Nov. 19, 1957 E. J. DIEBOLD 2,813,937

GUIDED PUSH ROD MECHANISM

Filed Dec. 2, 1955 3 Sheets-Sheet 1

FIG. 1.

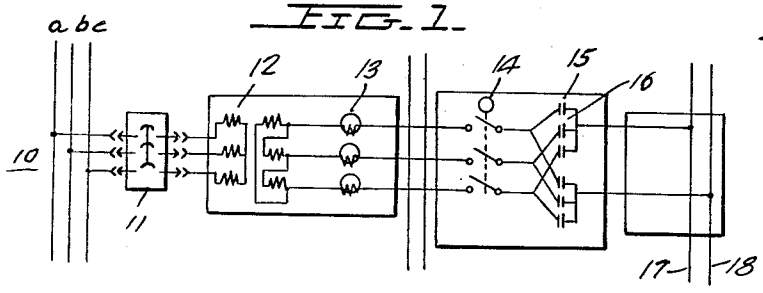
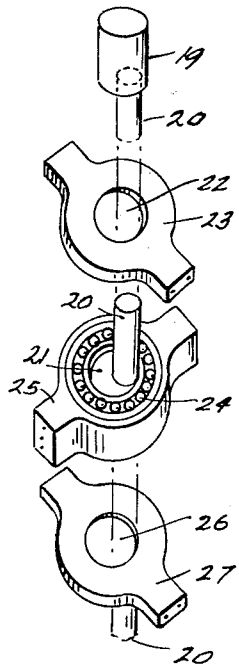


FIG. 3.



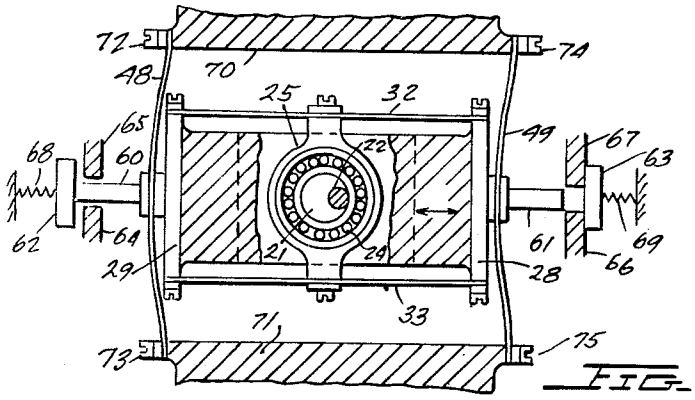


FIG. 4a.

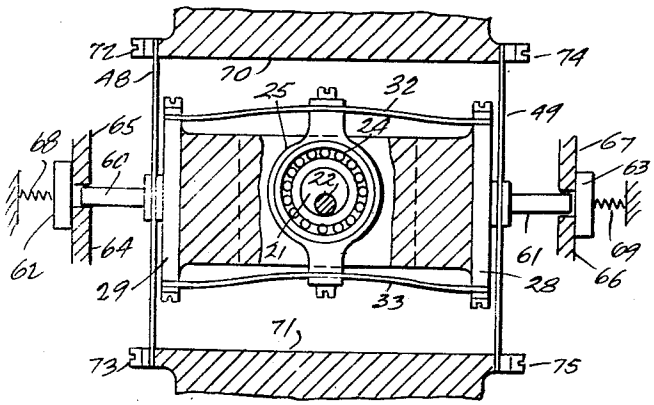


FIG. 4b.

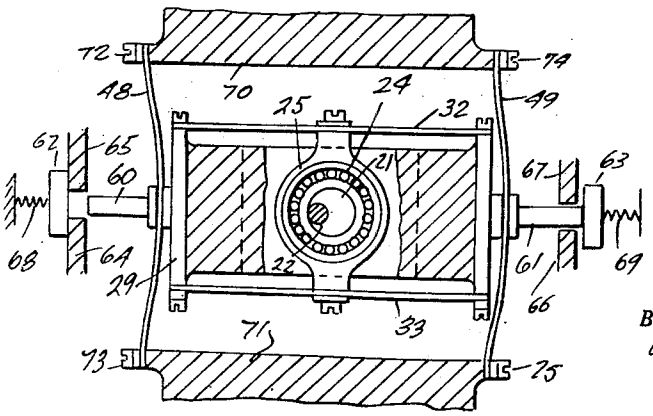


FIG. 4c.

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Nov. 19, 1957 E. J. DIEBOLD 2,813,937

GUIDED PUSH ROD MECHANISM

Filed Dec. 2, 1955 3 Sheets-Sheet 2

FIG. 2

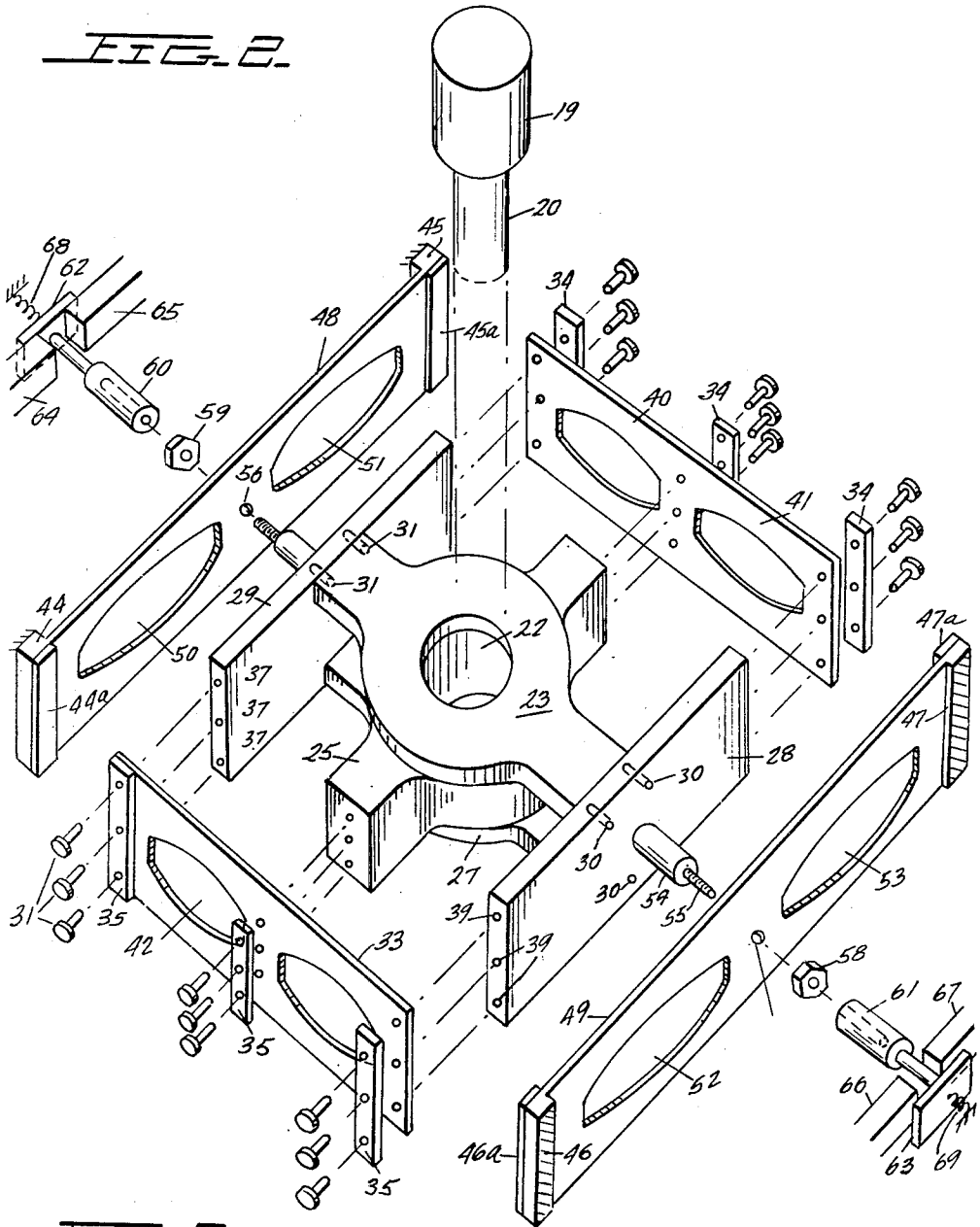
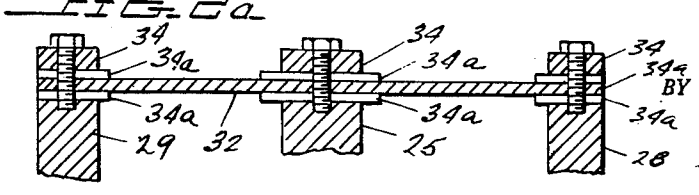


