# United States Patent

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[54] **LUBRICANT INJECTION SYSTEM**
**10 Claims, 7 Drawing Figs.**


[52] **U.S. Cl.** ..... **417/344,** 184/56
[51] **Int. Cl.** ..... **F04b 17/02,** F16n 7/34
[50] **Field of Search** ..... 417/344, 345, 345; 184/53, 56



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**ABSTRACT:** A lubricant supply line from a lubricant pump supplies a number of serially connected injectors, each of which has a connection with a bearing to be lubricated. A timing arrangement cyclically starts and stops the pump to supply and to release pressure in the lubricant supply line. Each injector is constructed so that, when the inlet pressure thereto rises, an accurately measured amount of lubricant is forced to its bearing connection and the risen inlet pressure is serially applied to the next injector in the series so that it subsequently forces a like measured amount of lubricant to its bearing connection. An accumulator is connected to the outlet of the last injector and becomes operative after the last injector has functioned. Thereafter the pump stops to release built-up pressure which causes serial recharging of the injectors to ready them for accurately measured lubrication during the next cycle. During this recharging event, only the first injector returns a relatively small amount of lubricant to the pump and each injector receives its recharge from the next one, except the last one which receives its recharge from the accumulator. The accumulator also serves as a malfunction indicator for the system.

