Feb. 7, 1967 A. J. ANDERSON 3,302,578

METERING PUMP

Filed April 28, 1965 4 Sheets-Sheet 1

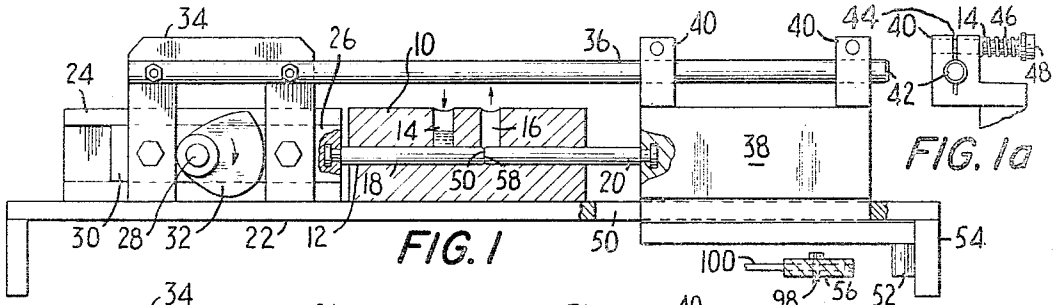

FIG. 1a

FIG. 1

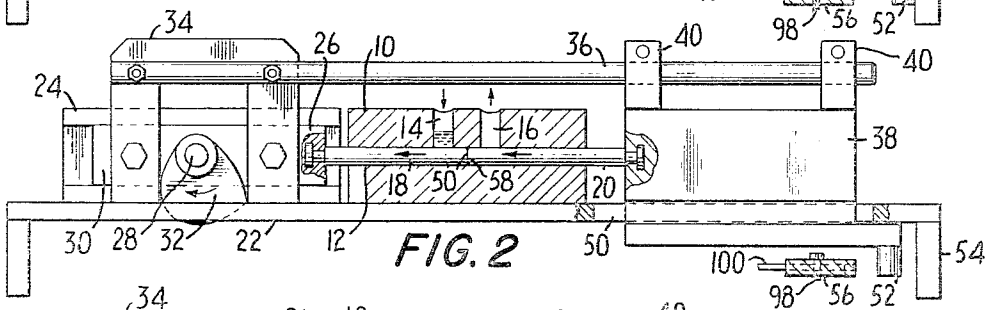

FIG. 2

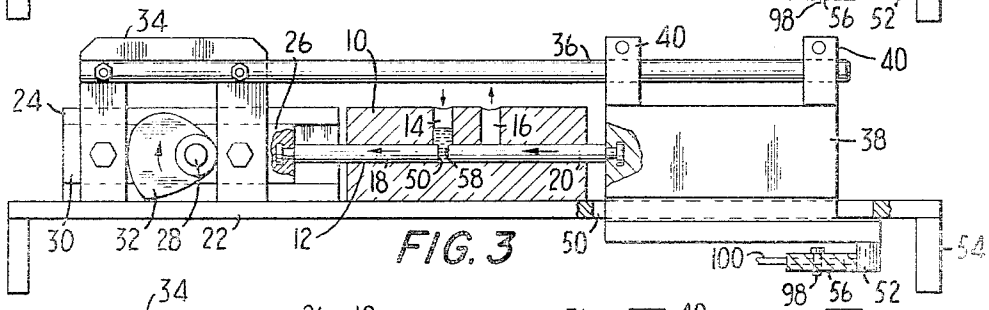

FIG. 3

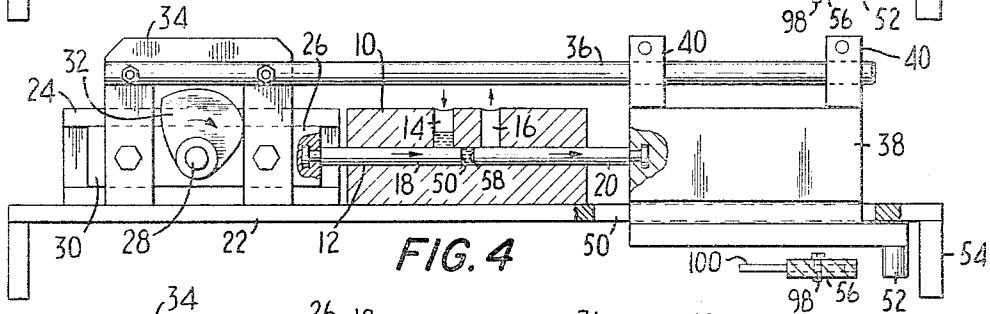

FIG. 4