FIG. 2a



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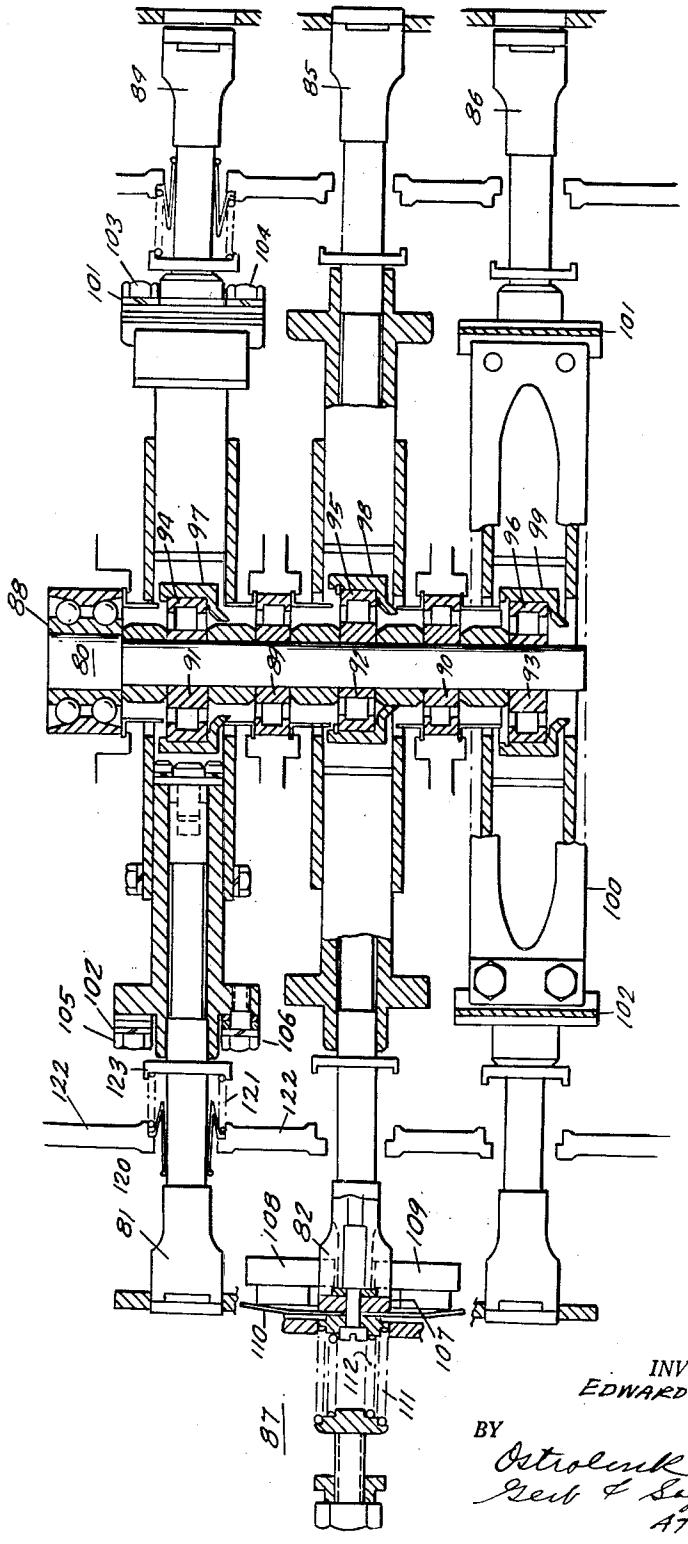
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GUIDED PUSH ROD MECHANISM

Filed Dec. 2, 1955 3 Sheets-Sheet 3

FIG. 5.



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2,813,937

GUIDED PUSH ROD MECHANISM

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Application December 2, 1955, Serial No. 550,617

18 Claims. (Cl. 200—30)

My invention relates to mechanical rectifiers and more specifically to an operating mechanism for operating the contacts of a mechanical rectifier into and out of engagement.

Mechanical rectifiers are used primarily in the conversion of large amounts of power wherein a pair of metallic contact in series with an A.-C. power source are opened and closed in synchronism with the input A.-C. power frequency to thereby deliver a uni-directional power to a D.-C. load which is placed in series with the A.-C. power source and the contact. That is, when the contact is closed, current may flow from the A.-C. source to the D.-C. load. Conversely, when the contact is opened (which would be the case when the potential of the A.-C. source is in a direction which is opposite to the potential desired for the D.-C. load) then the A.-C. potential will fall across the open contact and current will not flow to the D.-C. load.

Mechanical rectifiers operating according to these general principles are shown in copending application Serial No. 307,024, filed August 29, 1952.

Operating mechanisms for the contacts used heretofore are constructed to have a push rod which is brought into and out of engagement with a movable bridging contact. More specifically, this push rod is imparted an oscillatory motion in the direction of its axis by means of an oscillating link which is oscillated by an eccentric shaft which in turn is driven by a synchronous motor. Hence rotation of the synchronous motor eccentric shaft will oscillate the coaxial oscillating link which has the push rod fastened at one end thereof. This oscillatory motion is imparted to the push rod which is brought into engagement with the bridging contact of the mechanical rectifier to thereby move this contact out of engagement with the stationary contacts.

