Oct. 6, 1970 H. A. FOHRHALTZ 3,532,842

SWITCH ACTUATING AND CONTROL MECHANISM FOR VACUUM TYPE ELECTRIC CIRCUIT INTERRUPTERS WITH LOST-MOTION AND BELLOWS BIASING MEANS

Filed Aug. 5, 1966

4 Sheets-Sheet 1

Fig. 1.

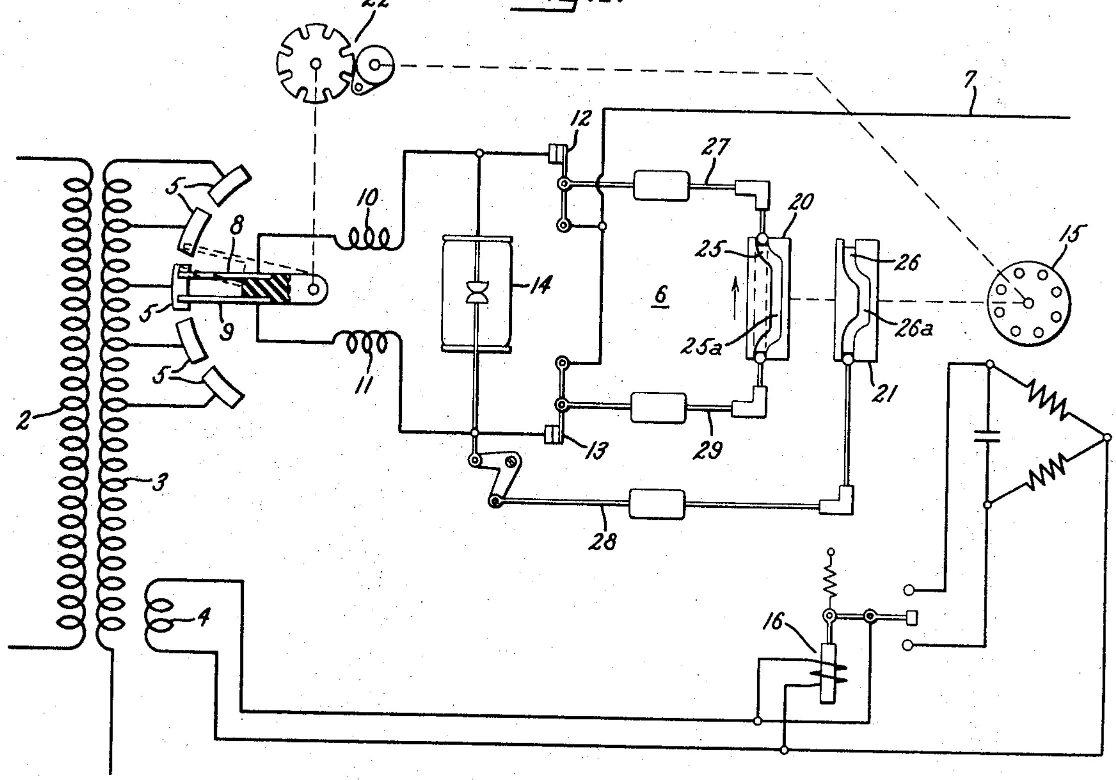

Fig. 5.

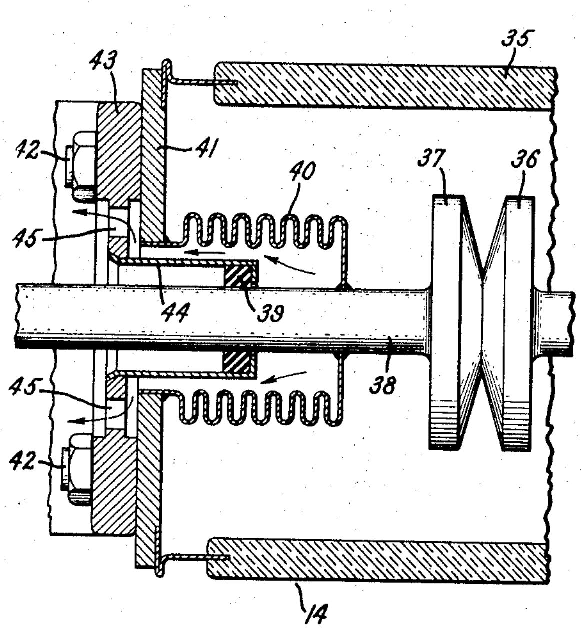

Fig. 6.

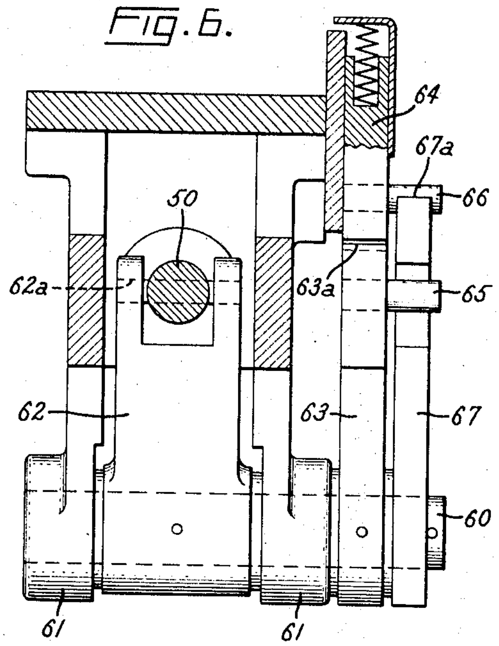

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FIG. 2.

