April 29, 1958 J. G. FREER 2,832,368

FLUID DISTRIBUTION DEVICE

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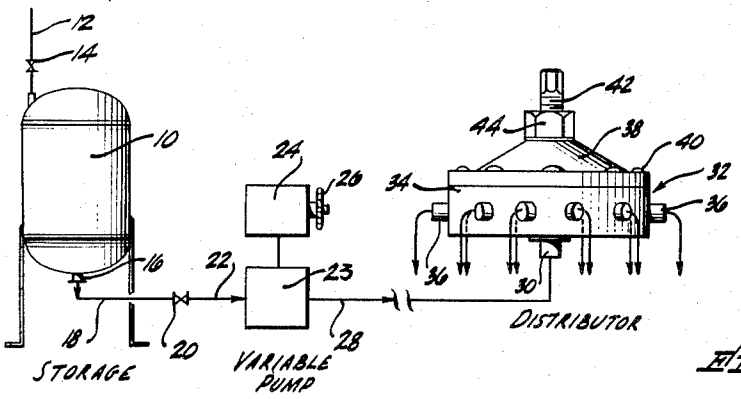


FIG. 1.

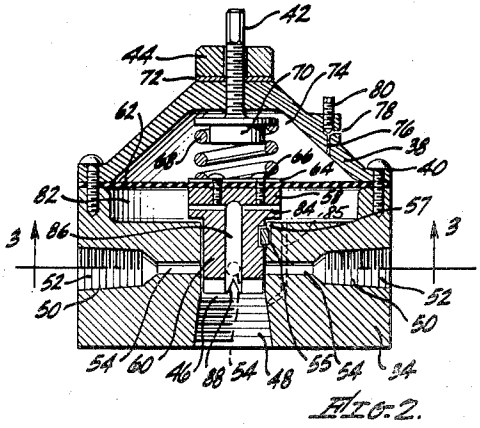


FIG. 2.

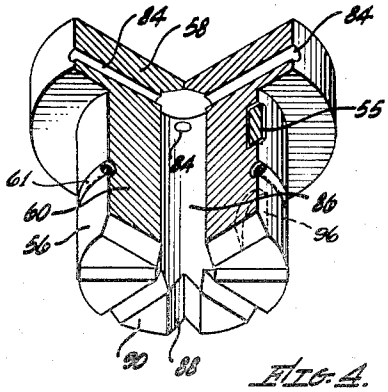


FIG. 4.

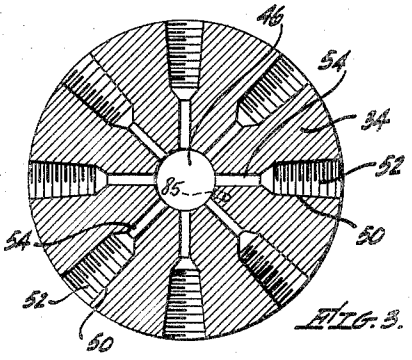
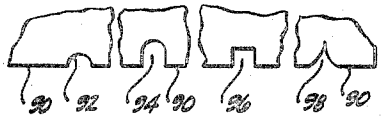


FIG. 3.

FIG. 5.



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FLUID DISTRIBUTION DEVICE

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5 Claims. (Cl. 137—118)

This invention relates to a method and apparatus for the dispensing of fluids and in particular relates to the dispensing of a plurality of streams of fluid from a single source wherein each of the plurality of flows has a predetermined flow rate. Specifically this invention relates to an improved method and apparatus for the division of a single fluid stream into a plurality of individual streams each having a flow rate bearing a predetermined relation to the flow rates of the other streams.

The controlled rate dispensing of fluids, either gaseous or liquid, in a plurality of closely controlled streams of interrelated flow rate from a single fluid source, is involved in many industrial and agricultural operations. A few of these include the injection of reagent fluids in separate streams and at several different locations in a chemical reaction process, the filling of a plurality of containers simultaneously with predetermined volumes of liquid such as in the canning of lubricating oils, vegetable juices, and in the bottling of liquid commodities such as beverages, the injection of gaseous or liquid fertilizers such as ammonia or ammonia hydroxide simultaneously at a plurality of either above ground or under ground delivery points, and the like. Other liquid synthetic fertilizers which may be so dispensed include aqueous solutions of the soluble salts of potassium, phosphorus, sulfur, and the like and these may be applied in a plurality of streams simultaneously to several individual streams of irrigation water above ground, or in an underground application as in combination with some sort of conventional soil tilling operation.

