United States Patent

Roeser

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[54] **MULTI-COMPONENT MIXING APPARATUS**

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[21] Appl. No.: **48,981**

[52] **U.S. Cl.**.....**259/8,** 23/252

[51] **Int. Cl.**.....**B01f 7/08**

[58] **Field of Search**.....259/8, 5, 6, 7, 23, 24, 43, 259/44, 95; 23/252

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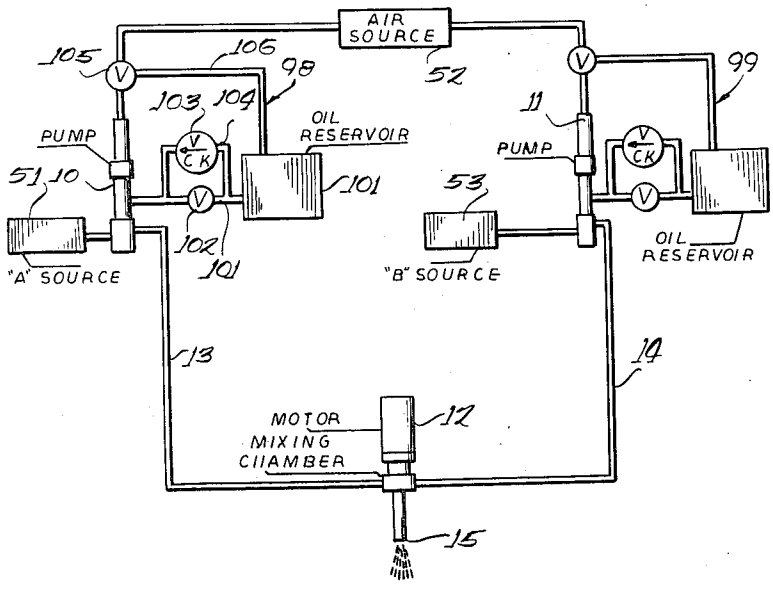
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[57] **ABSTRACT**

An apparatus for mixing a plurality of separate flowable materials in desired proportions. The apparatus includes a positive displacement piston pump for each material and a mixer. The piston displacement of each pump is regulated, either by an oil reservoir system or by adjustable crank arms, so that each pump delivers material in the proper proportion. The outlet of each pump is connected to the mixer, wherein the materials are thoroughly mixed by a rotating agitator vane and delivered as a thoroughly mixed composite of all of the individual materials.

11 Claims, 11 Drawing Figures



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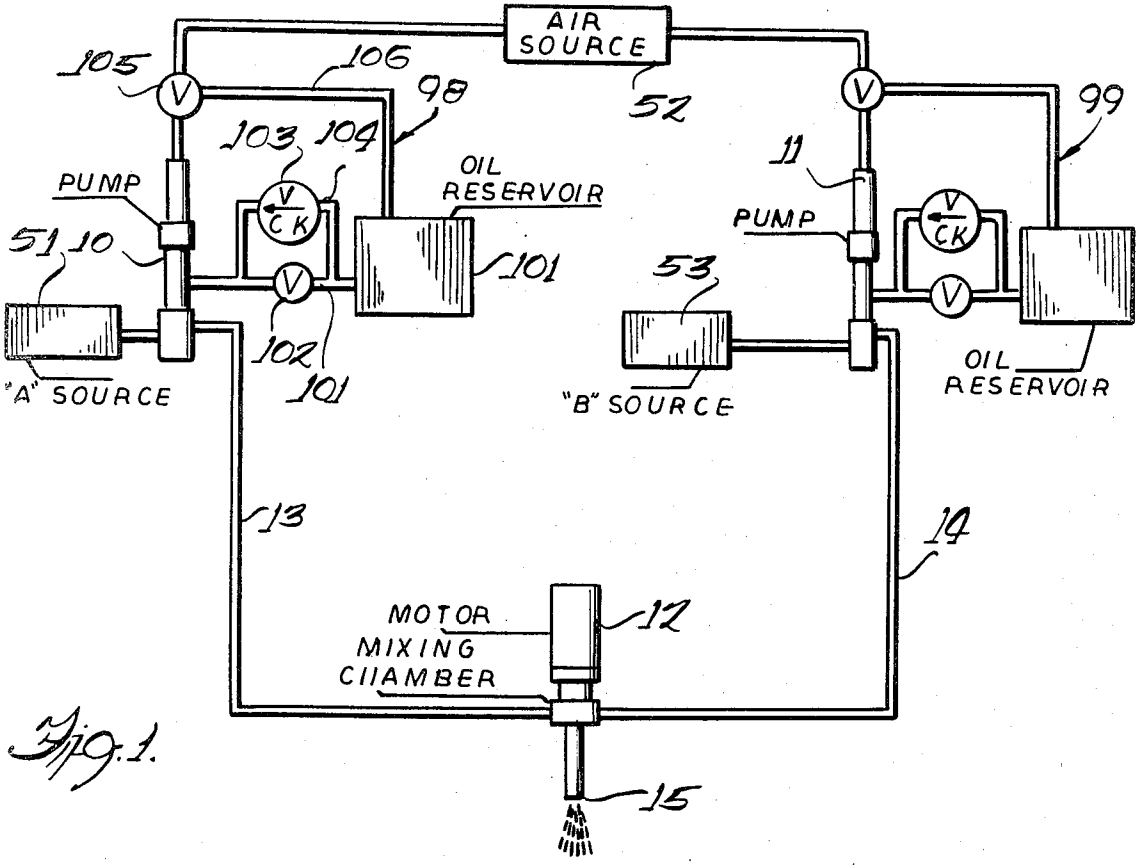
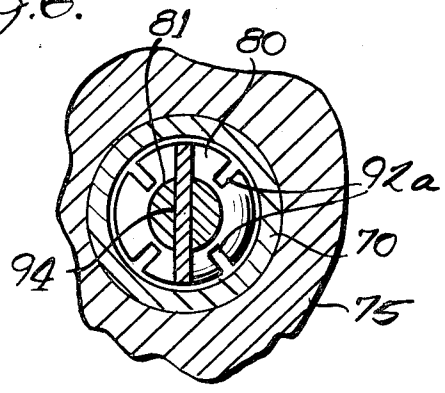


Fig. 1.

Fig. 6.



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Fig. 2.

