Aug. 2, 1966 R. R. RULAND 3,263,932

LIQUID PROPORTIONING APPARATUS

Filed Dec. 23, 1963 3 Sheets-Sheet 1

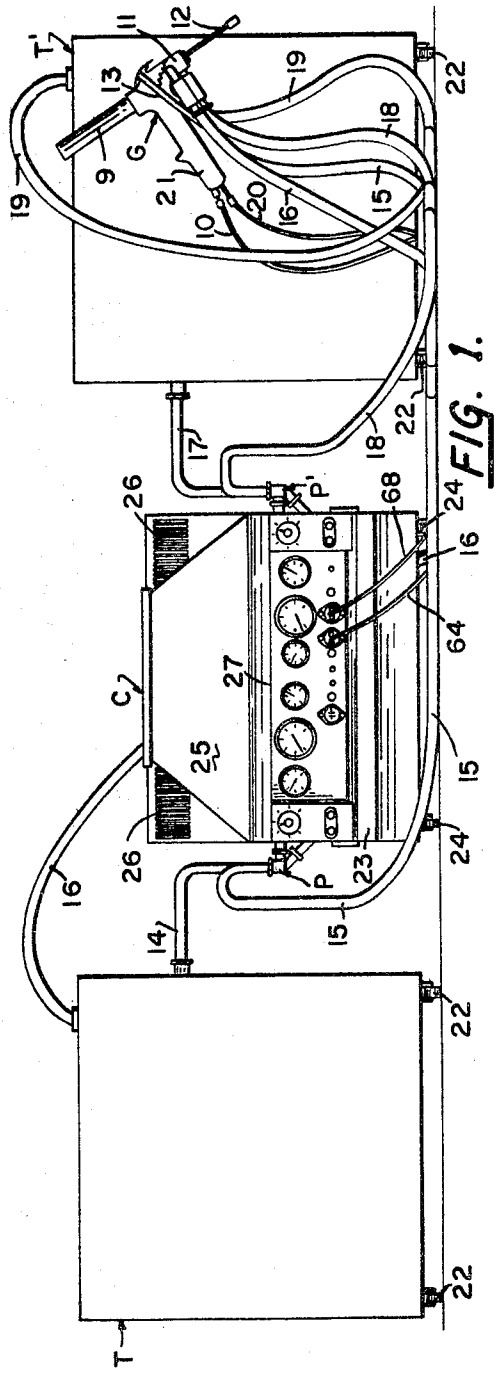


FIG. 1.

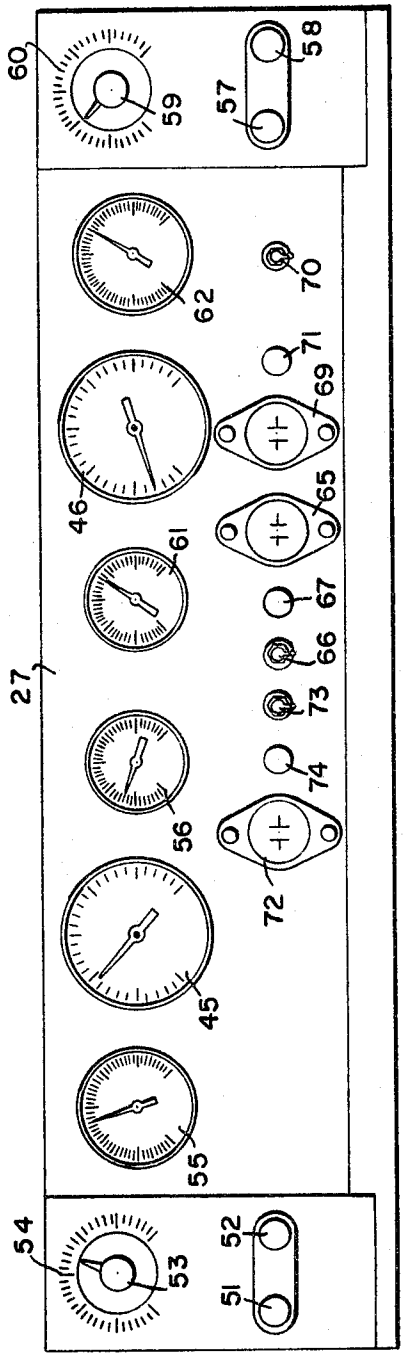


FIG. 2.

