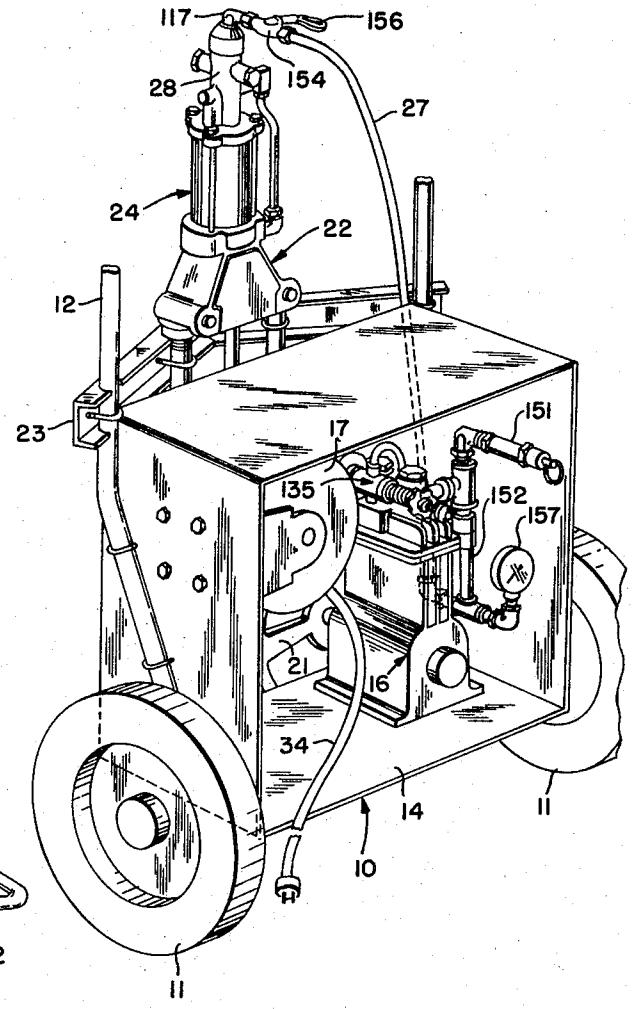
Jan. 30, 1968 G. S. LEVEY 3,366,066

SELF-CONTAINED PUMP SYSTEM FOR AIRLESS SPRAYING AND THE LIKE

Filed Jan. 5, 1966 4 Sheets-Sheet 1

Fig. 2



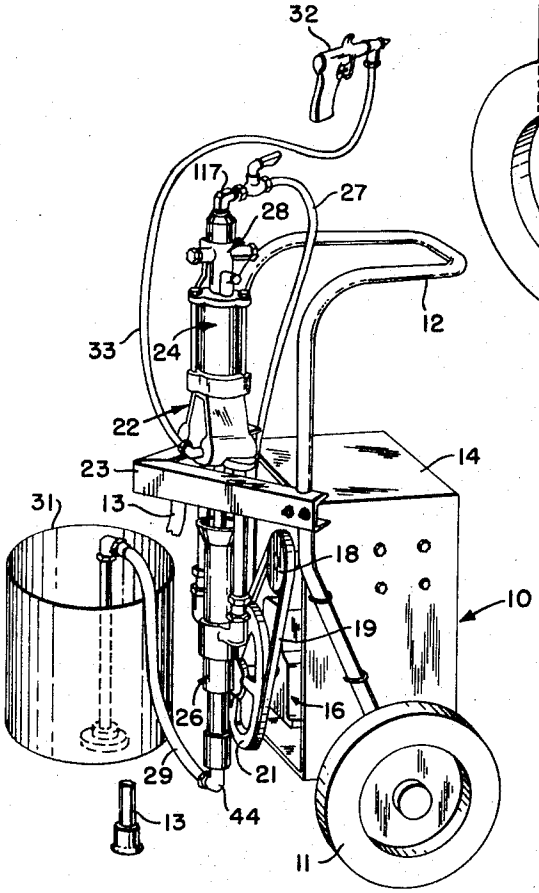


Fig. 1

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SELF-CONTAINED PUMP SYSTEM FOR AIRLESS SPRAYING AND THE LIKE

Filed Jan. 5, 1966 4 Sheets-Sheet 2

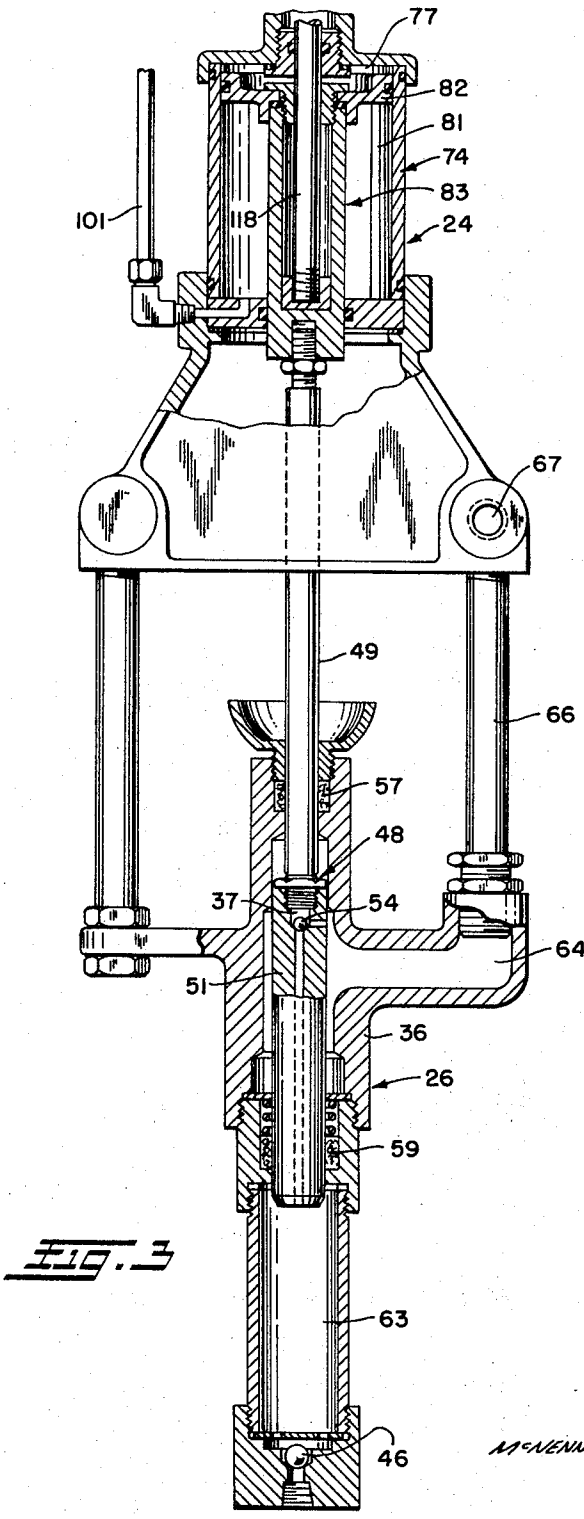


Fig. 3

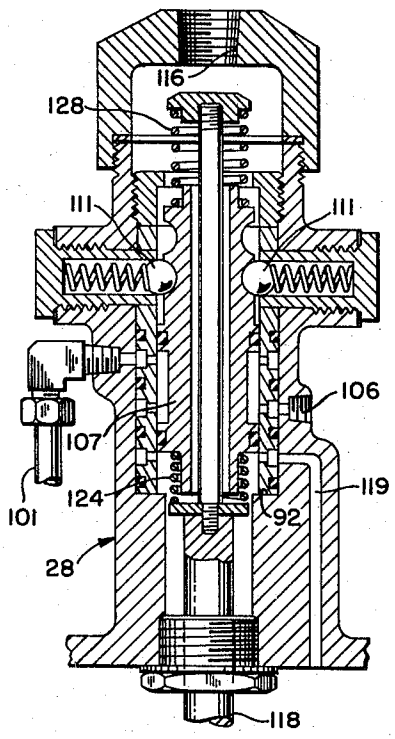


Fig. 4

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SELF-CONTAINED PUMP SYSTEM FOR AIRLESS SPRAYING AND THE LIKE

Filed Jan. 5, 1966 4 Sheets-Sheet 3

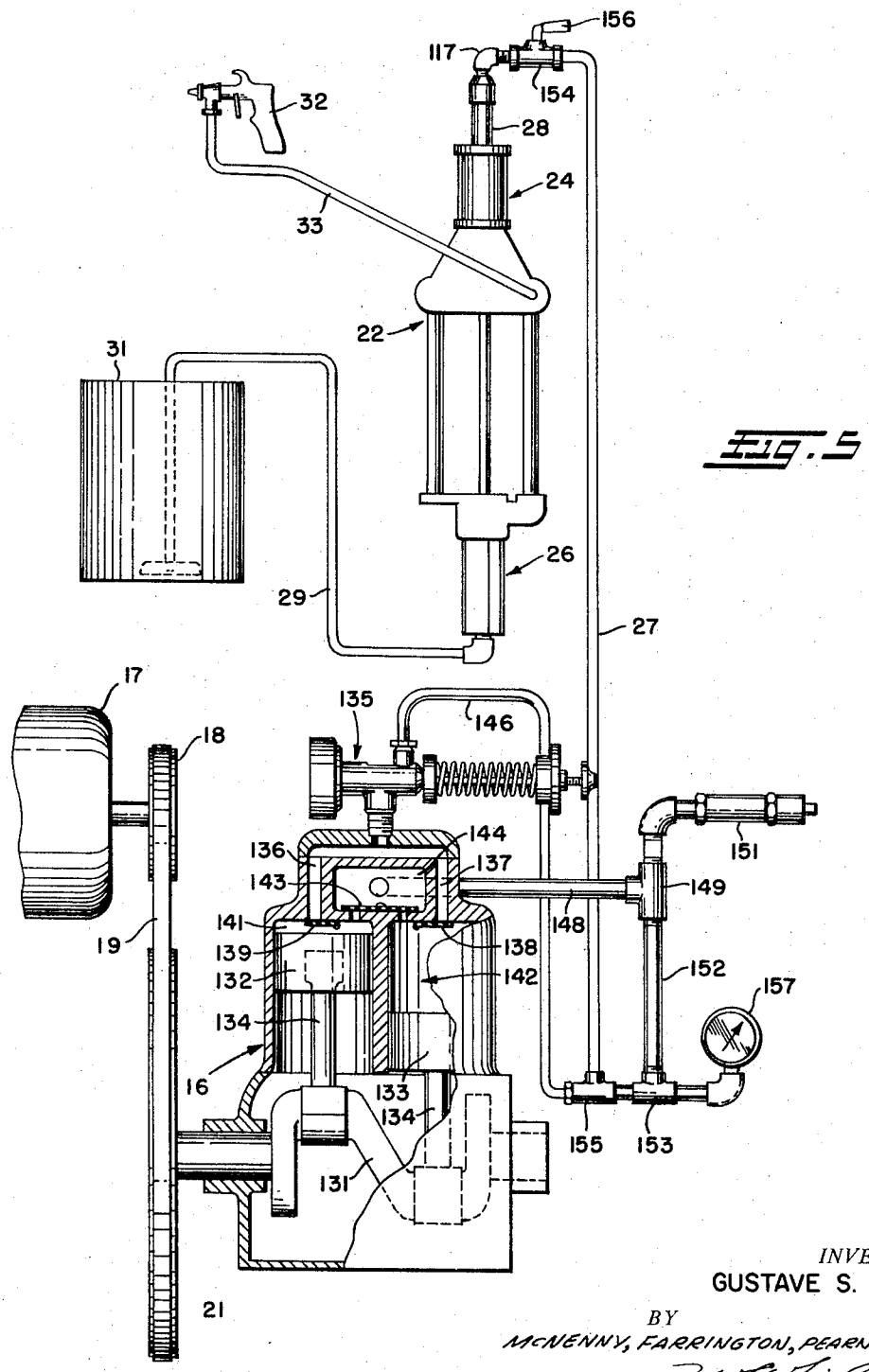