Heretofore each fluid stream in the plurality was individually adjusted by providing a main conduit opening from a storage container and delivering fluid into a manifold or header from which a plurality of branched outlet conduits opened. In each of such branch conduits was usually located some sort of flow controller such as a valve or an orifice. This sort of arrangement has a number of disadvantages. The principal problem when the flow control device is of the fixed area type, as are the common sharp edge and short tube type orifices and individual manually operated control valves, is that with attempted increases in fluid delivery rate by raising the source pressure, this source pressure increases at a much greater rate than does the flow it initiates. In dispensing of liquids, positive displacement pumps of the piston, diaphragm, bellows, or gear type are conventionally used in order to meter the total liquid output accurately at the pump. An attempt to increase the total delivery rate through fixed size restriction opening by increasing pump speed or stroke, rapidly causes an excessive build-up in pressure at the pump discharge. These pressure build-ups are readily capable of and frequently result in rupture damage to the pump or the equipment through which the liquid is distributed.

The present invention is therefore directed to an improved method and apparatus for the division of a fluid into a plurality of streams and the distribution of

said streams at predetermined variable rates in which the aforementioned difficulties are avoided.

It is an object of the present invention to provide a fluid splitting and distributing device adapted to the division and delivery of a plurality of fluid streams at equal or otherwise predetermined individual flow rates.

It is a more specific object of this invention to provide a device for the automatic regulation of the back pressure of the inlet fluid flow in a fluid dispensing device delivering a plurality of fluid streams while permitting predetermined division of the flow through a plurality of variable orifices.

It is a more particular object of the invention to provide an improved device for the dispensing of liquids in a plurality of streams, such as in the dispensing of liquid fertilizers into irrigation water or into the ground, in which a predetermined back pressure or fluid inlet pressure must be reached and exceeded before flow begins and in which further increases in pressure generated in order to increase the total flow rate result in an increase in the opened area of a plurality of simultaneously pressure operated variable area orifices permitting the increased flow rate in the same predetermined volumetric relation among the plurality of individual streams.

Other objects and advantages of the present invention will become apparent to those skilled in the art as the description and illustration thereof proceeds.

Briefly the present invention comprises in combination a fluid dispensing system comprising a container suitable for storage of the fluid to be dispensed, a fluid pressure control means such as a valve or a variable delivery pump connected in fluid receiving relation to the container, and an especially designed spring loaded variable orifice device having a single fluid inlet and a plurality of fluid outlets, the outlets each containing an orifice of predetermined size whose cross-sectional area open to fluid flow is opened or closed to a degree depending upon the pressure of the inlet fluid. A movable valve member is reciprocably disposed adjacent the inlet ends of a plurality of orifices and is spring loaded by means of an adjustable loading spring whereby the valve member is biased toward a position at which all of the orifices are normally closed.

The inlet pressure of the fluid to be divided and dispensed acts on a diaphragm integrally attached to the valve member and acts against the loading spring which at a preset pressure permits the valve member to move so as to expose at least a portion of each of the orifices whereby a small amount of fluid is permitted to flow through the orifices in a predetermined ratio. At a constant inlet fluid flow rate, the reciprocable valve member reaches and maintains an equilibrium position such that the quantity of fluid flowing through the orifices dissipates most of the inlet pressure by producing a pressure drop equal to the pressure difference between the pressure necessary to open the orifices against the loading spring and the outlet pressure head of the fluid into which the flow is being delivered by the distributing device. The loading spring, being adjustable, permits a predetermined minimum flow pressure to be set which the pump must deliver before the variable orifices are opened at all. For purposes of the present discussion this will be defined as P_0. When the outlet pressure of the pump, which usually is substantially the same as the fluid inlet pressure at the distributing device and herein defined as P_i, exceeds the preset minimum value P_0 by an amount equal to ΔP, this excess inlet pressure ΔP opens the orifices by an amount sufficient to permit a fluid flow through each orifice, the quantity of which is governed by the difference between the inlet pressure P_i and the outlet pressure head. With further increases in