Subsequent motion of the push rod will then release the engagement between the push rod and the bridging contact to thereby allow closing bias forces operating on the movable contact to move it into engagement with its cooperating stationary contacts.

The above mentioned type of contact actuating mechanism has shown many severe disadvantages. Since the contacts of a mechanical rectifier will operate 216,000 times per hour when rectifying a sixty cycle source, it is obvious that extremely efficient guiding of the contact is necessary. This fact is substantiated in that experience over many years of operation has shown that the life of mechanical rectifier contacts is materially impaired by poor guiding of the push rods which actuate their operation. In one example, a machine which performed satisfactorily under fully load for more than eight thousand hours without showing extensive contact wear failed after no more than eight hours of operation under similar conditions merely because the guiding of the push rod was not satisfactory.

Poor push rod guiding in the prior art type of mechanisms has been caused by insufficient length of support of the push rods and too much play between the support

and the moving push rod itself. The effect of the poor guiding is that the push rod jumps around during operation and hits the movable contact on different spots every time it operates. This of course imparts a slightly random motion to the contact which makes it sit a little different after each operation. Because the contact surfaces are always slightly rough (due to the passage and interruption of electric current) the random motion displaces these rough spots and creates surface deformations which very soon result in fatigue of material and loose metal particles. The loose metal particles dance around between the contacts and cause a new roughness every time they hit another spot which is then another cause of damage, and so on.

This damage once it has been started, has been shown to progress as an exponential function of time and becomes intolerable after a very short time. This in part explains why a very slight amount of play of the push rod can possibly reduce the contact life by one thousand times.

Another very severe problem in the presently used mechanical rectifier mechanisms is in the shock waves or pressure waves which travel from the push rod of any contact into the actuating mechanisms, the various component parts driving the actuating mechanisms and throughout each of the other contacts of the mechanism.

When the contact is opened, the mechanical drive system knocks the contact open by means of the push rod through the levers or linkages which are actuated by means of the bearings. As a result, the shock force between the various parts, one of which is in motion and the other of which is standing still, amounts to several tons of instantaneous pressure. This pressure wave travels from the push rod into the actuating mechanism, through the actuating mechanism and into the bearings, through the bearings and into the housing of the rectifier mechanism, and from the housing into the push bars and the stationary contacts of the other contacts of the mechanical rectifier.

Shock waves have been measured in mechanical rectifiers which have approximately .001 of an inch displacement at a frequency which may be several kilocycles, thereby causing great stresses and unduly high displacement of the members subjected to them.

Hence contacts which must open and close under these shock wave conditions are subjected to still another kind of random motion which has been shown above to be detrimental to the contact life.

As will be shown hereinafter, the operating mechanism of my invention still allows the contact to be opened suddenly and closed suddenly but the shock wave created thereby will be isolated from the actuating mechanism and will not travel back through the actuating mechanism and into the housing and subsequently to the other contacts of the rectifier.

A further drawback encountered in presently used mechanical rectifier actuating mechanisms is that the bearings used are subjected to short stroke oscillations, thereby resulting in very high wear of the bearings. That is, since the push rod only has to go through a short sine wave type of motion, the bearings which actuate it are subjected to short oscillations or oscillations which are only over a range of a few degrees. It is well known that it is difficult for roller or needle bearings to operate under such conditions because the rolls or needles are then given the poor property of rolling themselves into the races of the bearings because the lubricating oil is squirted out from under the rolls to thereby allow binding and damage.

In view of this property, which is inherent in short stroke oscillation and shock loads, a very strong lubrication must be used for the bearings. It should be noted, however, that in spite of the strongest lubrication, dam-

age of the bearings frequently occurs. However, the very strong lubrication which is required, imparts a serious drawback to the contact operation. That is, oil which is made to lubricate all of the movable parts of the mechanism can now reach to contact surfaces. The electrical contacts, which then are forced to operate under oily conditions are soon covered with a black tarry substance which has been shown to impair the operation, cause overheating of the contacts, and leads to subsequent contact failures.

The principle of my invention is to use an actuating mechanism which is essentially an oscillating mass suspended by at least one spring. The oscillating mass is then driven by the eccentric shaft of the synchronous motor and is either suspended or guided or both by the above mentioned suspension spring which guides the oscillating mass for a smooth linear oscillatory motion.

The push rod is then directly fastened to this oscillating mass which will now perform an essentially perfectly guided oscillating motion.

More specifically, the oscillating parts which assume the smooth linear oscillating motion can be directly and metallically fastened to the housing of the machine by means of springs such as flat blade springs. If desired, the spring constant of the suspending springs and the mass of the oscillating body can be adjusted in order to obtain a resonant frequency which is substantially equal to the operation frequency. Therefore, the power required to drive the mechanism will now only have to overcome the friction loss and is not needed to accelerate or decelerate the moving mass.

It is seen therefore that the use of my novel actuating mechanism provides a push rod which is substantially perfectly guided to thereby overcome the guiding problem which is inherent in the prior art actuating mechanism. Furthermore, since the oscillating mass can be connected to the rotating parts of the mechanism through blade springs which absorb not only the side way motion but also the sudden shock loads, the shock stresses which have been mentioned above as being a serious limitation in the presently used mechanical rectifier actuating mechanisms are now entirely confined to an oscillating mass which is entirely suspended by springs. Since, therefore, the mass is only connected to the rotating parts of the machine by springs, it is clear that the shock vibrations will be confined within this one solid part and the shock will not be transferred through the machine housing, bus bars and subsequently to the other contacts of the machine.

It should be further noted that the use of my novel oscillating actuating mechanism will similarly eliminate a great part of the noise which is made in a mechanical rectifier due to the shock waves traveling over the surfaces of the housing of the mechanism.

In a similar manner, the bearing problem which was present in the prior art type of actuating mechanism is now overcome in the use of my novel device. That is the only bearings required in my new mechanical rectifier actuating mechanism are the ones supporting the rotary drive shaft and the eccentrics actuating the mechanisms which can comprise a row of bearings along the shaft. Clearly, however, these bearings all rotate over the full arc of a circle and do not have the prior type of oscillatory motion. Therefore, the bearings which are used in the fulfillment of my novel invention are easily lubricated and of course cannot be damaged due to the non-existent short stroke motions.

It is now clear in discussing this phase of the advantages shown by my novel mechanism that the problem of oil which was previously required in the strong lubrication of the bearings will not reach the contacts since this strong lubrication has been now reduced to a minimum and contact life will accordingly be extended. Similarly, because my moving mass is suspended only by springs, the guiding is achieved without any play whatsoever to thereby eliminate the present problem of additional contact wear due to the play between the push rod and the push rod support.