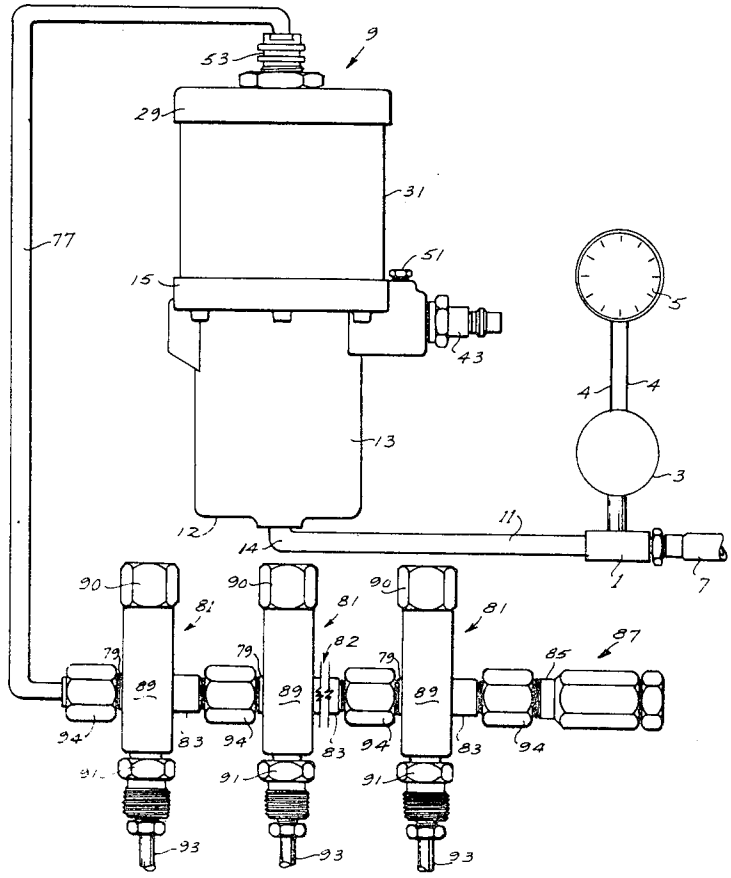



FIG. 1

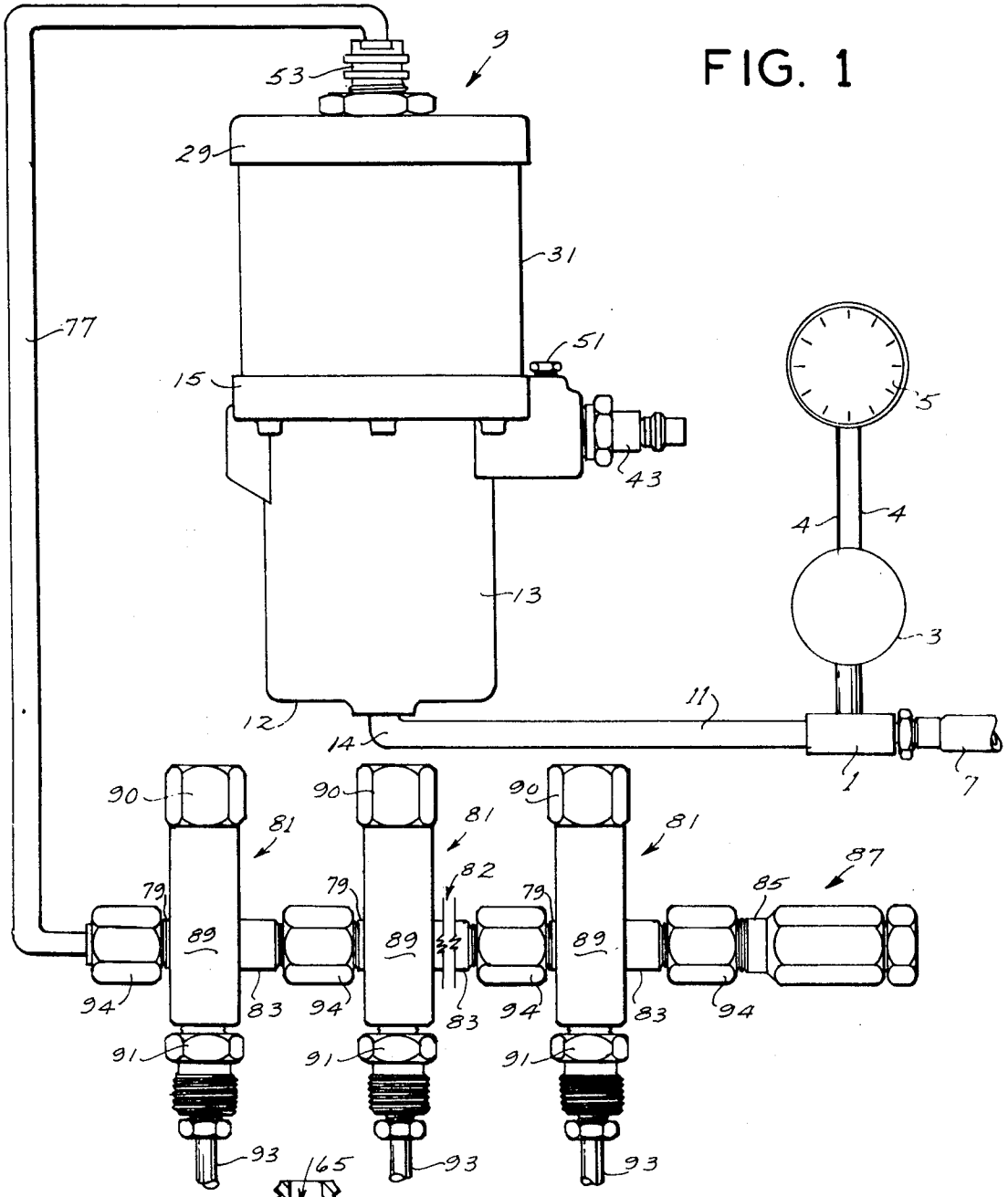
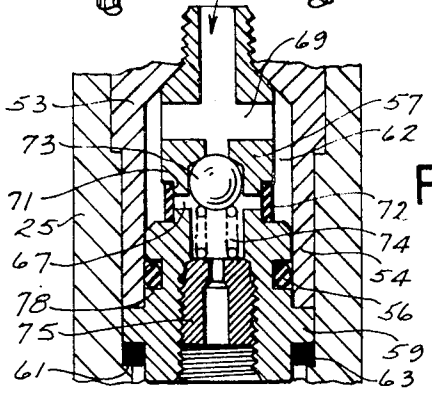



