United States Patent [19]

Flanagan et al.

[11] **3,711,797**

[45] **Jan. 16, 1973**

[54] TIMING DEVICE

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[73] Assignee: **Amerace Esna Corporation,** New York, N.Y.

[22] Filed: **July 19, 1971**

[21] Appl. No.: **164,062**

Related U.S. Application Data

[62] Division of Ser. No. 802,546, Feb. 26, 1969, Pat. No. 3,599,131.

[52] **U.S. Cl.**.....**335/61,** 335/59

[51] **Int. Cl.**.....**H01h 7/03**

[58] **Field of Search**.....335/61, 62, 59, 63, 64, 67; 200/39 R

[56] **References Cited**

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Primary Examiner—Harold Broome
Attorney—Samuelson & Jacob

[57] **ABSTRACT**

A pneumatic timing device in which a timing head includes an air chamber, a diaphragm is movable relative to the timing head to effect a change in the volume of the air chamber and establish a flow of air into or out of the air chamber, a timing member is coupled for movement with the diaphragm at a rate determined by the rate of flow of air to or from the air chamber, a passage in the timing head communicates with the air chamber for conducting the flow of air, a body of porous material is in the passage for throttling the flow to a predetermined maximum rate of flow, the body of porous material having a surface of prescribed area through which the air flow passes, and a shutter is in close engagement with the surface of the body of porous material and includes a relatively non-porous member selectively movable along the surface relative to the body to close off at least portions of the area to the air flow for selectively varying the rate of the flow to regulate the rate of movement of the timing member.

4 Claims, 8 Drawing Figures

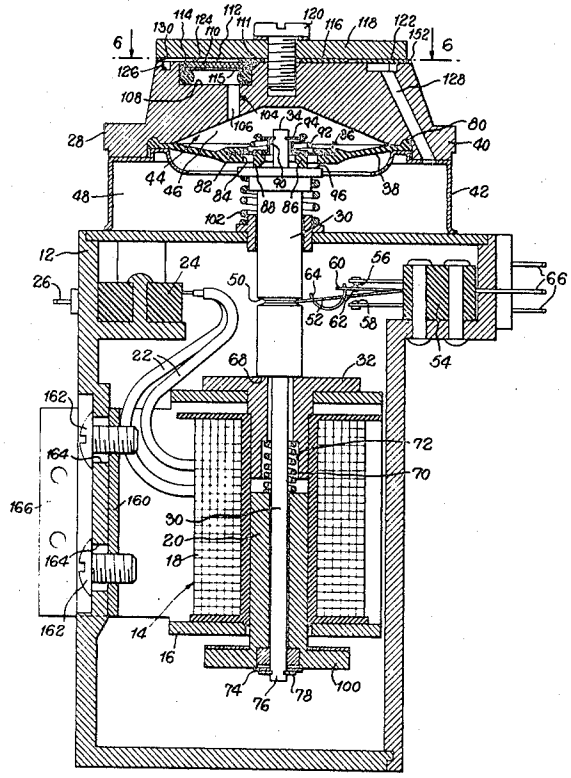


Fig. 1.

