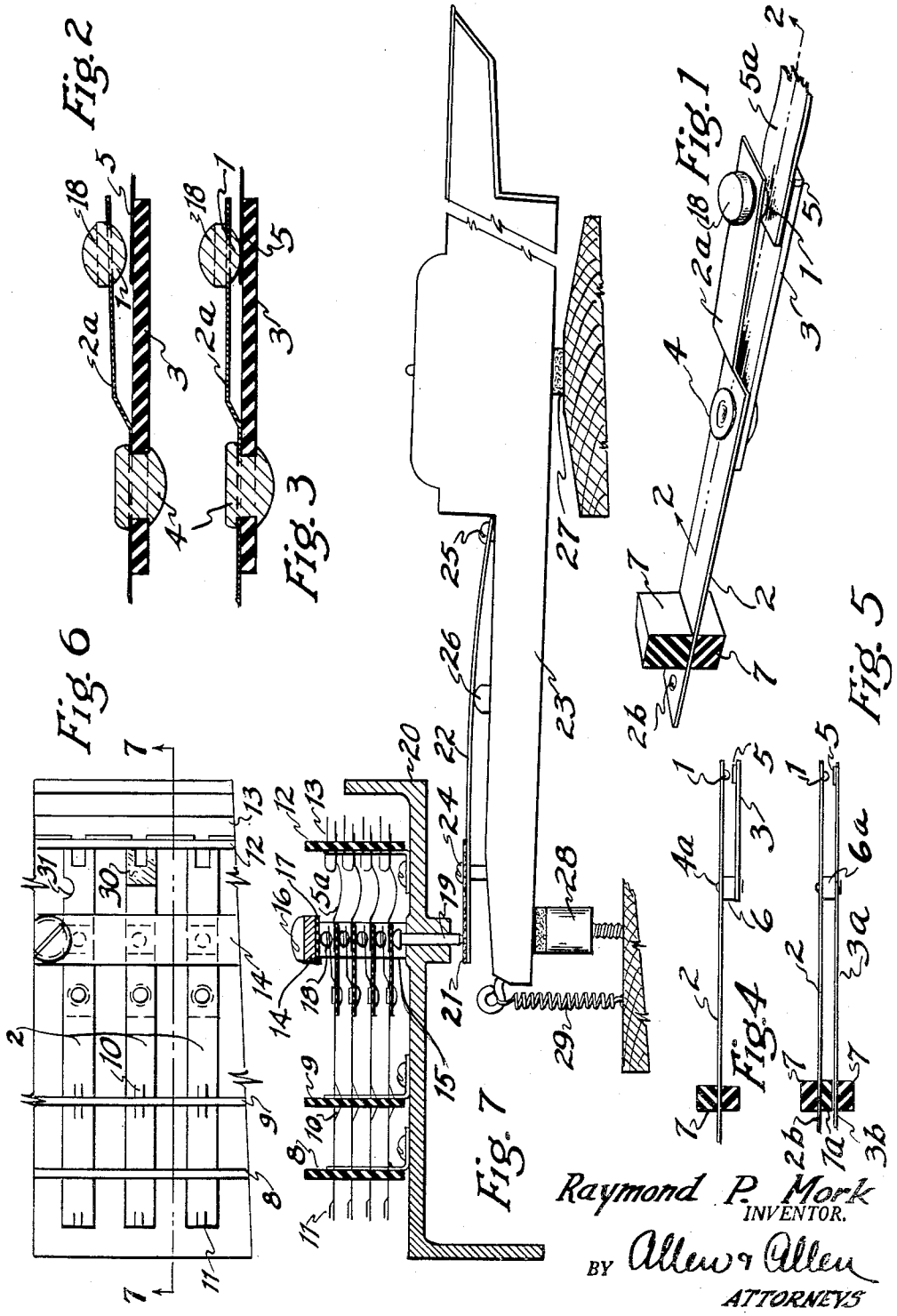


Fig. 2

Fig. 3

Fig. 1

Fig. 6

Fig. 7

Fig. 4

Fig. 5

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SWITCH DEVICE

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My invention relates to electric switches such as may be caused to close one or more circuits when actuated by a key or other operating means.

A more restricted aspect of my invention has to do with the provision of contact switches, whereby an electric circuit may be closed gradually through a continuously variable resistance. Such switches may be used, for example, in conjunction with playing keys in electric musical instruments for connecting sources of electric oscillations corresponding to musical tones to output and sound producing devices for effecting a gradual onset and release of the tones, thus eliminating from the tones undesirable transients, commonly known as key clicks or thumps, and producing a slower and more pleasing rise and fall of the tones.

