June 8, 1954 B. JANSEN 2,680,790

LOAD CHANGEOVER SWITCH FOR TAPPED TRANSFORMERS USING A COMBINATION OF CONTACT MOVEMENTS

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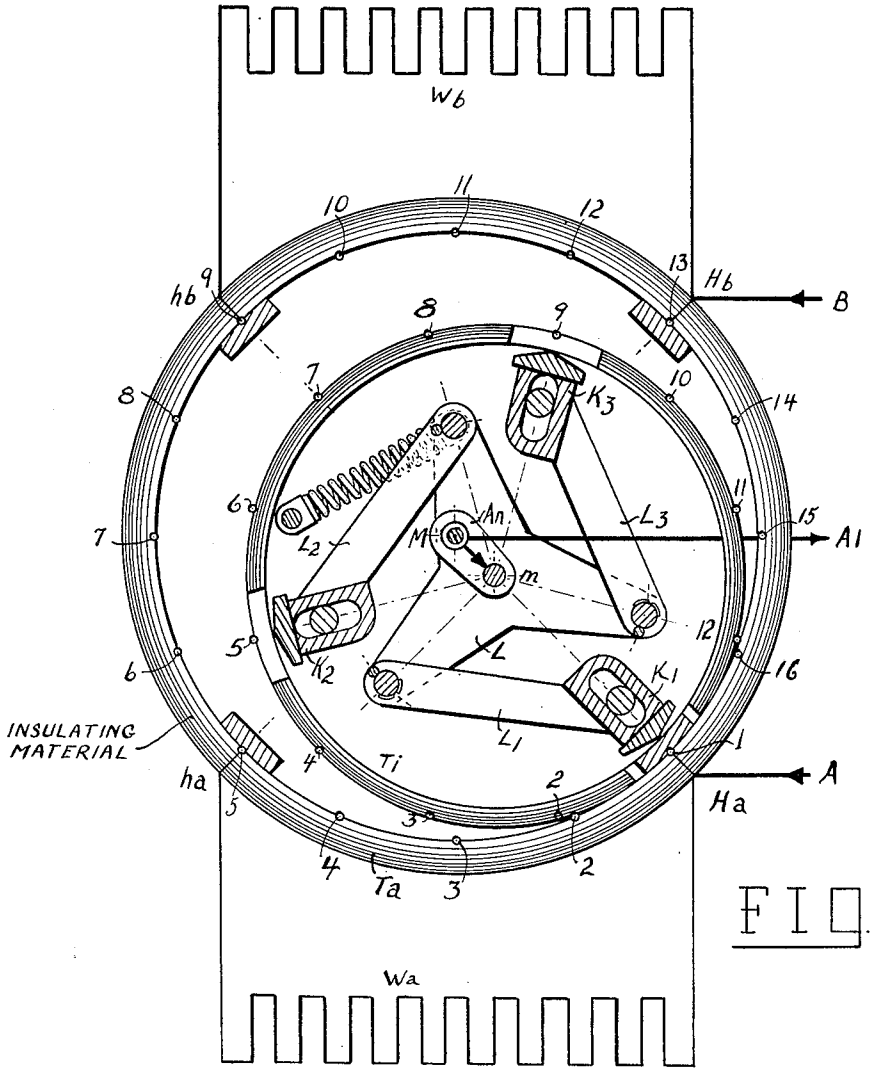


FIG.1A

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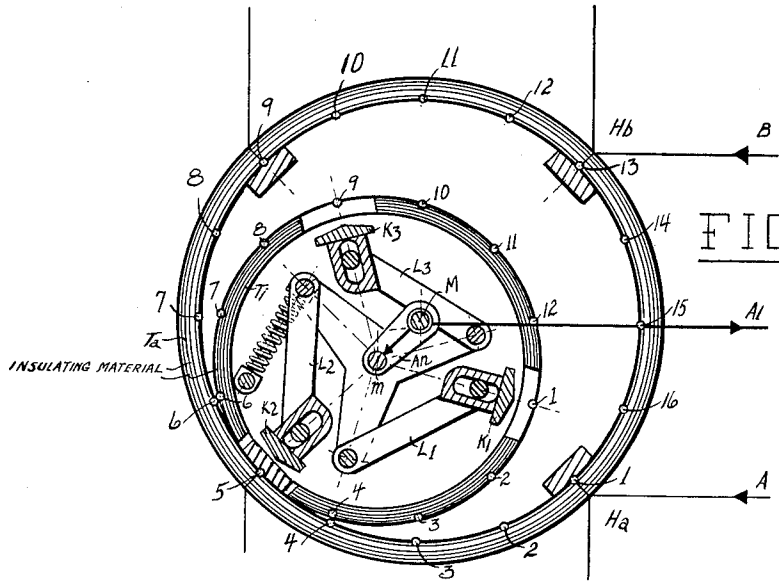


FIG. 1C.