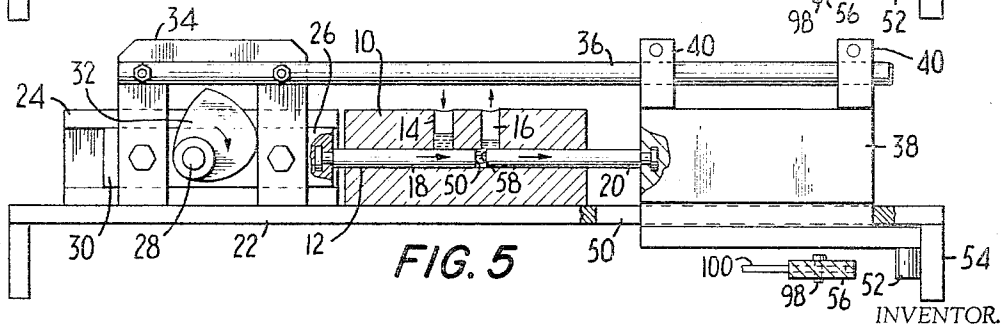

FIG. 5

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METERING PUMP

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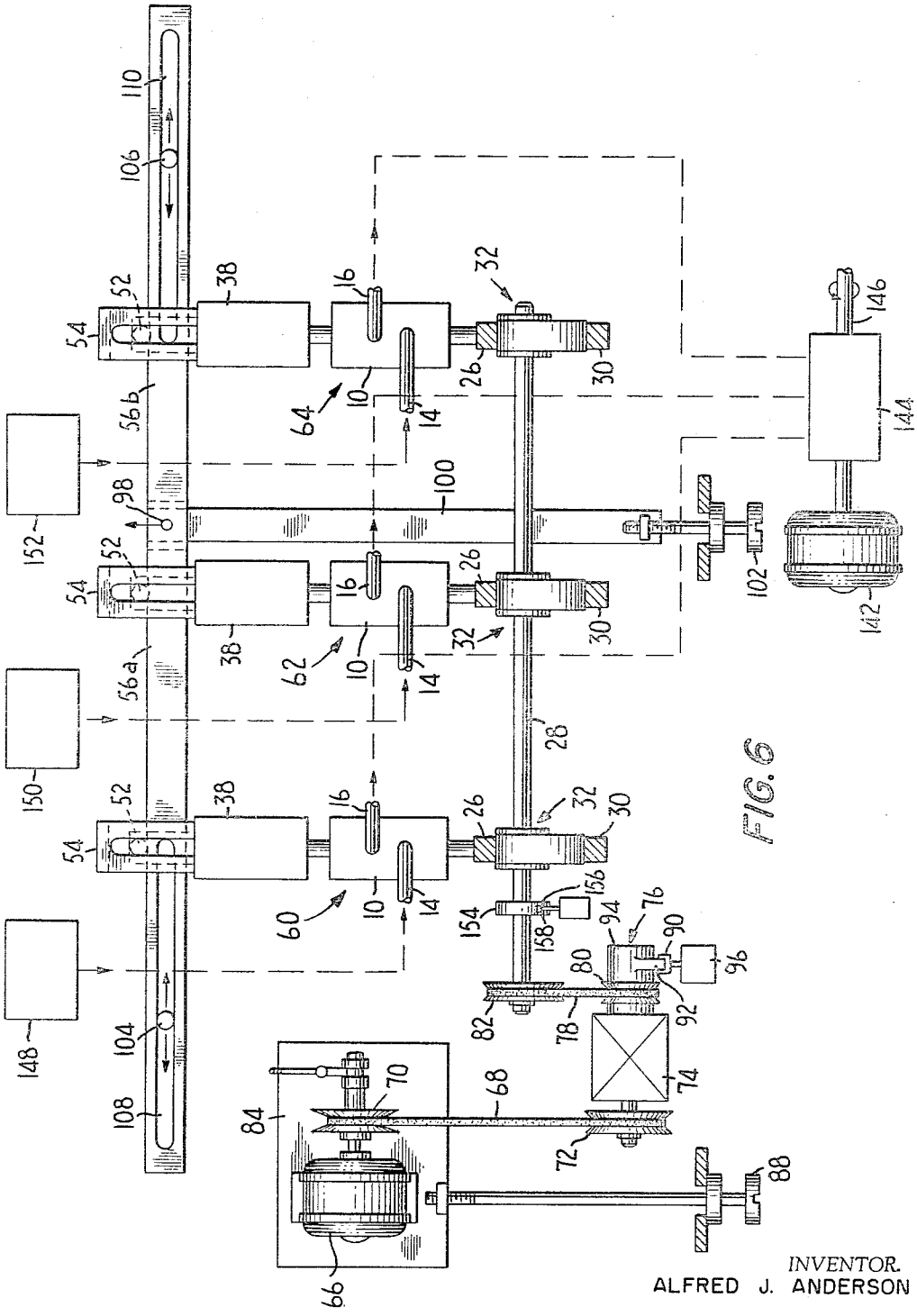

FIG. 6

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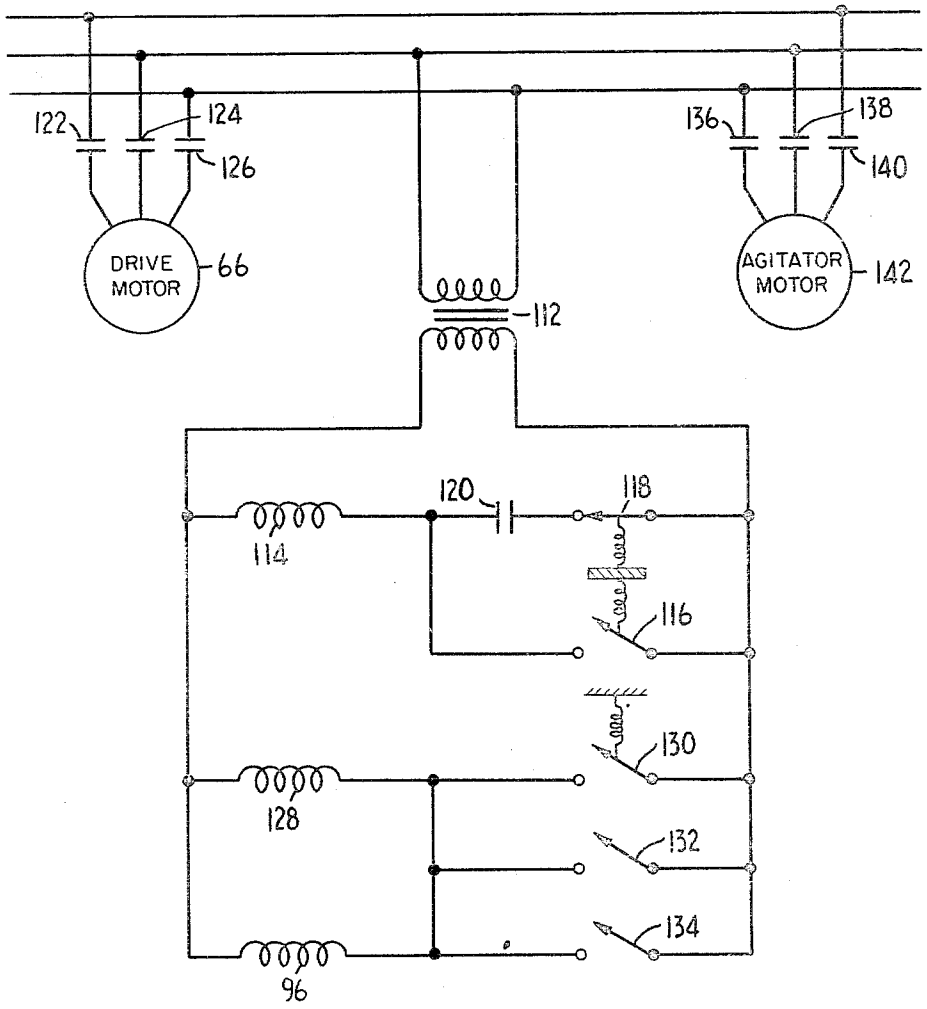
FIG. 7