Previously known practical switches of this type have been comparatively costly to manufacture, requiring extremely close control of manufacturing, inspection and assembly operations.

The primary object of my invention is to provide a simple, reliable switch unit or component which can be produced in large quantities quickly and cheaply, and which will be positive and reliable in its action.

It is an object to provide an assembly of such switch units by means of which assembly a plurality of circuits may be closed substantially simultaneously by a single actuator.

It is an object of my invention to provide a simple, economical and dependable switch unit or assembly of the gradual contact or resistive type.

Another object of my invention is to provide new and useful combinations of electric contact materials in switch units or assemblies, which will retain their resistance characteristics even after such rigorous use as, for example, may be expected in the key switches of electronic organs.

Still another object is to provide a switch construction wherein there is little or no tangential relative motion (wiping action) between the contacts as they are opened or closed.

It is a further object of my invention to provide a leaf-type switch assembly in which the contact leaves are substantially self-adjusting.

A still further object is to provide an assembly of switch units which may be actuated by a single force not appreciably greater than the closed-contact force required for a single unit.

These and other objects which will be apparent to those skilled in the art upon reading these

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specifications, I accomplish in those constructions and arrangements of parts, of which I shall now set forth exemplary embodiments. Reference is made to the drawings forming a part hereof, and wherein:

Figure 1 is a perspective view of a preferred form of individual switch unit according to my invention.

Figure 2 shows a sectional view 2—2 of the unit of Figure 1.

Figure 3 is similar to Figure 2 except that the switch contacts are shown in a closed position.

Figures 4 and 5 are elevation views of other examples of circuit closing units within the scope of my invention.

Figure 6 is a plan view of three adjacent assemblies of switch units of the type illustrated in Figure 1.

Figure 7 is a sectional view 7—7 of the structure of Figure 6, showing an assembly actuated by a playing key and associated parts.

I shall describe my invention in exemplary embodiments having to do with key switches for electrical musical instruments. Here the problems have to do with the provision of structures which are simple, economical and not liable to failure, as well as with the provision of structures which are essentially self-adjusting and readily replaceable, as well as small in size. My solutions of these problems lie in certain mechanical constructions hereinafter described.

Since for most key switches gradual contact means for the control of transients or "key clicks" is highly desirable, my invention further includes solutions of two interrelated problems. The first problem is the provision of electric contact combinations which, when brought together under a continuously increasing force, will exhibit a continuously variable contact resistance of wide range. My solution to this problem lies in the use of combinations of contact materials hereinafter described which must, for reasons to be stated, be brought together without the tangential relative motion or wiping action usually present, and in the use of combinations which are at the same time desirable in electric circuit closing devices of the kind involved. The second problem arising from my solution to the first is to provide means for closing the contacts without wiping action. My answer to the latter problem is a switch unit or component which may be used either singly or in groups in a mechanical series, as will now be set forth.

One form of the basic unit or component of my switch invention is illustrated in Figure 1.

Here a spring leaf 2 is clamped adjacent one end between insulative supports. Intermediate its ends there is attached to it an insulative member 3, as by a rivet 4 or other means. The adjacent end of the spring leaf 2 is bent upwardly and over, as indicated at 2*a*, so as to be spaced from the insulative member 3. Contact elements 1 and 5 are located respectively on end portions of the spring metal member 2*a* and the insulative element 3. The contacts may take various forms as hereinafter set forth. The member 3 may be of phenolic resin or other suitable insulative material, but may be electrically conductive if the contact 5 is insulated from it.

The switch element illustrated in Figure 1 is one which can be operated by a moving element engaging one of the switch parts and coacting with an opposed support to bring the contacts together. This operation involves moving the resilient element 2*a* toward the element 3; and it will be seen that the contacts are brought together without any tangential motion or rubbing. Figures 2 and 3 on an enlarged scale illustrate the contacts in open and closed position. The cantilever portion 2 of the spring will be flexed also in the operation of the switch element to the extent required to bring one or the other of the elements 2*a* and 3 against the abutment referred to above.

Electrical contact from one of the circuit leads may be made directly to the spring element 2, as at 2*b*, beyond the engagement of the clamping elements 7. Because of the movement of the other end of the switch element during operation, a flexible lead is required from the contact 5 and is represented in Figure 1 as a flexible extension 5*a* of the contact 5.