FIG. 3




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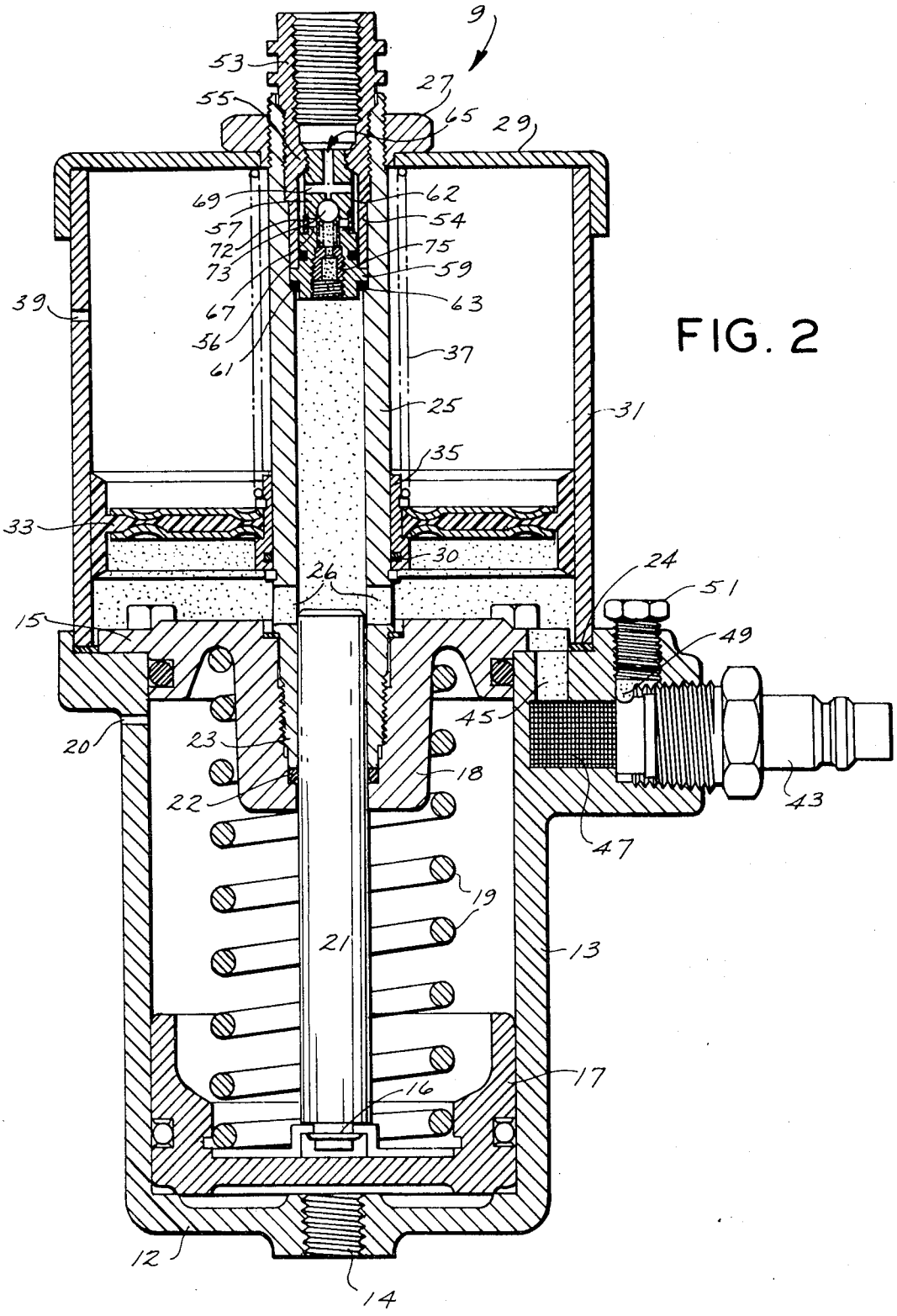

