

June 7, 1949.

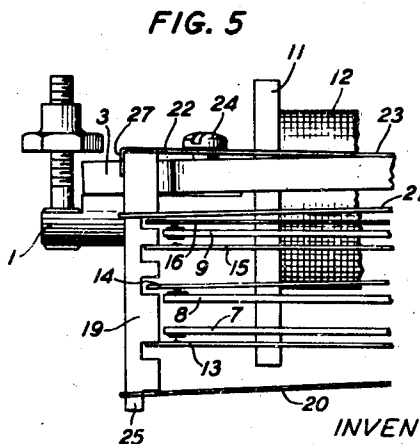
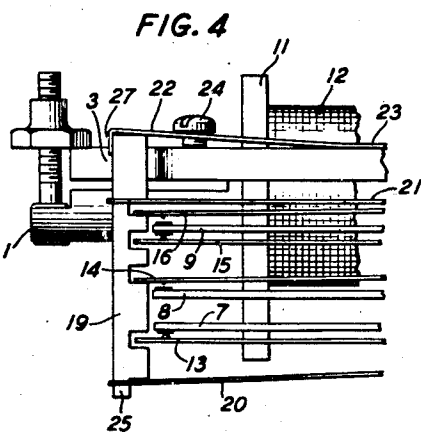
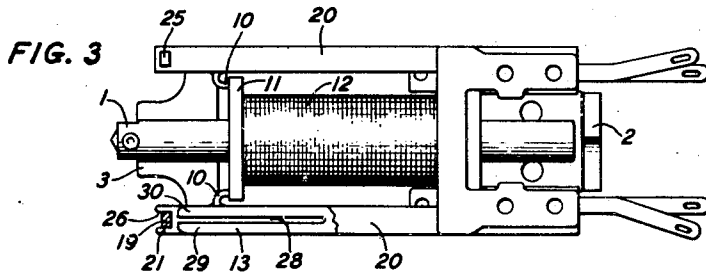
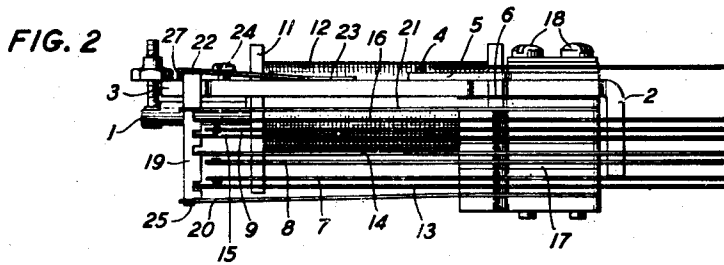
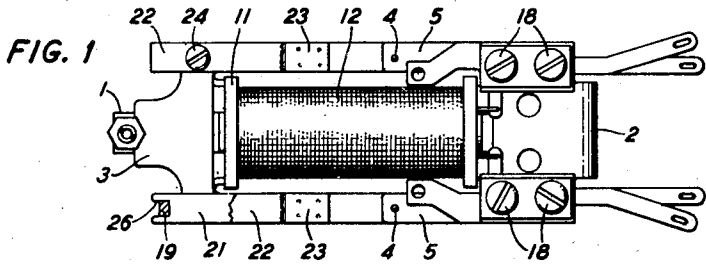
H. M. KNAPP