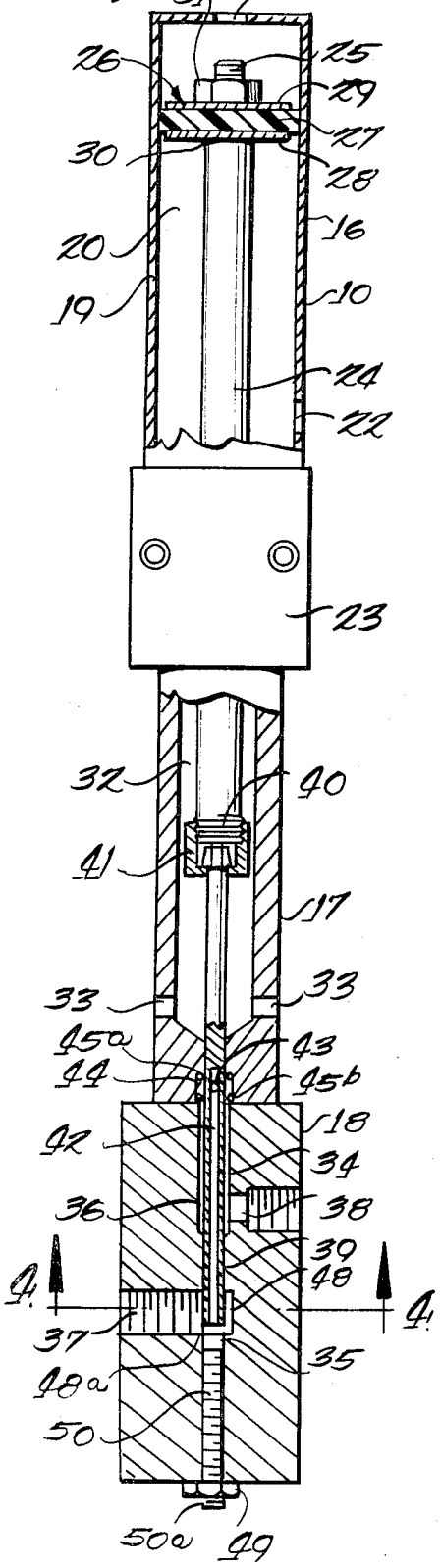
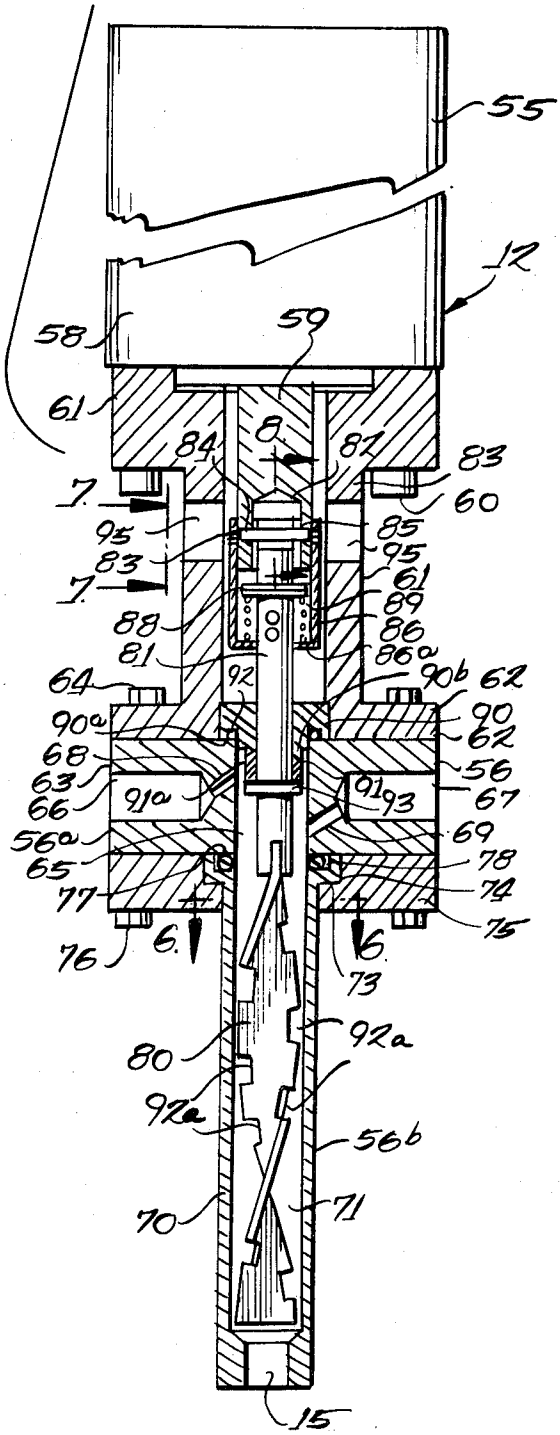


Fig. 5.



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Fig. 4.

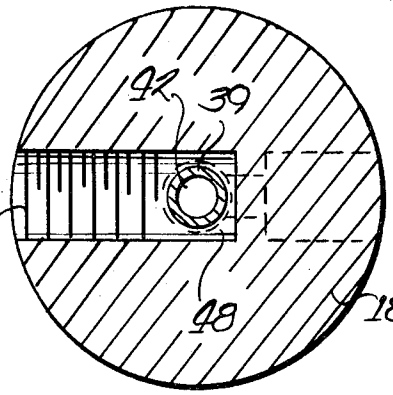


Fig. 7.

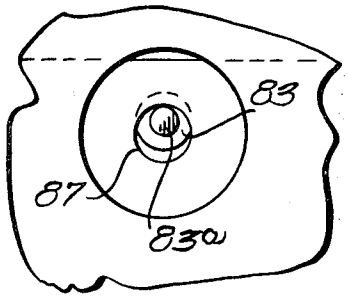


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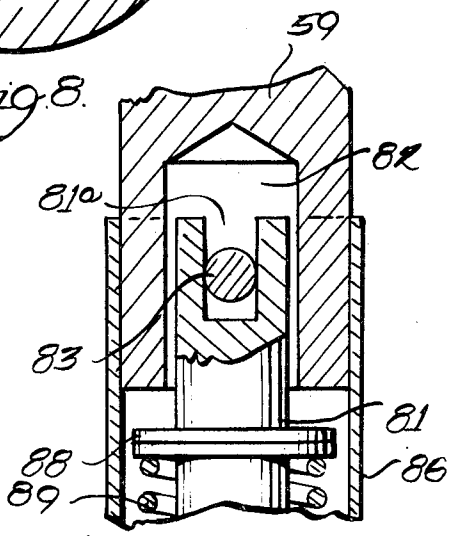


Fig. 9.

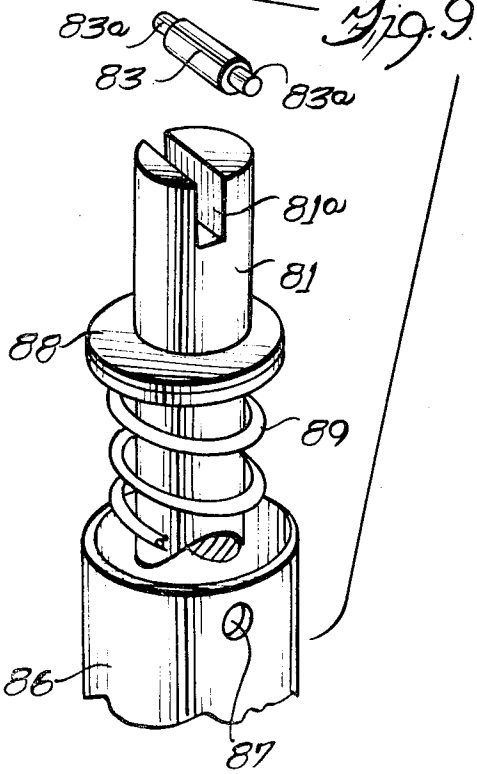
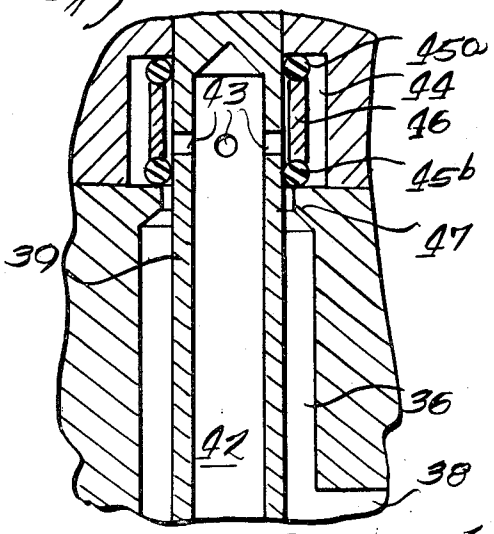


Fig. 3.