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METERING PUMP

Filed April 28, 1965 4 Sheets-Sheet 4

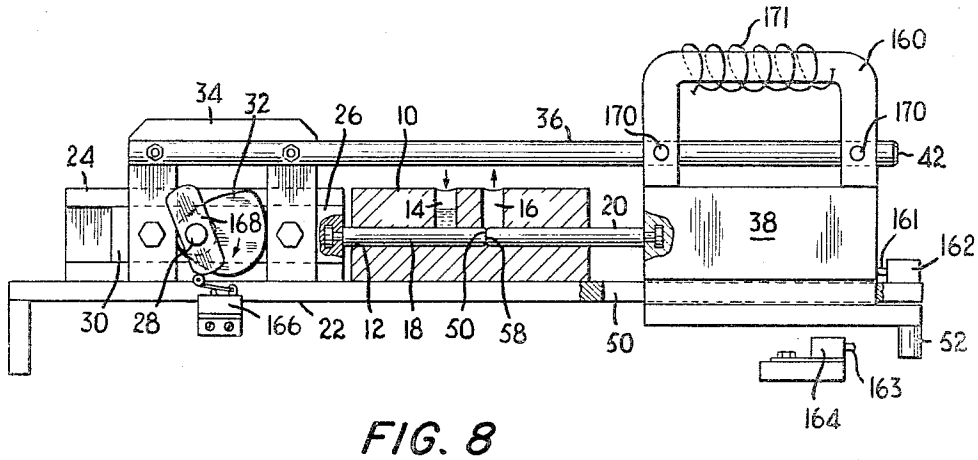

FIG. 8

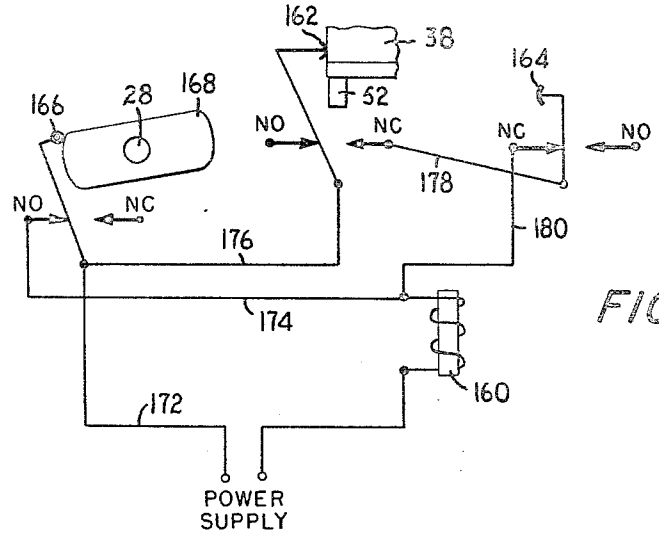

FIG. 9

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United States Patent Office 3,302,578 Patented Feb. 7, 1967

3,302,578

METERING PUMP

Alfred J. Anderson, Livingston, N.J., assignor to H. V. Hardman Co., Inc., a corporation of New Jersey

Filed Apr. 28, 1965, Ser. No. 451,589
13 Claims. (Cl. 103—38)

This application is a continuation-in-part of an earlier filed application Serial Number 324,334, filed November 18, 1963, now abandoned.

The present invention relates to dispensing flowable materials, such as liquids and pastes, in measured amounts and provides a pump for that purpose.

This pump has two pistons which are arranged in tandem within a cylinder and which are driven back and forth together in synchronous strokes that differ in magnitude from each other so as to cause the pistons to separate at one end of their strokes and come together at the other end of their strokes. The separation of the two pistons at one end of the strokes is employed to draw flowable material into the cylinder through an inlet port in the cylinder and the coming together of the two pistons at the other end of the strokes is employed to force this same flowable material out an outlet port in the cylinder.

With this arrangement there is no need for valves. While flowable material is being drawn into the chamber through the inlet port, one of the pistons covers the outlet port, and while the flowable material is being dispensed through the outlet port, the other of the piston covers the inlet port. In addition, pumping is accomplished with a minimum amount of wear and tear on piston and cylinder walls because the synchronous stroking of the pistons is substantially vibrationless.

In one embodiment of the pump, the first of the two pistons is driven directly by an eccentric cam mounted on a rotating shaft while the second of the two pistons is driven by a slide drive which couples the second piston to the first piston. This causes the pistons to stroke back and forth in synchronism. To obtain the difference in the magnitude of the strokes of the two pistons, two stops are provided which interfere with the stroke of the second piston at each end thereof stopping the second piston and making the slide drive slip so that the first piston moves away from the second piston at one end of the stroke and approaches the second piston at the other end of the stroke.

The stops may be very accurately positioned to set the separation of the pistons within close tolerences permitting small amounts of liquids to be pumped in very accurate portions.

In a second embodiment of the pump slippage of the slide drive is achieved by means of an electromagnet which couples the second piston to the first piston. To obtain the difference in the magnitude of the strokes of the two pistons, two switches are provided which deactuate the electromagnet at the end of each stroke of the second piston so that the slide drive slips and the first piston moves away from the second piston at one of the stroke and approaches the second piston at the other end of the stroke.

