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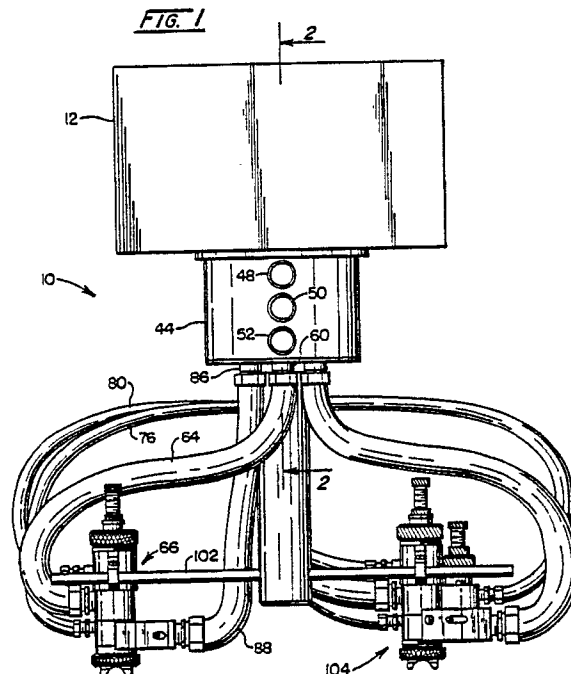
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(54) **Rotating head assembly.**

(57) A plurality of spray guns are mounted on one end of a robot arm and the other end of the arm is controlled in its orientation by appropriate mechanical apparatus. Air is fed from two supplies to each spray gun. One air supply is at high pressure low volume and controls the paint supply to the spray gun. The second supply of air is at high volume low pressure and it serves to atomize paint and control the pattern of the spray exiting from the spray gun.



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ROTATING HEAD ASSEMBLY

This invention relates to a plurality of paint spray guns mounted on a rotatable arm for automatically controlling spray painting of objects and the paint and air supply systems for accomplishing the desired result.

Automatic control of spray painting systems to spray paint automobile bodies and other articles in a paint spray booth using a paint spray gun carried by a robot or other automatic painting device is well known in the art. However, where the painting is to be done entirely by automatically controlled devices, it has been found difficult to paint the objects at a fast enough rate and with a minimized volume of paint. Most conventional systems use atomizing air at a high pressure, that is, above 15 psi and when high pressure air is used this resulting spray tends to explode out of the spray nozzle into the atmosphere with the result of a broad oval spray pattern. The greater the pressure of the atomizing air, the greater will be the angle subtended by the paint spray as measured from the spray nozzle.

In such environments, the paint spray gun must always be arranged adjacent to and facing the surface to be painted and there is an optimum spacing between the nozzle and the surface to be painted. The optimum spacing decreases with the increase in atomizing air pressure, partially because of the angle subtended by the spray. Accordingly, if there is an object to be painted which has an irregular surface, such as an automobile body or the inside of some container, the robot arm needs to maneuver the paint spray gun to a number of different positions. Also, the more irregular the surface to be painted combined with high atomizing air pressure can cause almost unpredictable turbulence and a resulting loss of misdirected paint.

Having two spray guns mounted on a single robot arm is known in the prior art. The object of having more than one spray gun or spray nozzle on the end of a robot arm is to minimize movement and orientation of the gun to successive spray orientations or the spray guns may have a uniform spray pattern for each gun but each gun may have a different spray pattern than the other one mounted on the same arm. Thereby, one spray gun may spray a thin line while the other sprays an oval pattern. Insofar as is known by the inventor herein, there is prior knowledge of having a plurality of spray guns on the robot arm but there is no knowledge of having different spray patterns from each gun.

Environmental problems of airborne paint and paint solvents must be solved by filtering air from

paint booths and the greater the quantity of misdirected paint, the greater will be the need for increased filtering.

In this invention, a robot arm bearing two or more spray guns is mounted to allow the robot arm to be oriented by computer program controls which are known in the industry and not a part of this invention.

The spray guns involved are specifically structured to use low pressure high volume air to atomize paint and control spray patterns to thereby minimize paint contamination of the atmosphere and wasted paint. Using low pressure high volume air and a laminar flow of the paint atomizing air exiting the nozzle results in a more confined pattern of paint spray leaving the nozzle and thereby, the control of the paint spray is simplified. With low pressure air there is less of a tendency to have transient spray patterns at irregular surfaces.

