UNITED STATES PATENT OFFICE

2,024,480

PROPORTIONING DEVICE FOR FLUIDS

Robert J. Short, Cincinnati, Ohio, assignor to The Procter & Gamble Company, Cincinnati, Ohio, a corporation of Ohio

Application July 9, 1934, Serial No. 734,269

12 Claims. (Cl. 137—165)

This invention relates to a device for delivering two or more fluids simultaneously in definite proportions to each other, which can be varied at will, and is particularly adapted to the proportioning of several fluids, although the physical condition of the fluid is not a limitation upon my invention, since one or more may be gaseous, and others liquid.

The object of the invention is to provide a device of this character which will be smooth, positive, and reliable in operation, adjustable to deliver different proportions as desired within reasonable limits, and which will stop all flow automatically if for any reason one fluid falls below or exceeds a predetermined limit.

This application is related to my copending applications, Serial No. 702,266, filed December 13, 1933, and Serial No. 729,377, filed June 6, 1934.

In many industrial operations it is desirable to continuously mix two or more fluids in definite and sometimes variable proportions. The continuous proportioning of molten kettle soap and silicate of soda or sal soda solution in soap making, of crude vegetable oil and caustic soda solutions for use in the continuous refining of vegetable oils, or of petroleum oils and sulfuric acid, are examples of the application of this device; and many others might be mentioned. Various devices have been proposed for accomplishing this object, but all are objectionable for one reason or another; some give a pulsating flow instead of a smooth, continuous flow; some of the devices cannot be closely controlled or cannot be readily adjusted to change from one proportion to another, and none, as far as I am aware, will automatically stop the flow if the flow of one of the fluids becomes interrupted. It is an object of my invention, therefore, to overcome all these difficulties.

The device herein described is especially applicable in cases where a pump is more desirable for measuring and delivering the secondary fluid, in contrast to the use of a valve. The invention is particularly true when the ratio of the secondary fluid to the primary fluid is extremely small.

My device in its simplest form as applied to two fluids consists essentially in the use of a suitable differential, one of whose primary shafts is caused to rotate by a rotatable member in the line of flow of the primary fluid; the other of whose primary shafts is caused to rotate by a variable speed motive means. The secondary member of the differential, whose action depends on the speed relation of the two primary shafts, actuates a valve or other suitable control device controlling the speed of the variable speed motive means so that the rotation of said motive means is always in fixed relation to the rotation of the primary rotatable member. In addition to operating the secondary primary shaft of the differential the variable speed motive means operates a rotary gear pump which delivers the secondary fluid in proportion to its speed. The above interrelated parts are so connected that when the two primary shafts of the differential are operating at the proper speed relation, the secondary pump will be operating at the speed required to deliver the correct proportion of the secondary fluid. An electrically operated valve or other suitable device, so arranged as to stop the flow of the primary fluid whenever the secondary fluid falls below or exceeds a desired limit, is inserted in the line of flow of either the primary fluid or of the mixture of primary and secondary fluids. A stopping of the primary fluid will in any event automatically stop the entire device. Various modifications of this principle may be used, and for the purpose of an exemplary disclosure, some of the preferred forms of the device and methods of applying the same are more fully set forth herein. The accompanying drawings will make these parts and their interrelated action clear.

Reference is now made to the drawings which form a part hereof, and in which—

Figure 1 shows a plan view of one form of my device, and

Figure 2 shows a plan view of a modification thereof.

Referring first to the general layout of the apparatus as shown in Figure 1, a pump 1, which may be any suitable form of positive acting pump, such as a gear pump, has an inlet 2 which is understood to lead from the primary fluid supply, and has an outlet 3; and leading from the outlet 3 to the inlet 2 is a by-pass 4, controlled by a yielding valve 5. A pump of this type will maintain a positive pressure depending upon its rate of operation, and upon the setting of the yielding valve 5. If its outlet is restricted to a certain extent, the by-pass valve 5 will open, so that there will be no overload upon the pump driving mechanism, such as a motor. If the outlet should be entirely closed, the entire amount of fluid passed by the pump gears will flow back through the by-pass. At the same time it will be seen that for a given rate of operation the pressure at the outlet end of the pump will remain constant as determined by the pressure on the valve in the by-pass. If the outlet is open, fluid will flow...
under this pressure; if the outlet is completely closed, the flow of fluid will be stopped, but the static pressure at the outlet end will be maintained.

