March 17, 1959 O. P. McCARTY ET AL 2,878,333

CONTROLLED SPEED TAP CHANGING MECHANISM

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2 Sheets-Sheet 1

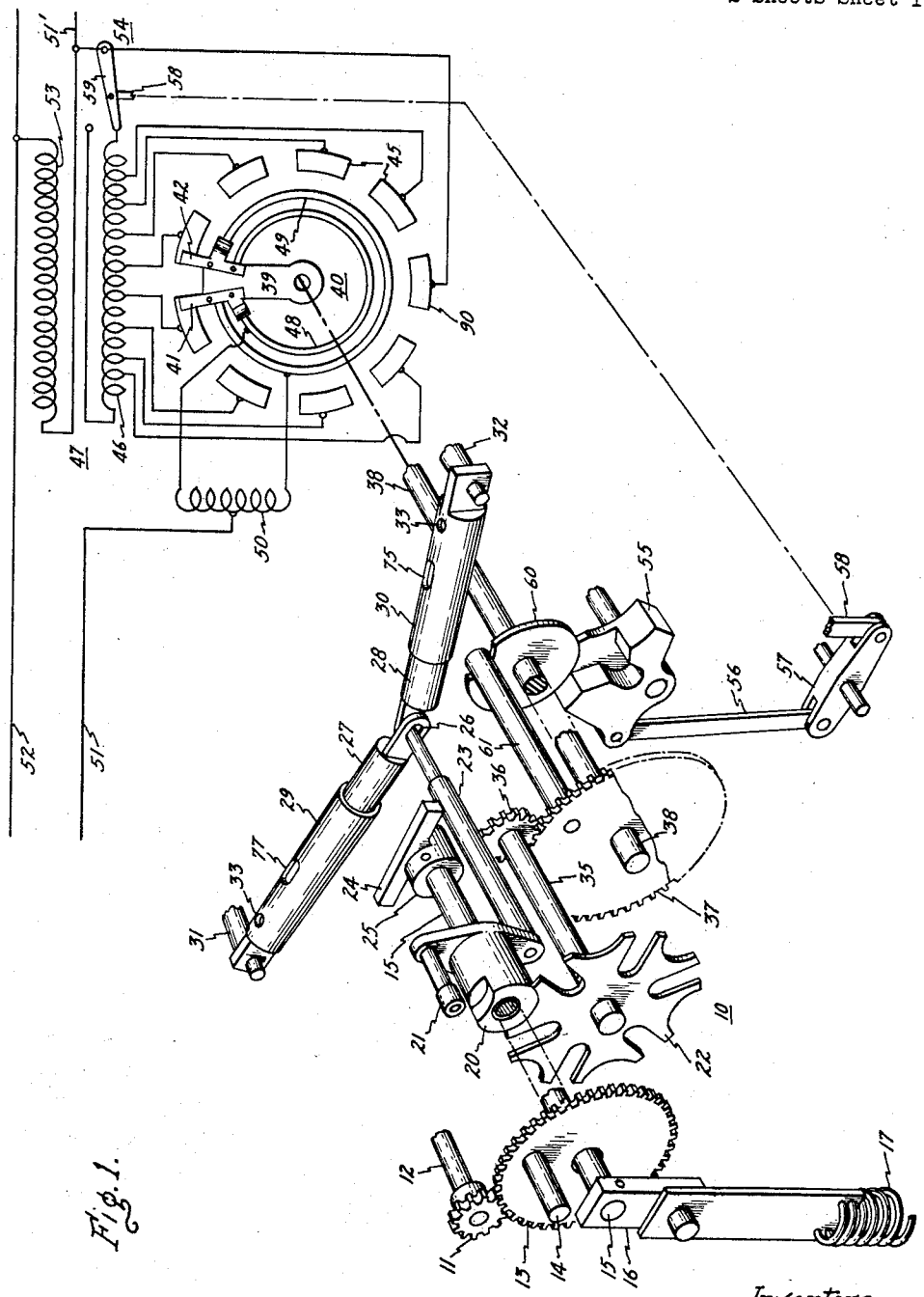


Fig. 1.

