Feb. 27, 1962 JO EMMETT JENNINGS 3,023,290

RELAY

Filed Aug. 18, 1958 2 Sheets-Sheet 1

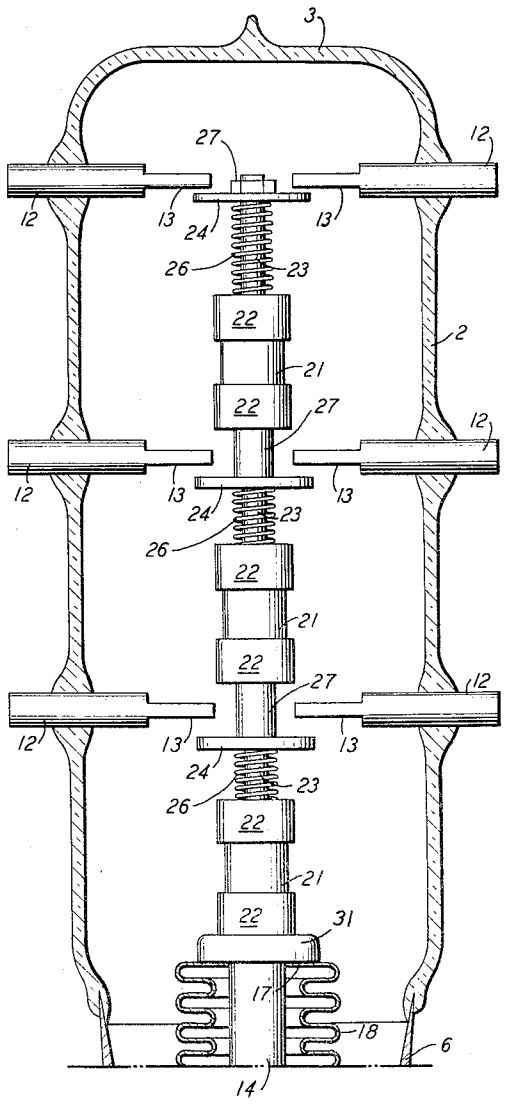


Fig. 1

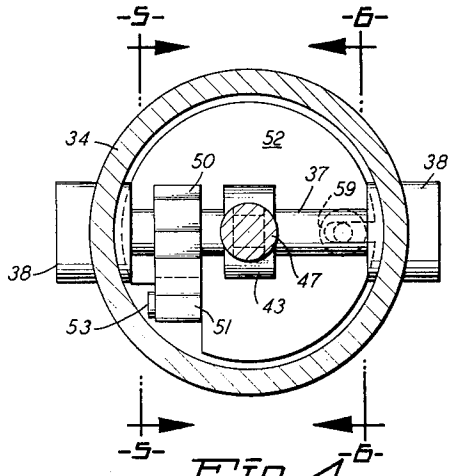


Fig. 4

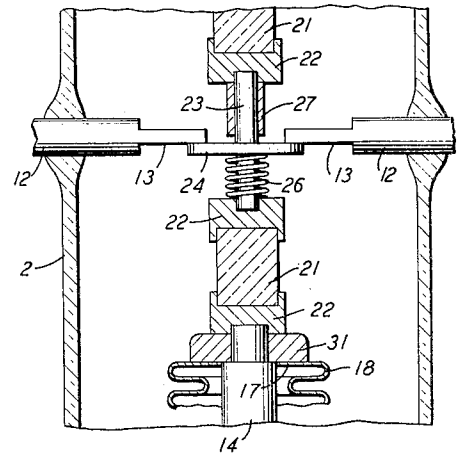


Fig. 3

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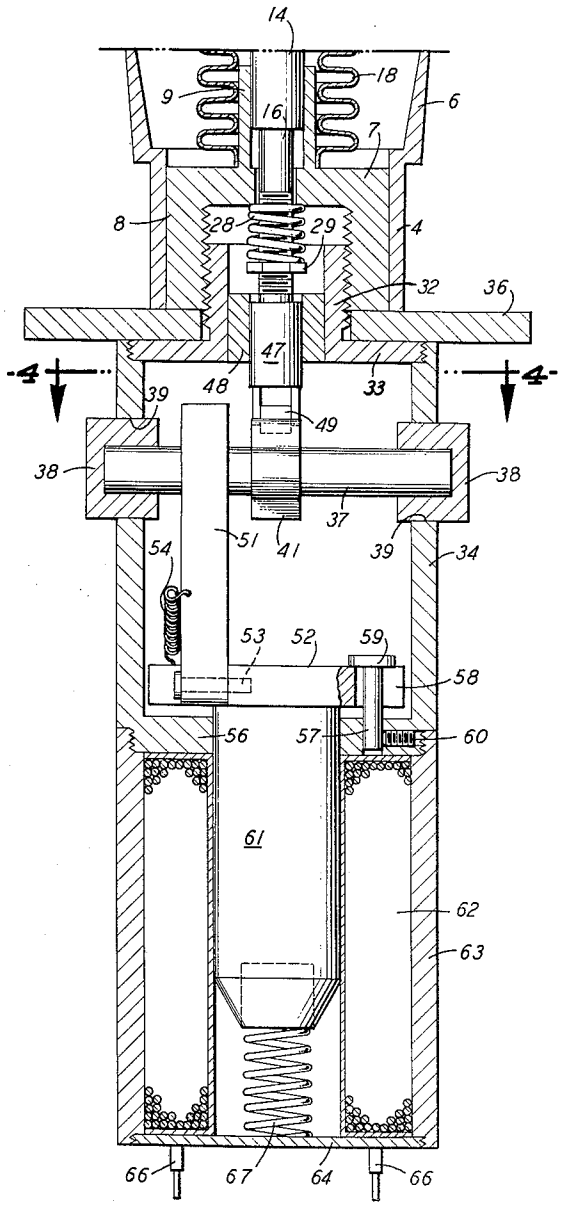


Fig_2

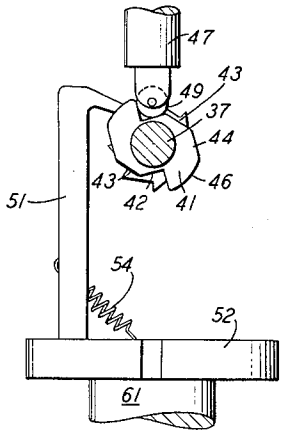


Fig_6

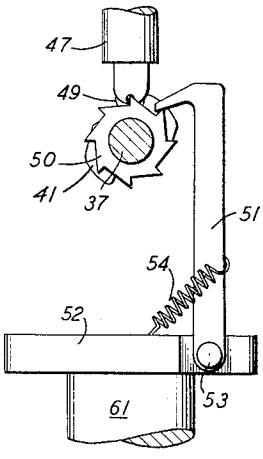


Fig_5

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RELAY

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5 Claims. (Cl. 200—144)

My invention relates to relays, and particularly to a single-pole, multiple-position remotely controllable relay.

One of the objects of the invention is the provision of a single-pole relay operable to sequentially energize a multiplicity of separate circuits.

Another object is the provision of a sequentially operable relay in which the contacts are opened and closed within an evacuated envelope.

Still another object is the provision of a single-pole sequentially operable vacuum relay which may be "latched" after any selected sequential operation.

A still further object of the invention is the provision of a single-pole sequentially operable pulse controlled vacuum relay.

Another object is the provision of a pulse responsive normally open vacuum relay cyclicly operable to energize sequentially a multiplicity of separate circuits and deenergize all the circuits simultaneously to complete the operating cycle.

Still another object is the provision of a pulse responsive vacuum relay in which the movable contact members are slidably mounted and resiliently pressed in a closing direction to provide self-alignment with the fixed contact points and to resiliently absorb the impact-shock of rapid closing of the contacts.

Still another object of the invention is the provision in a vacuum relay having a multiplicity of movable contacts insulated from one another and operatively associated adjacent a corresponding number of separate contact points of electromechanical means for closing successive sets of said contacts.