Modified structures of the basic element are illustrated in Figures 4 and 5. In the first of these figures the cantilever spring element is straight throughout its length. The insulative element 3 is fastened to the spring element in the desired position by a rivet or the like 4*a* and is spaced therefrom by a collar 6.

In Figure 5 there is a straight spring element bearing the contact 1 and a second straight spring element 3*a* paralleling the first and spaced from it. The spacing is maintained at the left hand ends of both springs by an intermediate insulative element 7*a*, the member 3*a* being free to slide between 7 and 7*a*, so as not to restrain the motion of the member 2 when it is flexed. The two springs are connected intermediate their ends by an insulative coupling means 6*a*. In this instance the spring element 3*a* bears the contact 5; and electrical connection to both springs may be made at their left hand ends, as at 2*b* and 3*b*. This switch construction is mechanically satisfactory but is not as suitable as the structures of Figures 1 and 4 for use in circuits where the open circuit electrical capacitance between contact leaves must be kept at a minimum, e. g. in key switching circuits for electrical musical instruments energized by potentials of high audio frequency.

The basic units of Figure 1 or the various modifications of Figures 4 and 5 may be actuated singly or in multiples by any suitable means. I prefer, in the case of a playing key switch, to employ the structure illustrated in Figures 6 and 7, the latter showing an assembly of four similar units whose respective parts are numbered so that they correspond to the nomenclature of Figure 1. Such a structure may be employed for gradually and substantially simultaneously closing a plurality of circuits by a common actuator. Also, such an assembly may be actuated by the relatively small force available with the usual playing key construction. A nominal force for instance of five ounces available at the inner end of a key under ordinary playing conditions will operate a plurality of circuit closing units in a mechanical series such as is illustrated in Figure 7 even though a force of as much as four ounces may be necessary to bring the resistance of a single pair of contacts to a desired minimum value.

In Figures 6 and 7 the insulative members 8 and 9 (corresponding to the clamping supports 7 of Figures 1, 4 and 5), provide support for the cantilever members 2, retaining lips 10 struck from the cantilever spring members serving to prevent longitudinal movement of these members in the exemplary construction. Electric connections to the members 2 may be made at 11. The contact members 1 and 5 are disposed in the same manner as in Figure 1. The flexible extensions 5*a* of the contact members 5 may be coated at their ends with a conductive paint and secured to an insulative support 12 by resilient clips 13 to which may be soldered electric connections as desired. A cross bar 14, supported by studs 15 and screws 16, has an electrically insulative surface 17 which acts as a stop or abutment to the upward movement of the uppermost one of the contact leaves 2*a*. Suitable projections 18 are disposed on the leaves 2*a* to transmit from one unit to an adjacent unit a contact closing force exerted by an actuator 19, slidably mounted in the base member 20 and resting on a felt cushion 21 affixed to the upper surface of a key spring 22. The spring 22 is held under an initial bending stress over a fulcrum 26 on the playing key 23 by the heads of the screws 24 and 25, which are threaded into the inner end of the playing key. The key 23 is supported in the usual manner, as at 27, and normally retained in the position shown against a stop member 28 by a coil spring 29.

The cantilever spring members 2 are flexible enough so that each insulative member 3 of each switch unit normally lies against the projection 18 on the leaf immediately below. The lowermost insulative strip 3 normally rests on the head of the actuator 19.

The operation of the playing key and switch assembly of Figure 7 may be described by dividing the action into three phases in the following order. First, a depression of the right hand end of the key 23 exerts a force through the spring 22 and actuator 19 upon the lowermost insulative strip 3. As the lowermost unit 2 is deflected upwardly, the actuating force is transmitted through the offset portion 2*a* of the lowermost member 2 and its respective projection 18 to the insulative member 3 next above in the switch. In a similar manner the actuating force is transmitted through the remaining insulative members 3 and their respective portions 2*a* and projections 18. The uppermost projection 18 will be restrained by the insulative surface 17 of the cross bar abutment 14, resulting in a simultaneous flexing of all offset portions 2*a* of the cantilever members 2.