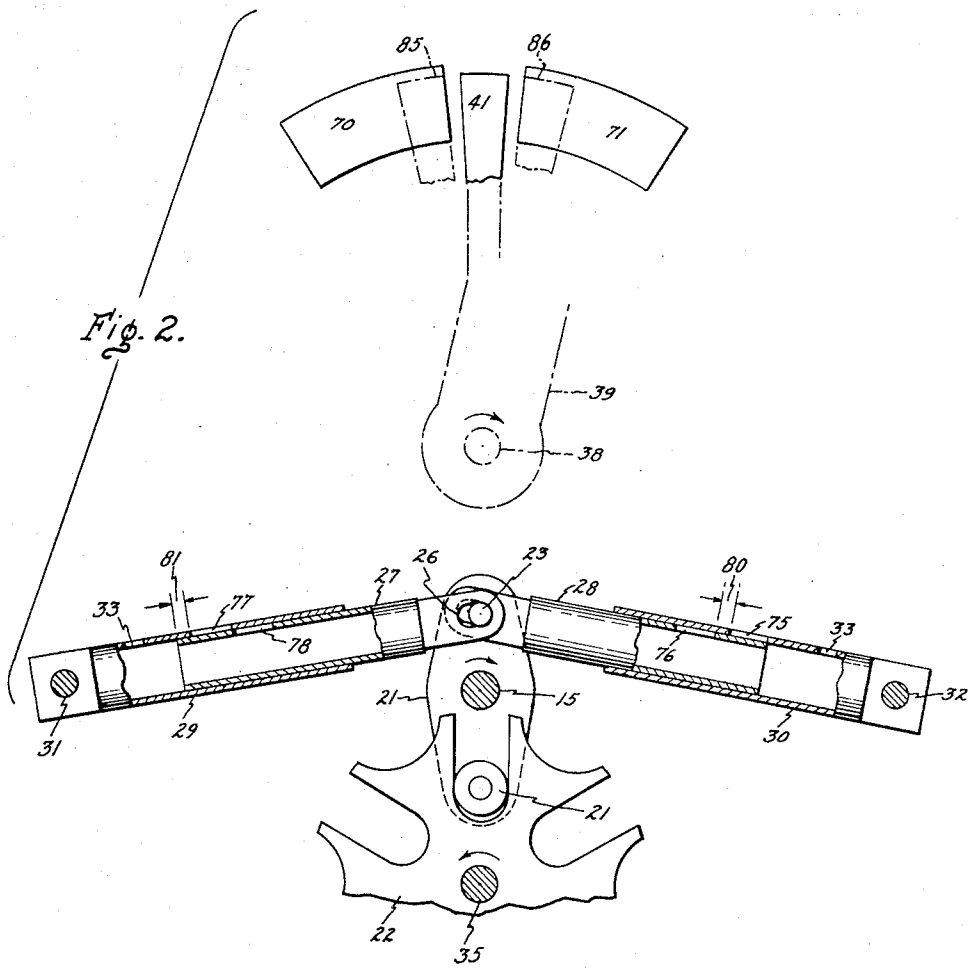
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Fig. 2.



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2,878,333

CONTROLLED SPEED TAP CHANGING MECHANISM

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6 Claims. (Cl. 200—62)

This invention relates to electrical switching mechanisms, and more in particular to an improved mechanism for controlling the speed of contact making and breaking in electrical tap changing mechanisms. Although the invention is particularly adapted for use with load tap changing transformers, it may also be employed in other types of electrical switching systems requiring a plurality of sequential tap changes.

In the switching of taps on such apparatus as load tap changing transformers, in order to obtain maximum contact life it is essential that the contacts be opened rapidly. In the type of mechanism disclosed in United States Letters Patent No. 2,680,164 issued on an application of T. C. Lennox and assigned to the present assignee, the rapid contact opening is provided by a spring driven mechanism. Basically, this mechanism is comprised of a spring having one end affixed to crank on a free running shaft and the other end pivoted to a fixed point. A motor drive is connected to a gear axial with the free running shaft, and a pin on the gear engages the crank on the shaft. Upon excitation of the motor drive, the pin on the gear engages the crank and thereby drives the free running shaft through an arc of about 180° until the spring has become extended and the crank has passed dead center. At this time the energy stored in the spring causes the free running shaft to rotate rapidly through the remaining 180° to return to its original position. During the rapid movement of the free running shaft, a Geneva gear driver pin on the free running shaft contacts a segment on a Geneva gear and drives the Geneva gear. The rotation of the Geneva gear causes a pair of switching contacts to rotate through a predetermined angle. This system has the advantage that high speed rotation of the switching contacts is accomplished without the necessity of costly starting, stopping, and positioning systems for a high speed direct motor drive.