The invention possesses other objects some of which with the foregoing will be brought out in the following description of the invention. I do not limit myself to the showing made by the said description and the drawings, since I may adopt variant forms of the invention within the scope of the appended claims.

Referring to the drawings:

FIG. 1 is a vertical half-sectional view, partly in elevation, showing the normally open physical relationship of the fixed and movable contact assembly in the upper portion of the envelope.

FIG. 2 is a vertical half-sectional view, partly in elevation, of the lower portion of the switch structure, showing the relationship of end cap, contact support stem and electromechanical actuating means. FIGS. 1 and 2 are continuations of one another with each view broken off at a plane common to both.

FIG. 3 is a fragmentary vertical sectional view through a portion of the stem supporting the movable contact disks and showing the lowermost contact disk in closed position.

FIG. 4 is a horizontal sectional view taken in the plane indicated by the line 4—4 of FIG. 2.

FIG. 5 is a fragmentary vertical section view taken in the plane indicated by the line 5—5 of FIG. 4.

FIG. 6 is a fragmentary vertical sectional view taken in the plane indicated by the line 6—6 of FIG. 4.

All of the figures are drawn to a scale approximately twice actual size.

In the electrical industry there is a continuing need for miniature multiple position electric switches and relays capable of carrying large currents at high voltages,

and in which engagement of the contacts is made by axial displacement of the switch armature rather than by rotary movement as in most convention relays.

Such a relay lends itself to variations from a normally open to a normally closed and other configurations, and may easily be arranged to provide simultaneous or sequential engagement of the contacts. Additionally, the relay may be varied so as to provide a single-pole, double throw configuration or a number of other useful and desirable configurations. The versatility of the relay makes it useful for shifting inductance or capacitance in high and low frequency A.C. circuits or in D.C. applications, and also for changing frequencies in amplifiers or oscillators and in paralleling various potentials to change the impedance of a certain circuit. Such versatility has not been found in conventional relays.

Broadly, my miniature relay has been designed to handle a current load of the order of 10 amperes R.M.S. and voltages from 10 kv. to 15 kv. peak, and comprises an envelope including a dielectric shell and a metallic end cap closing one end of the shell. Extending into the envelope is at least one pair of opposed contact rods which provide spaced contact points within the envelope and terminal leads outside the envelope. The number of pairs of contact rods is not critical and may be varied to suit the convenience of the purchaser. A stem movably mounted on the end cap also extends into the envelope and is axially movable thereon. Within the envelope the stem supports one or more contact disks, each being axially movable by the stem into and out of engagement with an associated pair of contact rods. An expansible metallic bellows integrally interposed between the stem and the end cap hermetically seals the union between stem and end cap while permitting relative movement of the parts. Axial movement of the stem is effected by means detachably mounted on the end cap and operatively interposed between the end cap and the associated end of the stem.

In more specific terms, the miniature relay of my invention comprises an elongated generally cylindrical envelope including a dielectric shell **2** closed at one end by an integral dielectric wall **3**. At its other end the envelope is closed by a metallic end cap formed by a sleeve having an outer cylindrical portion **4** integral with an inner flared portion **6** which is in turn hermetically bonded to the dielectric shell. An annular metallic insert **7** hermetically brazed within the sleeve to the cylindrical portion **4**, is provided on its outer end adjacent its outer periphery with an outwardly extending internally threaded cylindrical flange **8**. At its inner end and adjacent its inner periphery, the insert is provided with a second cylindrical bearing flange **9** extending inwardly toward the shell.

Supported on the shell at vertically spaced intervals therealong and extending transversely into the envelope are a plurality of pairs of opposed and aligned contact rods **12** forming terminal leads outside the envelope and contact points within the envelope. The contact rods are preferably cylindrical tungsten rods having their inner ends shaped to provide flat contact surfaces **13** on each rod. The inner ends of the contact rods are spaced apart, each rod terminating at a point spaced from the longitudinal axis of the shell.

Means are provided mounted on the metallic end cap and extending into the envelope and movable to engage or disengage opposed contact points of selected pairs of contact rods to make or break a circuit therebetween. Such means comprises an axially aligned stem having a metallic bearing portion **14** slidably journaled in the bearing flange **9** on the end cap. At its outer end the stem portion **14** is reduced in diameter and threaded to provide a connecting portion **16** extending out of the end cap.

