Aug. 3, 1965 C. W. LITTLE, JR 3,198,120

MULTIPLE POSITIVE DISPLACEMENT PUMP

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FIG. 1.

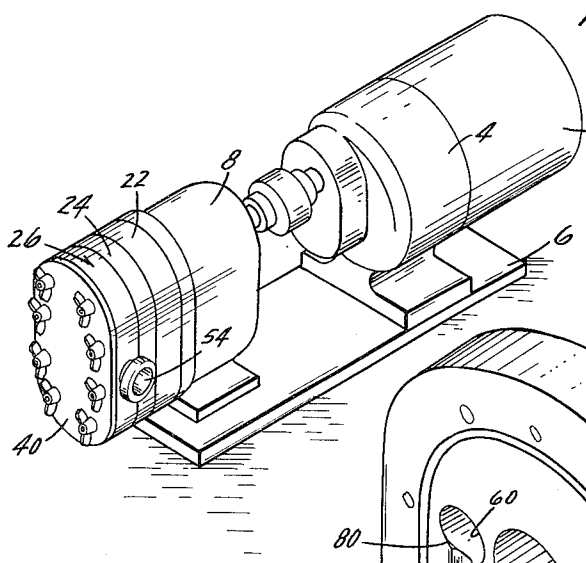


FIG. 9.

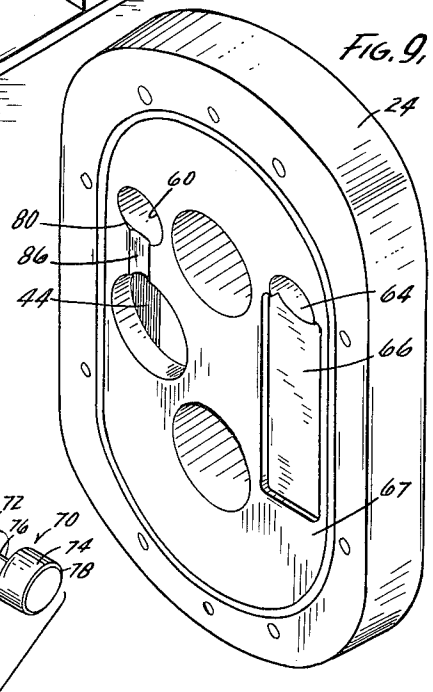
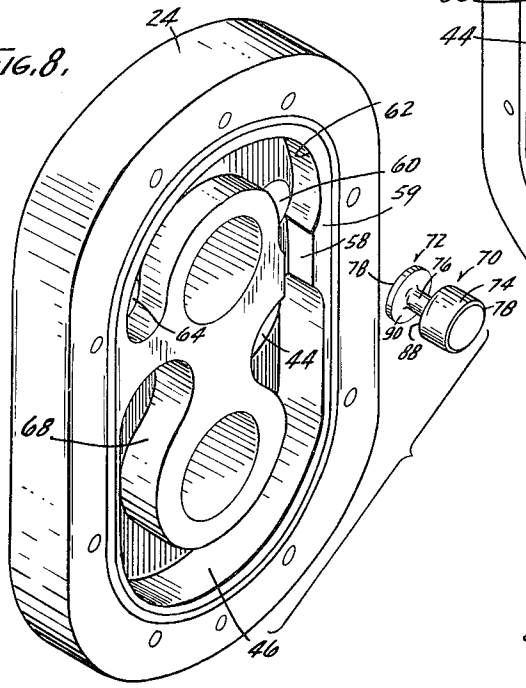


FIG. 8.



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FIG. 2

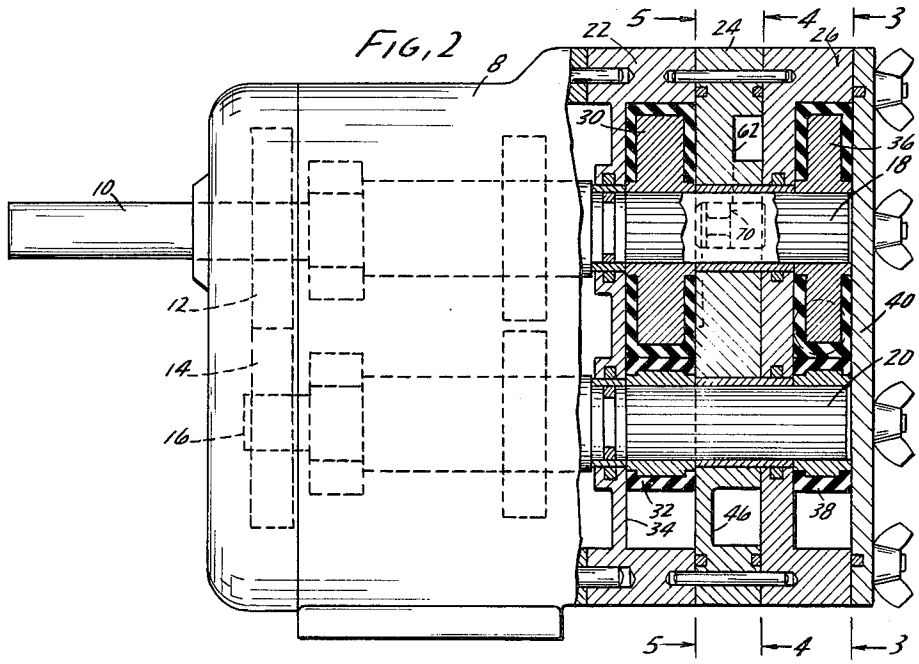


FIG. 3,

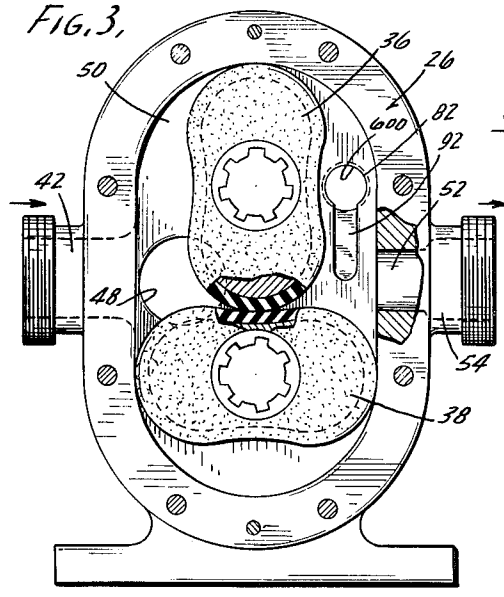
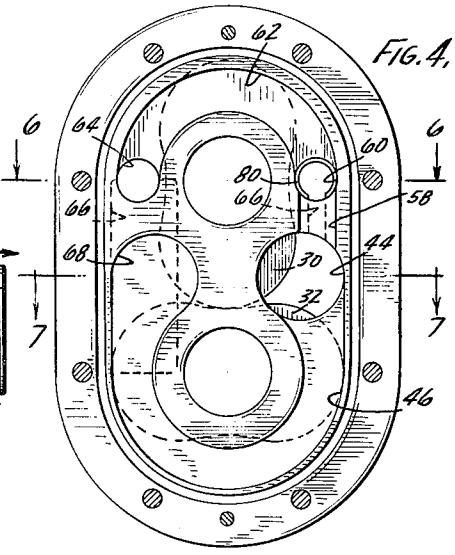