Fig. 5

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SELF-CONTAINED PUMP SYSTEM FOR AIRLESS SPRAYING AND THE LIKE

Filed Jan. 5, 1966 4 Sheets-Sheet 4

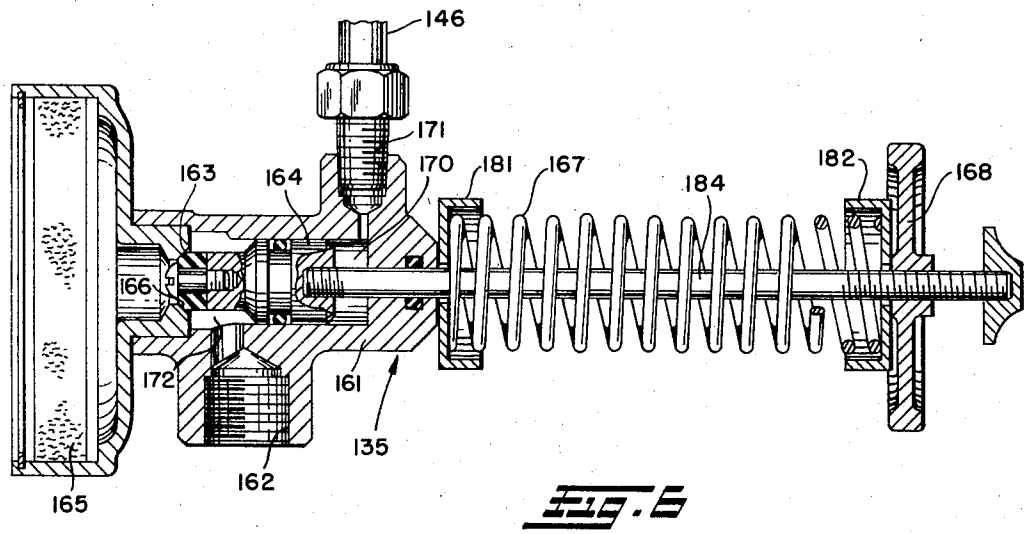


FIG. 6

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SELF-CONTAINED PUMP SYSTEM FOR AIRLESS SPRAYING AND THE LIKE

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Filed Jan. 5, 1966, Ser. No. 532,483
10 Claims. (Cl. 103—50)

ABSTRACT OF THE DISCLOSURE

A pneumatic transmission system including an air compressor and a compressed air motor operable to drive a liquid paint pump of the type adapted to supply an airless spray gun. The compressed air is delivered to the air motor without substantial loss of the heat of compression. The air motor operates throughout its power stroke at substantially constant air pressure and then exhausts to atmosphere. The temperature of the exhaust air is above the dew point and condensation does not occur. System efficiency is relatively high since the temperature of air in the air motor approaches the output temperature of the compressor. A modulating compressor unloader adjustably controls the compressor output pressure by throttling the compressor inlet. The unloader valve is urged toward its open position by the air entering the compressor so it operates smoothly and does not snap closed.

