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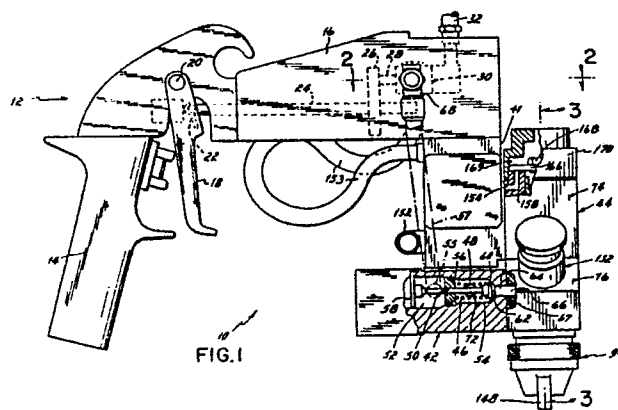
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54 **Apparatus for spraying hot melt adhesives.**

57 An apparatus for spraying molten thermoplastic adhesive in which the outside of a solid stream of adhesive ejected from a nozzle is impacted by atomizing air to form adhesive droplets and the droplets are then directed by pattern-shaping air into a pre-determined area of a substrate. The flow rate and velocity of the atomizing air and pattern-shaping air is independently controlled by separate regulating valves to permit variation of the size of the adhesive droplets formed and the width of the pattern of droplets deposited on a substrate. Control valves are provided to sequence the flow of adhesive discharged from the nozzle with the flow of atomizing and pattern-shaping air such that the flow of atomizing and pattern-shaping air is initiated before the flow of adhesive from the nozzle begins and after the flow of adhesive therefrom is terminated.



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Apparatus For Spraying Hot Melt Adhesive

Field of the Invention

This invention relates to apparatus for spraying hot melt adhesive, and, more particularly, to an apparatus for spraying droplets of molten thermoplastic adhesive onto a substrate for subsequent bonding with another substrate.

Background of the Invention

Hot melt thermoplastic adhesives have been widely used in industry for adhering many types of products, and are particularly useful in applications where quick setting time is advantageous. One application for hot melt adhesive which has met with considerable commercial success is the fabrication of cartons wherein the quick setting time of the hot melt adhesive is useful in assembling the flaps of a carton in high speed cartoning lines.

A number of dispensers have been employed to deposit hot melt adhesive onto the flaps of cartons, or on other substrates where quick setting time is required. For example, one type of adhesive dispenser is a gun formed with an adhesive passageway connected to a nozzle having a discharge orifice. The adhesive is pumped through the gun and ejected from the discharge orifice of the nozzle in the form of a relatively thick bead of molten thermoplastic adhesive which is applied to the substrate. Another substrate is then placed into contact with the first substrate to "flatten" or spread out the adhesive bead over a larger surface area so that an acceptable bond is produced between the substrates.

One disadvantage of adhesive dispensers which discharge an adhesive bead is that a relatively large quantity of adhesive is required to obtain the desired bond. Molten thermoplastic adhesive is highly viscous and does not readily spread over the surface of one substrate even when a second substrate to be bonded thereto is pressed against the adhesive bead. As a result, a relatively large quantity of adhesive is required in forming the bead to ensure the surface area of the bond between the substrates is sufficient to adhere the substrates together.

Several attempts have been made in the prior art to lessen the quantity of thermoplastic adhesive required to bond two substrates together while obtaining acceptable bond strength between the substrates. In one prior art apparatus, the hot melt adhesive is transmitted under pressure to the discharge orifice of a nozzle. When the hot melt adhesive is ejected into the ambient air, it atomizes

and forms a spray or mist of tiny droplets which are deposited onto the substrate. These small droplets cover a larger surface area than a single adhesive bead, and since bond strength is dependent in part on the surface area covered by the adhesive, a lesser quantity of adhesive in droplet form can be employed than is required with an adhesive bead.

One problem with spraying molten thermoplastic material in tiny droplets onto a substrate is that in order for the adhesive to completely atomize before it reaches the substrate, the nozzle must be positioned a relatively large distance from the substrate. As a result, the small droplets are exposed to ambient temperatures and tend to cool before they reach the substrate. It has been found that with some types of hot melt adhesives the droplets either harden before they contact the substrate or fail to retain sufficient specific heat after they reach the substrate to permit bonding to another substrate. Additionally, nozzles of the type designed to spray thermoplastic adhesive in atomized form can produce elongated strings or fibers of adhesive instead of droplets when the nozzle is first turned on and/or when the nozzle is shut off. These strings of adhesive tend to clog the nozzle and/or are deposited in that form onto the substrate.

Another attempt to reduce the quantity of adhesive utilized for cartoning applications and the like is found in U.S. Patent No. 3,348,520 to Lockwood. The apparatus disclosed in the Lockwood patent produces relatively large drops of molten thermoplastic adhesive which are deposited onto one substrate for bonding with another substrate. The individual drops of adhesive are obtained by alternately opening and closing valves located in the adhesive supply lines upstream from nozzles connected to the supply lines. One problem with apparatus of the type disclosed in the Lockwood patent is that the valves which form the adhesive drops must open and close at extremely high rates to keep up with the speeds of modern cartoning lines, and they tend to wear or fail after relatively short periods of use.

Another approach in the prior art for spraying hot melt adhesives is found in U.S. Patent No. 4,721,252 to Colton. This patent discloses an apparatus in which molten thermoplastic adhesive is ejected through the discharge orifice of a nozzle and a tube carrying pressurized air is positioned in the center of the adhesive stream ejected from the nozzle. As the pressurized air emerges from the tube, it expands radially outwardly and breaks up the hot melt adhesive in the stream to form droplets or blobs of adhesive which are then de-

posited on the substrate. Multiple air delivery tubes can be employed to control the width of the spray pattern of droplets formed.

One problem with the apparatus disclosed in the Colton Patent No. 4,721,252 is the potential for cut-off drool when the apparatus is shut off, i.e., the formation of strings or fibers of adhesive in the area of the nozzle and the air tubes when the flow of adhesive is discontinued. Additionally, since the pattern of the adhesive droplets deposited onto the substrate is dependent on the number and location of air delivery tubes, the entire nozzle must be removed and replaced in order to change the spray pattern.