FIG. 4,



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FIG. 5,

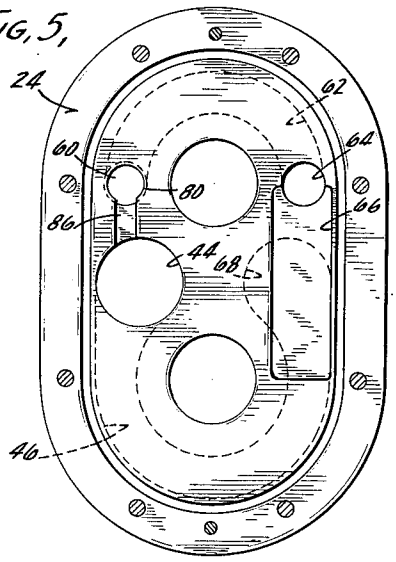


FIG. 6,

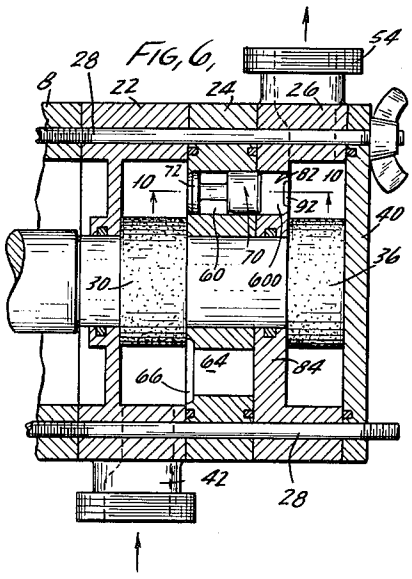


FIG. 11,

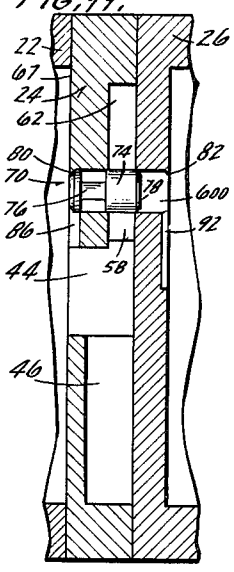


FIG. 10

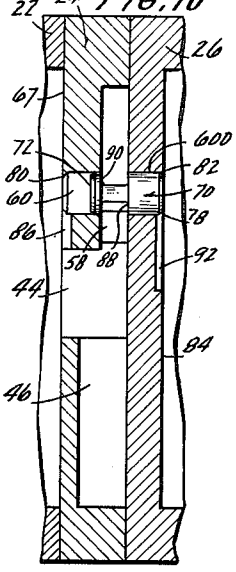
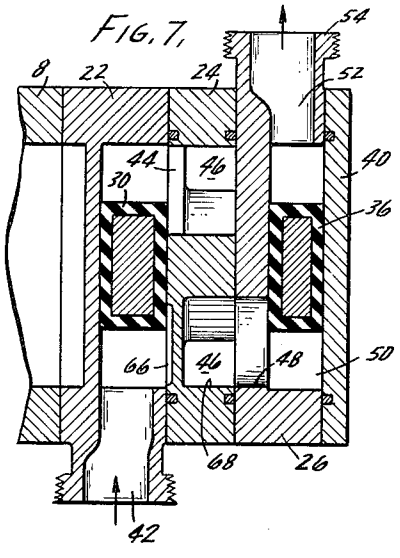


FIG. 7,



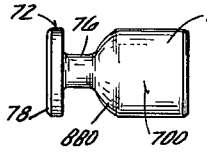


FIG. 12.

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FIG. 13

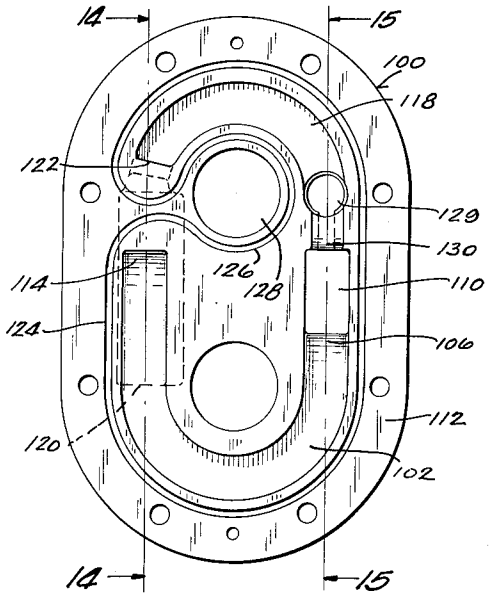


FIG. 14

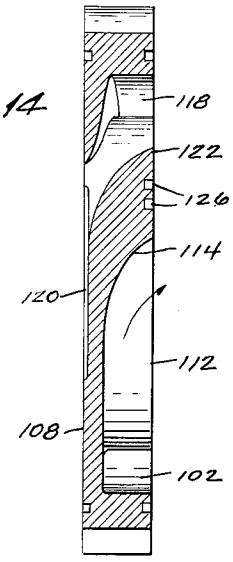
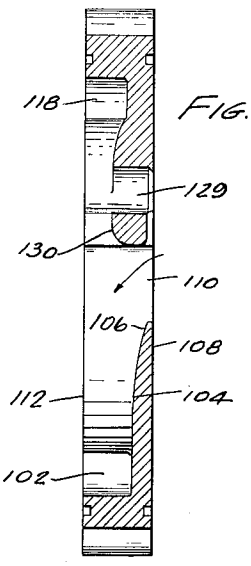


FIG. 15



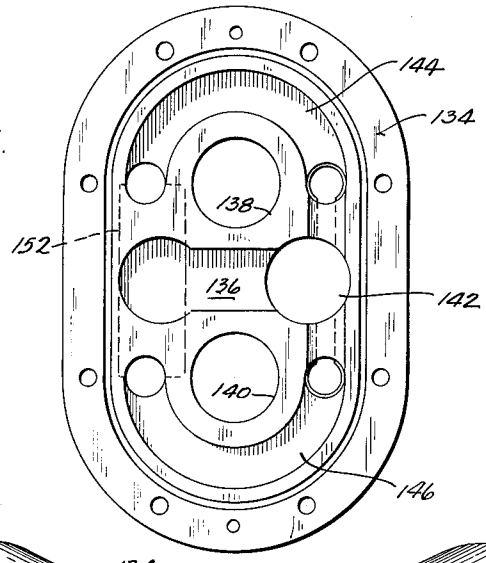
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MULTIPLE POSITIVE DISPLACEMENT PUMP

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FIG. 16.