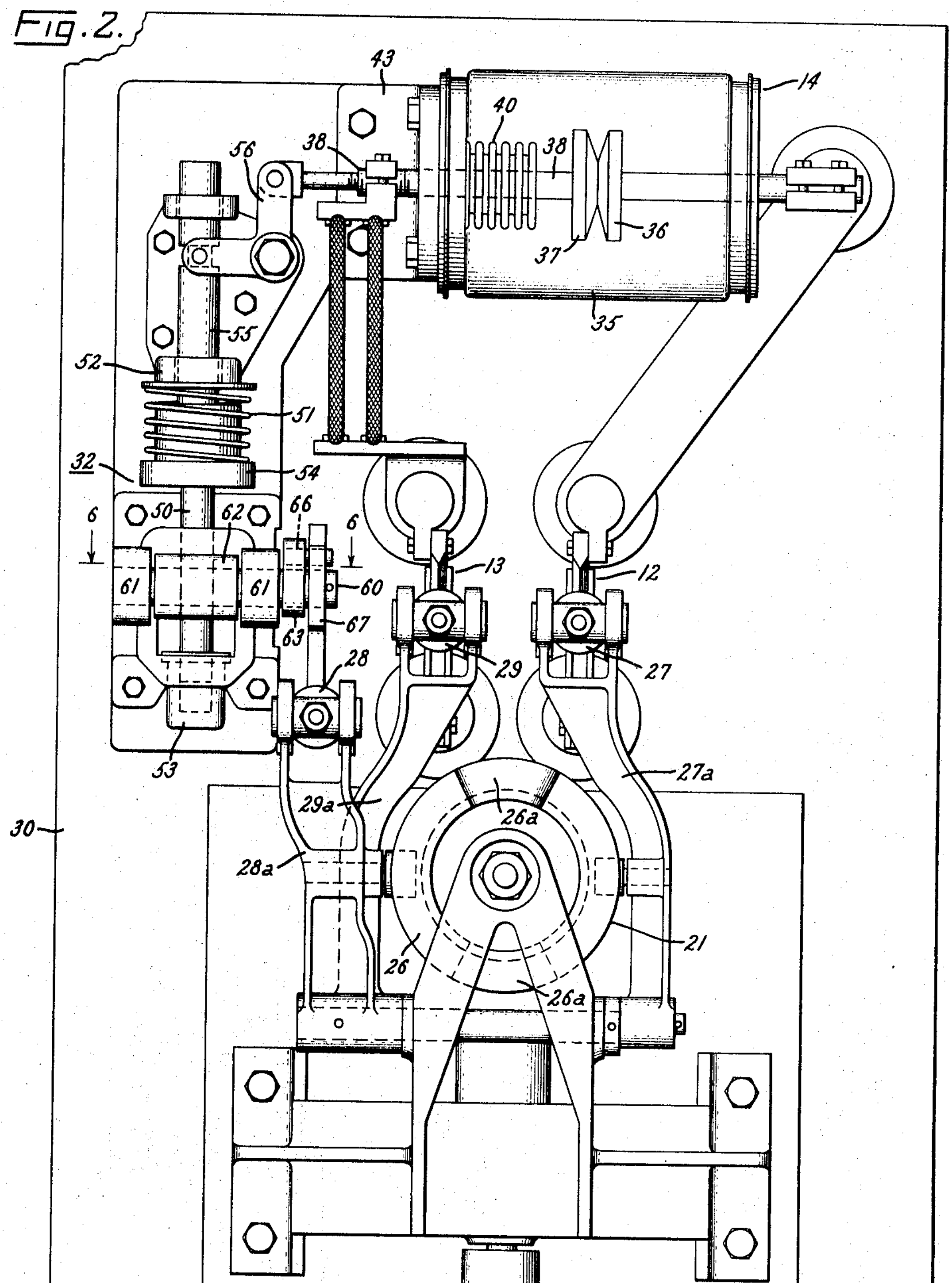

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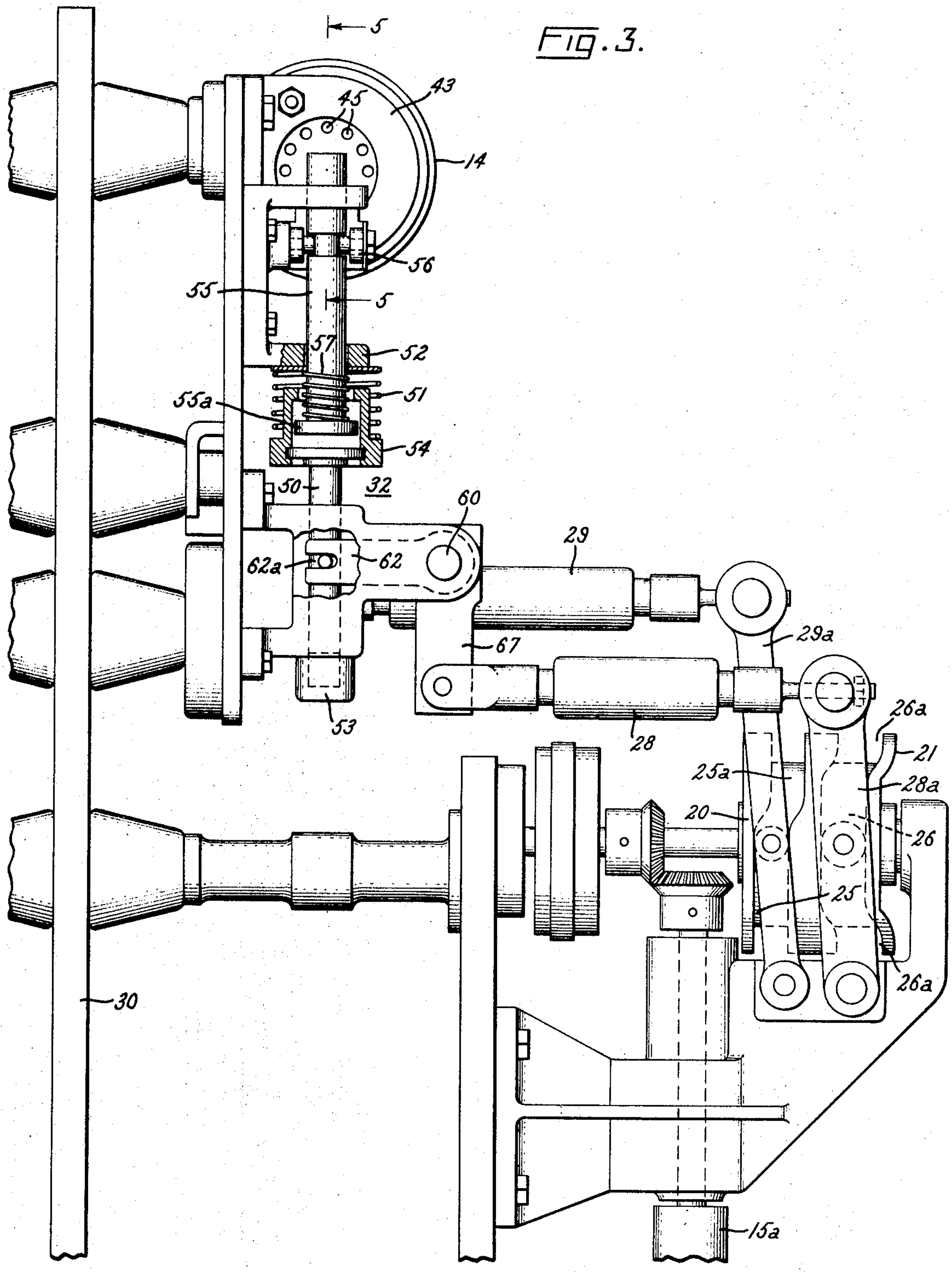
