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 said 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 airflow passes, and a shutter is in close engagement with the surface of the body of porous material and includes a relatively nonporous member selectively moveable along the surface relative to the body to close off at least portions of the area to the airflow for selectively varying the rate of the flow to regulate the rate of movement of the timing member.
TIMING DEVICE WITH PNEUMATIC DELAY MEANS

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 the 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 initiation of a control. Such devices, 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 fluid through 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 airflow 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 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.

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. 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 dimension 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 fluid through 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 same magnitude of the maximum rate of flow, the body of porous material having a surface of prescribed area through which the fluid passes, the porous means being selectively movable relative to one another to close off at least portions of the area to flow for selectivity 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 drawings, 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.

Reverting now to the drawings, 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-type 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 overcenter 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 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 overcenter spring 39 into engagement with a fixed upper 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 portion 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 he 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 he form of a block of porous metal in the form of a disk 110 within a solid rim 112 and having an upper surface 112 which is flat and which is urged upwardly by a resilient O-ring 114 pressed against rim 112. The O-ring 114 forms an air seal at the areas of contact between the O-ring 114, the rim 112 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 provided with a flat or planar surface 116 at the top thereof and a dia 118 is mounted for rotation upon the upper housing member by means of a screw 120 which passes through the dia 118 and into the upper housing member. Shutter members of relatively nonporous 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 dia 118 for rotation therewith, preferably by an adhesive, and includes a channel 123 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 engage by the shutter member. The upper housing member 40 has an annular groove 126 wherein 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 into 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 may be limited and restricted to a prescribed rate which, in turn, will restrict the upward movement of the rod 30 to a prescribed rate.

The upward movement 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 overcenter spring 64 will be reversed and the movable contact 62 urged upwardly by the overcenter spring 39 into engagement with the upper fixed contact 56.

Upon deenergization 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 deenergization 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 its diameter of the disk 110 of porous metal so that as the dia 118 and the shutter member 122 are rotated, the shutter member will slide over the flat surface and shutter reference 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 dia 118 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 dia 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 dia 110, into the groove 126 and, through passage portion 128 into the lower chamber portion 48. When the dia 118 and shutter member 122 are turned through a 90° displacement, as seen in FIG. 7, a lesser area 144 of the disk or 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 dia and into the channel 124 and through the notch 130 into the groove 126 and subsequently into the passage portion 128 and the lower chamber portion will be lower than the rate of flow of air when the dia 118 and shutter member are in the position shown in FIG. 6. Likewise, when the dia 118 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 airflow is decreased even more. Thus, the porous metal disk 110 serves
to throttle the airflow to approximately the order of magnitude of the maximum rate of flow while the configuration of the channel 124 forms the shunt member enables the airflow 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 shunt member 122 to expose the disk 110 which can then be removed from the recess 108 and replaced with any one of a number 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 on which is calibrated in accordance with the configuration of the scale with a pointer 152 (also see FIG. 2) will give a true reading of the duration of the time interval between actuation 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 the order of magnitude 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 overcenter 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 rod is brought to the center of the overcenter 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 overcenter 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 rod 30 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, thereby enabling the bushing 32, which is in fixed assembly with the frame 16, upwardly or downwardly. Since the bushing 32 cooperates with the shaft 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 overcenter 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 from 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. 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 we claim an exclusive property or privilege are defined as follows:

1. In a timing device wherein the movement of a timing member effected by a channel 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, said regulating means comprising:

a body of porous material in the passage for throttling the flow to approximate the order of magnitude of the maximum rate of flow, said body being adjacent to a surface of prescribed area through which said flow passes;

shutter means of relatively nonporous material juxtaposed in close engagement with said surface; and

said body of porous material and said shutter means being selectively movable relative to one another to close off at least portions of said area to said flow for selectively varying the rate of said flow to regulate the rate of movement of said timing member.

2. The invention of claim 1 wherein:

the body of porous material is a block of porous material having a flat surface; and

the shutter means include a shutter member having a flat surface and a channel communicat with said passage, said channel having a length and extending in the direction of the relative movement between the shutter member and the block of porous material, at least a portion of the flat surface of the shutter member engaging the flat surface of the block of porous material with a portion of the length of the channel juxtaposed with the flat surface of the block of porous material, said length being greater than the corresponding extent of the flat surface of the block of porous material in the direction transverse to said relative movement, and at least portions of said width being less than the corresponding extent of the flat surface of the block of porous material in the direction transverse to said relative movement such that relative movement of the shutter member and the block of porous material will position different portions of the length of said channel in juxtaposition with the flat surface of the block communicating with said passage.

3. The invention of claim 1 wherein the timing device includes first and second members mounted for rotational movement relative to one another and wherein:

the body of porous material includes a disk or porous metal seated within the first member, and said surface of prescribed area is a flat surface;

the shutter means includes a shutter disk affixed to the second member and having a flat surface in close engagement with the flat surface of the disk of porous metal;

a channel in the flat surface of the shutter disk, said channel communicating with said passage and having a length extending along an arcuate path about the center of said rotational movement and a width which varies over said length; and

said disk of porous metal being juxtaposed with a portion of said arcuate path and said length being greater than the corresponding extent of the flat surface of the disk of porous metal in the direction of said path, and at least
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7 portions of said width being less than the corresponding extent of the flat surface of the porous metal disk in the direction transverse to said path such that relative rotation of said first and second members will bring different portions of said disk into juxtaposition with the disk of porous metal to selectively vary the area of the flat surface of the disk of porous metal communicating with said passage.