The system also uses high pressure low volume air as a controlling device in the spray guns and the reason for the high pressure is to more accurately control the onset and termination of paint through a needle valve at the outlet end of the spray gun nozzle. High pressure (above about 15 psi) is transmitted by pressure waves relatively quickly from the high pressure air supply to the spray gun. The preferred range of high pressure air is in the range 50-150 psi but could be as high as 200 psi. In the system of this invention the high pressure low volume air is used as a control mechanism rather than paint atomizing or a spray pattern control. It may be used to control the opening and closing of the needle valve of the paint supply and/or it may be used to control the air feed to the spray pattern adjusting orifices mounted adjacent the outlet end of the spray gun downstream of where the paint has been atomized.

Objects of the invention not clear from the above will be fully understood by a review of the drawings and the description of the preferred embodiment which follows.

Fig. 1 is an elevational view of a robot arm having a plurality of paint spray guns mounted thereon and with air and paint supply hoses;

Fig. 2 is a combined sectional and schematic view taken along line 2-2 of Fig. 1 and showing schematically control and supply passages;

Fig. 3 is a sectional view taken along 3-3 of Fig. 2;

Fig. 4 is a sectional view of the paint spray gun shown on the left-hand side of Fig. 1; and

Fig. 5 is a sectional view of the paint spray gun shown on the right-hand side of Fig. 1.

Looking to Fig. 1, a computer controlled robot arm 10 includes a plurality of paint spray guns mounted on a cross-arm at one end and a housing 12 on the other end.

As best seen in Fig. 2, the housing 12 encloses a motor and computer control system 14 configured to orient the robot arm 10 in a desired position, it includes a sprocket drive 16 mounted on a shaft 18 which drives an endless chain 20 around another sprocket 22 surrounding the arm 10.

The upper end of the arm 10 includes a head 24 having radially opening apertures into fluid transmitting ducts 26, 28, 30 and 32. The number of ducts in arm 10 is limited by the cross-sectional area of arm 10 and the needed volume of fluid which must be conveyed through the ducts.

For convenience, a paint supply 34 is schematically illustrated as being connected directly to duct 26. A high pressure low volume air supply 36 is connected to duct 30 through a regulator 38, which may be a solenoid valve, and the regulator is controlled through a mechanism 40 such as a computer or perhaps a lever or trigger controlled mechanism relating to assembly line movement.

The robot arm 10 is mounted in appropriate bearings 42 as it passes through an aperture in the housing 12. This allows the housing to remain stationary while the robot arm 10 rotates about a vertical axis. In this discussion of the invention, the reference to a "vertical axis" is for convenience and relates to the orientation of Figs. 1 and 2 in the drawings accompanying this application. It is obvious that the orientation of the robot arm could be swung through a vertical plane of 360° if desired.

Circumscribing the arm 10 after it passes downward through bearings 42 is a cylindrical manifold 44 specifically structured to dispense low pressure high volume air from a low pressure air supply 46. For convenience, the drawings illustrate three inlet openings 48, 50 and 52 entering the manifold 44 for subsequent distribution as will be discussed in more detail subsequently. However, there is no known scientific or mechanical reason to place a limit on the number of annular air distribution rings.

Air entering the manifold 44 through opening 48 will be sealed off from other parts of the manifold by a circular wall 54. Wall 54 is securely mounted on arm 10 to rotate with the arm, however, the cylindrical manifold 44 is securely mounted on a plate 56 which in turn is securely mounted to the stationary housing 12. Therefore, the manifold 44 does not rotate when arm 10 rotates but wall 54 does rotate. A sliding seal 58 is mounted between wall 54 and manifold 44 to prevent the escape of air. Because the high volume low pressure air entering the manifold from supply 46 is at such a low pressure, the quality of the seal 58

does not have to be particularly significant. On the other hand, with conventional systems of high pressure, the system of this invention could not work because of air leakage and too great a pressure drop by air escaping around seal 58. The low pressure high volume air supplied by source 46 should be a pressure less than 15 psi and preferably in the range 7-10 psi. As indicated previously, the high pressure low volume air supply 36 supplies air above 15 psi and preferably in the range 50-150 psi.

