

Nov. 29, 1949

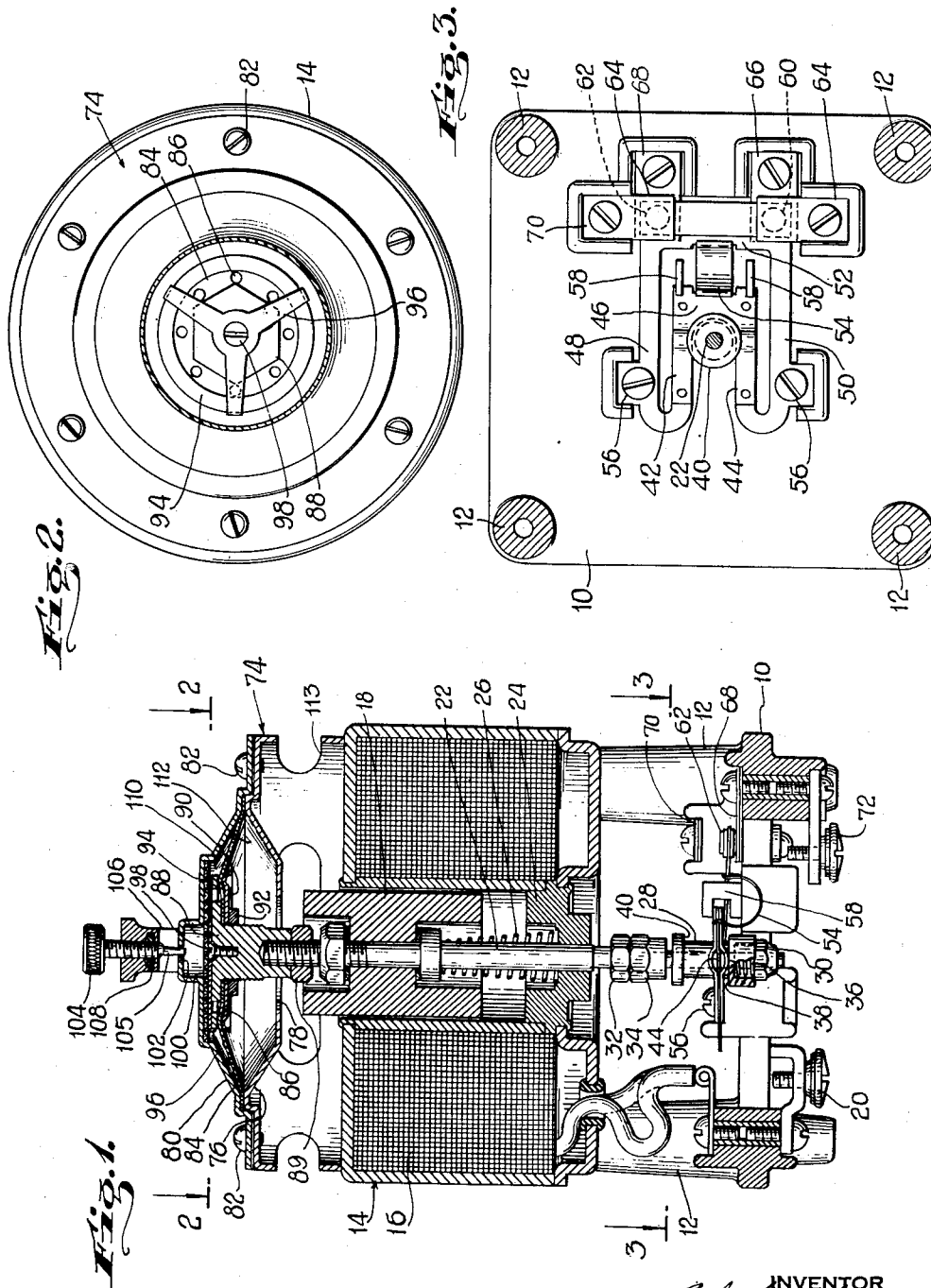
C. LINDAHL

2,489,381

TIME DELAY CONTROL APPARATUS

Filed May 12, 1944

2 Sheets-Sheet 1



INVENTOR
Carl Lindahl