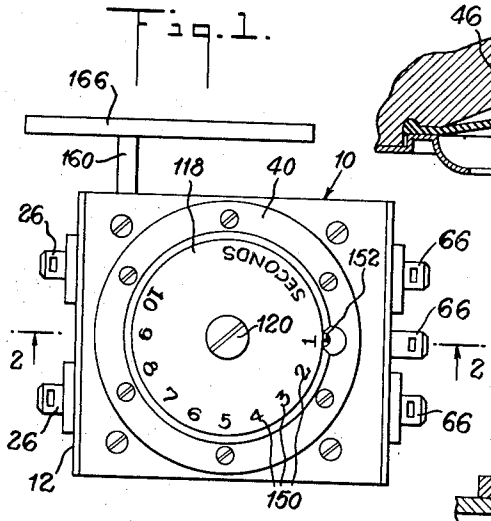
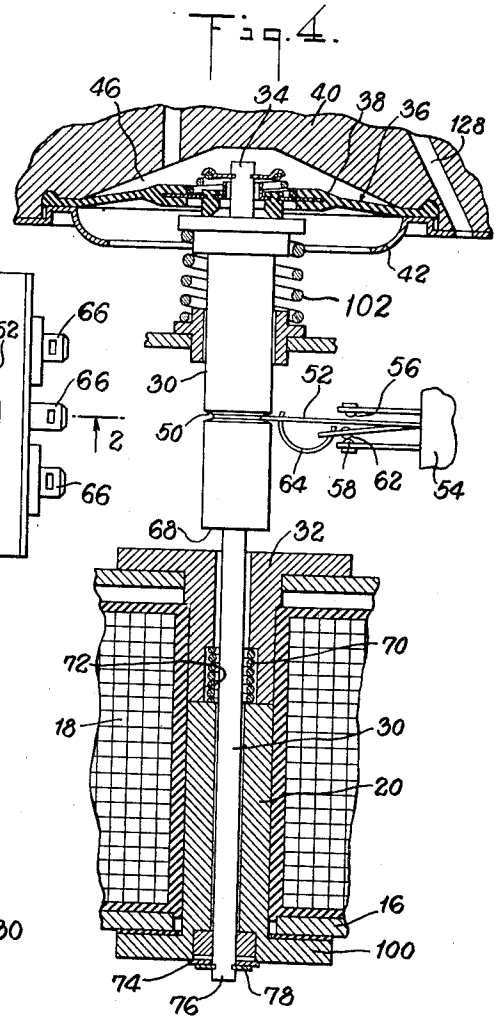


Fig. 4.



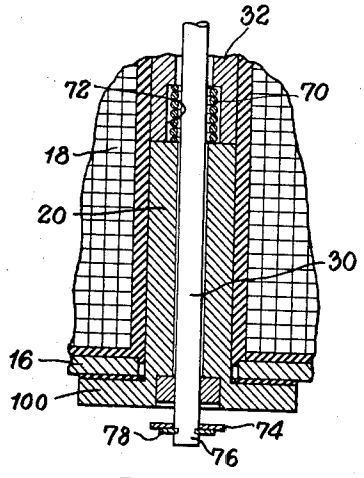


Fig. 3.

Fig. 2.