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FIG. 2

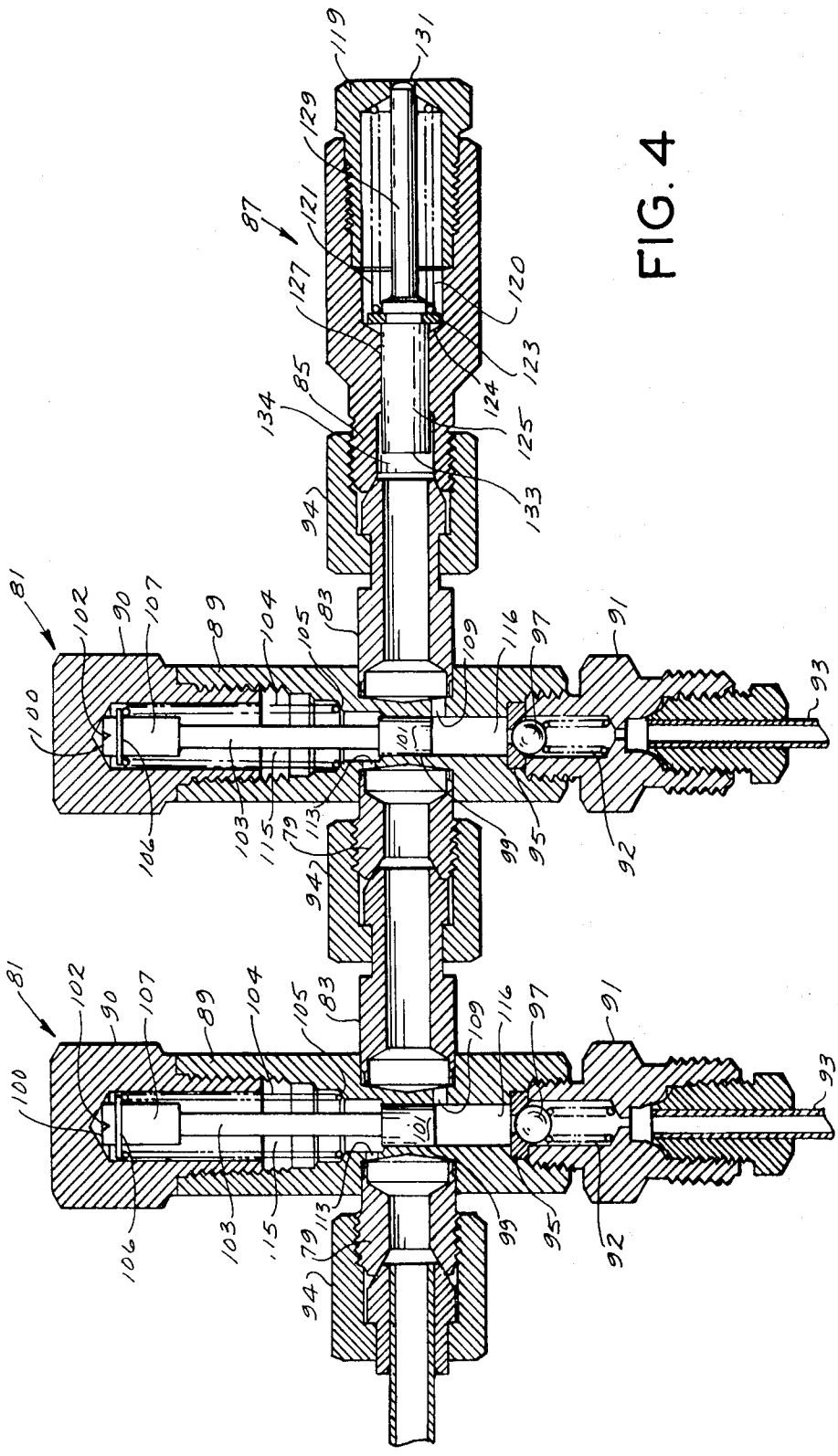

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FIG. 4

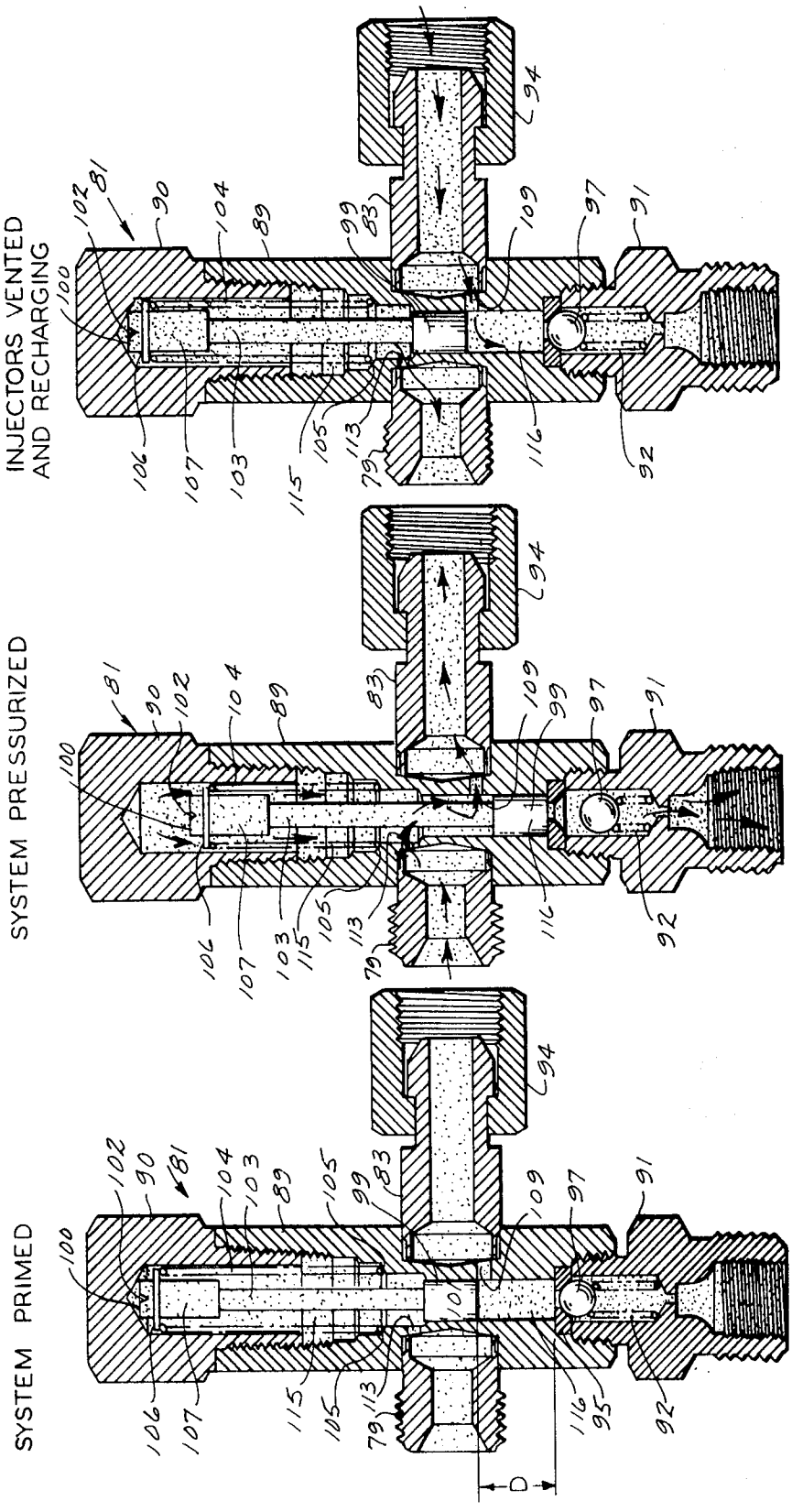



FIG. 7

FIG. 6

FIG. 5

# LUBRICANT INJECTION SYSTEM

## BACKGROUND OF THE INVENTION

Injectors have heretofore been arranged for multiple injection of measured amounts of lubricant to various bearings. They employed individual accumulators for measuring amounts to be delivered. The multiplicity of accumulators was costly and they required elastomeric seals which were undesirable in high temperature locations of the injectors on hot machinery. Moreover, in former arrangements during each cycle each injector-vented lubricant in parallel with the others all the way back to the sump of the pump. This wasted venting time and required much costly piping. According to the present invention a single accumulator is used in connection with the last injector of a series of them, and when the accumulator vents, each injector vents a small measured volume a short distance to the preceding injector, with the exception of the first injector which is the only one which vents back to the pump, thus saving accumulator and piping costs as well as improving performance and operating speed. At a given speed of operation more injectors can be connected to a given pump. Other advantages will be apparent from the following description.