In summary, therefore, it is seen that the use of my novel actuating mechanism for mechanical rectifier contacts eliminates the essential problems which were present in the previously used mechanism rectifier actuating mechanisms which were poor push rod guiding, play between the push rod and its support, shock waves which were transmitted to the mechanism housing, short stroke oscillations which caused high wear in the bearings, and oil reaching the contact surfaces.

Accordingly, a primary object of my invention is to provide an actuating mechanism for mechanical rectifier contacts which comprises a push rod fastened to a suspended oscillating mass, this mass being oscillated by the mechanical rectifier motor.

Another object of my invention is to provide an actuating mechanism for mechanical rectifier contacts which comprises an oscillating mass which is suspended from a stationary housing by means of at least one spring wherein a push rod fastened to this oscillating mass moves in a substantially perfectly guided oscillating motion and play is eliminated between the push rod and the stationary bodies.

Still another object of my invention is to provide a push rod for actuating mechanical rectifier contacts which is suspended by a spring for both support and guiding and is driven in an oscillating motion responsive to the rotation of a synchronous motor.

Still another object of my invention is to provide an oscillating mass for the actuating mechanism of a mechanical rectifier contact which is suspended by at least one spring and the mass and spring constants are so chosen to allow the oscillated mass to be oscillated at its natural resonant frequency.

A further object of my invention is to provide an actuating mechanism for mechanical rectifier contacts wherein all bearings used are rotated through 360° to thereby minimize lubrication requirements and substantially eliminate oil flow to mechanical rectifier contacts.

A still further object of my invention is to provide an actuating mechanism for mechanical rectifier contacts which is so constructed as to be mechanically isolated from the rectifier housing to thereby prevent the transmission of shock waves from the actuating mechanism and into the housing.

These and other objects of my invention will now become apparent from the following description taken in connection with the drawings, in which:

Figure 1 is a schematic electrical diagram of a mechanical rectifier to which my novel actuating mechanism can be applied.

Figure 2 is an exploded perspective view of an actuating mechanism for mechanical rectifiers contacts which is constructed in accordance with my novel invention.

Figure 2*a* is a detailed view of one possible method for clamping of the springs of Figure 2.

Figure 3 is an exploded perspective view of one portion of 2 which shows the eccentric drive shaft in greater detail.

Figures 4*a*, 4*b* and 4*c* show a motion picture sequence of the operation mechanism such as that of Figure 2.

Figure 5 is a more detailed drawing of a side view of a mechanism of the type shown in Figure 2 as extended to the operation of six mechanical rectifier contacts.

In Figure 1, the source of alternating current is derived from the A.-C. voltage source which energizes the conductors **10** and passes through the circuit breaker **11** to the transformer **12**. Current is subsequently passed through commutating reactor **13** to step the current for commutating purposes as set forth in U. S. Patent No. 2,693,569. The construction of the commutating reactor **13** is described in copending application Serial No. 301,880

filed July 31, 1952, now Patent No. 2,759,128, dated August 14, 1956.

The current then passes through the disconnect switches **14** to the contact assemblies **15** and **16**. The contact assemblies **15** and **16** which are sequentially operated in synchronism with the frequency of the A.-C. source (by the novel actuating mechanism of my invention) and then connected to the direct current buses **17** and **18**.

Referring now to Figures 2 and 3 which show one example of an actuating mechanism for mechanical rectifier contacts which is constructed in accordance with my invention, a motor **19** is shown which is the synchronous drive motor of the mechanical rectifier unit. The motor **19** rotates a drive shaft **20** which contains an eccentric **21** as shown specifically in Figure 3. As will be shown hereinafter, one eccentric can, if so desired, be used to accommodate two contacts. When a six contact system is used for rectification of a three phase source it is obvious that the shaft can then contain three eccentrics along its shafts being displaced by 120° from one another.

However, the mechanism shown in Figures 2 and 3 is described herein with reference to only a pair of contacts for purposes of simplicity and accordingly only a single eccentric **21** is shown along the drive shaft **20**.

The shaft **20** extends through an aperture **22** of the member **23** as shown in both Figures 2 and 3 and as shown more specifically in Figure 3, the eccentric **21** is positioned to be placed within the bearing **24** whereby member **25** will be oscillated responsive to rotation of the shaft **20**. As shown more specifically in Figure 3, shaft **20** further extends through a second aperture **26** of member **27** whereby further eccentrics placed on the shaft **20** may be inserted within other members similar to the member **25** for the operation of other pairs of contacts.

The oscillating mass can now be seen with reference to Figure 2 as comprising the members **23**, **25** and **27**. Members **23** and **27** are shown as being clamped together by means of the plate-like members **28** and **29** through the medium of a fastening means which could be screws **30** and **31**.

A spring means is then provided and is shown herein as comprising the flat springs **32** and **33**. Flat springs **32** and **33** are attached to the plates **28** and **29** by clamping bars **34** and **35**, respectively, and the corresponding screw means.

Apertures or slots **40** and **41** are provided in the spring member **32** and apertures **42** and **43** are provided in the spring member **33** to thereby form a member which is rigid in a plane parallel to its surface and flexible in a plane perpendicular to its surface.

Clearly there are many ways of providing an oscillating mass of this nature and the particular structure described herein is merely illustrative of one of those many ways.

A stationary body is shown as comprising the posts **44**, **45**, **46**, **47**. Clearly this is merely to indicate that a stationary housing or a body which is stationary with respect to the oscillating mass is present for purposes of suspending the oscillating mass. The suspension of the oscillating mass is then accomplished in Figure 2 in accordance with the principle of my invention by means of the two flat springs **48** and **49** respectively, which are fastened in some manner to the stationary support of the unit. For illustrative purposes only, the spring members **48** and **49** are shown herein as being clamped to the relatively stationary posts **44** and **45**, and **46** and **47** by the clamping bars *44a*, **45***a*, **46***a* and **47***a*, respectively.

It is to be noted that both of these suspending spring members **48** and **49** are provided with apertures **50** and **51** and **52** and **53**. Here again the apertures now provide a spring which is extremely flexible in a direction perpendicular to its plane and yet rigid in a direction parallel to its plane.

Similarly, the spring is so shaped that it is wide where high stresses are encountered and narrow where low stress is encountered whereby the flexibility of the narrow sections relieves stresses in the wide sections.

In order to assure dependable operation of the springs **32**, **33** and **48**, **49**, the clamping of the springs is done very carefully. The springs are made of flat spring steel clamped over their full width by means of the clamping bars and if desired, by clamping plates. As specifically shown in Figure 2*a*, the spring **32** is clamped at all points by the interposed clamping plates **34***a* which, by extending beyond the clamping edge of the clamping bars **34**, effect a more gentle fastening. Hence, spring breakage due to clamping stresses is substantially eliminated.

The suspension of the oscillating mass by means of the springs **48** and **49** can then be accomplished by means of post **54** which is fastened in any desirable manner to the plate **28** and a similar post which cannot be seen in Figure 2 which is fastened to the plate **29**.