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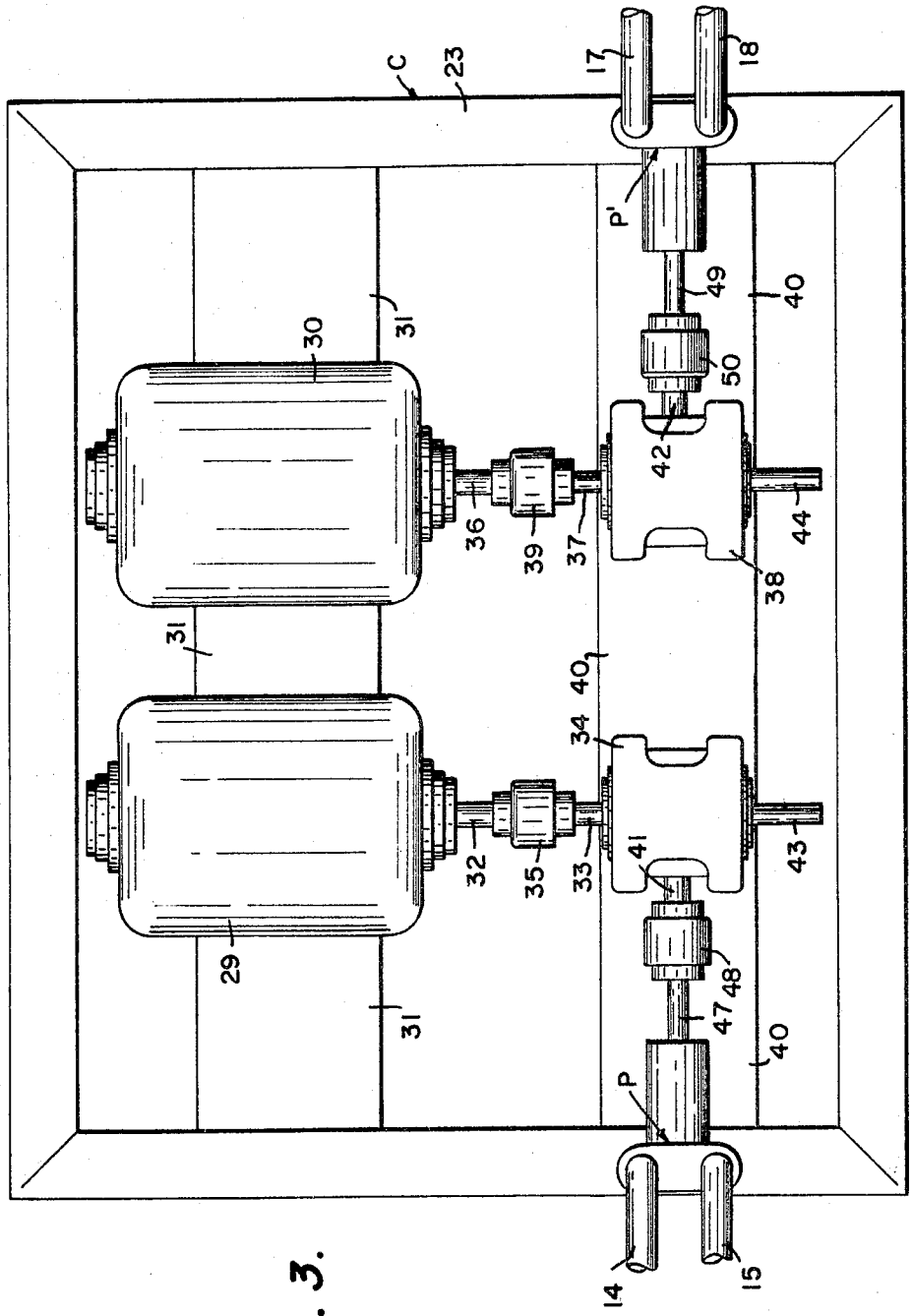


FIG. 3.