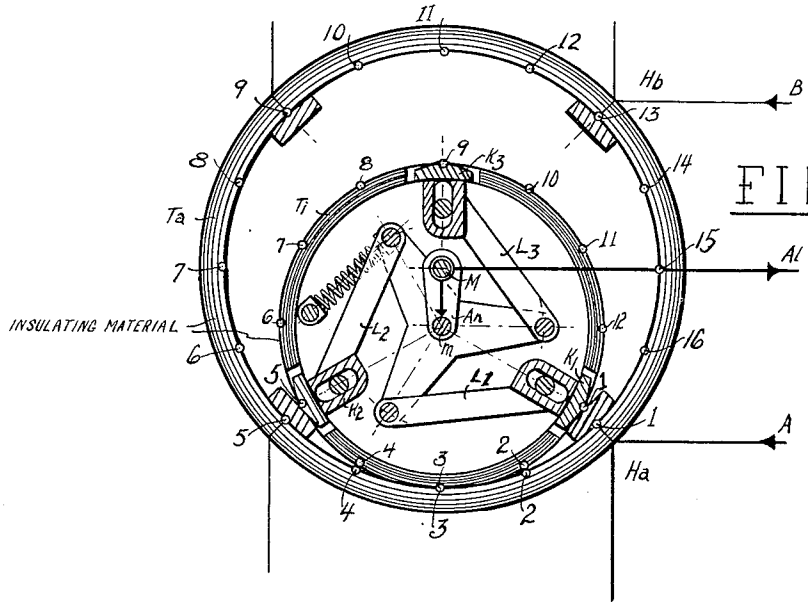


FIG. 1B.

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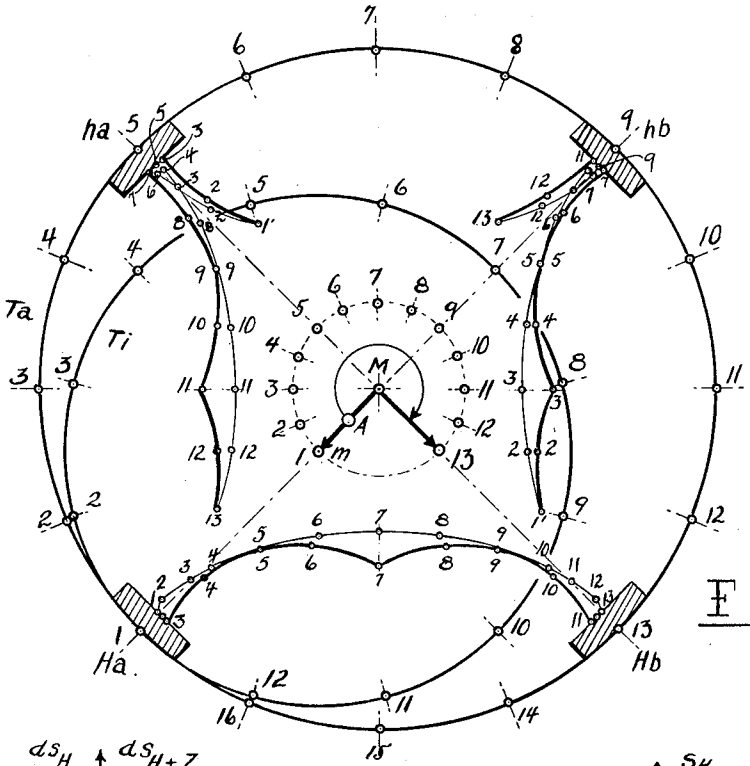