This invention relates generally to pneumatic power transmission systems and more particularly to an improved system for supplying paint or other liquid under pressure to an airless spray gun wherein a compressed air motor is used to drive the liquid pump.

A system incorporating the present invention provides improved efficiency so the power required, in a given installation, is substantially reduced.

In the airless spraying of liquid paints or the like it is necessary to be able to supply the liquid to the spray gun at any selected pressure generally within a pressure range of from one to three thousand pounds per square inch. The pressure on the paint and the size and shape of the spray nozzle are selected by the operator to produce the best pattern at the desired flow rate. It has been customary to utilize an air operated liquid pump which produces the high liquid pressures required when operated by a compressed air motor supplied through an adjustable pressure reducing valve from a reservoir or other source of air at a pressure of about one hundred pounds per square inch. Such pumps and motors utilize the principle of differential areas to deliver liquid at a relatively constant selected high pressure when operated by a supply of compressed air at a much lower substantially constant pressure. The air motor operated pump maintains the liquid under the selected pressure and operates intermittently in response to the intermittent triggering of the spray gun.

In industrial installations it has been customary to supply the paint pump with "shop air" usually available in industrial plants. In other instances, when electrical power is available with sufficient circuit capacity, electric motors have been utilized to drive an air compressor to supply the required compressed air. In still other instances, where "shop air" is not available and sufficient electrical power capacity is not available internal combustion engines are used to supply the required power. In any such installations the general practice in the art has been to deliver the air from the compressor into a reservoir wherein the compressed air cools from its compressor delivery temperature to a temperature approaching the atmospheric temperature. The air is then usually passed through a moisture separator for additional condensation removal.

This usually results in further cooling of the air. The air then passes through an adjustable pressure reducing valve, with further cooling, to the air motor. In such prior systems substantially all of the heat of compression is removed before the air reaches the motor.

In such systems it has been found that the power required to drive the compressor, even in systems supplying only one spray gun, is such that the electrical motor drive cannot be used on a typical 110 volt 15 ampere circuit. Generally the minimum power requirement of these prior systems has been in the order of 19 to 22 amperes when operating at 110 volts. Consequently, the use of electric motors for airless spraying has been limited to locations where heavy duty circuits are available or where limited spray capacity could be tolerated. Therefore, portable units have frequently required the use of gasoline engines to drive the compressor.

In these prior systems in which the heat of compresssion is removed from the air between the air compressor and the air motor, condensation problems often arise since the reduction of the pressure of the compressed air at the reducing valve and at the air motor produces further cooling of the air. In some instances of high ambient humidity freezing occurs and renders the system inoperative. Therefore, such systems have generally required the use of a condensate trap or other means to remove condensation. Such condensate traps also remove oil from the compressed air so it has generally been necessary to provide means to supply additional oil to the compressed air to provide lubrication for the air motor of the liquid pump. Where icing has nevertheless persisted because of high humidity conditions, it has been necessary to resort to reheaters to add heat to the air before entering the motor.

A pumping system incorporating the present invention provides a compressor driven by a suitable source of power such as an electric motor or gasoline engine, a liquid pump driven by an air motor of the piston and cylinder type and connecting means to directly deliver the compressed air from the compressor to the air motor. The system is arranged so that air leaving the compressor with the heat of compression is transferred directly to the pneumatically driven liquid pump with a minimum amount of heat loss so that the compressed air does not reduce in volume to any appreciable extent between the compressor and air motor. Consequently higher system efficiency results and it is possible to operate the compressor with less power. It has been found that by utilizing the compressed air with its heat of compression to drive the liquid pump the overall system efficiency is improved to a substantial extent. It has been found in actual practice that the improved efficiency of the present system makes it practical to power airless spray systems with normally available 110 volt 15 ampere capacity circuits. Prior systems, where the compressed air cools before delivery to the air motor, required current at a rate between 19 and 22 amperes when operating at similar output pressures and flow rates. This improvement in system efficiency provides the same advantages when internal combustion engines are used by reducing the engine size and fuel consumption required for a given output.

The use of the air with its heat of compression in the air motor eliminates the need of condensate removal from the compressed air since the temperature of the air at the exhaust of the air motor is maintained substantially above the dew point and normally at a temperature slightly above the atmospheric temperature. Further, the elimination of a requirement for removal of condensate from the compressed air eliminates the need of a device for adding a lubricant into the compressed air since the lubricant inherently supplied to the compressed air by the compressor remains in the com-

pressed air delivered to the air motor and provides sufficient lubrication for the air motor.