Were it not for the weight of the respective units and the small force necessary to deflect the cantilever members 2 from their normal positions, all switch units if identical would begin to close simultaneously. However, these last mentioned factors result in the meeting of the lower contacts slightly ahead of the meeting of the

upper ones. This difference in meeting is not of appreciable practical significance, but if desired the offset portions 2a of the lower switch elements may be initially adjusted so that the contacts of all individual switch units do meet simultaneously. During this first phase of the key movement, the key spring 22 is partially deflected about the head of the screw 24, which in a sense acts as a fulcrum during the first two phases, exerting an increasing force on the actuator 19 until all contact surfaces 1 and 5 meet. In the second phase, as the key 23 is further depressed, the key spring 22 is additionally deflected about the head of the screw 24 until a sufficient force is exerted on the actuator 19 to approximate the full desired closed contact force on all contacts. In the third phase, a further depression of the playing key merely deflects the spring 22 away from the head of the screw 24 without exerting any appreciable additional force upon the actuator 19 and all contacts 1 and 5. This overtravel feature improves the touch of the mechanism and prevents excessive forces from being exerted on the contacts after a desired minimum value of contact resistance has been reached. The initial stress on the spring 22 can be changed by adjusting the screw 25, thus providing means for varying the approximate maximum force which can be exerted on the series of switch units by the spring 22 through the actuator 19. The initial position of the left end of the spring 22 may be changed by adjusting the screw 24, thus providing means for determining the location of the actuator 19 with respect to the series of switch units.

It can readily be seen that the structure of Figure 7 satisfies the object of the invention relating to self-adjustment of the contact leaves, the offset portions 2a having sufficient stiffness to keep its contact member 1 apart from its respective contact member 5. It can also be seen that since the structure comprises four springs in series the force necessary to close all the contacts is greater than the force necessary to close one set of contacts by only the sum of relatively small forces required to deflect the cantilever members 2 to their respective closed-contact positions plus whatever small forces are present due to the weight of the respective units.

In the broad aspects of my invention the structure thus far described is of general utility irrespective of the nature of the contact elements. For example, contact 1 may be a metallic contact of desired composition, a similar cooperating contact may be affixed in the proper position on the member 3, and the flexible conductor 5a may be of any kind desired. However, one of the objects of the invention in a narrower aspect is the provision of resistive or gradual-acting switches for purposes set forth above. In this event, the contact 1 may still be a metallic or other rigid contact member, while the contact 5 may be of resilient deformable resistive substance so that the effect of varying pressure between the contacts will be a variation of resistance in a circuit connected with them. This variation of resistance may be brought about in various ways, one effective way being the shaping of the contact elements in such a way that variations of contact pressure between them will produce variations in the area of their mutual contact. Thus the member 5 may be of resilient resistive substance and the flexible conductor 5a may be a strip-like prolongation of the same substance.

I prefer to employ the extended portion 5a of the contact 5, which is disposed between the free end of the insulative member 3 and a clip 13 as a series resistor for the purpose known in art as anti-robbing—that is, the prevention of the interaction of one branch upon another—thus insuring adequate flow of current through each switch when several of the circuits are operated in parallel. If the resistance of the flexible conductor 5a is greater than that required in the circuit in which it is used, I may lengthen the previously mentioned coating of conductive paint over an area such as at 30 in Figure 6 to decrease the series resistance. If the resistance is less than that desired, I may notch the strip at one or more points 31 to increase the series resistance. I may also as a matter of design obtain a desired series resistance by employing a contact 5 of material having characteristics most satisfactory for contact purposes, inserting between the contact 5 and the insulative member 3 a strip of flexible material an extension of which is suitable for supplying an approximate desired series resistance in the circuit. The above mentioned notching and coating adjustments may then be used for desired final adjustments of series resistance.

It is not new to effect a variation of electrical resistance by varying the length and cross-section of the current path through an elastically yielding resistor by the application of pressure to a metallic electrode in contact with the resistor, and various structures for this purpose are shown in U. S. Patent 1,448,681. In such prior structures the materials were not subjected to a relatively large number of cycles of resistance variation. In resistive playing key switches, subject to rapid and repeated operation, my experience indicates that after prolonged use the resistivity of such deformable materials increases at the area subjected to deformation. Such increases in resisitivity alter the lower limit of resistance to such an extent that the hitherto known combinations are unsatisfactory unless improved as discussed hereinafter. Since I have not as yet been able to produce an elastically deformable conductive material whose resisitvity does not increase as described above after prolonged use, I have devised a combination of materials with which such changes in resisitivity are not of serious consequence.