FIG. 2

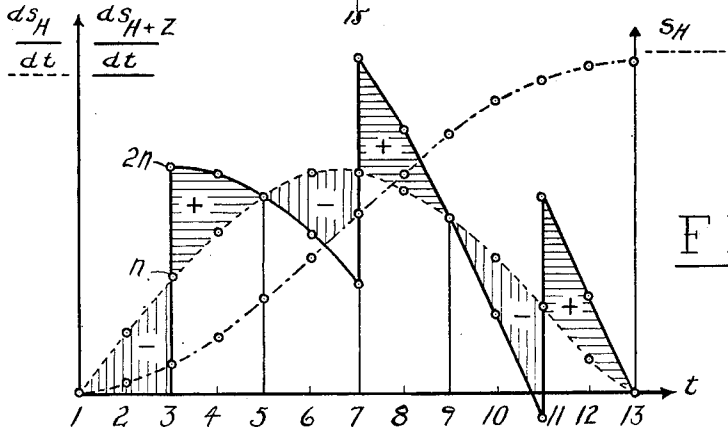


FIG. 3

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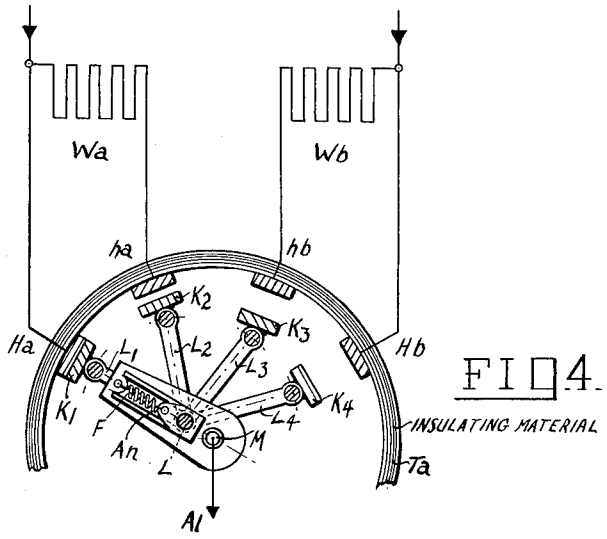


FIG. 4.

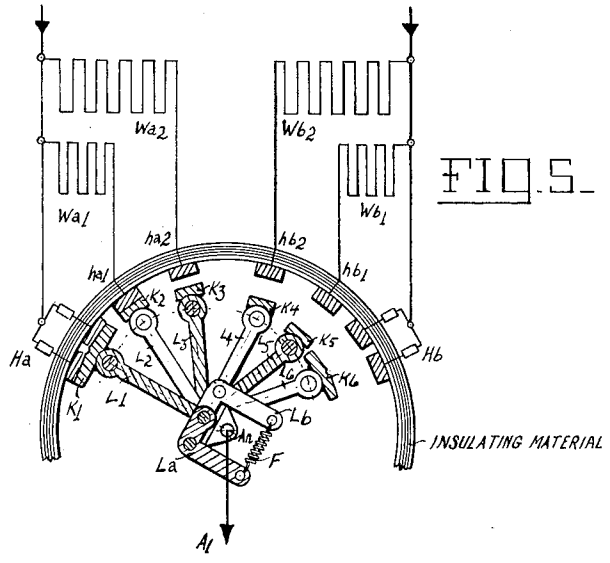


FIG. 5.

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Patented June 8, 1954

2,680,790

UNITED STATES PATENT OFFICE

2,680,790

LOAD CHANGEOVER SWITCH FOR TAPPED TRANSFORMERS USING A COMBINATION OF CONTACT MOVEMENTS

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Application March 7, 1951, Serial No. 214,280

2 Claims. (Cl. 200—6)

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A load changeover switch of customary design accomplishes its task of changing over the working current from the hitherto connected transformer tap to the next one by means of several main and auxiliary contacts and changeover resistances switched in between these contacts which are closed and opened consecutively in the required switching sequence and with the required switching velocity. Three patterns much used in practice are shown in the illustrations belonging to the patents DRP 474,613, 648,600 and 707,188. It is apparent, that the sequence of the contact closing and opening operations which in the case of using ohmic changeover resistances are supposed to be achieved within the shortest possible overall time, and the interrupting velocity of all contacts which for safe arc extinguishing is supposed to be as great as possible, is essentially influenced by three items, i. e. firstly by the spatial arrangement of the stationary and movable main and auxiliary contacts, secondly by the cinematics of the movable contacts and finally by the velocity trend of the primary driving organ. It is up to the designer to take these factors into account when designing such switches. The steadily increasing rated power of tapped transformers resulted in such dimensions of the load changeover switches as to require for reasons of mechanic strength great masses to be moved and consequently an expensive construction. Additional enlargement of the dimensions was required by two further phenomena which were hitherto considered inevitable, i. e. the factory inaccuracies of the load changeover switch contacts and the influence of burnt down contacts upon the process of the individual switching operations.