Summary of the Invention

It is therefore among the objectives of this invention to provide an apparatus for spraying droplets or blobs of molten thermoplastic adhesive which controls the size of the adhesive droplets, which controls the width of the spray pattern of the adhesive droplets deposited onto a substrate, which eliminates cut-off drool or stringing of adhesive and which ensures that the adhesive droplets retain sufficient heat when deposited on one substrate to form a bond with a second substrate.

These objectives are accomplished in an apparatus for spraying molten, hot melt thermoplastic adhesive wherein a stream of hot melt adhesive ejected from the discharge orifice of a nozzle is impinged by a stream of atomizing air which contacts the outside of the adhesive stream to form droplets of adhesive whose size is controlled by varying the velocity and flow rate of the atomizing air so that such droplets retain sufficient heat when they are deposited on a substrate to subsequently bond to another substrate placed in contact therewith. A stream of pattern-shaping air, which is controlled separately from the stream of atomizing air, is directed against the adhesive droplets before they reach the substrate to variably control the size and shape of the pattern of adhesive droplets on the substrate.

One aspect of this invention is predicated upon the elimination of cut-off drool in the operation of the apparatus, i.e., the elimination of elongated fibers or strands of adhesive formed at the discharge orifice of the nozzle when the flow of adhesive is shut off. This is achieved in the instant invention by valves which control the discharge of adhesive from the nozzle of the spraying apparatus and the supply of atomizing air and pattern-shaping air to the discharge orifice of the nozzle.

The apparatus is formed with an applicator head having an adhesive passageway within which a plunger is axially movable between an open

position which permits passage of adhesive to the nozzle and out its discharge orifice, and a closed position in which the flow of adhesive is blocked. A plunger control valve is mounted within a pilot air line connected to the applicator head which controls the movement of the plunger between the open and closed position.

Atomizing air is supplied to the nozzle through an atomizing air passageway which has an atomizing air regulating valve connected therein. Pattern-shaping air is supplied to the nozzle area through a pattern-shaping air passageway having a pattern-shaping air regulating valve connected therein which is adjustable separately from the atomizing air regulating valve. Both the atomizing air regulating valve and pattern-shaping air regulating valve communicate with a common supply line carrying heated or unheated air. This common supply line has a pilot-operated air supply valve located upstream relative to the regulating valves. Opening and closing of the pilot-operated air supply valve is controlled by an air control valve which communicates with a source of pressurized, pilot air.

Movement of the plunger in the adhesive supply passageway, and the flow of air through both the atomizing air passageway and pattern-shaping air passageway are synchronized so that atomizing and pattern-shaping air is supplied to the area of the discharge orifice of the nozzle both before the stream of adhesive is ejected from the discharge orifice and after the flow of adhesive is terminated. The air control valve which operates the air supply valve is an "unrestricted in-metered out" type of valve, i.e., it allows an unrestricted flow of pilot air to flow in one direction therethrough so that the air supply valve is pressurized and quickly opens to permit the flow of a stream of atomizing air and a stream of pattern-shaping air toward the discharge orifice of the nozzle. On the other hand, the air control valve meters the flow of air in the opposite direction so that the air supply valve is slowly depressurized and thus and slowly closes to stop the flow of atomizing and pattern-shaping air after the flow of adhesive through the adhesive passageway has stopped. This eliminates "cut-off drool" or the formation of strings of adhesive at the discharge orifice of the nozzle.

The plunger control valve which supplies pilot air to axially move the plunger between the open and closed position operates in the opposite manner from the air control valve, i.e., such valve is a "metered in-unrestricted out" type of valve. The plunger control valve meters the supply of pilot air therethrough to the plunger to delay movement of the plunger from a closed to an open position so that the flow of adhesive through the discharge orifice of the nozzle begins after the atomizing and pattern air flow has been initiated. When the stream

of adhesive needs to be shut off, the plunger control valve is "unrestricted out", i.e., the pilot air flowing to the plunger is allowed to bleed in the opposite direction through the plunger control valve along an unrestricted path so that a spring can quickly return the plunger to a closed position before the flow of air from the atomizing and pattern-shaping air passageways is discontinued.

Another aspect of this invention is predicated upon controlling both the size of the droplets formed from the adhesive stream, and the pattern of droplets deposited on a substrate. This is achieved by the air flow regulating valves in both the atomizing air passageway and the pattern-shaping air passageway which are controlled separately from one another to vary the air flow therein. Heated or unheated air is supplied through the air supply valve to each of the regulating valves, and such regulating valves are individually adjustable to direct a selected portion of the air flow into the atomizing air passageway and the pattern air passageway.

The air discharged from the atomizing air passageway impacts the outside of the stream of adhesive discharged from the nozzle so that the adhesive stream is broken up into blobs or droplets having a diameter of preferably about 1/4-7/16 inches. The width of the pattern of these droplets on a substrate is primarily controlled by the pattern-shaping air which contacts the droplets after they are formed but well before they reach the substrate.

The ratio of the flow rate and velocity of the atomizing air to the pattern-shaping air is adjustable by operation of the air regulating valves. Generally, as the ratio of the velocity and flow rate of the atomizing air to the pattern-shaping air is adjusted so that the velocity and flow rate of the atomizing air increases while that of the pattern-shaping air decreases, a relatively narrow spray pattern is produced on a substrate which contains relatively small adhesive droplets. On the other hand, if the ratio of the velocity and flow rate of the atomizing air to the pattern-shaping air is adjusted so that the velocity and flow rate of the atomizing air decreases while that of the pattern-shaping air increases, a relatively wide spray pattern is produced on a substrate which contains relatively large adhesive droplets.

Another aspect of this invention involves the versatility of the applicator head herein in accommodating different types of spraying applications. In one application, the applicator head is adapted to mount to the gun body of a hand held spray gun having an air control valve and a plunger control valve each connected to a source of pressurized air through a trigger operated supply valve. The applicator head is mounted to the gun body and

connected to the air control valve and plunger control valve for operation as described above.

Alternatively, a rod supported mounting block is provided for connection to the applicator head. The mounting block supports the air control valve, the plunger control valve and carries a supply line for adhesive, all of which are connected to the applicator head as in the hand held spray gun application. Pilot air to the air control valve and plunger control valve is supplied through lines connected to a controller, e.g., a programmable control device, which is capable of automatically controlling the flow of pilot air to the mounting block, and, in turn, the applicator head.