4. The invention of claim 3 including means for resiliently biasing the disk of porous metal and the shutter disk toward one another and said flat surfaces into said close engagement.

5. The invention of claim 3 wherein the timing device includes a base and wherein the first member is affixed to the base and the second member is mounted for rotation upon the base relative to the first member.

6. The invention of claim 3 wherein said disk of porous metal is releasably seated in said first member and including means for providing ready access to said disk of porous metal for selective removal and replacement of said disk with a similar disk of different porosity to change said order of magnitude of the maximum rate of flow.

7. A pneumatic timing device comprising:
   a timing head including an air chamber;
   means movable relative to said timing head to effect a change in the volume of the air chamber and the flow of aid into or out of the air chamber;
   a timing member coupled for movement with said movable means at a rate determined by the rate of flow of air to or from the air chamber;
   a passage in said timing head communicating with the air chamber for conducting said flow of air;
   a body of porous material at said passage for throttling said flow to a predetermined maximum rate of flow, said body having a surface of prescribed area through which said airflow passes and
   shutter means in close engagement with the surface of the body of porous material and including relatively nonporous means selectively movable along said surface relative to said body to close off at least portions of said area to said airflow for selectively varying the rate of said flow to regulate the rate of movement of the timing member.

8. The timing device of claim 7 wherein:
   said timing head includes an air chamber;
   said means movable relative to said timing head includes a diaphragm dividing said air chamber into first and second chamber portions and movable within the chamber to simultaneously decrease the volume of one chamber portion while increasing the volume of the other chamber portion;
   said timing member is affixed to the diaphragm for movement therewith at a rate determined by the rate of flow of air from one chamber portion to the other chamber portion during movement of the diaphragm; and
   said passage interconnects the chamber portions for conducting air from one chamber portion into the other chamber portion.

9. The pneumatic timing device of claim 7 wherein said timing member moves along a path of travel between first and second positions, said timing device including:
   a bracket for mounting said base upon an external structure;
   a control arm mounted upon said base for movement in response to movement of the timing member through a prescribed displacement from one of said first and second positions;
   a stop member carried by said bracket and abutting a portion of the timing member when the 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 the bracket to enable adjustment of the position of the stop member relative to the control arm.

10. The pneumatic timing device of claim 9 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.

11. The timing device of claim 7 wherein said timing head includes:
   a first member having a flat surface, a recess in said flat surface and a first portion of said passage communicating with the recess;
   a second member mounted upon the first member for movement thereon;
   said body of porous material including a block of porous material seated in said recess and having a flat surface coplanar with the flat surface of said first member; and
   said shutter means including a shutter member of relatively nonporous material on said second member and having a flat surface closely engaging the flat surface of said first member for relative sliding movement during movement of the second member, and a channel having a length extending along the direction of said movement and a width which varies along said length, the length being greater than the corresponding extent of the flat surface of the block of porous material in the direction of said movement and at last portions of the width being less than the corresponding extent of the flat surface of the block of porous material in the direction of said movement in communication with the flat surface of the block of porous material and communicating with a second portion of said passage such that said movement will position different portions of the length of said channel in communication with the flat surface of the block to selectively vary the area of the flat surface of the block in communication with said passage.

12. The timing device of claim 11 wherein:
   said body of porous material comprises a disk of porous metal having a predetermined diameter;
   said second member comprises a dial mounted for rotation upon said first member;
   said shutter member includes a disk of resilient, air-impermeable material affixed for rotation with the dial between the dial and the first member; and
   said channel extends along an arcuate path about the center of the rotational movement of said dial and has a length greater than the diameter of the porous metal disk and a width which includes portions less than the diameter and the width of the porous metal disk such that rotation of the dial will position different portions of the length of the channel in juxtaposition with the flat surface of the porous metal disk to selectively close off portions of the area of the flat surface of the porous metal disk to the flow of air and thereby vary the rate of flow of the air through said passage.

13. The timing device of claim 12 including means for resiliently biasing the porous metal disk against the disk of air-impermeable material.

14. The timing device of claim 12 including:
   means mounting said dial upon said first member for selective removal therefrom to expose the disk of porous metal; and
   means mounting said porous metal disk within said recess for selective removal therefrom such that upon removal of said dial, said disk of porous metal may be removed and replaced with a similar disk of different porosity to change the magnitude of said maximum rate of flow.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,599,131 Dated August 10, 1971

Inventor(s) Robert M. Flanagan and Glenn W. Johnson, Jr.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 12, "he" should read -- the --
Column 1, line 64, "part" should read -- parts --
Column 2, line 7, "the" should read -- flow --
Column 2, line 10, "he" should read -- the --
Column 3, line 70, "engage" should read -- engaged--
Column 4, line 45, "he" should read -- the --
Column 5, lines 30, 45 and 54, "he" should read -- the --
Column 5, line 70, "and...rod 30" should be deleted
Column 6, line 2, "he" should read -- the --
Column 6, line 43, "he" should read -- the --
Column 6, line 61, "or" should read -- of --
Column 7, line 26, "aid" should read -- air --
Column 7, line 43, should be deleted
Column 7, line 59, "—pl" should be deleted and a paragraph should begin with "a base..."

Signed and sealed this 6th day of March 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents