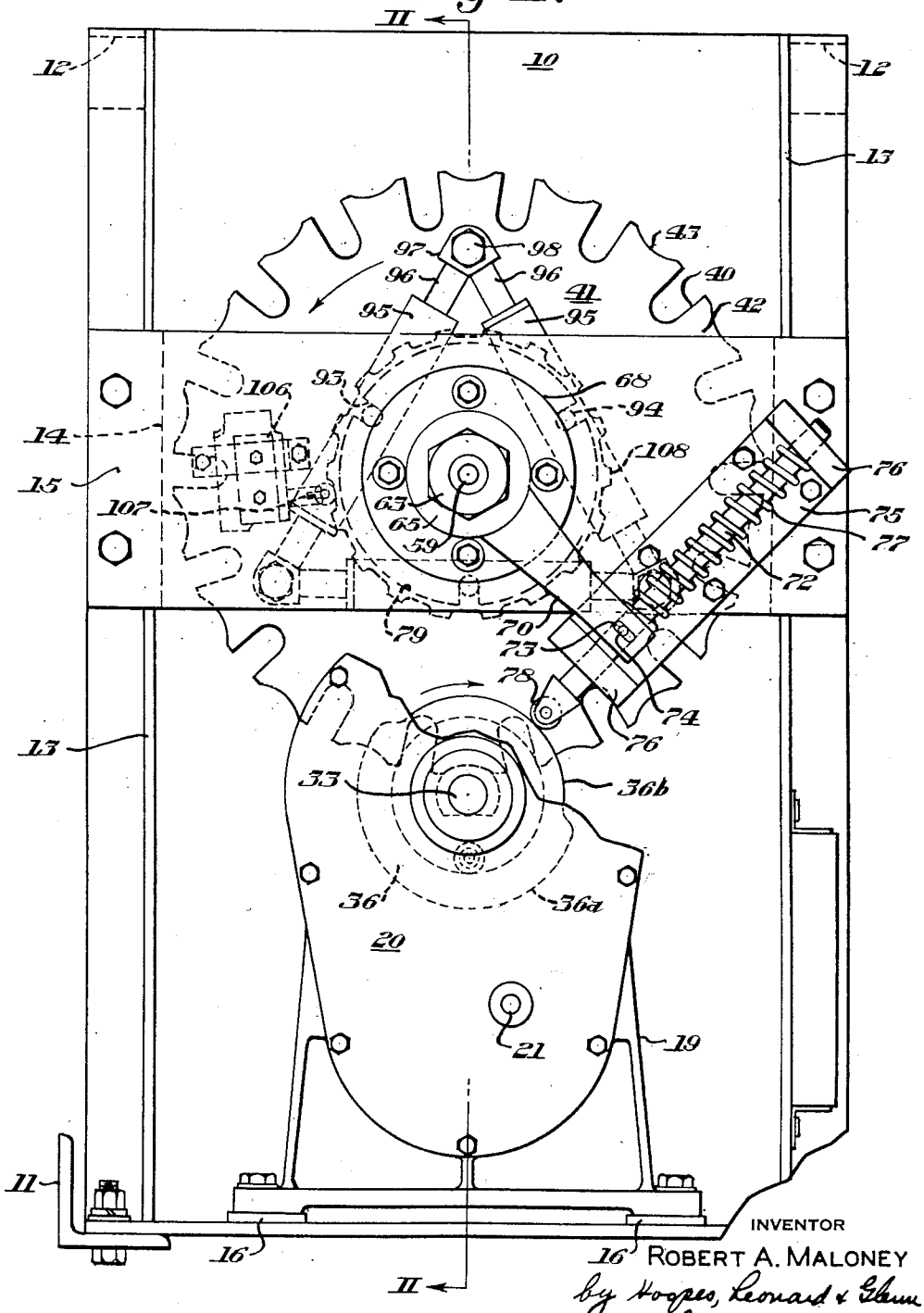
May 7, 1957 R. A. MALONEY 2,791,648

DRIVE MECHANISM

Filed Aug. 9, 1951 4 Sheets-Sheet 1

Fig. 1.



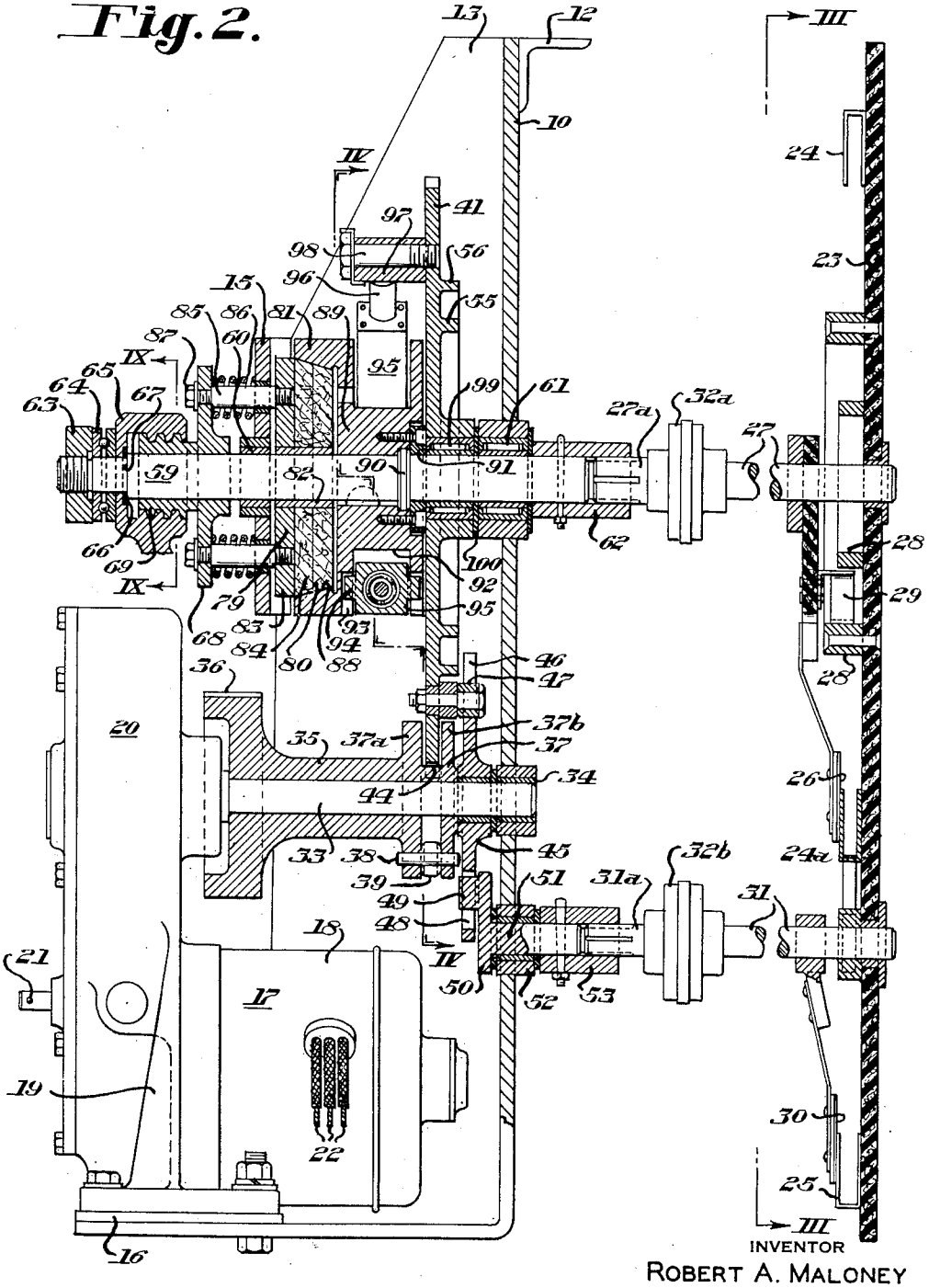
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DRIVE MECHANISM

Filed Aug. 9, 1951 4 Sheets-Sheet 2

Fig. 2.