2,472,709

CONTROL OF ELECTRICAL CONTACTING ELEMENTS

Filed Feb. 6, 1947

2 Sheets-Sheet 1



INVENTOR
H. M. KNAPP
BY *P. C. Smith*
ATTORNEY

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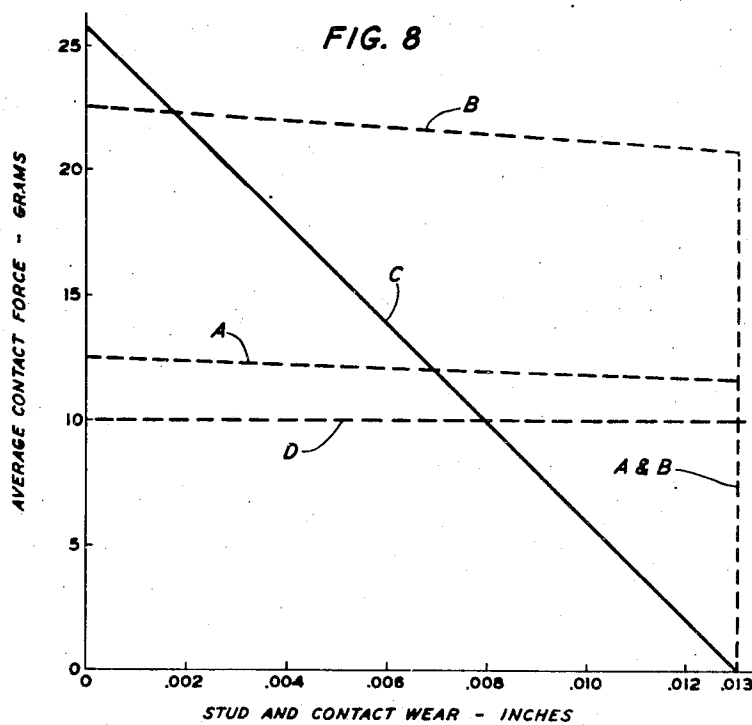
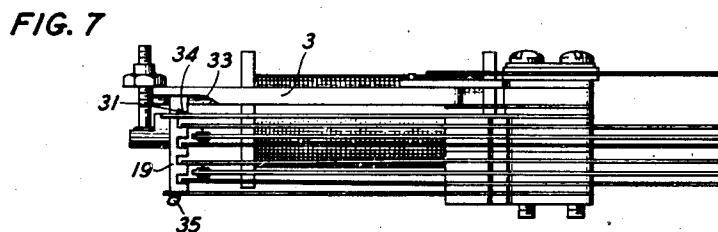
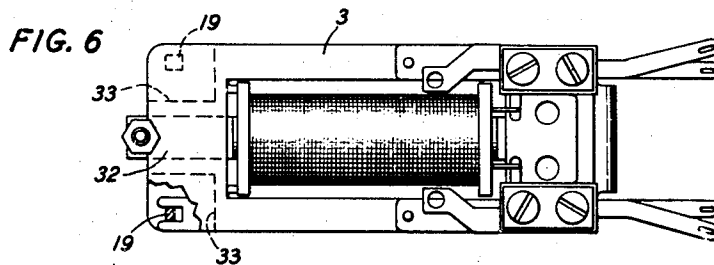
H. M. KNAPP

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CONTROL OF ELECTRICAL CONTACTING ELEMENTS

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2 Sheets-Sheet 2



INVENTOR
H. M. KNAPP
BY *P. C. Smith*
ATTORNEY

UNITED STATES PATENT OFFICE

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CONTROL OF ELECTRICAL CONTACTING
ELEMENTS

Harry M. Knapp, Scotch Plains, N. J., assignor
to Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

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9 Claims. (Cl. 200—104)

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This invention relates to means for controlling electrical contacting elements and more particularly to improvements in and relating to means for controlling the movable contact springs of electromagnetic relays.

The present invention is based upon the new and simple concept of providing that in an electrical contacting device, such as the familiar electromagnetic relay, all movable contacting elements, such as movable relay contact springs, be tensioned to normally make contact with the relatively fixed elements with which said movable elements cooperate, that the force required for the said contact closure be derived solely from the self-tension of the said movable elements and that the contacting element actuating means be capable of selectively separating normally closed pairs of elements in either the operated or unoperated condition of the contacting device or in both conditions to thereby effect the desired switching operations from the said plurality of cooperating elements.