Fig. 3.



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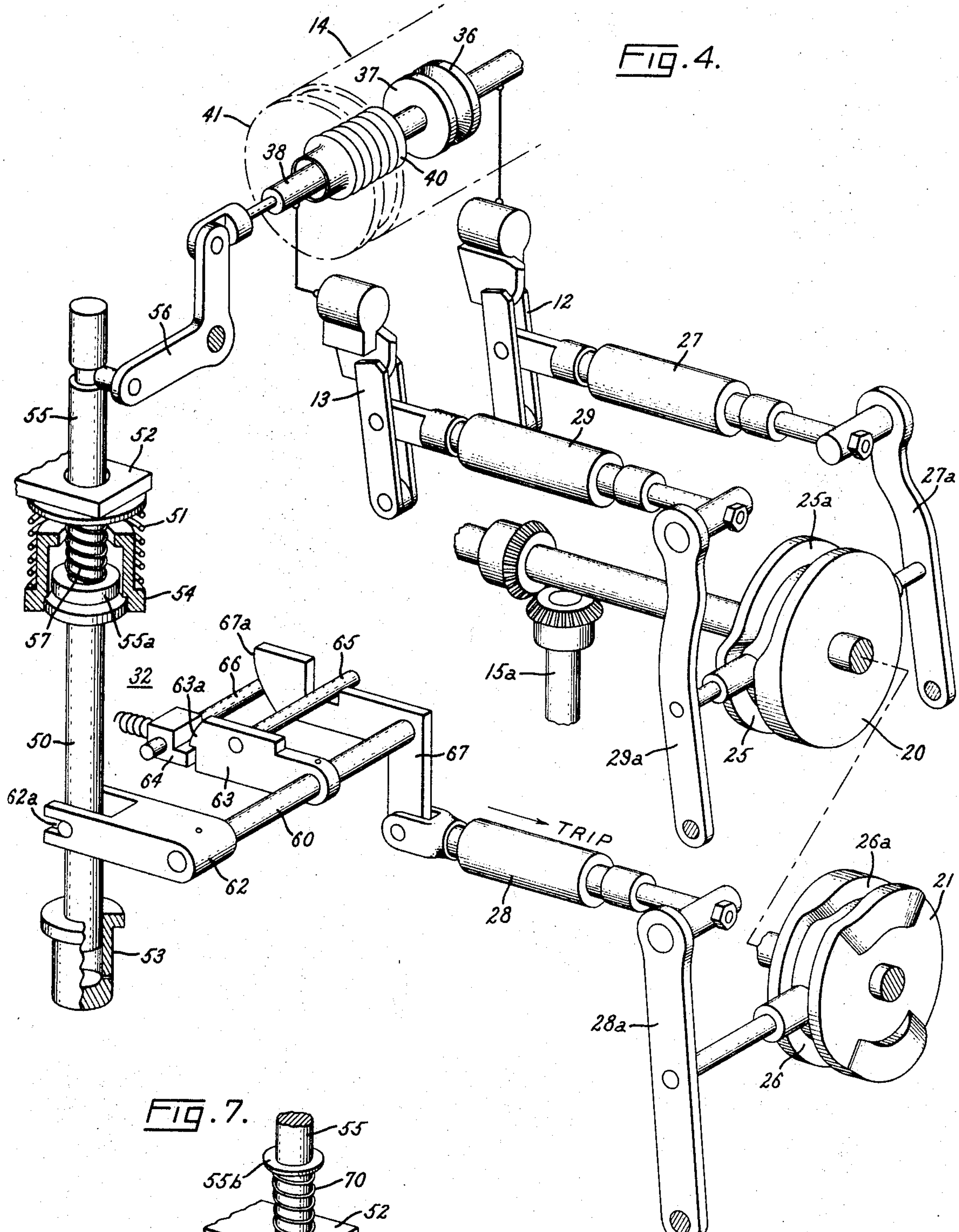

Fig. 4.