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May 7, 1957 R. A. MALONEY 2,791,648

DRIVE MECHANISM

Filed Aug. 9, 1951. 4 Sheets-Sheet 3

Fig. 8.

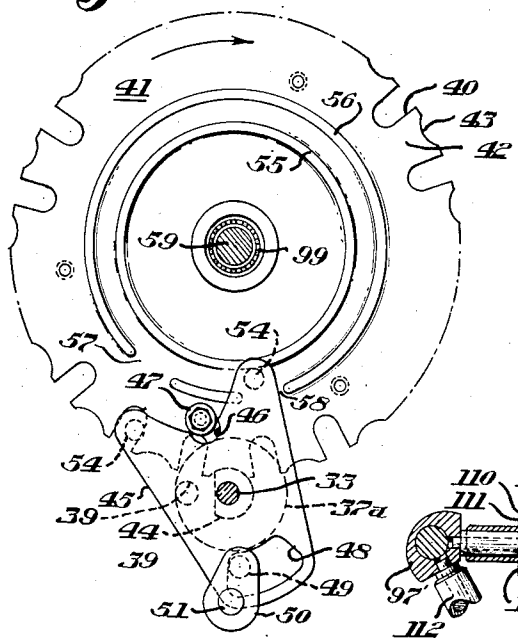


Fig. 9.

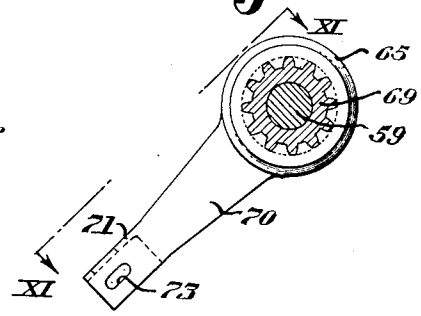


Fig. 11.

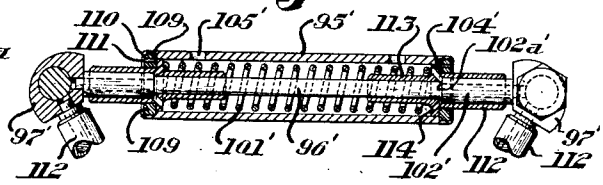


Fig. 3.

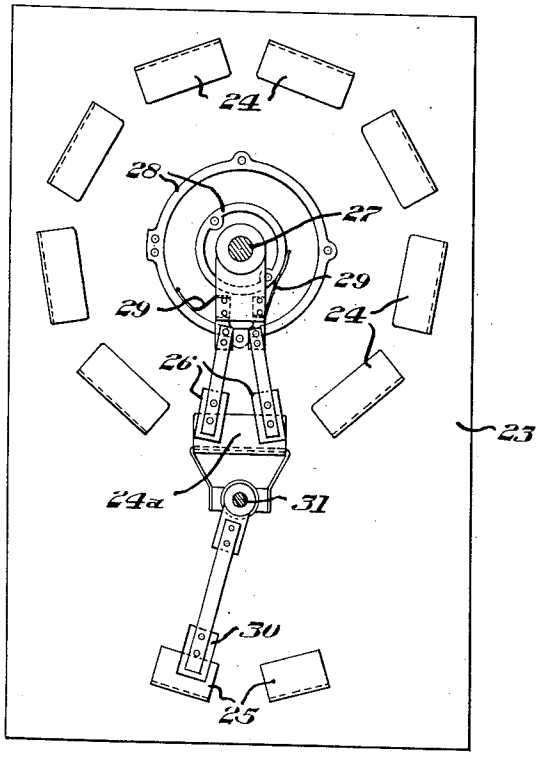
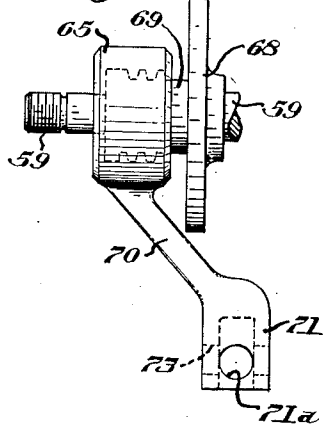


Fig. 10.



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May 7, 1957 R. A. MALONEY 2,791,648

DRIVE MECHANISM

Filed Aug. 9, 1951 4 Sheets-Sheet 4

Fig. 4.

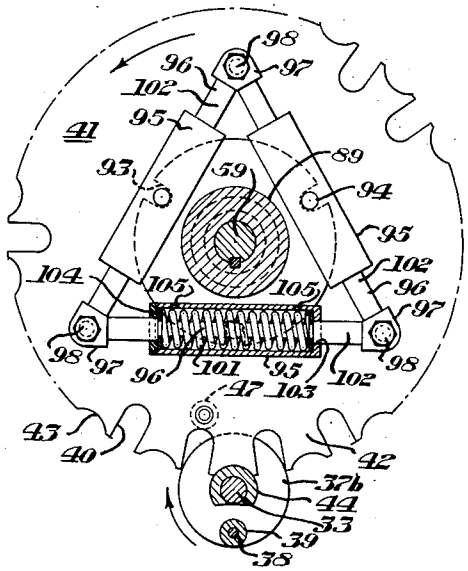


Fig. 7.

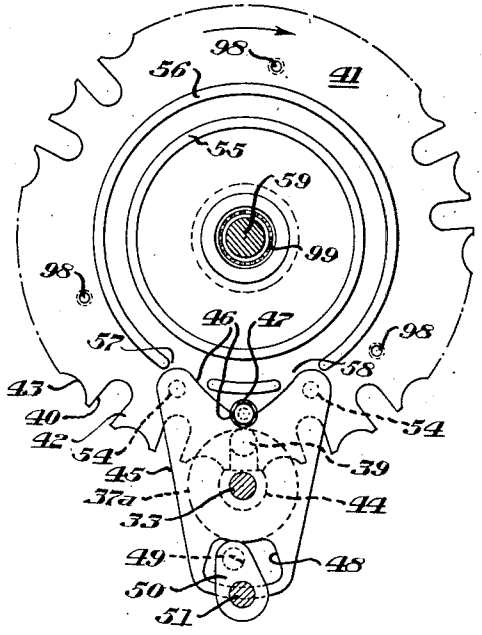


Fig. 5.