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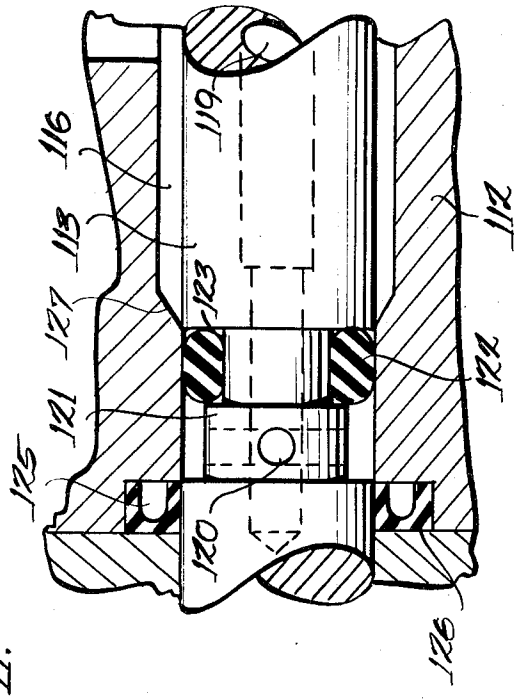


Fig. 11.

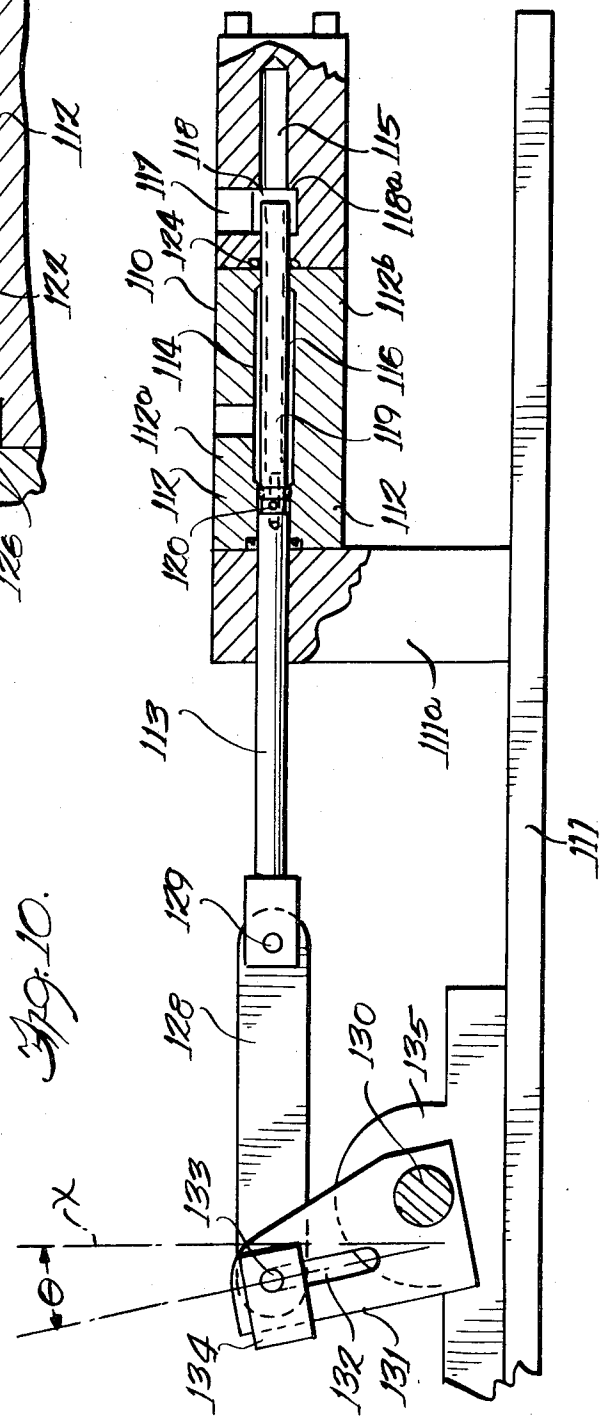


Fig. 10.

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MULTI-COMPONENT MIXING APPARATUS

BACKGROUND

This invention relates to a mixing apparatus, and, more particularly, to a mixing apparatus for mixing a plurality of separate flowable materials in desired proportions.

It is often desirable to deliver a mixture comprises of a plurality of flowable materials which must be mixed in definite proportions just prior to delivery, for example, multi-component flowable adhesives, sealers, foams such as epoxides, polyurethanes, polyesters, and the like. In many cases, it is important not only that the multiple components be mixed in relatively exact proportions but that the mixing occur only shortly before the mixture is used. For example, the invention is particularly suitable for delivering flowable epoxy resins and flowable hardeners or catalysts in desired proportions. Since the hardener or catalyst reacts with the resin relatively quickly, it is desirable that the mixing of the components occur just before the mixture is to be uses or applied.

While mixing apparatus for multi-component mixtures have been available in the past, these have generally been complicated and expensive systems which have been subject to a number of disadvantages. For example, it is important that the mixing system have a minimum of moving parts such as valves and the like which can be affected by the flowable materials, which frequently are of relatively high viscosity. Further, the various parts of the system should be able to be cleaned without difficulty. The usual procedure for mixing materials such as epoxy resins has been to pump the components from drums by air-driven material pumps to measuring cylinders and then to a mixer through hoses, four-way valves and other circuitry. Each of the various parts of prior art mixing systems has its particular problems due to the high pressure involved and the disagreeable nature of the materials being handled. Each part presents one or more opportunities for the resins to leak from the system, and a blockage in any of the valves, piping or cylinders can cause either partial or complete blocking in the flow of one or the other of the resins. Since the other resin would continue flowing, the operator of the mixing system might not be aware of the blockage, and the material delivered by the mixing system would not be properly proportioned.

The resins are delivered from the measuring cylinders to a mixer, and the usual practice has been to provide a fairly large volume mixer with complicated agitators consisting of a series of propellers which progressively agitate and shear the material as it passes through the mixer. The major drawbacks of this system have been the high cost of the large and relatively complicated mixers and also the fact that they contain a good deal of mixed resin. Large bodies of mixed resin should be avoided since the materials being handled are exothermic, and the heat generated tends to have an avalanche effect on the hardening of the resins. Large mixing chambers cannot be thus filled and static for any length of time, or the heat will cause all of the resin therein to react and become hardened.

SUMMARY

The invention provides a simple apparatus with a minimum of moving parts. The material pumps are connected directly to the mixer without the use of valves or complicated piping, and the components of the system are easily disassembled for cleaning. The individual pumps are synchronized by a simple proportioning system which insures the delivery of each of the component materials in the proper proportions, and each pump delivers an accurate, controlled amount of material. The inlet and outlet portions of the pump may provide full annular flow to reduce the pump stroke and to enable fast opening and closing of the inlet and outlet ports without compression lock. The mixer comprises three sections which are readily separated for cleaning, and the mixing chamber is of relatively small volume. The mixing agitator is rotatively driven but may float within the mixing chamber, and the design of the agitator insures good mixing of the resin components.