A pump such as above described is preferable because it can be used with the aforementioned methods, and the output of the apparatus can be controlled and determined by stopping the flow at the outlet end of the apparatus if desired.

The pipe line 55 conducts the primary fluid from the outlet of the rotary pump to the inlet of a device 6 having a rotating fluid member which is caused to rotate at a speed proportionate to the flow of the fluid through it. This device may conveniently be a meter of known type, having a counter 7 to indicate the quantity of fluid passing through the device in a given time. The shaft 8 of the rotatable member, which is caused to extend from the casing of the meter, is connected to one of the primary shafts 9 of the differential device 10. 11 indicates the pipe through which the primary fluid leaves the device 6 and flows through a suitable check valve 12 to join the secondary fluid.

The second primary shaft 13 of the differential is driven through suitable means by shaft 14 of a fluid motor 15, which may be of any well known type, whose speed of rotation is dependent on the volume of fluid passing through it. The external fluid 16 employed to drive the fluid motor may be water, mineral oil, or any similar material. A drum 17 is provided as a reservoir for the external fluid. 18 passes the delivery line leading from the drum 17 to the intake 19 of the pump 20 which is of any well known, positive delivery type similar to the pump 1 described above, and which is driven by a motor 21. The discharge of the pump 20 flows through a pipe 22 which is then divided into branches 23 and 24. The portion of the fluid conducted by the branch 23 passes through a check valve 25 and then to the fluid motor 15, the discharge line 26 of the said fluid motor returning the fluid to the reservoir 17. The branch 24 conducts the remaining portion of the fluid through a balanced control valve 27 operated by the secondary member of the differential to the reservoir 17. Although the external fluid system, as I have shown it, is an open system, it may well be a closed system, provided of course there are no leaks.

The shaft 14 which has been said to drive the secondary primary shaft 13 of the differential, also drives, through suitable connections, the shaft 33 of the secondary pump 28 which is also of the positive delivery type previously mentioned.

The secondary fluid is conducted through a pipe 29 from a source of supply to the pump 28 which discharges into a line 30, the secondary fluid passing through a check valve 31 to a conduit 32, there joining with the primary fluid. The mixture of proportioned primary and secondary fluids is then conducted to a mixer or elsewhere as desired.

Figure 2 shows a somewhat different arrangement of my invention, adapted to the proportioning of three fluids, in which the pump shafts of the secondary and tertiary fluids, 33 and 34 respectively, and the secondary primary shaft 13 of the differential, are operated by the variable speed shaft 14 actuated by the variable speed motor 35, which may be of any well known type. This motor and shaft are adapted to drive the rotary pumps 36 and 37 for the secondary and tertiary fluids, respectively, and the secondary primary shaft 13 of the differential 10. 38 is a rheostat through which power is applied to the motor 35. The arm 39 of the rheostat is caused to move by the arm 40 of the secondary member of the differential, through suitable connecting means, to increase or decrease the speed of the motor so as to obtain the proper speed relation between the two primary shafts 13 and 14.

In the drawings I have shown a chain and sprocket means of connecting the variable speed shaft 14 to the shafts of the rotary pumps delivering the controlled fluid. This method of connection is quite desirable when the proportion of the ingredients is relatively small. In other operations it is desirable to change readily from one proportion to another and in this case a variable speed transmission of any well known type may be used in place of the chain and sprocket shown. In this manner the proportions may be varied at will from time to time.

