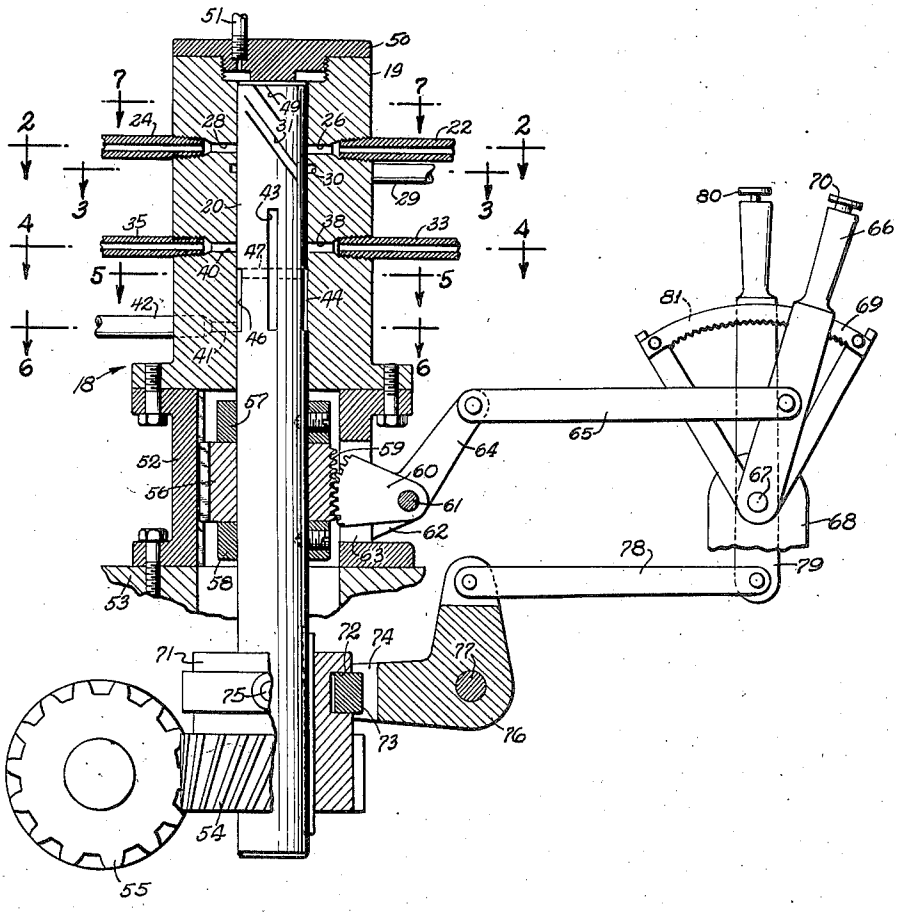
Jan. 31, 1939. C. R. ALDEN 2,145,383

FLUID DISTRIBUTOR

Original Filed March 19, 1930 3 Sheets-Sheet 1

Fig. 1




INVENTOR

Carroll R. Alden

By Parker, Carlson, Pitzner & Hubbard

ATTORNEYS

Jan. 31, 1939. C. R. ALDEN 2,145,383

FLUID DISTRIBUTOR

Original Filed March 19, 1930 3 Sheets-Sheet 2