According to this phase of my invention, I employ as the contact 1 of Figure 1, for example, a rigid material of relatively high electrical resistivity, such as the material used in commonly known fixed carbon resistors employed in radio circuits. The contact member 5 of Figure 1 may be a portion of a thin strip of relatively low electrical resistivity, elastically deformable mixture of a finely divided conducting material, for example, carbon, in a rubber-like material, such as neoprene, the mixture being processed in a suitable manner to obtain desired mechanical characteristics. The deformable material acts as a sort of low resistance brush or flexible contact which, upon the application of pressure, assumes the configuration of the high resistivity material, increasing the area of mutual contact. The total contact resistance is the sum of two series resistances which depend upon the resistivity of the respective contact materials; hence, if the greater of the two resistances is supplied by a contact material whose resistance does not change—in this case the rigid, relatively high resistivity material—a change in resistivity of the

deformable material, which supplies in this case the lesser of the two resistances, has less effect upon the total resistance than in the case of a combination such as employed by prior art workers. The greater the difference in resistivity between the materials of such a combination, the less will be the effect of progressive changes in the resistivity of the deformable material at the contact surfaces. I have found that a resistivity of the order of 30 ohm-centrimeters for the rigid material and of the order of 1 ohm-centimeter for the deformable material are particularly useful in electric musical instruments for connecting sources of electric oscillations to output and sound producing devices. A circuit showing such connections is illustrated and described in Patent No. 2,215,214 to Kock et al. An example of a desirable range of resistance to be provided by a key switch is one having a higher limit of not less than 200,000 ohms and a lower limit of not more than 1,000 ohms in key circuits employing anti-robbing resistances of the order of 5,000 ohms in series with each switch.

I may also reverse as to physical form the materials I have just described. The contact 4 may be a molded button of an elastically deformable material of relatively low resistivity while the contact 5 may be a rigid material of relatively high resistivity. The contact 5 may either be a strip of material fixed to the insulative strip 3 or it may be a resistive coating thereon, provided with a suitable flexible conductor.

Although I have shown as an exemplary embodiment an electric musical instrument playing key switch, I do not wish to limit my invention to such switches. I may employ similar switches with or without modification in conjunction with stop tabs to select tone color circuits of the electric filter type, for instance, used in instruments wherein complex electric oscillations are modified to obtain various tone colors. I may also connect a mechanical series of switch units as described herein in an electrical series to obtain a wide variation of resistance, or I may use such units to remove gradually from or replace into an electric circuit fixed resistances of desired values. The usefulness of such switch units and assemblies described herein is not necessarily limited to electric musical instruments. Such switches or modifications may be found useful in other types of circuits wherein relatively low values of electric current are to be controlled.

Modifications may be made in my invention without departing from the spirit of it. Having thus described my invention in certain exemplary embodiments, what I claim as new and desire to secure by Letters Patent is:

1. Electric circuit switching means comprising in combination two resiliently hinged, spaced leaves at least one of which is electrically conductive, two coactive electric contacts respectively disposed on said leaves, and a flexible, cantilever member having a free end and a fixed end, said leaves being supported by the free end of said cantilever means.

2. The combination claimed in claim 1 wherein one of said leaves is an extension of said cantilever member which is electrically conductive and the other of said leaves comprises a strip of electrically insulative material fastened to said cantilever member.

3. The structure claimed in claim 2 including flexible electrically conductive means connected

to the contact means disposed on said insulative leaf.

4. The combination claimed in claim 3 in which one of said contacts comprises a rigid material of relatively high electrical resistivity and the other of said contacts comprises a material of relatively low electrical resistivity material which is elastically deformable upon contact with said rigid contact.

5. The combination claimed in claim 3 in which one of said contacts comprises a material of rigid relatively low electrical resistivity and the other of said contacts comprises a material of relatively high electrical resistivity which material is elastically deformable upon contact with rigid contact.

6. A resistive switch comprising the combination as claimed in claim 3 including actuating means operative upon said leaves to bring said coactive contacts into a contacting relationship one with the other.

7. A resistive switch for gradually and substantially simultaneously closing a plurality of electric circuits, said switch comprising in combination a plurality of flexible contact leaves rigidly and substantially parallelly mounted near one end, a first series of electric contacts disposed respectively near the other end of said leaves, a series of insulative strips affixed respectively to said leaves intermediate their ends, the portion of each of said leaves containing one of said first series of contacts being offset with respect to its respective insulative strips, a second series of electric contacts disposed respectively on said insulative strips and coactive respectively with contacts of said first series, projections on each of said leaves on the side opposite the respective contacts of said first series and bearing against the insulative strip affixed to an adjacent leaf in said plurality, stop means adjacent the outermost outward-facing projection, an actuating member adjacent the outermost of said insulative strips operative to bring respective coactive contacts into contacting relationship with each other, and flexible electrically conductive means connected to respective contacts in said second series.