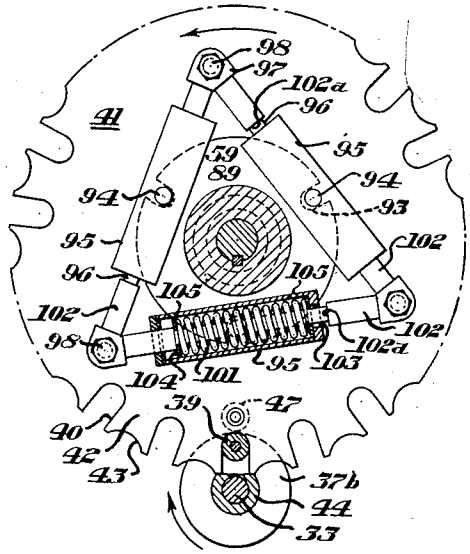
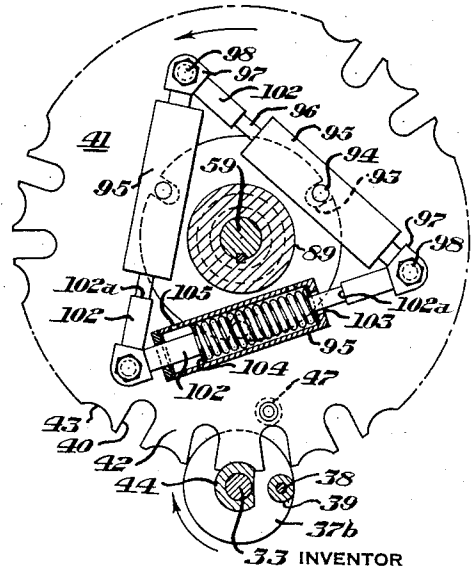


Fig. 6.



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2,791,648

DRIVE MECHANISM

Robert A. Maloney, Canonsburg, Pa., assignor, by mesne assignments, to McGraw-Edison Company, a corporation of Delaware

Application August 9, 1951, Serial No. 241,145

26 Claims. (Cl. 200—18)

This invention relates to a new kind of drive mechanism which is relatively silent and cushioned in operation and in which fewer principal or massive parts are accelerated or moved at a higher speed. In particular, this invention pertains to a novel drive mechanism suitable for switch gear such as those used in load ratio control or step voltage regulator equipment.

A variety of electrical equipment is used to maintain voltage of the load in electrical systems. A number of these devices include tap changing under load and many, particularly those having lower rating, are frequently fully automatic and employ high-speed switching between the respective contacts or transformer taps in the circuit. Further, in the lower ratings, the switching equipment may also perform the current interrupting service. In order to obtain relatively high-speed tap changing in such circuits, many prior drive mechanisms heretofore used employed springs for snap action and in this employment many of the principal or massive parts of the drive had to move at high speed in the course of the snap action portion of the cycle with attendant noise and shock. The difficulty was increased when the device was substantially moving at its greatest speed near the end of its travel. Such drives therefore frequently required relatively expensive alloys for construction and greater power for equivalent average speed of operation. Such tap changer drives were also used with equipment having higher kv.-a. and current ratings although at such higher ratings the use of separate circuit breakers for current interruption in the circuit is more common. Many of these devices have reversing gear by means of which the same winding can be employed both in opposing and in augmenting the line voltage under control, whether single phase or polyphase voltage control.

In this invention, a new kind of drive mechanism for voltage control switch gear is provided which overcomes the foregoing difficulties of prior devices. In the new construction of this invention, a snap action is obtained with relatively low speed operation of many principal or massive parts. The result is far quieter operation, less strain on the equipment, longer life and improved performance. Control of the speed-time action is obtainable with a device made under this invention with relatively more rapid breaking of the arc and less rapid speed near the end of the travel of the device. Further, in this new construction cushioning means are provided as well as a symmetry of structure which markedly minimizes any tendency to dynamic imbalance. A reversing arrangement may be included which is positive in operation and provides for opposition or augmentation of the supply voltage.

Other objects and advantages of this invention will be apparent from the following description and from the drawings, which are illustrative only, in which:

Figure 1 is an end view of one embodiment of the new drive mechanism of this invention with a portion thereof broken away;

Figure 2 is a view taken generally along line II—II of

Figure 1 with, in addition, a schematic showing in section of a tap changing and reversing switch gear arrangement;

Figure 3 is a view on a somewhat reduced scale of the last-mentioned addition only taken along line III—III of Figure 2;

Figure 4 is a view on a somewhat reduced scale taken along line IV—IV of Figure 2 with the intermittent-motion gear at rest;

Figure 5 is a view similar to Figure 4 as the intermittent-motion gear is being moved and is passing through its reference position from the position shown in Figure 4;

Figure 6 is a view similar to Figure 4 after the intermittent-motion gear has been still further moved from the position shown in Figures 4 and 5 and has come again to rest;

Figure 7 is a view in elevation of the other side of the intermittent-motion gear in the reference position shown in Figure 5 showing a reversing arrangement;

Figure 8 is a view similar to that shown in Figure 7 with the intermittent-motion gear in the position shown in Figure 6;

Figure 9 is an end view of the threaded coupling shown in Figure 2 and its arm taken along line IX—IX of Figure 2;

Figure 10 is a side view of the threaded coupling and arm shown in Figure 9; and

Figure 11 is a view partly in section of a modified spring retainer mechanism.

Referring to the drawings, a plate **10** of metal may be bent into the form of an angle to serve as a supporting shelf for the new drive mechanism of this invention. If, for example, the new drive mechanism is to be used inside the tank of a power transformer, plate **10** may be supported on and bolted to angles **11** forming a structural portion of the interior of the transformer tank. Angle pieces **12** may also be provided at the upper edge of plate **10** to complete the supporting attachment of the new mechanism to the structure with which it is to be used. Side plates **13** are welded to plate **10** and brackets **14** in turn are welded to plates **13**. A rigid bar **15** extends between the brackets **14** and is bolted thereto. Pads **16** are welded to the bottom of plate **10** on the inside of the angle.

A conventional prime mover **17** may be bolted to the pads **16** and thus affixed to plate **10**. Prime mover **17** may comprise a reversible electric motor **18** firmly mounted on and fastened to a casting **19** within which there is provided a conventional gear reducing mechanism **20**. The prime mover **17** is enclosed in such a manner that it may be submerged in the dielectric liquid, such as transformer oil, if the new mechanism of this invention is used in a liquid-type transformer. A short shaft **21** extends from the casing of gear reducer **20**. A hand crank may be used to turn shaft **21** and thereby operate as a prime mover to cause the new drive mechanism of this invention to function. Ordinarily, the new mechanism will be operated electrically by means of any of the many circuits available for tap changers in the load ratio control field. Such circuits, which need not be illustrated here, may be so arranged as to be fully automatic or manual in the sense that push buttons are used, for example, to control the electrical circuit to which the new drive mechanism is connected through leads **22** of motor **18**. In addition, such an electrical control circuit whether automatic, semi-automatic or manual or a combination of these may include limit switches or mechanical stops or both to limit the angular rotation in either direction of the mechanism with which the new drive of this invention is used.