Fig. 2

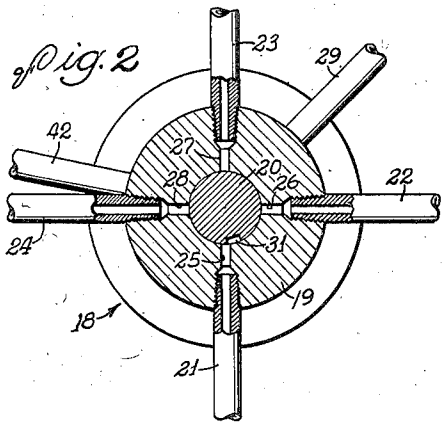



Fig. 5

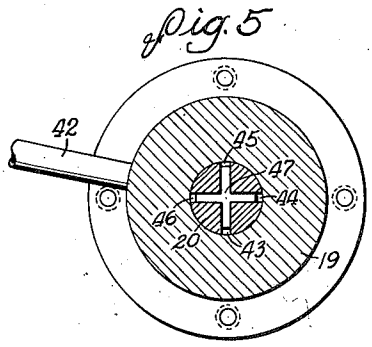



Fig. 3

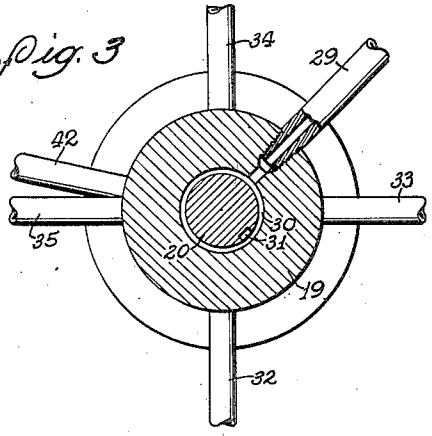



Fig. 6

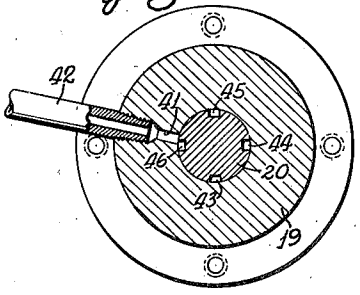



Fig. 4

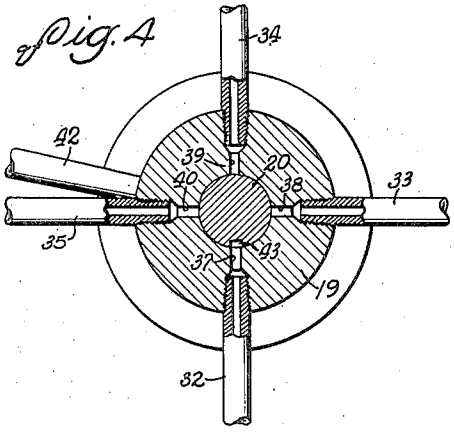
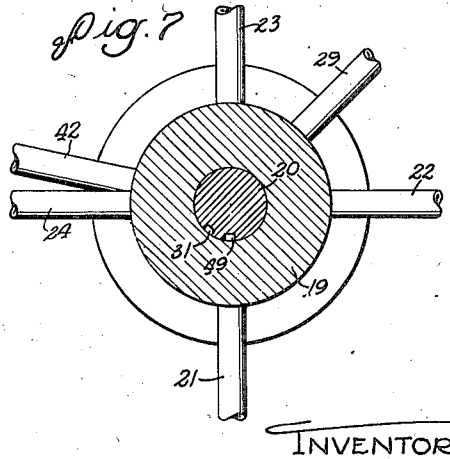