The system provides a compressor which compresses atmospheric air substantially adiabatically. Consequently, the compressed air leaving the compressor is at a relatively elevated temperature. This hot compressed air is directly delivered to the liquid pump air motor at a temperature relatively close to the delivery temperature from the compressor. In the air motor the compressed air is utilized to drive the paint pump at a substantially constant pressure without expansion in the motor. At the end of the stroke of the air motor the valve shifts and exhausts the compressed air to atmosphere. This blow-down of the compressed air to atmosphere does not completely reverse the adiabatic compression and the temperature of the exhaust air approaches and in many cases exceeds the atmospheric temperature.

In a preferred embodiment of this invention a novel modulating compressor unloader and regulator operates to throttle automatically the inlet air supplied to the compressor. This unloader senses compressor output pressure and permits the compressor to run continuously and smoothly, without abrupt "on" and "off" changes, while maintaining the selected output pressure substantially constant despite the necessarily intermittent operation of the spray gun.

It is an important object of this invention to provide a novel and improved pneumatic transmission system combining a compressor for adiabatically compressing atmospheric air containing water vapor, a pneumatic motor and conduit means for delivering the compressed air from the compressor to the motor, the rate of heat loss in the system being sufficiently low so that the temperature of the exhaust air from the motor is above the dew point and condensation does not occur.

It is another important object of this invention to provide a novel and improved pneumatic system according to the preceding object wherein the various elements of the system are arranged to radiate heat at sufficiently low rates so that the exhaust air leaving the pneumatic motor is at a temperature near the atmospheric temperature.

It is another important object of this invention to provide a pneumatic power transmission system according to either of the preceding objects wherein the conduit means for delivering the compressed air from the compressor to the pneumatic motor functions without substantial removal of either moisture or lubricant from the compressed air.

It is still another object of this invention to provide a pneumatic power transmission system including a combined compressor unloader and pressure regulator maintaining a smooth continuous operation of the compressor and a substantially constant selected pressure at the motor during intermittent operation of the motor.

It is still another object of this invention to provide a novel and improved pneumatically driven pumping system for an airless paint spray gun or the like which operates with sufficiently high overall efficiency to permit the operation of the system on conventional 15 ampere, 110 volt circuits.

Further objects and advantages will appear from the following description and drawings wherein:

FIGURE 1 is a perspective view of a pumping system incorporating this invention particularly suited for supplying high pressure liquid to an airless spray gun;

FIGURE 2 is another perspective view of the system of FIGURE 1 illustrating the arrangement of the compressor and motor drive;

FIGURE 3 is an enlarged fragmentary section partially in longitudinal section illustrating structural detail of the liquid pump shown in FIGURES 1 and 2;

FIGURE 4 is an enlarged fragmentary longitudinal section of the control valve for the liquid pump of FIGURE 3;

FIGURE 5 is a schematic illustration of the complete pumping system; and

FIGURE 6 is an enlarged view, partially in section, of the modulating unloader.

The embodiment of this invention illustrated in the drawings is particularly suited for the pumping of paint and the like for airless spraying. Such airless spraying is accomplished by supplying the liquid at a relatively high constant pressure to an airless spray gun which operates to produce a finely divided spray by hydraulic atomization without the aid of air or other gas at the gun.

In FIGURES 1 and 2 the pumping system incorporating this invention is illustrated mounted upon a cart **10** having large wheels **11** journaled thereon so that it can be easily rolled from one location to another and even moved up and down stairways without difficulty. A handle **12** permits the user to move the cart with ease and a leg **13** (illustrated in FIGURE 1) permits the cart to be rested in the vertical position, as illustrated, when the unit is being stored or used.

A generally rectangular open ended housing **14** is provided to house an air compressor **16** and electric drive motor **17**. A pulley **18** (illustrated in FIGURE 1) on the motor **17** is connected by a belt **19** to a drive pulley **21** on the compressor **16**.

A pneumatically operated liquid pump **22** is vertically mounted on the cart **10** by a U-channel frame **23**. The liquid pump **22** consists of two main assemblies. The upper assembly **24** includes a piston and cylinder air motor operable by compressed air to produce reciprocating movement and a lower liquid pumping assembly **26** which functions to pressurize the liquid. The air motor assembly **24** is supplied with compressed air from the compressor **16** through a hose **27** and control valve assembly **28**. Liquid is drawn into the liquid pumping assembly **26** through an intake line **29** from a liquid supply container **31**. The pressurized liquid is delivered from the liquid pump **26** to an airless spray gun **32** through a pressure line **33**. The preferred airless spray gun is disclosed in United States Letter Patent No. 3,000,576, dated Sept. 19, 1961. The spray gun of this patent permits fine finishing and operation at lower liquid pressures than prior airless guns. However, other types of airless spray guns may be used when fine finishing is not required. The motor **17** is provided with a cord **34** so that it can be plugged into a standard electrical outlet in the vicinity where the spraying is to be done.