A conventional tap changer for step voltage regulation,

for example, with which the new drive mechanism of this invention may be used, may comprise a panel 23 of an electrical insulating material of suitable nature. On that panel there may be mounted in circular fashion a plurality of fixed contacts 24. In addition, there may be provided a pair of fixed contacts 25 arranged in arcuate fashion. Suitable terminals to the respective fixed contacts extend, for example, through panel 23 and have leads connected thereto on the other side thereof. An annularly spaced pair of movable contacts 26 may coact with the fixed contacts 24 in both symmetrical and bridging positions to effect step voltage regulation as the movable contacts 26 are moved by a contact shaft 27 on which they are mounted. Each slip ring 28 and its brush 29 make an independent electrical connection with its respective movable contact 26.

In one form of tap changing apparatus when both movable contacts 26 are in contact with fixed contact 24*a*, a so-called symmetrical position, the apparatus is regarded as being in its single electrical neutral position. It is at that time that movable contact 30 is rotated into contact with the other of the fixed contacts 25 so that no current is interrupted and at the same time the regulation transformer windings are reversed in the circuit so as to prepare it for a contrary regulation action. That is, if the tap changer had been moving to boost line voltage, the action resulting from throwing movable contact 30 to the other fixed contact 25 would, for the same direction of movement of the equipment, buck the line voltage thereafter, and vice versa. Movable switch contact 30 is carried on an auxiliary contact shaft 31. Both shafts 27 and 31 may be connected by flexible couplings 32*a* and 32*b* respectively to coupling shafts 27*a* and 31*a* respectively.

To return to the new drive mechanism, an output shaft 33 from gear reducer 20 extends toward plate 10. A bearing 34, properly bushed, supports the other end of shaft 33 as it is turned in either direction under the influence of motor 18 or under the influence of a hand crank turning shaft 21. A sleeve 35 which may be a casting or forged metal shape fits over shaft 33 and is keyed thereto. The sleeve 35 comprises a cam 36 at the end and a pinion 37 at the other. Although as shown these parts are integral, they may be separately made and keyed to the shaft 33. Cam 36 is of a drum type and is provided with a rise portion 36*a* and a fall portion 36*b*, by means of the extent of the respective peripheral portions of which a suitable timing sequence of the new drive mechanism is obtained. The angular position of cam 36 on shaft 33 is symmetrical relative to the angular position of a pin 38 when the action of the new mechanism is reversible, as may normally be the case.

Pinion 37 comprises two spaced integral annular flanges 37*a* and 37*b*. The pin 38 connects the two flanges at the appropriate angular position corresponding to the angular setting on shaft 33 of cam 36 and of the respective positions of the electrical contacts in the tap changer previously described. A roller 39 is rotatably mounted on pin 38 for engagement with the sides of recesses 40 extending radially and in spaced relation around the periphery of an intermittent-motion rotary plate or gear 41 which may be of the Geneva type. Teeth 42 of gear 41 between the recesses 40 are provided at their crests with depressed portions 43 of concave arcuate nature which may be termed saddles. A hub 44 of pinion 37 which is integral therewith is shown in cross section in Figures 4 to 6 and provides means for locking gear 41 in rest position between operative engagements of roller 39 and the side of any tooth 42 of gear 41, as illustrated in Figures 4 and 6.

A rocking sector arm 45 is journalled on shaft 33 between sleeve 35 and bearing 34. Suitable washers may be interposed as required or desirable. The hub of rocking sector 45 is suitably bushed as shown in Figure 2. The upper side of arm 45 is slotted at 46 for engagement

by a roller 47. Roller 47 in turn is rotatably mounted on the rear side of gear 41. The lower side of arm 45 is provided with an arcuate slot 48 to provide a lost motion action between arm 45 and a pin 49 on a throw lever 50. When assembled, pin 49 extends into opening 48 at all times. An integral journal 51 is provided on lever 50 and is rotatably supported in a bearing 52 in plate 10, the said bearing being suitably bushed.

A sleeve 53 is keyed to the rear end of journal 51. In turn, the forward end of coupling shaft 31*a* is connected to sleeve 53 for rotation. Thereby, movement of throw lever 50 to one side or the other will move movable contact 30 of the reversing switch arrangement from one fixed contact 25 to the other but movable contact 30 will not stop between the contacts 25 because of the lost motion characteristic of the arcuate slot 48 even though gear 41 is in its reference position as shown in Figure 5. In that reference position, roller 47 has entered slot 46 bringing locking pins 54 into horizontal alignment and continuation of the movement of gear 41 in the same direction will rock arm 45 into the position shown in Figure 8 to effect, through pin 49, a throw over of movable contact 30 to the other fixed contact 25. The reference position shown in Figures 5 and 7 is located about midway of the reference position movement sector defined by the radii bisecting the saddles 43 immediately on each side of the roller 47. In the illustrated embodiment, gear 41 is provided with eighteen teeth 42 and is intended to be capable of substantially two full revolutions in either direction between its limits of rotational movement. In addition, there are 9 fixed contacts 24 for about sixteen steps in either direction since the contacts 26 are operative both in symmetrical position on a single contact 24 other than contact 24*a* and in a bridging position bridging two contacts 24. The direction of movement of contacts 26 will correspond to the direction of movement of the gear 41. The reference position movement sector in turn occurs about halfway through the substantially two full revolutions of gear 41 which may be provided in either one direction between its usual limits of movement for the illustrated embodiment. In general, the new mechanism will be so assembled that the switching of movable contact 30 from the fixed contact 25 on which it is resting to the other fixed contact 25 will take place during movement of the gear 41 through the reference position movement sector and will substantially be completed before either movable contact 26, as the case may be, leaves fixed contact 24*a*.

As shown in Figures 7 and 8, an inner annular locking flange 55 and an outer locking flange 56 are provided on the rear side of 41. Flange 56 is provided with the respective openings 57 and 58 to permit alternate entry and exit movement, as the case may be, between the two flanges for the right-hand and left-hand locking pins 54 as gear 41 swings through its reference position in one direction or the other. The positioning of the locking pins may be made such that no inner flange 55 is required. The track made by the locking flanges insures that no rotation of arm 45 on shaft 33 may take place except as gear 41 rotates substantially entirely through its reference position in one direction or the other, that is, substantially from its at rest position on one side of the reference position to its at rest position on the other side of the reference position. Reversal of movement of gear 41 when not in its reference position movement sector does not change the angular position of arm 45 relative to the axis of shaft 33 of the locking pins 54 one of which is inside flange 56.

A switch shaft 59 is rotatably supported in a bearing 60 in bar 15 and in a bearing 61 in plate 10, which bearings are respectively suitably bushed and provided with a needle bearing. A sleeve 62 is keyed to the rear end of switch shaft 59 preventing any forward axial movement of the shaft 59. In addition, coupling shaft 27*a* is also suitably connected for rotation to sleeve 62. The for-

ward end of switch shaft 59 is threaded for engagement by a nut 63 which backs up a thrust bearing 64. Thrust bearing 64 in turn bears against the closed end of the female portion 65 of a threaded coupling. As shown in Figure 2 the closed end of coupling 65 bears against a washer 66 which in turn is positioned by a shoulder 67 on shaft 59. Hence, the female portion 65 of the threaded coupling is axially immovable relative to shaft 59 but may be rotated relative thereto. A disc member 68 is journaled on shaft 59 and has an integral forwardly extending hub 69 the exterior of which is helically threaded in pitch and dimension corresponding to the threading of the female portion 65. Disc member 68 may be moved axially over shaft 59 but cannot be rotated relative to the axis of shaft 59 although shaft 59 can rotate relative to member 68. Thus portions 65 and 69 make an entire threaded coupling.