Fig. 7




INVENTOR

Carroll R. Alden

By Parker, Carlson, Pitzer & Hubbard

ATTORNEYS

Jan. 31, 1939. C. R. ALDEN 2,145,383

FLUID DISTRIBUTOR

Original Filed March 19, 1930 3 Sheets-Sheet 3

Fig. 9

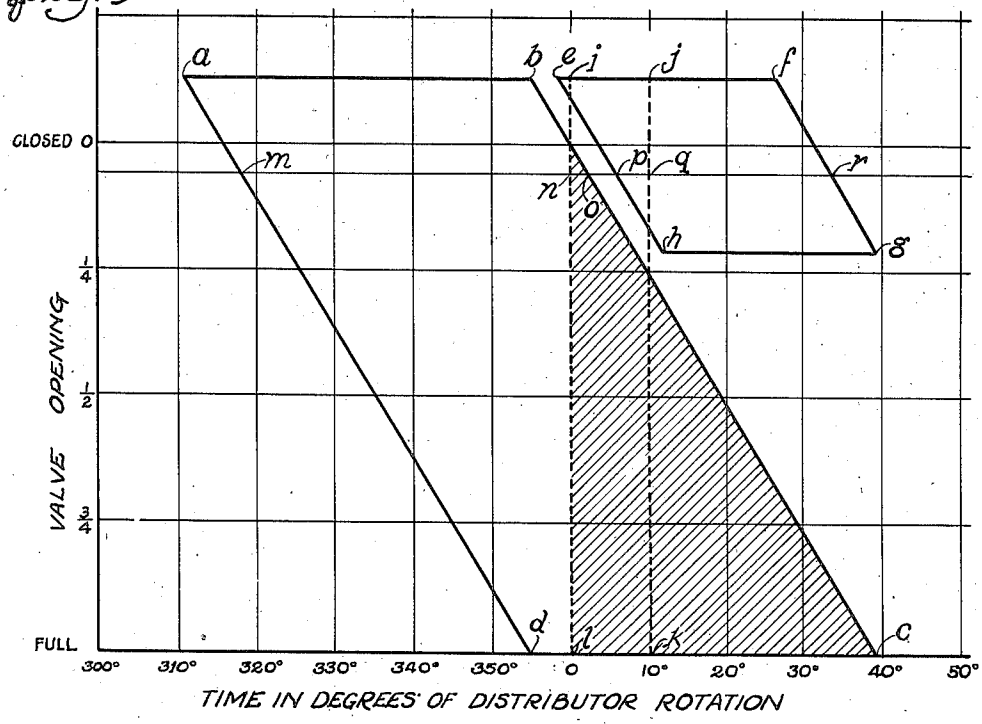
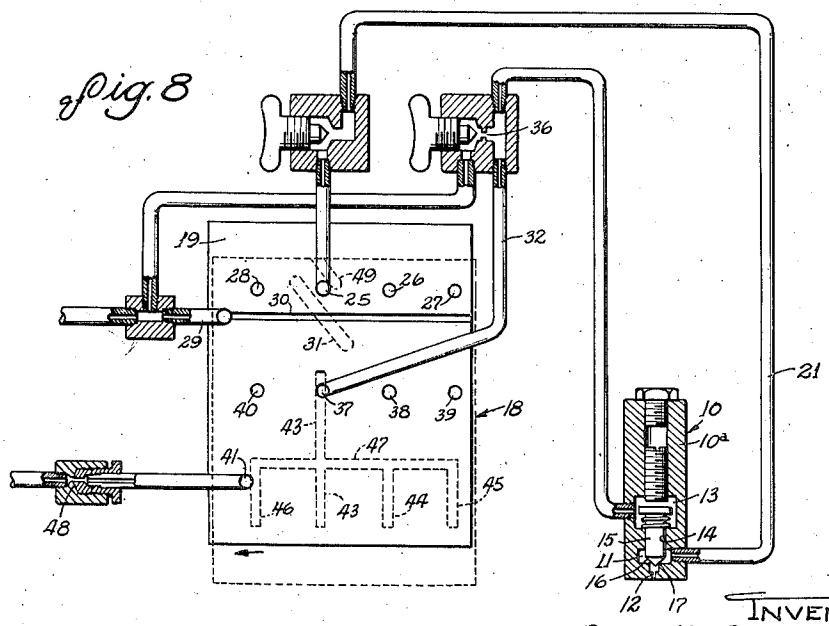



Fig. 8




INVENTOR
Carroll R. Alden

By Parker, Carlson, Pitzner & Hubbard,
ATTORNEYS

Patented Jan. 31, 1939

2,145,383

# UNITED STATES PATENT OFFICE

2,145,383

## FLUID DISTRIBUTOR

Carroll R. Alden, Detroit, Mich., assignor to Ex-Cell-O Corporation, a corporation of Michigan

Original application March 19, 1930, Serial No. 437,056, now Patent No. 2,027,360, dated January 14, 1936. Divided and this application November 29, 1935, Serial No. 52,165

16 Claims. (Cl. 251—107)

The present application is a division of my copending application Serial No. 437,056, filed March 19, 1930 (Patent No. 2,027,360), and relates to a new and improved fluid distributor which is especially adapted for use in fuel injection systems.

One of the primary objects of the present invention resides in the provision of a novel fluid distributor which is operable to supply fluid under pressure over a first predetermined period to one of two valve control lines, and simultaneously to control the pressure in the other of said lines over a second predetermined period in overlapping timed relation to the first period.

A further object is to provide a distributor of the foregoing character in which the pressure in the said other line is reduced from a normal value to a predetermined intermediate value below that of the pressure in the said one line during said periods, but is never completely dissipated.

Still another object is to provide a distributor of the foregoing character in which the degree of overlap of the respective periods is adjustable from zero to maximum.

A further object resides in the provision of novel means for relieving the pressure in the said one line immediately after the period of fluid supply.

A more specific object resides in the provision of a new and improved fluid distributor which comprises two primary elements, namely, a rotary valve for supplying fluid under pressure periodically and in timed sequence to a plurality of fluid supply lines for a series of valves, and a rotary valve for reducing the pressure in timed sequence and during periods overlapping those of the fluid supply in a plurality of control lines for said valves.

A general object resides in the provision of a novel rotary distributor valve having a casing with two spaced ports, and having an axially adjustable rotor with two generally longitudinal slots formed with relatively inclined controlling edges adapted for simultaneous coaction respectively with the ports, whereby the periods of respective communication between the ports and slots may be adjusted into different degrees of overlapping relation.