DESCRIPTION OF THE DRAWING

The invention will be explained in conjunction with illustrative embodiments shown in the accompanying drawings, in which

FIG. **1** is a schematic view of a mixing system embodying the invention;

FIG. **2** is a sectional elevational view of one of the measuring pumps;

FIG. **3** is an enlarged view of a portion of FIG. **2**;

FIG. **4** is a sectional view taken along the line **4—4** of FIG. **2**;

FIG. **5** is a sectional elevational view of the mixer;

FIG. **6** is a sectional view taken along the line **6—6** of FIG. **5**;

FIG. **7** is a fragmentary side view taken along the line **7—7** of FIG. **5**;

FIG. **8** is a sectional view taken along the line **8—8** of FIG. **5**;

FIG. **9** is an exploded fragmentary view of a portion of the mixer;

FIG. **10** is an elevational view partly in section of another measuring pump showing an alternate proportioning means and sealing means;

FIG. **11** is an enlarged view of a portion of FIG. **10**.

DETAILED DESCRIPTION OF THE SPECIFIC EMBODIMENT

My mixing system is shown schematically in FIG. **1**, and the particular system illustrated is for use in mixing two component materials such as resins A and B. It is to be understood, however, that my mixing system can be used for mixing more than two component materials.

The system includes measuring pumps **10** and **11** for resins A and B, respectively, and a mixer **12** connected to the outlet of pumps **10** and **11** by conduits **13** and **14**, respectively. As will be explained more fully hereinafter, each of the measuring pumps delivers a measured shot of material in the proper proportion to the mixer **12**, where the components are mixed and delivered through the nozzle **15** of the mixer.

Referring now to FIG. **2**, the measuring pump **10** includes an air cylinder portion **16**, an intermediate portion **17**, and a measuring portion **18**. The air cylinder

portion 16 includes a cylinder 19 provided with a central bore 20 and ports 21 and 22. The cylinder 19 is joined to the intermediate connecting portion 17 by block 23 which slidably supports piston rod 24. Suitable packing (not shown) is carried by the block 23 for sealingly engaging the piston rod to seal the lower end of the air cylinder. The upper end of the piston rod 24 is provided with a threaded end portion 25 of reduced diameter which carries piston assembly 26. The piston assembly includes a gasket 27 which sealingly engages the wall of the cylinder and which is held between a pair of washers 28 and 29. The washer 28 engages shoulder 30 provided by the narrowed end portion of the piston rod, and the piston assembly is secured by nut 31 threadedly received by the threaded end portion.

The intermediate connecting portion 17 is provided with a central bore 32 into which the lower end of piston rod 24 extends, and the wall of the intermediate portion may be provided with a pair of opposed openings 33 adjacent the lower end thereof.

Measuring portion 18 is secured to the lower end of the intermediate portion 17 and is also provided with a central bore 34 which is axially aligned with the bores 32 and 20. Bore 34 provides a measuring chamber portion 35 and a radially enlarged outlet chamber portion 36. Inlet port 37 communicates the measuring portion 35 of the bore with a suitable source of the material to be pumped, and outlet port 38 communicates the outlet portion of the bore with the mixer.

Plunger 39 is snugly received by the bore 34 and provides a substantially fluid-tight seal for the resin which is to be pumped. The piston rod 24 is provided with a threaded lower end 40, and nut 41 carried by the upper end of the plunger is threadedly secured thereto. A central bore 42 is provided in the plunger 39 for about half the length thereof and the upper end of the bore 42 communicates with the outside of the plunger through four cross drilled holes 43 located about 90° apart.

The lower end of the intermediate portion 17 is provided with a cavity 44 (FIG. 3) which receives a pair of O-rings 45a and 45b which sealingly surround the plunger 39 and which are spaced apart a spacer sleeve 46. An abutment or shoulder 47 extends radially inwardly from the wall of the outlet bore chamber 36 and retains the O-rings within the cavity 44. The shoulder 47 may extend circumferentially about bore or it may be segmented and extend inwardly at circumferentially spaced, discrete locations.

The bore 34 is enlarged adjacent the inlet port 37 to provide an enlarged inlet chamber 48 which surrounds the plunger 39 (FIG. 4). In the particular embodiment illustrated, the enlarged inlet chamber is provided by the intersection of the ¼ inch bore for the inlet port 37 and the ⅛ inch bore 34. Other ways of obtaining a circumferential, or a substantially circumferential enlargement of the bore 34 adjacent the inlet port can readily be envisioned.

The plunger 39 is shown in FIG. 2 at the beginning of a downward stroke, and the lower end thereof is spaced slightly above the bottom wall 48*a* of the annular inlet chamber 39. The cross drilled holes 43 in the plunger are positioned relative to the O-ring 45*b* and the shoulder 47 so that the cross drilled holes will not pass below the O-ring 45*b* into the radially enlarged outlet portion 36 of the bore 34 until the lower end of the plunger reaches the bottom wall 48*a* of the enlarged inlet chamber 48.

Since the resin is being forced through the inlet port 37 into the enlarged inlet chamber 48, there is full 360° flow at the plunger end, and the pressure exerted by incoming resin is equalized all the way around the plunger. This substantially eliminates the possibility that the plunger will be forced to one side as the resin is forced which may result in compression lock or binding of the plunger.

A nut 49 is secured to the lower end of the measuring portion 18 of the pump, and adjusting rod 50 is snugly receive by the central bore 34 of the measuring portion 18 and provided with a threaded lower end 50*a*. The axial position of the adjusting rod 50 within the central bore 34 can be varied by rotating the adjusting rod relative to the nut 49. The rod 50 serves to limit the downward movement of the plunger 39, thereby regulating the amount of resin that is pumped. It is to be understood, however, that other means of stroke adjustment and limitation might be employed.

In operation, the position of the plunger 39 shown in FIG. 2 can be considered the start of a downward or measuring stroke. Resin is supplied from resin source 51 (FIG. 1) through the material inlet port 37 to the inlet chamber 48 and the measuring chamber 35 of the central bore 34. Pressurized air from a suitable air source 52 (FIG. 1) is supplied to the cylinder 19 throughair inlet 21 to drive the piston rod 24 and plunger 39 downwardly, and the pressure developed on the resin causes the resin to flow upwardly through the central bore 32 of the plunger and through the cross drilled holes 43. When the lower end of the plunger passes the bottom wall 48a of the inlet chamber, the cross drilled holes will pass the O-ring 45b, and resin will flow into the radially enlarged outlet portion 36, through the outlet port 38 and to the mixer 12 through conduit 13 (FIG. 1). The forward or downward stroke of the plunger produces considerable pressure which is limited only by the amount of force supplied to the piston rod 24 by the air source. Commonly, this is in the range of 400 to 2,000 pounds per square inch. Since some resins which may be mixed are highly viscous, it is desirable to apply this much pressure in order to get adequate flow.

After the initial few strokes of the plunger, resin will fill the inlet chamber 48, measuring chamber 35, plunger bore 42, and cavity 44 so that resin will not flow through the plunger until the cross drilled holes 43 pass the O-ring 45b. Until this happens the downward stroke of the plunger will exert pressure on the resin and may cause backflow through the inlet port and into the inlet conduit. If enough pressure is exerted, the inlet conduit may even rupture. It is therefore desirable that the plunger stroke before the cross drilled holes are opened be relatively short, and I achieve this with my pump design.