In a still further embodiment, a manifold is provided which is adapted to support a number of individual applicator heads and control the flow of pilot air and adhesive to each. In turn, the supply of pilot air and adhesive to the manifold is controlled by a programmable controller so that adhesive is discharged from each of the applicator heads at the desired intervals of time and with the desired pattern.

Description of the Drawings

The structure, operation and advantages of the presently preferred embodiment of this invention will become further apparent upon consideration of the following description, taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is an elevational view in partial cross section of one embodiment of the adhesive spray apparatus herein;

Fig. 2 is a cross sectional view taken generally along line 2-2 of Fig. 1;

Fig. 3 is a cross sectional view of the applicator head herein taken generally along line 3-3 of Fig. 1;

Fig. 4 is a schematic, unassembled view of alternative structure for mounting the applicator head of this invention to convert the system from a hand held dispenser to an automatic dispenser; and

Fig. 5 is a diagrammatic view illustrating the atomizing and shaping air impacting a stream of dispersed hot melt adhesive.

Detailed Description of the Invention

Referring to Fig. 1, the adhesive spray apparatus 10 is adapted for hand held operation and comprises a spray gun 12 having a handle 14 connected to a gun body 16. A trigger 18 carried on a pivot 20 mounted to the gun handle 14 is connected by an actuator 22 to a trigger rod 24

movable axially within the gun body 16. The end of the trigger rod 24 opposite the trigger 18 is mounted to a connector plate 26 which, in turn, contacts a valve plunger 28.

As shown in Figs. 1 and 2, a three-way cartridge valve 30 is carried by the gun body 16 and is operatively connected to the valve plunger 28. One side of the cartridge valve 30 is connected to a source of actuating air (not shown) through a feed line 32. Branch lines 34, 36 extend outwardly from the cartridge valve 30 at outlet ports 38 and 40, respectively, formed therein. In the presently preferred embodiment, the cartridge valve 30 is a commercially available item and forms no part of this invention per se.

In order to open the cartridge valve 30 to permit the flow of air from feed line 32 into each of the branch lines 34, 36, the trigger 18 is first pulled to the left as viewed in Fig. 1 carrying the trigger rod 24 and connector plate 26 in the same direction. Movement of the connector plate 26 relative to the valve plunger 28 opens an internal seat (not shown) of the cartridge valve 30 allowing the passage of air from the feed line 32 through cartridge valve 30 and into each of the branch lines 34, 36. The cartridge valve 30 is placed in the closed position by releasing trigger 18 so that a spring (not shown) returns the trigger rod 24 and connector plate 26 to their original positions with respect to the valve plunger 28. See Fig. 1.

The flow of air through the cartridge valve 30 into branch lines 34, 36 provides pilot air which controls the flow of adhesive, and the flow of atomizing and pattern-shaping air, as discussed in detail below. The structure for obtaining the air flow, and for obtaining the adhesive flow, is described separately below.

Atomizing Air and Pattern-Shaping Air

Referring initially to Figs. 1 and 2, the gun body 16 is connected to a service body 41 which mounts an applicator head 44. The service body 41 carries adhesive heaters and other electrical components which form no part of this invention per se and are not described herein. A support block 42 is connected to the applicator head 44 having an air supply valve 46 located at its base which receives heated or unheated air from a supply line 48. The air supply valve 46 comprises a plunger 50 which extends between a pilot air chamber 52 and an air inlet chamber 54 both formed in the support block 42. The pilot air chamber 52 is formed with a port 55 connected to a pilot air supply line 57, which, in turn, is connected to the branch line 36 from cartridge valve 30. A seal 56 is interposed between the chambers 52, 54 and is formed with a bore

within which the plunger 50 is axially slidable.

The end of plunger 50 located within the pilot air chamber 52 carries a head plate 58, and the opposite end of plunger 50 located within the air inlet chamber 54 mounts a plunger head 60. The plunger head 60 is adapted to engage a seat 62 formed in the air inlet chamber 54 at the entrance to a passageway 64 in the support block 42. The passageway 64 is connected at the abutting faces of support block 42 and applicator head 44 to an air supply passageway 66 formed in the applicator head 44. An O-ring 67 is positioned between the abutting faces of support block 42 and applicator head 44 to form a seal therebetween.

Flow of heated or unheated air into the air supply passageway 66 of applicator head 44 is obtained as follows. In response to movement of the trigger 18, pilot air is supplied from the cartridge valve 30 into each of the branch lines 34 and 36. A pilot air control valve 68 is connected between the branch line 36 and the pilot air supply line 57. The pilot air control valve 68 is a commercially available "unrestricted in-metered out" type of actuating valve, i.e., the flow of pressurized, pilot air is allowed to flow in an unrestricted path in one direction through valve 68, but the air flow in the opposite direction through valve 68 is metered. When supplied with pressurized air from branch line 36, the pilot air control valve 68 allows an unrestricted flow of pilot air therethrough which is transmitted through the pilot air supply line 57 to the pilot air chamber 52 of valve 46. Pressurization of the pilot air chamber 52 moves the head plate 58 of plunger 50 to the left as viewed in Fig. 1, thereby unseating the plunger head 60 from the seat 62 in air inlet chamber 54. As a result, air supplied to the air inlet chamber 54 through supply line 48 is allowed to enter the passageway 64 in support block 42 and flow to the air supply passageway 66 in the applicator head 44.

When the trigger 18 is released, flow of air through cartridge valve 30 to the branch lines 34, 36 is discontinued. In response, the pilot air control valve 68 is operable to meter the flow of air therethrough which gradually bleeds back in the opposite direction from the pilot air chamber 52 of valve 46 and through the pilot air supply line 57. As the air pressure within pilot air chamber 52 gradually decreases, a spring 72 mounted within the air inlet chamber 54 of air supply valve 46 forces the plunger head 60 of plunger 50 into engagement with the seat 62 to close the flow of air from the air inlet chamber 54 into passageways 64, 66.

Referring now to Fig. 3, the applicator head 44 comprises an upper cylinder 74 connected to a base 76 within which the air supply passageway 66 is formed. The base 76 is formed with a stepped bore 78 having an upper end which mounts a

sleeve 80, and a smaller diameter, lower end forming an adhesive flow passageway 82. The sleeve 80 is formed with an annular slot 84 extending radially inwardly from the outer surface thereof which communicates with the air supply passageway 66 formed in the base 76. An atomizing air branch line 88 is connected to the annular slot 84, and a pattern-shaping air branch line 90 is also connected to the annular slot 84. These branch lines 88, 90 receive air from the air passageway 66 via the annular slot 84 for transmission to a nozzle 92 and air cap 94 mounted to the base 76 as described below.