Further objects and advantages will become apparent as the description proceeds.

Figure 1 is an axial sectional view of a distributor embodying the features of my invention.

Figs. 2 to 7 inclusive are transverse sectional views of the distributor taken respectively along lines 2—2 to 7—7 of Fig. 1.

Fig. 8 is a fragmentary diagrammatic representation of the distributor showing a development of the distributor casing in full outline, and a development of the rotor in superimposed dotted outline, and illustrating adaptation of the distributor to a hydraulically operable fluid discharge valve.

Fig. 9 is a time chart illustrating the operation of the distributor in various positions of adjustment.

The distributor may be adapted generally to various uses, but is particularly suited for and hence described in connection with a plurality of hydraulically operable fluid discharge valves, one of which is illustrated at 10 in Fig. 8.

The valve 10 has a casing 10a which is formed with a feed chamber 11 communicating with a discharge orifice 12, a control chamber 13, and a bore 14 connecting the chambers. A plunger 15 is reciprocable in the bore 14 and is exposed at opposite ends respectively in the chambers 11 and 13. One end of the plunger 15 carries a valve member 16 adapted to coact with a seat 17 at the inlet of the discharge orifice 12. When the orifice 12 is closed, the seat 17 reduces the effective area of the associated end of the plunger 15. When the orifice 12 is open, the opposite ends of the plunger 15 are equal in effective area.

It will be evident that when equal pressures exist in the chambers 11 and 13, the orifice 12 if closed will remain closed due to the differential area of the plunger 15. Upon reducing the pressure in the chamber 13 to a predetermined point at which the seating force is less than the lifting force, the pressure in the chamber 11 will lift the valve member 16. If the original pressure is now reestablished in the chamber 13, the orifice 12 still will remain open since the ends of the plunger 15 are equal in effective area. Upon subsequent reduction of pressure in the chamber 11, the pressure in the chamber 13 will actuate the plunger 15 to close the orifice 12 and thereby establish the initial conditions. Operation of the valve 10 therefore is effected by varying the pressures in the chambers 11 and 13, and the duration of the fluid discharge period is determined by the relative times at which pressure changes are produced.

The distributor 18 constitutes means for controlling the pressures in the feed and control chambers 11 and 13 to effect operation of the valves 10 in timed sequence, and to distribute

fluid to the feed chambers 11 during the respective periods of discharge, and is adjustable to vary the occurrence and period or duration of discharge. In its preferred form, the distributor comprises an outer cylindrical casing 19, and a rotor 20 disposed therein for rotary operation to effect timed sequential valve discharges, and for axial adjustment to vary the metering of the discharges.

A plurality of feed lines 21, 22, 23 and 24 open at their inlet ends to the interior of the casing 19 respectively, through equally spaced peripheral feed ports 25, 26, 27, and 28 formed therein. Preferably, these ports are arranged in the same transverse plane (see Fig. 2). The line 21 opens to the feed chamber 11 of the valve 10, and the lines 22 to 24 may be connected as shown in my aforesaid application to three similar valves (not shown).

A main fluid supply line 29, adapted to be connected to a suitable source of pressure fluid (not shown), opens through the side of the casing 19 to a continuous peripheral groove 30 formed in the interior of the casing in a transverse plane adjacent the plane of the feed ports 25 to 28 (see Fig. 3).

Formed in the periphery of the rotor 20 is a longitudinally inclined recess 31 which is always in communication with the groove 30, and which is effective upon rotation of the rotor to establish successive communication of the groove 30 with the feed ports 25 to 28. It will be evident that upon axial adjustment of the rotor 20, the opening and the cut-off of the feed ports 25 to 28 will be advanced or retarded relative to the degree of rotation.

Also opening to the interior of the casing 19 are a plurality of control lines 32 to 35 which may be connected through orifice means 36 to any suitable source of pressure fluid (not shown) such as that for the line 29. The line 32 is connected to the control chamber 13 of the valve 10, and the lines 33 to 35 may be similarly connected to the other corresponding valves.

The lines 32 to 35 open to the interior of the casing 19 respectively through equally spaced peripheral ports 37, 38, 39 and 40 formed therein. Preferably, these ports are arranged in the same transverse plane (see Fig. 4). Formed in the inner periphery of the casing 19 in a transverse plane spaced from that of the ports 37 to 40 is a drain port 41 (see Fig. 6) which is connected to a drain line 42.