As stated in the previously mentioned Lennox patent, however, conventional spring mechanisms for operating step type contacts result in contact speeds which are generally higher than the optimum speed from the standpoint of contact life.

In the device disclosed in the Lennox patent, a paddle wheel or impeller was connected to the tap changing mechanism to reduce the speed of the contacts. The paddle wheel was provided with flywheel characteristics to provide sufficient inertia to assure that the contacts closed without sticking. The spring for such a mechanism must be designed to provide additional energy for operation of the energy absorbing device in order that the speed of contact separation is sufficiently great and that the flywheel has sufficient energy to assure positive closure of the contacts.

It is therefore an object of this invention to provide an improved system for controlling the speed of the switching contacts of tap changing mechanisms.

Another object of this invention is to increase the contact life of tap changing mechanisms by providing means

for obtaining the optimum speeds of contact separation and contact making.

A further object of this invention is to provide an improved device for attaining the optimum contact speed of spring-driven tap changing mechanisms from the standpoint of contact life wherein the contacts are provided with a very high separation velocity and a retarded velocity at reengagement.

It has now been found that optimum life of the switching contacts is obtained by a high separation velocity of the contact arcing tips accompanied by a retarded contact velocity upon engagement of the switching contact with a tap or contact shelf. This retarded velocity avoids contact bounce and subsequent arcing. Briefly stated, in accordance with one embodiment of this invention, we provide a spring-driven tap changing mechanism of the type wherein the moving contacts or fingers are rotated by a Geneva gear and the Geneva gear driver is rotated through a predetermined arc at very high velocity due to the release of energy of a resilient member rapidly rotating the Geneva gear driver pin. The contacts are free to separate at a velocity determined by the energy of the resilient member, but the velocity of the moving contacts upon re-engagement with stationary contacts is greatly retarded by means of a dashpot arrangement.

By means of this arrangement, the spring for the drive mechanism does not have to provide additional energy to operate a paddle wheel or flywheel assembly, and therefor the size of the spring may be greatly reduced. This provides a more readily fabricated mechanism for use on large size tap changing transformers. This arrangement also provides a higher speed of contact separation, which has been found to be preferable in the operation of larger tap changing transformers, since it is not necessary to overcome the inertia of a flywheel to bring the contact assembly up to speed.

This invention will be better understood from the following description taken in connection with the accompanying drawings and its scope will be pointed out in the appended claims.

In the drawings:

Fig. 1 is an expanded perspective view of a spring driven tap changing mechanism incorporating one embodiment of the contact speed control arrangement of this invention and illustrating a typical circuit for the associated tap changing transformer, and

Fig. 2 is an enlarged partially cross-sectional view of a portion of the tap changing mechanism of Fig. 1 illustrating the position of the dashpots and a contact finger just prior to engagement between the contact finger and a contact shelf.

Referring now to the drawings, and more particularly to Fig. 1, therein is illustrated a tap changing speed control mechanism **10** in which a pinion gear **11** pinned to a shaft **12** drives a spur gear **13** having an off center pin **14** extending from one side thereof. The shaft **12** may be driven by any conventional reversible motor assembly and is not illustrated for purpose of clarity of the drawing. A free running shaft **15** extends concentrically through the spur gear **13** and a crank assembly **16** is pinned to one end of the free running shaft. A spiral spring **17** has one end pivoted to a fixed point (not shown), and the radially outward portion of the crank assembly **16** is pivotally attached to the other end of the spring **17**. The pin **14** on the gear **13** is positioned to engage the crank **16** upon rotation of the gear **13**.

A Geneva gear driver assembly **20** is rotatably mounted on the free running shaft **15**, and has a Geneva gear driver pin **21** extending parallel with the free running shaft **15** for engagement with a Geneva gear **22**. The Geneva gear is preferably of the tangential entry type for quieter operation. Extending from the Geneva gear

driver assembly 20 parallel to the free running shaft 15 and in the opposite direction as the Geneva gear driver pin 21 is a shaft 23 positioned for engagement with a transverse lug 24 on a collar 25 pinned to the free running shaft 15. The shaft 23 also extends through slotted holes 26 on the pistons 27 and 28 of a pair of oppositely disposed dash pot assemblies 29 and 30 respectively. The cylinder ends of the dash pots 29 and 30 are pivotally attached to fixed pins 31 and 32 respectively. As an alternative construction the pistons may engage a crank pinned to the free running shaft. The cylinders of the dashpots may have small holes 33 near their pivoted ends to control the retarding action of the dashpots.

The Geneva gear 22 is pinned to a shaft 35 extending parallel to the free running shaft 15, and by speed reduction gearing consisting of a pinion gear 36 and a spur gear 37 is connected to drive a shaft 38.

The shaft 38, which may be made of an insulating material, is rigidly connected to a rotatable switch arm 39 of tap switch 40. The switch arm is made of an insulating material, and has a pair of angularly separated radial contact fingers 41 and 42.

The tap switch has a plurality of spaced apart angularly disposed individual contact shelves 45 electrically insulated from one another which may be connected to taps on the series winding 46 of a regulating transformer 47. The contact fingers 41 and 42 are slidably connected to a pair of concentric conducting rings 48 and 49 respectively, and the conducting rings are connected to the ends of a center tapped reactor 50 according to the conventional practice.

A pair of power lines 51 and 52 are provided which may be connected to either the source or load side of an electrical system. Power line 51 is connected to the center tap of the reactor 50, and by way of the tap switch 40 and series winding 46 to a line 51'. The shunt winding 53 of the regulating transformer 47 is connected between the lines 51' and 52. A reversing switch 54 is connected to the line 51' so that the line 51' may be connected to either end of the series winding 46. This circuit is merely illustrative of one application of the tap changing mechanism of this invention, and it will be obvious to those skilled in the art that the tap changing system may be used in other types of electrical systems.

The tap switch 40 as illustrated has nine contact shelves 45, one of these contact shelves 90 being a neutral position. The tap switch 40 has 33 normal operating positions as follows: a neutral posiiton when both fingers are on contact shelf 90, sixteen positions as the contact fingers advance clockwise from the neutral position and sixteen positions as the contact fingers advance counterclockwise from the contact shelf 90. In the position shown in Fig. 1, the two contact fingers 41 and 42 are contacting adjacent contact shelves, while in the next adjacent tap switch positions the fingers 41 and 42 both contact the same contact shelf, according to the conventional practice. In the illustration of Fig. 1 the Geneva gear has six segments, and the ratio of teeth of pinion 36 to spur gear 37 is 3 : 1. Thus in moving from one contact position to the next adjacent position, the contact arm moves through an arc of about 20°, while the Geneva gear moves through an arc of about 60°.

The reversing switch 51 is mechanically driven by a Geneva segment 55 by way of a lever 56 pivoted on one end to the Geneva segment and on the other end to a one end of a pivoted arm 57, the other end of the arm 57 being pivoted to one end of another lever 58 which is also pivoted to the arm 59 of the reversing switch. The Geneva segment 55 is rotated by means of a Geneva segment driver assembly 60 having a driver pin 61 extending from one face of the spur gear 37. The reversing action occurs when the contact fingers are on neutral position contact shelf 90 (i. e. when no portion of the series winding 46 is in series with the line 51').

Referring now to Fig. 2 therein is illustrated the relative positions of a contact finger 41, the dash pot assemblies 29 and 30, the Geneva driver 21, and the Geneva gear 22 at the instant after the contact finger 41 has left one contact shelf 70 and before the contact finger 41 engages the adjacent contact shelf 71 during a switching operation. At this time the Geneva driver is rotating clockwise and forcing the piston of dash pot 30 into the cylinder of dash pot 30, and pulling the piston 27 of dash pot 29 outwardly from the cylinder of dash pot 29. The dash pot 30 is provided with an aperture 75 in its cylinder and an aperture 76 in its piston 28. Similarly the dash pot 29 is provided with an aperture 77 in its cylinder and an aperture 78 in its piston 27. Both of the pistons have open ends inside of their respective cylinders.