FIGURES 3 and 4 illustrate one form of pneumatically driven liquid pump which is suitable for use with this invention. The liquid pumping assembly **26** includes a main housing member **36** having a differential area piston assembly **48** reciprocable therein. A first packing gland **57** and a second packing gland **59**, respectively, seal against a small diameter section **49** and a large diameter section **51** of the piston assembly **48**. The glands cooperate with the housing **36** and piston assembly **48** to define an upper chamber **37** and a lower chamber **63**. A check valve **46** allows liquid flow into the chamber **63** and a check valve **54** allows liquid flow from the chamber **63** to the chamber **37**.

The illustrated structure provides for the delivery of liquid on both the up and down strokes of the piston assembly **48**. On the upward stroke liquid is drawn into the chamber **63** past the check valve **46**. During this operation the check valve **54** is closed. Since the piston section **51** has a larger effective area than the piston rod **49** the upward movement of the differential area piston assembly **48** results in a displacement of liquid in the chamber **37** and pumping of such displaced liquid out through a lateral exhaust passage **64** and up along a tubular support **66** to the output opening **67**. The spray gun pressure line **33** is connected to the output opening **67** so liquid is delivered to the gun on this stroke. On the downward stroke the liquid within the chamber **63** is displaced by the

larger diameter piston section **51** and flows past the check valve **54** into the chamber **37**. Because the quantity of liquid displaced from the chamber **63** to the chamber **37** is greater than the reduction in displacement by the piston assembly **48** in the chamber **37** liquid is also delivered to the spray gun **32** on the downstroke.

The pneumatic motor assembly **24** includes a cylinder assembly **74** and piston assembly **83** connected to drive the piston assembly **48** of the liquid pump. A piston head **82** on the piston assembly **83** divides the cylinder into an upper chamber **77** and a lower chamber **81**. When compressed air is admitted to the lower chamber **81** while the upper chamber **77** is vented to atmosphere upward movement occurs. Conversely when the opposite connections are provided downward movement results.

A control valve **107**, best illustrated in FIGURE 4, is mounted in the control valve assembly to alternately connect the upper and lower chambers **77** and **81** to supply pressure and to exhaust. The control valve **107** is operated in response to movement of the piston assembly **83** by a lost motion connection mechanism **118**. The proportions are arranged so that the valve **107** remains in one position until the piston assembly **83** reaches its extended position and then shifts almost instantaneously to reverse the connections to the cylinder **74**. The valve **107** then remains in the shifted position until the retracted position is reached at which time it again rapidly shifts to reverse the connections.

When the valve is in the position illustrated in FIGURE 4 compressed air supplied through the hose **27**, shutoff valve **117** (see FIGURE 2) and valve inlet **116** is delivered to the upper chamber **77** through the passage **119**. In this position of the valve the lower chamber **81** is connected through the line **101** to the exhaust port **106**. When the valve **107** moves down from the illustrated position the cylinder connections are reversed.

Spring loaded detents **111** cooperate with springs **124** and **128** to insure rapid shifting of the valve **107**. With this structure a substantially unrestricted connection of compressed air is provided to the respective chambers **77** and **81** until the end of the stroke so no adiabatic expansion occurs. When the valve **107** shifts the compressed air in the air motor is directly vented to atmosphere so the temperature drop during expansion is smaller than it would be if adiabatic expansion was provided. Also with this structure the output force of the piston assembly remains constant throughout each stroke so the liquid pressure developed remains constant.

The various elements are proportioned so that the pressure on the liquid is substantially the same on each stroke even though the effective area of the piston assembly **83** for one direction of movement is not the same as the effective area of the piston for movement in the other direction. This is achieved by properly balancing the effective areas of the piston assembly **83** and the differential areas of the differential area piston assembly **48**.

FIGURE 5 schematically shows the entire pumping system. The electric motor **17** drives the compressor **16** which in the illustrated embodiment is a two cylinder single stage compressor having a crank shaft **131** which drives two pistons **132** and **133** through connecting rods **134**. Atmospheric air enters through the modulating unloader **135** and is alternately drawn in through intake ports **136** and **137** and past automatic valves **138** and **139** to the respective cylinders **141** and **142**. Similarly, the air is compressed in the cylinders on the upstroke of the respective pistons **132** and **133** and pumped past an automatic valve **143** into an exhaust chamber **144** at the output pressure of the compressor.

The compression of the air is substantially adiabatic, except for the heat absorbed and radiated by the compressor. In this specification and the appended claims the term "adiabatic compression" is intended to include compression of this type. After continuous operation the compressed air delivered by the compressor **16** may reach a temperature in the order of 290° F. or higher when the output pressure is in the order of 80 pounds per square inch gauge.