My plunger need travel only a short distance between the point in which the inlet end of the plunger is fully opened and the outlet end fully closed and the point in which the outlet end of the plunger is fully opened and inlet end is fully closed. Because there is full resin flow around the circumference of the lower plunger end, this end need be positioned only slightly

above the bottom of the annular inlet chamber before beginning a downward stroke. As soon as the plunger end reaches the bottom wall of the inlet chamber, the inlet port is completely and suddenly closed. At the outlet end, no resin will flow through the cross drilled holes until the holes pass the O-ring **45***b*, but as soon as the holes pass the O-ring, the circumferentially enlarged outlet bore **36** permits full 360° flow and the outlet end of the plunger becomes fully opened.

Conversely, when the plunger is retracted, the lower end of the plunger becomes fully open to resin flow almost immediately upon passing above the bottom wall of the inlet chamber, and the outlet end becomes fully closed when the cross drilled holes reach the O-ring **45***b*. Thus, very little axial movement of the plunger is necessary to bring either end of the plunger from a fully open to a fully closed position or vice versa, and the total stroke of the plunger is relatively short.

In certain prior art pumps, the inward and outward flow of the resin would be through ports which communicate with the axial bore of the pump. Before the inlet or outlet ports could be changed from a fully open to a fully closed condition, or vice versa, the plunger would have to travel a distance corresponding to the axial dimension of the port.

For example, in one specific embodiment of my pump the diameter of the inlet port **37** was 7/16 in., and the outside diameter of the plunger **39** was ⅜ in. The cross sectional area of resin flow through the port was therefore $\pi\ (7/32)^2$sq.in. or 0.151 sq. in. In order to get the same flow past the end of the plunger into the measuring chamber, the plunger should be raised approximately a distance *d* above the bottom **48***a* of the inlet chamber, where

$$\tfrac{3}{8}\pi d = 0.151 \text{ or}$$

$$d = 0.126 \text{ in.}$$

If the inlet port opened directly into the axial bore of the pump, the plunger would have to travel approximately the same distance as the port diameter, or 7/16 in. (0.437 in.) before full flow into the axial bore was achieved.

Conversely, my plunger need travel downwardly only about 0.126 in. before the inlet port is closed and the outlet port is open whereas a comparable prior art pump would have to travel about 0.437 in. This difference in stroke can be significant because of the considerable pressure that can be applied by the plunger. If the downward movement of the plunger before the inlet port is closed and the outlet port is opened is too long, the back pressure created in the inlet conduit could rupture the conduit or cause a hydraulic lock of plunger movement, or damage or strain upstream apparatus.

As will be explained more fully hereinafter, the plunger **39** is returned by switching the air pressure from inlet **21** to inlet **22** of the cylinder to force the piston rod **24** upwardly. On the return stroke of the plunger, reduced pressure or vacuum is created in the measuring chamber **35** below the plunger. Initially, the material inlet port **37** is closed by the lower end of the plunger, and the vacuum in the chamber can be relieved in only one of two ways. The vacuum can remain unfilled until the plunger has returned far enough to expose a portion of the inlet chamber **48**, or the resin can be drawn back through the central bore **42** of the plunger from the conduit **13** and mixer **12** where it was initially delivered. LIttle if any resin will be returned to the measuring chamber because the viscosity of the resin limits its ability to flow under the small amount of pressure that is available in the evacuated measuring chamber, which theoretically can never be more than **15** psi. If relatively thin materials are being pumped, it may be desirable to position a check valve in the exit line from the pump. However, the slight backflow of material from the material outlet during the return stroke of the plunger is actually desirable since it causes a slight sucking back at the nozzle **15** of the mixer which prevents dribbling or stringing of the resin from the nozzle. Also, the return stroke of the plunger is generally considerably faster than the forward stroke. The only thing restricting the return stroke is the small vacuum at the forward end of the plunger, whereas on the forward stroke there is as much pressure as needed to develop flowing of the resin material. Accordingly, during the return stroke of the plunger, there is essentially a complete vacuum in the chamber that is maintained until the forward end of the plunger passes the bottom wall of the inlet chamber **48**, at which time resin flows into the measuring chamber, impelled both by the residual vacuum and by any pressure that may be applied to the resin source or reservoir.

As the lower end of the plunger moves upwardly past the bottom wall **48***a* of the inlet chamber, the cross holes **43** in the plunger are sealed by the O-ring gland **45***b* so that material flow through the pump is effectively blocked in both directions. This is desirable to prevent any continued suction of material back from the outlet port **38** and to prevent material from being pushed through the pump by pressure applied to the material at the material reservoir. Any flow from the reservoir through the pump could cause inaccurate measurement of one of the components and result in improper mixing and proportioning of the mixture.

It will be appreciated that the flow passages of the pump are opened and closed by the considerable force applied to the piston rod **24**, and the flow passages are closed by shearing action. It is therefore highly unlikely that the flow passages should fail to open or close. Further, it is apparent that the timing of the opening and closing of the flow passages is synchronized with the plunger movement, and no auxiliary mechanism is necessary to accomplish this cooperation. Accordingly, the need for high-pressure four-way material valves and other complicated synchronizing or proportioning apparatus is eliminated.

Measuring pump **10** is independent of the type of material reservoir or pumping that is used. For example, if the resin is not too thick, it might be allowed to flow into the measuring chamber by gravity alone. I have found that gravity feed works well even on materials that have a viscosity of about 2,000 centipoise. The material could also be supplied to the measuring chamber by simple pressure pots or by air driver high-pressure barrel pumps, both of which are well known in the art. The measuring pump works equally well whether the material is fed by gravity or by a pressure of several hundred psi, and it is unnecessary to make any adjustment in the measuring pumps which might be required if check valves or relief valves were used.

The measuring pump 11 is identical to the measuring pump 10, and delivers material B from material source 53 through conduit 14 to the mixer 12.

Referring now to FIG. 5, the mixer 12 includes a driving portion 55 and a mixer housing 56 which includes a distribution portion 56*a* and a mixing portion 56*b*. The driving portion 55 includes a suitable motor 58 and a rotating driving shaft 59, and the motor can be a conventional air-driven motor for rotating the driving shaft 59 at about 1,000 rpm. The motor 58 is secured by bolts 60 to a mounting block 61 which connects the motor to the mixer housing, and the lower end of the mounting head 61 includes an outwardly extending flange 62 which is connected to a generally cylindrical distribution head 63 by bolts 64. The distribution head 63 is provided with a central bore 65 and a pair of radially inwardly extending inlet ports 66 and 67. The inner end of inlet port 66 communicates with the bore 65 by means of passage 68 which is angled axially upwardly, while the inlet port 67 communicates with the bore 65 by means of passage 69 which is angled axially downwardly, thereby providing axially spaced inlet openings.

The mixing section 56b of the mixer includes an elongated generally cylindrical mixing tube 70 having an internal mixing chamber 71 therein and a nozzle or ejector opening 15 in the lower end thereof. The upper end of the mixing tube 70 includes radially enlarged shoulders 73 which engage correspondingly shaped recesses 74 provided in an annular clamping ring 75, and the mixing tube is secured to the distribution head 63 by bolts 76 which connect the clamping ring to the distribution head. The radially enlarged upper end portion of the mixing tube provides an annular cavity 77 which receives O-ring 78. The O-ring is compressed between the mixing tube and the distribution head to provide a seal therebetween.