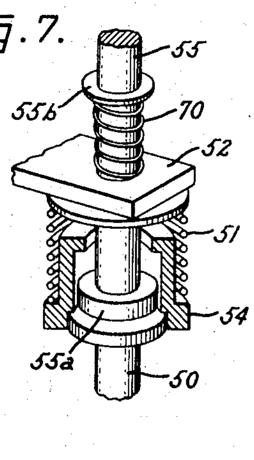

Fig. 7.

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SWITCH ACTUATING AND CONTROL MECHANISM FOR VACUUM TYPE ELECTRIC CIRCUIT INTERRUPTERS WITH LOST-MOTION AND BELLOWS BIASING MEANS

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Int. Cl. H01h 33/66
U.S. Cl. 200—144 5 Claims

ABSTRACT OF THE DISCLOSURE

The application discloses an improved switch actuating mechanism having discrete controlled opening and closing speeds especially applicable to the operation of vacuum interrupting devices biased to circuit closing position. Preferably the movable contact member of the vacuum interrupter is fixed to a flexible portion of the vacuum interrupter envelope, and is biased to circuit closing position by differential pressure. A switch actuating member biased to contact opening position by a strong operating spring is loosely coupled to the movable contact member through a lost-motion connection which permits overtravel of the actuating member in its contact-closing direction. In switch opening operation the overtravel of the switch actuating member permits rapid contact opening by impact of the switch actuating member against the movable switch member. In reclosing operation the closing bias of the movable switch member and positive drive of the switch actuating member acts to restrain the movable switch member to a desired relatively slow reclosing speed. For operation of the vacuum interrupting device under oil or other liquid, pressure relief passages are provided to permit egress of the liquid from the bellows and thus limit stress on the bellows in rapid switch-opening operation.

My invention relates to switch actuating and control mechanism particularly applicable to vaccum type electric circuit interrupters. This improved mechanism is suitable for operation totally immersed in dielectric liquid and is therefore especially useful with vacuum interrupters used as arcing contact devices in transformer load tap changing apparatus.

Stepping-contact type load tap changers for large liquid-immersed electric power transformers, reactors and the like ordinarily include an arcing duty current interrupting switch which is typically located in a separate air or liquid-filled compartment to avoid contamination of the main body of transformer liquid. To accommodate the mechanical interconnection of the arcing switch with the stepping contacts and other switches in a tap-changing apparatus, it has therefore been customary to locate the entire tap-changing apparatus in the separate compartment.

It is desirable for several reasons to utilize a vacuum type interrupter as the arcing duty switch in a load tap changer. In high voltage apparatus where the tap changing contacts must be immersed in dielectric fluid, it is possible to locate the entire tap-changing apparatus directly within the main tank and immersed in the main body of oil or other dielectric fluid. It is, therefore, possible to avoid the considerable expense of a separate fluid-filled tank and numerous tap connections between this and the main tank. In lower voltage apparatus where liquid immersion of the tap changer is not necessary, the same apparatus can be used inside or outside the main tank as other design parameters may suggest.

Transformer load tap-changing apparatus, especially

when automatically controlled for voltage or current regulation, is called upon to perform its operation at a high repetition rate. A vacuum type arc interrupter used in such apparatus therefore operates very frequently and must have an operating life measured in many thousands, and preferably millions, of switching operations. When such a vacuum interrupting device is located in the main tank of liquid-immersed transformer or the like, it is especially important that the device function dependably over a long period of time because of the difficulty and expense of exposing it for maintenance.

To ensure long operating life of a vacuum operating device, it is essential that the opening and closing speeds of its contacts be carefully controlled to minimize arcing, and that the switch parts be protected from high mechanical stress to avoid fatigue of the metal parts. Proper contact operating speed presents an additional problem in that opening speed must be relatively high to ensure current interruption at the first current zero with minimum arcing, while contact closing speed must be considerably lower to avoid contact bounce and needless arcing. Another problem related to frequency and speed of contact operation arises from the usual use of an expansible metallic bellows to mount and seal the movable contact in a vacuum interrupting device. Where operating duty is highly repetitive, it is particularly important that this bellows be protected from high stress in operation. This problem is particularly acute when the interrupter is operated in a liquid-immersed location. When an incompressible ambient liquid fills the interior of the bellows, high speed operation may be limited and the bellows may be overstressed by the pressures created.

Accordingly it is a principal object of my invention to provide improved contact actuating and control means for a vacuum type electric circuit interrupting device designed to provide long operating life and thereby to facilitate utilization in liquid-immersed locations and other locations not readily accessible.

It is another object of my invention to provide a vacuum interrupting device and operating mechanism therefore especially adapted for use as an oil-immersed arcing duty switch in transformer tap-changing under load apparatus.