The particular type of differential mechanism is not a limitation upon my invention. In my specific embodiment the first primary shaft 9 of the differential is threaded as shown, the threads extending substantially from end to end thereof inside the housing of the differential. Mounted on the said threaded shaft 9 is a gear or secondary member 41 threaded internally to match the thread on the shaft 9 so that its axis is concentric with the axis of the threaded shaft. The second primary shaft 13 carries a wide faced gear 42 which meshes with the gear 41. The hub of the gear 41 is grooved and fitted with a collar provided with pins 43 and 44 so arranged that the end of the lever 45 must move laterally with the gear 41 on a fulcrum 45 upon an external support not shown. The lever 40 is connected through a suitable linkage and lever to the arm of the rheostat 38. 47 indicates diagrammatically an electrical switch or switches arranged to be moved by the lever 40 against abutments 48 and 49 respectively so that an electrical contact will be made when the lever moves in extreme position either to the right or to the left. The closing of these contacts can be made to operate means for stopping the flow of fluids and/or suitable signals in any well known manner. For this purpose I have shown a switch 47 connected by leads 50 and 51, in one of which a source of current 52 is inserted, to the solenoid 53 of the normally operated valve 54 in the inlet line 55 of the device 6. I have likewise shown a signal nailing means 56 connected in parallel with the solenoid. This device will operate if for any reason the proper speed relation between the secondary pump and the primary rotatable member cannot be maintained. Any other known device for stopping the flow of the fluids may be used. An additional safety device may be inserted in the discharge line of the secondary fluid, preferably including a pressure gauge 51 which in addition to having a dial to indicate the pressure of the supply of the ingredients, also includes a pair of electrical contact elements 58 and 59 by means of which an element 60 moved by the pressure gauge will complete a circuit through the connections 58 and 59 and the coil of the solenoid 53. The parts are adjusted so that if the pressure in the secondary ingredient supply falls below a desired given value the gauge will make the contact and the solenoid will act to close the valve 54 and stop the flow of the primary fluid, to the extent that has been described, when this happens. By this means it is insured that the primary fluid will not be passed through the apparatus without the supply of the secondary fluid. The combined action of the dif-
ferential and the external motive means for mov-
ing the secondary pump insures proper corre-
spondence of the quantities of the primary and
secondary fluids so long as the pump 28 and the
other parts of the secondary fluid system are
in proper working order. This provision would
not function, however, should the pump 28 for
any of these reasons fail to supply the rated
amount of secondary fluid, notwithstanding that
its proper speed was maintained through the op-
eration of the differential and external motive
means.

The principle of operation of the device shown
in Figure 1 is as follows, assuming that two fluids
are to be mixed:

The flow of the primary fluid causes the rotat-
ing member of the meter 8 to rotate in direct re-
lation to the mount of fluid flowing, and through
suitable connections causes the primary shaft 9
of the differential to operate at a certain speed.
The primary fluid then flows through the pipe 11
to meet the secondary fluid which is being intro-
duced into the pipe at some other point 61.
The second primary shaft 13 of the differential
is caused to operate, through suitable connections,
by the fluid motor 15, its speed depending on
the amount of external fluid flowing there-
through. The control valve 30 is inserted in a
portion of the external fluid pumped from the
reservoir 71 through the line 22 may be allowed
to bypass the fluid motor 15. The shaft 14 of
the fluid motor also drives, through a chain and
sprocket, variable speed transmission, gears, or
any other suitable means, the rotary pump 28
for supplying the secondary fluid. Since this
secondary rotary pump is of the positive acting
type, similar to the pump 1 described before, the
amount of secondary fluid discharged into the
primary fluid will depend on its speed of rotation.