Just prior to the occurrence of the position of the dash pots 29 and 30 in Fig. 2, the dash pot 30 was not retarding the rotation of the Geneva driver since the end of the piston 28 was passing under the aperture 75 in the cylinder of dash pot 30, and the dash pot 29 was not retarding the rotation of the Geneva driver since the aperture 77 in the cylinder of the dash pot 29 was adjacent the aperture 78 in the piston 27. At the instant illustrated in Fig. 2, however, the apertures in the cylinders of both dash pots have been closed by movement of the respective pistons, and dash pot 30 retards the rotation of the Geneva driver by compression in the dash pot until the piston 29 of dash pot 30 has been forced a distance 80 when the aperture 76 in the piston 28 becomes adjacent to the aperture 75 in the cylinder of dash pot 30. Similarly, the dash pot 29 retards the rotation of the Geneva driver by expansion in the dash pot 29 until the piston 27 has been pulled out of its cylinder a distance 81 when the end of the piston 27 becomes adjacent to the aperture 77 in the cylinder of dash pot 29. The distance 81 is preferably the same as the distance 80, so that the retarding action of the two dash pots is simultaneous. As will be disclosed more fully in the following paragraphs, the dash pots do not affect the speed of rotation of the finger 41 as it leaves the contact shelf 70, but start exerting retarding forces on the speed of the finger 41 prior to the engaging of finger 41 with the shelf 71, and continue to exert such retarding forces until contact has been made between the finger 41 and the shelf 71.

Operation

In the operation of the tap changing mechanism of Figs. 1 and 2, the shaft 12 is driven by conventional means in response to detection of the necessity of making a tap change on the tap switch 40. Various means for detecting the necessity for such tap changes are well known and will not be discussed herein. Rotation of the shaft 12 may be in either direction depending upon the tap change required to be made. Assuming that the shaft 12 is driven in a counterclockwise direction, the pinion 11 drives the spur gear 13 in a clockwise direction, thereby carrying the pin 14 into contacting relationship with the crank 16. Upon further rotation of the spur gear 13, the pin 14 rotates the crank 16 and thus expands the spring 17. When the crank just passes top dead center position, the energy stored in the spring rapidly advances the crank to its initial position as shown in Fig. 1. Since the free running shaft 15 is pinned to the crank, the shaft is driven clockwise relatively slowly by the motor for about the first 180° of each rotation, and driven relatively rapidly for the remaining 180° of each rotation by the release of energy of the spring in advancing the crank to its initial position. During the last portion of the initial 180° of relatively slow rotation of the free running shaft 15, the lug 24 on collar 25 engages the shaft 23 on Geneva driver 20, and causes

the shaft 23 to revolve about the free running shaft 15, thereby rotating the Geneva driver clockwise. At the time the crank 16 reaches dead center position, rotation of the Geneva driver has positioned the Geneva driver pin 21 ready to enter a slot of the Geneva gear 22. After the crank passes dead center position and during the relatively rapid movement of the next 180° of rotation of the free running shaft 15, the Geneva driver pin 21 enters the slot in the Geneva gear, rotates the Geneva gear counterclockwise one segment, and leaves the Geneva gear slot. The counterclockwise rotation of the Geneva gear effects the clockwise rotation of the shaft 38 by means of gears 36 and 37, and the fingers 41 and 42 of tap switch 40 are thereby moved to an adjacent clockwise tap position. Since the rotation of the fingers 41 and 42 is accomplished during the relative rapid rotation of the Geneva gear 22, the movement of the fingers is also relatively rapid.

Referring to Fig. 2, the finger 41 is shown in a mid position during the switching operation, after moving about 10° from its initial position 85. At this position the trailing edge of the finger is about 3° from the shelf 70, and the leading edge must still travel about 3° before contacting the shelf 71. When the finger 41 is in the mid position, the shaft 23 has moved the dash pot pistons 29 and 30 into a position where the dash pot 30 just begins to retard the revolving of the shaft 23 by compression within the dash pot 29. This retarding of the speed of revolving of shaft 23 results in the retarding of the speed of motion of the finger 41 until just after the leading edge of the finger 41 has contacted the shelf 71, at which time the retarding action of the dash pot is released due to the apertures 75 and 76 in dash pot 30 becoming adjacent and the aperture 77 in dash pot 29 becoming adjacent the end of the piston 27 of dash pot 29. After the finger 41 contacts the shelf 71 and the retarding action of the dash pots is released, the finger is allowed to rapidly attain its final position 86 on shelf 71. This release of the retarding means allows the remaining energy in the spring to be expended in sliding the contacts into full engagement position.