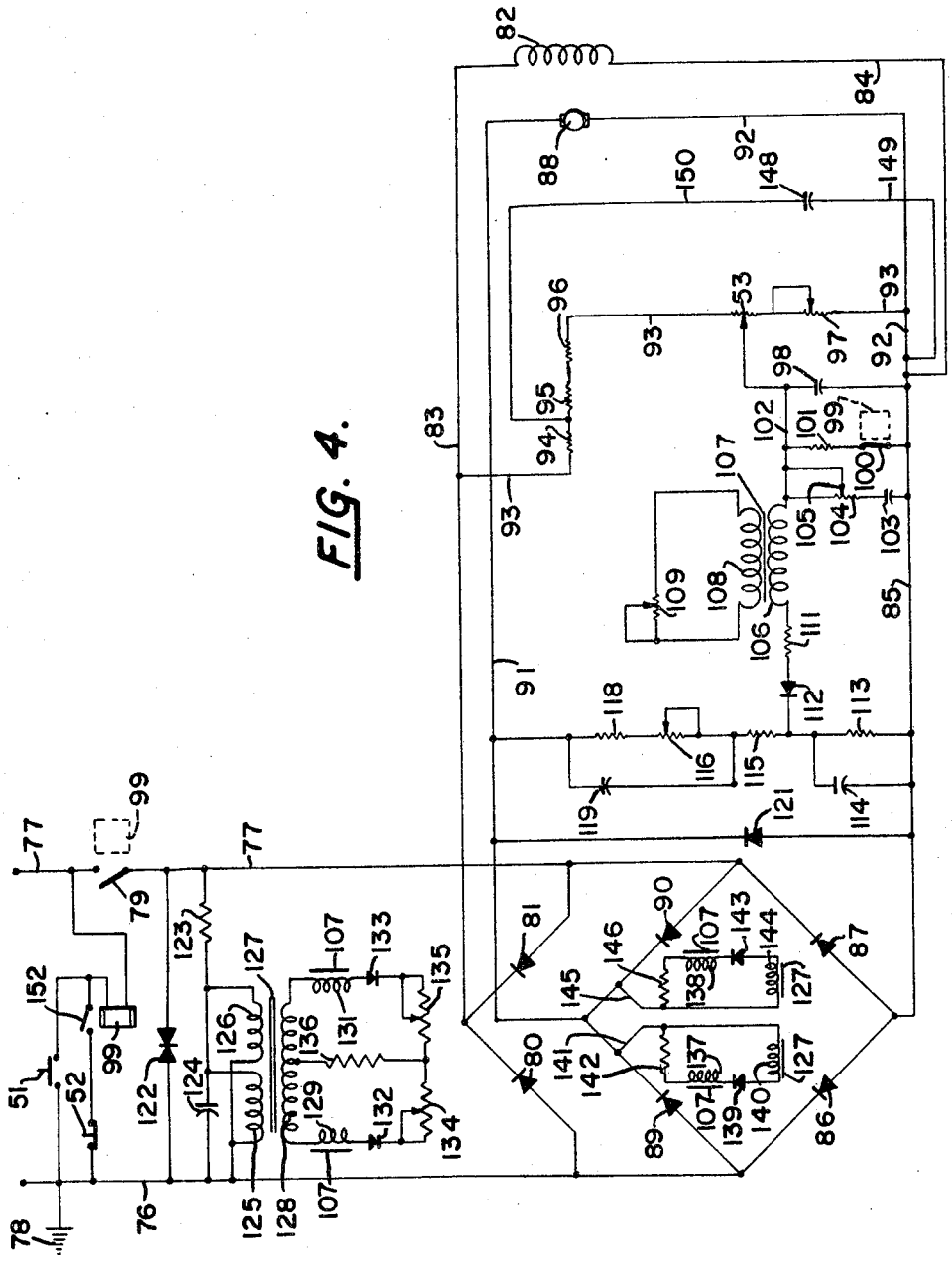
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FIG. 4.



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3,263,932

LIQUID PROPORTIONING APPARATUS

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Filed Dec. 23, 1963, Ser. No. 332,763
4 Claims. (Cl. 239—304)

This invention relates to liquid proportioning apparatus, and more particularly to apparatus for proportioning two liquids, such as a prepolymer and a cross linking compound to be mixed and pumped by a spray gun for use as a polyurethane insulation.

Prior to the present invention, before applying such insulation, it was necessary to pump the prepolymer out of one tank for 10 seconds, then pump the cross linking compound out of another tank for 10 seconds and weigh the two samples on a scale to ascertain the ratio of the weights. If the ratio was incorrect, then it was necessary to adjust the speed of one or the other or both of the pumps, in order to change the ratios of the material pumped in a given amount of time and repeat the test. Thus, sometimes as much as 30 minutes would be spent attempting to obtain the proper proportions of material for use in the spray gun. Also, changes in room temperature and humidity made the tests more difficult and time consuming.