A plurality of equally spaced longitudinal grooves or recesses 43, 44, 45 and 46 are formed in the periphery of the rotor 20, and are in intercommunication through a branched duct or passage 47 (see Fig. 5) formed in the rotor. The recesses 43 to 46 are in the same transverse plane, and are of such a length and so located longitudinally of the rotor that upon rotation of the latter in any position of axial adjustment, they will be moved successively into and out of communication with the drain port 41.

One of the recesses 43 to 46, for example the recess 43, is extended in length at one end to project through the plane of the control ports 37 to 40, and is adapted upon rotation of the rotor 20 in any position of axial adjustment to be moved successively into and out of communication with the control ports. It will be evident that when the recess 43 is open to one of the control ports 37 to 40, and one of the recesses 43 to 46 is open to the drain port 41, the control port in question will be vented to the drain and a drop in pressure in the connected control line will result.

Preferably, means is provided for preventing a pressure drop to zero or a pressure drop substantially greater than necessary upon selective venting to the drain. To this end, a suitable pressure restriction means, such for example as a pressure reducing orifice 48, is interposed in the drain line 42. The orifice 48 may be larger than the orifice means 36, but not necessarily so. Sub-dividing the pressure results in that after the drain cut-off, the maximum control pressure can be quickly established, thus providing a sensitive and highly responsive control.

The duration of any one period of valve discharge is determined by the interval between the instant of pressure reduction in the related control line and the variable instant of cut-off of the related feed line. In the present illustration, the duration of discharge varies from maximum to zero as the rotor 20 is adjusted downwardly. Thus, when the upper end of the inclined recess 31 is adjusted into the plane of the ports 25 to 28 for movement into successive communication therewith (see Fig. 8), the duration of valve discharge if not zero is short. Under such condition, it is desirable to dissipate the pressure in each feed line immediately after it is cut off from the fluid supply.

Hence, a second groove or recess 49, which is parallel to and spaced rearwardly of the recess 31, and which slightly overlaps the upper end of the latter is formed in the rotor 20 (see Fig. 7). The recesses 31 and 49 are spaced apart just sufficiently to prevent any one of the ports 25 to 28 from being in communication with both simultaneously. The bleeder recess 49 may be vented to any suitable exhaust, and in the present instance opens to the upper end of the rotor 20. For convenience, the ports 25 to 28 and the recesses 31 and 49 are therefore located near the upper end of the distributor 18. The upper end of the casing 19 which is closed by a removable cover 50 opens through a suitable line 51 to the exhaust.

The casing 19 is removably secured on a cylindrical housing 52 in turn removably secured to a suitable support 53, and one end of the rotor 20 extends from the casing through the housing and the support for a suitable drive connection. This connection is shown as comprising a spiral gear 54 slidably splined to the rotor 20 and meshing with a spiral gear 55. The latter may be driven by any suitable means, such as an engine crank shaft (not shown).

A sleeve 56 within the housing 52 is secured on the rotor 20 for relative rotation. Two collars 57 and 58 rigidly clamped to the rotor 20 in end abutting engagement with the sleeve 56 serve to hold the latter against relative endwise movement. The sleeve 56 is splined to the housing 52 for axial movement with the rotor 20, and is formed along one side with a longitudinal gear rack 59.

A gear sector 60 secured to a shaft 61 journaled in a bracket 62 on the outside of the housing 52 extends through a longitudinal slot 63 in the latter into mesh with the gear rack 59. Any suitable means, either manual or governor actuated, may be provided for adjusting the sector 60 to adjust the rotor 20 axially. Herein, I have shown a manual means comprising an arm 64 secured to the shaft 61 and pivotally connected at its free end to one end of a link 65. The other end of the link 65 is pivotally connected to a control

lever 66 pivotal on a stud 67 projecting through a suitable support 68. Preferably, a suitable ratchet sector 69 is rigidly secured on the stud 67 at one side of the support 68, and the lever 66 is provided with a manually releasable spring-pressed detent 70 for engaging said sector to maintain the rotor 20 in axial position of adjustment. Thus, the rotor 20 may be adjusted axially to vary the degree of overlap of the respective periods of communication between the ports 25 to 28 and recess 31 and the ports 37 to 40 and recess 43.