A generally helical agitator or mixing vane 80 is rotatably received by the mixing chamber 71 and is rotated by shaft 81 which is operatively connected to the drive shaft 59 of the motor. Referring to FIGS. 5 and 8, the lower end of the drive shaft is counterbored as at 82 for receiving shaft 81, and the upper end of the shaft 81 is provided with a slot 81a. A pin 83 is positioned in openings 84 and 85 in the drive shaft 59 and extends through the slot 81a in the shaft 81.

A generally cylindrical cup or sleeve 86 having an inside diameter slightly greater than the diameter of the drive shaft is received on the drive shaft and retained thereon by the radially reduced end portions 83*a* of the pin. The pin ends 83*a* extend through openings 87 (FIG. 9) in the cup, which are slightly larger than the diameter of the central portion of the pin.

The shaft 81 carries a ring 88 which may be swaged onto the shaft or which may be a snap ring or the like received in a suitable annular groove in the shaft. A helical spring 89 is positioned on the shaft 81 between the ring 88 and the bottom wall 86*a* of the cup and urges the cup downwardly with respect to the shaft 81 so that the upper portion of the periphery of the openings 87 press against the pin ends 83*a*. The cup is secured against further axial movement away from the drive shaft, and the pin 83 is prevented from inadvertent displacement from the drive shaft by the cup since the enlarged central portion of the pin cannot pass through the cup openings 87 unless the cup is lifted against the bias of the spring.

The shaft 81 extends axially through the central bore 65 of the distribution head, and the upper end of the bore is closed by a metal-to-metal face type seal provided by a stationary bronze bushing 90 and a rotating hardened steel ring 91. The bushing 90 is provided with a central opening for rotatably receiving the shaft 81 and is seen to include an annular shoulder 90*a* which provides a flat lower surface which extends radially outwardly beyond the wall of the bore 65. The shoulder 90*a* is received in an annular recess 61*a* in the mounting block 61 and held firmly against the distribution head 63. An O-ring 92 is received by a suitable annular recess in the bushing and provides a seal between the bushing and the distribution head.

THe lower end of the bushing is provided with an inclined conical bearing surface 90*b* which mates with a corresponding shaped bearing surface 91*a* on the steel ring 91. The shape of the bearing surfaces may also be spherical or the shape of some other surface of revolution.

The lapped hardened steel ring 91 is secured to the shaft 81, as by epoxy adhesive or the like, and the steel ring is anchored against downward movement by a ring 93 which is swaged or otherwise secured to the shaft 81. Suitable abutment or shoulder means other than the ring 93 may also be used. The bearing surface 91*a* of the steel ring 91 is urged firmly against the bearing surface 90*b* of the bushing by the spring 89 which urges the shaft upwardly with respect to the cup 86 and the drive shaft 59. The spring 89 also insures that the slotted end 82 of the shaft does not fall below the pin 83.

The mixing vane 80 extends substantially the full length of the chamber provided in the mixing housing 70 and may advantageously be formed from an elongated flat strip of aluminum which is twisted into a helix and provided with a plurality of notches 92*a* which are spaced alternately along the opposite longitudinal sides thereof.

Referring to FIG. 4, the flat upper end of the mixing vane 80 is slidably received by a slot 94 provided in the lower end of the driving shaft 81, and the mixing vane is free to float transversely and seek its own center within the mixing chamber, thereby eliminating the need for close tolerances within the mixer housing. The mixing vane may also slide somewhat axially within the chamber.

Resin A is delivered to the distribution head 63 through inlet port 66 and enters the distribution chamber 65 through the inlet port 68. Similarly, resin B which is pumped by pumped 11 through conduit 14 enters the distribution chamber through inlet port 67 and passage 69. It will be seen that the two resins enter the distribution chamber at axially spaced locations and that resin A will predominate in the upper end of the chamber around the seal provided by the steel ring 91 and bushing 90 so that the proper proportions for a hard mix are not present in this area. Accordingly, if any of the material should leak through the seal it would not adhere to the members and prevent proper action.

The resin materials flow downwardly into the mixing chamber 71 where they are mixed by the rotating vane 80 and forced axially downwardly through the nozzle 15. The alternating notches of the vane allow resin material to adhere to the wall of the mixer housing 70

for a discrete period of time before being swept off by the diametrically opposite portion of the vane, thereby preventing the resin from being whirled about as a unit within the mixing chamber and assuring good mixing. The helical shape of the mixing vane not only allows the vane to find its own center within the mixing chamber but contributes to axial motion of the resin materials so that blending is obtained both axially and circumferentially within the mixing chamber. Further, the free-floating helical vane can wipe resin material from the walls of the mixer housing so that there is no buildup of cured resin during operation.

The free-floating feature of the helical vane is of considerable importance if for any reason a material is allowed to harden in the chamber. The mixer must then be disassembled, and with the usual design where a complicated multi-bladed agitator is fixed firmly to the shaft, it is very difficult to disassemble the mixer or to remove the blades from the solidified resin. My mixer, however, can be readily disassembled merely by removing the bolts **76**. The mixer housing and helical vane can thereafter easily be pulled away from the driving shaft **81** since the vane is slidably retained therein. The mixing housing is advantageously made of stainless steel and the vane made of aluminum so that in the event of very solidly cured resin within the mixer housing, it is possible to drill out the accumulation of resin and the aluminum agitator. The agitator is relatively simple and can be readily and economically replaced.

If resin material does leak through the seal between the distribution head **63** and the mounting block **61**, openings **95** in the central portion of the mounting block permit the resin material to flow outwardly, thereby preventing resin from reaching the motor and interfering with its operation.

The conduits **13** and **14** which connect the mixer to the measuring pumps are preferably provided by flexible tubing to permit the mixer to be moved relative to the pumps. The ejector nozzle of the mixer may thereby be guided by the operator to apply material in different locations.

The mixer can be readily disassembled for cleaning merely by removing the bolts **64** and **76** to separate the motor section, distribution section and mixing section. If necessary, bolts **60** can be removed to permit separation of the mounting block from the motor **58**. The shaft **81** can easily be detached from the drive shaft **59** by lifting the cup **86** slightly upwardly against the bias of the spring so that the enlarged central portion of the pin **83** can be pushed through the openings **87** in the cup. This step can be performed through the access openings **95** in the mounting block.

However, after the mixer has been used and is to be shut down, it is very easy to clean the mixer without disassembly. The flow of resin material will stop by closing the valve that admits pressurized air to the driving air cylinders of the pumps. Solvent may then be admitted to the mixing chamber of the mixer, and, for this purpose, the distribution head may be provided with an inlet port similar to inlet ports **66** and **67**. The solvent is pumped through the mixer while the vane is rotated, and a few ounces of solvent is usually enough to accomplish cleaning within a matter of minutes. THe elongated, narrow mixer housing **70** permits the mixer to be thoroughly cleaned with only a small amount of solvent. It is not necessary to clean the measuring pumps **10** or **11** or their delivery conduits **13** and **14**, since these parts contain only a single resin which will not harden until mixed with the other.