Thus in order to obtain the desired retarding action of the contact fingers, the distance 80 between the tight end of the aperture 76 in piston 30 and the left end of the aperture 75 in the wall of the cylinder 30 must correspond to the distance of travel of the finger 41 from a position just prior to its contacting contact shelf 71 to its position just subsequent to the contacting of shelf 71, and the open end of the piston 28 must be positioned to prevent compressive action in the dash pot except during the retarding period. (Retarding action may occur during the winding period of the spring 17, but this is of minor nature because of the relative slow velocity.) Similarly the distance 81 between the left end of piston 27 and the left end of the aperture 77 in the cylinder wall of dash pot 29 must correspond to the same distance of travel of finger 41 as the distance 80.

The action of the switching mechanism in the opposite direction is similar to that above described, but in this case the dash pot 27 exerts a retarding force due to compression within its cylinder and dash pot 30 exerts a retarding force due to tensile forces within its cylinder. In other words, in the case of tap changes in the opposite direction, the relative positions of the two pistons in their respective dash pots are exactly reversed. The slots 26 are provided in the ends of the pistons in order that the pistons may be in the correct position for such opposite rotation. It can be readily seen that, in the embodiment of this invention illustrated in Fig. 2, the slack taken up by the slot must be approximately equal to the distance 80 on piston 30 or the distance 81 on piston 29.

Although it is preferred that a pair of dash pots be used for the retarding action, since compression in the dash pot gives a better retarding action than tension, a single dash pot may be used if desired.

It will be understood, of course, that, while the form of the invention herein shown and described constitutes a preferred embodiment of the invention, it is not intended herein to illustrate all of the possible equivalent forms or ramifications thereof. It will also be understood that the words used are words of description rather than of limitation. Thus the various specific angles mentioned in the previous disclosure are merely illustrative of a typical tap changing mechanism embodying this invention. Similarly, various changes, such as changes in shape, relative size, and arrangement of parts, may be made without departing from the spirit or scope of this invention, and it is aimed in the appended claims to cover all such changes as fall within the true spirit and scope of the invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. In an electrical tap changing under load mechanism of the type in which a movable electric contact is moved with a rapid motion out of engagement with a first fixed electrical contact and into engagement with a second fixed electrical contact, spring driven operating means for moving said movable electrical contact, and dash pot means operatively connected to said operating means to decrease the speed of said movable electric contact, said dashpot means having aperture means preventing retarding said speed prior to the time that said movable contact has separated from engagement with said first fixed contact, and subsequent the time that the speed of said movable contact has been decreased to engage said second fixed contact in order that said operating means may freely drive said moving contact in full engagement with said second electrical contact.

2. An electrical tap switching under load mechanism comprising a crank member rigidly mounted on a first shaft, a spring having one end fixed and the other end pivotally fastened to the radial extremity of said crank, reversible motor means releasably engaging said crank for driving said crank for substantially the first 180° each rotation of said first shaft to expand said spring and releasing said crank to be rapidly driven by energy stored in said spring for substantially the second 180° of each rotation of said first shaft, a second shaft, Geneva gear means connecting said second shaft in driving relation with said first shaft during said second 180° of each rotation of said first shaft, a rotatable electric contact on said second shaft, a fixed electrical contact engageable with said rotatable electric contact, and an energy absorbing device operatively connected to said mechanism to decrease the speed with which said rotatable contact moves into engagement with said fixed contact without decreasing the speed with which said rotatable contact moves out of engagement with said fixed contact.