The angular phase relation between the venting of the control lines 32 to 35 to the exhaust and the rotation of the rotor 20 is unaffected by this adjustment, and may be constant over the entire range of valve discharge from zero to maximum. The angular phase relation, however, may be adjusted when desired by adjusting the spiral gear 54 axially relative to the gear 55, movement in one direction (upwardly) serving to delay the valve operation, and movement in the opposite direction (downwardly) serving to advance same. The gear 54 has a hub 71 formed with a peripheral groove 72 in which a ring 73 is rotatably disposed. A yoke 74 pivotally engages trunnions 75 on the ring 73, and is formed on one arm of a bell crank lever 76 pivotal on a stud 77. The other arm of the lever 76 is connected through a link 78 to one end of control lever 79 pivoted intermediate its ends on the stud 67. The other end of the lever 79 constitutes a handle having a manually releasable spring pressed detent 80 for engaging a ratchet sector 81 mounted on the support 68 to hold the gear 54 in position of adjustment.

The operation will now be described by reference to Figs. 8 and 9.

Fig. 9 is a time chart in which the duration of valve opening is plotted along the ordinate, and in which the degrees of distributor rotation including any period of valve discharge are plotted along the abscissa. The area *a—b—c—d* represents the recess 31, the feed line 21 opening to the fluid source along line *a—d*, the feed line cut-off occurring along line *b—c*, and any abscissa between said lines indicating the duration of feed line opening in degrees of distributor rotation. The area *e—f—g—h* represents the recess 49, the feed line 21 opening to this recess along the line *e—h* and moving out of communication therewith along line *f—g*. The area *i—j—k—l* represents the period of pressure reduction in the control line 32, the pressure being reduced along line *i—l* and being reestablished along line *j—k*. It will be understood that the invention is not limited to the specific relation of these areas to the degrees of distributor rotation.

In Fig. 8, the rotor 20 is shown adjusted axially into its lowermost position. Assuming movement of the rotor 20 in the direction of the arrow, the recess 31 will move into communication with the port 25 at *a* (311°) thereby connecting the feed line 21 to the fluid source. The valve 10, however, will not open since the differential area, which is equal to the area embraced by the valve seat 17, is acted on by the pressure in the control line 32, the pressures at this time in the lines being equal. Subsequently, the elongated recess 43 will open to the port 37. However, the pressure in the control line 32 will not be reduced since the port 41 is still closed. At *b* (356°) the port 25 will be closed, thereby cutting off the feed line 21 from the fuel source, but trapping fuel therein at the pressure of the fuel source. The period during which the feed line 21 is open is represented by the line *a—b*. Thereafter, at *e* (358°) the recess 49 will open to the port 25, thereby causing the trapped pressure to be dissipated.

At *i* the recess 46 will open to the drain port 41, and since the recess 43 is still open to the port 37, pressure fluid will bleed from the control line 32. The pressure fluid will bleed past the orifice 48, and hence a pressure reduction will occur. However, since the fuel pressure is not impressed through the line 21 at this time, the valve 10 will remain closed. Subsequently, at *j* (10°) the port 37 will be closed, thereby causing the original pressure in the line 32 to be reestablished. At *f* (26°), the recess 49 will move out of communication with the port 25. The operation is the same for each of the associated sets of feed and control lines excepting for successive phase differences of 90°.

Assume now that the rotor 20 is adjusted upwardly into a position where the recess 30 will open to the port 25 at *m* (318°). At *n* (0°), the recess 46 will open to the port 41, thereby resulting in a pressure reduction in the control line 32 sufficient to overcome the differential pressure initially acting to keep the valve 10 closed. Thereupon, the fluid pressure in the line 21 will raise the valve member 16 to open the orifice 12. The port 25 will be closed at *o* (2°) to cut off the supply of fluid. The pressure in the line 21 will fall quite rapidly to a point below the reduced pressure in the line 32 to effect closing of the valve 10. At *p* (5°) the recess 49 will open to the port 25, thereby venting the pressure in the line 21 to insure effective closing of the valve 10. It will be evident that fluid is discharged over only a very small period of time, i. e., along the line *n—o*. Subsequently, the recess 43 will move out of communication with the port 37 at *q* (10°) to reestablish the pressure in the line 32. The recess 49 will leave the port 25 at *r* to disconnect the line 21 from the bleed.

The operation is similar in other axial adjustments of the rotor 20 with the exception that at a predetermined point in the upward adjustment, the recess 49 will be moved beyond the ports 25 to 28. As the rotor is adjusted upwardly, the degree of overlap, represented by the cross-hatched area in Fig. 9, will increase. The rotor 20 constitutes a single control for all of the valves. The pressure drop in the lines 32 to 35 is just sufficient to insure opening of the valves at the desired times.