As long as the primary rotatable member and
the secondary pump operate at the required speed
relatiion, the first and second primary shafts 9
and 13, respectively, will operate at their required
speed relation, in which event the secondary
member 41 will maintain its position without lat-
eral movement along the shaft 9; but if the pri-
mary shafts fail to rotate at the required speed
relation indicating that the primary rotatable
member and secondary pump are not operat-
ing at the required speed relation, the member 41
will move in a lateral direction to the right or
to the left along the threaded shaft, the direction
of motion depending on which shaft is moving
faster. The lever attached to this secondary
member 41 is thereby caused to move in the same
direction as the member 41 and in combination
with a suitable fulcrum will operate the stem of
the balanced control valve 27 to open or close
the said valve as required, thus decreasing or in-
creasing respectively the flow of the secondary
fluid through the fluid motor, until the desired
speed relation is again restored, whereupon the
two primary shafts of the differential, the sec-
ondary pump, and the primary rotatable member
will again rotate at the required speed relation,
with the member 41 in a position of equilibrium.
By suitably adjusting the length or position of
the lever arms a proper setting is obtainable, so
that the gear 41 in its lateral movement disen-
gages from the gear 42 at the maximum and
minimum openings, respectively, of the valve 27.
If the rate of flow of the primary fluid is changed
by throttling at any point in the system, it is ob-
vious that the device will automatically com-
penate for this through the differential, by caus-
ing the rate of flow of the external fluid through
the fluid motor to change so that the speed rela-
tion between the two primary shafts of the dif-
ferential is maintained. Likewise any throttling
of the discharge line carrying the mixed fluids
will reduce the total flow without permitting the
proportions of the two fluids to vary.

The operation of the device shown in Figure 2
is the same as that of Figure 1, except that the
required speed relation of the various rotating
parts is maintained by increasing or decreasing
the power supplied to the variable speed motor
through the rheostat which is actuated by suit-
able means connected to the secondary member
of the differential.

It is, of course, possible to design this type of
differential so that the two primary shafts, in-
stead of rotating at identical speeds, will rotate
at different speeds while maintaining the sec-
ondary member 41 in its proper lateral stationary
position of equilibrium. This could be the case,
for example, if the gear 42 were made with a
different diameter and different number of teeth
from the secondary member 41. Such a variation,
however, would be considered equivalent to the
differential described for all intents and pur-
poses. It is also obvious that any other type of
differential may be used, provided only that it has
two primary driven members co-acting on a sec-
ondary member in such a way that the motion of
the latter, whether rotary or lateral, can be used
to control the secondary fluid. My invention is
not limited to the type of differential shown, but
covers the use of any differential in substantially
the manner described in connection with a suit-
able means of control.

It is to be understood also that means of power
transmission other than a lever or levers, as shown
and described may be used between the secondary
member of the differential and the stem of the
control valve or other control means. A rotary
screw motion or a worm gear type of transmis-
sion may be used, or any other of the well known
mechanical means for accomplishing this object.

My invention is not limited to the use of the lever,
therefore, but is intended to cover any means
of transmitting motion from the secondary mem-
ber of the differential to the stem of the control
valve, or to the pump, or to the rheostat, or to
any other control means in such a way as to control
the speed of the variable speed shaft 14.

The relative proportions of the two fluids can
readily be changed to any desired figure within
the limits of the apparatus, by changing the size
of the sprockets or by changing the setting of
the variable speed transmission apparatus as de-
sired. It is hereby understood that the relative
sizes of the rotatable member or meter, pipe lines,
pumps, fluid motors, and the like, may be sele-
ced in accordance with the relative amounts
of the different fluids to be handled, so as to ob-
tain suitable speeds of rotation of the shafts with-
in the desired range for use in this device.

Three or more fluids may be mixed by deliv-
ered proportionally in the same way that two
are mixed, as shown in Figure 2, by extending
the variable speed shaft 14 and by connecting to it,
through chain and sprockets or through variable
speed transmissions, another rotary pump for 70
each added fluid being proportioned, it being un-
derstood that the choice of the size of the spro-
cokets, or the setting of the variable speed trans-
missions, be such that each added pump oper-
ates at the required speed to deliver the cor-
rect proportion of corresponding fluid when the primary shafts of the differential are operating at the required speed relation. It is, of course, preferable that a gauge, containing the electrical contacts previously described, be inserted in the discharge line carrying each added fluid, and that the said contacts be connected in parallel to the solenoid 53 and/or to the signaling means 56.