The compressed air from the compression chamber **144** flows through a pressure line **148** to a T **149** one side of which is connected to a relief valve **151** and the other side of which is connected to a pressure line **152** leading to a second T **153**. One side of the second T **153** connects through a third T **155** with the pressure hose **27** which in turn connects to the valve housing **28** through the fitting **117** and the manually operated shutoff valve **154**. Preferably, an insulated handle **156** is provided on the shutoff valve **154** so that the operator will not be burned when the valve is operated. Also, it is preferable to utilize a high temperature hose **27** having substantial insulating qualities to minimize the heat loss from the compressed air as it flows therethrough.

Connected to the other side of the second T **153** is a pressure gauge **157** and connected to the third T **155** is a pressure line **146** which supplies the unloader **135** with air at system pressure.

Referring now to FIGURE 6, the modulating unloader **135** includes a main body **161** having a lateral threaded nipple **162** which is connected to the intake port of the compressor **16**. Mounted within the housing **161** is a modulating valve **163** carried by an operating plunger **164** and movable into engagement with a valve seat **166**. A spring **167** extends between retainers **181** and **182** and resiliently urges the valve **163** in a direction away from the seat **166** normally maintaining free flow into the unit through a filter **165**, past the valve seat **166** and to the nipple **162**. The retainer **181** seats against the body **161** and the retainer **182** seats against an adjusting nut **168** threaded on an operating rod **184**. The force of the spring **167** is adjustable by threading the nut **168** in or out along the rod **184**.

System pressure is admitted to the chamber **170** at the right end of the plunger **164** through the pressure line **146** (illustrated in FIGURE 5) which is threaded into a port **171** in the housing **161**. When the pressure in the line **146** increases to a value sufficiently high to overcome the action of the spring **167**, the plunger **164** and valve **163** move to the left toward the seated position of the valve illustrated in FIGURE 6. When this occurs the inlet is shut off so the compressor ceases to deliver additional compressed air even though it continues to run. When the pressure in the line **146** is below the desired pressure, the spring **167** produces a greater force than the compressed air acting on the plunger **164** and the valve **163** moves away from its seat **166** allowing intake air to flow through the unloader into the compressor.

When the valve **163** is in a throttling position or fully closed a vacuum occurs on its downstream side **172**. Since substantially atmospheric pressure is always present upstream from the valve **163** the differential pressure across the valve produces a force augmenting the spring force in urging the valve toward its open position. This force increases as the valve approaches its seat. Therefore, the valve does not tend to snap closed but rather provides good flow regulation even at very low flow rates.

The setting of the adjusting nut **168** determines the output pressure which is maintained in the pneumatic motor. When the size of the spray nozzle, the viscosity of the paint being sprayed and the selected pressure are such as to require the maximum output of the compressor when the gun is triggered, the spring **167** maintains the valve **163** at or near its maximum open position. When the trigger of the spray gun is released, abruptly stopping the flow of paint, the pressure in the air motor rises and rapidly moves the valve **163** to the left toward its closed position. As the valve approaches its seat the increasing pressure drop across the valve resists complete closing, so that without substantial hunting or chattering the valve reaches a position at which the amount of inlet air admitted to the compressor just balances the loss of

pressure from leakage and from the cooling of the air trapped in the pressurized side of the motor.

In normal operation the spray gun is triggered or opened at the beginning of a pass across the work to be painted and the trigger is released and the gun closed at the end of each pass. The unloading valve **163** responds quickly to the opening or closing of the spray gun but in normal use seldom, if ever, closes completely, thus maintaining a smooth continuous operation of the compressor and its driving motor without abrupt changes in loading and power requirements such as are produced by an on-off unloading action or pressure switch. When the spray gun is used with a smaller spray nozzle or with a lower liquid pressure the operation is substantially the same except that the valve **163** maintains some throttling of the inlet at all times.

The modulating unloader **135** eliminates the need for the separate pressure regulator required in prior systems between the reservoir and the air motor. Rapid response is achieved because the volume of compressed air in the system is small. Still further the need of a check valve between the compressor and air motor is eliminated since the unloader regulates properly even at low flow rates. Such a check valve would be required with a pilot operated unloader, since small amounts of leakage cause sufficient changes in system pressure to produce operation of the pilot valve and repeated cycling of the unloader. With the present system small rates of compressed air flow caused by leakage or by cooling merely hold the valve **163** open a small amount, without hunting or chattering, to maintain desired pressure.

As stated above, it is desirable that the conduit means connecting the compressor with the pneumatic motor, which conduit means includes the chamber **144**, the hose **27** and the connecting piping, be constructed with a relatively small volume, both to minimize loss of the heat of compression of the compressed air and to insure prompt response and accurate regulation of the liquid pressure by the adjustable unloader **135**. In the illustrated embodiment the volume of this conduit means is no greater than about the displacement volume of the pneumatic motor. This construction has been found to operate satisfactorily and to obtain an improvement of 20% to 25% in efficiency over prior systems having a conventional sized receiver between the compressor and the motor. In such prior systems the total volume of the conduit means, including the receiver, is substantially more than the displacement volume of the motor and the compressed air reaching the motor is substantially at ambient atmospheric temperature. In order to regulate properly the liquid pressure such prior systems include a pressure regulator between the receiver and the motor in addition to an on-off switch or unloader for the compressor.