For a better understanding of my invention and other advantages thereof reference should be had to the accompanying drawing in which:

FIGURES 1 to 5 show a single two piston metering pump in various positions in its operating cycle;

FIGURE 6 shows three of the two piston metering pumps shown in FIGURES 1 to 5 coupled together to enable pumping three liquids in predetermined proportions and desired amounts; and

FIGURE 7 is an electrical schematic for the arrangement of the three two piston metering pumps shown in FIGURE 6;

FIGURE 8 illustrates the form of slide drive which includes an electromagnet;

FIGURE 9 is an electrical schematic for the switches which control operation of the electromagnet.

In the two piston metering pump shown in FIGURES 1 to 5, the pump cylinder 10 is a cylindrical steel block having a horizontal bore 12 extending there through and two spaced vertical bores 14 and 16 extending into the horizontal bore 12 from the top surface of the block 10. Extending into the horizontal bore 12 from the left side of the block 10 is a piston 18, hereinafter referred to as the slave piston, and extending into the horizontal bore 12 from the right side of the block 10 is another piston 20, hereinafter referred to as the volume piston. These pistons slide freely in the bore 12 and as they move, change their positions under the vertical bores 14 and 16.

The cylinder 10 is mounted on a plate 22 on which a horizontal guide 24 is fixed. A block 26 which is fixed to the slave piston 18 slides freely in this guide 24 moving the slave piston 18 back and forth in the horizontal bore 12 as it slides.

A drive shaft 28 extend through a rectangular opening 30 in the guide 24 horizontally at right angles to the bore 12. Mounted on the drive shaft 28 is an eccentric cam 32, and mounted on the sliding block 26 is cam follower 34, in the shape of an inverted U, which engages this cam 32. The cam follower 34 is positioned with one leg of of the U on either side of the cam 32 with the legs so spaced that one of them is always in contact with the cam 32 and being driven thereby so that movement of the cam 32 with rotation of the shaft 28 causes the slide block 26 to reciprocate in the horizontal guide 24 and move the slave piston 18 back and forth in the horizontal bore 12.

A horizontal polished rod 36 is fixed at one end to the cam follower 34 by screws and at the other end to a second sliding block 38 by friction blocks 40. The friction blocks 40 each have a horizontal circular passageway 42 through which the rod 36 passes. Each friction block 40 is slotted along the entire length of the passageway and has a bolt 44 mounted along an axis transverse to the slot and passageway. This bolt is threaded to the friction block 40 on one side of the slot and passes through an oversized hole in the friction block on the other side of the slot. A spring 46 is mounted on the bolt 44 on the side of the friction block with the oversized hole and is held against the friction block by an adjustable nut 48 thereby holding the bar 36 in the friction block 40.

The second slide block 38 is fixed to the volume piston 20 and slides freely in an opening 50 in the support plate 22 so that as the cam follower moves back and forth its movement is transmitted to the volume piston 20 through the bar 36, the friction blocks 40, and the sliding block 38. Therefore, as the shaft 28 rotates, the pistons 18 and 20 stroke back and forth in synchronism in the bore 12, the slave piston 18 being driven directly by the cam follower 34 while the volume piston 20 is driven by the cam follower 34 through the rod 36 and the friction blocks 40.

The stroke of the slave piston is arranged so that its face moves from a position adjacent the bore 14, which is the inlet port of the pump, to a position adjacent the bore 16, which is the outlet port of the pump. To provide the pumping action, the movement of the volume piston 20 is limited at each end of its stroke so that the stroke of the volume piston is not as long as that of the slave piston. This is done by having an extension 52 which is fixed to the underside of the sliding block 38 contact a fixed stop 54 and a movable stop 56 at opposite ends of the volume piston's stroke stopping the volume piston and causing the bar 36 to slide in the friction blocks 40. The movement of the pistons due to the interaction of the slide drive and the stops can best be

understood by reference to the FIGURES 1 to 5 in numerical sequence.

In FIGURE 1 the two pistons are shown at one end of the stroke. In this position the extension **52** is against the fixed stop **54**, preventing further movement of the volume piston **20** to the right and the slave piston **18** is in its furthest position to the right with the face **50** of the slave piston **18** under the outlet port against the face **58** of the volume piston. As is shown in FIGURE 2, the pistons then start moving to the left, the slave **18** piston being driven by the cam **32** and the volume piston **20** being forced to follow by the slide drive thereby maintaining its position relative to the slave piston **18**. This continues until the extension **52** contacts the movable stop **56**, causing the rod **36** to slide in the friction blocks **40** and the volume piston **20** to stop its movement to the left. As is shown in FIGURE 3, this causes the slave and volume pistons **18** and **20** to separate under the inlet port **14** drawing liquid into the bore **12** between their respective faces **50** and **58**.

The amount of liquid drawn into the cylinder **10** may be controlled by positioning the movable stop **56**. When the stop **56** is positioned more to the right the separation of the pistons is greater, drawing more liquid into the cylinder and when the stop **56** is positioned further to the left the separation of the pistons is smaller, drawing less liquid into the cylinder. The movable stop can be positioned quite accurately providing very precise control over the amount of liquid drawn into the cylinder.

When the slave piston reaches its most leftward position this drawing portion of the pumping cycle is completed and the pistons start moving to the right retaining their spaced positions to transport the liquid drawn into the cylinder during the drawing portion of the cycle from under the inlet port **14** to under the outlet port **16** as is shown in FIGURE 4. In doing this the slave piston **18** closes off the inlet port in anticipation of dispensing the liquid out the outlet port just as the volume piston, as is shown in FIGURE 2, closes off the outlet port in anticipation of drawing liquid into the cylinder. Therefore, valves for the closing of the ports need not be provided.