Referring now to FIGS. **1** and **2**, the means for obtaining synchronism between the two measuring pumps **10** and **11** comprise simple hydraulic circuits **98** and **99**. The portion of cylinder **19** of pump **10** below the piston assembly **26** is filled with suitable hydraulic fluid such as hydraulic oil or the like, and the portion of the cylinder above the piston is filled with air. The port **22** of the cylinder is connected by conduit **100** to hydraulic fluid reservoir **101**, and a micrometer needle valve **102** is interposed in the conduit between the fluid reservoir and the pump. Check valve **103** in bypass conduit **104** bypasses the micrometer needle valve to permit fluid to flow from the fluid reservoir to the pump without restriction, but the flow of fluid from the pump to the fluid reservoir can be very accurately controlled by the micrometer needle valve **102**.

Resin material is pumped by pump **10** by admitting pressurized air from air source **52** through valve **105** into cylinder **19** to move the piston rod **24** and plunger **39** downwardly, and the speed of the downward movement of the plunger is accurately regulated by the setting of the micrometer needle valve. The desired speed of operation can therefore be obtained regardless of the viscosity of the resin that is being pumped.

Each of the measuring pumps has a similar hydraulic circuit, and the micrometer needle valve of each circuit can be set so that the cylinders of each pump operate in unison. Synchronism of the pumps prevents stratification of the resins in the mixing chamber which might occur if one pump was delivering resin when another was not and also insures that the resins are always fed in the proper proportion even if only a partial stroke of the measuring pumps is utilized.

When the plunger of the measuring pump is to be returned, the valve **105** directs pressurized air through conduit **106** to force fluid from fluid reservoir **101** through check valve **103** and into the cylinder **19** through port **22** to return the piston assembly **26**. As discussed hereinbefore, the return stroke of the piston rod can be very rapid, and fluid can flow into the cylinder through the check valve in an unrestricted manner.

The oil in the cylinder **19** below the piston **26** lubricates the piston rod and prevents accumulation of resin around the packing gland of the piston carried by block **23**. Oil will not enter the resin portion of the system, since the pressure of the resin is considerably higher than the pressure on the oil.

The hydraulic circuits **98** and **99** insure simultaneous operation of a plurality of measuring pumps without any interconnection therebetween, and it is possible to have two, three, or more resin measuring pumps operating together. The hydraulic circuit synchronism means is especially useful on pumps which are intended for small volume resin pumping. If the volume of resin materials which is to be pumped is relatively large and large volume measuring pumps are used, the oil reservoirs of the hydraulic circuit synchronism means might be too large, and I have found that it is desirable to achieve synchronization through a mechanical interconnection between the measuring pumps.

REferring to FIGS. **10** and **11**, measuring pump **110** supported by platform **111** and stand **111a** includes a cylinder **112** and plunger or piston **113**. The measuring pump **110** is similar to the measuring portion **18** of the pump **10** and is provided with a central bore **114** having a measuring chamber **115** and radially enlarged outlet portion **116**. Material to be pumped enters through inlet port **117** and flows into the enlarged inlet chamber **118** provided by the intersection of the larger bore of the inlet **117** with the smoother central bore **114**. During the pumping stroke of the plunger, resin flows through central bore **119** of the plunger and through four cross-drilled holes **120**. However, a modified sealing means for the outlet end of the pump is shown in FIGS. **10** and **11**. The cross drilled holes are provided through an annularly reduced portion **121** of the plunger, and a sealing O-ring **122** is received by an annular groove **123** provided by a further annularly reduced portion of the plunger. The O-ring is retained in the annular groove **123** between the radially enlarged annular portion **121** and the radially enlarged main portion of the plunger.

The particular cylinder **112** illustrated is formed of forward and rearward portions **112***a* and **112***b*, respectively, which are sealed together by O-ring **124**. The bore **114** is provided with an annular enlargement **125** in rearward portion **112***b* which receives a sealing ring **126** having a generally U-shaped or cup-shaped cross section. The sealing ring provides a seal between the plunger and the cylinder wall and prevents leakage of the resin.

As the plunger moves forwardly, or to the right in FIG. **10**, resin flow through the cross drilled holes **120** into the annular space between the wall of the bore **114** and the annularly reduced plunger portion **121**. The resin will not flow into the enlarged outlet portion **116** of the bore until the O-ring **122** passes the inclined shoulder **127** which joins the bore **114** and the radially enlarged outlet portion **116**. However, as soon as the O-ring passes the shoulder **127**, resin flows into the outlet portion **116** throughout a full 360° and the outlet end of the pump becomes fully open.

When the plunger is retracted, the outlet end of the pump remains fully open until the O-ring **122** engages the shoulder **127**, at which time the outlet end will become fully closed. Thus, very little axial movement of the plunger is required to bring the outlet end from a fully closed to a fully open position and vice versa. Equivalent operation can be obtained by mounting the O-ring **122** in the wall of the cylinder and providing the shoulder on the plunger.

The inlet end of the pump is constructed similarly to that of the pump **10** hereinbefore described. Because of the enlarged inlet chamber **118**, full 360° inward flow of resin is obtained as soon as the plunger end passes to the left of the inlet chamber wall **118***a*, and very little axial movement of the plunger is required to obtain full flow.

The O-ring **122** is positioned relative to the shoulder **122** and the forward end of the plunger so that the O-ring will pass the shoulder to permit outflow at the same time or very shortly after the plunger end passes the inlet chamber wall **118***a* to close off inflow.

Either sealing means for the outlet end of the pump may be used — that shown in FIGS. **2** and **3** or that shown in FIGS. **10** and **11**. Each sealing means utilizes a resilient O-ring of rubber or other suitable material which is not affected by the resin, and the O-ring provides desired elasticity.

An elongated link **128** is pivotally connected at **129** to the rearward end of plunger **113**, and the ink is connected to a rotatable cross-shaft **130** by crank arm **131**. The crank arm **131** is fixedly secured to the cross-shaft **130** and is provided with an adjusting slot **132** which slidably and rotatably receives pin **133** which extends transversely from the elongated link **128**. The pin **133** can be provided with a threaded outer end, and the pin can be secured in a desired position along the length of slot **132** by means of nut **134**. Cross-shaft **130** is journaled in bushings **135** mounted on platform **111** and is connected to a suitable drive power source for imparting reciprocatory rotary motion to the cross-shaft, for example, a double acting air cylinder provided with crank linkage for trAnslating linear reciprocatory motion into rotary reciprocatory motion.

The other pumps of the mixing system are similarly provided with connecting links and crank arms for mechanically connecting the plungers thereof to the cross-shaft **130**, and the effective stroke of each of the measuring pumps can be varied by sliding the connecting link **128** along the slot in the associated crank arm. It will be seen that when the link **128** and plunger **113** are axially aligned, the slot **132** is inclined from a line *x* perpendicular to this common axis at an angle θ of about 12°. This slight angle will cause the connecting link **128** to move downwardly as the pin **133** is moved from the outer end of the slot toward the cross-shaft **130**, and the effective length of the crank arm **131** is reduced while the position of the lower end of the plunger of the measuring pump is changed relative to the inlet port for the resin material. As explained hereinbefore, the early part of the downward stroke of the plunger is used in closing the material inlet port, and it is only after this port is closed by the plunger that pumping action starts. It is therefore necessary to slightly advance the lower end of the plunger as the total stroke is reduced in order that the proportion of the port-closing and pumping-portion of the stroke be kept constant. Changing the effective length of each crank arm will change the speed of the associated plunger but each plunger will start and stop pumping at substantially the same time because of this adjustment to the relative starting positions of the plungers. It is important that each pump start and stop pumping at substantially the same time so that the proportions of the various resins being delivered to the mixer remain constant.