Previously, in relays having a plurality of movable and fixed contact springs, mating springs have been employed in such combinations as normally open pairs, normally closed pairs, make before break combinations, break before make combinations and other transfer combinations and various arrangements of two or more of these combinations, the normal condition referred to being the condition of said contact springs when the armature of the particular relay is unoperated. These various combinations, appearing for instance on one relay, have been actuated by means of an insulating member, such as a card or spring separator stud assembly, both of which are well known and which have been adapted to be moved by the armature of the relay to perform in turn the indicated combination spring operations. It has been the practice in some cases to provide normally closed pairs where the movable or armature spring of the pair is tensioned to normally contact the fixed spring of the said pair by reason solely of its own tension and the operating card, when moved by the armature, moves said movable spring away from the fixed spring to effect the break of said pair. In the same or other relays normally open pairs have been provided where the movable spring of the pair is normally in the open condition such that the operating card is required to overcome the natural self-tension of the movable spring when deflected to effect the required closure of the pair. This occurs in either normal or operated condition depending

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on the nature of the combination desired for the operated condition. Likewise it has been the practice to provide all normally open contacts free of external forces in the open position and to provide normally closed contacts where the movable spring is tensioned to either open or closed position when under no external forces.

It has been known previously that a movable spring which normally by reason of its own tension is open and is moved against its own resilience is required to be moved or urged beyond closure in order to effect a satisfactory contact pressure. It has been known that the rate of loss of this contact pressure with contact wear and wear of the card or separator stud is objectionably rapid. This condition has necessitated one or more of at least three general types of corrective measures; namely, starting with large initial contact pressure to permit appreciable wear before the contact pressure has decreased to the minimum allowable, or constant readjustment of the relative open separation of mating contacts to permit closure earlier in the armature stroke with attendant increase in contact follow effective to overcome the lost pressure due to wear, or increasing the armature travel to compensate for the wear, or various combinations of these measures.

It is the primary object of this invention to eliminate substantially the necessity for the above corrective measures. The present invention contemplates a simple means for eliminating the required initial high contact pressure, eliminating necessity for constant or frequent readjustment of contact springs and elimination of the requirement for increased armature travel. It has been discovered that the rate of loss of contact pressure with wear of contacts or contact spring actuating means for normally closed contacts, where the closed condition is due solely to the self-tension of the movable spring, is considerably less than the rate of loss with the same sources of wear for normally open contacts, where closure is the result of force applied externally of the movable spring. The present invention provides that not some, nor most, but all movable contact springs be tensioned normally to make closure with the required contact pressure and that the normally open, normally closed, etc. combinations previously mentioned are to be effected by means of a card for selectively separating the normally closed contact springs either in the unoperated or operated positions of the armature actuated card. This simple arrangement enables from a more prac-

tical standpoint the assembly of springs which are preset for the required contact pressure by being given a bend or deflection prior to assembly. By employing the above-mentioned type of spring actuation the rate of stiffness build-up of the movable springs is low thus requiring a substantial set or bend for a given contact force. Because of this large set less accuracy is needed in an initial bend or deflection prior to assembly to insure the required tolerancy of contact pressures after assembly. This difference is enough to make more practical the pretensioning of springs prior to assembly whereas with previously used normally open springs this practice was not advisable and consequently the tensioning had to be done by adjustment after assembly, except in cases where the initial contact pressure tolerance was large enough to permit said tensioning prior to assembly.

Relative to the previously outlined prior art regarding relay contact springs, the said operating cards or separator stud assemblies used therewith generally have been positioned relative to the contact end of said springs and the supporting ends of said springs such that upon actuation of these springs, by the said cards for instance, the movable springs were bowed due to the contact follow necessary to insure satisfactory contact pressure. This condition of bowing of the movable springs created a relative sliding of the mating contacts due to the concave or convex nature of the bow in the movable spring and produced potential mechanical oscillations in the bowed spring which were materially responsible for initial contact chatter. It has been discovered that this sliding action is largely responsible for mechanical interlocking of pitted contacts, the pitting being caused, as is well known, by arcing at the said contacts on closure and break effecting an exchange of contact material from one contact to its mating contact depending on the polarity of the arcing or attendant current discharge. One of the pitted contacts generally assumes a built-up conical configuration having jagged sides, the mating contact generally assuming a configuration resembling a conical depression having jagged sides. Any lateral or transverse or sliding motion between these mating contacts in the closed position tends to interlock the respective jagged edges and cause mechanical locking of the contacts. Several methods have been devised for limiting the build-up of these pits and depressions such as providing condenser-resistance networks for said contacts to limit the discharge current of the arc. There has been no completely effective means of eliminating the pitting and consequently large restoring forces have been resorted to for overcoming the mechanical locking condition caused by the bowing of the movable spring.