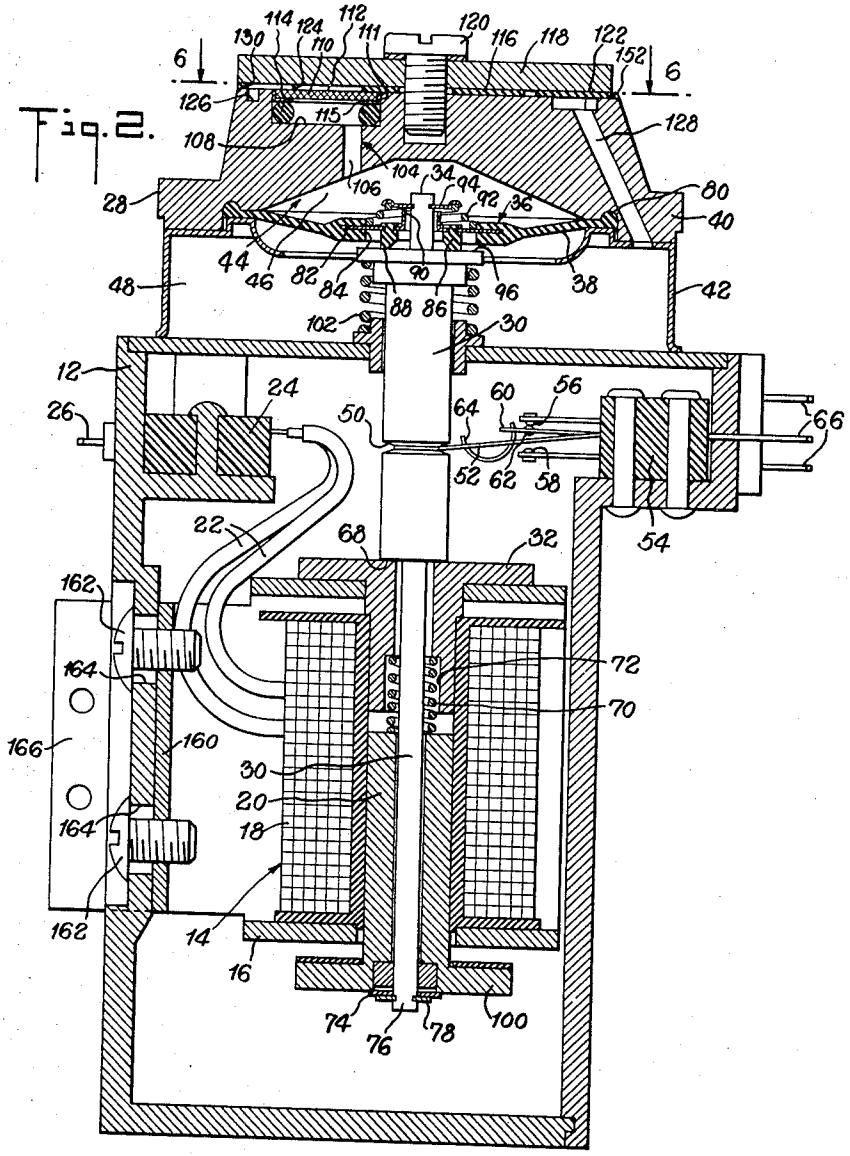

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Fig. 5.

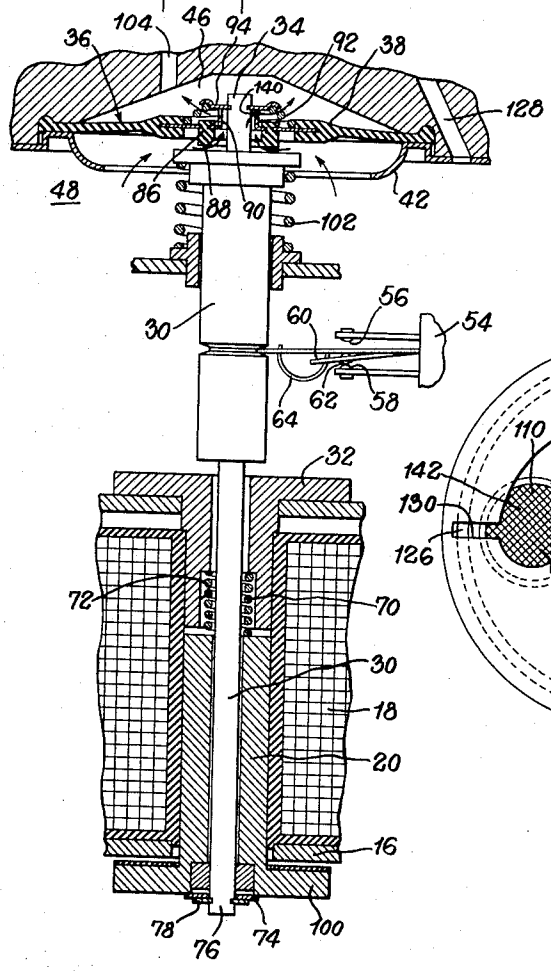

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Fig. 6.

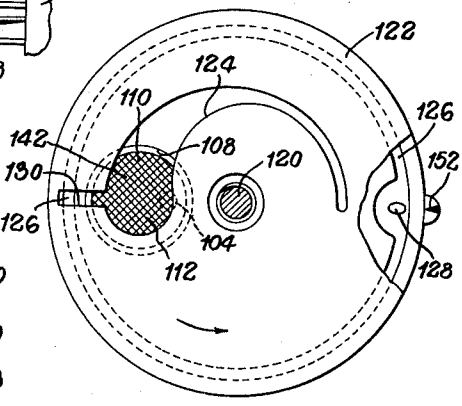

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Fig. 7.