pressure effected to increase the fluid delivery rates, the slightly higher values of ΔP cause the valve member to move to open greater areas of the orifices resulting in increased fluid flows through each orifice sufficient to dissipate the higher value of P_i. At maximum rate, the orifices are opened entirely to permit a fluid flow which is substantially equal to the capacity of the pump thus preventing the build-up of destructive pressures under any conditions of fluid flow desired. In this manner the maximum pressure and energy necessary to discharge a certain volume of liquid are considerably reduced relative to the fixed area flow restrictions. It is to be noted that a spring with a low spring constant (pounds per inch deflection) will permit the maximum flow rate with less increase in P_i than will occur using a spring with a high spring constant.

The present invention also briefly comprises an improved variable orifice distributing device consisting of a body element having a longitudinal fluid inlet channel opening through from one end, a plurality of outlet channels peripherally disposed around the body element end opening radially into the inlet channel, a movable valve member disposed in said inlet channel and adapted to open and close the inner ends of the orifice outlet channels, a cover containing an adjustable loading spring in compression to apply a force against the movable valve member tending to bias it into a position in which the aforementioned orifices are normally closed, and a diaphragm on which the pressure acts to open the orifices. The operation of this device under conditions of increasing inlet pressure to produce a plurality of fluid flows having a predetermined relation has been generally described above and will be more clearly described below with reference to the attached drawings in which,

Figure 1 is a schematic flow diagram of the fluid distribution system of this invention,

Figure 2 is an elevation view in cross section of the spring loaded fluid distributing device,

Figure 3 is a transverse cross section of the device shown in Figure 2 in which the section is taken through the plane of the radial fluid outlet channels and the orifices,

Figure 4 is a cutaway isometric view of the reciprocable element indicated in Figure 2, and

Figure 5 is a schematic representation of a few of many shapes of ports which may be employed at the fluid inlet end of the reciprocable valve member.

Referring now to Figure 1 a storage vessel **10** is provided having fluid inlet **12** and shutoff valve **14** and an outlet opening **16**. Discharge opening **16** opens into outlet line **18** having valve **20**. Fluid pump **23** is connected through its inlet **22** wth valve **20** and is provided with a variable speed drive **24** with means **26** for varying the volumetric output of pump **23**. The variable drive may convenient consist of an electric motor and one of the several continuously variable shaft speed reduction mechanisms presently commercially available whereby the pump shaft speed may be varied over any desired range, or the variable speed may be derived from the traction wheel drive of a ground vehicle such as a farm implement. Output line **28** opening from pump **23** is directly connected to fluid inlet **30** which opens into the spring loaded fluid distributing device **32**, the structural details of which are given below in connection with Figures 2, 3 and 4.

This device consists generally of an orifice body **34** into which fluid inlet **30** opens and from which a plurality of outlets **36** open radially from the orifice body. An orifice body cover **38** is provided and is attached by any of the well-known and conventional mechanical attachments such as machine screws or bolts **40** to the opposite side of orifice body **34** from fluid inlet **30**. Through the apex of cover **38** extends adjustment screw **42** provided with lock nut **44** by means of which the loading spring, discussed in detail below, is adjusted so as to vary the minimum inlet pressure P_0 discussed previously. Any number of outlet openings **36** may be radially disposed around the periphery on orifice body **34** and it may have as few as two such outlets or as many as eight or ten or more depeneding upon the number of streams desired and the sizes of orifice body **34** and the fluid inlet channel.

Referring now more particularly to Figure 2, showing an elevation view in cross section of distributor device **32**, the individual elements which are the same as those indicated in Figure 1 are herein indicated with the same numbers. Orifice body **34** and body cover **38** are shown connected together by machine screws **40**. The fluid inlet **30** shown as a conduit in Figure 1 is connected into inlet channel **46** by means of screw threads **48** at the lower part of orifice body **34**. The outlet conduits **36** are connected to outlet channels **50** by means of screw threads **52**. It is noted that these outlet channels **50** open radially outward from inlet channel **46** to the periphery of orifice body **34** through a plurality of radially disposed orifices **54** of the short tube type. The radial arrangement of fluid outlet channels **50**, orifices **54**, and fluid inlet channel **46** is more clearly shown in Figure 3 in which the same reference numerals are used.