The base 76 is formed with a threaded bore 96 which receives an atomizing air regulating valve 98 therein. The regulating valve 98 has a chamber 100 connected to a discharge orifice 102. A plunger 104 is carried by the regulating valve 98 which includes a rod 106 extending axially therethrough. The outer end of the rod 106 is connected to a cap 108 exteriorly of the valve 98. The inner end of rod 106 has a tapered edge 110 which is adapted to mate with a seat 112 formed in the regulating valve 98 at the intersection of chamber 100 and discharge orifice 102.

An annular slot 114 is formed in the outer surface of regulating valve 98 which is connected to the atomizing air branch line 88 carrying air from supply line 57. Radial passageways 116 connect the annular slot 114 to the chamber 100 of the regulating valve 98 upstream relative to the discharge orifice 102. The flow of air from branch line 57 through the flow path defined by passageways 64, 66, branch line 88, slot 114, passageways 116 and chamber 100 is controlled as it passes through discharge orifice 102 by rotating the cap 108 and thus moving the rod 106 axially within the regulating valve 98. Axial movement of the rod 106 varies the space between the tapered edge 110 of rod 106 and the seat 112 at the entrance to the discharge orifice 102 which, in turn, controls the flow rate of air passing therebetween.

Atomizing air is ejected from the discharge orifice 102 of regulating valve 98 into a connector passageway 118 formed in the base 76 of applicator head 44. This connector passageway 118 terminates in an annular chamber 120 formed at the upper end of a threaded bore 122 in base 76 within which the nozzle 92 is mounted. The nozzle 92 is formed with a plurality of radial passageways 124 having upper ends which communicate with the annular chamber 120. The opposite, lower end of the radial passageways 124 terminate at the tip 126 of the nozzle 92 within an annular atomizing air discharge passageway 128 formed between the outer surface of the nozzle tip 126 and a facing surface 130 of the air cap 94. As discussed below, atomizing air discharged from the atomizing air

discharge passageway 128 impacts a stream of adhesive ejected from the nozzle 92 to break up such adhesive into droplets for deposition onto a substrate.

Referring again to Fig. 3, pattern-shaping air is transmitted to the nozzle 92 in a manner similar to the atomizing air described above. The pattern-shaping air branch line 90 connected at one end to the air passageway 66 via annular slot 84 communicates at its other end with a pattern-shaping air regulating valve 132. The structure and operation of pattern-shaping air regulating valve 132 is identical to that of atomizing air regulating valve 98 and is not repeated herein. The same reference numerals are used on regulating valve 132 to designate the same structure as in regulating valve 98, with the addition of a "prime" to the reference numbers for the pattern-shaping air regulating valve 132.

The discharge orifice 102' of pattern-shaping air regulating valve 132 communicates with a connector passageway 134 formed in the base 76 of applicator head 44. The connector passageway 134 terminates at an annular chamber 136 formed in the base 76 which, in turn, is connected to a plurality of radial passageways 138 formed in the nozzle 92. The radial passageways 138 are connected to an annular chamber 140 formed around the periphery of nozzle 92. The chamber 140 communicates with one end of a pair of pattern air-shaping passageways 144 formed in air cap 94. The opposite end of the pattern air-shaping passageways 144 terminate at at least one orifice 146 formed in each air horn 148 of air cap 94. As described in more detail below, pattern-shaping air is ejected from the discharge orifice 146 of each pattern air-shaping passageway 144 and impacts the droplets of hot melt adhesive formed by the atomizing air ejected from the atomizing air discharge passageway 128. This pattern-shaping air controls the width of the pattern of adhesive deposited onto a substrate, i.e., the height and width of the pattern of droplets on the substrate.

As best shown in Figs. 1 and 3, both regulating valves 98, 132 are connected to the common air supply passageway 66 and thus the total flow of air in the system is divided among the atomizing air and pattern-shaping air branch lines 88, 90. An important aspect of this invention, is that the regulating valves 98, 132 are separately adjustable so that the flow rate of the air streams therethrough can be varied independently of one another.

Hot Melt Adhesive Supply

Referring now to Fig. 3, the structure for delivering hot melt adhesive to the nozzle 92 is illustrated. The upper cylinder 74 is formed with the

stepped bore 156 having a lower end connected by an adhesive connector passageway 150 to a supply line 152 from a source of adhesive (not shown). See also Fig. 1. This lower end of stepped bore 156 mounts the upper portion of sleeve 80 thus forming a flow path for molten hot melt adhesive from passageway 150 in upper cylinder 74 into the adhesive flow passageway 82 in base 76 of applicator head 44. The upper end of stepped bore 156 mounts a packing cartridge 158 formed with a recess 162. A compression spring 163 is received within the recess 162, and mounts to the upper end 164 of a plunger 165 which is carried by the packing cartridge 158 and is axially movable therealong. A header plate 166 is mounted at the top of plunger 165 by a nut 168 forming an air chamber 171 between the packing cartridge 158 and header plate 166. The outer edge of header plate 166 seals against an inner wall 169 of a cap 170 forming the top of applicator head 44. Pilot air is supplied by a feed line 153 connected to a passageway 154 formed in the upper cylinder 74 beneath the header plate 166 of plunger 165 and into air chamber 171. See also Figs. 1 and 2.

The lower end 172 of plunger 165 extends downwardly from the upper cylinder 74 through the adhesive flow passageway 82 in base 76 to the nozzle tip 126 of nozzle 92. An adhesive discharge passageway 178 (shown closed) is formed in the nozzle 92 having an upper end connected to the adhesive flow passageway 82 in base 76 and a discharge orifice 180 at the nozzle tip 126. The nozzle tip 126 is tapered at the discharge orifice 180 to mate with the tapered tip 184 formed in the lower end 172 of plunger 165 to control the flow of adhesive therethrough.