Looking again to Fig. 2, air entering manifold 44 through inlet 48 will exit in a downward direction through a tube 60. Similarly, air entering manifold 44 through inlet 50 will exit through a tube 62.

For illustrative purposes attention is called to Fig. 3 which shows six tubes to dispense air from the manifold. Whether there are six tubes to serve six inlets to the manifold or ten tubes to serve five inlets to the manifold is a matter of design by the user and will depend on how many spray nozzles he intends to use on the lower end of the robot arm. As stated earlier, there is no known mechanical reason to place a limit on the number of air feeding tubes.

Looking now to Fig. 1, air dispensed through tube 60 is transmitted by hose 64 to a first spray gun indicated generally at 66 and illustrated in cross-section in Fig. 4. Hose 64 is connected to an inlet 68 in gun 66 and will then pass through a first flow path 70 to a chamber around a nozzle 72 where it serves to atomize paint discharged through a needle valve 74 at outlet orifice 75.

Looking to Figs. 2 and 3, paint from paint supply 34 is delivered through duct 26 and conveyed by a hose 76 to a paint inlet 78 in gun 66 to feed paint into a channel 79 leading to the needle valve 74.

The high pressure low volume air supply 36 supplies air to duct 30 and subsequently to a hose 80 which delivers the air through an inlet 81 in the spray gun of Fig. 4 and serves to start and stop paint flow through the needle valve 74. An application of pressure by the high pressure supply 36 through inlet 81 into gun 66 will cause the piston 82 in cylinder 83 to retract or move to the left as illustrated in Fig. 4 which will in turn adjust the needle 84 which controls the volume of paint flowing through the needle valve 74 and nozzle 72.

Air is supplied to spray gun 66 to control the pattern of the spray exiting nozzle 72 and it is supplied from the manifold 44 through a tube 86 and subsequently through hose 88 to an inlet 90 leading into the gun 66. Air through inlet 90 moves through a second flow path 92 to one or more orifices 94. Orifices 94 are specifically located and oriented downstream of the nozzle 72 to impinge on the oval spray pattern of the atomized paint and

to compress it into the desirable spray pattern. What constitutes a desirable spray pattern depends upon the object to be sprayed and the provision of orifices to correspond with the control mechanism turning the spray pattern control air on and off. The flow of air to the pattern control orifices is completely controlled by the operator during the process even though that operator may be a computer program.

It will be observed that the flow paths 70 and 92 in the gun 66 are always completely open, having no obstructions to inhibit constant uniform flow. The only on and off concerns in gun 66 are the paint. Exactly when the paint is on and when it is off is controlled through the control mechanism 40 which controls the regulator 38 to allow air to flow through inlet 81 and retract the needle 84 or to bleed air from the cylinder to allow the needle valve 74 to close. A hand controlled adjustment screw head 96 controls the degree of bias on the shoulder 98 by the coil spring 100.

Fig. 1 shows only two spray guns and both are oriented in the same direction and both are mounted on a cross-bar 102. This is purely for illustration and there could be two cross-bars or ten cross-bars depending on the needs of the particular robot arm. Fig. 1 also illustrates two different kinds or models of spray guns and it is possible that two different spray guns could be mounted on cross-bar 102. However, two spray guns identical to spray gun 66 might be appropriate. On the other hand, the operator could use two spray guns such as 104 illustrated in Fig. 5 on cross-arm 102.

Without going through the exercise of describing the exact flow paths and hoses leading to the gun 104 illustrated in Figs. 1 and 5, it will be clear from the above description what the source of each of the air and paint supplies is identified by like numbers illustrating like elements. However, there are certain additional features in the second spray gun 104 and they will be described specifically. The prime difference between spray guns 66 and 104 is that spray gun 104 includes a control mechanism for controlling the flow of high volume low pressure air to the spray pattern control orifices 94. This is accomplished by a housing 105 attached to spray gun 104 and connecting the hose 88 to pass through inlet 90. Inlet 90 directs the air into a passage 106 within housing 105 which may be blocked by a piston 108. Piston 108 reciprocates in a cylinder 110 in response to a high pressure low volume air supply which feeds to inlet 112 and may retract the piston 104 by pressure in cylinder 110 applied against the C-shaped seal 114. Note that the cross-sectional area of the seal 114 and its mechanical backing is greater than the cross-sectional area of the backside of piston 108. As a result, a pressure in the cylinder 110 which is

great enough to overcome the bias of coil spring 116 will cause the piston 108 to move to the left as shown in Fig. 5. Thereby, air flowing in passage 106 from inlet 90 will pass on through to flow path 92 and out through the orifices 94.