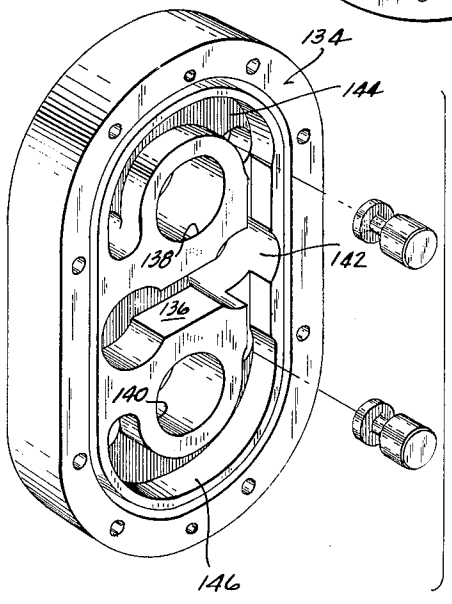


FIG. 17.

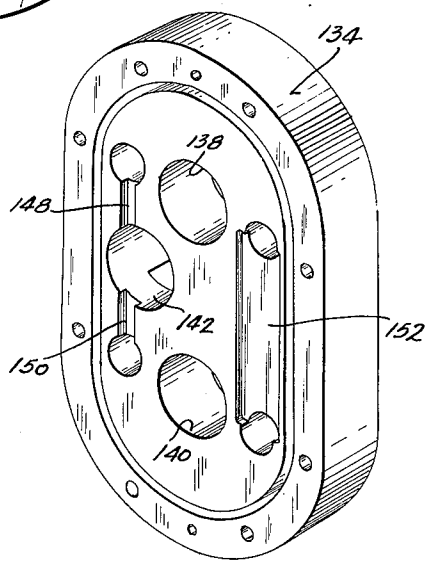


FIG. 18.

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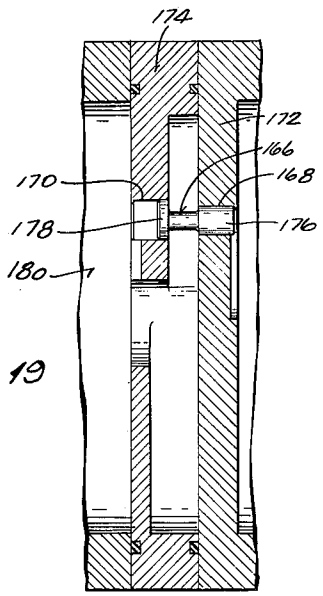


FIG. 19

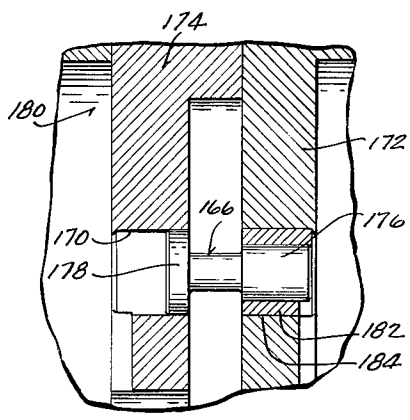


FIG. 21

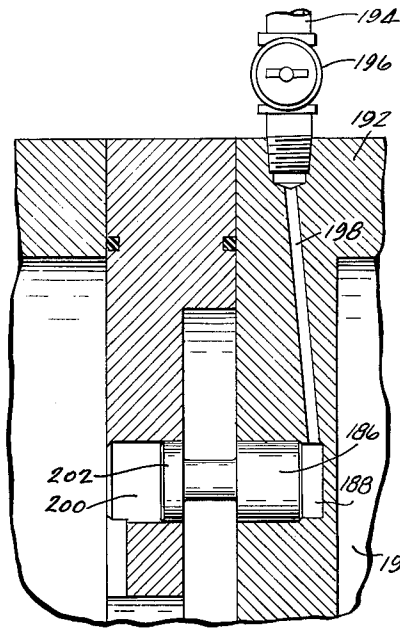


FIG. 20

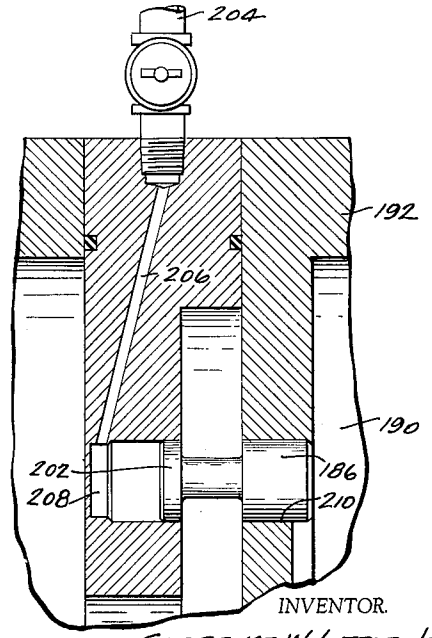


FIG. 22

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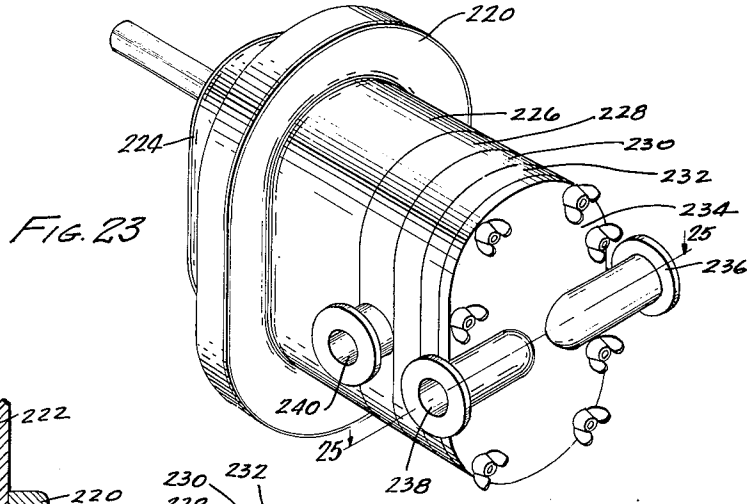