## SUMMARY

The gist of the invention is in the connection of injectors and an accumulator in serial order, such that the first injector is pressurized from a timed lubricant pump and then the others are pressurized in order, to perform injections, the accumulator being finally pressurized and charged. Upon venting at the pump, the injectors are vented in the same serial order. Only the first one returns lubricant back to the pump as it is recharged by bleedback from the second injector. Then the third one bleeds back to the second recharging it. This sequence of events continues throughout the series until the accumulator is reached which forces lubricant back to the last injector in the series to recharge it. Thus all of the injectors are recharged but only the first is required to return lubricant to the pump upon venting.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation illustrating a typical complete system made according to the invention;

FIG. 2 is a vertical section through a lubricant pump of the system which is shown as part of FIG. 1;

FIG. 3 is an enlarged axial section of line-venting parts at the outlet of the pump;

FIG. 4 is an enlarged axial section of several injectors and an accumulator; and

FIGS. 5–7 are views illustrating operating events.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

## PREFERRED EMBODIMENT OF THE INVENTION

Referring to FIG. 1, numeral 1 indicates a solenoid operated three-way air supply and vent valve. Its operating solenoid 3 is excited and deexcited at intervals by an adjustable electric timing switch 5. The connecting wiring is shown at 4. These parts are shown diagrammatically, being known per se. Thus the air valve 1 is opened and closed at adjustably timed intervals according to the timing adjustment of switch 5. A compressed air supply line 7 feeds valve 1. The valve is connected to a pump 9 by air line 11. When the valve 1 is closed it vents line 11, and when open supplies pump 9 with air at a nominal pressure, for example at 40 to 50 p.s.i.

The pump 9 is detailed in FIGS. 2 and 3. It comprises an air cylinder 13 having a sealed upper head 15. The air line 11 connects at 14 with the lower end 12 of cylinder 13. In the cylinder 13 is an air operated piston 17 biased downwardly from the head 15 by a return spring 19. Above piston 17 is an atmospheric relief passage 20. In a gland portion 18 of the head 15 is located a packing 22 around a plunger 21. Plunger 21 is connected to the piston 17 at 16.



Threaded into the gland portion 18 is the threaded end 23 of a pump cylinder 25. The end 23 confines the packing 22. The plunger 21 reciprocates in cylinder 25. Threaded to the outside of the upper end of the cylinder 25 is a nut 27 which bears on a head 29 of a lubricant supply cylinder 31. The lower end of cylinder 31 is sealed to head 15 by a washer 24.

In the cylinder 31 is a lubricant follower piston 33. A hub 35 of piston 33 slides on the outside of cylinder 25, being sealed by packing 30. The piston 33 is biased downwardly by a spring 37. Ports for admission and exit of air above piston 33 are shown at 39. Lubricant is carried under piston 33 as indicated by stippling. A minimum amount is shown in FIG. 2. The lubricant has access to the inside of cylinder 25 through lower ports 26 in the latter.

At 43 is shown a conventional lubricant charging nipple connected to a passage 45 leading to the bottom of cylinder 31. In the passage 45 is a strainer 47 from the inside of which is connected a port 49 which leads to a threaded openable drain plug 51. The nipple 43 contains a conventional one-way check valve (not shown) to admit lubricant.

Threaded into the inside upper end of cylinder 25 is an outlet nipple 53. Threaded into an inner shoulder 55 of this nipple 53 (see also FIG. 3) is a valve body 57 which has an outer shoulder 59 engaging a gasket 63 on an inner shoulder 61 of cylinder 25. Body 57 is held in place by an inner sleeve 54 of the nipple 53. An O-ring 56 seals body 57 to the part 54 of nipple 53. Above the O-ring the body 57 is arranged with radial clearance 62 inside of the nipple 53 for accommodating flow of lubricant. The body 57 has an axial passage 65 through it. It also has lower and upper cross ports 67 and 69. Port 67 terminates in a peripheral groove 71 which contains a constrictive elastomeric sleeve 72 forming a ring check valve permitting outward flow from passage 67 to clearance 62 but not the reverse, thus functioning as a reverse check valve. Located in the passage 65 (between the transverse ports 67 and 69) is a spring-pressed ball check valve 73 which checks against egress to nipple 53 of lubricant but permits ingress of lubricant to the cylinder 25. The spring of ball valve 73 is numbered 74. The spring 74 and the ball valve 73 are held in place by an inlet nipple 75 threaded into the lower end of the body 57.

Operation of the pump 9 is as follows: First it is primed (FIGS. 2 and 3). This is accomplished by connecting a lubricant supply under pressure to nipple 43. This infills the space under follower piston 33 pushing it up against action of spring 37 until hole 39 is crossed and lubricant weeps out indicating a full condition. Ring check valve 72 holds against a greater lubricant pressure than is supplied by action of spring 37 on piston 33. Hence, until the pump starts no lubricant is discharged to the remainder of the system.