As the volume piston and the sliding block **38** move to the right the extension **52** eventually contacts the fixed stop **54**, starting the dispensing portion of the cycle. This occurs with the face **58** of the volume piston **20** positioned under the outlet port **16** and results in the stopping of the piston in that position. The rod **36** then slides in the friction blocks **40** allowing the slave piston **18** to approach the stopped volume piston **20** forcing the liquid into the outlet port as it moves as is shown in FIGURE 5. This continues until the faces **50** and **58** of the slave and volume pistons respectively are positioned against each other, as is shown in FIGURE 1, to complete the pumping cycle. If the shaft **28** continues to rotate a similar cycle will follow.

Three such two piston metering pumps can be hooked up in the manner shown in FIGURE 6 to feed three separately stored liquids into a mixing chamber in predetermined proportions and amounts. In this three pump arrangement, the same drive shaft **28** drives the cams **32** in all three pumps **60**, **62** and **64** and the adjustable stops for the pumps are lever arms **56***a* and **56***b* which are moved to simultaneously adjust the amounts pumped by all the pumps without disturbing the proportions.

The drive shaft **28** is driven by a three phase A.C. motor **66**, through a belt **68** mounted on a first set of pulleys **70** and **72**, a reduction gear train **74**, a single revolution clutch **76**, and a belt **78** mounted on a second set of pulleys **80** and **82**. The motor **66** is mounted on a movable platform **84** which may be very accurately positioned closer and farther away from the pulley **72** by rotation of knob **88**. The pulley **72** is a spring loaded split pulley of the type which separates in two sections under force so that as the platform **84** is positioned further away from the pulley **72**, the two sections of pulley **70** separate allowing the belt **68** to come closer to the shaft **86** of the motor **66** and as the platform is moved closer to the pulley **72**, the two sections of the pulley come closer together positioning the belt further away from the shaft **86**. This varies the speed at which the shaft **28** is rotated by the motor **66** and therefore changes the repetition rate of the pumping cycles since it will change the length of time it takes to complete each pumping cycle.

The single revolution clutch normally prevents transmittal of power from the motor **66** to the shaft **28** because an arm **90** positioned under a stop **92** prevents the shaft **94** on which pulley **80** is mounted from rotating with the output of the reduction gear train **74**. However, when the electromagnetic coil **96** is energized it draws the arm **90** out from under the stop **92** allowing the shaft **94** to rotate with the output of the gear train **74** and transmit power from the motor **66** to the shaft **28**. For continuous operation the electromagnet is kept energized continuously to allow the shaft to continually rotate to provide a number of successive complete pumping strokes. However, if it is desired, the clutch can be actuated momentarily thereby returning the arm **90** to its unenergized position after completion of one revolution of the stop **92**, providing but a single pumping cycle. Unless there is an electrical or mechanical failure this one revolution clutch insures that the pumps run through complete pumping cycles so that they always start and stop at the same point in their pumping cycle.

The two lever arms **56***a* and **56***b* are joined together at point **98** to a shaft **100** which is moved by rotating a knob **102** to position the lever arms **56** closer and further away from the fixed stops **54** on each of the pumps **60**, **62** and **64**. As pointed out above, as these lever arms or movable stops are positioned closer to the fixed stops **54** they increase the amount of liquid pumped during each stroke and as they are positioned further away from the fixed stops they decrease the amount of liquid pumped during each stroke. Therefore as the shaft **100** is moved it simultaneously adjusts the amount of liquid pumped each cycle by each of the pumps and therefore the shaft **100** can be moved until the desired total amount of liquid is being pumped.

The proportions, by volume, in which the liquids will be pumped will depend on the positions of the pivots **104** and **106** for the lever arms **56**. These pivots **104** and **106** are movable being adjustable back and forth in slots **108** and **110** respectively. When the pivots **104** and **106** are positioned under the pumps **60** and **64** the pump **62** supplies all the liquid pumped provided that arms **56***a* and **56***b* are not in a straight line as shown in FIG. 6 and as the pivots are moved outwardly towards the ends of the levers the proportion pumped by the pumps **60** and **64** increases with respect to the proportion pumped by pump **62**.

The exact proportions not only depend on the position of the pivots **104** and **106** but also depend on the relation between the size of the bores **12** in the three pumps. The relation between the sizes of the bores **12** in the pumps is selected so as to put the liquids pumped within the range of the desired proportions. For instance, assuming it is desired to pump two parts of the liquid by pump **60** for each 100 parts of the liquid being pumped by pump **62**, the bore of pump **62** would be made ten times as large as the bore of pump **60** and the pivot **104** would be positioned to make the separation of the two pistons in pump **60** to be one fifth the separation of the pistons in pump **62**.

Once the pivots **102** and **104** are set then point **98** is moved by rotating the knob **102** until the desired total amount of liquid is being dispensed during each stroke of the pumps. Where the lever arms **56** are at right angles to the shaft **100** as is shown in FIGURE 6, there is no liquid being pumped by any of the pumps since the lever arms in this position permit volume pistons **20** of each of the pumps to travel just as far the slave

pistons 18 so that there is no separation, as is shown in FIGURE 3, to draw liquid into the cylinders. However, as the lever arms 56 are moved closer to the stops 54 the separation of the slave and volume pistons increases in length in each of the pumps. Of course, this increase in each of the pumps depends on the position of the pivots 104 and 106 which, as has been pointed out previously, should first be adjusted to give the desired proportions.

With the desired proportions set by positioning of the pivots 104 and 106, the desired amount set by adjustment of knob 102, and the desired speed set by adjustment of knob 88, the pump is ready for operation. The circuit which controls the operation is shown in FIGURE 7. As therein shown, a step down transformer 112 is connected across two wires of a three wire 220 volt A.C. power source. The coil 114 of a first A.C. relay, hereinafter referred to as the drive motor relay, is connected across the secondary of this transformer in series with a normally open push button 116 and also in series with a normally closed push button 118 and a pair of normally open contacts 120 of the drive motor relay.