FIG. 23

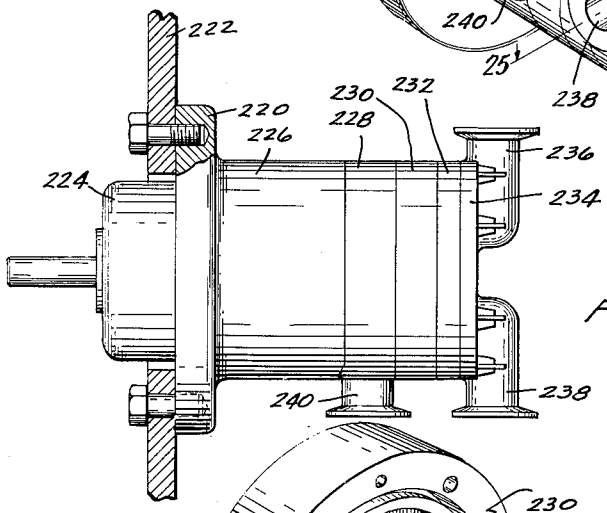


FIG. 24

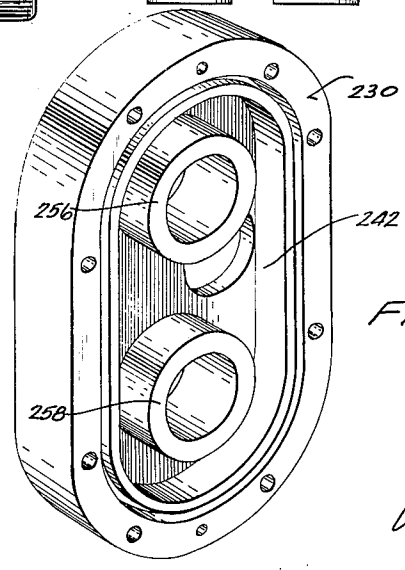


FIG. 26

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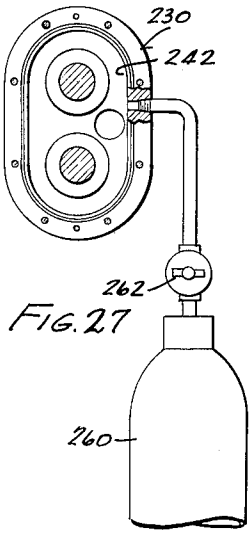


FIG. 27

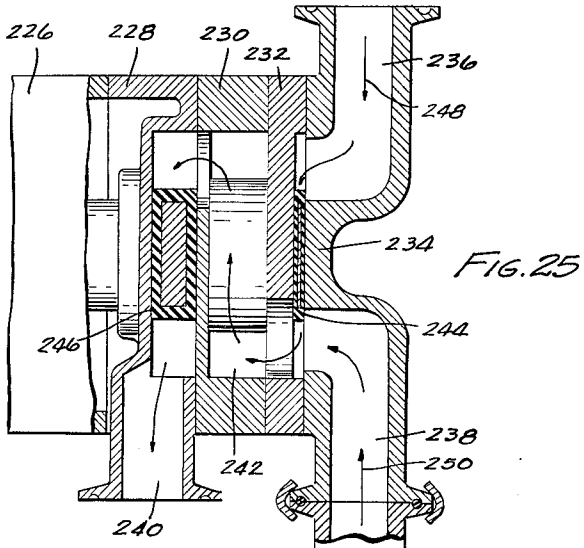


FIG. 25

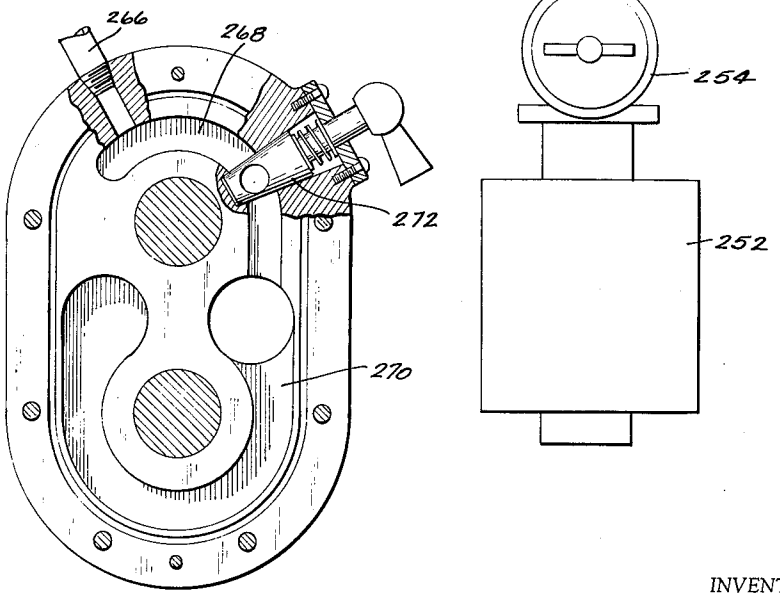


FIG. 28

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United States Patent Office 3,198,120 Patented Aug. 3, 1965

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MULTIPLE POSITIVE DISPLACEMENT PUMP

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Filed Oct. 29, 1962, Ser. No. 233,659
13 Claims. (Cl. 103—5)

This invention relates to a multiple positive displacement pump. Its preferred usage is a sanitary pump, certain features of the invention having to do with the ease of cleaning its component parts. According to design, the pump may function as a device for producing controlled metered flow or, alternatively, it may function as an aerating or mixing pump. Reference will first be made to the operation of the pump as a metering pump.

It is well-known that the output of a rotary positive displacement pump can be greater or less than its theoretical volumetric displacement. The discrepancy is due to slip resulting from variations in pressure between inlet and outlet. If the outlet pressure exceeds inlet pressure, a portion of the pumped fluid will by pass the pump rotor back to the inlet through pump clearances, thus reducing output. If the pressure at the inlet exceeds that of the outlet, then additional fluid will traverse the pump through such clearances, thus increasing output. Changes in pressure differential between inlet and outlet, and changes in clearances due to wear or to thermal expansion, and changes in viscosity of the fluid pumped can change the output in relation to the number of revolutions.

Only if a positive displacement rotary pump is operated with zero pressure differential between inlet and outlet chambers, can the pump be used as a dependable meter. With zero pressure differential across the pump, the total angular displacement of the rotor or rotors is a true measure of the total volume pumped and the rate of angular displacement of the rotors is a true measure of the rate of volumetric delivery. Several devices have been suggested for the purpose of attempting to equalize pressures across the metering pump, a common device for this purpose having a feeder pump in association with the metering pump and with capacity slightly exceeding that of the metering pump, the relative capacity of the two pumps being adjustable to achieve equalized pressure. In some instances, the feeder and meter pumps have separate shafts in order that the rate of drive between the two pumps may be used to achieve a wider range of control. In other devices of this kind, the feeder pump section and metering pump section have common shafts for purposes of compactness and lower cost, despite the fact that the ratios in such a case are fixed. In both types of pumps, the control has been attempted manually and also automatically. The present invention is an improvement on the arrangement in which the metering pump and feeder pump have common shafts and the pressure control is achieved automatically.

For sanitary reasons, it is an important object of the present invention to provide an arrangement in which all surfaces are readily accessible for cleaning, there being no blind-end holes in the bypass or elsewhere and no locking rings or other devices required to restrain the movement of the valve which controls bypass.

Particularly when the device is used as a metering pump, a very basic advantage of the present invention consists in an arrangement whereby a spool-type valve is used to control bypass, the arrangement being such that the heads of the valve are exposed only to pressure and not to flow, thus eliminating the effect of velocity.