BY *Garvial, Mark*
his ATTORNEY

Nov. 29, 1949

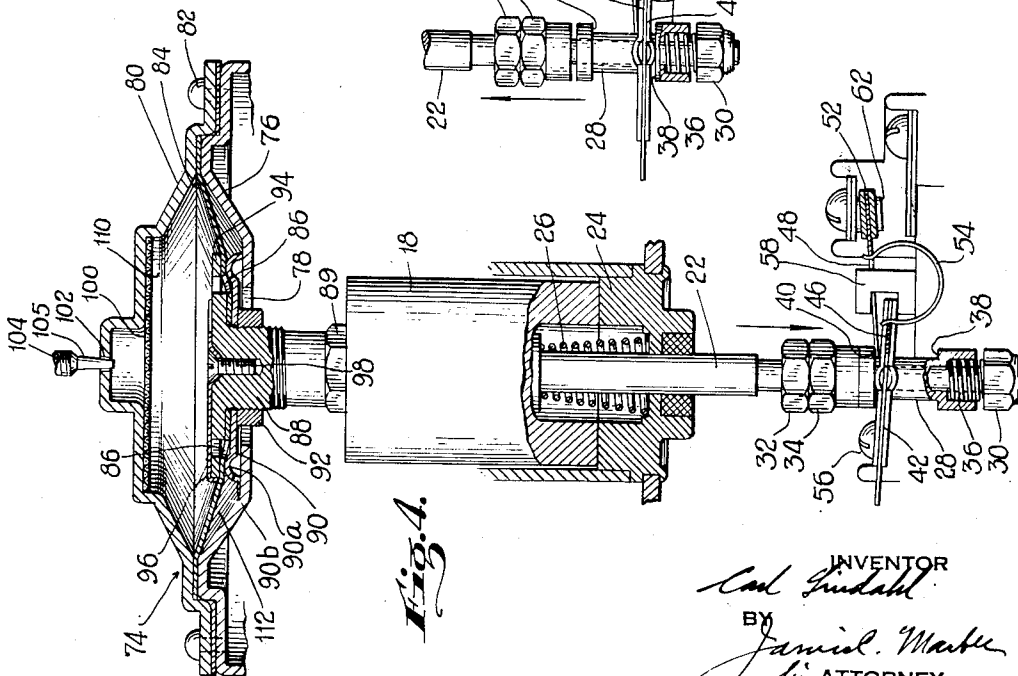
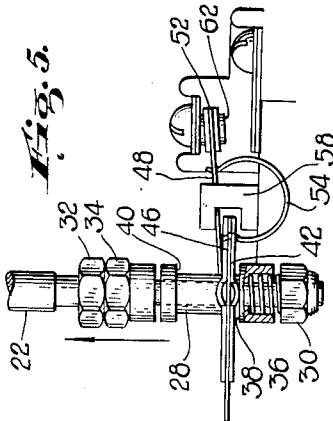
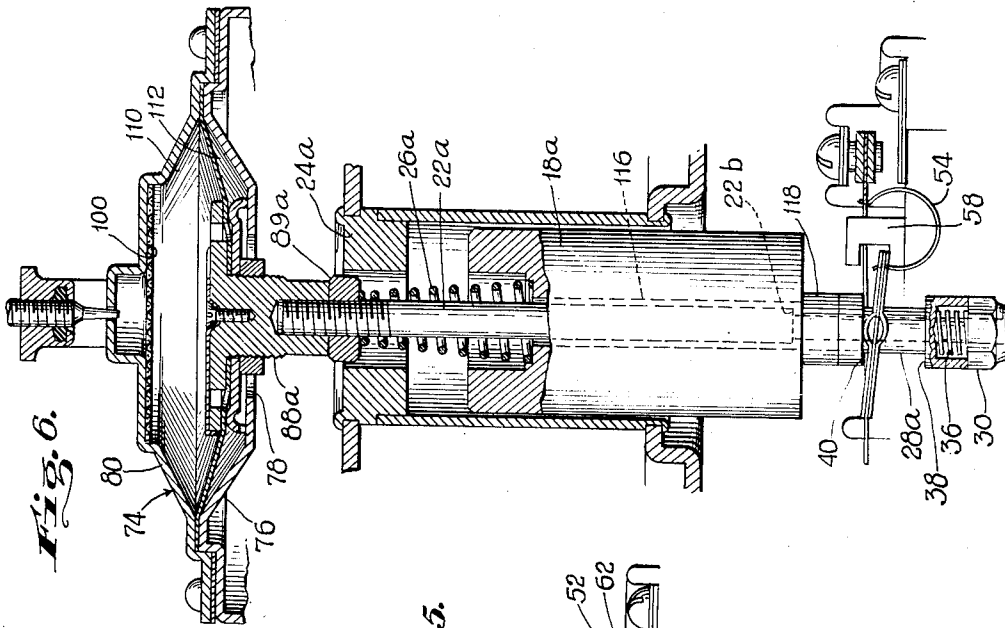
C. LINDAHL