As indicated previously, this application is a continuation-in-part of two prior applications involving paint spray guns and each of those applications includes specific detailed description of the internal structure of the spray guns themselves and to the extent any additional information is required for a complete understanding of this invention, both applications are incorporated herein by reference. Both of those applications disclose structure illustrated in Figs 4 and 5 surrounding the nozzle 72 which insures laminar flow of the high volume low pressure air passing through pathways 70 so that the oval spray pattern exiting the spray gun will be of a smaller cross-sectional area than the guns of the prior art system which use relatively high pressure air for atomizing paint. As should be abundantly clear, any high pressure air will tend to expand at a much more rapid rate and accordingly, the spray pattern of a conventional prior art nozzle will have a greater cross-sectional area at every distance from the spray gun than will the spray of this invention involving low pressure high volume air when measured at the same distance from the spray gun. Because of this feature, the guns of the instant invention may be located further from the object to be spray painted and still concentrate the paint in a more limited area. Thereby, there is less random turbulent air flow from the guns of the instant invention and thereby less paint is lost from the paint booth and less paint must be filtered from the air to prevent external pollution. Alternatively, the guns of this invention may be located even closer to the surface to be painted than prior art spray guns because there will be less of a reflected air blast from the surface.

In discussing the operation of the robot arm 10 there was no mention of a use for some of the vertical ducts 26, 28, 30 and 32. The number of ducts, their cross-sectional area and their length all combine to limit their use. They could provide a plurality of high pressure air supplies of different pressures and one paint supply duct. On the other hand, there could be one high pressure air supply duct and a plurality of paint supply ducts. Perhaps, the different paint supply ducts could have different colors of paint.

Claims

1. In a spray painting system including two air supply systems of different pressures, at least two paint spray guns, means for supplying paint to

each gun, all of said guns being mounted on an adjustable arm, means for adjusting said arm, and means for adjusting the supply of paint to each gun,

each gun including a needle valve at a nozzle, liquid connecting means for conducting paint from said paint supply means to each said needle valve, each of said air supply systems being connected in air communication with each gun, one air supply system supplying high volume and low pressure air and the other air supply system supplying high pressure and low volume air,

said high pressure air being supplied at a pressure greater than about 15 psi,

said low pressure air being supplied at a pressure less than about 15 psi,

said low pressure air supply system being connected to continuously supply a flow of air in a first flow path through said gun and out of said nozzle for atomizing paint flowing through said needle valve,

said high pressure air being connected to a cylinder in each said gun to control a means for opening, closing and the degree of opening of said needle valve,

a second flow path for said low pressure air through said gun, said second flow path leading to a plurality of orifices so located and oriented to direct low pressure air toward atomized paint after said paint exits said gun in atomized condition, said orifice directed air serving to control the pattern of the paint spray.

2. The system of claim 1 wherein the low pressure air is in the range 7-10 psi.

3. The system of claim 2 including means for controlling the volume of air flowing through said second flow path to control the shape of the paint spray.

4. The system of claim 3 including means in the flow path of the atomizing air to provide laminar flow of air at the exit of the atomizing air from the gun.

5. The system of claim 4 wherein at least one of said guns includes a low pressure flow control apparatus which is controlled through application of said high pressure air, said control apparatus including a reciprocal piston which is moveable from open to closed position, said piston being biased to closed position,

when in closed position said reciprocal piston blocking the flow of air through the second flow path from the low pressure air supply to the orifices, a second cylinder in said gun being configured to receive said reciprocal piston in a retracted open position to open the second flow path from the low pressure air supply to the orifices,

means for causing said high pressure air to move the piston to a retracted open position.

6. The system of claim 5 wherein the means for supplying paint includes a duct through the arm and the means for supplying high pressure air includes another duct through the arm.

7. The system of claim 6 wherein the low pressure air is supplied from a cylinder mounted around said arm, said cylinder being sealed to said arm by means to prevent the escape of low pressure air when the arm rotates and the cylinder remains stationary.

8. The system of claim 1 including means for controlling the volume of air flowing through said second flow path to control the shape of the paint spray.