Reciprocably disposed in the upper portion of fluid inlet channel **46** is valve element **56** which consists essentially of an upper cylindrical section **58** or cap of relatively large diameter and a lower cylindrical section **60** of some smaller diameter. The diameter of upper section **58** is slightly larger than the inside diameter of fluid inlet channel **46** so that a stop is provided in the closed position for the reciprocable valve member **56**. An O ring seal **61** is provided in valve element **56** as indicated in Figure 4. The length of the lower cylindrical section is such that when valve member **56** is in the closed position shown in Figure 2, the O ring is below orifices **54** and they are sealed against fluid flow at their inlets in fluid inlet channel **46**. Key **55** and key-way **57** may be provided if necessary to prevent the valve element from rotating in channel **46**.

A flexible diaphragm **62** such as neoprene impregnated fabric is secured in the position shown by suitably clamping it at its periphery between orifice body **34** and body cover **38**, such as by means of machine screws **40**. The diaphragm is secured to the valve body member **56** by means of plate **64** and machine screws **66**. Loading spring **68** is disposed in the position shown between plate **64** and upper flanged member **70** to which machine screw **42** is integrally attached and extends upwardly through cover **38** as indicated. A washer **72** and lock nut **44** are provided with machine screw **42** to maintain the adjustment of loading spring **68**.

The space **74** enclosed between diaphragm **62** and cover **38** communicates through orifices **76** and **78** with the atmosphere and provides an atmospheric vent from space **74**. Needle valve **80** is provided at this vent point and serves to dampen any pulsation effects imparted to the inlet fluid by the pump employed as indicated in Figure 1 or by any other pulsating source.

Space **82** contained between diaphragm **62** and orifice body **34** is sealed from the atmosphere and communicates with fluid inlet channel **46** through radial ports **84** in the large diameter portion of valve member **56** and longitudinal port **86** which opens directly into fluid inlet channel **46**. Radial ports **84** are preferably of small diameter so as to restrict the fluid flow to the diaphragm **62** which also serves to dampen any pulsation effects present in the supply fluid. A desirable alternative to ports **86** and **84** consists in port **85** drilled through orifice body **34**. An 0.040 inch diameter hole is adequate for aqua ammonia dispensing service. Port **85** may be drilled straight through to space **82** if threaded inlet **48** is made larger in diameter than inlet channel **46**.

With the construction shown and described briefly above the inlet fluid pressure existing in fluid inlet port **46**

is applied through longitudinal port 86 and radial ports 84 to the underside of diaphragm 62 and the force thus acting on diaphragm 62 is resisted by the compression of loading spring 68. A predetermined minimum inlet pressure P_0, at which orifices 54 will begin to open due to movements of valve element 56 permitting an intersection of V-shaped opening 88 with orifice 54, is determined by the compression of loading spring 68 and this in turn is determined by the relative adjustment of upper element 70 and machine screw 42. Opening 88 may be provided at its outer end with a quarter circular narrow milled slot 96 to give a square-shaped opening as shown in Figures 4 and 5. This minimum pressure is increased or decreased as the compression of loading spring 68 is increased or decreased respectively.

With applied inlet pressures P_i exceeding the minimum inlet pressure P_0, determined by the setting of loading spring 68, valve element 56 is moved so as to expose at least part of the inlet area of orifices 54 so as to permit a fluid flow therethrough sufficient to generate a pressure differential substantially equal to the difference between P_i and the pressure head in the delivery or outlet conduits 36 which communicate as described with outlet ports 50.

It will now be appreciated that with orifices 54 of the same cross-sectional area and the same length and disposed radially in the same plane around fluid inlet channel 46 as shown, equal fluid flow rates through each orifice at all times will be effected independently of the fluid inlet pressure. At higher or lower fluid inlet pressures, greater or smaller outlet flows will result through the plurality of fluid outlet ports 50, but for any given inlet pressure these flows will be equal. Similarly, through the use of different sized orifices, it is evident that a plurality of outlet fluid flows can be provided in any predetermined proportions other than equal.