The flow of adhesive through the spray apparatus 10 is obtained by axial movement of the plunger 165 relative to the discharge orifice 180 in the nozzle 92, and movement of the plunger 165 is controlled as follows. Air entering the branch line 34 through operation of valve 30, as described above, flows to a plunger control valve 186 connected to branch line 34. In turn, the plunger control valve 186 controls the flow of pilot air into the feed line 153 and through the passageway 154 formed in the upper cylinder 74 beneath the header plate 166 of plunger 165.

The plunger control valve 186 is a standard, commercially available "metered in-unrestricted out" type of actuating valve. In other words, the flow of pilot air from branch line 34 is metered in one direction through the plunger control valve 186 into feed line 153 and through the passageway 154 and then beneath the plunger header plate 166. In response to the pressurization of passageway 154, the header plate 166 is forced upwardly from the top of the upper cylinder 74 toward the cap 170

thereabove. In turn, the tapered tip 184 of plunger 165 is lifted upwardly from the tapered seat in nozzle tip 126 so that adhesive flowing through the adhesive discharge passageway 178 in nozzle 92 is ejected from the discharge orifice 180 of nozzle tip 126. In moving upwardly as viewed in Fig. 3, the plunger 165 places the compression spring 163 in compression against the lower guide 160.

To return the plunger 165 to a closed position relative to the nozzle 92, the plunger control valve 186 is operable to permit the unrestricted flow of air in the opposite direction therethrough, i.e., the air contained beneath the header plate 166, in air chamber 171, within passageway 154 and within feed line 153 is allowed to bleed back through plunger control valve 186 without restriction and then vents to atmosphere through the three-way cartridge valve 30. When the above-described pilot air path to the plunger header plate 166 is depressurized, the compression spring 163 forces the plunger 172 downwardly as viewed in Fig. 3 so that its tapered tip 184 seats within the discharge orifice 180 of the nozzle tip 126.

System Operation

An important aspect of this invention is that the plunger control valve 186 and pilot air control valve 68 connected to branch lines 34 and 36, respectively, operate so that atomizing air and pattern-shaping air are supplied to the area of the nozzle tip 126 both before the adhesive flow through the nozzle 92 is initiated, and after the adhesive flow therethrough is terminated. As mentioned above, the pilot air control valve 68 is an "unrestricted in-metered out" type of valve whereas the plunger control valve 186 is a "metered in-unrestricted out" type of valve. As a result, pilot air is quickly supplied by the pilot air control valve 68 to the air supply valve 46 which, in turn, allows atomizing air and pattern-shaping air to flow to the area of the nozzle tip 126 as described above. At the same time, the plunger control valve 186 is "metered in" so that pressurization of the air chamber 171 in upper cylinder 74 is slightly delayed. The axial, upward movement of the plunger 165, and subsequent discharge of adhesive from nozzle 92, therefore occurs after atomizing air and pattern-shaping air are present at the nozzle tip 126. On the other hand, the "unrestricted out" plunger control valve 186 ensures that the flow of adhesive from nozzle 92 is terminated before the pilot air within the pilot air chamber 52 of air supply valve 46 is bled off by the "metered out" pilot air control valve 68, thus allowing air supply valve 46 to close and stop the air flow to the atomizing and pattern-shaping air lines.

The operation of valves 68, 186 in this manner substantially eliminates cut-off drool, i.e., the formation of strands or thin fibers of adhesive in the area of the nozzle tip 126. No excess adhesive is allowed to remain in the area of the discharge orifice 180 of the nozzle tip 126 after the flow of adhesive is discontinued because the atomizing air and pattern-shaping air continues for some period of time after the flow of adhesive is shut down. Similarly, no start-up drool or formation of strand-like fibers of adhesive is obtained when the flow of adhesive is initiated because the atomizing air and pattern-shaping air is directed to the nozzle tip 126 prior to the time the adhesive flow begins.

As shown in Fig. 5, an adhesive stream 188 is ejected from the discharge orifice 180 of nozzle tip 126 and encounters the atomizing air ejected from the atomizing air discharge passageway 128. The atomizing air expands radially outwardly from the discharge passageway 128 and impacts the exterior surface of the adhesive stream 188 with sufficient flow rate and velocity so that the adhesive stream 188 is broken up into globules or droplets 190 for deposition onto a substrate 192. These droplets 190 are then impacted by pattern-shaping air ejected from the discharge orifices 146 in the air horns 148 to control the width of the pattern of adhesive droplets 190 deposited onto the substrate 192.

An important aspect of this invention is the versatility of the operation of applicator head 44 in accommodating a number of different types of hot melt adhesives to obtain the desired size and pattern of adhesive droplets 190. Thermoplastic adhesives have a relatively long "open time", i.e., the time in which they remain sufficiently molten to bond one substrate to another, but the open time of different types of thermoplastic adhesive varies from one to another. Moreover, some thermoplastic adhesives are pressure sensitive and thus have an extended open time wherein the adhesive can provide an effective bond even after it cools.

The applicator head 44 of this invention is operable to spray various types of hot melt adhesives in droplet form such that the individual droplets 190 are large enough to retain their specific heat once deposited onto a substrate 192 for a sufficient time period to permit a second substrate to be adhered to the first substrate 192. This is achieved in the instant invention by the provision of separate control valves 98 and 132 for the atomizing air and pattern-shaping air, respectively.

For example, the flow rate of the atomizing air and its velocity are primarily responsible for the size of the adhesive droplet produced for a given nozzle design. An increase in flow rate and velocity of the atomizing air tends to decrease the size of the adhesive droplets 190 because the adhesive

stream 188 is impacted more violently by the higher velocity atomizing air which breaks it up into smaller droplets 190. On the other hand, a decrease in the flow rate and velocity of the atomizing air tends to produce droplets 190 of larger size because of the reduced turbulence or violence of the impact between the slower moving atomizing air and adhesive stream 188.

In this manner, the size of the droplets 190 can be adjusted for different types of hot melt adhesives to match or correspond to the open time thereof so that the droplets 190 are large enough to retain their specific heat once deposited onto the substrate 192 for a sufficient time to create an effective bond with another substrate. Generally, hot melt adhesives with limited open time should be sprayed in relatively large droplets 190 and the size of the droplets 190 can be decreased as the open time of the adhesive increases or when using pressure sensitive adhesives.