The present invention for which patent is applied increases the velocity of closing and opening by an unsteady secondary movement which is superimposed on the steady primary contact movement in the deciding moments and is using for this purpose technical means which at the same time paralyse the influence which factory inaccuracies of the load changeover switch contacts or their steadily increasing burning down might have upon the total duration of the changeover switching operation, thereby reducing the total changeover switching period to the lowest possible limit. Related to the same switching velocity, which is obviously prescribed by the extinguishing requirements of the switching arcs, the invention entails smaller dimensions, reduces in this way the masses of the moved load changeover switch parts and lowers the stresses which

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arise in the material during the quick changeover switching operation.

The object of the invention realizes the increase of the closing and opening velocity of the movable contacts by their movements being determined by two elements, i. e. the driving organ of the movable load changeover switch part and the main or auxiliary contact switched on at the moment. The driving organ transmits to all closing or opening contacts a steady primary movement which is accelerated or retarded in its individual phases, by using customary cinematic means which have partly been applied already hitherto in the design of load changeover switches. The contact which is closed presently, impresses on the contacts which are in the state of being closed or opened with the above-mentioned steady primary movement and which are connected with it over a common guide, an additional unsteady secondary movement which added to the steady primary movement, yields the desired and actually obtained combined movement of the switching contacts. The capability of the stationary switched-on contact to transfer an additional movement to other moved contacts, is based on the fact, that this contact is connected pliably over a common guide, moved directly or indirectly by the driving organ, with the other contacts engaged in the closing or opening movement, thus having an accelerating or retarding effect on them, dependent on the direction of movement of the guide. The impressed unsteady secondary movement is therefore a so called relative movement, and by designing the cinematics of the contact guide and its links to the switching contacts in accordance with the present invention it is possible to give the closing and opening contacts the greatest additional movement in the desired direction just in the deciding instant of opening or closing them.

At the same time, the effects of factory inaccuracies on the load changeover switch contacts and of their increasing loss of substance by burning down are compensated by the causal dependence of the secondary movement on the fact of the actually completed closing of that contact which initiates the secondary movement. There is no more need of providing "additional safety runs" of the contacts for the timely overlapping of contact closing; for the secondary movement of the opening contact begins with a sudden start just in that instant when the controlling contact is actually closed, and the secondary movement of the closing contact finishes in the same sudden unsteady way in the moment

of its actual closing and is used from that instant on for the benefit of the acceleration of the next opening contact. In this way, when moving the load changeover switch from the initial position to the final position, a continual alternation of increase of closing velocity up to the moment of actual closing and from then on of increase of opening velocity is attained for each switching contact, progressing from the first to the last contact coupled through the guide.

The application of the invention brings about a reduction of dimensions which is especially remarkable in cases where the stationary main and auxiliary contacts of the load changeover switches are arranged on contact carriers which have the shape of circles or circle arcs. The application of the invention is also especially appropriate for load changeover switches, in which several changeover resistances are to be connected at the same time by corresponding contact pairs, in order to obtain a distribution of the current to several branch resistances, and in order to have to interrupt by consecutive opening and closing of such parallel branch circuits only small arc currents on the switching contacts what is much for the benefit of the lifetime of the contacts.

Figs. 1A, 1B and 1C show respectively a single embodiment of the present invention in three different positions which it assumes during the course of a complete cycle of operation.

Fig. 2 shows movement diagrams illustrating the effects of the secondary movements on the closing and opening velocities.

Fig. 3 shows velocity curves illustrating the same effects as in Fig. 2.

Fig. 4 shows another embodiment of this invention for use with a slot guide on less than a full circle, and

Fig. 5 shows a different embodiment of this invention, employing a rocker type guide.

Figs. 1A, 1B and 1C demonstrate on the example of a load changeover switch, the four stationary switching contacts of which *Ha*, *ha*, *hb*, *Hb* are distributed on a circular contact carrier *Ta*, how the problem can be solved by means of intermediate member shown as a starshaped guide L, which is connected to the movable contacts K_1, K_2, K_3 over links pushing rods L_1, L_2, L_3 and how the changeover process from the initial position 1 to the final position 13 is going on in load changeover switches with ohmic potential dividers in severals phases (Jansen switch).