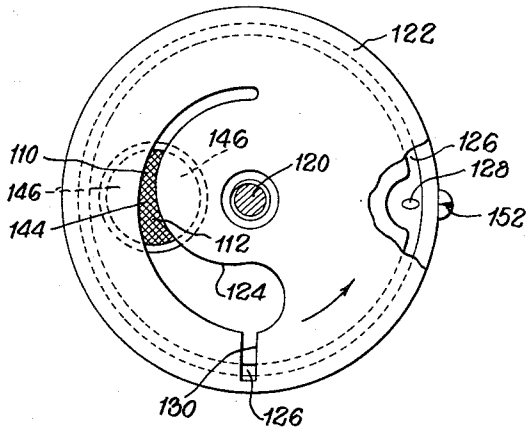
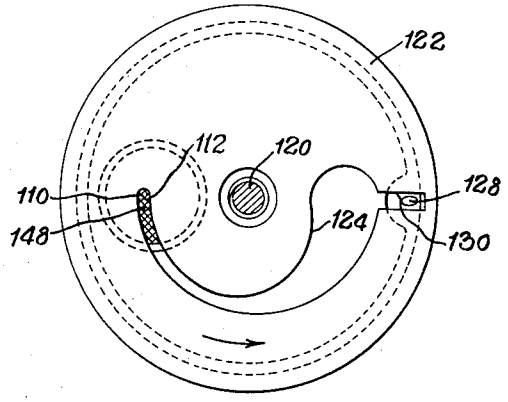

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Fig. 8.


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TIMING DEVICE

This application is a division of copending application Ser. No. 802,546, filed Feb. 26, 1969, for TIMING DEVICE now U.S. Pat. No. 3,599,131.

The present invention relates generally to timing devices and pertains, more specifically, to time delay 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 adjustable time interval following the actuation of the apparatus by an operator or some automatic control.

Pneumatic timing devices have been devised in order to provide a time delay period between the activation of the timing device and the actuation of a control, such as, for example, an electrical switch. In such timing devices, a timing member generally effects the control function and the rate of movement of the timing member is determined by the rate of flow of a fluid, such as air, through a passage communicating with a chamber of variable volume. These timing devices are usually selectively adjustable so as to provide a desired time delay period, the duration of which may be selectively varied within a prescribed range. A variety of mechanisms have been employed for selectively adjusting or dialing the duration of the time delay period. Various valving arrangements have been used, such as needle valves, but such valving arrangements have been found to be unreliable in that accurate adjustments are difficult to execute, dial adjustments are usually not related to the corresponding time intervals in a linear fashion and the dial settings vary from device to device so that standardization is difficult to achieve.

One type of adjustable mechanism which has been successful in attaining uniformity and which has achieved a linear relationship between dial settings and corresponding timed intervals employs a timing groove through which air flows and which may be varied in length to vary the rate of air flow and thus vary the duration of the timed interval. Such a mechanism, while attaining uniformity of operation, has been found expensive to manufacture in view of the close tolerances which must be maintained in the fabrication of component parts of the mechanism.

It is therefore an important object of the invention to provide a timing device having an adjustable time delay mechanism which is relatively inexpensive to manufacture, yet provides uniformity of adjustment and an easily repeatable relationship between increments of adjustment and increments of change of the duration of the interval of the time delay.

Another object of the invention is to provide an inexpensive timing device wherein the duration of the timed interval may be selected by operation of a dial having a scale which bears a linear relationship with the actual duration of the timed interval.

Still another object of the invention is to provide an inexpensive timing device wherein the duration of the timed interval of the time delay mechanism may be varied over a prescribed range and wherein that range may be changed readily with minimal effort.

A further object of the invention is to provide a timing device having a construction which allows ready calibration of the time delay mechanism so as to attain uniformity of operation from device to device.

A still further object of the invention is to provide a timing device having a minimum number of component parts, each of which is easily fabricated and each of which may be manufactured without the necessity of maintaining close tolerances in highly critical dimensions so as to reduce the cost of manufacture.