Upon starting the pump lubricant is pumped from under piston 33, entering cylinder 25 via ports 26. The pump forces it up into the central passage 65 of body 57 via nipple 75, from whence it escapes radially out through cross port 67, through ring check valve 72, clearance 62, inward through cross port 69 and then out from the central passage 65 to nipple 53. This supplies lubricant under pressure to the remainder of the system to be described. Discharge through body 57 to nipple 53 occurs when the plunger 21 is pushed up by piston 17. The ratio of the area of piston 17 to the end area of plunger 21 is made large enough so that a pressure which is greater than priming pressure is obtained under a nominal air pressure in air line 11. This pressure may be on the order of 800 to 1,000 p.s.i. or more, for example. When the air in line 11 is vented, the piston 17 and plunger 21 are retracted under expanding action of spring 19 to receive in cylinder 25, first, through check valve 73 a small measured amount (to be described) of returned lubricant from a first injector in the system, and second, an additional amount through ports 26 when the plunger 21 reaches the bottom of its stroke. The latter amount is equal to the total amount of lubricant which has been ejected by all injectors in the system during the preceding cycle of its operation, as will appear below.

Referring again to FIG. 1, the nipple 53 will be seen to be connected with a lubricant line 77 which feeds an inlet nipple

79 of a first one of a series of identical connected injectors 81. The number of injectors in the series is arbitrary, three being shown for example in FIG. 1, the break lines 82 indicating that more may be included in the series. An outlet nipple 83 of each injector 81 connects with the inlet nipple 79 of the next one, except as to the last one in the series, the outlet nipple 83 of which connects with the inlet 85 of an accumulator 87 (see FIGS. 1 and 4). FIG. 4 shows details of the accumulator and of the last two injectors of a series of them. Coupling nuts are shown at 94.

Each injector 81 (FIG. 4) is in the form of a manifold composed of a hollow body 89 to which is threaded an upper hollow cap 90 and a lower fitting 91, the latter being for the attachment as shown of a branch lubricant line 93 (FIGS. 1 and 4). Lines such as 93 lead to machine bearings (not shown) to be lubricated by the system under the stated high pressure of 800 to 1,000 p.s.i. for example. Each fitting 91 holds in place the seat 95 of a spring pressed ball check valve 97 supported in the fitting 91. The spring is numbered 92.

Each manifold body 89 is also formed with a dividing mid portion 99 of cylindric form in which slides a piston 101. An extension 103 from the upper side of piston 101 has a head 107. The unbalanced pressure transmitting area 100 of the upper end of head 107 equals the lower end area of the piston 101. The outer rim of this area is notched as shown at 102 so that pressure can gain access to the area when said rim contacts the cap 90.

Parts 101, 103 and 107 constitute a double-acting plunger. The plunger is held up (under vented conditions to be described) by a spring 104 reacting from a shoulder 105 in body 89 and to a collar 106 on head 107. The cap 90 forms a stop for determining the normal position of the plunger with its piston 101 in the mid cylindrical portion 99. This normal position of the piston 101 is just above a lower port 109 connecting with the outlet nipple 83. Port 109 is above what will be referred to as an injection chamber 116. The piston in said normal position is also just below an inlet port 113 leading from nipple 79. At 115 is shown an upper stepped chamber, one of the steps of which forms the shoulder 105 upon which spring 104 rests. Entering pressure reaches the top of head 107 to drive down the piston 101 into the lower chamber 116 while retracting the plunger parts 103, 107 from the upper chamber. This compresses spring 104. When this pressure is released the spring pushes the piston 101 up from chamber 116 and into the mid cylinder 99, at the same time driving the plunger parts 103, 107 back into chamber 115. Each of the screw couplings 94 connects an outlet nipple 83 of a preceding injector 81 with the inlet fitting 79 of the next succeeding injector as shown in FIGS. 1 and 4.

The last coupler 94 in the series connects with the inlet 85 of the accumulator 87, details of which appear in FIG. 4. This includes a hollow threaded cap 119 forming a pocket 120 for a spring 121. The spring reacts from cap 119 to a collar 123 on a plunger 125, the latter slidably fitting a cylindrical portion 127. A signal stem 129 projecting from plunger 125 is movable in and out through an opening 131 in the cap 119. Pressure on the end 133 of plunger 125 pushes it in to provide pressurized lubricant-receiving space 134 in the inlet 85. When pressure is relieved, the spring 121 returns plunger 125 to return the contents of this space 134 back to the last of the series of injectors under conditions described below. The limiting position of the plunger 125 in space 134 is determined by engagement of the collar 123 on shoulder 124. Its other limiting position is determined by the point at which the spring 121 bottoms out upon compression. The plunger 125 is thus arranged to provide the same lubricant displacement as that of each injector piston 101 in its chamber 116 below its port 109. Instead of bottoming spring 121 to limit the position of plunger 125, other stop means may be used.

Injection operation is as follows, referring to FIGS. 5–7:

The stippling in FIG. 5 indicates a primed starting condition of each injector of the system at low lubricant pressure, as when air pressure is relieved in line 11 by action of timer 5 deexciting solenoid 3 so as to shut air valve 1 and allow it to bleed air line 11. The pump 9 and accumulator 87 are then as shown in FIGS. 2 and 4 respectively. Check valve 73 holds this low pressure.