3. An electrical tap switching mechanism under load of the step type comprising a crank member rigidly mounted on a first shaft, a spiral spring having one end fixed and the other end pivotally fastened to the radial extremity of said crank, reversible motor means releasably engaging said crank for driving said shaft for substantially the first 180° of each rotation of said first shaft to expand said spring and releasing said crank to be rapidly driven by energy stored in said spring for substantially the second 180° of each rotation of said first shaft, a second shaft, Geneva gear means connecting said second shaft in driving relation with said first shaft during said second 180° of each rotation of said first shaft, a rotatable electric contact on said second shaft, said rotatable contact being movable by said second shaft to separately engage each of a plurality of fixed spaced apart electrical contacts disposed on the circumference of a circle, and dash pot means operatively connected to said mechanism to decrease the speed with which said rotatable contact engages each said fixed

contacts without decreasing the speed with which said rotatable contact moves out of engagement with said fixed contacts.

4. An electrical tap switching under load mechanism of the step type comprising a crank member rigidly mounted on a first shaft, a spiral spring having one end fixed and the other end pivotally fastened to the radial extremity of said crank, reversible motor means releasably engaging said crank for driving said shaft for substantially the first 180° of each rotation of said first shaft to expand said spring and releasing said crank to be rapidly driven by energy stored in said spring for substantially the second 180° of each rotation of said first shaft, a second shaft, Geneva gear means connecting said second shaft in driving relation with said first shaft during said second 180° of each rotation of said first shaft, a rotatable electric contact on said second shaft, said rotatable contact being movable by said second shaft to separately engage each of a plurality of fixed spaced apart electrical contacts disposed on the circumference of a circle, and dash pot means having one end pivotally fixed and the other end driven in a circular path by off-center means on said first shaft to retard the speed of rotation of said first shaft during the interval between the time prior to engaging of said rotatable contact with each of said fixed contacts and the time just subsequent to the engaging of said rotatable contact with the respective fixed contact without decreasing the speed with which said rotatable contact moves out of engagement with any of said fixed contacts.

5. An electrical tap switch under load mechanism of the step type comprising a crank member rigidly mounted on a first shaft, a spiral spring having one end fixed and the other end pivotally fastened to the radial extremity of said crank, reversible motor means releasably engaging said crank for driving said shaft for substantially the first 180° of each rotation of said first shaft to expand said spring and releasing said crank to be rapidly driven by energy stored in said spring for substantially the second 180° of each rotation of said first shaft, a second shaft, Geneva gear means connecting said second shaft in driving relation with said first shaft during said second 180° of each rotation of said first shaft, a rotatable electric contact on said second shaft, said rotatable contact being movable by said second shaft to separately engage each of a plurality of fixed spaced apart electrical contacts disposed on the circumference of a circle, dash pot means having one end pivotally fixed and the other end connected to be driven in a circular path by off-center means on said first shaft to retard the speed of rotation of said first shaft during the time interval between the time just prior

to engaging of said rotatable contact with each of said fixed contacts and the time subsequent to the engaging of said rotatable contact with the respective fixed contact without decreasing the speed with which said rotatable contact moves out of engagement with any of said fixed contacts, and slot means in the driven end of said dash pot means in order to provide the same action by said dash pot means in retarding the speed of rotation of said first shaft prior to the engaging of said rotatable contact with a fixed contact regardless of the direction of rotation of said first shaft.

6. An electrical tap switching under load mechanism of the step type comprising a crank member rigidly mounted on a first shaft, a spiral spring having one end fixed and the other end pivotally fastened to the radial extremity of said crank, reversible motor means releasably engaging said crank for driving said shaft for substantially the first 180° of each rotation of said first shaft to expand said spring and releasing said crank to be rapidly driven by energy stored in said spring for substantially the second 180° of each rotation of said first shaft, a second shaft, Geneva gear means connecting said second shaft in driving relation with said first shaft during said second 180° of each rotation of said first shaft, a rotatable electric contact on said second shaft, said rotatable contact being movable by said second shaft to separately engage each of a plurality of fixed spaced apart electrical contacts disposed on the circumference of a circle, a pair of opposed dash pot means each having one end pivotally fixed and the other end connected to be driven in a circular path by off-center means on said first shaft to retard the speed of rotation of said first shaft during the time interval between the time prior to engaging of said rotatable contact with each of said fixed contacts and the time just subsequent to the engaging of said rotatable contact with the respective fixed contact without decreasing the speed with which said rotatable contact moves out of engagement with any of said fixed contacts, and slot means in the driven end of each of said dash pot means to provide simultaneous retarding action by each of said dash pot means regardless of the direction of rotation of said first shaft.

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