2,489,381

TIME DELAY CONTROL APPARATUS

Filed May 12, 1944

2 Sheets-Sheet 2



INVENTOR

INVENTOR
Carl Lindahl
BY *Jamies. Marble*
his ATTORNEY

BY

Daniel. Marble
his ATTORNEY

his ATTORNEY

UNITED STATES PATENT OFFICE

2,489,381

TIME-DELAY CONTROL APPARATUS

Carl Lindahl, Union, N. J., assignor to American Gas Accumulator Company, Elizabeth, N. J., a corporation of New Jersey

Application May 12, 1944, Serial No. 535,365

6 Claims. (Cl. 200—97)

1

The present invention relates to time delay apparatus and has particular reference to electro-pneumatic apparatus of the kind in which some desired event such as the closing or opening of an electric circuit is accomplished after the lapse of a predetermined and preferably adjustable time interval following the actuation of the apparatus by an operator or some automatic control.

The general object of the invention is the provision of novel apparatus of the character under consideration which will be simpler in construction and cheaper to manufacture than devices of similar character heretofore available and which will at the same time be reliable in operation under varied conditions of operation.

For a better understanding of the more detailed nature of the invention and the manner in which the above noted as well as the more specific objects of the invention are attained, reference may best be had to the ensuing portion of this specification, taken in conjunction with the accompanying drawings, disclosing by way of example but without limitation suitable examples of apparatus embodying the principles of the invention.

In the accompanying drawings:

Fig. 1 is a longitudinal section through an apparatus, embodying the invention;

Fig. 2 is a section on line 2—2 of Fig. 1;

Fig. 3 is a section on line 3—3 of Fig. 1;

Fig. 4 is a fragmentary view on larger scale of parts of the structure of Fig. 1 in different operative position;

Fig. 5 is a fragmentary view of parts of the structure of Fig. 1 in still another position; and

Fig. 6 is a fragmentary view similar to Fig. 4 showing a different form of apparatus embodying the invention.

Referring now to the drawings, the apparatus shown in Fig. 1 and related figures comprises a base 10, which may advantageously be molded from suitable insulating compound, provided with legs 12 on which a solenoid 14 is mounted. The solenoid comprises the usual coil 16 and armature 18, the terminals for the coil being carried by the base, one such terminal being shown at 20. Since in so far as the present invention is concerned, the specific type or construction of the solenoid is not critical, any suitable construction of known kind may be employed to accommodate the kind and voltage of current available for its energization.

A motion transmitting member is secured to the armature 18 for reciprocatory motion there-

2

with, this member including a rod 22 passing through a guide bore in a stop member 24 carried by the solenoid casing and providing a stop for limiting movement of the armature and rod in the direction taken when the solenoid is energized. A spring 26 between the stop 24 and a collar on rod 22 acts to force the armature out of the coil to the position shown in Fig. 1 when the coil is energized.

The lower end of rod 22 is of reduced diameter and has slidably mounted thereon a lost motion element in the form of a sleeve 28, the travel of which relative to the rod is limited on the one hand by the nut 30 and on the other by the adjustable locknuts 32 and 34 threaded on rod 22. The lower end of sleeve 28 is recessed to receive a spring 36 which acts to bias the sleeve away from nut 30 and against the locknut 34. The outer surface of the sleeve is channelled to provide end shoulders or abutments 38 and 40.