Still another object of my invention is to provide contact actuating and control apparatus for a vacuum type circuit interrupting device designed to minimize stress on the switch parts and predetermine opening and closing speeds of the contacts whether the ambient medium be gaseous or liquid.

A still further object of the invention is to provide a switch actuating mechanism operable by a reversible operating member to open a pair of cooperating switch contacts at high speed and reclose at slow speed irresponsive of the direction of movement of the reversible operating member.

In carrying out my invention in one preferred embodiment, I locate a vacuum type circuit interrupting device under oil in a transformer housing and connect it as an arcing duty switch for actuation in proper sequence by a reversible tap-changing motor. A reversible switch operating cam driven by the motor moves a switch operating rod in one direction to open the vacuum interrupter and in the opposite direction to reclose. A movable switch actuating member spring-pressed to circuit opening position is connected to the movable switch contact by a lost-motion linkage and normally latched in an overtravel position beyond its circuit closing position. The movable switch contact itself is biased to closed position to follow the switch actuating member in closing movement but its bias is overcome by the actuating spring. In opening operation, therefore, unlatching of the actuating member resulting from movement of the operating cam in either direction releases the actuating spring to open the contacts rapidly by impact action at the end of overtravel movement of the switch member. In closing operation the movable contact is returned to engaged position at a predetermined slower rate determined by positive drive of the actuating member to latching position. To facilitate contact opening operation at predetermined high speed without unduly stressing the expansible metallic bellows in the interrupting device, especially when operated in an oil-immersed location, I provide a metering orifice of ample size which, if desired can be calculated to control the bellows by dashpot action.

My invention will be more fully understood and its various objects and advantages further appreciated by referring now to the following detailed specification taken in conjunction with the accompanying drawing wherein:

FIG. 1 is a schematic circuit diagram of a transformer load tap-changing apparatus including a vacuum type arc interrupting switch.

FIG. 2 is a front elevational view of a cam-operated vacuum interrupting switch suitable for use in the circuit location shown at FIG. 1 and including lost-motion switch actuating and control mechanism embodying my invention.

FIG. 3 is a side elevational view of the cam-operated vacuum interrupting device and actuating mechanism shown at FIG. 2.

FIG. 4 is an exploded perspective view of the switch apparatus shown in FIGS. 2 and 3.

FIG. 5 is a fragmentary cross-sectional view of the vacuum interrupting device and its mounting, taken along the line 5—5 of FIG. 3 and showing particularly the movable contact mounting.

FIG. 6 is a cross-sectional view of the latching mechanism taken along the line 6—6 of FIG. 2, and

FIG. 7 is a fragmentary perspective view of a modified form of the switch actuating mechanism shown at FIGS. 2, 3 and 4.

Referring now to the drawing, I have shown at FIG. 1 a schematic circuit diagram of a transformer load tap changing apparatus of a type to which my improved switching apparatus is especially adapted. The transformer itself comprises a pair of main windings **2**, **3** and an auxiliary control power winding **4**, all of which are inductively coupled and preferably immersed in a dielectric fluid such as oil or askarel. The main winding **3** is provided with a plurality of selectable voltage taps each having a tap terminal contact **5**. A selected one of the tap terminals **5** is adapted to be connected through a load tap-charging apparatus **6** to a line conductor **7**.

The load tap-changing apparatus designated generally by the reference numeral **6** includes a pair of contact fingers **8**, **9** of a double finger non-arcing duty tap selector switch movable in step-by-step manner along the tap contacts **5**, a pair of current limiting reactors **10**, **11** associated respectively with the contact fingers **8** and **9**, a pair of non-arcing duty transfer switches **12** and **13**, and a vacuum type arc interrupting switch **14**. A reversible cycle timer including a driving motor **15** is provided for controlling the operation of the foregoing transfer, interrupting and selector switches. The motor **15** is controlled by a voltage regulating relay **16**, and the entire apparatus except the voltage regulating relay is preferably immersed in the main body of dielectric fluid surrounding the transformer windings **2** and **3**.

The tap selector circuit of the apparatus **6** is of a well-known type and is similar to that illustrated in Pat. 3,206,580—McCarty. The circuit provides two parallel current paths, or branch circuits, between any selected tap terminal **5** and the line conductor **7**, each parallel path including one of the tap selector fingers **8**, **9** in series with one of the reactors **10**, **11** and one of the transfer switches **12**, **13**. The arcing duty vacuum interrupting device **14** is connected between the parallel branch circuits with the transfer switches **12**, **13** in series circuit relation directly across the arcing contacts of the vacuum switch.

The timing motor **15** is selectably operable in either direction under the control of the voltage regualting relay **16** to effect sequential stepping movement of the tap selector fingers **8**, **9** progressively in either direction along the group of transformer tap terminals **5**. The reversible timing motor **15** drives a switch operating cam **20** coupled to actuate the transfer switches **12**, **13**, a switch operating cam **21** coupled to actuate the arcing duty vacuum switch **14**, and intermittent motion transmitting device, such as a Geneva gear **22**, coupled to actuate the selector fingers **8**, **9**. The switch operating cams **20**, **21** and the Geneva gear **22** for the tap selector fingers are arranged to actuate the selector fingers and the several switches in appropriate sequential relation in any cycle of tap changing movement. The cam **20** has a circumferential cam slot **25** having a single axially offset section **25*a*** as shown at FIG. 1. The cam **21** has a circumferential cam slot **26** provided at diametrically opposite points with axially offset sections **26*a*** (FIGS. 2 and 4) only one of which is shown at FIG. 1. The slot sections **26*a*** are angularly shorter than the slot section **25*a***, and one is centrally located with respect to slot section **25*a***.