At its inner end the stem bearing portion **14** is integrally united hermetically to the inner end **17** of an expansible metallic bellows **18**, the other open end of which is integrally and hermetically united to the end cap about the bearing flange **9**. The bellows thus lies hermetically interposed between the stem and the end cap while permitting axial movement of the stem.

Within the envelope the stem continues in a contact support portion made up of axially arranged integrally united alternate dielectric and metallic portions or segments. This construction is best shown in FIGS. **1** and **3**, where the dielectric portions are shown to be short ceramic posts **21**. Brazed on each end of each ceramic post is a flanged metallic cap **22** which serves to strengthen the post and also provides a base on which may be brazed one end of a metallic rod **23**. The rods **23** are axially aligned with the axially spaced ceramic posts and serve to rigidly and integrally unite adjacent posts. As shown in FIG. 1, three such rods and ceramic posts are alternately arranged in the present embodiment. It will of course be understood that the ceramic posts insulate the individual rods **23** from one another, but that in a different embodiment the ceramic posts may be eliminated and the three rods **23** merged into a single continuous rod.

Slidably and rotatably mounted on each rod **23** is a flat annular conductive contact disk **24** proportioned to span the space between an associated pair of opposed contact points. A coil spring **26** surrounding each rod is interposed between the underside of the associated disk and the post immediately underneath. The spring resiliently holds the disk pressed against a fixed stop **27** surrounding the rod **23** above the disk. The stop **27** and spring cooperate to return and retain each contact disk at a predetermined position in relation to the associated contact points. Also cooperating to position the contact support stem and through it the contact disks, is a coil spring **28** interposed between the lower connecting portion **16** of the stem and the adjacent end cap. This spring overbalances the force exerted by atmospheric pressure and retains all of the contact disks in a normally open position. A nut **29** on the threaded connecting portion **16** of the stem under the spring is adjustable to increase or decrease the force exerted by the spring to thus control the spacing of the contact disks from the associated contact points.

It will thus be seen that with the parts proportioned as shown in FIG. 1, the nut **29** is adjusted so that the uppermost contact disk is normally open and spaced approximately .025" from the flat contact surfaces **13** of the associated pair of opposed contact points. The next lowest contact disk is spaced approximately .050" from the contact surfaces associated with it, and the lowermost disk is spaced .075" from the contact points. These positions are maintained when the relay is in an "OFF" or normally open position for all contacts. Inward movement of the stem at least .025" will thus engage the uppermost contact disk with the associated contact points. Since inward travel of the stem is difficult to control to precisely .025", the parts are arranged to accommodate relative movement between disk **24** and rod **23**. Such relative movement is resiliently impeded by the interposed spring **26**, which thus absorbs the impact shock of the rapidly closed contacts. This relationship of the parts is shown in FIG. 3.

Movement of the stem to close the first pair of contacts results in placement of the intermediate contact disk in position to be engaged by an additional inward movement of the stem of .025". The contacts may thus be closed sequentially, with the springs **26** providing impact-shock protection by absorbing overtravel of the stem as in FIG. 3. The entire contact support portion of the stem is integrally united to the inner closed end of the bellows by a metal washer **31** apertured to receive the reduced inner end of the bearing portion **14**.

The washer serves to strengthen and insure a rigid and hermetic union of the parts.

Means are provided mounted on the end cap for effecting movement of the stem to sequentially close the contacts. Detachably engaging the threaded cylindrical flange **8** of the end cap is a hollow cylindrical flange **32** extending from and integrally concentric with the annular peripherally threaded plate **33** which forms a removable cap on the cylindrical downwardly extending hollow housing **34**. The housing **34** is axially aligned with the shell **2**, and with the plate **33** serves to clamp the switch on a mounting flange **36**. Intermediate its ends, the housing **34** is provided with a transverse shaft **37** having its ends rotatably journaled in cap bearings **38** pressed into opposed and aligned apertures **39** in the housing wall.