Kinetic energy resulting from impact of fluid on the valve has impaired the accurate response of poppet valves previously used for this function. In the particular valving arrangement, the flow occurs at right angles to the direction of adjusting movement of the valve, the valve being adapted to function as a variable restriction in an otherwise unobstructed bypass of relatively large cross section. No seal of any kind is required since the valve floats between its extreme positions in a direction of movement which is transverse with respect to bypass flow, and has both ends exposed to the same pressure when in balance.

The present arrangement further eliminates all external piping such as the loop tubes sometimes used externally of the pump casings. There may be an appreciable pressure drop in such tubes and they not only have to be removed for cleaning (in the case of a sanitary pump) but they obstruct the use of the required quickly detachable connections to the inlet and outlet. In the present invention, the transfer passage is a channel formed internally. It can be made as large as is necessary to avoid pressure drop. It eliminates all external ports other than the pump inlet and the pump outlet spuds.

The preferred construction involves a three-section casing, the several sections being joined in face contact on parallel planes. The metering pump rotor means is entirely disposed in one section of the pump casing. The feeder pump rotor means is entirely disposed in another section. The flow ports between such sections, as well as the bypass port and valve are all disposed in an intermediate section. With such a pump, it is possible to vary the relative displacement of the feeder and metering pumps by simply substituting rotor means of proportionately varying relative capacity and making corresponding changes in the dimensions of the casing sections housing such rotor means.

For example, an increase in the axial dimension of the feeder pump rotor means and a corresponding decrease in axial dimension of the metering pump rotor means, together with corresponding changes in the dimensions of the respective housing sections, will leave the overall dimensions of the pump unchanged while accomplishing the desired modification of the output ratio of the two pumping sections.

Likewise the control and transfer section can be exchanged as desired to place the midpoint of the calibrated zone of operation of the pump in proper relation to the viscosity of the particular product to be pumped, this being achieved without the need of exchange of any other parts of the pump.

Due to the features above described, it has been established by tests that embodiments of the present invention can be disassembled and reassembled in a fraction of the time required for assembly or disassembly of previously manufactured devices for the purpose. Moreover, when the parts are disassembled, all internal cavities of the chambers have their faces exposed for rapid and easy cleaning and inspection.

Many of the advantages above described are also found in embodiments of the invention which are used for mixing in general or for aerating (which may be regarded as a specific form of mixing). In such usage, the pump apparatus may be essentially identical with that used to produce metered flow but the operation is reversed in the sense that the pump having the higher capacity is used as a secondary pump rather than a primary pump, with the result that the excess displacement of the discharge pump draws into the system such supplemental fluid (liquid or gas) as is required to satisty its demand in excess of displacement of the primary pump.

Various points at which such supplemental fluid may

be admitted and various valving arrangements for controlling relative flow are herein disclosed.

In the drawings:

FIG. 1 is a view in perspective showing a meter flow controlled pump embodying the invention.

FIG. 2 is an enlarged detail view of the pump and gear casing partially in side elevation and partially in vertical section through the feeder and metering pump housings in the plane of the shafts common to the metering and feeding pump rotors.

FIG. 3 is a view taken in section on the line 3—3 of FIG. 2.

FIG. 4 is a view taken in section on the line 4—4 of FIG. 2.

FIG. 5 is a view taken in section on line 5—5 of FIG. 2.

FIG. 6 is a view taken in section on the line 6—6 of FIG. 4.

FIG. 7 is a view taken in section on the line 7—7 of FIG. 4.

FIG. 8 is a view in perspective of the transfer section of the apparatus showing that face which is closed by the back of the metering pump casing and showing in slightly separated position a spool valve used to control bypass.

FIG. 9 is a view in perspective of the transfer section of the apparatus showing that face thereof which closes the feed pump casing.

FIG. 10 is an enlarged fragmentary detail view taken in section on the line indicated at 10—10 in FIG. 6.

FIG. 11 is a view similar to FIG. 10 showing the valve in a different position.

FIG. 12 is a detail view in elevation of one of a variety of modified forms of valve.

FIG. 13 is a view in end elevation showing a modification of the pump transfer section illustrated in FIG. 8.

FIG. 14 is a view taken in section on the line 14—14 of FIG. 13.

FIG. 15 is a view taken in section on the line 15—15 of FIG. 13.

FIG. 16 is a view similar to FIG. 13 showing a further modified embodiment of the transfer housing section.

FIG. 17 is a view in perspective similar to FIG. 8 showing the embodiment of FIG. 16 with the spool valves separately illustrated in positions removed from the position of use.

FIG. 18 is a view in perspective comparable to FIG. 9 showing the other side of the embodiment illustrated in FIGS. 16 and 17.

FIG. 19 is a view similar to FIG. 10 showing a modified embodiment of the invention.

FIG. 20 is a fragmentary detail view on an enlarged scale showing a further modified spool valve arrangement in a section comparable to that of FIG. 19.

FIG. 21 is a fragmentary detail view on a section comparable to that of FIG. 20 showing a further modified embodiment of the invention.

FIG. 22 is a fragmentary detail view on a section comparable to those of FIG. 20 and 21 and showing a further modified embodiment of the invention.

FIG. 23 is a view in perspective similar to FIG. 1 showing an embodiment of the invention specifically designed for fluid admixture.

FIG. 24 is a plan view of the device shown in FIG. 23.

FIG. 25 is an enlarged detail view in section taken on the line 25—25 of FIG. 23.

FIG. 26 is a view in perspective separately illustrating the embodiment of the transfer section shown in FIGS. 23 to 25 inclusive.

FIG. 27 is a view in end elevation showing the transfer section of the fluid mixing pump as it appears with the primary pump casing removed, the arrangement for admitting gas being different from that shown in FIGS. 25 and 26.

FIG. 28 is a view of a further modified fluid mixing pump transfer section as viewed in end elevation, with portions broken away to the plane of an internal plug valve which is manually operable to control the flow of admitted gas in this embodiment.

The organization for metering pump service as shown in FIGS. 1 to 11 will first be described.

A motor 2 is mounted from a reduction gear set 4, on a base 6 which also supports a gear casing 8 wherein the pump shaft 10 directly driven from the motor is connected by gears 12 and 14 with pump shaft 16. The splined end portions 18 and 20 of shafts 10 and 16 project from the gear and bearing housing 8 to operate rotors of the primary or feed pump and the secondary or metering pump respectively. The disclosed embodiment being a sanitary pump, the various housing sections are made readily separable. The feed pump casing section 22, a transfer section 24, metering pump casing section 26, and closure plate 40 are not only doweled to each other but assembled to the bearing and gear housing 8 by means of bolts 28 and wing nuts or the like.

The respective rotors 30 and 32 of the feed pump are mounted on the respective shafts 10 and 16 within an outwardly opening cavity 34 in casing 22, for which the transfer section 24 provides a closure. The rotors 36 and 38 of the meter pump are mounted on the same shafts and may be of identical contour with rotors 30 and 32 of the feed pump. The cavity of the meter pump casing 26 in which rotors 36 and 38 operate is closed by plate 40.