The drive motor 66 is connected to the 220 volt 3 phase line through three sets of normally open contacts 122, 124 and 126 of the drive motor relay. When the normally open push button 116 is pressed it momentarily completes the circuit between the secondary of the transformer 112 and the coil 114 of the drive motor relay. This energizes the relay, locking the relay in through the normally closed push button 118 and the normally open contacts 120 of the relay which have been closed by the passing of current through the coil 114 of the relay. With the drive motor relay energized current flows to the drive motor 66 through the contacts 124, 126 and 122 which are closed by the relay 114.

Also connected across the secondary of the transformer 112 is the coil 96 of the clutch 76 and the coil 128 of a second A.C. relay, hereinafter referred to as the agitator motor relay. Both the coil 96 of the clutch and the coil 128 of the agitator motor relay are connected to the secondary in series with 3 sets of normally open contacts 130, 132 and 134 arranged in parallel. These contacts are actuated by a foot pedal, a single pole switch, and a cam respectively. When the foot pedal is depressed or the single pole switch is closed, either the contacts 130 or the contacts 132 are closed energizing the agitator motor relay coil 128 and the coil 96 of the clutch.

Energization of the coil 128 of the agitator motor relay closes normally open contacts 136, 138 and 140 which supply power to a motor 142 that powers an agitator in the mixing chamber 144. As is shown in FIGURE 6 the mixing chamber receives liquids from each of the pumps 60, 62 and 64 as it is pumped, mixes this liquid together by the action of the agitator and dispenses it as a mixture out the nozzle 146 of the mixing chamber. Supplying the power to the agitator motor 142 starts rotation of the agitator in anticipation of liquid being supplied to the mixing chamber by the pumps 60, 62 and 64.

As pointed out previously, energization of the clutch coil 96 withdraws the arm from under the stop 92 thereby transmitting power from the drive motor 66 to the shaft 28. With the shaft being driven by the motor 66, each of the pumps is driven through a pumping stroke as outlined in the discussion with respect to FIGURES 1 to 5 drawing liquids from three separate reservoirs 148, 150 and 152 and dispensing it into the mixing chamber 144 in the desired amounts and proportions.

Operation of the device after the completion of the stroke depends on whether the foot pedal had been depressed or the single pole switch has been closed. If the foot pedal has been depressed more than likely the pressure on the foot pedal was released prior to the completion of the one stroke of the pumps and the switch 130 had been opened. When the switch 130 is opened the current flow to the agitator motor coil 128 and the electromagnet clutch coil 96 is continued through contacts 134 which have been closed by a cam 154 mounted on the shaft 28. At the start of each cycle a cam follower 156 which controls the opening and closing of contacts 134 is positioned in a groove 158 of the cam 154 in the groove. With the cam follower in the groove, the contacts 134 are opened. However, as soon as the shaft 28 starts rotating, the cam follower 156 moves out of the groove 158 and on to the periphery of the cam 154. This closes the contacts 134 and keeps them closed until the cam 154 completes one rotation and the groove 158 is again positioned under the cam follower 156.

When the pole switch is closed more than likely the contacts 132 will remain closed for more than one complete stroke, since the switch is normally used for continuous pumping operations. However, when the switch is finally opened again more than likely it will fall within the middle of the stroke of the pumps. When this occurs, the switch 134 will be kept closed by the cam 154 until the completion of the stroke by the pumps.

The above device was designated primarily for mixing and measuring very minute quantities of epoxy resin of a desired viscosity and an amine catalyst therefor. However, it is obvious that this device may be used wherever it is desirable to mix two or more liquids together in predetermined proportions and desired amounts.

A modified form of slide drive is shown in FIGURE 8. As there shown the pump and its parts and operation are identical to the pump shown in FIGURES 1 to 5 with the single exception that the friction blocks 40 are replaced by an electromagnet 160 and the stops 54 and 56 are replaced by switches 162 and 164 respectively which control the flow of electric current to the electromagnet. Switch 164 is a movable switch. A third switch 166 and a cam 168 mounted on the drive shaft 28 have been added to aid in controlling the electromagnet. Otherwise the reference characters in FIGURE 8 identify the same parts as shown and described in FIGURES 1 to 5.

The electromagnet 160 is mounted in a fixed position on bar 36 as by means of pins 170. The electromagnet is free to slide on the surface of block 38 when the coil 171 is deactuated and no electric current flows through the coil.

The position of the pistons on the pumps and other parts shown in FIGURE 8 is the same as that shown in FIGURE 1. As shown the two pistons are at the end of a stroke. In this position the contacts of switch 162 are open since slide block 38 is holding button 161 of switch 162 depressed. At this time the contacts of switch 166 are held closed by cam 168.

The electric circuit connecting the switches and electromagnet is shown in FIGURE 9. As there shown when the two pistons are at the end of the stroke (FIGURES 1 and 8) with switch 162 open and switch 166 closed electric current from the supply line 172 will flow through switch 166 and line 174 to actuate the coil of the electromagnet which so tightly grips slide block 38 that the slide block will move with bar 36 to the left as illustrated in FIGURE 2. The slave piston 18 is being driven by the cam 32 and the volume piston 20 is forced to follow by the bar 36 and the grip of electromagnet 160 to maintain its position relative to the slave piston 18.

The movement of the pistons continues and while the movement continues the contacts of switch 162 are closed since slide block 38 has moved away from button 161 to close switch 162. After switch 162 is closed cam 168 rotates away from switch 166 and as a result the contacts of switch 166 open. The two pistons continue to move to the left and there is no interruption of such movement since switch 162 closes before switch 166 opens. When switch 166 opens current to the electromagnet is supplied from line 172 by line 176, switch 162 line 178, switch 164 (closed) and line 180.