These posts **54** can then be provided with an extension such as the threaded extension **55** which cooperates with holes **56** and **57** of springs **48** and **49**, respectively. In order to maintain the post **54** to the spring **49** and similarly to maintain the post of the plate **29** to the spring **48**, nuts such as **58** and **59** are provided which will cooperate with the threaded extension **55** to thereby maintain the post **54** to the spring **49** and similarly maintain the post of the plate **29** to the spring **48**.

It is to be emphasized that the fastening method as described herein is merely illustrative of many desirable methods. To continue this example, it is seen that the push rods **60** and **61** which could be made to cooperate with the portion of the threaded extension **55** which extends past the nut **58** are then fastened to the oscillating mass. It is now seen that when an oscillating motion is imparted to the push rods **60** and **61**, the movable contacts shown schematically as contacts **62** and **63** can be made to move into and out of engagement with the A.-C. bus **64** and D.-C. bus **65** and A.-C. bus **66** and D.-C. bus **67** respectively against the action of the closing bias springs **68** and **60** respectively. Contact structures of this type may be seen in more detail in copending application Serial No. 307,067 filed August 29, 1956.

That is to say that oscillation of the push rod **61** will first bring it into engagement with the movable contact **69**. Continued motion of the push rod **61** will then force the contact **63** to move against the action of its closing bias **69** to thereby separate the A.-C. bus **66** from the D.-C. bus **67** and interrupt the flow of current between the A.-C. source and the D.-C. load. Upon oscillation of the push rod **61** in the opposite direction, it is clear that the bias spring **69** will move the movable contact **63** into a bridging engaged position with the A.-C. bus **65** and D.-C. bus **67** to thereby effectively connect an A.-C. source to a D.-C. load for energization thereof.

The operation of the system shown in Figures 2 and 3 will now be apparent since it is clear that rotation of the shaft **20** will oscillate the member **25** in view of the eccentric **21** shown in Figure 3. This eccentric motion will then be imparted to the complete oscillating mass which comprises the members **23**, **27**, **28**, **29**, **32** and **33**. This oscillating motion will, in view of the stationary guide springs **48** and **49**, drive the oscillating mass and hence the push rods **60** and **61** in a linear or straight line motion. Obviously, the springs **32** and **33** will merely flex, depending upon the position of the eccentric **21** to thereby absorb any stresses which might be provided in the system and the oscillating mass is completely guided only by the springs **48** and **49**.

For a clearer understanding of the operation of the device shown in Figures 2 and 3, a top view of the device of Figure 2 is shown in Figures *4a*, *4b* and *4c*. In these figures the vertical drive shaft **20** carries the eccentric **21** which is positioned within the bearing **24** for oscillating the member **25**. However, whereas Figure 2 shows the stationary circuit of the spring mem-

bers 48 and 49 as being the four posts 44, 45, 46 and 47, Figures 4a, 4b and 4c show this support as comprising a first stationary body 70, and a second stationary body 71 where the spring 48 is fastened between boxes 70 and 71 by means of the screws 72 and 73 and the spring 49 is similarly fastened by means of the screws 74 and 75. For the sake of simplicity only the operation of the right hand contact is described although a contact could be shown as being operated by the push rod 60 as well as push rod 61.

It is now clearly understood with reference to Figure 4 that rotation of the shaft 20 about its fixed axis will drive the eccentric 21 which in turn will affect the member 25 through the bearing 24 to transmit a force through the springs 32 and 33 to subsequently cause a linear oscillation of the push rods 60 and 61 which are suspended from the stationary housing by means of the springs 48 and 49. This oscillation will be in the direction given by the double arrow indicated by the number 76. As the eccentric is moved up and down with respect to the figure, it is clear that the force imparted to the springs 32 and 33 will be in a directional proportional to their plane and the springs will therefore flex to thereby absorb this energy.

Referring now to Figure 4c, the position shown is that of the contact engaged position, the push rod 61 being completely removed from the movable contact 63. In this position, it is seen that the springs 48 and 49 are flexed to their maximum left hand position and that the springs 32, 33 are unflexed.

As the shaft 22 is rotated (by the synchronous motor which is not shown here) in a clockwise direction, it is seen that the mechanism will move from the position of Figure 4a to that of Figure 4b. In this motion, the eccentric 21 will drive the push rod 61 to engage the movable contact 63 through the mechanical connection comprising the eccentric 21, member 21, springs 32, 33, plate 28 and the push rod 61. It is further seen in Figure 4b that the springs 48, 49 have moved from their leftwardly deflected position to a straight position and that the springs 32, 33 have deflected upward due to the upward motion of the eccentric 21.

Further rotation of shaft 22, by its driving means, will subsequently move the oscillatory mass to its extreme right hand position of Figure 4c to cause subsequent disengagement of movable contact 63 from its cooperating contacts 66, 67 by means of the push rod 61. It is seen that the springs 48 and 49 are deflected to their extreme right hand position and that the springs 32 and 33 are undeflected since the eccentric 21 is in a central position.

Hence the advantages presented by the use of my novel actuating mechanism are now apparent when referring to Figures 2, 3, 4a, 4b and 4c.

Clearly, the shock vibration which is due to the impingement of push rods 60 or 61 upon the movable contacts 62 or 63 respectively will be transmitted through the push rod 60 and 61 and into the oscillating mass which is represented in Figure 2 by the members 23, 25, 27, 28, 29, 32 and 33.

This shock however, will not be transmitted to the stationary supports shown as support members 44, 45, 46 and 47 in Figure 2 and as members 70 and 71 in Figures 4a, 4b and 4c. That is to say, that by suspending the oscillating mass on springs 48 and 49 the mechanical shock and vibration will be isolated to the isolating mass since the springs 48 and 49 cannot transmit this shock to their stationary supports.

Furthermore, reference to the operation of the mechanism of Figs. 4a, 4b and 4c has shown that the oscillating mass will oscillate only in the direction shown by the arrow 76. Since the push rods are directly attached to this oscillating mass, it is clear that they will be perfectly guided in a linear oscillating motion and the point at which the push rods 60 and 61 of Figure 2 impinge upon the movable contacts 62 and 63 will not vary.

As a further advantage, it is seen that the bearings 24 of Figures 4a, 4b and 4c do not perform a short stroke type of oscillation but rather perform a continuous rotating motion to which bearing operation is best adapted.

Hence, lubrication of the bearings may now be at a safe minimum and the lubricating oil of the bearings is substantially isolated from the contact surfaces. As a further advantage of the actuating mechanism shown in Figures 2, 4a, 4b and 4c, it is clear that the size of the driving motor may be decreased if the mass of the oscillating body and the spring constant of the springs 48 and 49 is so chosen as to be resonant with the desired oscillating frequency, thereby requiring that only frictional forces be overcome.

Although in the foregoing I have described my novel actuating mechanism in conjunction with a mechanism for driving a pair of contacts such as the movable contacts 62 and 63 of Figure 2, it is clear that this mechanism could be utilized for the operation of only one contact or a plurality of contacts.