Fixed on the shaft for rotation therewith is a multiface cam **41**, shown best in FIG. 6. The cam is shaped to provide two complete cycles for one revolution of the shaft **37**, one cycle constituting operation of the relay from the normally open position shown through sequential closing of all three pairs of contacts and return to the normally open position. Cycling in this manner is effected by providing a cam face **42** corresponding to the normally open position of all contacts as shown, and providing successively elevated faces **43**, **44**, and **46**, corresponding respectively to the closed position of the uppermost, intermediate and lower contact points. Rotation of the cam to present increasingly elevated cam faces is translated into axial movement of the stem by a cam follower **47** detachably mounted on the threaded connecting portion **16** of the stem and slidably journaled in a bushing **48** pressed into the hollow flange **32**. A roller bearing **49** rotatably journaled on the cam follower resiliently and rollably impinges against successive cam faces. While the elevation of each cam face increases successively between faces **42** and **46**, a sharp decline is provided between adjacent faces **42** and **46**, so that when the cam follower rolls off face **46** onto face **42**, all of the contacts are returned to a normally open position to complete one cycle. It will of course be understood that while the cam follower is resting on any one of the faces, the relay mechanism is "latched" in corelated position until rotation of the cam to bring the next succeeding cam face under the cam follower is initiated. It will also be obvious that various cam shapes may be used, each consistent with the desired sequence of operation of the relay contacts.

To rotate the cam a proper amount, an appropriately toothed ratchet wheel **50** fixed on the shaft **37**, cooperates with a pawl **51** pivotally mounted on armature head **52** by pivot pin **53**. The pawl is resiliently urged into engagement with the toothed ratchet wheel by a spring **54** interposed between the pawl and the armature. The armature is slidably mounted on and extends through the centrally apertured lower end wall **56** of the housing **34**. A pin **57** having its lower end adjustably extending into the end wall **56** extends upwardly through a slot **58** in the armature head and is provided with a head **59** to limit and adjust movement of the armature upwardly. The pin also prevents rotation of the armature and thus retains the pawl operatively related to the ratchet wheel. A set screw **60** threaded transversely into the end wall **56** impinges against the pin **57** to insure against accidental displacement of the pin.

Below the housing **34** the armature is provided with an axially aligned cylindrical core portion **61** extending into a hollow energizable solenoid coil **62** contained within coil housing **63**. At its upper end the coil housing is threaded for detachable connection to the complementarily threaded lower end wall **56** of housing **34**. At its lower end, coil housing **63** is threaded to receive a flat terminal plate **64** through which extend terminal leads **66** adapted for connection into an operative control circuit. A coil spring **67** interposed between the terminal plate

64 and the lower recessed end of the armature core, resiliently returns the armature to its uppermost position against stop pin 57 after each operation.

It will thus be seen that armature travel can be adjusted by merely unscrewing the coil housing from end wall 56 and readjusting pin 57. Likewise, removal of ratchet housing 34 exposes nut 29 which may be adjusted to vary the tension in coil spring 28 and thus control the spacing between contact disks and associated contact points. Slidability of the disks on their support rods permits self-alignment of the disks in the event of irregularities in contact surfaces 13, while the springs 26 under the disks insure a resilient contact pressure, thus reducing contact resistance.

I claim:

1. A vacuum relay comprising an evacuated envelope including a dielectric shell and a metal end cap closing one end of the shell, an axially movable stem mounted on the end cap and extending into the envelope and tending to be moved into the envelope by atmospheric pressure, a pair of opposed contact rods supported on the shell and extending into the envelope to provide spaced contact points within the envelope and terminal leads outside the envelope, a contact disk within the envelope electrically insulated from said end cap and mounted on the stem for axial movement therewith to selectively engage and disengage said pair of spaced contact points, spring means operatively interposed between said stem and end cap to normally resiliently retain the contact disk in disengaged position against atmospheric pressure, and electromechanical means including a solenoid detachably mounted on the end cap and comprising a magnetizable housing enclosing an energizable coil and a magnetically responsive axially movable armature associated therewith, a pawl on the armature movable therewith, a ratchet wheel journaled for rotation by said pawl, a cam journaled for rotation with said ratchet wheel, and a cam follower operatively interposed between the cam and the stem to limit the outward movement thereof as urged by said spring means and to effect axial movement of the stem into the envelope against the pressure of said spring to engage the contact disk with the contact points when the solenoid is energized.