A typical single cycle of operation of the tap-changing apparatus described above is as follows. If the cycle timing motor **15** is energized for operation in either direction through the voltage regulating relay **16**, one of the selector switches **12**, **13** is first opened while the other remains closed. Assuming rotation of the cams **20**, **21** in the direction indicated by the arrow, it is evident that a cam follower rod **27** first opens the transfer switch **12** thereby to transfer the branch circuit through the selector finger **8** from the switch **12** to the vacuum interrupting device **14**. Thereafter the cam **21** (through its diametrically opposite offset sections **26*a***) actuates a cam follower rod **28** to open the vacuum interrupting device **14**. With the circuit through the selector finger **8** thus interrupted, the Geneva gear **22** moves the double finger ratio adjuster switch **8**, **9** to the dotted position shown with the contact finger **9** remaining on the original tap terminal **5** and the contact finger **8** on the next adjacent tap terminal **5**. Continued rotation of the cam **21** next recloses the vacuum interrupting device **14** and further rotation of cam **20** closes the transfer switch **12** and thereafter actuates a cam follower **29** to open the transfer switch **13**. Following opening of the transfer switch **13** the cam **21** again opens the vacuum interrupting device **14** to interrupt the branch circuit through the selector finger **9**, and the Geneva gear **22** then moves the double finger selector switch to a position where both fingers **8** and **9** are again on a common tap terminal one position beyond that at which the transfer cycle was begun. To complete the transfer cycle, continued rotation of the cam **20** and **21** next reclose the vaccum interrupting switch **14** and thereafter reclose the transfer switch **13**.

At FIGS. 2, 3 annd 4 I have shown a structural arrangement of the switch operating cams **20**, **21**, the transfer switches **12**, **13** and the vacuum interrupting device **14** mounted upon a common supporting base **30** in combination with an actuating and control mechanism for the interrupting device **14** which embodies my invention. Referring now to these figures, the cams **20** and **21** are driven through suitable gearing from a motor shaft **15*a*** coupled to the motor **15** (not shown) and are provided with circumferential cam slots **25** and **26**, respectively, axially offset in the manner previously described. The cam **20** is coupled to actuate both of the transfer switches **12**, **13** through the operating rods **27** and **29**, respectively, and associated cam follower levers **27*a*** and **29*a***, respectively. The operating cam **21** is connected by means of the operating rod **28** and a cam follower lever **28*a*** to control a vacuum switch actuating mechanism designated generally by the reference numeral **32**.

The vacuum interrupting device **14** is illustrated generally at FIGS. 2, 3 and 4 in greater detail at FIG. 5. This device comprises a cylindrical evacuated envelope **35** containing a fixed contact member **36** and a movable contact member **37** carried by a slidable contact rod **38**. The rod **38** is mounted in a suitable slide bearing **39** shown at FIG. 5. The movable contact rod **38** is sealed to the evacuated envelope **35** by means of a deformable wall portion of the envelope shown as an expansible metallic bellows **40**. The bellows **40** is mounted at its fixed end upon a metallic plate **41** forming a one end closure of the envelope **35** and the movable end of the bellows is sealed to the contact rod **38**. The end plate **41** is centrally apertured and the aperture is closed by the bellows **40** with the bellows on the inner side of the end plate. The bellows being thus re-entrantly positioned, its interior is open to ambient fluid surrounding the switch **14**.

The vacuum interrupter end plate **41** is provided with several studs **42** by means of which the switch **14** is bolted to a mounting plate **43** attached to the supporting panel **30**. The moving contact bearing **39** is carried by an inwardly extending cylindrical projection **44** fixed to the mounting plate **43** and extending into the bellows **40** with appreciable clearance between the bearing projection **44** and the central aperture of the end plate **41**. The mounting plate **43** is provided with a plurality of apertures **45** located peripherally about the movable switch rod **38** to provide free flow of ambient fluid into and out of the interior of the bellows **40**.

It is evident that the apertures **45** in the mounting plate **43** serve as metering orifices for controlling the flow of fluid into and out of the bellows as the bellows **40** is expanded or contracted by contact movement. Preferably the orifices **45** provide relatively little resistance to the ingress or egress of an ambient liquid and thus permit high speed collapse or expansion of the bellows in switching operation without unduly stressing the bellows. While the orifice **45** are thus of sufficient size to limit pressure stresses in the bellows **40**, it is evident that by precise control of the area of these orifices for operation in any predetermined ambient fluid, the orifices may be utilized to produce a controlled dashpot action of the bellows and thus to regulate its speed of movement under certain circumstances. In my preferred switch actuating mechanism the desired high opening speed of the vacuum interrupting device is attained by a spring drive and dashpot action of the orifices **45** cooperating to limit pressure upon the bellows. The desired slower contact closing speed is produced by positive mechanical drive but, being slower, does not overstress the bellows.