The above objects as well as further objects and advantages are attained by the invention which may be described briefly as a timing device wherein the movement of a timing member effects a control function and the rate of movement of the timing member is determined by the rate of flow of a fluid, such as air, through a passage communicating with a chamber of variable volume, means for selectively regulating the rate of flow of the fluid through the passage to vary the rate of flow between a predetermined maximum rate and a minimum rate, the regulating means comprising a body of porous material in the passage for throttling the flow to approximately the order of magnitude of the maximum rate of flow, the body of porous material having a surface of prescribed area through which the flow passes, shutter means juxtaposed in close engagement with the surface, and the body of porous material and the shutter means being selectively movable relative to one another to close off at least portions of the area to the flow for selectively varying the rate of flow to regulate the rate of movement of the timing member. Means may be provided for allowing ready access to the body of porous material so that the body may be selectively removed and replaced with a similar body of different porosity to change the order of magnitude of the maximum rate of flow.

The invention will be more fully understood and still further objects and advantages thereof will become apparent in the following detailed description of an embodiment of the invention illustrated in the accompanying drawing, in which:

FIG. 1 is a plan view of a pneumatic timing device constructed in accordance with the invention;

FIG. 2 is an enlarged cross-sectional view taken along line 2—2 of FIG. 1,

FIG. 3 is a fragmentary cross-sectional view illustrating the component parts of the device of FIG. 2 in another operating position;

FIG. 4 is a fragmentary cross-sectional view illustrating the component parts in another operating position;

FIG. 5 is a fragmentary cross-sectional view illustrating the component parts in still another operating position;

FIG. 6 is a cross-sectional view taken along line 6—6 of FIG. 2;

FIG. 7 is a cross-sectional view similar to FIG. 6 showing the component parts thereof in another selected position; and

FIG. 8 is a cross-sectional view similar to FIGS. 6 and 7 but showing the component parts in still another selected position.

Referring now to the drawing, and especially FIGS. 1 and 2, a time-delay control apparatus 10 is shown to comprise a base 12, which is advantageously fabricated from a dielectric material, and upon which is mounted a solenoid assembly 14. The solenoid assembly comprises a frame 16 in which is found the usual coil 18 and armature 20. The terminals of the coil are connected to insulated electrical conductors 22 which are, in turn,

connected to a rectifier 24 mounted on the base 12 and having input terminals 26 passing through the base for external connection. Since, insofar as the present invention is concerned, the specific type or construction of the solenoid assembly is not critical, any suitable construction of known kind may be employed to accommodate the voltage and type of current available for its energization.

A pneumatic timing device is shown in the form of a timing head 28 including a timing member illustrated in the form of a rod 30 which passes through the armature 20 and is reciprocatable independent of the movement of the armature. Rod 30 also passes through a bushing 32 which is affixed to the solenoid frame 16 adjacent the upper end of the coil 18. The rod 30 is connected at its upper end 34 to a diaphragm assembly 36 which includes a flexible diaphragm 38 which is clamped at its periphery between an upper housing member 40 and a lower housing member 42 so as to establish a timing chamber 44 having an upper chamber portion 46 for containing a fluid such as air between the diaphragm 38 and the upper housing member 40 and a lower chamber portion 48.

Intermediate the ends of the rod 30 there is an annular groove 50 in the rod which is engaged by a forked control arm 52 of an overcenter type snap-action electrical switch 54 mounted upon the base 12. The overcenter snap-action electrical switch has a pair of fixed electrical contacts 56 and 58 between which a support member 60 carries a movable contact 62 in such a way that the support member 60 may be actuated to bring the movable contact 62 into electrical contact with either one or the other of the fixed contacts. Traverse of the movable contact 62 is accomplished by movement of the arm 52 which is coupled to the movable contact support member 60 by means of a U-shaped over-center spring 64. The terminals 66 of the electrical switch 54 extend through the base 12 so as to enable external connections to be made to the switch. In the operating position shown in FIG. 2, a shoulder 68 on the rod 30 is urged into engagement with the bushing 32 of the solenoid assembly 14 by means of a helical spring 70 which is located in a recess 72 in the bushing 32 and which urges the armature 20 downwardly and into engagement with a collar 74 retained at the lower end 76 of the rod 30 by means of a retaining ring 78. In this position the actuating arm 52 of the electrical switch 54 is in its downward position and the movable contact 62 is urged upwardly by the over-center spring 64 into engagement with the upper fixed contact 56.