The fluid to be pumped enters the assembly through the inlet spud 42, which leads into the feed pump casing 22. The fluid displaced by the rotors 30 and 32 of the feed pump is delivered from feed pump casing 22 through port 44 (FIG. 6) into a transfer passage 46 which is here illustrated as extending circuitously to the port 48 but need not be circuitous. The function of port 44 and transfer passage 46 and port 48 is simply to deliver the pumped fluid into the pumping chamber 50 of the meter pump casing 26 (FIG. 3). In this chamber, the fluid is acted upon by the impellers 36, 38 and discharged through port 52 to the outlet coupling spud 54.

In order to render the output of the apparatus substantially precisely proportionate to the revolutions of the drive shaft 10, a bypass is provided from the feed pump outlet to the feed pump inlet and a valve controlling the bypass is made responsive to pressure differentials across the meter pump. The valve operates automatically to bypass exactly the correct fraction of feed pump output to maintain zero pressure differential across the meter pump.

The bypass comprises a channel 58 in the face 59 of the transfer section 24 and leading from the feed pump outlet port 44 to one side of the bore 60 in which the control valve is operable as hereinafter described. From the opposite side of this bore the bypass channel 62 continues to a hole 64 which opens through the transfer section 24 to communicate with a shallow channel 66 in the opposite face 67 thereof. Channel 66 overlies the portion of the feed pump into which the incoming fluid is admitted from spud 42 as already described. Channels 58 and 62 are closed by the rear face of wall 84 of meter pump section 26 to constitute a closed bypass duct. All surfaces of the bypass duct are exposed for inspection and cleaning when the transfer section 24 of the pump is disassembled from the feed pump section and the meter pump section.

Thus, depending on whether the bypass duct system is open or is closed by its valve, and according to the extent of such opening, a greater or lesser amount of fluid acted upon by the feed pump will be returned from the feed pump outlet to the feed pump inlet through the bypass.

Reciprocable in the bore 60 is a valve 70. It is important to the invention that this valve be a spool valve having bearing portions 72 and 74 and provided with a connecting spindle 76 of lesser radius. Desirably both heads of the valve are chamfered as indicated at 78 to

engage stop lips 80 and 82 which limit the range of valve reciprocation. The lip 80 encircles the bore 60 at one end thereof, adjacent the face 67 of the intermediate section 24 of the apparatus. The other end of the bore 60 is completely unobstructed so far as the intermediate section 24 is concerned, but an extension 600 of the bore is provided in the rear wall 84 of metering pump casing 26. The lip 82 is formed on the inner surface of wall 84 as clearly appears in FIGS. 10 and 11.

Except for special purposes, the bearing portions 72 and 74 of the valve 70 may end in surfaces 88 and 90 which are substantially normal to the axis valve, thus giving abrupt opening and closing, as is desirable for some purposes. However, in FIG. 12, I have shown a valve at 700 in which at least one of the valve heads, as illustrated at 740, has a surface 880 which is convex in axial profile so as to deviate gradually from the cylindrical surface of the bearing portion 740. By varying the axial contours of the valve head, it is possible to vary the rate at which the valve will vary the flow in response to the differential pressure to which the valve is subject. According to the kind of liquid being pumped and the percentage of pressure variation to which it is subject, a valve of one contour may produce substantially perfect regulation within a given range, but a valve of slightly different contour may be required in apparatus which is called upon to function at a different range of pressures. FIG. 12 is, therefore, merely exemplary of the fact that I may use any appropriate specific valve contour. The valve 700 has an almost imperceptible opening in response to its initial displacement, the rate of opening, as well as the amount of opening, increasing as the displacement increases.

Pressures which operate the spool valve are not derived from the flow controlled by the spool valve but are separately communicated to the ends of the valve as best shown in FIGS. 8 and 9. The intermediate casing section 24 is provided in its face 67 with a very shallow channel 86 leading through the lip 80 to one end of the bore 60 wherein the valve 70 is reciprocable. This channel opens from the passage 44 as best shown in FIG. 9 and communicates to the end of the shorter bearing portion 72 whatever pressures exist at the outlet side of the feed pump. These pressures are, of course, the pressures existing at the inlet side of the metering pump.

The pressures at the outlet side of the metering pump are communicated to the end of the larger bearing portion 74 of valve 70 by means of a shallow channel 92 in the inner surface of the end wall 84 of the meter pump casing section 26. This channel penetrates the lip 82 which limits valve reciprocation. It leads from the zone adjacent the discharge port 52 as is apparent from FIG. 3. Thus one end of the valve 70 is subject to pressure at the outlet side of the meter pump while the other end is subject to pressure at the inlet side of the meter pump.

It is a feature of this device that the displacement of the valve is determined solely by the pressure differentials to which its ends are subjected, this being uninfluenced by the kinetic energy of flow past the valve through the bypass channels above described. Such flow is at right angles to the direction of valve movement and it does not displace the valve from the adjusted position which the valve has assumed in response to pressure differentials across the meter pump. Consequently, a valve as here disclosed can be made to give perfect accuracy of response in order that the revolutions of the pump shaft 10 will accurately predetermine and reflect the fluid pumped.

In tests, it has been determined that metering accuracy can be maintained over the entire pressure range from zero pounds per square inch to the pressure at which the slip through the feeder pump equals the excess capacity of the feeder pump over the meter pump, and for fluid viscosities which range from that of water to over 500,000 S.S.U. This is an improvement by a factor of up to 10 over devices previously known to me. Also,

a single device made as herein disclosed will operate with metering accuracy over a viscosity range which may require as many as ten different section ratios or separate hydraulic controlling devices in other metering pumps.

It will, of course, be understood that in accordance with the indicated objective of the present invention, means (not shown) will be provided for regulating and/or counting the revolutions of the drive shaft 10 as a means of predetermining or registering the amount or rate of delivery of fluid by the pump assembly. Electrical, magnetic, and optical, as well as mechanical apparatus for this purpose is known, the improvement herein disclosed being concerned with the accuracy with which rotation of the drive shaft reflects actual flow, and with compactness, sanitation, and ease of cleaning.

The provision of the unitarily connected laminar housing sections constituting the enclosure for the rotor means is a feature and another feature is the location of all passages internally and in a manner such that all are fully accessible when the sections are disassembled.

The embodiment of intermediate or transfer section 100 shown in FIGS. 13 to 15 has two significant differences from the construction heretofore described. These features of difference are individually usable if desired. The first of these features consists in an arrangement which preserves the accessibility of all surfaces for cleaning but minimizes eddy currents and facilitates fluid flow by avoiding any sharp turns in the various paths followed by the fluids acted on by the pump. Thus the transfer channel or passage 102 has its bottom wall 104 diverging gradually at 106 from the face 108 through which the inlet port 110 opens, the said wall 104 progressively approaching the opposite face 112 as shown at 114 in FIG. 14 for delivery of fluid to the inlet of the secondary or metering pump. Similarly, the bypass passage 118 merges gradually with the shallow channel 120, the latter corresponding to the channel 66 shown in FIG. 9.