I claim as my invention:

1. A fluid distributor comprising, in combination, a casing, an axially adjustable distributing rotor in said casing, an annular groove in said casing, a fluid supply port in said casing and opening to said groove, a plurality of feed ports in uniformly peripherally spaced relation in a common transverse plane in said casing, and an elongated recess formed in said rotor and in communication with said groove and projecting through said plane, said recess being adapted upon rotation of said rotor in various axial positions to connect said groove in timed sequence to said feed ports.

2. A fluid distributor comprising, in combination, a casing, an axially adjustable distributing rotor in said casing, a fluid supply port in said casing in one transverse plane, a plurality of feed ports in peripherally spaced relation in said casing in another transverse plane, an elongated narrow recess formed in the periphery of said rotor and extending through said planes and adapted upon rotation of said rotor in various

axial positions to connect said supply port in timed sequence directly to said feed ports, said recess being inclined longitudinally of said rotor, and means for axially adjusting said rotor to adjust the angular phase relation of said recess to said feed ports simultaneously.

3. A fluid distributor comprising, in combination, a casing, a fluid supply port in one transverse plane in said casing, a plurality of feed ports in peripherally spaced relation in another transverse plane in said casing, a drain port opening from said casing, a rotor in said casing, a recess formed in said rotor and extending through said planes and effective upon rotation of said rotor to connect said supply port successively to said feed ports, and a recess peripherally spaced to said first mentioned recess in said rotor and extending through said last mentioned plane, and effective upon rotation of said rotor to connect said drain port successively to said feed ports after cut-off of said feed ports from said first mentioned recess.

4. A fluid distributor comprising, in combination, a cylindrical casing and a rotor in said casing, said casing being formed with a plurality of peripherally spaced feed ports in a first common transverse plane, with an inlet port in a second plane closely adjacent said first plane, with a plurality of peripherally spaced pressure ports in a third common transverse plane, and with a single drain port in a plane closely adjacent said third plane, said rotor being formed with an elongated longitudinally inclined recess projecting through said first and second planes for connecting said inlet port in timed sequence successively with said feed ports, and with a plurality of drain recesses movable in timed sequence into communication with said drain port, one of said drain recesses extending through said third plane for successive communication with said pressure ports.

5. A fluid distributor comprising, in combination, a casing, and an axially adjustable rotor in said casing, the interior of said casing being formed with an annular groove, a fuel supply port opening to said groove, the interior of said casing being formed with a plurality of peripherally spaced feed ports in a common transverse plane, said rotor being formed with an elongated longitudinally inclined recess in communication with said groove and projecting through said plane in various axial positions of adjustment and adapted upon rotation of said rotor to connect said groove successively with said feed ports, a drain opening from said casing, said rotor being formed with a second longitudinally inclined recess parallel to, spaced rearwardly of and overlapping only one end of said first mentioned recess, said second mentioned recess opening to said drain and being adapted upon rotation of said rotor when adjacent one limit of axial adjustment to move successively into communication with said feed ports.

6. A fluid distributor comprising, in combination, a casing, said casing being formed with a plurality of peripherally spaced inlet ports and with a drain port spaced longitudinally of said casing from said first mentioned ports, and an axially adjustable rotor in said casing, said rotor being formed in its periphery with a plurality of peripherally spaced longitudinal recesses corresponding in number and peripheral spacing with said inlet ports, said recesses being in intercommunication and projecting through the transverse plane of said drain port in all positions of axial adjustment, one of said recesses projecting past the plane of said inlet ports in all positions of axial adjustment.

7. A fluid distributor comprising, in combination, a casing, an axially adjustable rotor in said casing, and a drain opening from said casing, the interior of said casing being formed with a plurality of peripherally spaced ports, said rotor being formed with a drain recess in communication with said drain opening, said recess being movable upon axial adjustment of said rotor into and out of position for movement into successive communication with said ports upon rotation of said rotor.

8. A fluid distributor comprising a casing and a rotor axially adjustable in said casing, a fluid supply port in said casing in one transverse plane, a plurality of feed ports in said casing in peripherally spaced relation in another transverse plane, an elongated recess of substantially uniform width formed in the periphery of said rotor and extending through said planes in all axial positions of said rotor to connect said supply port in timed sequence directly to said feed ports, said recess being inclined longitudinally of said rotor to adjust the phase relation of said recess to said feed ports while maintaining the duration of communication therebetween constant.