A downwardly and rearwardly extending lever arm 70 is integral with coupling portion 65. A modified clevis 71 at the lower end of arm 70 has an opening 71*a* therein which surrounds rod 72. The diameter of opening 71*a* is sufficient to permit arcuate movement of arm 70 relative to rod 72. Registering slots 73 in the sides of the clevis, which are of sufficient length to permit the arcuate movement of arm 70, engage the ends of a pin 74 which extend thereinto. Pin 74 passes through and is affixed to follower rod 72 at that position along the length of rod 72 at which a proper location of the axial movement of hub 69 along shaft 59 is obtained. Follower rod 72 is axially movable in a bracket 75 which is bolted to bar 15. Properly bushed registering openings in the sides 76 of bracket 75 enable movement of follower rod 72 to take place along its own axis and generally radially relative to cam 36. A spring 77 presses arm 70 downwardly, that is in a clockwise direction as viewed in Figure 1, until and unless arm 70 is moved in a counterclockwise direction by engagement of cam rise 36*a* and a roller 78 fastened to the lower end of rod 72.

In the embodiment shown in the drawings, the hub 69 is provided with a left-hand thread. Therefore, counterclockwise movement of arm 70 as viewed in Figure 1 will shift disc 68 axially along switch shaft 59 toward the front, that is, toward nut 63. On the other hand, movement of arm 70 in a clockwise direction tends to separate the parts 65—69 of the threaded coupling and move disc 68 toward bar 15 for a purpose which will be described. Such movement in a counterclockwise direction of arm 70 as viewed in Figure 1 will take place when the roller 78 is engaged by cam rise 36*a*. When the roller 78 leaves cam rise 36*a*, spring 77 will return arm 70 to its original position as shown in Figure 1. Thus, the axial movement of disc 68 in either direction along shaft 59 will be positive and will minimize any tendency of the parts of a clutch 79 to stick.

Clutch 79 comprises a frusto-conical male portion 80 which may be designated the driven or holding part and a female portion 81 which may be designated the driving part. Clutch portion 80 is in the general form of an annulus which is provided with a bushing 82 which is freely slidable and rotatable on switch shaft 59. A clutch plate 83 has affixed to it a pair of discs 84 of frictional material the conical peripheries of which form the engaging surface thereof. Sleeve bolts 85 slidably extend through bar 15, proper bushings again being provided, and are screwed into plate 83. Sleeve bolts 85 also serve as guides for springs 86 extending between the front of bar 15 and the rear of disc 68. Bolts 87 hold the forward end of the sleeve bolts 85 tightly against disc 68 around the axis thereof. Thus, springs 86 normally urge hold portion 80 away from engagement with clutch part 81 to disconnect the two parts. In some embodiments the springs 86 will not be necessary and reliance for disconnection may be placed entirely on the action of coupling 65—69. The influence of spring 77, which is more powerful than the total force of springs

86, acts to connect the two parts 80—81 and thereby holds part 81 and shaft 59 immovable in the manner of a brake whenever rod 72 is not in engagement with cam rise 36*a*. However, when arm 70 is lifted by cam rise 36*a* then coupling 65—69 tends to foreshorten and since portion 65 cannot move axially along shaft 59, disc 68 moves forwardly forcing clutch portion 80 out of connective engagement with clutch portion 81 freeing the latter for a snap action driving movement of shaft 59.

Driving portion 81 is the female part of the clutch 79 and has an interior frusto-conical surface 88 adapted to engage the discs 84 when plate 83 is moved rearwardly along switch shaft 59. Member 81 is part of a casting or forged metal shape 89 which is immovably keyed to switch shaft 59. In addition, an integral circumferential flange 90 on switch shaft 59 fits into a corresponding recess in sleeve 89 and is there held by thrust cap 91. The rear portion of sleeve 89 is provided with a circumferential groove 92. Symmetrically arranged around the axis of switch shaft 59, the sides of the groove 92 normal to the said axis are provided with opposed registering pairs of generally radial slots 93 extending to the outer edges of the groove 92. Each pair of slots 93 engages the trunnions 94 of a spring retainer 95 respectively. In elevation these spring holders 95, as shown in Figures 4 to 6, for example, generally form a polygonal figure. Extending through each retainer 95 from end to end thereof there is a rod 96 positioned somewhat in the manner of a chord relative to gear 41. The ends of each rod 96 fit into corresponding recesses in corner posts 97. Corner posts 97 in turn are fastened by bolts 98 to the front side of the gear 41. The gear 41 is rotatably supported on switch shaft 59, a needle bearing 99, for example, being interposed therebetween. A washer 100 may be positioned between the hub of gear 41 and the front end of bearing 61.

When the new mechanism of this invention is at rest or gear 41 is momentarily in its dwell period it may be in a position such as that generally shown in Figure 1. In that position hub 44 is in locking engagement with a saddle 43 of a tooth 42 and the roller 78 extends toward cam portion 36*b* under the influence of spring 77. Arm 70 therefore is in its lowermost position and clutch parts 80—81 are connected holding switch shaft 59 against turning.

If an impulse from the voltage regulating control circuit is received causing motor 18, for example, to turn in one direction or the other, or if such impulse is continuing, the shaft 33 will rotate and if continued for a sufficient length of time, the roller 39 will engage that recess 40 toward which it is approaching. Continued movement in the same direction of shaft 33 will turn gear 41 in the opposite direction to the direction of movement of shaft 33 through one succeeding movement sector after the other until shaft 33 stops turning or is reversed in movement causing a reversal of movement of the gear 41. For each full revolution of shaft 33 the tooth 42 immediately above the shaft will be moved through a movement sector angle defined by the radii bisecting the saddle 43 of the tooth 42 immediately above shaft 33 and the saddle 43 of the adjoining tooth 42 moving toward shaft 33. Preferably adjacent the end of that movement sector, roller 78 will be engaged by cam rise 36*a* raising arm 70 and disconnecting parts 80 and 81 of clutch 79 to permit sleeve 89 to snap the movable contacts 26 to the next contact position. Meanwhile hub 44 will become engaged in locking relation with saddle 43 of the said adjoining tooth 42 which is now over shaft 33. Clutch 79 will remain disconnected until roller 78 again comes opposite the cam fall portion 36*b*. In ordinary operation, voltage regulation will involve one or more steps in one direction interspersed with one or more steps in the opposite direction depending upon the conditions in the circuit being controlled.