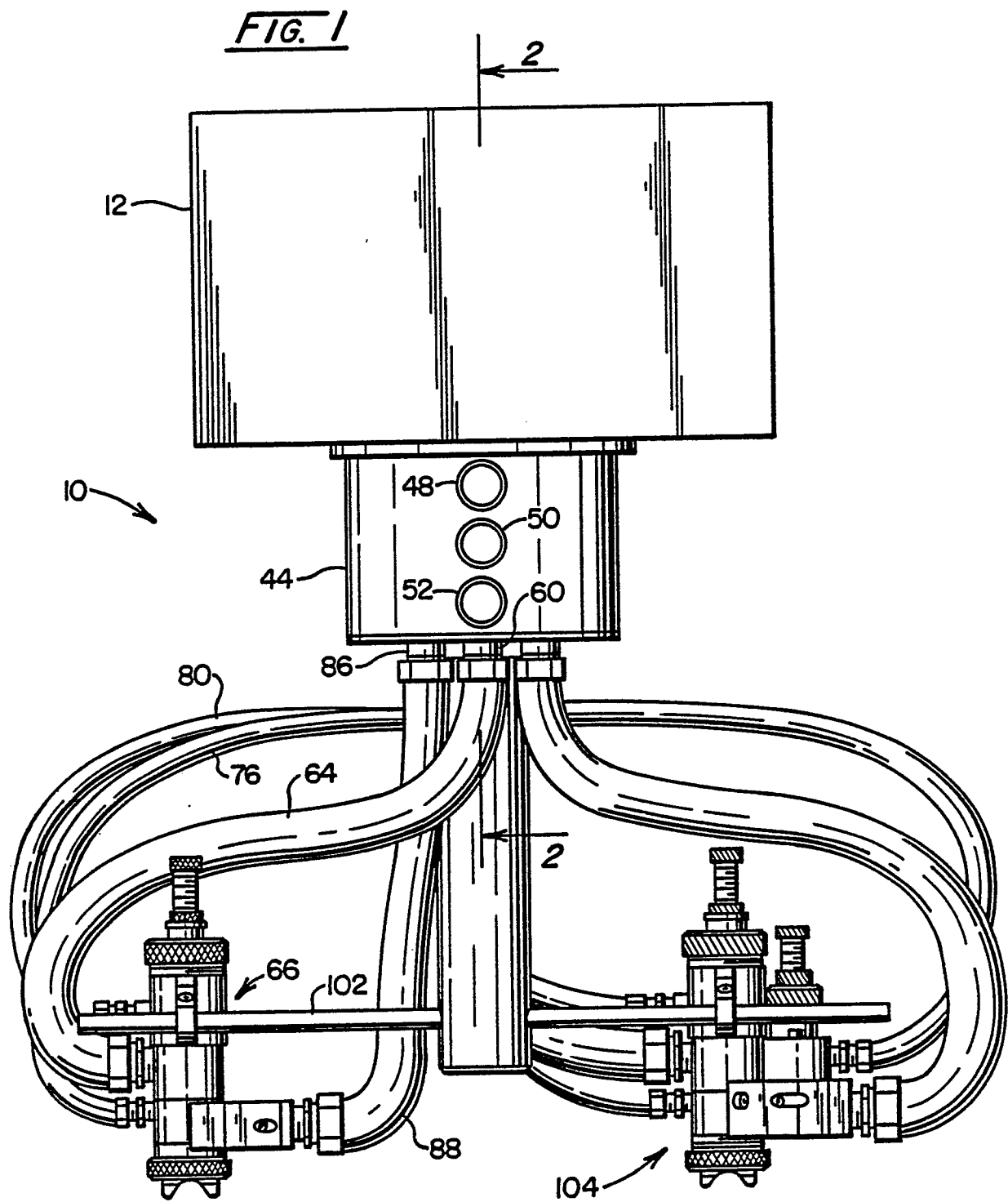
9. The system of claim 1 including means in the flow path of the atomizing air to provide laminar flow of air at the exit of the atomizing air from the gun.