It is another object of this invention to prevent this mechanical interlock. The present invention provides a simple means for preventing the aforementioned mechanical locking condition and thereby relieves the necessity for using large restoring forces to overcome same. The invention also substantially eliminates storing up in the spring of potential mechanical oscillations to thereby effect substantial elimination of a large source of initial contact chatter. This means comprises simply arranging the contact spring actuating member, such as a card or separator, to exert its moving influence on the movable springs as near the contact area as possible and

arranging all closures of contacts to be made solely due to self-tension of the movable springs to position the contacting force directly at the contact area. This prevents any undue bowing of either spring due to the movement of either spring after closure previously required to insure contact pressure and limits the possibility of bowing of contact springs on opening operations. It is apparent that if the springs on contact have been freed of any excessive bending or bowing there will be little tendency for mechanical oscillation upon initial contact closure and thus a source of initial contact chatter will be eliminated.

Bifurcated springs are old in the art but one feature of such springs which has been a constant source of requirement for improvement has been the high degree of relative mechanical dependence of the bifurcations. The slots in these springs have been required to be shallow for separator stud operated springs because the stud generally has been positioned between the contacts of the springs and the spring support thus mechanically limiting the depth of these slots. It is apparent that shallow slots permit the bifurcations to interact mechanically to a greater extent than for a deep slot and consequently previous types of bifurcated springs have not exhibited the best desirable degree of mechanical independence of the bifurcation. For instance, a small particle of dust or dirt under one bifurcation could easily effect non-closure of the other due to the close mechanical linkage between same resulting from a shallow slot. This condition has demanded large contracting forces to overcome the latter tendency.

An incidental feature of the present invention is to create greater mechanical independence of the bifurcations of contact springs. The present invention, by providing actuation of the springs at or near the contact area, permits, as one example, the card or other operating member to be placed at the free ends of said springs, which arrangement enables one to make the bifurcation slot as deep as desired thus adding, to an already improved situation, a substantial increase in the independence of the bifurcations. It is apparent that large contact pressures formerly required to insure satisfactory contact may now be reduced since no longer is it necessary to overcome resistance to closure movement represented by dirt or dust on the contact of one bifurcation.

The foregoing objects of the invention are further explained in the subsequent description of an exemplary embodiment of the invention, the following being general descriptions of the various figures of the drawings which form a part of the said description:

Fig. 1 shows the armature side of a well-known type of relay embodying the present invention.

Fig. 2 is a side elevation of the relay shown in Fig. 1 and may represent either side of said relay.

Fig. 3 is a view showing the contact spring pile-up side of the relay of Fig. 1.

Fig. 4 is a magnified view of the contact end of the relay of Fig. 2 and illustrates an unoperated condition of the armature of said relay.

Fig. 5 is similar to Fig. 4 except that it shows an operated condition of the armature.

Figs. 6 and 7 are views similar to Figs. 1 and 2, respectively, and show a modified construction embodying the invention.

Fig. 8 is a set of curves illustrating an outstanding advantage in utilizing the invention.

These curves will be referred to later with suitable comment.

Figs. 1 through 5 show a familiar form of electromagnetic relay comprising a core 1, heel piece 2, armature 3 pin hinged at 4 to hinge bracket 5 clamped to heel piece 2 and held to the extension 5 by means of leaf springs 6, a spring pile-up assembly 17 comprising relatively fixed spoolhead springs 7, 8 and 9 having lugs 10 which engage spoolhead 11 on one end of coil 12 and relatively movable or armature springs 13, 14, 15 and 16 held together by means of screws 18 and operating cards 19 each fixed and guided by an outer balance spring 20, inner balance spring 21 and a buffer spring 22 welded or otherwise fixed to the armature 3 at area 23 and provided with an adjusting screw 24 carried by the armature 3.