The liquid proportioning apparatus of this invention is particularly adapted to proportion the liquids applied to a spray gun, utilized in the method and apparatus and to form the polyurethane product of the copending application of Ernest M. Bond, Serial No. 306,115, filed September 3, 1963. As disclosed therein, the prepolymer may be a polyisocyanate, such as diisocyanate, while the cross linking compound may be an hydroxol polyester or an hydroxol polyether, having a reactive hydrogen atom, while suitable additives are preferably added to both the prepolymer and the cross linker, in small amounts, to provide better control of the reaction. The prepolymer is conveniently formula PP–151 and the cross linker is conveniently formula PA–123, each obtained from the Phelan Chemical Company of Burlington, Iowa. Also, a Freon blowing agent, such as CCl_3F or CCl_2F_2, is preferably added to the cross linker, for reasons set forth in the aforesaid application. As will be evident, the liquid proportioning apparatus of the present invention is also adapted to the utilized in proportioning other liquids of a different chemical nature, particularly where the temperature of each liquid is a factor.

Among the objects of this invention are to provide novel liquid proportioning apparatus; to provide such liquid proportioning apparatus which may utilize a pair of identical, constant volume pumps for respectively pumping liquid from each of two tanks; to provide such liquid proportioning apparatus in which each pump is driven by a variable speed motor; to provide such liquid proportioning apparatus in which the variable speed motors may be identical; to provide such liquid proportioning apparatus wherein each variable speed motor may be provided with a tachometer so that the relative speeds thereof can be observed; to provide such liquid proportioning apparatus which may have means for indicating the pressure of the liquid as it is pumped from each tank; to provide such liquid proportioning apparatus which may have means for indicating the temperature of the liquid in each tank; to provide such liquid proportioning apparatus having means for independently varying the speed of each motor, to change the amount of liquid being pumped from each tank; to provide such liquid proportioning apparatus which is efficient in operation; and to provide such liquid proportioning apparatus which is of simple construction and relatively inexpensive to manufacture.

Additional objects and the novel features of this invention will become apparent from the description which follows, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a front elevation of apparatus for applying polyurethane foam, together with the storage tanks for the prepolymer and cross linker and the novel apparatus for proportioning the liquids, constructed in accordance with this invention;

FIG. 2 is an enlarged, front elevation of the instrument panel of the proportioning apparatus of FIG. 1;

FIG. 3 is an enlarged, top plan view of the base of the proportioning apparatus of FIG. 1 showing the parts mounted therein; and

FIG. 4 is a schematic wiring diagram of a power control circuit for each of a pair of pump motors of FIG. 3.

In liquid proportioning apparatus constructed in accordance with this invention, a control unit C is adapted to regulate the flow of a first liquid, such as a prepolymer, from a first tank, such as tank T, and the flow of a second liquid, such as a cross linker, a from a second tank, such as tank T'. The metered prepolymer and cross linker are then pumped to a spray gun G, which is adapted to spray the mixture, as into a space between a truck body wall and a layer of aluminum foil, as described in the aforesaid application of Ernest M. Bond, Serial No. 306,115. The spray gun G includes an air motor **9** supplied with compressed air through a hose **10**, whose opposite end may be attached to an air compressor or other source of air under pressure (not shown). The air motor drives an impeller within a housing **11** which mixes the prepolymer and cross linker and discharges the mixture through a nozzle **12**, under control of a hand lever **13**.

Conveniently, the first liquid is pumped from tank T through a hose **14** by a constant volume pump P and then is pumped through a hose **15** to spray gun G. When the spray gun is not in operation, the first liquid may be return to tank T by a return hose **16**, which enters the top of the tank so that it can be maintained at a constant temperature, as will appear below. Similarly, the second liquid is pumped from tank T' through a hose **17** by a constant volume pump P'. From the pump, the second liquid is pumped through a hose **18** to the spray gun G. When the spray gun is not in operation, the second liquid may be returned to tank T' through a return hose **19**, entering the tank T' through the top so that the second liquid may also be maintained at a constant temperature, as discussed below. Conveniently, a purge hose **20** enters the spray gun through the end of a handle **21**, so that a solvent purge may clean out housing **11** and nozzle **12** at the end of each use of the spray gun, so that the gun need not be dismantled and cleaned each time it is used. It will be noted that tanks T and T' are each mounted on casters **22**, so that the tanks may easily be moved from place to place.