Similarly, my invention has been described in conjunction with a motor drive. However, the motor driving system could clearly be replaced by a system for driving a spring suspended oscillatory mass which could be actuated by electromagnetic, pneumatic, hydraulic or any other system.

As an obvious extension, it is equally clear that my novel actuating mechanism can be extended to drive the six contacts of a six contact mechanical rectifier wherein each pair of contacts are 120° displaced in their mechanical operation. This embodiment is shown in Figure 5 wherein six contacts are driven from what is essentially three mechanisms of the type shown in Figure 2 where the view is taken from the front of Figure 2.

As shown in Figure 5, six push rods extend in a plane parallel to a plane containing the drive shaft 80. As shown, the first three push rods 81, 82, and 83 extend to the left of the drive shaft axis and push rods 84, 85 and 86 extend to the right hand side of the drive shaft axis. A contact structure has been shown in conjunction with the push rod 82 and is shown generally at 87. Although each of the other push rods 81 through 86 will have similar contacts associated with them, they are not shown here in order to simplify the drawing.

It is now seen that the drive shaft 80 is supported by the main bearing 88 and is guided by the bearings 89 and 90 and bears the eccentrics 91, 92 and 93.

These eccentrics are surrounded by the bearings 94, 95 and 96 which are standard roller bearings each of which being surrounded by a member 97, 98 and 99, the members 97, 98 and 99 serving the function which was served by the member 25 of Figure 2.

In order to obtain the 120° phase shift between each pair of six contacts, it is clear that the eccentrics 91, 92 and 93 are mechanically offset by 120°. Referring now to the mechanism for actuating the lowest pair of contacts, the spring 100 is clearly seen, this spring being similar to the spring 33 of Figure 2. Hence, in the rotation of the eccentric 93, a force is transmitted to the spring 100 and from this spring to the supporting springs shown in cross section as springs 101 and 102. Obviously, the springs 101 and 102 correspond to the supporting springs 48 and 49 of Figure 2.

The means whereby the springs 101 and 102 are fastened to the oscillating mass is clearly shown in the upper oscillating mechanism of Figure 5 which oscillates the push rods 81 and 84 and comprises the bolt means shown as bolts 103, 104, 105 and 106. Therefore, upon rotation of the shaft 80 by means of a synchronous motor which is not shown here, the pair of push rods 81 and 84 will be imparted a linear oscillating motion by the eccentric 91.

In order to further isolate the contact from oil and

dust, each push rod is provided with a rubber sleeve which is oil and dust tight, such as the rubber sleeve **120** seen in conjunction with push rod **81**.

The return spring **121** is then supported between the stationary housing **122** and a member **123** which is fastened to the push rod **81**, this return spring serving to maintain its push rod assembly in engagement with its associated eccentric.

Hence, when the middle structure is moved to the left it is seen that the push rod **81** would actuate the operation of its contact shown generally at **87**. This contact generally comprises a movable contact **107** which is movable into and out of engagement with the stationary contacts **108** and **109**. Details of this typed contact structure and the bus arrangement may be had with reference to copending application.

If further guiding of the movable contact is desired, a guide spring such as the spring **110** which is clearly described in copending application Serial No. 438,465 filed June 22, 1954, can be fastened to the movable contact.

Hence when the shaft **80** is rotated by a synchronous motor which is not shown, the middle mechanism of Figure 5, which is suspended for oscillation by means of the springs **101** and **102** as shown in the upper mechanism of Figure 5 will bring the push rod **82** into engagement with the movable contact **107** to thereby drive the contact against its biasing springs **111** and **112** to effect contact disengagement. As the rotation of shaft **80** continues, it is clear that the oscillation of the movable mass will be in the right hand direction and the push rod **82** will thereby release the movable contact **107** and allow the bias springs **111** and **112** to bring the movable contact **107** into engagement with the stationary contacts **108** and **109**, one of which would be fastened to the D. C. side of a load and the other being fastened to the A. C. side of a load.

By now proceeding in this manner, it is clear that contacts on the left hand side of Figure 5 will be driven into and out of engagement according to a phase displacement of 120° to thereby allow effective rectification of a three phase A. C. source wherein each of the contacts is connected between one of the phases and one potential of the D.-C. load. Similarly, the push rods **84** and **85** and **86**, shown to the right of Figure 5 will achieve contact rectification with 120° phase displacement from each other and 180° from its opposite contact for connecting the same three phases of the A.-C. source to the opposite potential of the D.-C. load.

Hence it is seen that in a six contact mechanical rectifier, my novel invention can be applied wherein a first, second and third oscillatable mass are provided being driven by the eccentrics **91**, **92**, and **93** respectively from the shaft **80** of the mechanical rectifier motor. Clearly each of these masses is suspended by means of the relatively strong springs **101** and **102** to thereby impart extremely efficient guiding of each of the associated push rods **81** through **86**.

It is further seen that in view of the rigid connection between the oscillatable body and the push rods, that there will be no play between the push rod and the stationary structure. Similarly, since the bearings **88**, **94**, **95** and **96** rotate through a complete 360° cycle lubrication need be only at a minimum. Hence, excess oil which will not be present will not in any way be able to eventually contaminate the contact surfaces such as the surfaces between the movable contact **107** and the stationary contacts **108** and **109**.

In order to decrease the size of the motor, it is clear that the mass of the moving parts and the strength of the springs can be adjusted to have its natural resonant frequency at the oscillating frequency of the rectifying system.

Although I have described preferred embodiments of my invention, it will now be evident that many modifications and variations may be made by those skilled in the art. I therefore prefer to be limited, not by the specific disclosure herein, but only by the appended claims.

I claim:

1. A mechanism for operating a pair of cooperable contacts into and out of engagement, said contacts being biased to the engaged position; said mechanism including a synchronous motor having an output eccentric shaft, a push rod, supporting spring means and a relatively stationary body for supporting at least a portion of said supporting spring means; said eccentric shaft being operatively connected to said push rod to impart linear oscillatory motion to said push rod responsive to rotational motion of said eccentric shaft; a portion of said push rod being positioned to engage one of said pair of cooperable contacts when moved in a first direction along its oscillatory path to effect contact disengagement between said cooperable contacts, said push rod being operatively connected to said supporting spring means; said supporting spring means being constructed to isolate mechanical shock due to the engagement of said push rod and said one contact of said pair of cooperable contacts from at least said relatively stationary body.

2. A mechanism for operating a pair of cooperable contacts into and out of engagement, said contacts being biased to the engaged position; said mechanism including a synchronous motor having an output eccentric shaft, a push rod, supporting spring means and a relatively stationary body for supporting at least a portion of said supporting spring means; said eccentric shaft being operatively connected to said push rod to impart linear oscillatory motion to said push rod responsive to rotational motion of said eccentric shaft; a portion of said push rod being positioned to engage one of said pairs of cooperable contacts when moved in a first direction along its oscillatory path to effect contact disengagement between said cooperable contacts, said push rod being operatively connected to said supporting spring means; said supporting spring means being constructed to be flexible in the direction of said oscillatory motion of said push rod, said supporting spring means thereby being guided in its direction of oscillatory motion.