The two transformer tappings A and B which are to be changed are connected to the stationary main contacts *Ha* and *Hb*. From there, the path of the current is going through the changeover resistances *Wa* and *Wb* to the two auxiliary contacts *ha* and *hb* respectively. The current is led off from the center of the movable contact system K_1, K_2, K_3. These contacts are mounted on a circular contact carrier *Ti* which by means of an outer tooth system 1 to 12, is unrolling in an inner tooth system 1 to 16 which is mounted on the contact carrier *Ta* of the stationary contacts, so that the contact K_1 moves during one complete changeover operation from the one main contact *Ha* (position 1) on a circular track to the right to the other main contact *Hb*; cf. Fig. 2. The unrolling of *Ti* in *Ta* is done in a customary way by using a driving arm A which revolves around the axis M of *Ta* under the influence of the driving force and turns the axis *m* of *Ti* in a circular track.

When viewing the positions shown in Figs. 1A, 1B and 1C, it is evident, that always that contact is coming to bear which is situated in the direction of the arrow of the driving organ A. Since this arrow is coming progressively into the direction of each of the stationary contacts in consequence of the unrolling action of *Ti* in the stationary contact circle *Ta*, it is clear, that thereby the contact sequence planned by the designer is attained. From Fig. 1B it will be gathered however, that upon moving on from one closing position to the other always an intermediate position is happening, in which the arrow is passing just between two stationary contacts (e. g. *Ha* and *ha*, Fig. 1B), two movable contacts (e. g. K_1 and K_2) touching two stationary contacts (e. g. *Ha* and *ha*) and connecting them with the leading-off point A1. In order to expedite the said simultaneous closing of two neighbouring contacts which is necessary for changing over without interruption, the three movable load switching contacts K_1 to K_3 can glide in radial direction in slots of their contact carrier *Ti*. Their movement is however not free, but positively controlled, for they are connected by pushing rods L_1 to L_3 to the arms of starshaped guide L revolving around the axis *m* of the movable contact system. This star L enforces a simultaneous movement of all three load switching contacts K_1 to K_3 by the same radial way in relation to the axis *m*. In addition, a spring F acting upon the star L is taking care that there is always a tendency to push the three load switching contacts as far out of their contact carrier as possible. This tendency finds its limitation not by a stop within the contact carrier *Ti*, but merely by one of the contacts K_1 to K_3 firmly resting on one of the corresponding countercontacts *Ha* or *ha* or *hb* or *Hb*. In the intermediate positions (e. g. in the above treated Fig. 1B) two contacts (e. g. K_1 and K_2) are transiently closed. Since from the geometrical point of view this intermediate position of the driving organ A in relation to *Ha* and *ha* is given only on one single point of its circular track, the duration of simultaneous contact making of *Ha* and *ha* with A1 can last only a short moment (oscillograph recordings give $^2/_{1000}$ to $^3/_{1000}$ of a second.

A close examination of the movements going on in the intermediate positions shows that the time of contact overlapping i. e. the period, during which both contact pairs (e. g. $Ha+K_1$ and $ha+K_2$ in Fig. 1B) are closed simultaneously, always lasts a very short moment, irrespective of any factory inaccuracies and irrespective of the burning loss of substance of the individual switching contacts. Factory inaccuracies and burning loss are only able to effect the instant of contact change a trifle sooner or later what is however of no consequence. It is essential that of the total duration of the changeover switching time no spaces need be taken up by contact overlapping necessary in former load changeover switches, and that the total changeover switching time can thus be shortened by increasing the angular velocity of *m* revolving around M. In consequence, the contact opening velocity is increased.