In time the switch 5 causes solenoid 3 to open valve 1 as its relief port closes. This forces up the pump piston 17 and its plunger 21 (FIG. 2) to force lubricant under pressure past the sleeve 72 to line 77. This pressure is conveyed to the first injector in the series as shown in FIG. 6. The arrows on FIG. 6 illustrate the action, pressure being admitted through upper port 113 above piston 101 forcing it down into the discharge chamber 116, thereby ejecting lubricant under pressure through its check valve 97 to its line 93 leading to the bearing which it serves. As plunger 101 descends below the lower port 109, pressure is delivered to the upper chamber 115 of the next succeeding injector in the series via its inlet port 113. This succeeding injector repeats the action of the preceding injector (as in FIG. 6) to supply lubricant to its branch bearing supply line 93. The injection action as illustrated in FIG. 6 is repeated sequentially throughout all of the injectors in the series until the last injector, through its lower port 109, supplies the accumulator 87, forcing out the plunger 125 to accumulate the last lubricant charge in space 134 while raising the signal stem 129 to show that the cycle has been successfully completed. If the signal stem 129 does not appear, this is an indication of trouble in the system requiring investigation and correction. In either event the pump 9 stalls when the maximum lubricant pressure of which it is capable is reached. The system then remains static under pressure until the timer switch 5 causes solenoid 3 to close valve 1 and vent the air line 11.

When the air line 11 is vented, pump piston 17 and plunger 21 descend under return action of its spring 19. This permits entry into its cylinder 25 of lubricant through its ball check valve 73, whereby the pressure is relieved first above the piston 101 of the first injector in the series (FIG. 7) Its spring 104 lifts its plunger 101, 103, 107) back into compartment 115 to drive lubricant back through upper port 113 to pump cylinder 25 via ball check valve 73. Lifting of the piston 101 uncovers lower port 109 which admits to compartment 116 a measured amount of lubricant from the compartment 115 of the next injector in line. This action is repeated in sequence through all of the injectors, the last one receiving lubricant back into its compartment 116 from the accumulator 87 under action of spring 121. The injector system is then back in the condition illustrated in FIG. 5. In the following claims compartment 115 is referred to as a first compartment and compartment 116 as a second compartment.

Thus it will be seen that the injectors discharge serially and also recharge serially after an injection cycle, only the first one discharging back to the pump and the last one receiving its measured amount of lubricant from the accumulator.

The interval over which switch 5 causes valve 1 to be held shut should be made long enough for all injectors of a series to operate throughout an injection cycle. Thus a greater number of injectors in a series will require more time. Other than this, the timing is not critical. After injection the system may be held for a time as long or as short as desired under pressure maintained by the pump under stall condition until pressure release effected by closing valve 1 and venting line 11.

It is to be understood that the spring of the ball check valve 73 in pump 9 is designed to let its ball open in response to a pressure drop across it under return flow of lubricant which is on the order of 25 to 75 p.s.i. or so. Thus the pressure of the system in normal condition between cycles (FIG. 5) is on that order. The springs of the ball check valves 97 in the injectors 81 are designed to hold their balls shut under return flow of lubricant under pressure involved in recharging (FIG. 7). They also assure prompt closure of check valves 95 when the pistons 101 rise so that no substantial amount of lubricant will be drawn back from the bearing supply lines 93.

Referring to FIG. 5, the distance D is a measure of the stroke of piston 101 and of the length of the compartment

116. Thus it is apparent that the measured volumetric discharge upon each downward piston stroke (FIG. 6) is substantially $\pi r^2 D$ wherein $r$ is the piston radius. An equal volume is at this time received above the piston which, when the piston returns, is vented out of compartment **115** to charge lubricant into the lower compartment **116** of the adjacent injector (FIG. 7) to make it ready for its next injection event. Thus all injectors vent to one another, except, the first one which vents back to the pump through the lubricant feed line **77**. This accounts for the saving in vent line costs in addition to the reduction in cost by use of only a single accumulator and malfunction indicator such as **87**. It is to be understood that the simultaneous volumetric displacements of pistons **101** into and out of the chambers **116** and **115** are equal, and that the volumetric displacement of the plunger **125** of accumulator **87** becomes equal to each of them as pressure builds up and releases.

As pointed out above, the injector and the accumulator are characterized by the absence therein of any elastomeric or like sealing parts which might be damaged by heat. Although there are such parts in the pump, as shown in FIG. **2**, it will be understood that, unlike the injectors and the accumulator, the pump is mounted at some distance from the quite often hot machinery in or upon which the injectors and accumulator are mounted and by reason of which it is undesirable for them to include such parts.

It will be appreciated that although the accumulator which is illustrated operates to receive and return fluid by means of a spring-backed piston, an equivalent well-known resilient diaphragm type of accumulator may be employed.