The sleeve 28 passes between the inner arms 42 and 44 of a spring loaded toggle or over-center switch, these arms being connected at their free ends by a notched bar 46. At their opposite ends the inner arms are reversely turned outwardly to form outer arms 48 and 50, respectively, these latter arms being bridged at their free ends by the notched bar 52. The notches in bars 46 and 52 confront each other and receive the ends of a compressed U-shaped spring 54 which provides the spring load for the switch. The arms of the switch are of spring metal and the switch is attached to the base by screws 56 engaging the outer arms near the ends where they join the inner arms. The travel of the bar 46 at the free ends of the inner arms is limited by stops 58 on the base 10. The bar 52 connecting the outer arms 48 and 50 carries contacts 60 and 62, the former arranged to travel between contact strips 64 and 66, and the latter arranged to travel between the contact strips 68 and 70. The several contact strips are connected to suitable binding posts on the bottom of the base, one of which appears at 72 in Fig. 1.

Mounted above the solenoid casing is a diaphragm casing indicated generally at 74, this casing comprising a lower dished plate 76 having a central aperture 78 and an upper and oppositely dished cover plate 80 detachably secured to the lower plate by suitable screws 82. A flexible diaphragm 84 is clamped at its periphery between the lower and upper plates 76 and 80. This diaphragm is preferably of very light and flexible material such as cloth, suitably impregnated with varnish, resin or the like to render

it impervious to the passage of air and is provided with a plurality of perforations 86 near its center. The central part of the diaphragm inside of the circle of perforations is clamped between a member 88 threaded on to the upper end of rod 22 and locked in position by a locknut 89 and an annular disc 90 the rim of which is crimped upwardly to semi-circular form as indicated at 90a. Advantageously but not necessarily a small notch 90b may be provided in the edge of the rim which, as will be seen from Figure 4, bears against the lower diaphragm plate 76 in one position of the apparatus. The disc 90 is held in clamping position against the diaphragm by means of a retaining ring 92 threaded over the member 88. Above the diaphragm an annular valve ring 94 is yieldably held in centered position by means of a retaining spring 96 having a series of radially extending arms, in the present instance three, the ends of which are turned downwardly to provide fingers engaging the outer periphery of the valve ring 94. Spring 96 is held in position by means of a screw 98 threaded into the top of the member 88. As will be seen more clearly from Fig. 2, the diameter of the valve ring is such that it bears against the diaphragm on a circle lying outside perforations 86 and from Fig. 4 it will be seen that the valve ring diameter is also such that it overlies the rim 90a of the disc 90.

The central portion of the upper plate 80 is recessed to provide for the reception of a filter 100 of any suitable material such as felt or the like which is glued or otherwise secured to the plate. Plate 80 is provided with an additional recess above the filter, this recess having a central aperture or port 102, the free area of which is governed by an adjusting screw 104 having a tapered pilot portion 105 extending into the port. The screw 104 is held by a suitable bridge member 106 through which it is threaded and the bridge member may advantageously be provided with an insert 108 of elastic material through which the screw 104 is threaded and in the bore of which the screw impresses a thread. The material of the insert may be of vulcanized fibre or the like, which provides a gripping action for holding the screw against turning so as to eliminate movement thereof from desired adjusted position. Obviously other means for locking the screw in adjusted position may be employed.

The type of apparatus just described is designed to effect the desired time delay operation commencing with the instant when the solenoid is deenergized after having been energized to activate or arm the apparatus. The apparatus is shown in its normal non-operating position in Fig. 1. In this position the motion transmitting member comprising the rod 22 and its associated parts is at the top of its travel due to the action of spring 26, the diaphragm chamber 110 formed between the upper plate 80 and the diaphragm 84 being of minimum volume and the sleeve 28 at the lower end of the motion transmitting member being held in its lower position relative to the rod 22 by the contact between the switch arms 42 and 44 and the shoulder 38 at the lower end of the sleeve. These switch arms force the sleeve to its lowest position in which the spring 36 is compressed, because of the limit to the upward movement of the switch arms by the stops 58 on the base. Obviously the spring 26 is stronger than the spring 36 and capable of moving the assembly to the position