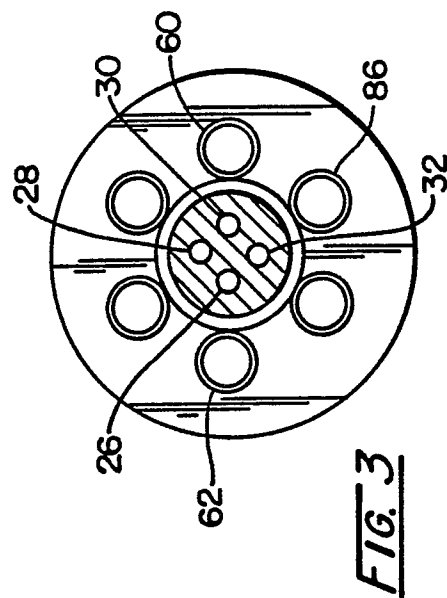
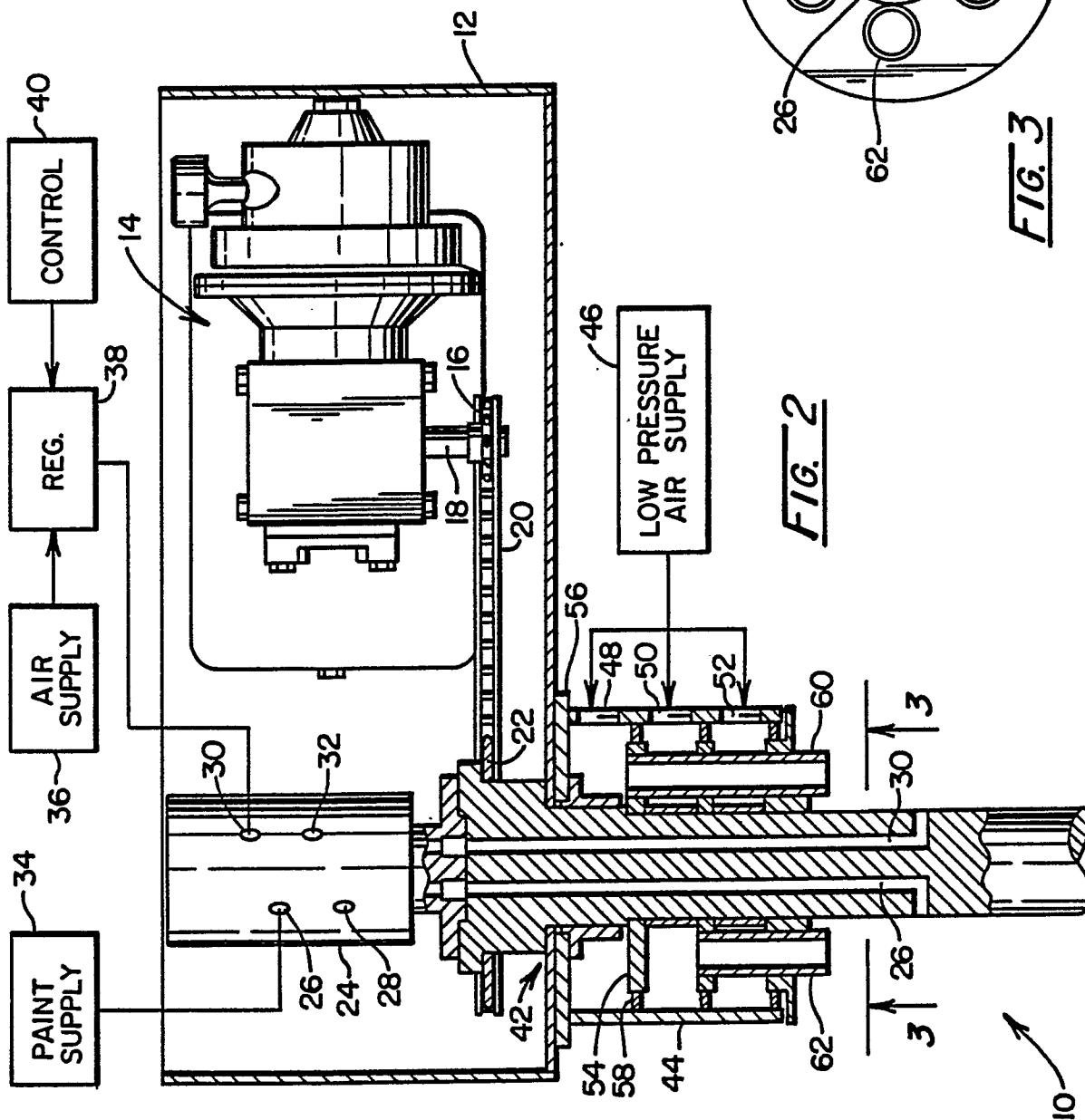
10. The system of claim 1 wherein at least one of said guns includes a low pressure flow control apparatus which is controlled through application of said high pressure air, said control apparatus including a reciprocal piston which is moveable from open to closed position, said piston being biased to closed position,