Control unit C includes a base **23**, mounted on casters **24** for readier movement, and an upper housing **25** in which is installed a selective speed control unit directly behind each vent **26**, provided for cooling purposes. A control and indicating panel **27** is mounted atop base **23**, at the front. Motors **29** and **30**, as in FIG. 3. which are coveniently disposed in base **23** and respectively drive pumps P and P', may be mounted on a support **31**, such as a channel, extending between opposite sides of base **23**. For the installation shown, each of motors **29** and **30** are ⅓ horsepower, 60 cycle motors designed to operate on 115 volts A.C., being adapted to operate at a maximum of 1800 r.p.m. and a minimum of 60 r.p.m. Motor **29** has a drive shaft **32** connected to an input shaft **33** of a speed reducer **34** by means of a coupling **35**, while motor **30** similarly has a drive shaft **36** connected to an input

shaft 37 of a speed reducer 38 by means of a coupling 39. Conveniently, speed reducers 34 and 38 are mounted on a transverse support 40, narrower than support 31 but similarly extending between opposite sides of base 23. The speed reducers shown are adapted to reduce the speed from the motors at the ratio of 10 to 1. Thus, the output shaft 41 of speed reducer 34 will rotate at one-tenth the speed of motor shaft 32. Similarly, the output shaft 42 of speed reducer 38 will rotate at one-tenth the speed of motor shaft 36. The speed reducers also have tachometer shafts 43 and 44, respectively, for attachment to conventional tachometers 45 and 46 on control and indicator panel 27 of FIG. 2. The speed reducer output shaft 41 is connected to shaft 47 of pump P by means of a coupling 48 while speed reducer shaft 42 is connected to a shaft 49 of pump P' through a coupling 50. Pumps P and P' may be of the impeller type, creating a suction which causes a flow of liquid from tanks T and T', through hoses 14 and 17 to the respective pump, the liquids then being pumped under pressure through hoses 15 and 18, respectively.

The instruments on the left side of panel 27 relate to pump P and motor 29, while the instruments on the right side of panel 27 relate to pump P' and motor 30. Motor 29 may be started by momentarily pressing a start button 51 and may be stopped by momentarily pressing a stop button 52, each of which is connected in the motor circuit. Also, the speed of motor 29 may be varied by means of a rheostat 53 which is provided with indicia 54 to indicate the relative speed of the motor. A pressure gauge 55 is connected to pump P by a conventional pressure hose (not shown) to indicate the pressure of the first liquid being pumped to spray gun G, while a temperature gauge 56 indicates the temperature of the liquid in tank T, by means of a conventional temperature sensing unit in tank T (not shown). The speed of motor 29 is indicated by tachometer 45, as stated above, mounted between pressure gauge 55 and temperature gauge 56. Similarly, motor 30 may be started by momentarily depressing a start button 57 and may be stopped by momentarily pressing a stop button 58, each of which is connected in the motor circuit. The speed of motor 30 may be controlled by a rheostat 59 connected in the motor circuit and having indicia 60 to indicate the relative speed thereof. A pressure gauge 61 is connected to the pump P' by a conventional pressure hose (not shown) to indicate the pressure of the liquid flowing therefrom, while a temperature gauge 62 is connected to tank T' by means of a conventional temperature sensing device (not shown) to indicate the temperature of the liquid within tank T'. Tachometer 46 is connected to shaft 44, as stated above, to indicate the speed of motor 30 and is mounted between pressure gauge 61 and temperature gauge 62. By adjusting rheostats 57 and 63, respectively, the speed of the two motors may be adjusted to a desired speed ratio, as will be indicated by the number of RPM shown on tachometers 45 and 46, respectively. Thus, the amount of liquid pumped from tank T and the amount of liquid pumped from tank T' may be set at any suitable ratio, merely by adjusting rheostats 57 and 63 to vary the speed of the respective motors which drive the constant volume pumps P and P'.