shown in which spring 36 is compressed. If the solenoid circuit is now closed to activate or arm the apparatus, the armature 18 is pulled downwardly until it meets the stop 24, against the force of the spring 26 which is compressed by this movement. When the armature and motion transmitting member is thus pulled to its lower or armed position, spring 36 is first permitted to expand to move the sleeve 28 relative to rod 22 until the sleeve reaches its upper position in contact with the adjusting nut 34. As the downward movement continues the shoulder 38 moves away from the switch arms 42 and 44, and further movement of the motion transmitting member brings the shoulder 40 at the upper end of the sleeve into contact with arms 42 and 44. Continued downward movement causes the arms 42 and 44 to be depressed from the position shown in Fig. 1, against the resistance of the spring 54 until the dead center position of the toggle switch is passed, whereupon the switch acts to reverse the position of the contacts 60 and 62 from that shown in Fig. 1 to the position shown in Fig. 4. At the termination of the downward movement the inner switch arms 42 and 44 are in contact with the stops 58 as shown in Fig. 4.

The downward movement of the armature and motion transmitting member effected by energizing the solenoid operates also to move the diaphragm 84 from the position shown in Fig. 1 to the position shown in Fig. 4. This is accomplished without material resistance or the creation of an appreciable vacuum in the chamber 110, the action being as follows:

The space 112 between the diaphragm and the lower plate 76 is in substantially open communication with the atmosphere by way of the openings 113 in the casing and the annular space provided by the opening 78 in the lower plate 76. Consequently so far as any air in the space 112 is concerned, the diaphragm is free to move downwardly without resistance. Also, as the volume of the chamber 110 is enlarged, air is permitted to flow from space 112 into this chamber past the check valve formed by the valve ring 94 since the arms of the retaining spring 96 are extremely light and flexible and permit a very slight depression in pressure in the chamber 110 to cause the valve ring to lift so that air can flow between the lower side of the diaphragm and the rim 90a and thence to chamber 110 through the openings 86 in the diaphragm. In this connection it is important to note that the valve associated with the diaphragm is constructed so as to permit the flow therethrough upon such a slight differential pressure that substantially no flow of air into chamber 110 takes place through the metering orifice formed by the port 102 and pin 105, since there is a certain amount of resistance to rapid flow of air through the filter 100.

After the apparatus is moved to its armed position by energizing the solenoid, as shown in Fig. 4, the time delay action is then commenced whenever the solenoid is deenergized. When this is done the spring 26 commences to push the armature and motion transmitting member upwardly, the rapidity of the movement being determined by the size of the metering orifice at the port 102, which controls the rate at which the air can flow from the diaphragm chamber. Upon upward movement of the assembly it will be apparent that the valve ring 94 and the rim 90a of disc 90 will form a check valve preventing back flow of air through the openings 86 in the diaphragm.

5

As the assembly moves upwardly under the influence of spring 26 the shoulder 40 on sleeve 28 moves away from the switch arms and the sleeve remains in its upper position relative to the rod 22 under the influence of spring 36. At an intermediate point in the travel of the assembly the switch arms are brought into contact with the lower shoulder 38 on sleeve 28 and the sleeve 28 is then moved downwardly relative to the rod 22, compressing spring 36 as seen in Fig. 5. When the switch arms first come into contact with the shoulder 38 the resistance to movement of the switch provided by spring 54 is sufficient to initially compress spring 36, but as the movement continues and spring 36 is further compressed the resistance provided by this spring finally reaches a value sufficient to overcome the resistance of spring 54 with the result that the switch is suddenly snapped over its dead center position from the position shown in Figures 4 and 5 to the position shown in Figure 1. This is permitted because of the lost motion connection between the sleeve 28 and the rod 22.

This feature of the apparatus is important for the reason that it maintains a substantial pressure contact between the switch points or contacts at all times, a condition which would not obtain if this feature were absent. The reason for this latter may best be understood by a consideration of Fig. 5, letting it be assumed that the sleeve 28 is fixed on the rod 22. It will be apparent that the action of spring 26 working against the pressure in the diaphragm chamber from which air is permitted to escape at a constant rate through the metering orifice results in uniform speed of movement of the rod 22. Consequently, if the sleeve 28 were fixed on this rod 22 the switch arms 42 and 44 would be moved upwardly at uniform rate until dead center position was reached, that is, a position in which these arms would lie in the same plane as the outer switch arms 48 and 50. When in this position the spring 54 would exert force only in the common plane of the switch arms and there would be no component of force from this spring providing any contact pressure for the contacts at the ends of the switch arms.