9. A fluid distributor comprising, in combination, a casing, an axially adjustable rotor in said casing, an inlet port in said casing, a plurality of feed ports opening in peripherally spaced relation in said casing, a drain opening from said casing, a recess formed in said rotor and effective upon rotation of said rotor to connect said inlet port successively to said feed ports, and a second recess formed in said rotor and peripherally spaced from and lagging said first mentioned recess and adjustable upon axial adjustment of said rotor into and out of position for rotary movement into communication with said feed ports while simultaneously communicating with said drain opening.

10. A fluid distributor comprising, in combination, a cylindrical casing, and a rotor axially adjustable in said casing, said casing being formed with a plurality of peripherally spaced feed ports in a first common transverse plane, with an inlet port in a second transverse plane, with a plurality of peripherally spaced pressure ports in a third common transverse plane and with a single drain port in a fourth transverse plane, said rotor being formed with an elongated generally longitudinal recess projecting through said first and second planes in all axial positions of said rotor for connecting said inlet port in timed sequence with said feed ports, and being formed with a second elongated generally longitudinal recess projecting through said third and fourth planes in all axial positions of said rotor for connecting said drain port in timed sequence with said pressure ports, said recesses being relatively inclined longitudinally of said rotor whereby upon axial adjustment of said rotor the interval during which each feed port is connected to said inlet port is adjusted relative to the interval that the corresponding pressure port is connected to said drain port so as to permit varying degrees of overlap of said intervals.

11. In a fluid distributor, in combination, a casing having two ports in spaced transverse planes, a rotor axially adjustable in said casing and having two generally longitudinal recesses in its periphery for rotary movement into communication respectively with said ports, said ports and

said recesses being so related that the two respective periods of communication are adapted to overlap in certain axial positions of said rotor, said two recesses having relatively inclined controlling edges whereby axial adjustment of said rotor will result in varying the degree of said overlap.

12. A fluid distributor comprising, in combination, a casing having a fluid supply port in one transverse plane and a feed port in an adjacent transverse plane and having an inlet port and a drain port in two other transverse planes, a rotor axially adjustable in said casing and having a generally longitudinal recess extending through said two first mentioned planes for periodically connecting said supply and feed ports and having a second generally longitudinal recess extending through said last mentioned planes for periodically connecting said inlet and drain ports, said ports and recesses being so related that the two communications are adapted to occur in overlapping periods in certain axial positions of said rotor, said recesses being relatively longitudinally inclined.

13. A fluid distributor comprising, in combination, a casing having a fluid supply port and a fluid discharge port in two adjacent transverse planes, a rotor in said casing having an elongated recess extending through said planes for periodically connecting said ports and having a second recess projecting only into the plane of said discharge port for periodical communication therewith, said second recess trailing said first mentioned recess by a distance greater than the width of said discharge port, and means for venting said second recess to exhaust.

14. A fluid distributor comprising, in combination, a casing formed with a cylindrical bore, inlet and discharge ports opening to said bore in spaced transverse planes, a rotor mounted for rotation and axial adjustment in said bore, an elongated inclined recess formed in the periphery of said rotor and extending through said planes for movement periodically into simultaneous communication with said ports, a bleed recess formed in the periphery of said rotor in parallel relation to said first mentioned recess and trailing said first mentioned recess by a distance not less than the width of said discharge port, said bleed recess being movable into and out of the plane of said discharge port upon axial adjustment of said rotor.

15. A fluid distributor comprising, in combination, a casing having opening thereto a plurality of peripherally spaced first ports and a second port spaced longitudinally of said casing from said first ports, and a rotor in said casing and formed in its periphery with a plurality of peripherally spaced interconnected recesses corresponding in number and peripheral spacing with said first ports and adapted for communication successively with said second port upon rotation of said rotor, one of said recesses projecting longitudinally into position for successive communication with said first ports simultaneously with communication of said recesses with said second port.

16. A fluid distributor comprising, in combination, a cylindrical casing and a rotor in said casing, said casing being formed with a plurality of peripherally spaced feed ports in a first common trasverse plane, with an inlet port in a second plane closely adjacent said first plane, with a plurality of peripherally spaced pressure ports in a third common transverse plane, and with a single drain port in a plane adjacent said third plane, said rotor being formed with an elongated recess projecting through said first and second planes for connecting said inlet port in timed sequence successively with said feed ports, and with a plurality of drain recesses movable in timed sequence into communication with said drain port, one of said drain recesses extending through said third plane for successive communication with said pressure ports, the arrangement of said ports and recesses being such that each period of communication between said inlet port and one of said feed ports overlaps the period of communication between said drain port and one of said pressure ports.

CARROLL R. ALDEN.