The flexible diaphragm assembly 36 includes the diaphragm 38 fabricated of a flexible material, preferably an elastomer, which has a bead 80 molded around its outer periphery and secured between upper and lower housing members 40 and 42. A relatively rigid annular member 82 is affixed within a central aperture 84 of the diaphragm 38 and carries an annular valve member 86 which is also preferably fabricated of an elastomer and has a lowermost surface 88. The uppermost end 34 of the rod 30 passes through a tubular extension 90 of the annular member 82 and a helical spring 92 extends between a retainer 94 carried by the rod 30 and the annular member 82 so as to urge the annular member downwardly until the lower surface 88 of the valve member 86 engages a valve seat 96 on the rod 30 to close off any pathway for air between the upper and lower chambers 46 and 48 through the diaphragm assembly 36.

When the coil 18 of the solenoid is energized by an operator or some automatic means, the armature 20 is drawn vertically upwardly into the coil against the force of the helical spring 70 until a flange 100, which is located at the lowermost portion of the armature 20, comes into abutment with the solenoid frame 16, as seen in FIG. 3. A further helical spring 102, which has been in compression up to this time, is now permitted to move the rod 30 vertically upwardly since the upward movement of the armature will free the collar 74 for upward movement. However, such upward movement of the rod 30 is restrained by the pressure of the air in the upper timing chamber portion 46 acting against the upward deflection of the flexible diaphragm 38.

The air in the upper chamber portion 46 is thus forced by the upward movement of the diaphragm assembly 36 to pass through a passage 104 in the upper housing member 40, the passage 104 including a portion 106 which communicates with a recess 108 in which there is seated a body of porous material shown in the form of a block of porous metal in the form of a disk 110 placed within a solid rim 111 and having an upper surface 112 which is flat and which is urged upwardly by a resilient O-ring 114 pressed against rim 111. The O-ring 114 forms an air seal at the areas of contact between the O-ring 114, the rim 111 and the recess 108 so that any flow of air through the recess 108 must pass through an opening 115 in the rim and through the porous disk 110. The upper housing member 40 is itself provided with a flat or planar surface 116 at the top thereof and a dial 118 is mounted for rotation upon the upper housing member by means of a screw 120 which passes through the dial and into the upper housing member. Shutter means of relatively non-porous material are shown in the form of a relatively thin resilient shutter member 122 which is in the form of a disk affixed to the dial 118 for rotation therewith, preferably by an adhesive, and includes a channel 124 therein (also see FIG. 6). Shutter member 122 is fabricated of an air-impervious elastomer and establishes an air seal where the flat surface 116 is engaged by the shutter member. The upper housing member 40 has an annular groove 126 therein which communicates with the lower chamber portion 48 through a further passage portion 128 which interconnects the annular groove 126 with the lower chamber portion. A notch 130 in the shutter member 122 interconnects the channel 124 with the annular groove 126 such that the air which is forced from the upper chamber portion 46 through the passage portion 106 and into the recess 108 may pass through the porous metal disk 110 and the portion of the channel 124 which is juxtaposed therewith, across the notch 130 and into the annular groove 126 to be directed to the passage portion 128 and to the lower chamber portion 48. Since the porous metal disk 110 will present a certain amount of resistance to the passage of the air therethrough the flow of air out of the upper chamber portion will be impeded and restricted to a prescribed rate which, in turn, will restrict the upward movement of the rod 30 to a prescribed rate. The upward move-

ment of the rod will move the actuating arm 52 of the electrical switch 54 upwardly until, after the lapse of a prescribed period of time, rod 30 will reach the position shown in FIG. 4, the bias of the over-center spring 64 will be reversed and the movable contact 62 of the electrical switch 54 will be driven from engagement with the upper fixed contact 56 into engagement with the lower fixed contact 58.