In the position of the switch shown in Fig. 5, there is a substantial component of force from spring 54 providing contact pressure but if it is assumed that sleeve 28 is fixed relative to rod 22 this component of force from spring 54 would gradually diminish to zero value at the time when dead center position is reached after which the switch would snap over to its other position by virtue of the inner switch arms being moved past the dead center position. This would result in an appreciable period of time, particularly if the setting of the diaphragm chamber orifice were such as to give very slow motion to the rod 22, during which the switch contacts would not be firmly held together, with the resultant possibility of a premature break in the circuit controlled by the contacts or chattering of the contacts due to inertia if the apparatus were in service under conditions where it was subjected to vibration.

With the present construction the above difficulty is avoided since the compressed spring 36 overcomes the resistance of spring 54 before the dead center position is reached and while the latter spring is still positioned so as to exert a contact pressure on the contacts. From a consideration of Fig. 5, it will be seen that as the rod

6

22 continues to move upwardly from the position shown in the figure the spring 36 is in effect applying pressure to the switch contacts, the latter acting as a stop or abutment for determining the position of one end of spring 54 and the force from the compressed spring 36 acting on the opposite end of spring 54.

In some instances it may be desirable to have the time delay period commence at the instant when the solenoid is energized rather than at an instant when the solenoid is deenergized after having previously being armed by being energized. Such an arrangement is shown in Fig. 6 in which a solenoid armature 18a is mounted to be lifted against gravity when the solenoid coil is energized. In this case the armature is free to move relative to the rod 22a of the motion transmitting member and when the solenoid is energized the armature moves upwardly to contact the stop member 24a and to compress the spring 26a. Spring 26a acts against a lock-nut 89a which locks the member 88a in position. The upward movement of the assembly is identical with that previously described in so far as the action of the diaphragm chamber for controlling the rate of movement of the motion transmitting member is concerned, and need not against be described in detail.

In this form of the device the normal position is with the armature and the motion transmitting member at the lower end of their travel, this being accomplished by gravity acting on the weight of the armature. As will be seen from the figure, the lower end of rod 22a is made of smaller diameter than the upper portion so that the shoulder 22b is provided, this shoulder being located at a height such that it is slightly within the bore 116 of the armature 18a when the latter is in its lower position. In this lower position the armature bears on the distance piece or washer 112 which in turn bears on the sleeve 28a so that the spring 36 is fully compressed. When the solenoid is energized the armature moves away from the distance piece and under the influence of spring 36 the assembly of sleeve 28a and distance piece 112 moves upward slightly until the latter strikes the shoulder 22b. The switch and sleeve parts are then in the same position relative to rod 22a as the corresponding parts are in the position shown in Fig. 4. Thereafter, it being assumed that the solenoid continues energized, the action is, as previously described, with the motion transmitting rod 22a moving at uniform velocity and with the lost motion sleeve and spring acting to throw the switch from a position ahead of the dead center position switch.

In both embodiments described the spring 36 acts in the nature of a booster spring which in effect boosts the switch across its dead center position from a position ahead of that at which the switch would be caused to pass its dead center position in the absence of the lost motion connection and booster spring.

In order for the device to be and remain accurate in its timing over a considerable length of life, it is necessary for the diaphragm chamber orifice to remain constant in cross section. The inclusion of dust or other foreign matter in the orifice tends to destroy this accuracy and it has in the past been proposed to avoid this difficulty by using two diaphragm chambers between which a sealed body of air is transferred through a metering orifice so that the same body of air, which can be freed from impurities, is used over and over again. This construction is not only

relatively expensive but has proved to be imperfect for apparatus to be used in aircraft where altitude and ambient air pressure may vary between wide limits. In the present device an extremely simple and inexpensive diaphragm chamber and valve construction is achieved and at the same time difficulty arising from a clogged or partially clogged metering orifice is eliminated, since the flow of air through the orifice is always in the one direction in which it is filtered before passing through the orifice. As previously explained, when the device is shifted from the position in Fig. 1 to the position in Fig. 4, the relatively slight resistance to air flow from the chamber 112 to the chamber 110 is substantially less than the resistance to flow to the chamber 110 through the metering orifice and the filter. The flow through the orifice is thus in effect entirely outward from the chamber through the filter to the ambient atmosphere.