In order to prevent the continued flow of the primary fluid when the flow of the secondary fluid is not required for any reason or when the required proportions cannot be maintained, suitable electrical safety devices are provided. These devices may include an electrical switch conveniently placed on the lever operating the balanced control valve and/or a gauge which contains adjustable electrical contacts and which is inserted in the discharge line of the pump delivering the secondary fluid. If the speed of the secondary pump exceeds or falls below the set limit, the secondary member 41 of the differential will then automatically travel in a lateral direction along the shaft 9 far enough to operate the electrical switch which will then operate a suitable electrically controlled valve, stopping the flow of the primary fluid or both fluids. The electrical contacts located on the gauge are provided to complete the electrical circuit when the secondary pump, although it may be operating at the required speed, is not delivering the required amount of secondary fluid, and therefore is not maintaining the pressure in the discharge line within the set limits. These electrical devices may be conveniently connected in parallel with the electrically controlled valve and/or the signaling means. The safety device may also be arranged to cut off the current supplying the motor which operates the pump supplying the primary fluid. Either method, therefore, stops the apparatus entirely, and it will not resume operation until the trouble is corrected. This feature is important and, I believe, has never been accomplished in any prior proportioning device. The apparatus is, in operation, simple and inexpensive. It gives a smooth flow of both fluids without pulsations, can be readily adjusted to any desired proportion of two or more fluids, and will not permit any flow if desired proportion for any reason cannot be maintained above a set limit.

Fluids of practically any kind or degree of viscosity can be handled satisfactorily in this device. Even liquids containing suspended matter forming a so-called "sludge" will operate satisfactorily if the materials provided the said materials will flow like a liquid.

It is to be understood that different forms of my preferred embodiment may be made without departing from the spirit of my invention.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. A device for controlling the flow of a fluid in definite proportion to the flow of a primary fluid comprised in cooperating members in the line of flow of the primary fluid adapted to rotate in definite relation to the amount of fluid flowing, a pump for delivering the secondary fluid adapted to discharge said secondary fluid in definite relation to its speed of rotation, a suitable member or members for controlling a plurality of primary shafts and a secondary member, an external fluid delivery means, a fluid motor adapted to rotate in definite relation to the amount of external fluid flowing therethrough, and power transmitting means between the different elements so arranged that the said rotatable member causes one primary shaft of said differential to operate and that the variable speed fluid motor causes both the secondary shaft of said differential and said pump to operate so that the said primary shafts being caused to rotate at such a ratio of speed to each other as will hold the secondary member in a stationary position when the two fluids are flowing in the desired proportion, a secondary member of said differential when said ratio is disturbed; said movement being of such nature as to vary the speed of said fluid motor by varying the flow of the external fluid therethrough so as to cause the secondary fluid to flow again in the desired proportion.

2. A device for controlling the flow of a fluid in definite proportion to the flow of a primary fluid and for stopping the flow of the primary fluid when the flow of the secondary fluid falls below or exceeds predetermined limits, comprising the device described in claim 1 combined with a device comprising an electrical switch actuated by the movement of the secondary member of the differential and an electrically operated valve on a line carrying the primary fluid so arranged that when the flow of the secondary fluid falls below or exceeds predetermined proportions, the movement of the secondary member of the differential will actuate the electrical switch causing an electrical current to close a valve in the line carrying the primary fluid.

3. A device for controlling the flow of a fluid in definite proportion to the flow of a primary fluid and for stopping the flow of the primary fluid when the flow of the secondary fluid falls below predetermined limits, comprising the device described in claim 1 combined with a control mechanism comprising means responsive to a control device located in the discharge line of the pump for the secondary fluid and an electrically operated valve in a line carrying the primary fluid so arranged that when the flow of the secondary fluid falls below a predetermined limit, the control device will close an electrical circuit causing an electrical current to close a valve in the line carrying the primary fluid.