2. A vacuum relay comprising a vacuumized envelope including a dielectric shell and metal end cap closing one end of the shell, an expansible metallic bellows having an open end hermetically united to the end cap and a closed inner end extending into the envelope, a stem fixed to the closed end of the bellows and movably mounted on the end cap and extending into the envelope, a plurality of axially spaced pairs of opposed contact rods supported on the shell and extending into the envelope to provide spaced pairs of contact points within the envelope and terminal leads outside the envelope, a contact disk associated with each of said pairs of contact points within the envelope and slidably mounted on the stem for movement therewith to selectively engage and disengage an associated pair of spaced contact points, said contact disks in open position being spaced from the associated contact points by varying amounts, and electromechanical means operatively interposed between the end cap and the stem and including a solenoid detachably mounted on the end cap and comprising a magnetizable housing enclosing an energizable coil and a magnetically responsive axially movable armature associated therewith, a pawl on the armature movable therewith, a ratchet wheel journaled on the solenoid housing for cyclic rotation by said pawl, a cam journaled for cyclic rotation with said ratchet wheel, and a cam follower operatively interposed between the cam and the stem, the cyclic rotation of the cam by the pawl being correlated to said variations in spacing of the contact disks to effect sequential closing and simultaneous opening of the contacts upon cyclic operation of the solenoid.

3. In a vacuum relay having an envelope closed at one end by a metallic end cap, the combination comprising a stem for closing contacts within the envelope and movably mounted on the end cap and extending therethrough into and out of the envelope, and electromechanical means detachably mounted on the end cap and including a rotatable cam operatively impinging against the stem to effect axial movement thereof into the envelope and limit the outward movement of the stem, spring means disposed between the end cap and a portion of the stem to urge movement of the stem outward from the envelope and into engagement with said cam, a ratchet and pawl assembly associated with said cam and operable to effect rotation thereof, and a solenoid including an energizable coil and a coil responsive movable armature, said armature operatively connected to said ratchet and pawl assembly to effect operation thereof to rotate the cam when said coil is energized.

4. The combination according to claim 3, in which adjustable means are provided to limit responsive movement by said armature.

5. A vacuum relay comprising a vacuumized envelope including a dielectric shell and metal end cap closing one end of the shell, an expansible metallic bellows having an open end hermetically united to the end cap and a closed inner end extending into the envelope, a stem fixed to the closed end of the bellows and movably mounted on the end cap and extending into the envelope, a plurality of axially spaced pairs of opposed contact rods supported on the shell and extending into the envelope to provide spaced pairs of contact points within the envelope and terminal leads outside the envelope, a contact disk associated with each of said pairs of contact points within the envelope and slidably mounted on the stem for movement therewith to selectively engage and disengage an associated pair of spaced contact points, said contact disks in open position being spaced from the associated contact points by varying amounts and operating means connected with said stem cyclicly correlated to the variations in spacing of said contact disks to effect sequential closing and simultaneous opening of the contacts upon cyclic operation of said operating means.

References Cited in the file of this patent

UNITED STATES PATENTS

983,976	Carpenter	Feb. 14, 1911
1,783,279	Burnham	Dec. 2, 1930
1,814,851	Prince	July 14, 1931
2,363,683	Mallina	Nov. 28, 1944
2,547,999	Brockway	Apr. 10, 1951
2,721,914	Cheltz	Oct. 25, 1955
2,794,093	Morschel	May 28, 1957
2,794,101	Jennings	May 28, 1957
2,908,780	Walters	Oct. 13, 1959

FOREIGN PATENTS

407,725	Germany	Jan. 2, 1925
698,918	Germany	Nov. 19, 1940
74,461	Norway	Jan. 10, 1949