It will be evident from the foregoing that many specific changes in design of the apparatus may be made without varying from the principles of the invention and it is particularly to be noted that in so far as the present invention is concerned many other specific types of known switches which are characterized by snap action across a dead center position and which for the purposes of this specification and the ensuing claims are generically designated as toggle switches, may be employed. Obviously the nature of the action effected by operation of the time delay apparatus is not material to the invention and the performance of the action through the making or breaking of one or more circuits controlled by the switch may be whatever is dictated by the use to which it is desired to put the apparatus.

The invention is accordingly to be understood as embracing all forms of apparatus within the scope of the appended claims.

Certain subject matter herein disclosed but not claimed forms a part of the claimed subject matter of my continuation-in-part application Serial No. 701,515, filed October 5, 1946, which application, as to subject matter common to this application, constitutes a division hereof.

What is claimed:

1. Time delay control apparatus comprising actuating means including a spring, a motion transmitting member acted on by said spring and including a lost motion connection, a pneumatic time delay device associated with said member for controlling the rate of travel thereof under the influence of said spring, a toggle switch operatively associated with said member for governing that which is to be controlled and a booster spring biasing said lost motion connection to shift the switch over its dead center position from a position in advance thereof.

2. Time delay control apparatus comprising a motion transmitting member, an actuating spring for moving said member, electrically energized means for compressing said spring, a pneumatic time delay device for controlling the rate of movement in said member under the influence of said spring, a spring loaded toggle switch for governing that which is to be controlled, said member including an element having a lost motion connection with the remainder of said member for shifting said switch and a booster spring acting on the said element in opposition to the spring load on the switch to shift the switch over its dead center position from a position in advance thereof.

3. Time delay control apparatus comprising a solenoid having a coil and an armature, a motion transmitting member mounted to move with said armature, a spring located to be compressed by movement of said armature when said coil is energized and acting to force the armature outwardly of the coil when the coil is deenergized, a pneumatic time delay device associated with said member for controlling the rate of travel thereof under the influence of said spring, a toggle switch operatively associated with said member for governing that which is to be controlled, said member including an element having a lost motion connection with the remainder of the member for shifting said switch and a booster spring biasing said lost motion connection to shift the switch over its dead center position from a position in advance thereof.

4. Time delay control apparatus comprising a solenoid having a coil and an armature, a motion transmitting member mounted to have relative movement with respect to said armature, a spring between said armature and said member located to be compressed by movement of the armature when said coil is energized for moving said member relative to the armature when the latter is in energized position, a pneumatic time delay device associated with said member for controlling the rate of travel thereof under the influence of said spring, a toggle switch operatively associated with said member for governing that which is to be controlled, said member including an element having a lost motion connection with the remainder of the member for shifting said switch and a booster spring biasing said lost motion connection to shift the switch over its dead center position from a position in advance thereof.

5. Time delay control apparatus comprising a motion transmitting member, means for moving said member at a substantially constant and slow rate, an over-center switch having contacts, a lost-motion connection between said member and said switch, and a spring biasing said lost-motion connection to shift the switch rapidly over its dead center position from a position in advance thereof whereby substantially maximum contact pressure is maintained prior to shifting of said switch.

6. Time delay control apparatus comprising a motion transmitting rod, means for moving said rod at a substantially constant and slow rate in one direction, spaced abutments on said rod, a sleeve slidably mounted on said rod between said abutments, a spring for biasing said sleeve against one of said abutments, and an over-center switch operably associated with said sleeve so as to be rapidly shifted over its dead center position by force stored in said spring.

CARL LINDAHL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
970,169	Birnsfield	Sept. 18, 1910
2,033,417	Dezotell	Mar. 10, 1936
2,266,804	Roby	Dec. 23, 1941
2,103,378	Oestnaes	Dec. 28, 1937