The liquid in tank T, such as a prepolymer, may be utilized at room temperature or below; thus, cooling of the liquid in tank T may be obtained by suitable conventional cooling equipment installed therein. Also, the liquid in tank T' is heated, as to 90° F., by a conventional heater (not shown) in the tank. Since the second liquid, in the installation shown, should be maintained above room temperature, it is desirable to supply heat to hose 18. Thus, hose 18 may be heated by a conventional heating element wrapped therearound and supplied by a cord 64 which may be plugged into an electrical outlet 65 which is controlled by a switch 66, with an indicating light 67 in the circuit to show when the heater is turned on. Similarly, pump P' and hose 17 may be heated by a heating element supplied by a cord 68 which may be plugged into an outlet 69, which is controlled by a switch 70 and which will also turn on a light 71 when the heater is on. If during the operation, the second liquid is returned through hose 19 other than for spaced and short periods of time, it may be desirable to heat that hose, as by a heating element wrapped therearound and supplied with current by a cord plugged into an auxiliary outlet 72 controlled by a switch 73, with a light 74 in the circuit to indicate when the auxiliary heater is in operation. Of course, outlet 72 may be used for other purposes, as for connection of any other electrical device which may be necessary, such as a light on an extension cord.

One suitable circuit for the control of the speed of one of motors 29 and 30, and consequently the speed and output of pump P or P', is illustrated in FIG. 4. In this regard, it will be understood that, although the circuit for control of one motor is shown and described below, the other motor is controlled in a similar manner. Thus, A.C. current is supplied through line wires 76 and 77, wire 76 being connected to ground 78 and wire 77 having a starting switch 79 interposed therein. The A.C. current is rectified by rectifiers 80 and 81 interposed between lines 76 and 77, respectively, as shown, so that pulsating D.C. is provided to the motor field winding 82 by wire 83 and is returned by wires 84 and 85 through power rectifiers 86 and 87 to line wires 76 and 77, respectively. The voltage across the field 82 also serves as a reference voltage, as will become apparent below. The motor armature 88 is supplied with power through a bridge circuit connected between lines 76 and 77 and including silicon control rectifiers 89 and 90 forming two legs of the bridge, with the power rectifiers 86 and 87 forming the other two legs of the bridge, and supplying power to armature 88 through a wire 91, the other side being connected to the bridge through wires 92 and 85.

The reference voltage, i.e. the voltage through field 82, is controlled by a circuit including a wire 93 connected between wires 83 and 85, in parallel to field winding 82 and having interposed therein serially connected resistors 94, 95, 96, the rheostat 53, used to control the voltage drop across the field winding and thereby vary the speed of the motor, and a variable resistor 97, for adjusting the minimum speed at which the motor is to run. Conveniently, this variable resistor may be adjusted by means of a set screw at the time of installation to set the minimum motor speed and after once adjusted, normally need not be touched again. The movable tap of rheostat 53 is connected through a capacitor 98 to wire 85, while a starting relay coil 99, connected in series with the button operated start switch 51, is adapted to open a normally closed switch 100, in series with a resistor 101 connected between wire 85 and a wire 102 and across capacitor 98, for a purpose to be described. Another capacitor 103 is in series with a variable resistor 104 which is also in parallel with capacitor 98 and has a movable tap 105, for a purpose to be described. Also connected between wire 102 and wire 85 is a secondary coil 106 of a gate transformer 107 having a number of secondary coils, including a coil 108, which is connected in series with a variable resistor 109 to permit adjustment for stability of the circuit. A resistor 111 and a rectifier 112 are placed in series with coil 106, while another resistor 113 and a capacitor 114 are connected in parallel between rectifier 112 and wire 85. Resistor 113 forms part of a voltage divider, which is completed by a resistor 115, a variable resistor 116 and a resistor 118 connected to wire 91, while a capacitor 119 is connected across resistor 118 and variable resistor 116, as shown. A "fly-back" rectifier 121 is in parallel with the voltage divider and extends between wire 91 and wire 85, for a purpose to be described. Variable resistor 116 may be adjusted, as by a set screw, to set the maximum speed at which the motor is to operate. As with the minimum speed adjustment, variable resistor 116

may be adjusted at the time of installation and normally need not be adjusted again. A dual rectifier **122** extends across the main lines **76** and **77**, in parallel with a circuit comprising a resistor **123** in series with a capacitor **124** having parallel coils **125** and **126** of a transformer **127** connected thereto. The transformer secondary winding **128** energizes coils **129** and **131** of gate transformer **107**, which are respectively in series with rectifiers **132** and **133** and variable resistors **134** and **135**. These variable resistors provide for bias adjustment of the circuit. Transformer coil **128** is center tapped, with a resistor **136** connected between the center of the coil and variable resistors **134** and **135**.