This velocity, however, is still more raised by the unsteady secondary movement transmitted by the common guide L. The secondary movement is produced as follows:

If each of the three movable contacts K_1 to K_3 were spring-cushioned for itself independent of the others as usual with customary load changeover switches, it would rest before opening so long on the countercontact (e. g. K_1 on *Ha* in Fig. 1A to Fig. 1B) until taken along by a latch or other catch. Its opening velocity would then

equal only the local velocity of the contact carrier T*i* on point K_1, and it would withdraw from its countercontact H*a* only as quick as allowed by the movement of the contact carrier T*i*. By introducing the common contact guide L, however, K_1 is withdrawn from H*a*, when moving on from position 3, not only with the local velocity of the contact carrier T*i* on the point K_1, but receives furthermore from its follow contact K_2 which when moving on from position 3 is pressed back in its contact carrier T*i* on account of its resting on *ha*, an additional (secondary) withdrawing impulse through the starshaped guide L. On account of the common contact control by this guide, K_1 is retiring with double the velocity from H*a* as would prevail in the case of the formerly used individually spring-cushioned contacts. This fact of doubled velocity upon opening the contacts by means of the unsteady secondary movement grants an essential diminution in size of the load changeover switch and in the masses of its moved parts.

Fig. 2 shows in thickly drawn lines the movement curves of the footings of the three contacts K_1 to K_3 from the initial positions 1 to the final position 13. The thinly plotted curves represent the steady primary movements of the three points near 1, 5, 9, which correspond to the footings of the three contacts on the contact carrier T*i*. A comparison of the mutual distances of the intermediate position points 2 to 12 marked on both curves—the mutual distance of two neighbouring points of each curve (positions 3 to 4, 5 to 6, 9 to 10) being of importance especially in the moment of opening the contacts—shows the doubling effect of the unsteady secondary movement upon the way of the contacts.

This is still better illustrated by the fully plotted and dotted velocity curves of Fig. 3. They are referring to the opening of the contact pair $Ha-K_1$ during the movement, shown in Fig. 2 of the unrolling contact carrier T*i* from position 1 to position 13. This movement originating from the movement, steady after a short starting period, of the driving organ A, the contact ways gained from positions 1 to 13 of Fig. 2 are in direct relation to the intervals t_1 to l_{13} of Fig. 3. Thus the way-time-diagram $s_H=f(t)$ plotted in Fig. 3 in interrupted lines, is gained by compassing out of Fig. 2 the distances s_H of the two opening contacts H*a* and K_1 in the individual positions 1 to 13. The dotted velocity-time-diagram

$$\frac{ds_H}{dt}=f(t)$$

of the steady primary movement is obtained by differentiation. A sine-shaped curve is resulting thereby, to which the unsteady secondary movement is superimposed in such manner that the vertically hatched negative way-areas and the horizontally hatched positive way-areas originate which compensate each other to zero three times during the total movement. The resulting actual contact velocity is thus represented by the solidly drawn unsteady curve

$$\frac{ds_{H+Z}}{dt}=f(t)$$

which corresponds to the equally solidly drawn movement curve of Fig. 2. Only the passing from − to + in the contact positions 3, 7, 11 is ensuing in an unsteady way, whereas the passing from + to − in the fully closed positions 5 and 9 (closing of contacts *ha* and *hb*) is going on in a steady way.

The effect which is aimed at by the invention, i. e. the increase of the closing velocity before the intermediate positions 3 and 7 and of the opening velocity behind these positions, is fully attained. The rate of velocity increase is proved by the solidly drawn curve of Fig. 3 to be a full doubling (*n* compared with 2*n* in Fig. 3) in the moment $t=3$ which is decidingly important for the main contact pair $Ha-K_1$.

Figs. 4 and 5 give examples for a different design of the contact guide which transmits the unsteady secondary movement, for the case of arranging the stationary contacts on the third part of a full circle for use in a three-phase load changeover switch connected in the neutral point, whereas these contacts were arranged in a full circle in Fig. 1. In Fig. 4, the guide L consists of a mere axle with which the movable contacts K_1 to K_4 are pliably connected by means of guiding pushing rods L_1 to L_4. This guide L is mounted radially gliding in the driving organ A, revolving around the center M, of the movable load changeover switch part. Hence upon L is impressed in the first place the steady primary movement in tangential direction of and by the revolving driving organ A, but moreover the unsteady secondary movement is impressed in radial direction, upon turning of A, by the presently closed contact (in the position shown in Fig. 4 it is K_1) by means of the corresponding pushing rod L_1. The guide L transmits the movement which results from the tangential and radial components to the contacts K_2 to K_4 by means of the pushing rods L_2 to L_4, thus achieving the same way and velocity effect as described with the aid of Figs. 2 and 3 for the load changeover switch Fig. 1. It is, therefore, superfluous to show in a drawing the respective changeover positions of the load changeover switch of Fig. 4. There is still a third function of the guide L: the transmission of the contact pressing force exerted by the spring F upon the contacts K_1 to K_4, this force also being transferred by the pushing rods L_1 to L_4. The radial arrangement of the spring F on the driving organ A which turns from contact *zu* contact grants the possibility of using for all 4 contacts not more than one single spring which need not neutralize the steady primary contact movement, but only the much smaller unsteady secondary movements. Thus the lifetime of the spring F is long on account of short working ways.