It will be noted in Figure 2, at a point immediately below orifice 54 indicated by the broken lines, that the lower surface of the reciprocable valve element is provided with an inverted V-shaped opening 88. With increases in fluid inlet pressure exceeding the minimum preset pressure P_0, the apex of the V-shaped port intersects the inlet opening of orifice 54 thereby permitting a small flow of fluid therethrough. These V-shaped ports are obtained by milling diametrically across the inlet surface of valve element 56 a plurality of V-shaped grooves equal in number to the plurality of radially disposed orifices 54. In this manner movements of valve body 56 bring into communication all of the orifices 54 with fluid inlet channel 46 through equal open areas.

Referring now particularly to Figure 4, the structure of the fluid inlet end of valve member 56 is more clearly shown. Herein elements which have been previously described in connection with Figure 2 are also indicated by the same numbers. The large diameter portion 58 and the smaller diameter portion 60 are shown, and the intercommunicating radial ports 84 and longitudinal port 86 are also indicated. The fluid inlet surface 90 of valve element 56 is provided with a plurality of V-shaped channels or notches 88 disposed radially across surface 90. The outer extremities of these V-shaped channels present a V-shaped opening at the outer periphery, the apex of which provides the initial small open area when the V-shaped notch intersects the inlet opening of orifices 54 previously described. An optional milled slot 96 is shown providing a square shaped orifice opening port.

These channels cut radially in fluid inlet surface 90 of the valve body are meant to be illustrative only and channels having other than V-shapes or having channels of several different shapes or having other than equal sized shapes may be employed when desirable. Several desirable cross sections of channels are indicated generally in Figure 5.

Referring now to Figure 5 a semicircular channel 92, an inverted U-shaped channel 94, a square shaped channel 96 and a tapered V-shaped channel 98 are indicated. To one skilled in the art of fluid flow, it will be obvious that different variations in flow rate between zero and maximum flow depending on the longitudinal position of valve element 56 may be obtained by substituting any one or a combination of these cross sections for the inverted V-shaped channel 88 indicated in Figures 2 and 4. If desired any one or a combination of the five types of channels indicated may be used with orifices 54 of circular cross section, or orifices of other cross section may be substituted such as those having the general shapes indicated in Figure 5. Such unusual orifice cross sections may be readily obtained by splitting orifice body 34 into two sections along the plane of orifices 54, and milling an orifice of the desired shape in either one or both of the contacting surfaces along said plane. The two sections of the orifice body 34 then are clamped together by suitable flanges or machine screws with or without gasket material therebetween in well known manners.

As a typical example of the structure of the present invention, a fluid distributing device is constructed substantially as shown in Figures 2, 3 and 4 for the dispensing of aqueous ammonia containing the equivalent of 25% nitrogen at a total rate of about 1380 gallons per hour simultaneously at equal rates in eight streams through eight fertilizer injection shanks for subsurface application on a suitable piece of moving farm equipment. The orifice body is generally cylindrical in shape having outside diameter of 5.00 inches and a length of 2.50 inches. A plurality of eight orifices 0.250 inch inside diameter and 0.750 inch in length are disposed radially around a fluid inlet channel which is 1.00 inch inside diameter. Fluid outlet openings are provided with one-half inch nominal pipe size threads at the outlet end of the orifices. V-shaped ports are milled in the fluid inlet end of the valve element substantially as shown in Figure 4. The valve element is 1.65 inches in length and machined to a close fitting tolerance. The fluid inlet is connected by means of 1¼ inch nominal pipe size threads opening longitudinally into the fluid inlet channel. The device in operation is capable of delivering eight streams of aqueous ammonia at a total rate of up to 1380 gallons per hour and at individual rates which can be within any desired degree of equality to one another at all various inlet pressures with accurate construction.

The same device is applicable to the dispensing of gaseous fluids just as well as in the dispensing of liquids and no material modification of the device is required.

Obviously for greater or smaller flows than those given in the example, above, any or all of the dimensions of the device may be made larger or smaller as necessary and may be provided with a greater or few number of orifices.