The movement of the two pistons continues until the extension **52** depresses the button **163** to open the contacts of switch **164**. The opening of switch **164** interrupts the flow of current to the coil **171** of the electromagnet **160** which is thereupon deactuated. Switch **166** is still open. As soon as the electromagnet is deactuated it slides on the surface of block **38** and the volume piston **20** stops its movement to the left. The movement of volume piston **20** to the left is stopped with piston **20** in the position shown in FIGURE 3. Slave piston **18** however continues to move to the left and the volume piston **20** and slave piston **18** separate under the inlet port **14** to draw liquid into the bore **12** between the respective faces of the pistons **50** and **58** as illustrated in FIGURE 3.

The amount of liquid drawn into cylinder **10** may be controlled by the position of switch **164**. When switch **164** is positioned more to the right the separation of the pistons is greater and more liquid is drawn into the cylinder. When switch **164** is positioned further to the left, the separation of the pistons is smaller and less liquid is drawn into the cylinder.

When the slave piston **18** reaches its most leftward position the drawing portion of the pumping cycle is complete and thereupon cam **168** closes switch **166** to supply current to the coil **171** of the electromagnet which is thereby actuated to tightly grip slide block **38** which will now move volume piston **20** to the right along with slave piston **18**. The distance between the two pistons is maintained to transport the liquid drawn into the cylinder during the drawing portion of the cycle from under inlet port **14** to the outlet port **16** as illustrated in FIGURE 4.

When the pistons start to move to the right the current to the electromagnet is initially supplied through switch **166**. But as soon as extension **52** moves away from switch **164**, this switch closes and thereafter switch **166** is opened as cam **168** rotates away from switch **166**. Current to the coil of the electromagnet is then supplied through switch **162** and **164** as the pistons continue to move to the right in spaced relationship into the position shown in FIGURE 4. As the pistons move to the right, slave piston **18** closes off the inlet port **14** in anticipation of dispensing the liquid through the outlet port.

When piston **20** has moved into the position shown in FIGURE 5, slide block **38** contacts button **161** of switch **162** to depress the button and open switch **162**. The opening of switch **162** interrupts the flow of current to the coil of the electromagnet which thereupon slides on the surface of the slide block **38**. Switch **166** is still open and piston **20** stops in the position shown in FIGURE 5. In this position outlet port **16** is open and piston **18** continues to move toward piston **20** to force the liquid to be dispensed from the outlet port.

Piston **18** continues to move to the right until the faces **50** and **58** of the slave and volume pistons respectively are positioned against each other as shown in FIGURE 1. This completes the pumping cycle and slave piston **18** is in its furthest position to the right. When piston **18** reaches its furthest position to the right cam **168** again closes switch **166** to supply current to the coil of the electromagnet so that both pistons will move together to the left on the next pumping cycle.

Referring to the system of the plurality of pumps shown in FIGURE 6, it will be understood that the electromagnet and electric circuit used for controlling the electromagnet may be substituted for the friction blocks and stops employed in each of the pumps shown in FIGURE 6 just as described hereinabove for the pump shown in FIGURES 1 to 5.

The above description involves two particular embodiments of the present invention. Obviously a number of changes can be made without departing from the scope of the invention. Therefore, it will be understood that it is intended to cover all changes and modifications of the invention herein chosen for the purpose of illustration which do not constitute departures from the spirit and scope of the invention.

What is claimed is:

1. A pump for pumping flowable materials comprising:

(a) a cylinder with an inlet port in its sidewall at one point along the longitudinal axis of the cylinder and an outlet port in its sidewall at another point along the longitudinal axis of the cylinder,

(b) two pistons arranged in tandem within the cylinder,

(c) cyclic drive means which strokes the two pistons back and forth in synchronism within the cylinder, said cyclic drive means being connected to one of said pistons through a single drive rod without employing cams and to the other piston through a connection which during operation of the drive means provides continuous engagement of said drive means with said other piston and

(d) means for varying the magnitude of the stroke said single rod connected piston with respect to the other piston so that said two pistons move relative to each other at each end of the stroke, moving away from each other adjacent the inlet port to draw the flowable material into the cylinder and towards each other adjacent the outlet port to expel the flowable material from the cylinder.

2. The structure of claim **1** wherein said means for varying the magnitude of the second of the two pistons is a variable means which can be adjusted to change the magnitude of the relative movement between the pistons to vary the amount of liquid pumped by the pump with each stroke of the two pistons.

3. A pump for pumping liquids comprising:

(a) a cylinder with an inlet port in its sidewall at one point along the longitudinal axis of the cylinder and an outlet port in its sidewall at another point along the longitudinal axis of the cylinder,

(b) two pistons which are arranged in tandem within the cylinder and are frictionally coupled together so that when force is exerted on either piston tending to displace said piston both pistons move together along the longitudinal axis of the cylinder so long as the force exerted on the pistons in opposite direction does not exceed a level which will cause relative movement between the pistons,

(c) eccentric cam means for exerting a force on the first of the pistons which causes the pistons to reciprocate back and forth in synchronism along the longitudinal axis of the cylinder, said eccentric cam means being connected to the second of the two pistons through a single drive rod and to the first piston through a connection which during operation of the eccentric cam means provides continuous engagement of said cam means with said first piston,

(d) a first stop means for limiting the magnitude of the movement of the second of the two pistons in the direction towards the first of the two pistons so that as the pistons reciprocate said eccentric cam means and said first stop means exert a force on said pistons in opposite directions that exceeds a level causing said pistons to separate adjacent the inlet valve and thereby draw liquid into the cylinder in direct proportion to the magnitude of the separation the position of said stop means being variable to vary the magnitude of the separation, and

(e) second stop means for limiting the magnitude of the movement of the second of the two pistons in the direction away from first of the two pistons so that as the pistons reciprocate said eccentric cam means and said first stop means exert a force which exceeds a level causing said pistons to come together adjacent the outlet port and thereby force liquid from the cylinder.