Upon de-energization of the solenoid coil 18 the helical spring 70 will urge the armature 20 downwardly and since the flange portion 100 of the armature 20 is in engagement with the collar 74 carried by the rod 30, the rod will be urged downwardly against the bias of the helical spring 102. As best seen in FIG. 5, the downward movement of the rod 30 will tend to draw the diaphragm assembly 36 downwardly and in so doing will allow the helical spring 92 to compress until the retainer 94 at the upper end 34 of the rod 30 is seated upon the tubular extension 90 of the annular member 82 and the valve seat 96 is drawn away from the valve member 86 to enable air to pass from the lower chamber portion 48 through perforations 140 in the tubular extension 90 of the annular member and into the upper chamber portion 46, as indicated by the arrows in FIG. 5, with relatively little resistance so that the downward movement of the rod 30 and the diaphragm assembly 36 after de-energization of the solenoid is practically instantaneous.

The rate at which the rod 30 moves in the upward direction may be regulated by regulating the rate of flow of air from the upper chamber portion 46 to the lower chamber portion 48 during the upward movement of the rod and the diaphragm assembly as described above. Turning now to FIGS. 6, 7 and 8, it will be seen that the channel 124 of the shutter member 122 extends along an arcuate path and has a length which is greater than the diameter of the disk 110 of porous metal so that as the dial 118 and the shutter member 122 are rotated, the shutter member will slide over the flat surface 116 and different portions of the channel 124 are brought into juxtaposition with the porous metal disk 110. Since the channel varies in width from end to end, as the dial and the shutter member are rotated, the exposed area of the porous metal disk is varied to vary the amount of air which may pass through the disk and thus vary the rate of flow of air out of the upper chamber portion 46. Thus, as seen in FIG. 6, a relatively large area 142 of the porous metal disk 110 is exposed, thereby permitting air to flow rather rapidly through the disk 110, into the groove 126, and through passage portion 128 into the lower chamber portion 48. When the dial 118 and shutter member 122 are turned through a 90° displacement, as seen in FIG. 7, a lesser area 144 of the disk of porous metal is exposed while other areas 146 of the disk are closed to any flow of air by virtue of the surface 112 of the disk 110 being urged against the shutter member 122 to seal off those areas 146 and the rate of flow of air from the upper chamber portion through the disk and into the channel 124 and through the notch 130 into the groove 126 and subsequently into the passage portion 128 and to the lower chamber portion will be lower than the rate of flow of air when the dial and shutter member are in the position shown in FIG. 6. Likewise, when the dial and shutter member are further rotated through an additional 90° displacement, as seen in FIG. 8, an even lesser area 148 of the surface 112 of the disk is exposed and the rate of air flow is decreased even more. Thus, the porous metal disk 110 serves to throttle the air flow to approximately the order of magnitude of the maximum rate of flow while the configuration of the channel 124 in the shutter member enables the air flow to be regulated over a range between the predetermined maximum rate and a minimum rate.

When it is desired to change the order of magnitude of the maximum rate of flow, it becomes a relatively simple matter to merely remove the screw 120 to thereby allow removal of the dial 118 and the shutter member 122 to expose the disk 110 which may then be removed from the recess 108 and replaced with any one of a variety of disks having different degrees of porosity. The disks are preferably fabricated of porous metal and the porosity of such disks may be easily controlled in the fabrication thereof. Sintered metal disks of varying degrees of porosity are easily fabricated for this purpose.

As seen in FIG. 1, the dial 118 may be provided with a scale 150 which is calibrated in accordance with the configuration of the channel 124 so that a visual alignment of a portion of the scale with a pointer 152 (also see FIG. 2) will give a true reading of the duration of the time interval between activation of the solenoid and the actuation of electrical switch 54 by movement of rod 30 through the required displacement.

Although channel 124 has a configuration which provides a linear relationship between increments of displacement of the dial and shutter means and corresponding increments of change in the duration of the time delay interval, it will be apparent that different configurations may be provided in channel 124 where other relationships are desired.