As gear 41 is moved, for example, from the position

shown in Figure 4 to the position shown in Figure 6, that is, through a sector of movement, thereby loading the spring retainers 95 to complete by snap action a single step in the movement of contacts 26 relative to contacts 24, the rods 96 compress the springs 101. The rods 96 are provided with shouldered portions 102 adjacent the extremities of each thereof. Hence, as the rods move under the influence of the movement of gear 41, that shoulder 102*a* facing in the direction of such movement as illustrated in Figures 5 and 6 passes through an opening 103 in the adjacent end of the spring holder or box 95. As a shoulder portion 102 enters retainer 95 the shoulder 102*a* will abut a piston 104 interposed between that shoulder and spring 101, thereby compressing spring 101. A similar piston 104 slidable in box 95 is interposed between the other end of spring 101 and the other end of the box 95 for corresponding action in the other direction when gear 41 is turned in the other direction. During the turning of gear 41 or at least during the initial stages of that turning, the clutch 80—81 prevents any rotation of hub 89 and the trunnions 94 are held immovable except for such pivoting and sliding of them as takes place in slots 93 during the movement of the respective rods 96 through boxes 95. When follower rod 72 moves away from the axis of shaft 33 upon reaching cam rise 36*a*, the threaded coupling 65—69 will disconnect portions 80 and 81 of the clutch 79. The springs 86 also act to disconnect clutch 79. Immediately, the springs 101, compressed as shown in Figure 6, will release their energy and through trunnions 94 of spring holders 95 will snap hub 89 and thereby rotate switch shaft 59 through the same movement sector angle with a corresponding snap, without any of the parts associated with shaft 33 or gear 41 being correspondingly moved in any such snap action. The snap action rotation of switch shaft 59 in turn, as aforesaid, will through shafts 27 and 27*a* and their respective insulating coupling 32*a* move the movable contacts 26 to the next contact position at high speed thereby minimizing arcing and interruption of current. In the event that the prime mover 18 should stop in the course of a movement sector before clutch 79 is disconnected, the springs 101 will return gear 41 to its original position before the step began to await a further actuation in one direction of the other. Seal-in switches may be used in the electrical circuit of the new drive mechanism to insure against any suspension of a voltage regulation step after it has once begun and proceeded through some predetermined portion of the movement sector angle corresponding to such a step.

The symmetrical arrangement of the rods 96 and the spring retainers 95 about the axis of switch shaft 59, gear 41 and hub 89 insures against troublesome stresses or dynamic imbalance in the operation of the new device. In addition, adjacent each end of each spring box 95 and spaced therefrom there are provided openings 105. These openings in connection with whichever piston 104 in each retainer 95 is being moved, at the time being, regulate the time-travel characteristic of the operation.

In the new drive mechanism each spring 101 preferably will be precompressed or preloaded and will fill its entire box 95 when in an at rest or dwell position as shown in Figure 4. After the springs are compressed as illustrated in Figure 6, the disconnection of parts 80 and 81 of clutch 79 to permit the snap action will cause the depressed piston 104 in each retainer 95 to snap back, relatively speaking, toward the adjacent end of the retainer 95. Once the respective piston 104 in so returning passes the openings 105 there will be a deceleration during the remainder of the travel of the respective spring boxes 95 thereby cushioning the snap action and preventing shock to the parts so snapped. In such snapping, the hub 89 and hence the switch shaft 59 catch up with the gear 41. If there is any tendency of the spring boxes 95 to overrun, that tendency will be substantially completely prevented by the preloaded springs 101. In other words, when the springs 101 regain their original length as shown in Figure 4, renewed or continued movement of a prime mover is required to begin a new compression of the springs 101.

A conventional operation counter switch 106 having a contact arm 107 may be mounted on bar 15 so that arm 107 engages the exterior periphery of clutch part 81. That exterior periphery may be provided with a number of lands 108 equal in number to the number of teeth 42 on gear 41. Hence, each time oblique-surfaced coupling 65—69 passes through a holding and release cycle relative to the two parts of clutch 79 for each step or movement sector, Geneva gear 41 will have moved an angular distance of one tooth 42, and hub 89 and therefore lands 108 will have been snapped a distance of one land, thereby operating switch 106 once to enable it to cumulate the number of tap changes made.

A spring and spring retainer subassembly is illustrated in Figure 11. In this subassembly a spring rod 96′ is immovably mounted by its ends in corner posts 97′ fastened to an intermittent-motion gear like gear 41. A spring 101′, preferably precompressed or preloaded, surrounds rod 96′ between the enlarged end shoulder portions 102′ of rod 96′. Spring retainer box 95′ surrounds the spring 101′ and annular end wall members 109 fit into corresponding recesses in each end of each spring box 95′. Annular upstanding edges 110 of spring boxes 95′ are crimped inwardly over the end wall members 109 to hold them firmly in place. One or more openings 105′ extend through spring boxes 95′ a predetermined distance inwardly from each end. The size and number of these openings 105′, like the openings 105, will determine in part the speed-time snap action characteristics of the new mechanism. An opening 111 extends axially through each member 109 between the outer side of the ends of spring box 95′ and the outer face of respective pistons 104′ adjacent thereto. Each piston 104′ is provided with a hollow differential hub the outer portion 112 of which closely surrounds shoulder 102′ and the inner portion 113 of which closely surrounds the narrower diameter of rod 96′ on the other side of the body of piston 104′. One or more openings 114 extend through the body of piston 104′ from the inner face thereof to the interior of the aforesaid hollow hub. Shoulder 102*a*′ abuts a corresponding opposed shoulder on the inside of the hollow hub of piston 104′ at the plane separating the two portions 112 and 113.

The operation of the subassembly is similar to the operation as illustrated in Figures 4 to 6. Thus, if we assume that the left-hand corner post 97′ under an actuating impulse is rotated to the right, spring retainer 95′ in that portion of the step being held against rotation, the left-hand shoulder 102*a*′ as viewed in Figure 11 will move the left-hand piston 104′ to the right shortening spring 101′. If the subassembly is immersed in transformer oil, for example, such oil will move inside the spring retainer 95′ between the inside of left-hand member 109 and the outer face of left-hand piston 104′ through opening 111. The movement of piston 104′ will continue until the body thereof moves inwardly past the opening or openings 105′ at the left-hand end of spring retainer 105′, and right-hand piston 104′ will slide inwardly relative to rod 96′.

When the clutch corresponding to clutch 79 is disconnected, the spring 101′ will snap the right-hand piston 104′ and thereby spring retainer 95′ to the right as viewed in Figure 11 since right-hand piston 104′ abuts against right-hand member 109. The interior shoulder of right-hand piston 104′ will snap toward the right-hand shoulder 102*a*′ and any oil that may have accumulated between rod 96′ and right-hand piston 104′ will be vented through the openings 114 therein.

As spring box 95′ snaps to the right, the left-hand piston 104′ will move to the left in a relative sense and the accelerating force will pass its maximum as when the left-hand piston 104′ goes past the left-hand opening or openings 105′. Thereafter the relative approach between left-

hand piston 104' and left-hand member 109 will be principally governed by the diameter and length of the opening 111 until the parts are again in equilibrium at the end of the snap action. Movement of the parts in the other direction will operate in the same manner but in reverse.