The velocity and flow rate of the pattern-shaping air is adjustable primarily by adjustment of pattern-shaping air regulating valve 132 to control the width of the pattern of droplets 190 deposited onto the substrate 192. For example, as the velocity and flow rate of the pattern-shaping air increases, the pattern of droplets 190 tends to widen. On the other hand, as the flow rate and velocity of the pattern-shaping air decreases, the resulting pattern of droplets 190 narrows on the substrate 192.

It is contemplated that in most instances, the ratio of the flow rate and velocity of atomizing air to pattern-shaping air would be adjusted instead of adjusting only one of the atomizing air stream or the pattern-shaping air stream while maintaining the other constant. For example, adjustment of the ratio of atomizing air to pattern-shaping air so that the velocity and flow rate of the atomizing air increases while the velocity and flow rate of the pattern-shaping air decreases, results in the formation of a relatively narrow spray pattern on substrate 192 consisting of relatively small droplets 190. Adjustment of the ratio of atomizing air to pattern-shaping air so that the velocity and flow rate of the atomizing air decreases while the velocity and flow rate of the pattern-shaping air increases results in the formation of a relatively wide spray pattern on substrate 192 consisting of relatively large droplets 190.

Given the wide variety of thermoplastic adhesives which are commercially available, and the differing requirements of the types of applications for which such adhesives are utilized, it is contemplated that the ratio of the flow rate and velocity of atomizing air to pattern-shaping air for a particular application would be determined by experimenting with the settings of the atomizing air regulating valve 98 and pattern-shaping air regulating valve

132. Additionally, the particular configuration of the nozzle 92 employed in the applicator head 44 affects the velocity of the atomizing air and the pattern-shaping air depending upon the dimensions of the annular atomizing air passageway 124 and the two pattern-shaping air orifices 146 in the air horns 148 of the air cap 94.

The following examples provide representative of parameters for the atomizing air and pattern-shaping air flow rates, in a nozzle 92 and air cap 94 of the type shown in the Figs., which have been proven experimentally to provide acceptable results for a given application.

Example 1

Type of Adhesive: Eastman A148 adhesive

Adhesive Temperature: 375 °F

Adhesive Flow Rate: 300 g/min

Nozzle Spacing: 12" from substrate

Atomizing Air Flow Rate: 2.76 scfm

Pattern-Shaping Air Flow Rate: 3.22 scfm

Using the type of adhesive and adhesive flow rate given above, the stream of adhesive discharged from the spray nozzle was impacted in this Example 1 by a stream of atomizing air having a flow rate of 2.76 scfm. This produced adhesive blobs or droplets 190 having a transverse dimension of about 1/4" to 7/16". The pattern of droplets 190 obtained by the stream of pattern-shaping air at a flow rate of 3.22 scfm was approximately 14" in width. For the type of adhesive utilized, the size of the droplets 190 was considered sufficient to insure that they would have sufficient open time for the desired application.

Example 2

Type of Adhesive: Eastman A148 adhesive

Adhesive Temperature: 375 °F

Adhesive Flow Rate: 300 g/min

Nozzle Spacing: 12" from substrate

Atomizing Air Flow Rate: 3.47 scfm

Pattern-Shaping Air Flow Rate: 3.21 scfm

In this example, the same adhesive and adhesive flow rate was employed as in Example 1. The difference in this example is that the flow rate of the atomizing air was increased relative to the flow rate of the pattern-shaping air. This produced adhesive droplets 190 which were slightly smaller in transverse dimension, and also the pattern width decreased so that the droplets 190 were more tightly grouped together, than in Example 1.

Alternative System Configurations

Referring now to Fig. 4, a schematic illustration is provided of the adaptability of applicator head 44 to different dispensing systems. The applicator head 44 is useful for hand-held types of operations as shown in Figs. 1-3 and at the top of Fig. 4, and for more automated applications as shown in intermediate and lower segments of Fig. 4 wherein the applicator head 44 mounts to different support means which supply pilot air, adhesive and heated air to the applicator head 44.

More specifically, the uppermost portion of Fig. 4 illustrates the applicator head 44 in combination with the spray gun 12 shown in Fig. 1 and discussed in detail above. This combination would be utilized in hand held applications for applicator head 44 such as certain types of assembly operations.

Referring to the center portion of Fig. 4, the spray gun 12 is eliminated and replaced by a mounting block 200 supported by a rod 202. The mounting block 200 carries the service block 41 which, in turn, mounts the applicator head 44 in a position to support the support block 42. The service block 41 is formed with a port 204 to receive pilot air for the plunger 165 of applicator head 44 and a port 209 for hot melt adhesive. A port 206 is formed in support block 42 to receive air for the atomizing and pattern-shaping passageways of applicator head 44, and a port 208 is also formed in support block 42 to receive pilot air for operating an air supply valve (not shown) such as the air supply valve 46. The embodiment in the center of Fig. 4 operates in an essentially identical manner to that disclosed in Figs. 1-3 and 5 except that the supply of pilot air and hot melt adhesive thereto is preferably controlled by a programmable controller (not shown) instead of a hand operated trigger 18 as in spray gun 12.

Referring to the bottom portion of Fig. 4, a manifold 210 is illustrated which is supported on a mounting rod 212. The manifold 210 is adapted to mount several applicator heads 44 on either of its sides, each of which are operated by a programmable controller (not shown). In the manifold there shown, ports are provided to mount two applicator heads on one side and one applicator head on the opposite side. To this end, the manifold 210 is formed with ports 214 adapted to connect to the port 154 of applicator head 44 to supply pilot air for moving the plunger within applicator head 44. Hot melt adhesive is transmitted into the passage 150 of applicator head 44 from ports 216. Additionally, the manifold 210 is formed with ports 218 which connect to the port 66 in applicator head 44 to supply air for the atomizing air and pattern-shaping air passageways thereof. The manifold 210 has suitable passageways (not shown) which connect control air supply line 215 with ports 214, hot melt

adhesive supply line 219 with ports 216 and shaping and atomizing air supply line 219 with ports 218.

While the invention has been described with reference to a preferred embodiment, it should be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out the invention, but that the invention will include all embodiments falling within the scope of the appended claims.

Claims

1. Apparatus for spraying droplets of thermoplastic adhesive onto a substrate, comprising:
first means for ejecting a stream of molten thermoplastic adhesive from the discharge orifice of a spray nozzle;

second means for directing a stream of atomizing air against the exterior of said stream of molten thermoplastic adhesive to break up said stream of molten thermoplastic adhesive into droplets;

flow control means associated with said first means and said second means for initiating the flow of said stream of atomizing air prior to initiating the discharge of said stream of molten thermoplastic material from said discharge orifice, and for stopping the flow of said stream of atomizing air after terminating the flow of said stream of molten thermoplastic material from said discharge orifice.