It is noted that the air in the timing device is circulated and recirculated between the upper and lower chamber portions 46 and 48 so that a constant volume of air remains in chamber 44. Thus, no outside air need be introduced into the timing device and a high level of cleanliness may be maintained within the chamber 44. Such cleanliness will enhance the accuracy of the device.

Returning now to FIG. 2, it will be seen that the actuation of the electrical switch 54 takes place at the point where the bias of the over-center spring 64 will be reversed and will therefore take place after the lapse of the period of time necessary for the rod 30 to move from the first position shown in FIG. 2 upwardly to a second position where the bias of the over-center spring will be reversed. Since the duration of that period is directly related to the amount of displacement of the rod 30 prior to the time when the rod reaches the second position where the bias of the over-center spring will be reversed, it will be seen that small variations in the magnitude of that displacement will produce corresponding variations in the actual duration of the timed interval. Therefore, when it is necessary to calibrate the time delay control apparatus so as to correlate the actual duration of the timed interval with the scale 150 appearing on the dial 118 (see FIG. 1) the device incorporates means for allowing adjustment of the initial position of the rod 30 with respect to

the actuating arm **52** as seen in FIG. **2**. Thus, the solenoid frame **16** is affixed to the base **12** by means of a bracket **160** and a pair of mounting screws **162** which pass through slots **164** in the base. Bracket **160** is integral with the frame **16** and extends through the base **12** to a mounting pad **166** (see FIG. **1**) which is provided for mounting the bracket and the apparatus **10** upon an external structure. By loosening the screws **162** the bracket **160** may be moved upwardly or downwardly with respect to the base **12**, such displacement being permitted by the slots **164**, thereby moving the bushing **32**, which is in fixed assembly with the frame **16**, upwardly or downwardly. Since the bushing **32** cooperates with the shoulder **68** of the rod **30** to serve as a stop member which defines the first position of the rod **30**, such upward or downward movement of the bushing **32** will change the first position of the rod **30** and especially the position of the annular groove **50** in the rod with respect to the dead-center position of the over-center snap-action electrical switch **54** thereby enabling slight adjustments in the displacement of the rod **30** necessary to actuate the electrical switch.

In addition, the integral construction of the bracket **160** and solenoid frame **16** permits rapid dissipation of heat from the solenoid coil by fabricating the bracket and frame of a heat conductive material. Thus, heat generated during operation of the solenoid coil may be carried out of the apparatus **10** and dissipated in surrounding structures to which the apparatus is attached, thereby enabling a compact construction which will operate effectively and reliably over extended periods of time.

The above detailed description of an embodiment of the invention is presented by way of example only. Various details of design and construction may be modified without departing from the true spirit and scope of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A pneumatic timing device comprising:

a base;

a timing head including an air chamber mounted upon said base;

means movable relative to said timing head to effect a change in the volume of the air chamber and movement of air into or out of the chamber;

a timing member coupled for movement with said movable means along a path of travel between first and second positions at a rate determined by rate of flow of air to or from the chamber;

a bracket for mounting said base upon an external structure;

a control arm mounted upon said base for movement in response to movement of said timing member through a prescribed displacement from one of said first and second positions to actuate a control means;

a stop member carried by said bracket and abutting a portion of the timing member when said timing member is at said one of said positions; and

means mounting said base upon said bracket for selective adjustment of the relative position of the base and bracket to enable adjustment of the position of the stop member relative to the control arm.

2. The pneumatic timing device of claim **1** including:

a solenoid;

means coupling said solenoid with said timing member such that the timing member moves in response to operation of the solenoid;

a frame upon which the solenoid is mounted, said frame being integral with said bracket; and

said frame and said bracket being fabricated of a heat-conductive material.

3. The timing device of claim **1** wherein said control means includes an electrical switch capable of being actuated by the control arm as said control arm is moved in response to movement of the timing member from said one of said positions toward the other of said positions.

4. The timing device of claim **3** wherein said control means includes over-center spring means coupling said control arm with said electrical switch and arranged such that the bias of the overcenter spring means will be reversed as the timing member moves from said one of said positions to the other of said positions.

* * * * *