4. In or as an advice for proportioning the flow of fluids, means for delivering a controlling fluid, motive means actuated by the flow of said fluid in said delivery means in proportion to said flow, means for delivering a controlled fluid, motive means in said second delivery means adapted to discharge the controlled fluid into said second delivery means in proportion to the operation of said motive means, an equilibrium motive device having a plurality of primary driven parts and a secondary part adapted for movement upon the disturbance of a given relationship of motion of the primary driven parts, a variable speed motive means, individual motion transmitting means between the variable speed motive means and both the motive means for delivering the controlled fluid and one of said primary driven parts, a connection between said secondary part and the variable speed motive means, valve means in delivery means of said controlling means, and a secondary part for closing said valve means when said secondary part exceeds a given range of movement.
5. In a device for proportioning two or more liquids, a differential device having a plurality of primary moving parts and a secondary part which maintains a position of equilibrium as long as the several primary parts are moving in a definite speed relation, but which is adapted to move as soon as this relation is disturbed, means causing one of said primary parts to move in direct proportion to the flow of one of the liquids, an external fluid delivery means, a fluid motor adapted to rotate in definite relation to the amount of external fluid flowing therethrough, means causing other of said primary parts to move in direct proportion to the speed of said fluid motor, means driven by said fluid motor adapted to cause a flow of other of the liquids, and means responsive to the action of said secondary part to vary the speed of said fluid motor.

6. In a device according to claim 5, means for stopping the flow of the first mentioned liquid when the flow of the other several liquids falls below or exceeds predetermined limits, comprising an electrically operated valve in the line of flow of said first mentioned liquid, a switch actuated by the said secondary member at either extremity of its movement, and an electrical connection between the said switch and the said electrically operated valve.

7. In a device according to claim 5, means for stopping the flow of the first mentioned liquid when the flow of any of the several other liquids falls below predetermined limits, comprising an electrically operated valve in the line of flow of said first mentioned liquid, control devices in the lines of discharge of each of the other liquids, and means associated with the said control devices adapted to close an electrical circuit to the said electrically operated valve.

8. In a proportioning device whereby a primary fluid flow controls a secondary fluid flow, the combination of a power drive for the primary fluid flow, a device responsive to the pressure of secondary fluid flow, and connections whereby movements of said flow responsive device beyond a prescribed range will cut off the power from said power drive.

9. In a proportioning device whereby a primary fluid flow controls a secondary fluid flow, the combination of an electric motor drive for the primary fluid flow, a device moving in accordance with the pressure of the secondary fluid flow, and connections whereby movements of said flow responsive device beyond a prescribed range will cut off the electric current from said electric motor drive.

10. In a liquid proportioning device having a differential with a plurality of primary parts and a secondary part, a prime mover which operates a pump for a secondary liquid and also one primary part of the differential, and a rotatable member in the line of flow of a primary liquid to operate another primary shaft of the differential, said prime mover comprising a fluid motor, and a valve for regulating the amount of fluid delivered to said fluid motor, said valve being controlled by the secondary part of the differential.

11. In a device according to claim 10, means for stopping the flow of the primary liquid when the flow of a secondary liquid falls below or exceeds predetermined limits, comprising an electrically operated valve in the line of flow of said primary liquid, an electrical device actuated by the said secondary member at either extremity of its movement, and an electrical connection between the said electrical device and the said electrically operated valve.

12. In a device according to claim 10, means for stopping the flow of the primary liquid when the flow of the secondary liquid falls below predetermined limits, comprising an electrically operated valve in the line of flow of said primary liquid, a control device in the line of discharge of said secondary liquid, and electrical means associated with the said control device suitably connected to said electrically operated valve and adapted to operate same.

ROBERT J. SHORT.