The improved efficiency of this invention makes it practical to use a 15 ampere, 110 volt supply circuit (or an equivalent circuit at a different voltage) for airless spraying. Also the manufacturing cost of the system is reduced since this invention eliminates the need for receivers, condensate traps and oilers and extra check valves and pressure regulators. Further, the problems of condensation and icing are overcome. In the preferred form of this invention the components are arranged so that in normal continuous operation the exhaust temperature is above atmospheric temperature. If required, insulation may be added to various parts of the system to reduce heat loss until this condition is reached.

Although a preferred embodiment of this invention is illustrated, it is to be understood that various modifications and rearrangements of parts may be resorted to without departing from the scope of the invention as defined in the following claims.

What is claimed is:

1. A pneumatic transmission system for use with atmospheric air containing water vapor and having a dew point temperature, comprising a compressor operable to compress said atmospheric air to a first pressure and first temperature each higher than atmospheric pressure and temperature, a pneumatic motor operable by compressed air to produce work without substantial expansion of such compressed air and operable thereafter to exhaust such compressed air to atmosphere, and conduit means connected to receive air from said compressor at said first pressure and temperature and deliver the same to said motor, said conduit means and said motor being constructed and arranged to maintain the water vapor content of said air and retain a sufficient amount of the heat of compression in said air so that the air exhausting from said motor has a temperature at least equal to said dew point temperature whereby vapor condensation does not occur at any location within said system.

2. A pneumatic transmission system as set forth in claim **1** wherein said exhaust temperature is at least equal to atmospheric temperature.

3. A pneumatic transmission system as set forth in claim **1** wherein said compressor operates to adiabatically compress the atmospheric air and supplies sufficient lubricant thereto during compression to lubricate said pneumatic motor, and said conduit means delivers said compressed air from said compressor to said pneumatic motor without removing any substantial amount of lubricant therefrom.

4. A pneumatic transmission system as set forth in claim **1** wherein said compressor includes modulating unloader means operable in response to compressor output pressure to control rate of compressor intake and reduce compressor output as the pressure of the compressed air delivered to said pneumatic motor approaches a predetermined selected value.

5. A pneumatic transmission system as set forth in claim **1** wherein said pneumatic motor includes a double acting piston and cylinder actuator with said piston and cylinder relatively movable with respect to each other between an extended position and a retracted position, and a control valve operable to selectively connect one side of said piston to said conduit means and the other side of said piston to atmosphere, said control valve operating in response to relative movement between said piston and cylinder to reverse such connections each time said actuator reaches one of said positions.

6. A pneumatic transmission system according to claim **1** in which said pneumatic motor includes piston and cylinder means having a predetermined displacement volume during each cycle of operation and said conduit means has a volume not substantially greater than said displacement volume.

7. A compressor system comprising a compressor having an inlet and an outlet, an unloader and pressure regulator providing a valve connected to said compressor inlet operable to throttle inlet flow thereto, adjustable means biasing said valve toward its open position, pressure operated means connected to said compressor outlet and biasing said valve toward a position closing off said inlet with a force directly proportional to the pressure in said outlet, said valve being arranged in said inlet so as to be additionally biased toward its open position by the pressure differential across said valve.

8. A liquid pumping system for an airless spray gun comprising a piston pump operable to pressurize and deliver liquid on each piston stroke, an air motor connected to drive said pump, an air compressor having an inlet to inspire atmospheric air and an outlet to deliver compressed air at a first pressure and first temperature each substantially higher than atmospheric pressure and temperature, conduit means connecting said compressor outlet with said air motor, said air motor and liquid pump cooperating to deliver liquid throughout each piston stroke of said liquid pump at a substantially constant liquid pressure which is substantially higher than the pressure of the compressed air delivered by said outlet and is a direct function thereof, and a combined liquid

pressure regulator and unloader including a throttle valve in said compressor inlet, adjustable means biasing said throttle valve toward open position, and means responsive to the pressure in said outlet biasing said throttle valve toward closed position.

9. A pneumatic transmission system comprising pneumatically operated load means having a variable compressed air requirement, a compressor having an inlet and an outlet, conduit means connecting said compressor outlet with said load means, and a compressor unloader and pressure regulator including a valve in said compressor inlet, adjustable means biasing said valve toward open position, pressure operated means connected to said conduit means and biasing said valve toward a position closing off said inlet with a force directly proportional to the pressure in said conduit means, said valve being arranged in said inlet so as to be additionally biased toward open position by the pressure differential across said valve.

10. A pneumatic transmission system as set forth in claim **9** wherein said conduit means operates to deliver compressed air from said compressor to said load means without substantial heat loss so that the temperature of compressed air delivered to said load means approaches the temperature at the output of said compressor.

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