In Fig. 4 are shown the operating ends of the contact springs on one side of the relay, the drawing being intended if desired, to represent the structure on the other side of said relay as well. Fig. 4 indicates the normal or unoperated condition of the relay, of card 19 and of armature contact springs 13, 14, 15 and 16. In this relay all of the armature springs are tensioned to make contact with their respective mating spoolhead springs with satisfactory contact pressure when no external force acts on the movable springs. That is, if card 19 were not present armature spring 13 would contact spoolhead spring 7, as shown since this is a break pair, armature spring 14 would contact spoolhead spring 8, shown separated by intervention of the card 19 because this is a make pair, and armature springs 15 and 16 would contact spoolhead spring 9, armature spring 15 being shown in contact and armature spring 16 being shown separated since this is a make and break combination.

The card 19 is positioned in outer balance spring 20 by means of the reduced end 25 of card 19 entering a suitable rectangular hole in the end of outer balance spring 20 as shown more clearly in Fig. 3. The free end of the inner balance spring 21 is shown most clearly in the part of Fig. 1 wherein parts of buffer spring 22 and armature 3 are broken away. A rectangular slot 26 in the end of inner balance spring 21 is adapted to fit snugly under the top shoulder of the card 19 as shown in Fig. 2. The buffer spring 22, attached to armature 3 along with its adjusting screw 24, is provided with a depending end portion 27 which is adapted to prevent the card 19 from slipping out of the slot 26 in the inner balance spring 21. These balance springs 20 and 21, as well as the buffer spring 22, are of resilient character in order to hold the card 19 as shown and also to permit movement thereof by armature 3.

The outer balance spring 20 is tensioned to urge the card 19 upward to the position shown in Fig. 4. The buffer spring 22 urges the card 19 downward as viewed in Fig. 4. The inner balance spring 21 urges the card 19 upward as viewed in Fig. 4 an amount substantially equal to that exerted by the outer balance spring 20. The relative forces produced on the card 19 by the respective balance springs may be divided between them in any proportion desired.

From the status of Fig. 4 to that of Fig. 5 it is seen that the card 19 has engaged the end of armature spring 13 and has pushed it away from contact with spoolhead spring 7, this movement being against the natural tension in armature spring 13. On the other hand, card 19,

which previously held armature spring 14 out of contact with spoolhead spring 8, has now moved so as to permit spring 14 to make contact with spring 8 under its own tension. The action of the make and break combination of springs 15, 16 and 9 is merely a combination of the functioning of the preceding pairs. Upon release of armature 3 the combined forces stored in the balance springs 20 and 21, the armature hinge spring 6, and the armature springs 13 and 15 will return the armature 3, card 19 and all springs to their normal positions of Fig. 4.

The contact springs of the relay may be bifurcated for whatever length of spring is desirable since by the use of the invention the card 19 is shown as acting at or substantially at the contact area and does not interfere with the cross section of these springs. As shown in the part of Fig. 3 wherein part of one of the outer balance springs is broken away, the armature spring 13 may be provided with a deep slot 28 which will permit the individual bifurcations 29 and 30 to be considerably more independent of each other mechanically, and consequently electrically as far as contact closure is concerned, than they would be if slot 28 were shallow as in previous types of similar construction where the separator stud type of actuating member was placed between the contact ends of these springs and the supporting pile-up assembly 17. A particle of dust or dirt which might reside under bifurcation 29 would have small tendency to interfere with or prevent bifurcation 30 making adequate electrical contact with spoolhead spring 7. Consequently, less contact pressure is required with the proposed type of deep bifurcation than was required in the previous shallow type to insure electrical contact.

As outlined previously, the rate of loss of contact pressure with contact and card wear for springs which are normally tensioned to closure by reason solely of self-tension of the movable spring is considerably less than of that for springs normally in the open position when no external forces act thereon. In the former situation the loss in contact pressure is determined by the loss in tension in the armature spring alone as wear occurs due to the fact that the spring approaches further to equilibrium and thus represents less potential contacting force. In the other case the loss in contact pressure is due to the fact that the actual total movement of the spring by its actuating member is the same but the effective contact follow is reduced by the amount of wear.