For the radial alignment of the guide L also other methods can be made use of besides the slot guiding of Fig. 4. Fig. 5*a* shows for instance a rocker guiding, the spring F acting upon one arm of the rockers S*a*. This design is especially appropriate for big surface contacts with great axial length (vertically of the drawing plane), because the rocker S*a* which is supported above and below, is guiding the contacts K_1, K_3, K_5 in parallel to the stationary countercontacts by means of parallel pushing rods L_1, L_3, L_5, two for each contact, thus securing uniform burning down of the contacts.

The rocker guiding of the guide L is also well fit for the application of two separate contact groups according to Fig. 5. In this case, two independent contact systems are arranged with their guides L*a* and L*b* gearing in such a way, that each of the guides can make its unsteady secondary movement independent from the other on the same radial center line of the driving organ

A, if they are arranged above each other seen vertically to the drawing plane.

With regard to the switching properties, the fact results therefrom, that always two neighbouring contacts (at first K_1 and K_2) are closed at the same time, and that with the illustrated alternating contact arrangements the closings and openings are taking place alternately in the one (1, 3, 5) or other (2, 4, 6) group. Thereby the loading by the current is distributed to two parallel contacts, the closing and opening current in the individual contact is smaller, and it is up to the designer to obtain from step to step a transition, which is equalized with regard to current and tension, by an expedient gradation of the ohmic values of the subdivided changeover resistances (cf. patent application J70,675). These advantages are attained without enlarging the space required by the load changeover switch of Fig. 5 as compared with the non-subdivided switch of Fig. 4. Thus, by subdividing into groups as in the present invention the capacity of the load changeover switch is further augmented.

The design as per Figs. 4 and 5 is especially suitable for three-phase load changeover switches situated in the neutral point, whereas according to Fig. 1 a single-phase load changeover switch of advantageous dimensions is obtained. The latter type can also be enlarged by adding further contacts in circular arrangement to serve as multiple step load tap selector (tap selector switching under load), whereby a very favourable saving of space results.

I claim:

1. A switch of the class described, comprising: a plurality of stationary contact members having contact surfaces, said contact members being disposed in spaced relationship about a first circular arc with their contact surfaces directed toward the center of said first arc; a movable contact carrier comprising a plurality of movable contact members having contact surfaces, said movable contact members being disposed in spaced relationship about a second circular arc of radius smaller than the radius of said first arc for consecutive engagement between said last-named contact surfaces and said contact surfaces of said stationary contact members; a revoluble operating shaft concentric with said first arc;

eccentric contact actuating means carried by said shaft and movable therewith interconnecting said shaft and said carrier; and resilient means acting on said contact actuating means and urging engaging movable and stationary contact members into engagement with each other, said last means including a common link so connected as to superimpose on the normal continuous main motion a discontinuous additional motion.

2. A switch of the class described, comprising: a plurality of stationary contact members having contact surfaces, said contact members being disposed in spaced relationship about a first circular arc with their contact surfaces directed toward the center of said first arc; a movable contact carrier comprising a plurality of movable contact members having contact surfaces, said movable contact members being disposed in spaced relationship about a second circular arc of radius smaller than the radius of said first arc for consecutive engagement between said last-named contact surfaces and said contact surfaces of said stationary contact members; a revoluble operating shaft concentric with said first arc; an arm carried by said shaft; an intermediate member revolubly connected to said arm; a link connecting each movable contact to said intermediate member, each movable contact being radially movable with respect to said second arc; and resilient means acting on said intermediate member and urging said movable contacts radially outwardly by means of said connecting links, said switch further comprising arcuate interengaging means for maintaining said movable contact carrier positioned for said consecutive engagement between said contact surfaces.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,626,970	Rooth	May 3, 1927
1,931,869	Jansen	Oct. 24, 1933

FOREIGN PATENTS

Number	Country	Date
705,659	Germany	May 6, 1941
886,836	France	July 19, 1943