Hence, in the snap action of the new drive mechanism of this invention, the parts thereof that are moved in the course of the snap action received their maximum acceleration in the forepart or in an intermediate part of their travel and at the end of their travel they are moving relatively more slowly. Thereby, a cushioning effect is achieved and substantially less shock results to the parts undergoing the snap action. At the same time, the greater speed in the earlier portion of the snap action results in breaking of the arc as the contacts separate with lessened opportunity for pitting caused by the arc.

Various modifications may be made in the number, shape and size of the parts and in other details of the new drive mechanism of this invention without departing from the spirit thereof or the scope of the appended claims.

I claim:

1. In a drive mechanism, in combination, a prime mover, an intermittent-motion gear driven by said prime mover, a switch shaft continually connected operatively to a movable contact member, means providing a constant resilient connection between said gear and said shaft, movable means for holding said shaft substantially immovable during at least a portion of the movement of said gear by said prime mover, and means controlled by said prime mover for releasing said shaft to permit it to catch up with said gear under the force of said first-mentioned means.

2. In a drive mechanism, in combination, a reversible prime mover responsive to a change in electrical conditions or the like, an intermittent-motion gear operatively connected to said prime mover, a holding device having a driving member and a holding member movable relative to said driving member to permit engagement and disengagement thereof, a switch shaft continually connected operatively to a contact shaft, said switch shaft further being connected to said driving member for rotation therewith, means providing a continuous resilient connection between said gear and said driving member, means for connecting said holding member to said driving member during at least a portion of the movement of said gear, and means for moving said holding member to disconnect it from said driving member.

3. In a drive mechanism, in combination, an electric motor responsive to a change in voltage or the like, an intermittent-motion gear operatively connected to said motor, a holding device having a driving member and a holding member movable axially relative to each other to permit engagement and disengagement thereof, said holding member holding said driving member immovable when in engagement therewith, a switch shaft continually connected operatively to a contact shaft, said switch shaft further being rigidly connected to said driving member, resilient means connecting said gear and said driving member, means urging said members into engagement to hold said driving member immovable during at least a portion of the movement of said gear, and means for moving said members axially away from each other.

4. In a drive mechanism, in combination, a prime mover responsive to a change in electrical conditions or the like, a rotatable intermittent-motion member operatively connected to said prime mover, a switch shaft coaxial with said member and continually connected operatively to a movable contact member, a rod connected to said member and disposed away from the axis thereof, a spring adjacent said rod in the path of movement thereof, a retainer for said spring pivotally connected to said shaft, said retainer operatively engaging both ends of said spring and coacting with said rod to compress said spring when said member is rotated and to provide a continuous resilient connection between said member and said shaft, and means to hold said shaft against movement during at least a portion of the movement of said member.

5. In a drive mechanism, in combination, an electric motor responsive to a change in voltage or the like, an intermittent-motion gear operatively connected to said motor, a brake having a driving member and a holding member, a switch shaft connected to said driving member for rotation therewith, a movable contact member continually connected operatively to said switch shaft, said switch shaft being coaxial with said gear, means rigidly connected to said gear, a spring engaging said means, a retainer engaging said spring, said retainer being pivotally connected to said driving member, means for connecting said holding member to said driving member to hold the latter immovable during at least a portion of the movement of said gear, and means for disconnecting said members to cause said spring to turn said switch shaft.

6. In a drive mechanism, in combination, a prime mover responsive to a change in electrical conditions or the like, a rotatable intermittent-motion gear operatively connected to said prime mover, a switch shaft coaxial with said gear, a movable contact member continually connected operatively to said switch shaft, a plurality of rods mounted on said gear substantially in the form of a polygon, said rods being generally equidistant from the axis of said shaft and symmetrically arranged about the axis thereof, a spring on said rods respectively, a retainer extending between the respective ends of each spring, said retainers being pivotally connected to said shaft, said rods carrying means to engage said springs and coacting with said retainers to compress said springs when said gear is rotated and to provide a continuous resilient connection between said gear and said shaft, and means for holding said shaft against movement during at least a portion of the movement of said gear to cause the compression of said springs.

7. In a drive mechanism, in combination, an electric motor responsive to changes in voltage or the like, a rotatable member operatively connected to said motor, a switch shaft, a compressing member connected to said rotatable member, a box pivotally connected to said shaft, a spring in said box, a piston slidable in said box, said piston being interposed between said compressing member and said spring, means for holding said shaft against movement during at least a portion of the movement of said rotatable member compressing said spring, and means for releasing said shaft when said spring has been compressed to make said shaft catch up with said member, the movement of said piston within said box controlling the rotational velocity of said switch shaft during at least a portion of the movement of said switch shaft.

8. In a drive mechanism, in combination, an electric motor responsive to changes in voltage or the like, a driving gear operatively connected to said motor, a driven gear engaged by said driving gear, said gears having different axes, a switch shaft coaxial with said driven gear, a compressing member connected to said driven gear in the manner of a chord, a spring holder connected by trunnions to said shaft, a spring between said member and said holder, means coaxial with said driven gear to hold said shaft against movement during at least a portion of the movement of said driven gear, and means coaxial with and actuated by said motor for controlling the operation of said last-mentioned means.

9. In a drive mechanism, in combination, an electrical motor responsive to changes in voltage or the like, an intermittent-motion gear operatively connected to said motor, a holding device having a driving portion and a holding portion movable relative to each other to permit engagement and disengagement thereof, said holding portion holding said driving portion against movement when in engagement therewith, a switch shaft keyed to said driving portion, a movable contact continually connected operatively to said switch shaft, means resiliently connecting said gear and said driving portion, means urging

said holding portion into engagement with said driving portion, said last-named means including a coupling having complementary threadably engageable parts adapted when rotated relative to each other to disengage said holding portion from said driving portion, and means for rotating said parts relative to one another after a portion at least of a single movement step of said gear has been made.

10. In a drive mechanism, in combination, an electric motor responsive to a change in voltage or the like, a cam connected to said motor, an intermittent-motion gear operatively connected to said motor, a brake having a drive member and a hold member movable axially relative to each other to permit engagement and disengagement thereof, a switch shaft connected to said drive member for rotation therewith, means rigidly connected to said gear, a spring engaging said means, a retainer for said spring, one portion of a pivotal bearing rigidly connected to said retainer and engaging another portion of said bearing in said drive member, and means normally holding said hold member in engagement with said drive member, said last-named means including an oblique-surfaced coupling actuated by said cam to move said hold member axially out of engagement with said drive member.

11. In a drive mechanism, in combination, an electric motor responsive to a change in voltage or the like, a Geneva gear driven by said motor, a brake having a drive portion and a hold portion, a switch shaft connected to said drive portion for rotation therewith, means symmetrically arranged on one side of said gear, a resilient member connected between said means and said drive portion, means to hold said hold portion against said drive portion of said brake during at least part of the movement of said gear, means for disconnecting said portions to permit said switch shaft to catch up with said gear, a rocking sector arm engaging said gear on the other side thereof, a flange on said other side to lock said arm in position until said gear passes through its reference position, and a throw lever engaging said arm.

12. In a drive mechanism, in combination, a prime mover, a rotary plate, a spring, a spring box, means for holding said spring box against rotation about the axis of said plate, means on said plate engaging said spring, said spring box having an opening adjacent to and spaced from at least one end thereof, a piston slidable in said spring box adjacent that end thereof, said piston engaging said spring, and means for releasing said first-mentioned means after said spring has been at least partly compressed by the rotation of said plate, whereby when said spring box is released the snap action thereof will attain its maximum speed prior to the end of its travel.