The slidable engagement between the pin **133** and slotted crank arm and the angle θ are selected to retain the same ratio of inlet porting to pumping stroke in order to afford simultaneity of delivery to the mixing chamber. In one specific embodiment the angle θ was about 12°, the center of the shaft **130** was about 1–11/16 inches below the axis of the plunger, and the center of the pin **133** was about 1 inch to the left of the center of the shaft **130** when the link **128** was axially aligned with the plunger.

The apparatus described herein is essentially of the shot-type, i.e., the apparatus delivers a predetermined quantity of properly proportioned mixed material. This is particularly useful when it is desired to fill containers

or cavities or to pot connectors with a predetermined amount of material. A further advantage is that the operator would readily note a change in the size of the shot that is delivered by the mixer and would be made aware of some malfunction in the system such as insufficient material in one of the reservoirs, a clogged line, or the like. With continuous flow type machines, there is no indication of a change in the proportion of the components, and the machine might continue to be used even though the material will not properly cure. My system can be adjusted, however, to give one measured stroke after another to provide an essentially continuous flow.

If desired, the pumps may be provided with suitable means to protect the equipment in the event one of the plungers becomes jammed, for example, overload clutches, springs, shear pins, and the like.

While in the foregoing specification I have described specific embodiment of my invention in considerable detail for the purpose of illustration, it is to be understood that many of the details herein given may be varied considerably by those skilled in the art without departing from the spirit and scope of my invention.

I claim:

1. A mixing apparatus for mixing two or more materials comprising an elongated mixer housing providing a mixer chamber therein, said housing having an inlet and an outlet end and being provided with an inlet port adjacent the inlet end thereof for each material to be mixed, an elongated mixing vane rotatably received by the mixing chamber, rotatable drive shaft means, means for connecting the drive shaft means to the mixing vane for rotating the vane whereby the materials entering the inlet ports are mixed and delivered to the outlet end of the housing, seal means for closing the inlet end of the mixer housing, the drive shaft means including an elongated shaft, the seal means including a stationary portion rotatably receiving the elongated shaft and a rotating portion secured for rotation with the elongated shaft, and spring means on the elongated shaft for urging the rotating seal portion against the stationary seal portion.

2. The apparatus of claim 1 in which the drive shaft means includes a driving shaft, connecting means between the driving shaft and the elongated shaft securing the elongated shaft for rotation with the driving shaft but permitting relative axial movement between the shafts, the elongated shaft including abutment means thereon, a sleeve carried by the driving shaft and secured against axial movement toward the seal means, said sleeve extending from the driving shaft toward the seal means beyond the abutment means on the elongated shaft and including a radially inwardly extending portion between the abutment means and the seal means, said spring means including a helical spring ensleeved on the elongated shaft between the abutment means and the radially inwardly extending portion of the sleeve whereby said abutment means is urged away from the inwardly extending sleeve portion.

3. The apparatus of claim 2 in which the driving shaft is provided with a bore which slidably receives one end of the elongated shaft, said one end of the elongated shaft being slotted, the connecting means including a pin extending transversely through the driving shaft and through the slotted end of the elongated shaft.

4. The apparatus of claim 3 in which said pin extends through openings in the sleeve and restrains the sleeve against axial movement toward the seal means.

5. The apparatus of claim 1 in which the stationary portion of the seal means is provided with a bearing surface of revolution and the rotating portion of the seal means is provided with a bearing surface of revolution matingly engaging the bearing surface of the stationary portion.

6. A mixing apparatus for mixing two or more materials comprising an elongated mixer housing providing a mixer chamber therein, said housing having an inlet and an outlet end and being provided with an inlet port adjacent the inlet end thereof for each material to be mixed, and elongated mixing vane rotatably received by the mixing chamber, a drive shaft having a slotted end slidably receiving the mixing vane, the mixer housing including a distribution portion provided with a central bore and an elongated mixing portion provided with a central bore aligned with the bore of the distribution portion, the inlet ports being provided in the distribution portion and the distribution portion being boltably secured to the mixing portion whereby the mixing portion can be removed from the distribution portion and the mixing vane can e removed from the drive shaft.

7. The apparatus of claim 6 including a motor for rotating the drive shaft and a connecting portion for connecting the motor to the distribution portion, the connecting portion being boltably secured to the distribution portion.

8. A mixing apparatus for mixing two or more materials comprising an elongated mixer housing providing a mixer chamber therein, said housing having an inlet and an outlet end and being provided with an inlet port adjacent the inlet end thereof for each material to be mixed, an elongated mixing vane rotatably received by the mixing chamber, a drive shaft having a slotted end slidably receiving the mixing vane, a motor for rotating the drive shaft, and a connecting portion boltably secured to the mixing housing for connecting the motor to the mixer housing whereby the mixer housing can be removed from the connecting portion and the mixing vane can be removed from the drive shaft

9. A mixing apparatus for mixing two or more materials comprising an elongated mixer housing providing a mixer chamber therein, said housing having an inlet and an outlet end and being provided with an inlet port adjacent the inlet end thereof for each material to be mixed, an elongated mixing vane rotatably received by the mixing chamber, rotatable drive shaft means, means for connecting the drive shaft means to the mixing vane for rotating the vane whereby the materials entering the inlet ports are mixed and delivered to the outlet end of the housing the mixer housing including a cylindrical distribution head provided with a central bore and an elongated generally cylindrical mixer portion provided with a central bore axially aligned with the bore of the distribution head, one end of the mixer portion being provided with a radially outwardly extending shoulder, an annular clamping ring engaging said shoulder and being boltably secured to the distribution head, said inlet ports comprising generally radially inwardly extending passages provided in he distribution head.

10. An apparatus for mixing a plurality of separate flowable materials in desired proportions comprising a positive displacement piston pump for each material to be mixed, a mixer, conduit means connecting each pump to the mixer for delivering the output of each pump to the mixer, means for regulating the piston displacement of each pump for delivering the materials to the mixer in the desired proportions, the mixer being provided with an elongated mixing chamber having an inlet end and an outlet end, the inlet end of the chamber being provided with an inlet port for each of the conduit means, a mixing vane rotatably received by said mixing chamber, power means for rotating the mixing vane to mix the materials entering the inlet ports and to deliver the mixed material to the outlet end of the mixer, each positive displacement piston pump including a double-acting cylinder having a pair of axially spaced ports and a piston movable within the cylinder between the ports, the piston displacement regulating means including a liquid reservoir, means connecting the liquid reservoir to one of the cylinder ports for delivering liquid to the cylinder, and valve means for permitting relatively unrestricted flow of liquid from the liquid reservoir to the cylinder and for adjustably regulating the flow of liquid from the pump to the liquid reservoir.

11. The apparatus of claim 10 in which the valve means includes a check valve interposed in the connecting means for permitting relatively unrestricted flow of liquid from the liquid reservoir to the cylinder and a regulating valve interposed in the connecting means for permitting regulation of the flow of liquid from the cylinder to the liquid reservoir.

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