A particular embodiment of the present invention has been hereinabove described in considerable detail by way of illustration. It should be understood that various other modifications and adaptations thereof may be made by those skilled in this particular art without departing from the spirit and scope of this invention as set forth in the appended claims.

I claim:

1. In a fluid dividing and flow regulating apparatus which comprises a pressure resistant body element having a central fluid inlet channel extending therethrough and a plurality of orifices opening radially outward from said inlet channel through a plurality of fluid outlets, a movable valve element reciprocably disposed in said fluid inlet channel, a cover element detachably connected to said body element at the opposite end thereof from said central fluid channel, a diaphragm retained at its edges between said body element and said cover and extending transversely through the apparatus, said valve element being connected at one end to the central portion of said diaphgram, a loading spring disposed within said cover element and biasing said valve element toward a position in said inlet channel at which its other end

covers the inlet openings of said orifices whereby the pressure of the inlet fluid tends to move said valve element in said fluid channel against said loading spring and thereby open said orifices to provide a plurality of fluid flows bearing a predetermined volumetric relation to one another dependent upon the flow characteristics of each of said orifices, the improved valve element which is provided with a cap of larger cross-sectional area than that of said fluid inlet channel, said valve element being further provided with a longitudinal channel extending from the end thereof within said fluid inlet channel into said cap and into communication with at least one transverse channel extending through said cap into the open space contained between said diaphragm and said body element.

2. In a fluid dividing and flow regulating apparatus which comprises a pressure resistant body element having a central fluid inlet channel extending therethrough and a plurality of orifices opening radially outward from said inlet channel through a plurality of fluid outlets, a movable valve element reciprocably disposed in said fluid inlet channel, a cover element detachably connected to said body element at the opposite end thereof from said central fluid channel, a diaphgram retained at its edges between said body element and said cover and extending transversely through the apparatus, said valve element being connected at one end to the central portion of said diaphragm, a loading spring disposed within said cover element and biasing said valve element toward a position in said inlet channel at which its other end covers the inlet openings of said orifices whereby the pressure of the inlet fluid tends to move said valve element in said fluid channel against said loading spring and thereby open said orifices to provide a plurality of fluid flows bearing a predetermined volumetric relation to one another dependent upon the flow characteristics of each of said orifices, the improved cover element provided with an opening therethrough in combination with a valve connected at said opening to restrict flow of fluids into and out of the otherwise closed space between said cover element and said diaphragm to dampen pulsations of the valve element induced by pulsations in the inlet fluid pressure.

3. A fluid dividing and flow regulating apparatus adapted to receive a single fluid stream and discharge a plurality of fluid streams at flow rates bearing a predetermined relation to each other which comprises a generally cylindrical pressure resistant body element having a vertical fluid inlet channel extending longitudinally from a fluid inlet at one end of said body element and opening into a cylindrical recess of somewhat larger diameter at the other end, said body element further having a plurality of orifices radially disposed around said

inlet channel and having the axis of their inlet openings in the same horizontal plane and opening therefrom through a plurality of fluid outlets disposed around the periphery of said body element, a cover element detachably sealed against the end of said body element around said recess, a flexible diaphragm between said cover and said body element and sealed at its periphery therebetween, a movable valve element vertically reciprocable at a close tolerance within said fluid inlet channel and having a cap of larger cross section than said inlet channel secured to said diaphragm and disposed within said recess, said movable valve element extending through said channel a sufficient distance to cover the entrance to each orifice, said valve element further having a longitudinal port extending vertically from the fluid inlet end thereof into said cap and a plurality of radial ports opening from said longitudinal port radially through said cap, a loading spring extending at one end from said diaphragm at a point opposite said valve element toward said cover, a threaded rod extending through said cover into engagement with the other end of said loading spring an adapted to vary the compression of said spring, and a throttling valve connected to a port extending through said cover element.

4. An apparatus according to claim 3 wherein said valve element is provided with a plurality of V-shaped channels milled along radii in the surface of said valve element which is within said fluid inlet channel, said V-shaped channels being equal in number to the number of said orifices and angularly disposed so as to coincide with said orifices.

5. An apparatus according to claim 4 in combination with means for preventing said valve element from rotating about its longitudinal axis relative to said body element.

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