13. In a high speed, snap action switch mechanism, in combination, a reversible prime mover, a switch shaft, a plurality of stationary electrical contacts arranged in a circular path, a movable contact member continually connected operatively to said shaft and arranged for sequential engagement with said stationary contacts, a rotatable member engaging said prime mover, means resiliently connecting said rotatable member and said shaft, means for holding said shaft substantially immovable during at least a portion of the movement of said member by said prime mover, said resilient means including energy-absorbing means for retarding the speed of movement of said movable contact member as it moves out of engagement with one of said stationary contacts and in a direct path into engagement with an adjacent stationary contact.

14. In a drive mechanism, in combination, a reversible prime mover, a switch shaft, a plurality of stationary contacts arranged in a circular path, a movable contact member continually connected operatively to said shaft and arranged for sequential engagement with said stationary contacts, and snap acting energy storage means including a lost motion mechanism between said prime mover and said shaft for driving said shaft, means for holding said shaft substantially immovable during at least a portion of the movement of said lost motion mechanism by said prime mover, means actuated by said prime mover for releasing said shaft, and an energy-absorbing device including a piston movable in a fluid-filled cylinder for controlling the rate of movement of said movable contact member during at least a portion of its travel between said stationary contacts.

15. In a drive mechanism, in combination, a reversible prime mover, a plurality of stationary contacts arranged in a circular path, a movable contact member arranged for sequential engagement with said stationary contacts, Geneva gear, intermittent-motion, energy storage means connecting said prime mover and said movable contact member including a rotatable driving member operatively connected to said prime mover, a driven member coaxial with said driving member and operatively connected to said movable contact member, resilient means continually connecting said driving member and said driven member including a plurality of springs disposed symmetrically about the common axis of said members, and means for frictionally holding said driven member substantially immovable during at least a portion of the movement of said driving member by said prime mover.

16. In a drive mechanism, in combination, a reversible prime mover, a switch shaft, a plurality of stationary contacts arranged in a circular path, a movable contact member continually connected operatively to said shaft and arranged for sequential engagement with said stationary contacts, snap acting energy storage means connecting said shaft and said prime mover for driving said shaft including an intermittent-motion gear operatively connected to said prime mover, means for frictionally holding said shaft substantially immovable during at least a portion of the movement of said intermittent-motion gear by said prime mover, and means for locking said intermittent-motion gear in its position of rest.

17. In a drive mechanism, in combination, a prime mover, a rotatable member operatively connected to said prime mover, a driven member coaxial with said rotatable member, a movable contact operatively connected to said driven member, at least three resilient means continually connecting said rotatable member and said driven member, each of said resilient means including an accelerating spring, said springs being disposed symmetrically about the common axis of said members, and means to hold said driven member substantially immovable during at least a portion of the movement of said rotatable member by said prime mover, all of said accelerating springs being loaded in the same sense when said rotatable member is rotated relative to said driven member.

18. In a drive mechanism, in combination, a reversible prime mover, a plurality of stationary contacts disposed in a circular path, a rotatable contact member arranged to sequentially engage said stationary contacts, energy storing and releasing means between said prime mover and said contact member for driving said contact member, said means including a reversible intermittent-motion gear resiliently connected to said contact member, said intermittent-motion gear having a reference position and being rotatable in both directions from said reference position, a reversing switch operable between a first and a second position, means for operating said reversing switch from one of said positions to the other when said intermittent-motion gear is moved through its reference position, and means for locking said reversing switch in either of said positions selectively when said intermittent-motion gear is away from its reference position.

19. In a drive mechanism in accordance with claim 18 wherein said means for locking includes a pair of concentric circular flanges on said intermittent gear and said reversing switch includes a member pivotable between a first and a second position, and a control pin on said intermittent-motion gear for operating said member from one to the other of said positions, said member having finger

portions engageable between said flanges to lock said member in either of said positions selectively.

20. In a tap changing mechanism having a reversible prime mover connected by energy storage and releasing means including an intermittent-motion gear to a movable contact adapted to sequentially engage a plurality of contacts arranged in a circular path, said intermittent-motion gear having a reference position and being rotatable in both directions from said reference position, the combination with said intermittent-motion gear of a pair of concentrically arranged circular flanges on said gear, the outer of said flanges having spaced entrances, a pivoted member having a pair of spaced fingers each disposed adjacent an entrance in said outer flange, said fingers being movable alternately through the spaced entrances to a position between said flanges as said member is pivoted, a control pin on said intermittent-motion gear engageable with said pivoted member when the intermittent-motion gear is in its reference position to pivot said member in either of two directions to move one of said fingers into the entrance adjacent thereto, and a reversing switch actuated by said pivoted member.

21. A tap changing mechanism in accordance with claim 20 wherein said reversing switch includes a pair of spaced stationary contacts, a shaft, and a movable contact connected to said shaft and arranged to alternately engage said stationary contacts, said shaft having a radially extending arm connected to said pivoted member and being adapted to operate said movable contact into engagement with either of said spaced stationary contacts selectively when said arm is actuated by the pivoting of said member.

22. A tap changing mechanism in accordance with claim 21 wherein a lost motion connection is provided between said arm and said pivoted member.

23. In an electrical switching mechanism of the step type in which a movable electrical contact is moved with rapid motion out of engagement wtih a fixed first electrical contact and into engagement with a fixed second electrical contact, a spring-driven operating means for moving said movable electrical contact, said means comprising a spring and an energy absorbing device operatively connected to said operating means to retard the speed of movement of said movable contact as it moves from said first contact to said second contact, said energy absorbing device including a plunger movable in a fluid-containing dashpot.

24. In an electrical switching mechanism of the step type in which a movable electrical contact is moved with rapid motion out of engagement with a fixed first electrical contact and into engagement with a fixed second electrical contact, a spring-driven operating means for moving said movable electrical contact, said means including a spring and an energy absorbing device continually operatively connected to said operating means and opposing said spring to thereby retard the speed of movement of said movable contact as it moves in a direct path from said first contact to said second contact.

25. In an electrical switching mechanism of the step type in which a movable electrical contact is moved with rapid motion out of engagement with a fixed first electrical contact and into engagement with a fixed second electrical contact, a spring-driven operating means for moving said movable electrical contact, said means including a spring and an energy absorbing device operatively connected to said operating means to retard the speed of movement of said movable contact as it moves from said first contact to said second contact, said energy absorbing device including a piston movable in a liquid-containing cylinder having a liquid relief aperture.

26. In an electrical switching mechanism of the step type in which a movable electrical contact is moved with rapid motion out of engagement with a fixed first electrical contact and into engagement with a fixed second electrical contact, a spring-driven operating means for moving said movable electrical contact, said means including a spring and an energy absorbing device operatively connected to said operating means to decrease the speed with which said movable contact moves into engagement with said second contact, said energy absorbing device including a piston movable in a liquid-containing cylinder having a liquid relief aperture disposed at a point intermediate the two positions of extreme movement of said piston in said cylinder.

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