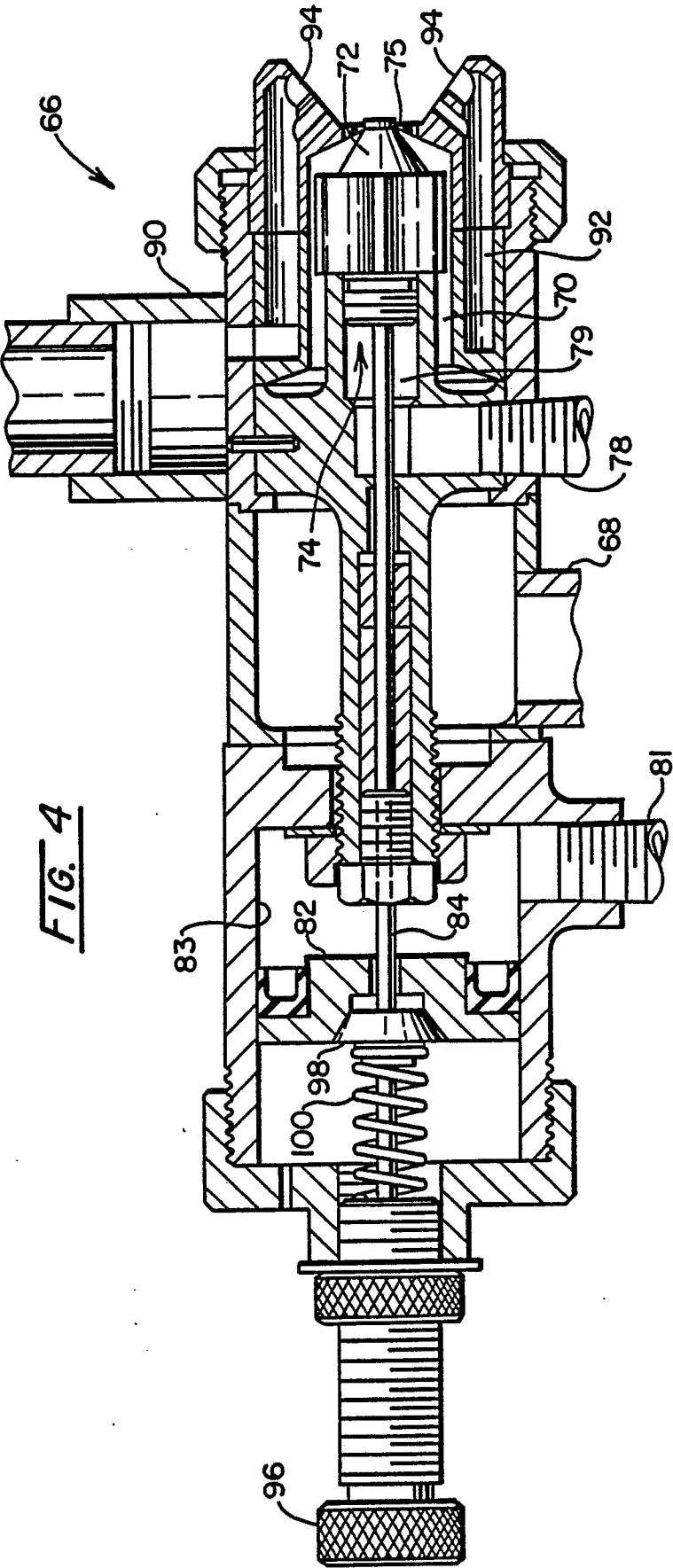
when in closed position said reciprocal piston blocking the flow of air through the second flow path from the low pressure air supply to the orifices, a second cylinder in said gun being configured to receive said reciprocal piston in a retracted open position to open the second flow path from the low pressure air supply to the orifices, means for causing said high pressure air to move the piston to a retracted position.