Conveniently, transformer **127** steps down the A.C. input to the correct operating level of windings **129** and **131** of gate transformer **107**. The current of the gate windings is supplied to additional secondary coils **137** and **138** of transformer **107** in a "mag.-amp." circuit, wherein coil **137** is connected in series with a rectifier **139**, and a coil **140** of transformer **127**. As will be apparent, this circuit is connected between a gate of full wave rectifier **89** and the bridge circuit adjacent wire **91**, by a wire **141**, with a resistor **142** connected across the same. Similarly, coil **138** is connected in series with a rectifier **143** and transformer winding **144**, between the gate of rectifier **90** and the bridge circuit adjacent wire **91**, by a wire **145**, with a resistor **146** across the same. Until a pulse is fed to the gates, rectifiers **88** and **89** provide a high impedance to the input voltage. But when the gates are triggered by current in the mag.-amp. circuit, just described, the gates of the rectifiers are triggered, so that they approach zero impedance and the conducted current is then limited only by the impedance of armature **88**. The point at which the rectifiers are triggered determines the length of conduction during any one cycle. This is more commonly called the "firing" angle. When the firing angle is 0°, the maximum current will flow, since all of the applied voltage appears across the armature. However, if the firing angle is retarded to 180°, a minimum armature current will flow, since the applied voltage appears across the cut-off rectifiers **89** and **90**, which provide a high impedance throughout the complete cycle. Thus, by adjusting the firing angle between 0° and 180°, the average power delivered to the armature may be controlled. The firing angle is adjusted by reset current applied to rectifiers **89** and **90** through the mag.-amp. circuit by an error signal fed to this circuit from the speed control circuit, as described below. The rectifier **121** across the circuit serves as a discharge diode for the armature voltage on the off-portions of the cycle and is thus commonly referred to as a "fly-back" rectifier.

The sensing mag.-amp. circuit must be "told" what speed is desired and what error, if any, is present. This information is supplied by error voltage from winding **106** of transformer **107** through windings **137** and **138** of the mag.-amp. circuit. The reference supply is essentially a constant voltage source between lines **83** and **85**, which is filtered by a capacitor **148** connected by a wire **149** to line **85** and by a wire **150**, between resistors **94** and **95** to wire **93** and line **83**, as shown. Speed detection is accomplished by sensing armature voltage, which is directly proportional to the motor speed, and comparing it to the reference voltage. The magnitude of the reference voltage is determined by setting the speed of the motor by means of rheostat **53**. Thus, when the armature voltage equals the reference voltage setting, an equilibrium is established by the proper current flowing in the control winding. When there is variation in motor speed, such as through a load on the motor, which will result in variation in armature voltage, the equilibrium is disturbed and error current proportional to the error in speed flows by means of winding **106** through transformer **107** to the mag.-amp. control windings **137** and **138**. This flow in current causes a change in the gate winding impedance and thereby adjusts the firing angle of rectifiers **89** and **90**, to reestablish the necessary equilibrium, by restoring the armature voltage and hence the motor speed, to the original value.

For smooth motor starting, the high inrush of current must be suppressed and a gradual application of armature current initiated. For this purpose, a normally closed switch **100**, which is in series with resistor **101**, short circuits capacitor **103**, so that it remains in a discharged state. When start button **51** is momentarily depressed, relay coil **99** is energized to close starting switch **79**. This immediately closes a contact **152** and locks the circuit to coil **99** through stop button switch **52**, so that when start button switch **51** is released, the circuit will still be energized. Simultaneously, contact **100** is opened through the energization of coil **99** and the capacitor **103** appears as a short circuit electrically clamping the reference voltage to zero. The power rectifiers **89** and **90** receive their signal from the control circuit through windings **137** and **138**, which changes the firing angle to 180°, thereby attempting to reduce the armature voltage to zero and accordingly the inrush of current to the armature **88** is suppressed. As the capacitor **103** slowly charges, at a rate determined by the R.C. time constant of the capacitor and the ohms of the resistor **104**, the reference voltage also rises and the motor slowly accelerates to the speed which was preset by rheostat **53**. Momentarily depressing stop button **52** deenergizes coil **99**, allowing contact **100** to close and thereby discharging the capacitor **103**.