As illustrated at FIGS. 2, 3 and 4, the actuating linkage <u>32</u> interposed between the vacuum interrupting device **14** and its operating cam **21** is centered around a movable switch actuating member **50** shown as an axially slidable rod. The actuating rod **50** is biased to its circuit opening position by means of a strong compression spring **51** interposed between the rod and a fixed mounting bracket **52** and is provided at its lower end with a dashpot **53** to cushion the end of its spring actuated movement. The actuating member, or rod, **50** is loosely connected through a limited lost-motion coupling to the movable contact rod **38** of the vacuum interrupter **14** and is thus capable of limited overtravel movement with respect to the movable contact member **38**. The limited lost-motion coupling comprises a cup-like cage **54** fixed to the upper end of the rod **50** and a slidable rod **55** axially aligned with the rod **50** and having a shouldered lower end **55*a*** extending into the cage **54** for relative movement with respect thereto. The rod **55**, being coupled to the movable contact rod **38** through a bell crank lever **56** and thus movable in fixed synchronous relation with respect to the movable contact, may be referred to generally as a movable switch member. The relatively movable switch actuating rod **50** is coupled to the operating cam **21** through a positive drive and latch release mechanism to be described hereinafter.

Before examining the latch and drive mechanism for the actuating rod **50**, it should be noted that the movable vacuum interrupter contact rod **38** and the connected bell crank lever and switch member **55** are all biased to contact closing position by the differential pressure exerted upon the switch bellows **40**, one end of which is sealed to the switch rod **38**. It will be understood of course that the actuating spring **51** acting upon the actuating member **50** is sufficiently strong to overcome the contact closing bias exerted by the bellows **40**. In the embodiment of my invention illustrated at FIGS. 2, 3 and 4, I have shown in addition to these opening and closing bias forces a relatively weak compression spring **57** interposed between the fixed bracket **52** and the headed end **55*a*** of the switch rod **55**. This compression spring **51** serves to oppose, but normally not to overcome, the closing bias of the bellows **40**. The purpose of the spring **57** is to serve as a push-off spring to separate the vacuum interrupter contacts **36** and **37** without movement of the actuating member **50** in the event that differential pressure on the bellows **40** is significantly reduced by loss of vacuum in the device **14**. The pushoff spring **57** is not essential to the operation of my invention but is useful primarily in the loss of vacuum arrangement briefly described. Such an arrangement is the subject matter of a co-pending application Ser. No. 570,484 filed by O. P. McCarty and F. S. Urbanek on Aug. 5, 1966, and now issued as U.S. Letters Patent 3,472,981.

The latch release and relatching drive mechanism for the switch actuating rod **50** is best illustrated at FIGS. 4 and 6. This mechanism comprises a rocket shaft **60** having a pair of radial arms **62** and **63** and pivotally mounted in spaced-apart bearings **61** carried by the supporting panel **30**. The arms **62** and **63** are fixed to the shaft **60** and, therefore, move in fixed relation to each other. The radial arm **62** is connected in positive driving relation to the actuating rod **50** by means of a pin and slot connection **62*a***, while the radial arm **63** is provided at its outer end with the latching shoulder **63*a*** cooperable with a spring-pressed latch detent **64**. The latching arm **63** and the latch detent **64** are provided, respectively, with laterally extending fingers **65** and **66** parallel to each other and to the rocker shaft **60**. A bell crank lever **67** having one end coupled to the cam follower rod **28** is rotatably mounted upon the shaft **60** and disposed at its opposite end to cooperatively engage the latch arm and detent fingers **65** and **66** respectively.

As most clearly illustrated at FIG. 4, the bell crank lever **67** forms a one-way driving connection with the latch finger **65** so that when the bell crank **67** is moved in driving relation with the finger **65** the latch arm **63** and connected driving arm **62** are moved upwardly (as viewed at FIG. 4) to drive the switch actuating rod **50** vertically upward against the bias of the spring **51** and bring the latch finger **63** in latching relation with the detent **64**. In addition, the bell crank lever **67** is provided at its outer upper end with a cam surface **67*a*** engaging the detent finger **66** so that when the bell crank lever **67** is rotated in the opposite direction (counterclockwise as viewed at FIG. 4), the latching detent **64** is moved toward latch-releasing position while the bell crank lever **67** moves independently of the rocker shaft **60** and its connected radial arms **62** and **63**. It will be evident that when the cam surface **67*a*** acting upon detent finger **66** releases the mechanical latch **63*a***, **64**, the latching arm **63** and driving arm **62** are released for sudden downward movement under the driving action of the actuating spring **51** acting upon actuating rod **50**.

The mode of operation of my improved switch actuating and control mechanism will now be evident from the following brief description of a typical contact-opening and reclosing sequence for the vacuum interrupting device **14**. Referring particularly to the perspective view at FIG.

4, the mechanism is shown in its circuit-closing position with the mechanical latch **63***a*, **64** engaged to hold the actuating rod **50** in its circuit closing position against the bias of the actuating spring **51**. The movable switch member, or rod, **55** and connected contact rod **38** are in circuit-closing position as a result of the contact closing bias exerted by the switch bellows **40**.

To separate the contacts of the vacuum interrupting device **14**, the operating cam **21** is rotated either clockwise or counterclockwise and in either event the cam follower lever **28***a* is moved in a clockwise direction (FIGS. 3 and 4) to move the operating rod **28** in the trip direction indication on the drawing at FIG. 4. The bell crank lever **67** is accordingly moved in a counterclockwise direction independently of the latch arm **63** and driving arm **62**, but in so moving the cam surface **67***a* drives the latch detent **64** toward releasing position. When the latch **63***a*, **64** is released, the actuating rod **50** is suddenly released and driven rapidly downward under the action of the actuating spring **51**. After a limited amount of free travel the rod **50**, through the cage **54**, engages the shouldered switch rod **55**, **55***a* with a hammer blow and drives the movable contact rod **38** to open position at high speed.