From the channel 120, the bypass 118 extends on an incline beneath the face portion 122 of face 112, thus not only minimizing eddy current obstruction but also extending the surface 122 sufficiently to permit the packing groove 124 to be continuously extended at 126 around the shaft opening 128, thereby improving the seal between the transfer passage 102 and the bypass port 118. Beyond the bore 129 in which the spool valve operates (not shown in these views), the bypass conduit 118 merges gradually at 130 with the port 110.

The extended seal provided at 126 is the second feature which, independently of the inclined wall surface of the channel may be used in the various other embodiments illustrated.

FIGS. 16, 17 and 18 illustrate a further modified transfer section 134 which likewise has two features independently usable in other embodiments illustrated. The first of these features consists in extending the transfer passage 136 directly across the transfer section 134 between the shaft receiving bores 138 and 140. The port 142 corresponds to the port shown at 110 in FIGS. 13 and 15.

The second feature consists in provision of two bypass passages at 144 and 146 around the respective ends of the section. By means of channels 148 and 150, respectively, these communicate with the port 142. At their opposite ends, the bypass passages open into the channel 152.

There being two bypass conduits, two separate spool valves are required at 160 and 162. They function identicaly like the spool valves already described, being operated by pressure differential to control flow through the respective bypass conduits 144 and 146. Since the respective pump rotors turn in opposite directions, there is some tendency for pulsating flow to occur when there is only a single non-symmetrical bypass, this being attributable to the fact that the kinetic energy of fluid entering and leaving the lobes of the respective rotors is

exerted in opposite directions with respect to the bypass conduit. When two bypass conduits are provided, as in the transfer section shown in FIGS. 16 to 18, the kinetic energy effect is equalized and there is a tendency to eliminate pulsation.

The description thus far has assumed that the spool valve might be designed to equalize pressures across the secondary pump rotor. In some installations, it is desirabel that these pressures should be unequal to maintain a predetermined differential across the rotor. Thus in the construction shown in FIG. 19, the spool valve **166** is reciprocable in the bores **168** and **170** of the primary pump section **172** and the transfer section **174** in the manner already described. However, it will be noted that the head **176** of the valve **166** is materially smaller in diameter than the head **178**, thereby making the valve respond to maintain differential pressures rather than identical pressures across the rotors in the secondary pump section **180**. The differential pressure is inversely related to the end face areas of the heads **176** and **178**.

In instances in which it might be desirable to provide a multiple section pump with interchangeable spool valve means, the construction shown in FIG. 21 may be employed. The spool valve **166** is identical with that shown in FIG. 19, but the smaller diametered head **176** is reciprocable in a sleeve **182** interchangeably seated in a bore **184** which is equal in diameter to the bore **170** in which the valve head **178** is reciprocable. Thus, by simply removing the sleeve **182** and the valve **166** and substituting a valve like that shown at **70** in FIG. 8, equalized pressures can be maintained instead of the differential pressures contemplated by the assembly of FIG. 21. With a different sleeve and valve, other relative pressure differentials are obtainable.

The construction shown in FIG. 20 is one in which the spool valve head **186** operates in a blind bore **188**, being thereby isolated from the pressure in the pump cavity **190** of the primary pump section **192**. This is done in order that fluid pressure from a separate source, here represented by the pressure line **194**, may be admitted, subject to the control of pressure regulating valve **196**, through duct **198** into the blind bore **188** to act on the head **186** in opposition to the pressures in bore **200** to which the spool valve head **202** is subject. Thus the spool is here controlled in part by the pressures developed by the pump and applied to the head **202** and in part from pressures from an exterior source as applied to the spool valve head **186**.

The construction shown in FIG. 22 is a counterpart arrangement in which the exterior source **204** is connected by duct **206** with a blind bore **208** in which the head **202** of spool valve is reciprocable. In this instance, the bore **210** in which the head **186** is reciprocable is exposed to the chamber **190** in which the primary pump rotor operates. Thus the pressure differential to which the valve responds is in part attributable to the inlet pressure and in part is attributable to the pressure of the extraneous source **204**.

The various constructions illustrated in FIGS. 23 to 28 inclusive are, for the most part, dual pump organizations used to mix fluids in predetermined ratios. To this end, these devices have plural inlets and, in general, the secondary pump has a larger displacement as compared with the constructions previously described in which the primary pump is usually the pump of larger displacement. However, while these constructions are primarily mixing pump organizations, they do disclose some features which may be useful in the metering pump organizations.

One feature of general utility is disclosed in FIG. 23 and has to do with the mounting. Instead of having the pump casing sections and the motor separately supported, as in FIG. 1, the arrangement shown in FIGS. 23 and 24 is one in which the mounting flange **220** is bolted to an apertured panel **222** through which the gear case cover **224** projects to the back side of the panel. The flange **220** directly carries the gear casing section **226** to which the secondary pump section **228**, the transfer section **230**, the primary pump section **232** and the closure plate **234** are successively assembled.

As illustrated in FIGS. 23 to 25, the first inlet **236** and the second inlet **238** are both mounted on the closure plate **234**. The outlet connection **240** opens as usual from the secondary pump section **228**. However, the second inlet need not necessarily open into the primary pump casing section **232** but may open into the transfer section **230** or even into the inlet side of the secondary pump section **228**, since all areas of the transfer passage between the pressure side of the primary pump and the inlet side of the secondary pump are at the same or substantially the same pressure.

While reference has been made to the pressure side of the primary pump, it will be understood that normally, in a device of the type presently under discussion, the pressure side of the primary pump may be at subatmospheric pressure in order that a separate fluid may be drawn under atmospheric pressure into the transfer passage **242** to be commingled with the fluid admitted through the inlet **236**.

The positive displacement rotors may be of the type heretofore disclosed. They are here shown only in section. The reduced displacement of the pump rotor means **244** is here indicated by the fact that this rotor means has very much less axial extent than the rotor means **246** in the secondary pump section **228**. Since the displacement of the secondary rotor means **246** greatly exceeds the displacement of the primary pump rotor means **244**, the fluid entering inlet **236** and represented by arrow **248** is supplemented by fluid entering inlet **238** as represented by arrow **250**. For example, the fluid entering inlet **236** may be a liquid to be aerated by a gas such as air admitted through the inlet **238** subject to a filter **252** and the control valve **254**. The two fluids are commingled in the transfer passage **242** and thoroughly mixed by the action of the rotor means **246** in secondary pump section **228**. The passage **242** preferably completely surrounds the bosses **256** and **258** for the rotor shafts (FIG. 26).

FIG. 27 shows the second fluid admitted into the transfer section **230** from a tank **260** which is under pressure and delivers the second fluid to the transfer passage **242** subject to control of the pressure regulator or reducer **262**.

FIG. 28 shows another arrangement in which the second fluid conduit **266** opens into a bypass duct **268** which is compable to that shown at **62** in FIG. 8. However, instead of an automatic valve for regulating flow of the second fluid into the transfer passage **270**, a manually operable plug valve **272** is provided for this purpose, the plug valve being a well-known and easily cleanable valve.