Although the invention is described for use in injecting lubricants, it is applicable to the injection of other fluids presenting problems analogous to those arising in the case of lubricant injection.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

**1**. A fluid injector comprising,

a hollow manifold forming

a. an internal cylindrical portion, with

b. a pressurizable and venting compartment extending from one end of the cylindrical portion, a first fluid port in said venting compartment adjacent said one end of the cylindrical portion, through which said compartment may be pressurized or vented, and

c. an injection compartment extending from the other end of said cylindrical portion, said injection compartment having a second port closely adjacent said other end of said cylindrical portion through which fluid may be moved into the injection compartment or fluid moved out from the venting compartment, said injection compartment in addition having an outlet check valve for outward irreversible flow of fluid from the injection compartment;

a reciprocable piston in said cylindrical portion, stop means for locating the piston at a normal position in said cylindrical portion between said ports so that the injection compartment communicates with said second port,

resilient means for urging the piston toward the venting compartment and to said normal position under a normal pressure in said venting compartment thereby to vent the venting compartment through said first port,

said piston under pressure substantially above normal in the venting compartment moving into the injection compartment to a point below said second port, whereby fluid is injected through said outlet check valve from the injection compartment and whereby fluid under pressure may transfer from said first port, through the venting compartment and to said second port.

**2**. A fluid injector according to claim **1**, wherein the volumetric displacements of the piston are the same in moving to and from said injection and venting compartments.

**3**. A fluid injector system for use with a fluid pump, a fluid pressure supply line leading from the pump, timed means for intermittently starting and stopping the pump intermittently to pressurize said supply, means for venting said line during stoppage of the pump, a variable volume accumulator having a port for the reception and return therefrom of fluid, a series of injectors made according to claim **1**, fluid transmission means connecting the second port of each preceding injector in the series to the first port of each succeeding injector in the series except the last, the second port of which is connected to said port of the accumulator by fluid transmission means, fluid transmission means connecting the pressure supply line from the pump with the first port of the first injector of the series, an accumulator, and a malfunction indicator means forming part of the accumulator and movable in response to variable fluid volume therein.

**4**. A fluid injector system for use with a fluid pump, a fluid pressure supply line leading from the pump, timed means for intermittently starting and stopping the pump intermittently to pressurize said supply, means for venting said line during stoppage of the pump, a variable volume accumulator cylinder having a reciprocating piston therein and having a port for the reception into the cylinder and return therefrom of fluid under action of said piston, resilient means biasing the accumulator piston toward the accumulator port, a series of injectors made according to claim **1**, fluid transmission means connecting the second port of each preceding injector in the series to the first port of each succeeding injector in the series except the last, the second port of which is connected to said port of the accumulator by fluid transmission means, and fluid transmission means connecting the pressure supply line from the pump with the first port of the first injector.

**5**. A fluid injector comprising,

a hollow manifold forming

a. an internal cylindrical portion, with

b. a pressurizable and venting compartment extending from one end of the cylindrical portion, a first fluid port in said venting compartment closely adjacent said one end of the cylindrical portion through which said compartment may be pressurized or vented, and

c. an injection compartment extending from the other end of said cylindrical portion, said injection compartment having a second port closely adjacent said other end of said cylindrical portion through which fluid may be moved into the injection compartment or fluid moved out from the venting compartment, said injection compartment in addition having an outlet check valve for outward irreversible flow of fluid from the injection compartment;

a piston movable in said cylindrical portion and forming part of a reciprocable plunger, an extending part of the plunger projecting into said venting compartment,

a stop for the plunger locating it at a normal position wherein said piston is located in said cylindrical portion between said ports whereby the injection compartment communicates with said second port,

resilient means for driving the plunger into the venting compartment against said stop under a normal pressure in said venting compartment to vent the venting compartment through said first port,

said plunger under pressure substantially above normal in the venting compartment moving therefrom, thereby to force said piston from said cylindrical portion into the injection compartment to a point below said second port, whereby fluid is injected through said outlet from the injection compartment and fluid under pressure may transfer from said first port, through the venting compartment and to said second port.

6. A lubricant injection system for use with a timed lubricant pump, comprising

a series of manifolds each of which has a first and a second compartment, said compartments of each manifold being separated by a cylinder fitted with a reciprocable piston having a normal position in said cylinder and movable away from the first compartment and into the second compartment or reversely out of the second compartment toward the first compartment,

said piston in a normal position lying between spaced first and second ports, the first one of which connects with the first compartment and the second one of which when the piston is in normal position connects with the second compartment,

said piston in its movement from normal position and into the second compartment crossing said second port to connect the port with the first compartment,

said second compartment having an outlet for connection with an injection line and a check valve in said outlet,

a hollow accumulator having an inlet communicating with a cylinder therein, a reciprocable accumulator piston in the accumulator cylinder for the reception and expulsion of fluid from and to said inlet, means biasing the accumulator piston toward the accumulator inlet,

a fluid connection between said pump and the first port of the first manifold in the series,

a fluid connection between the second port of the first and every other manifold in the series and with the first port of the next manifold in the series, and

a fluid connection between the second port of the last manifold in the series and the inlet of the accumulator.

7. An injector according to claim 6 including stop means limiting movement of each manifold piston from the second compartment of its manifold, and wherein the volumetric displacement of the accumulator is at least equal to that of each manifold piston in the second compartment of its injector.

8. An injector according to claim 6 including stop means limiting movement of each injector piston from the second compartment of its injector and wherein the volumetric displacements of the accumulator piston and of each injector piston in the second compartment of its injector are equal.

9. An injector according to claim 8 wherein each injector piston completely empties the second compartment of its injector in moving into it.

10. An injector according to claim 9 including signal means operable by the accumulator piston to indicate when the accumulator cylinder has been filled.