Movement of the moving contact rod **38** to contact opening position is opposed by the ambient fluid, which may be a dielectric liquid, trapped within the bellows **40**. As previously explained the exhaust orifices **45** in the switch mounting plate **43** (FIG. 5) are so proportioned that this fluid will be exhausted from the bellows at the desired rate without imposing excessive stress upon the bellows. By properly proportioning the size of these orifices and the force of the actuating spring **51**, the speed desired of opening and limited fluid pressure may be attained.

As previously explained, it is desirable to reclose the vacuum interrupter contacts **36**, **37** at a speed less than the speed of opening. For this purpose a positive reclosing drive is provided through the bell crank lever **67**, the driving arm **62** and the switch actuating rod **50**. The speed of this reclosing movement is positively controlled by the speed of rotation of the operating cam **21** and the configuration of the cam slot **26**. In such reclosing movement the cam follower lever **28***a* is positively moved in a counterclockwise direction by the cam **21** and positively moves the bell crank lever **67** in a clockwise direction. In so moving, the lever **67** releases the latch detent **64** for return to its latching position and positively engages finger **65** to drive the latch arm **63** and the driving arm **62** upward. When the driving arm **62** is thus positively driven upward at controlled speed, the actuating rod **50** is similarly moved upward. During the initial portion of this movement the shouldered switch member **55** is restrained against its contact closing bias by engagement with the upper portion of the cage **54** and is thus allowed to move toward closing position only so rapidly as the actuating rod **50** is moved. When the vacuum interrupter contacts come into engagement, upward movement of the switch member or rod **55** ceases and the actuating rod **50**, due to its lost motion cage connection with the rod **55**, continues to move upward in an overtravel portion of its motion to the latching position shown at FIG. 4.

It will be understood by those skilled in the art that in the contact-closing movement described immediately above, the movable switch member **55** and connected moving contact member will move upward in following relation with the actuating rod **50** only if the closing bias on the moving contact member and switch rod **55** is sufficient to move these members at at least the reclosing speed of the actuating rod **50**. Since it is desired that such following relationship shall be maintained in order that the reclosing speed may be positively determined, it may be desirable to provide additional closing bias beyond that inherently provided by the differential pressure on the interrupter bellows **40**. For this purpose an additional closing spring may be provided as shown at FIG. 7. In that figure the movable switch rod **55** is provided with an additional shoulder **55***b* and a compression spring **70** is positioned between that shoulder and the fixed bracket **52**. It will of course be understood that in providing any such additional closing bias it is necessary that the opening force of the actuating spring **51** be considerably larger than the total closing bias applied to the movable switch member so that in opening operation the actuating spring **51** will positively overpower the total closing bias of the contact member.

It will now be understood that while I have illustrated a preferred embodiment of my invention by way of example, various modifications will occur to those skilled in the art. I, therefore, wish to have it understood that I intend in the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

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

1. Electric switching apparatus comprising a vacuum type electric circuit interrupter having fixed and movable contact members mounted for closing and opening operation within an evacuated envelope, said envelope including a deformable wall portion sealed to said movable contact member and acting by differential pressure to bias said movable contact member to contact-closing position, said differential pressure constituting at least a major portion of a net closing bias normally constantly acting upon said movable contact member, a movable switch actuating member, lost-motion means loosely coupling said switch actuating member to said movable contact member for limited relative movement, said switch actuating member being movable from contact-opening position to contact-closing position with said movable contact member in following engagement under the influence of its closing bias and said lost-motion means permitting further movement of said switch actuating member in its contact-closing direction to an overtravel position, releasable mechanical latch means engaging and holding said switch actuating member in said overtravel position, an actuating spring connected to move said switch actuating member at high speed from said overtravel position to its contact-opening position against the closing bias of said movable contact member, said lost-motion means providing sudden impact to said movable contact member in contact-opening movement, and driving means positively connected to move said switch actuating member from its contact-opening position to said overtravel position at a predetermined speed sufficiently low to permit following engagement of said movable contact member to the limit of its contact closing movement.

2. A switching apparatus according to claim **1** wherein said driving means includes a driving member positively engaging said switch actuating member in one direction of movement and reversibly movable independently of said switch actuating member to release said mechanical latch means.

3. The combination with a switching apparatus according to claim **2** of a rotatable operating member movable in either direction from a predetermined rest position to actuate said driving member in one predetermined direction of movement and thereafter to reversely actuate said driving member in continued rotation toward said rest position.

4. A switching apparatus according to claim **1** in which said driving means includes a pivotally mounted latch member positively connected to said switch actuating member and having a portion engaging said releasable latch means, a pivotally mounted driving member movable in one direction to engage and drive said latch member to latching position and movable in the opposite direction independently of said latch member, said driv-

ing member including cam means operable in said opposite direction of movement to engage and release said latch means.

5. A switching apparatus according to claim 1 wherein a push-off spring normally overcome by said differential pressure is connected to bias said movable contact member to circuit-opening position upon significant reduction of said differential pressure.

References Cited

UNITED STATES PATENTS

2,472,625	6/1949	Smith	200—144.2 X
2,838,636	6/1958	Schwager	200—144.2 X
3,038,980	6/1962	Lee	200—144.2
3,159,731	12/1964	Luebring	200—144.2
3,206,580	9/1965	McCarty	200—144.2
3,250,880	5/1966	Jennings	200—144.2 X
3,267,247	8/1966	Ross	200—144.2 X
3,383,484	5/1968	Arp et al.	200—83.1
3,399,286	8/1968	Kerr	200—144.2
3,319,121	5/1967	Lee	200—144.2
3,025,375	3/1962	Frank	200—144.2

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