It will be understood that either or both of the fluids admitted to the mixing pump embodiments of the invention may be a liquid and either or both may be a gas. The devices shown are well adapted to mix two gases or two liquids or to aerate liquids with gases.

Aside from the blind bores shown in FIGS. 20 to 22, all of the passages in the various embodiments illustrated can be cleaned with the utmost ease.

I claim:

1. A multiple positive displacement pump comprising primary and secondary pump casing sections and an intermediate transfer section, each of the pump casing sections having a transverse wall and pumping recesses, a plurality of shafts extending through the several sections and the recesses aforesaid, material pumping means comprising complementary positive displacement pump rotors on the shafts in the respective recesses, and means for detachably connecting the several sections, the primary pump casing section having an inlet and the sec-

ondary pump casing section having an outlet, said transfer section and said transverse wall of one of said pump casing sections having complementary means providing a passageway for delivery of material pumped from the primary pump casing section to the secondary pump casing section and said complementary means having surfaces completely exposed for cleaning upon the separation of said sections.

2. A pump according to claim 1 in further combination with bypass means in the transfer section for returning across one such pumping means a portion of the material displaced thereby, the bypass likewise having surfaces fully exposed upon the separation of said sections and including a channel in one section and for which another section provides a removable top wall, whereby the channel is open when said sections are separated, and a valve controlling the bypass means.

3. A pump according to claim 2 in which the pump is a metering pump, the material pumping means in the primary pump casing section having displacement capacity exceeding that of the pumping means in the secondary pump casing section, the bypass means comprising means for returning across the pumping means in the primary pump casing section a part of the material acted on thereby, and means for making the valve operation responsive to pressure differential across the pumping means of the secondary pump casing section, the amount of flow bypassed being adapted to maintain such pressure differential substantially at zero.

4. A pump according to claim 3 in which the valve is a spool valve having spaced piston heads subject to pressure differential for controlling the position of the valve respecting the bypass means, flow through the bypass means occurring between said heads.

5. A pump according to claim 3 in which the bypass means comprises means for returning across the pumping means in the secondary pump casing section a part of the material acted on thereby.

6. A pump according to claim 5 in further combination with making the valve operate responsively to pressure differential across the pumping means of the primary pump casing section.

7. In a positive displacement pump having feeder and metering rotor means, the combination with such means, of housing sections having transverse walls and cavities in which the respective means are disposed, an intermediate section constituting a closure for the housing section in which the feeder rotor means is disposed and having passages in the form of channels for which a closure is provided by the transverse wall of the housing section in which the metering rotor means is disposed, the several sections having passages including the said channels and constituting means for the delivery of pumped material from the feeder rotor means to the metering rotor means and for the bypassing of a portion of such material across the feeder rotor means, a valve controlling the flow of bypassed material, and means for subjecting the valve to the pressure differentials across the metering rotor means, all of said passages being fully exposed for cleaning merely upon the separation of the several sections aforesaid, and means for connecting such sections for ready separation.

8. A pump according to claim 7 in which said valve comprises a spool valve having an intermediate portion across which flow of bypassed material is accommodated when the valve is open, only the ends of the valve being exposed to the pressure differentials across the metering rotor means and the flow of bypassed material being transverse with respect to the direction of valve movement in response to changes in such pressure differentials.

9. In a rotary positive displacement metering pump the combination with feed rotor means and metering rotor means having correlated driving connections, of a housing section comprising readily separable laminar

sections including a first section provided with a cavity in which the feed rotor means is disposed and another section provided with a cavity in which the metering rotor means is disposed, and an intermediate housing section constituting a closure for the cavity of the first housing section and having channels closed by said other housing section, said first section having fluid inlet and discharge portions at opposite sides of the feed rotor means and having an inlet port communicating with its inlet portion, the intermediate section having a port communicating with the discharge portion of the first section and with one of said channels, said other housing section having a port communicating with the same channel last mentioned to receive fluid from the discharge portion of the first housing section, another channel of the intermediate section constituting a bypass from the discharge portion to the inlet portion of said first section, the intermediate section having a valve bore intersecting the bypass channel, the said other housing section having an extension of said bore, a spool valve having bearing portions reciprocable in the bore and extension and having reduced cross section between said portions, one of said bearing portions being registrable in varying amount with the bypass channel whereby to regulate flow therethrough, the portion of said valve which is of reduced section being adapted in certain positions of said valve to accommodate such flow to a varying extent, according to the valve position, and passage means in said other housing section and in said intermediate section leading to the ends of said bore for communicating thereto pressures existing at opposite sides of the metering rotor means whereby to subject the ends of the valve to differential pressures across the metering rotor means, said other housing section having a closure for its cavity to house the metering rotor means therein and having inlet and outlet portions whereof the inlet portion communicates with the discharge portion of the first mentioned section, and means providing an outlet port opening from the outlet portion of said other housing section.

10. The combination with a pump, of means providing a bypass passage, means providing a valve bore intersecting said passage, means for subjecting the ends of the bore to differential pressures, and a spool valve having spaced bearing portions fitted to the bore, the valve being reciprocable in the bore in response to said differential pressures and between positions in which one of said bearing portions obstructs to varying extent the flow through the bypass passage, such flow being transverse between the bearing portions of the valve whereby the kinetic energy of such flow is substantially ineffective upon the valve position in said bore as determined by said differential pressures, the means for subjecting one end of the bore to pressure constituting a manually variable source of fluid pressure independent of the material pumped.

11. In a metering pump assembly, a housing organization comprising a plurality of sections in unitary laminar assembly, rotary pump means in a first section, rotary pump means in a third section, the respective pump means differing in capacity and each of said first and third sections including inlet and discharge portions for material pumped by the respective pump means, a second section intermediate the first and third sections and provided with a transfer passage providing communication between the discharge portion of the one section and the intake portion of the other section and further provided with a bypass passage across one of said pump means, certain portions of the respective passages comprising holes opening completely through the second section and other portions of said passages comprising channels completely open to a face of the second section, whereby all of said holes and channels are fully accessible for cleaning upon the disassembly of said sections, said channels having walls gradually changing in direction whereby to merge gradually with said holes whereby to streamline flow and reduce eddies in material traversing said second section, and

means releasably connecting the several sections for ready disassembly and assembly, and a valve controlling flow through the bypass passage.

12. A metering pump according to claim **11** in which the valve has a slide valve portion movable transversely across the bypass passage whereby to be substantially unaffected by the kinetic energy of flow through said passage.

13. A metering pump according to claim **12** in which said valve comprises a spool valve having spaced bearing portions, one of which has sufficient extent to substantially close the bypass passage in one position of said valve, the said second section and one of the other housing sections having complementary bores in which said valve is reciprocable and having passage forming means respectively providing pressure communication ducts leading to said bores at opposite ends of the valve, whereby said valve is subject to differential pressures.

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