3. A mechanism for operating a pair of cooperable contacts into and out of engagement, said contacts being biased to the engaged position; said mechanism including a synchronous motor having an output eccentric shaft, a push rod, a supporting spring means and a relatively stationary body for supporting said supporting spring means; said eccentric shaft being operatively connected to said push rod to impart linear oscillatory motion to said push rod responsive to rotational motion of said eccentric shaft; said operative connection between said push rod and said eccentric shaft including a bearing surface, the relative rotation between said eccentric shaft and said push rod at said bearing surface being 360°; a portion of said push rod being positioned to engage one of said pair of cooperable contacts when moved in a first direction along its oscillatory path to effect contact disengagement between said cooperable contacts, said push rod being operatively connected to said supporting spring means; said supporting spring means being constructed to isolate mechanical shock due to the engagement of said push rod and said one of said pair of cooperable contacts from at least said relatively stationary body.

4. A mechanism for operating a pair of cooperable contacts into and out of engagement, said contacts being biased to the engaged position; said mechanism including a synchronous motor having an output eccentric shaft, a push rod, a supporting spring means and a relatively stationary body for supporting said spring means; said eccentric shaft being operatively connected to said push rod to impart linear oscillatory motion to said push rod responsive to rotational motion of said eccentric shaft; said

operative connection between said push rod and said eccentric shaft including a bearing surface, the relative rotation between said eccentric shaft and said push rod at said bearing surface being 360°, bearing lubrication and wear being minimized by the rotation of the bearings over a full 360° cycle; a portion of said push rod being positioned to engage one of said pairs of cooperable contacts when moved in a first direction along its oscillatory path to effect contact disengagement between said cooperable contacts, said push rod being operatively connected to said supporting spring means; said supporting spring means being constructed to be flexible in the direction of said oscillatory motion of said push rod, said spring thereby being guided in its direction of oscillatory motion.

5. In a mechanism for operating a movable contact into and out of engagement with a fixed contact; said mechanism including a synchronous motor for driving an eccentric shaft, an oscillating mass and a spring means for supporting said oscillating mass from a relatively stationary support; said eccentric shaft being operatively connected to said oscillating mass to impart linear oscillatory motion to said oscillating mass responsive to rotary motion of said eccentric shaft; said oscillating mass being positioned to engage said movable contact and move said movable contact out of engagement with said fixed contact when moved in a first direction; biasing means for said movable contact; said biasing means being constructed to move said contact to its engaged position when said oscillating mass is moved in a direction opposite said first direction.

6. In a mechanism for operating a movable contact into and out of engagement with a fixed contact; said mechanism including a synchronous motor for driving an eccentric shaft, an oscillating mass and a spring means for supporting said oscillating mass from a relatively stationary support; said eccentric shaft being operatively connected to said oscillating mass to impart linear oscillatory motion to said oscillating mass responsive to rotary motion of said eccentric shaft; said oscillating mass being positioned to engage said movable contact and move said movable contact out of engagement with said fixed contact when moved in a first direction; biasing means for said movable contact; said oscillating mass being moved out of engagement with said movable contact when said oscillating mass is moved in a direction opposite said first direction, said movable contact being moved to the engaged position by said biasing means.

7. In a mechanism for synchronously operating a movable contact into and out of engagement with a fixed contact; said mechanism including a synchronous motor for driving an eccentric shaft, an oscillating mass and a spring means for supporting said oscillating mass from a relatively stationary support; said eccentric shaft being operatively connected to said oscillating mass to impart linear oscillatory motion to said oscillating mass responsive to rotary motion of said eccentric shaft; said oscillating mass being positioned to engage said movable contact and move said movable contact out of engagement with said fixed contact when moved in a first direction; biasing means for said movable contact; said biasing means being constructed to move said contact to its engaged position when said oscillating mass is moved in a direction opposite said first direction; the mass of said oscillating mass and the spring constant of said supporting spring having valves to place the resonant oscillating frequency of said oscillating mass at the frequency at which said movable contact is moved into and out of engagement with said fixed contact.

8. A mechanism for synchronously operating a movable contact into and out of engagement with a fixed contact; said movable contact being movable between an engaged and disengaged position with respect to said fixed contact; said mechanism including a motor having an output eccentric shaft, a first spring, and a push rod; said first spring being constructed to support said push rod from a relatively stationary support whereby said push rod is linearly movable with respect to said relatively stationary body in a first and second direction; said push rod being positioned to move said movable contact to the engaged position responsive to linear motion thereof in said first direction, said movable contact being moved to said disengaged position responsive to motion of said push rod in said second direction; said motor output eccentric shaft being operatively connected to said push rod; said operative connection being constructed to impart said linear oscillating motion to said push rod responsive to the rotary motion of said output eccentric shaft.

9. A mechanism for synchronously operating a movable contact into and out of engagement with a fixed contact; said movable contact being movable between an engaged and disengaged position with respect to said fixed contact; said mechanism including a motor having an output eccentric shaft, a first spring, a second spring, and a push rod; said first spring being constructed to support said push rod from a relatively stationary support whereby said push rod is linearly movable with respect to said relatively stationary body in a first and second direction; said push rod being positioned to move said movable contact to the engaged position responsive to linear motion thereof in said first direction, said movable contact being moved to said disengaged position responsive to motion of said push rod in said second direction; said motor output eccentric shaft being operatively connected to said push rod; said operative connection being constructed to impart said linear oscillating motion to said push rod responsive to the rotary motion of said output eccentric shaft; said second spring being included in said operative connection between said eccentric shaft and said push rod whereby rotary motion of said eccentric shaft imparts linear oscillating force for said push rod to said second spring in a direction substantially perpendicular to the direction of maximum flexibility of said second spring.

10. A mechanism for synchronously operating a movable contact into and out of engagement with a fixed contact; said movable contact being movable between an engaged and disengaged position with respect to said fixed contact; said mechanism including a motor having an output eccentric shaft; a first spring, a second spring and a push rod; said first spring being constructed to support said push rod from a relatively stationary support whereby said push rod is linearly movable with respect to said relatively stationary body in a first and second dierction; said push rod being positioned to move said movable contact to the engaged position responsive to linear motion thereof in said first direction, said movable contact being moved to said disengaged position responsive to motion of said push rod in said second direction; said second spring being constructed to operatively connect said push rod to said eccentric shaft, the direction of flexing of said first spring being substantially perpendicular to the direction of flexing of said second spring; the connection between said second spring and said eccentric shaft being constructed to transmit a linear oscillating motion to said push rod responsive to the rotary motion of said eccentric shaft.

11. A mechanism for synchronously operating a movable contact into and out of engagement with a fixed contact; said movable contact being movable between an engaged and disengaged position with respect to said fixed contact; said mechanism including a motor having an output eccentric shaft, a first spring, a second spring and a push rod; said first spring being so constructed to support said push rod from a relatively stationary support whereby said push rod is linearly movable with respect to said relatively stationary body in a first and second direction; said push rod being positioned to move said movable contact to the engaged position responsive

to linear motion thereof in said first direction, said movable contact being moved to said disengaged position responsive to motion of said push rod in said second direction; said second spring being constructed to operatively connect said push rod to said eccentric shaft, the connection between said second spring and said eccentric shaft being constructed to transmit a linear oscillating motion to said push rod responsive to the rotary motion of said eccentric shaft.

12. A mechanism for synchronously operating a movable contact into and out of engagement with a fixed contact; said movable contact being movable between an engaged and a disengaged position with respect to said fixed contact; said mechanism including a motor, having an output eccentric shaft, a push rod and a spring means; said spring means being constructed to support said push rod for linear oscillating motion and to operatively connect said output eccentric shaft to said push rod; the operative connection between said push rod and said eccentric shaft being constructed to transmit linear oscillating motion to said push rod responsive to rotary motion of said eccentric shaft; said push rod being positioned to move said movable contact to the engaged position responsive to linear motion thereof in said first direction, said movable contact being moved to said disengaged position responsive to motion of said push rod in said second direction.

13. A mechanism for synchronously operating a movable contact into and out of engagement with a fixed contact; said movable contact being movable between an engaged and a disengaged position with respect to said fixed contact, said mechanism including a motor having an output eccentric shaft, an oscillating mass and a first and second spring means; said first spring means being constructed to operatively support said oscillating mass from a relatively stationary body for linear oscillating motion, said second spring means being constructed to operatively connect said output eccentric shaft to said oscillating mass; the operative connection between said oscillating mass and said eccentric shaft being constructed to transmit linear oscillating motion to said oscillating mass responsive to rotary motion of said eccentric shaft; said oscillating mass being positioned to move said moveable contact to the engaged position responsive to linear motion thereof in said first direction, said movable contact being moved to said disengaged position responsive to motion of said oscillating mass in said second direction; the resonant frequency determined by the mass of said oscillating mass and the spring constant of said first spring means being substantially that of the oscillating frequency of said oscillating mass.

14. A mechanism for synchronously operating a movable contact into and out of engagement with a fixed contact; said movable contact being movable between an engaged and a disengaged position with respect to said fixed contact; said mechanism including a motor having an output eccentric shaft, an oscillating mass and a first and second spring means; said first spring means being constructed to operatively support said oscillating mass from a relatively stationary body for linear oscillating motion, said second spring means being constructed to operatively connect said output eccentric shaft to oscillating mass; the operative connection between said oscillating mass and said eccentric shaft being constructed to transmit linear oscillating motion to said oscillating mass responsive to rotary motion of said eccentric shaft; said oscillating mass being positioned to move said movable contact to the engaged position responsive to linear motion thereof in said first direction, said movable contact being moved to said disengaged position responsive to motion of said oscillating mass in said second direction; the operative support of said oscillating mass from said stationary body by said spring means being incapable of transmitting shock waves between said oscillating mass and said stationary body.

15. A mechanism for synchronously operating a movable contact into and out of engagement with a fixed contact; said movable contact being movable between an engaged and a disengaged position with respect to said fixed contact, said mechanism including a motor having an output eccentric shaft, an oscillating mass and a first and second spring means; said first spring means being constructed to operatively support said oscillating mass from a relatively stationary body for linear oscillating motion, said second spring means being constructed to operatively connect said output eccentric shaft to oscillating mass; the operative connection between said oscillating mass and said eccentric shaft being constructed to transmit linear oscillating motion to said oscillating mass responsive to rotary motion of said eccentric shaft; the operative connection between said eccentric shaft and said oscillating mass being a bearing assembly, the rotating elements of said bearing assembly being rotated through 360°; said oscillating mass being positioned to move said movable contact to the engaged position responsive to linear motion thereof in said first direction, said movable contact being moved to said disengaged position responsive to motion of said oscillating mass in said second direction.

16. A mechanism for synchronously operating a movable contact into and out of engagement with a fixed contact; said movable contact being movable between an engaged and a disengaged position with respect to said fixed contact; said mechanism including a motor having an output eccentric shaft, an oscillating mass and a first, second, third and fourth leaf spring; said first and second leaf spring lying in parallel planes and constructed to support said oscillating mass at a first and second point from a relatively stationary body for linear oscillating motion; said third and fourth leaf springs lying in parallel planes and constructed to operatively connect said output eccentric shaft to a third and fourth point on said oscillating mass; the operative connection between said oscillating mass and said eccentric shaft being constructed to transmit linear oscillating motion to said oscillating mass responsive to rotary motion of said eccentric shaft; said oscillating mass being positioned to move said movable contact to the engaged position responsive to linear motion thereof in said first direction, said movable contact being moved to said disengaged position responsive to motion of said oscillating mass in said second direction; the direction of flexing of said third and fourth leaf springs being parallel to the direction of linear motion of said oscillating mass, shock waves thereby being incapable of transmission between said stationary body and said oscillating mass; the planes of said first and second leaf springs being substantially perpendicular to the planes of said third and fourth leaf springs, the direction of flexing of said third and fourth leaf springs being perpendicular to the linear motion performed by said oscillating mass.

17. A mechanism for operating a pair of cooperable contacts into and out of engagement, said contacts being biased to the engaged position; said mechanism including a driving means, a push rod, supporting spring means and a relatively stationary body for supporting said supporting spring means; said driving means being operatively connected to said push rod to impart linear oscillatory motion to said push rod; a portion of said push rod being positioned to engage one of said pair of cooperable contacts when moved in a first direction along its oscillatory path to effect contact disengagement between said cooperable contacts, said push rod being operatively connected to said supporting spring means; said supporting spring means being constructed to isolate mechanical shock due to the engagement of said push rod and said one of said pair of cooperable contacts from at least said relatively stationary body.

18. A mechanism for synchronously operating a movable contact into and out of engagement with a fixed contact; said movable contact being movable between an en-

gaged and disengaged position with respect to said fixed contact; said mechanism including driving means, a first spring, a second spring and a push rod; said first spring being constructed to support said push rod from a relatively stationary support whereby said push rod is linearly movable with respect to said relatively stationary body in a first and second direction; said push rod being positioned to move said movable contact to the engaged position responsive to linear motion thereof in said first direction, said movable contact being moved to said disengaged position responsive to motion of said push rod in said second direction; said driving means being operatively connected to said push rod; said operative connection being constructed to impart said linear oscillating motion to said

push rod; said second spring being included in said operative connection between said driving means and said push rod whereby said driving means imparts linear oscillating force for said push rod to said second spring in a direction substantially perpendicular to the direction of maximum flexibility of said second spring.

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