2. The apparatus of claim 1 in which said first means includes a pilot air actuated plunger carried in an adhesive passageway formed in said spray nozzle, said plunger being movable between an open position relative to said discharge orifice of said spray nozzle to permit the passage of adhesive therethrough, and a closed position relative to said discharge orifice to stop the passage of adhesive therethrough.

3. The apparatus of claim 2 in which said flow control means comprises:

first valve means for supplying pilot air to said plunger to move said plunger between said open position and said closed position;

second valve means for supplying atomizing air to said second means, said second means directing the atomizing air against said stream of molten thermoplastic adhesive ejected from said spray nozzle;

said second valve means being operable to initiate the supply of atomizing air to said second means prior to movement of said plunger to said open position in response to operation of said first valve

means, and said second valve means being operable to terminate the supply of atomizing air to said second means subsequent to the movement of said plunger to said closed position in response to operation of said second valve means.

4. The apparatus of claim 3 in which said first valve means is a plunger control valve which is effective to meter the flow of pilot air therethrough in a first direction to said plunger to slowly move said plunger to said open position, said plunger control valve being effective to permit the unrestricted flow of pilot air therethrough in an opposite, second direction to quickly bleed air from said plunger and permit said plunger to quickly move to said closed position.

5. The apparatus of claim 3 in which said second valve means comprises:

a pilot operated valve communicating with said second means, said pilot operated valve being movable between an open position in which a stream of atomizing air passes therethrough to said second means and a closed position in which the flow of said stream of atomizing air to said second means is terminated;

an air control valve connected to said pilot operated valve and to a source of pilot air, said air control valve being effective to permit the unrestricted flow of pilot air therethrough in a first direction to said pilot operated valve to quickly move said pilot operated valve to said open position, said air control valve being effective to meter the flow of air therethrough in an opposite, second direction to slowly bleed pilot air from said pilot operated valve and permit said pilot operated valve to slowly move to said closed position.

6. Apparatus for spraying droplets of thermoplastic material onto a substrate, comprising:

an applicator head comprising:

(i) an applicator body;

(ii) a spray nozzle mounted to said applicator body, said spray nozzle being formed with an atomizing air passageway and an adhesive passageway having an outlet orifice;

(iii) a plunger carried in said adhesive passageway of said nozzle, said plunger being movable between an open position relative to said outlet orifice of said adhesive discharge passageway to permit the passage of a stream of thermoplastic adhesive therethrough, and a closed position to stop the flow of thermoplastic adhesive through said outlet orifice;

(iv) pilot air operated, air supply valve means connected to a source of atomizing air and to said atomizing air passageway in said nozzle for opening and closing the flow of atomizing air to said nozzle;

support means for mounting said applicator head and for supplying pilot air and molten thermoplastic

adhesive thereto, comprising:

(i) air control valve means for controlling the flow of pilot air to said air supply valve means to open and close said air supply valve means;

(ii) plunger control valve means for controlling the flow of pilot air to said plunger to move said plunger to said open position and to allow said plunger to return to said closed position;

(iii) means for continuously supplying adhesive to said spray nozzle.

7. The apparatus of claim 6 in which said support means comprises a hand-held spray gun having means for manually operating said air control valve means and said plunger control valve means.

8. The apparatus of claim 6 in which said support means comprises a manifold adapted to mount at least one of said applicator heads, said manifold being formed with a first internal passageway carrying molten thermoplastic adhesive communicating with said nozzle, a second internal passageway carrying pilot air communicating with said plunger and a third internal passageway carrying pilot air communicating with said air supply valve means.

9. A method of spraying droplets of thermoplastic adhesive, comprising:

directing a stream of atomizing air in the area of the discharge orifice of a spray nozzle;

thereafter initiating the flow of a stream of thermoplastic material from said discharge orifice of said spray nozzle;

impacting the outside of said stream of thermoplastic material with said stream of atomizing air to cause said stream of thermoplastic adhesive to break up into droplets;

discontinuing the flow of said stream of thermoplastic material from said discharge orifice;

thereafter discontinuing the flow of said stream of atomizing air in the area of said discharge orifice of said nozzle.