8. The combination claimed in claim 7, wherein the contacts in one of said series of electric contacts comprise rigid material of relatively high electrical resistivity and the contacts in the other of said series of electric contacts comprise relatively low electrical resistivity material which is elastically deformable upon contact with said rigid contacts.

9. The combination as claimed in claim 7, wherein the contacts in one of said series of electric contacts comprise rigid relatively low resistivity material and the contacts in the other of said series of electric contacts comprise relatively high electrical resistivity material which is elastically deformable upon contact with said contacts of rigid material.

10. The structure of claim 7 including a base upon which said plurality of means is mounted, said stop means being mounted on said base, and said actuating member being a plunger slidable in said base.

11. In combination in a switch construction a first electric contact comprising a rigid material of relatively high electrical resistivity, a second electric contact coactive therewith and comprising a material of relatively low electrical resistivity which material is elastically deformable upon contact with said rigid material, and operating

means for bringing said first means into contact with said second means.

12. In combination in a switch construction a first electric contact comprising a rigid material having an electrical resistivity of the order of 30 ohm-centimeters, a second electric contact comprising a material having an electrical resistivity of the order of 1 ohm-centimeter and which is elastically deformable upon contact with said rigid material, and operating means for bringing said first contact under pressure against said second contact.

13. In combination in a switch construction, a pair of contacts and means for bringing said contacts together under pressure, one of said contacts being a rigid member of relatively high resistivity, and the other of said contacts being a flexible, deformable member of relatively lower resistance, said last mentioned contact having an integral prolongation in strip form serving as a flexible, resistive lead.

14. In combination in an electric switching device, a stacked plurality of resilient metallic leaves each rigidly and substantially parallelly supported near one end by insulative means, electric contacts disposed one to each of said leaves, a plurality of electrically insulative strips affixed one to each of said leaves, the portion of each of said leaves containing said contacts being offset with respect to its respective insulative strip, electrical contacts disposed one to each of said insulative strips on the sides thereof facing the respective leaves to which said strips are affixed, said leaves having a projection on the face opposite said first-mentioned contact surfaces and bearing against the insulative strip affixed to an adjacent leaf in said series, stop means adjacent the outermost of said projections, and an actuating member adjacent the innermost of said insulative strips, whereby said offset portions may be flexed in bringing each of said first-mentioned plurality into contact with the corresponding surface of one of said second-mentioned plurality.

15. In a switch construction a metallic spring member mounted as a cantilever adjacent one end and bearing a contact adjacent its other end, a leaf connected with said member intermediate its ends and bearing a contact opposite said first mentioned contact and normally spaced therefrom, and a flexible electrical conductor extending from said second mentioned contact.

16. The structure claimed in claim 15 wherein said second mentioned contact and said flexible conductor are integral and are formed of deformable resistive substance.

17. In combination with the structure claimed in claim 10, a playing key having a rearwardly extending portion, a resilient flexible lever lying along said portion and having a rear end underlying said plunger, a fulcrum for said lever intermediate its ends and mounted on said key portion, and a pair of headed, threaded retaining members engaged in said key portion, one of said members engaging the forward end of said lever at one side of said fulcrum, and the other engaging said lever at the other side of said fulcrum and at a point forward of the rear end of said lever.

18. A variable resistance key action for a musical instrument, comprising the combination of at least one circuit closing component having a fixed end and a free end, a pair of resiliently hinged, spaced leaves supported by the free end of said component, two coactive electric contacts respectively disposed on said leaves, a vertically disposed actuating plunger operative to impart vertical motion to said free end, the electrical resistance of said component being dependent upon the force exerted by said plunger on said component, stop means adjacent the free end of the outermost circuit closing component, a playing key having a rearwardly extending portion, a resilient flexible lever lying along said portion and having a rear end disposed against said plunger, a fulcrum for said lever intermediate it sends and mounted on said key portion, and a pair of headed, threaded retaining members engaged in said key portion, one of said members engaging the forward end of said lever at one side of said fulcrum, and the other engaging said lever at the other side of said fulcrum and at a point forward of the rear end of said lever.

19. In combination in a switch construction, a pair of contacts and means for bringing said contacts together under pressure, one of said contacts comprising a rigid material of relatively low electrical resistivity, and the other of said contacts comprising a material of relatively high electrical resistivity which material is elastically deformable upon contact with said rigid material.

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