The latter consideration as well as the previous discussion concerning the prevention of mechanical interlock of contact, as well as the enabling of deep slotted bifurcations, all combine to materially reduce the contact pressure requirements for contact springs of such relays as are provided with the invention. The reduction is due to the use of contact springs which are all normally positioned to closure by reason solely of the self-tension of the movable springs and which are actuated by a card or separator stud or similar member acting substantially at the contact area.

The simplicity of this invention in concept and in the manifestation of the parts and conditions necessary for its functioning make it readily adapted to manufacture and assembly in or with standard relays and alleviates maintenance problems by eliminating mechanical interlock of contacts and necessity for frequent readjustment of springs to compensate for contact and card or stud wear. The aforementioned small loss of

contact pressure with contact and card wear enables the practicality of assembling pretensioned armature springs with an assurance that the specified tolerances for contact pressure are met.

A further advantage of arranging the card or stud to actuate the springs substantially at the contact areas and arranging the springs to be normally tensioned to closure is that no excessive bending or bowing or deforming of the armature springs is necessary to insure contact pressure and even if a substantial amount is represented by the natural tension of the armature springs the contacting force is still applied directly at the contact area on closure. On break conditions the card or stud is arranged to apply its pushing force on the armature springs at or substantially at the contact area. These provisions, as previously mentioned, eliminate the storing of potential mechanical oscillations in the springs by not deforming them. Consequently no potential mechanical oscillations can become dynamic to effect contact chatter.

In Figs. 6 and 7 are shown two views of a relay similar to the one previously discussed. The relay of Figs. 6 and 7 embodies a modification of the card and armature relationship whereby, instead of a buffer spring to position and actuate the card 19, the top shoulder of the card 19 is provided with a recessed inner edge 31 which is adapted to accommodate an upstanding tang 34 in the end of the inner balance spring. This positions the card 19 and also prevents it from slipping out of the spring assembly, it being noticed that the top end of the card merely rests against the underface of armature 3. The armature 3 comprises a broad end area 32 which may cover the entire width of the relay including the contact ends of all springs. The dotted portions of Fig. 6 indicate the general configuration of the undersurface of armature 3, numeral 33 designating recesses in the underface of armature 3 which are provided to accommodate the armature ends of cards 19, as shown in Fig. 7. The other parts of the relay and their functions are the same as for like parts previously discussed in connection with Figs. 1 through 5. A hooklike end 35, as shown in Fig. 7, may be provided for the card 19 to prevent the outer buffer spring from accidentally being jarred from its retaining position on card 19.

Fig. 8, derived from test data, shows the rate of loss of contact pressure with card or stud and contact wear for relays having normally open contact springs and for those having normally closed contact springs. It is to be noted that curves A and B represent relays provided with the invention whereas curve C represents relays according to prior art in that self-tensioned normally closed springs are not used universally. The curve C indicates that for previous types of normally open contacts the average contact pressure of say 25 grams is reduced rapidly to zero with contact and stud wear from zero up to say .013 inch. Curve B indicates that an average contact pressure of about 23 grams is substantially constant up to wear of about .013 inch, where it drops abruptly to zero. If an average contact pressure of say 13 grams is all that is required, curve A would suffice for the entire range of wear of the old type of relay arrangement provided the invention is employed. In addition it is apparent that the full depth of contact material is used without requiring readjustment or replacement of springs because

the contact pressure is substantially constant for say .013 inch which might very well be the depth of the contacts; whereas, according to curve C, the full depth of .013 inch cannot be used since the minimum allowable contact pressure is exceeded making readjustment or replacement of springs necessary before that amount of wear is reached. The minimum contact force, or pressure, is illustrated by curve D at about 10 grams. This curve D is an order of magnitude only and represents the neighborhood of the unsatisfactory operating zone. It is of course possible that this curve D can be at any magnitude below about 20 grams and still indicate the point above mentioned.

Having set forth the objects and purposes of the invention with a detailed description of how to apply same, I append claims which alone define the scope of the invention since many modifications, rearrangements, new aspects and other embodiments than the one disclosed herein by example will be suggested to those skilled in the art.