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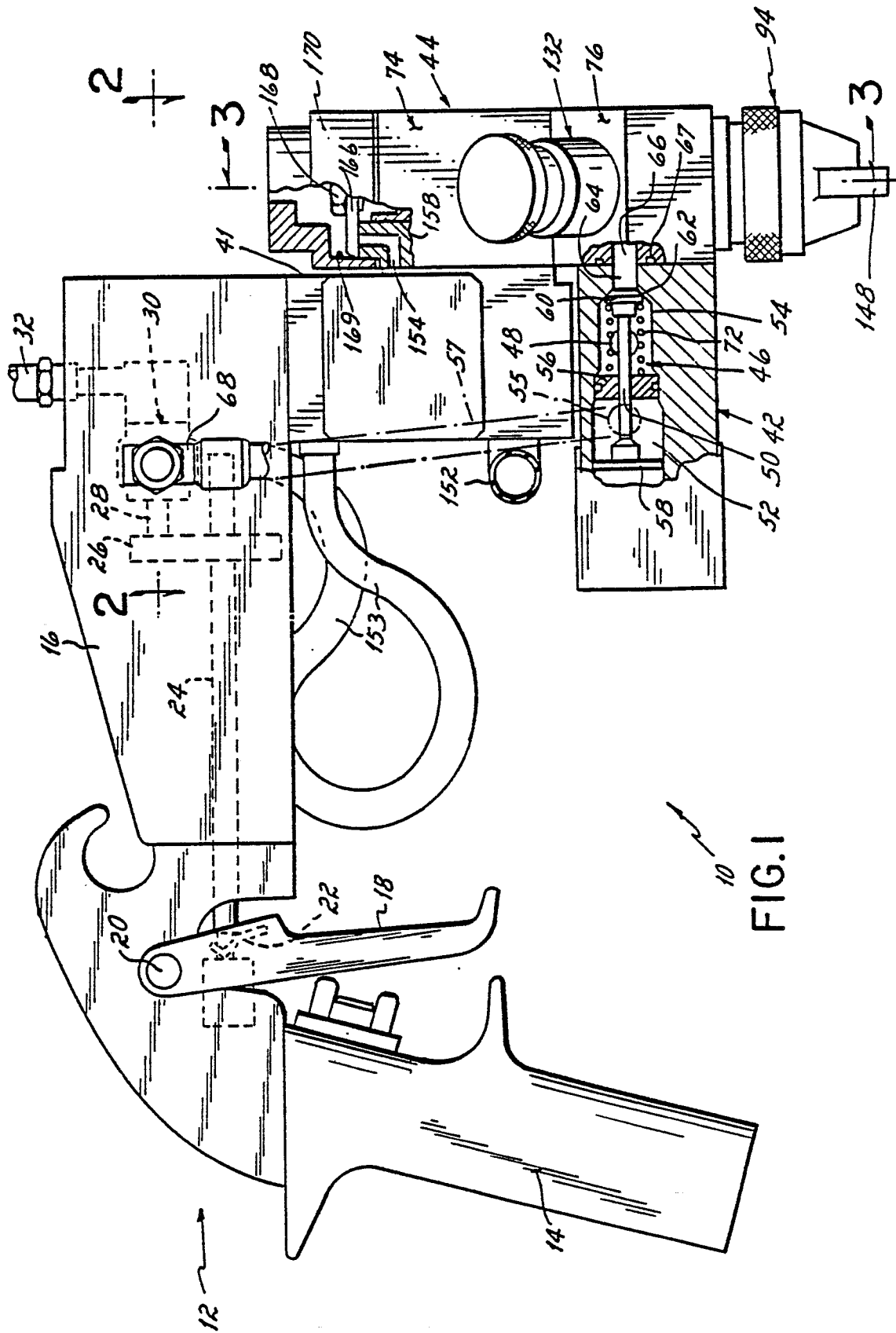
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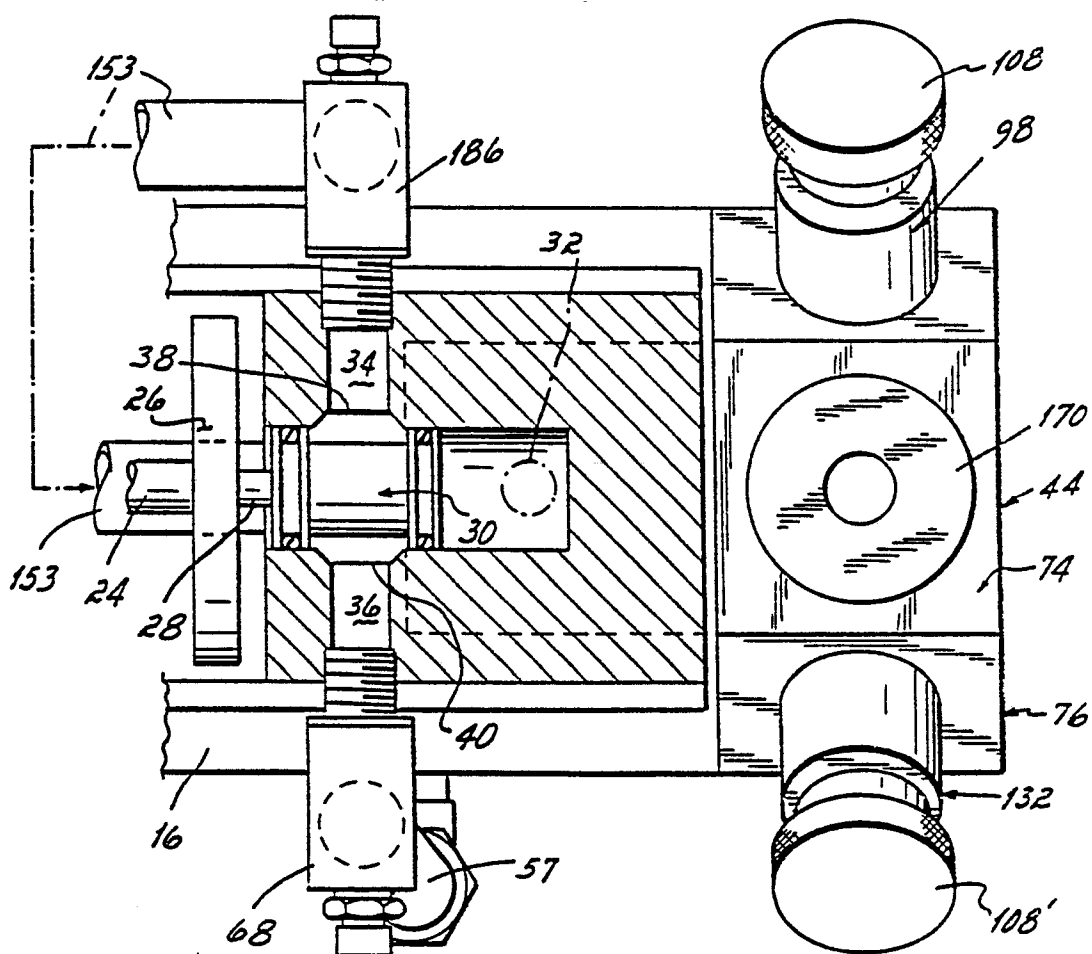


FIG. 2

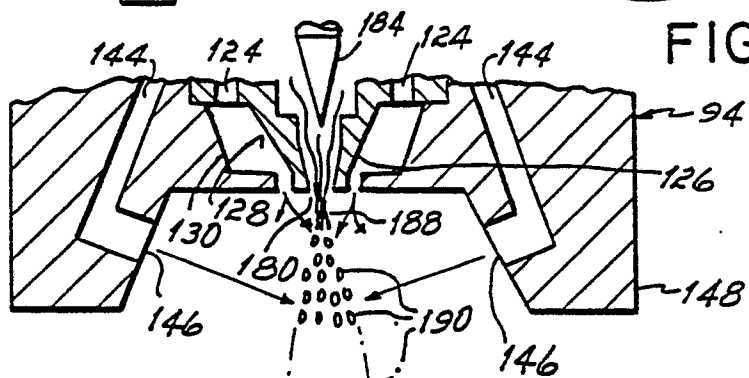


FIG. 5