11. The system of claim 1 wherein the means for supplying paint includes a duct through the arm and the means for supplying high pressure air includes another duct through the arm.

12. The system of claim 1 wherein the low pressure air is supplied from a cylinder mounted around said arm, said cylinder being sealed to said arm by means to prevent the escape of low pressure air when the arm rotates and the cylinder remains stationary.







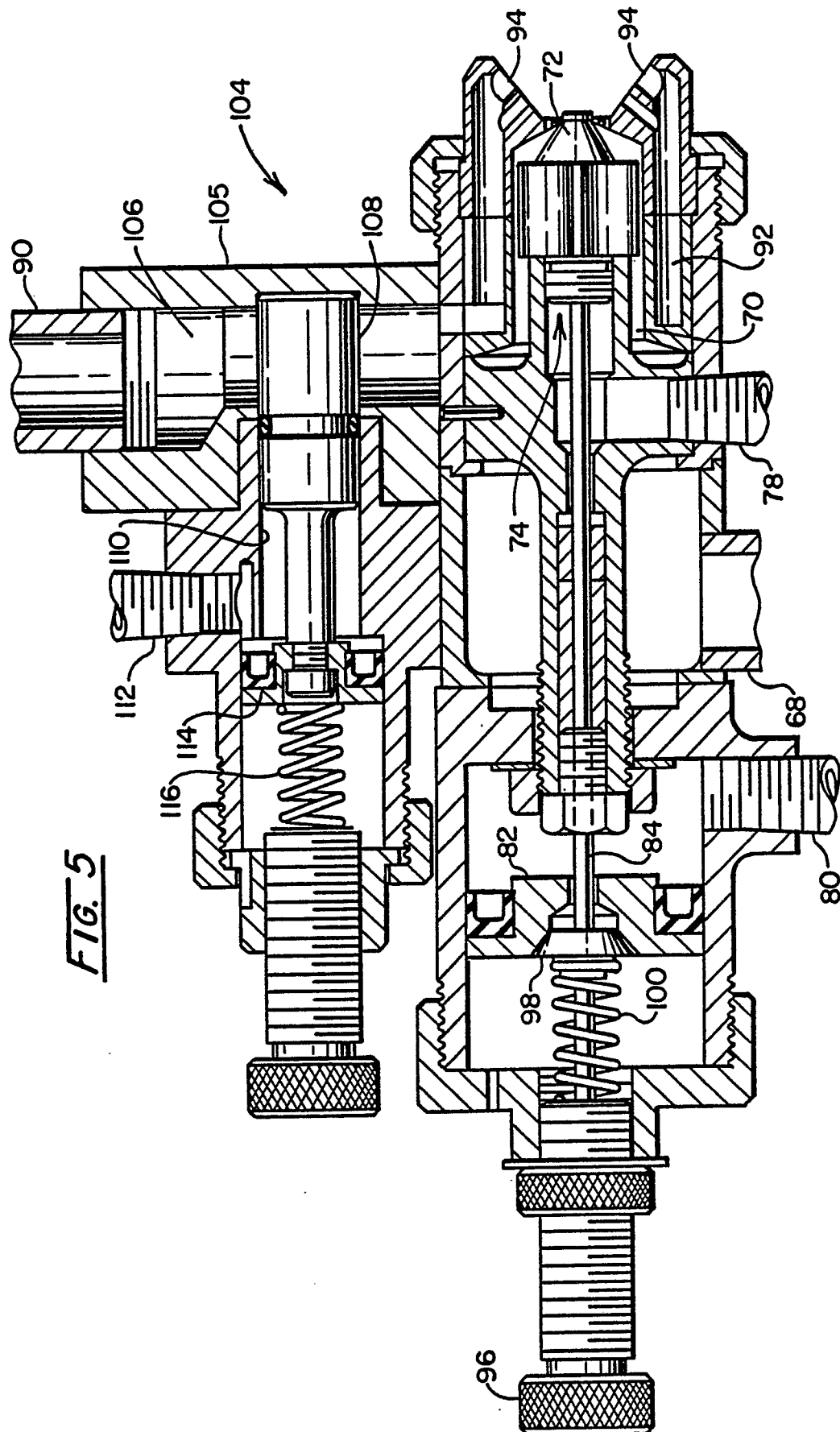


FIG. 5