What is claimed is:

1. In an electrical contacting device, a plurality of relatively fixed contacting elements, a plurality of relatively movable resilient contacting elements cooperating therewith, all of the said movable elements being tensioned normally to make contact with respective fixed elements by reason solely of their own tension, actuating means, and mechanical means controlled by said actuating means having shouldered portions for selectively opposing the tension of said movable elements to effect switching operations thereby.

2. In a relay, cooperating pairs of relatively fixed and relatively movable resilient contact springs, each of said movable springs being tensioned normally to make contact with the cooperating fixed spring of the pair by reason solely of its own resilient tension, an armature, and an operating member controlled by said armature having shouldered portions for selectively opposing the tension of said movable springs to effect switching operations thereby.

3. A relay having a plurality of relatively fixed contact springs having contacts thereon, a plurality of relatively movable resilient contact springs having contacts thereon and adapted to make contact with the said fixed springs at respective contacts thereof, means for applying the contacting forces between respective contacts of said springs only at and directly at the contact area, the said means comprising tensioning inherent by reason solely of their own tension of all movable springs urging same to normal closure with said fixed springs, and additional means provided with shouldered portions to selectively separate said normally closed pairs of springs.

4. A relay comprising an armature, relatively fixed contact springs, relatively movable resilient contact springs all tensioned normally by reason solely of their own tension to contact cooperating fixed springs, and a resiliently suspended member having shouldered portions actuated by said armature and adapted, under the control of said armature and by said shouldered portions to selectively separate the said normally contacting pairs of movable and fixed springs.

5. A relay comprising an armature, relatively fixed contact springs, relatively movable resilient contact springs all tensioned normally by reason solely of their own tension to contact cooperating fixed springs, and a resiliently suspended

member actuated by said armature, having shouldered portions normally positioned to separate some contacting pairs of said movable and fixed springs and having other shouldered portions effective when said member is actuated to separate other contacting pairs of movable and fixed springs and to enable contact between springs of the pairs previously separated by the said member when in its normal position.

6. A relay comprising an armature, a plurality of relatively fixed contact springs having contacts, a plurality of relatively movable resilient contact springs having contacts, all of the movable springs being tensioned normally by reason solely of their own tension to make closure with the said fixed springs at respective contacts thereof, and means having shouldered portions controlled by the said armature, certain of its shouldered portions being disposed to separate at least one of said closed pairs of springs when said armature is unoperated, the said means, when controlled by operation of said armature, being effective by said certain shouldered portions to release the separated pair or pairs to permit same to make closure due to the inherent tension of said movable springs and by others of its shouldered portions to separate the remaining closed pairs of said plurality of cooperating pairs of fixed and movable springs.

7. In a card operated relay a relatively fixed contact spring having contacting areas, a relatively movable resilient contact spring having a contacting area and located on each side of the said fixed spring, each of the said movable springs being tensioned normally by reason of its own tension to contact the said fixed spring at respective contacting areas thereof, a card having shouldered portions and an armature, the said card adapted, under the control of said armature, to selectively engage shouldered portions thereof with the said movable springs substantially at the contacting areas thereof to selectively disconnect same from the said fixed spring.

8. In a card operated relay a plurality of relatively fixed contact springs having contacting

areas, a plurality of relatively movable resilient contact springs having contacting areas, each of said movable springs being tensioned normally by reason solely of its own tension to contact at least one of said fixed springs at respective contacting areas thereof, a card having shouldered portions and an armature, the said card adapted, under the control of said armature, to selectively engage shouldered portions thereof with the said movable springs substantially at their contacting areas to thereby selectively disconnect same from said fixed springs.

9. In a card operated relay, a plurality of relatively fixed contact springs having contacting areas on one of the ends of each, a plurality of relatively movable resilient contact springs having contacting areas on one of the ends of each, all of said springs being assembled in a superimposed pile with all contacting areas at one end of said pile, an armature and a card having shouldered portions actuated thereby, all of the said movable springs being tensioned normally by reason solely of their own tension to contact the said fixed springs at respective contacting areas, the said card adapted, under the control of said armature, to selectively disconnect contacting pairs of said springs by selectively engaging shouldered portions thereof with said movable springs substantially at their contacting areas and selectively disconnecting same from the mating fixed springs.

HARRY M. KNAPP.

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