4. A device for pumping a plurality of liquids in predetermined porportions comprising:

(a) a plurality of cylinders each having axially spaced inlet and outlet ports,

(b) a plurality of first pistons one positioned in each of said cylinders,

(c) drive means to stroke said first pistons back and forth within their respective cylinders,

(d) a second plurality of pistons one positioned in each of said cylinders,

(e) friction drive means which drives said second plurality of pistons back and forth in synchronism with said first plurality of pistons,

(f) lever arm means limiting the travel of said second plurality of pistons at one end of their strokes causing said first and second pistons to separate and draw liquid into said cylinders, said lever arm means can be moved to change the amount of liquid being pumped by all said pistons in fixed proportions and

(g) stop means limiting the travel of said second plurality of pistons at the other end of their strokes causing said first and second pistons to come together and force liquid out of the outlet port.

5. The structure of claim 4 including electrical control means for driving said pistons in complete strokes.

6. A pump for pumping liquids comprising:

(a) a cylinder with an inlet port in its sidewall at one point along the longitudinal axis of the cylinder and an outlet port in its sidewall at another point along the longitudinal axis of the cylinder,

(b) two pistons which are arranged in tandem within the cylinder and coupled together with an electromagnet so that when the electromagnet is actuated and a force is exerted on either piston to move such piston in the cylinder, both pistons move together in the cylinder and when the electromagnet is deactuated the pistons will move relative to each other in the cylinder,

(c) means for exerting a force on one of said pistons to cause both pistons to reciprocate in strokes back and forth in the cylinder,

(d) means for supplying electric current to the electromagnet adapted to supply current to the electromagnet when the pistons start a stroke and to interrupt the flow of current to the electromagnet before the pistons complete the stroke whereby the pistons are caused to change position relative to each other in the cylinder and draw liquid into the cylinder and dispense such liquid from said cylinder.

7. A device for pumping a plurality of liquids comprising:

(a) a plurality of cylinders each having axially spaced inlet and outlet ports,

(b) a plurality of first pistons one positioned in each of said cylinders,

(c) drive means to stroke said first pistons back and forth within their respective cylinders,

(d) a second plurality of pistons one positioned in each of said cylinders,

(e) slide drive means which include electromagnets which when actuated by electric current will drive said second plurality of pistons back and forth in synchronism with said first plurality of pistons and which electromagnets when deactuated by interrupting the said supply of current will discontinue the drive of said second plurality of pistons,

(f) first switch means to interrupt the supply of electric current to the electromagnet to deactuate it and limit the travel of said second plurality of pistons at one end of their strokes to cause said first and second pistons to separate and draw liquid into said cylinders, and

(g) second switch means to interrupt the supply of electric current to the electromagnet to deactuate it and limit the travel of said second plurality of pistons at the second end of their strokes to cause said first and second pistons to come together and force liquid out of the outlet port,

(h) third switch means to initiate the supply of current to the electromagnet to actuate it at the start of a stroke.

8. A structure as specified in claim 7 which includes electric control means for driving said pistons.

9. A pump for pumping flowable materials comprising:

(a) a cylinder with an inlet port in its sidewall at one point along the longitudinal axis of the cylinder and an outlet port in its sidewall at another point along the longitudinal axis of the cylinder,

(b) two pistons arranged in tandem within the cylinder,

(c) cyclic drive means which strokes the two pistons back and forth in synchronism within the cylinder, said cyclic drive means being connected to one of said pistons through a single drive rod and to the other piston through a connection which during operation of the drive means provides continuous engagement of said drive means with said other piston, said single drive rod being attached to a magnetic coupling which slides upon a block when said coupling is electrically deenergized and which remains stationary upon said block via magnetic connection when said coupling is electrically energized, said block being connected to said rod-driven piston, and

(d) means for varying the magnitude of the stroke of said single rod connected piston with respect to the other piston so that said two pistons move relative to each other at each end of the stroke, moving away from each other adjacent the inlet port to draw the flowable material into the cylinder and towards each other adjacent the outlet port to expel the flowable material from the cylinder.

10. A structure as specified in claim 1 wherein said magnitude-varying means is adjusted to cause said rod-driven piston to move in shorter strokes than the strokes of the said other piston.

11. A device for pumping a plurality of liquids in predetermined proportions comprising:

(a) a plurality of cylinders each having axially spaced inlet and outlet ports,

(b) a plurality of first pistons one positioned in each of said cylinders,

(c) a plurality of second pistons one positioned in each of said cylinders and arranged in tandem with one of said first pistons,

(d) a plurality of drive means, each of said drive means stroking a first and a second piston back and forth in synchronism within a single cylinder and each of said drive means being connected to the second piston through a single drive rod without employing cams and to the first piston through a connection which during operation of the drive means provides continuous engagement of said drive means with said first piston; and

(e) means for varying the magnitude of the stroke of the second piston with respect to the first piston in each cylinder so that the two pistons move relative to each other at each end of the stroke, moving away from each other adjacent the inlet port to draw the flowable material into the cylinder and towards each other adjacent the outlet port to expel the flowable material from the cylinder.

12. A structure as specified in claim 11 wherein said magnitude-varying means is adjusted to cause said second piston to move in shorter strokes than the strokes of said first piston.

13. A pump for pumping flowable materials comprising:

(a) a cylinder with an inlet port in its sidewall at one point along the longitudinal axis of the cylinder and an outlet port in its sidewall at another point along the longitudinal axis of the cylinder,

(b) two pistons arranged in tandem within the cylinder,

(c) cyclic drive means which strokes the two pistons back and forth in synchronism within the cylinder,

said cyclic drive means being connected to one of said pistons through a single drive rod and to the other piston through a connection which during operation of the drive means provides continuous engagement of said drive means with said other piston wherein said single drive rod is sliding directly in friction bearings during a portion of the drive of said cyclic drive means, said bearings being connected to said rod-driven piston, and

(d) means for varying the magnitude of the stroke of said single rod connected piston with respect to the other piston so that said two pistons move relative to each other at each end of the stroke, moving away from each other adjacent the inlet port to draw the flowable material into the cylinder and towards each other adjacent the outlet port to expel the flowable material from the cylinder.

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