It will be understood, of course, that other suitable control circuits for the motors **29** and **30**, such as by providing D.C. motors, may be utilized.

From the foregoing, it will be evident that a liquid proportioning apparatus constructed in accordance with this invention fulfills to a marked degree the requirements and objects hereinbefore set forth. An apparatus has been provided wherein two similar motors drive similar constant volume pumps, so that the ratio of the materials pumped by the pumps may be adjusted by varying the speed of the motors. Also, instruments are provided to indicate the temperature of the fluid in the respective tanks, as well as the pressure at which the fluid is being pumped by the pumps. By means of tachometers, the speed of the motors may be determined. With this arrangement, considerable time is saved in arriving at the desired proportions for the temperature at which the material is being used. Furthermore, the apparatus is of simple construction, yet is efficient in operation and is relatively inexpensive.

Although a preferred form of this invention has been illustrated and described, it will be understood that various changes and variations may be made without departing from the spirit and scope of this invention.

What is claimed is:

1. An apparatus for spraying two liquids including:
first and second tanks;
a control unit disposed adjacent said tanks;
a first cross support in said control unit;
first and second motors mounted in adjacent positions on said first cross support;
a second cross support in said control unit spaced from said first cross support;
first and second speed reducers mounted in adjacent positions on said second cross support and respectively operatively connected to said first and second motors;
first and second pumps mounted within said control unit and respectively operatively connected to said first and second speed reducers;
hoses connecting said first and second pumps with said first and second tanks, respectively;
a spray gun;
hoses connecting said spray gun to said first and second pumps;
first and second temperature gages mounted on said control unit and operatively connected to said first

and second tanks for indicating the temperature of the respective liquids in said tanks;

first and second tachometers mounted on said control unit and respectively operatively connected to said first and second speed reducers for indicating the speed of said motors; and

first and second speed control devices mounted in said control unit and respectively operatively connected to said first and second motors for varying the speed thereof and thereby varying the rate at which said pumps pump liquid from said tanks.

2. An apparatus as set forth in claim **1**, including:

first and second pressure gauges mounted on said control unit and respectively operatively connected to said first and second pumps for indicating the fluid pressure of the liquid being pumped by said pumps, each said temperature gage and pressure gage being mounted adjacent the corresponding tachometer.

3. In a system for proportioning and supplying two liquids to a mixing device adapted to mix such liquids and discharge such mixture therefrom and to return such liquids when the discharge is to be interrupted, the combination of:

a first tank containing a first liquid;

a second tank containing a second liquid;

means for returning each liquid to the respective tank upon interruption of the discharge from said mixing means;

separate means for maintaining the liquid in each tank at a temperature appropriate for the mixing and discharge of said liquids;

a first constant volume pump having an inlet connected with said first tank and an outlet connected with said mixing means;

a second constant volume pump having an inlet connected with said second tank and an outlet connected with said mixing means;

separate variable speed drive means for said first and second pumps;

means for separately varying the speed of said drive means;

means for indicating the temperature of said liquid in each tank; and

means for separately indicating the relative speed of each said drive means, whereby said drive means may be adjusted concurrently to a speed ratio corresponding to the volumetric ratios of the liquids necessary for the temperature relations thereof.

4. An apparatus for proportioning two liquids supplied to mixing means and including:

a first tank containing a first liquid;

a second tank containing a second liquid;

a first pump operatively connected for pumping liquid from said first tank to said mixing means;

a second pump operatively connected for pumping said second liquid from said second tank to said mixing means;

a first motor connected with said first pump for driving said first pump;

a second motor connected with said second pump for driving said second pump;

a control panel;

a first tachometer mounted on said control panel and operatively connected to said first motor for indicating the speed thereof;

a second tachometer mounted on said control panel and operatively connected to said second motor for indicating the speed thereof;

first and second speed reducers;

means coupling said first speed reducer to said first motor;

means coupling said first speed reducer to said first pump;

means connecting said first speed reducer to said first tachometer;

means coupling said second speed reducer to said second motor;

means coupling said second speed reducer to said second pump;

means connecting said second speed reducer to said second tachometer;

a first speed control device for varying the speed of said first motor to regulate the rate at which said first liquid is pumped from said first tank; and

a second speed control device for independently regulating the speed of said second motor to control the rate at which said second liquid is pumped from said second tank.

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