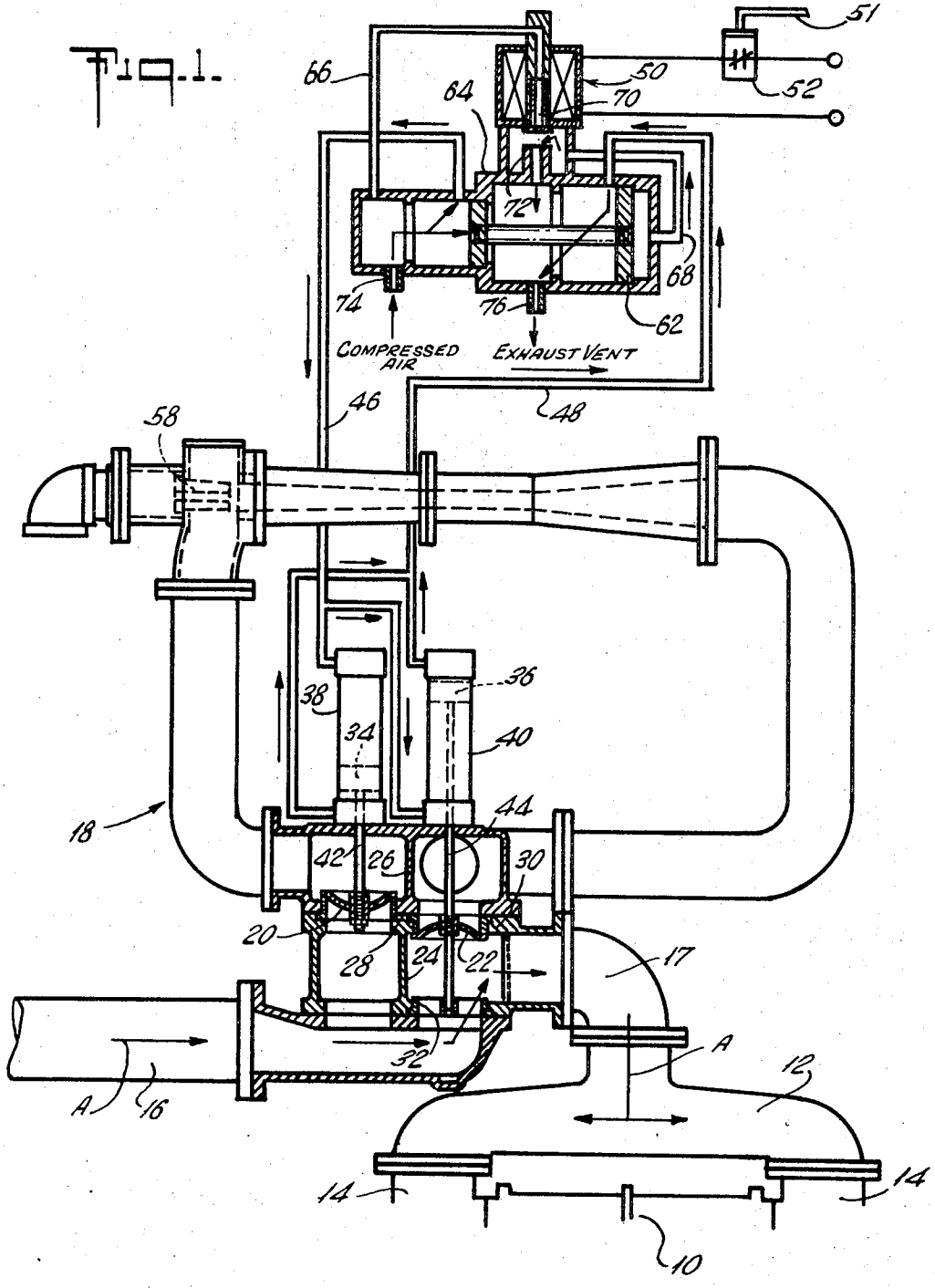
Jan. 19, 1971 I. C. JENNINGS 3,556,681

HIGH VACUUM PUMP WITH AIR JET HAVING AUTOMATIC CUT-IN VALVE

Filed Feb. 3, 1969 2 Sheets-Sheet 1

Fig. 1.



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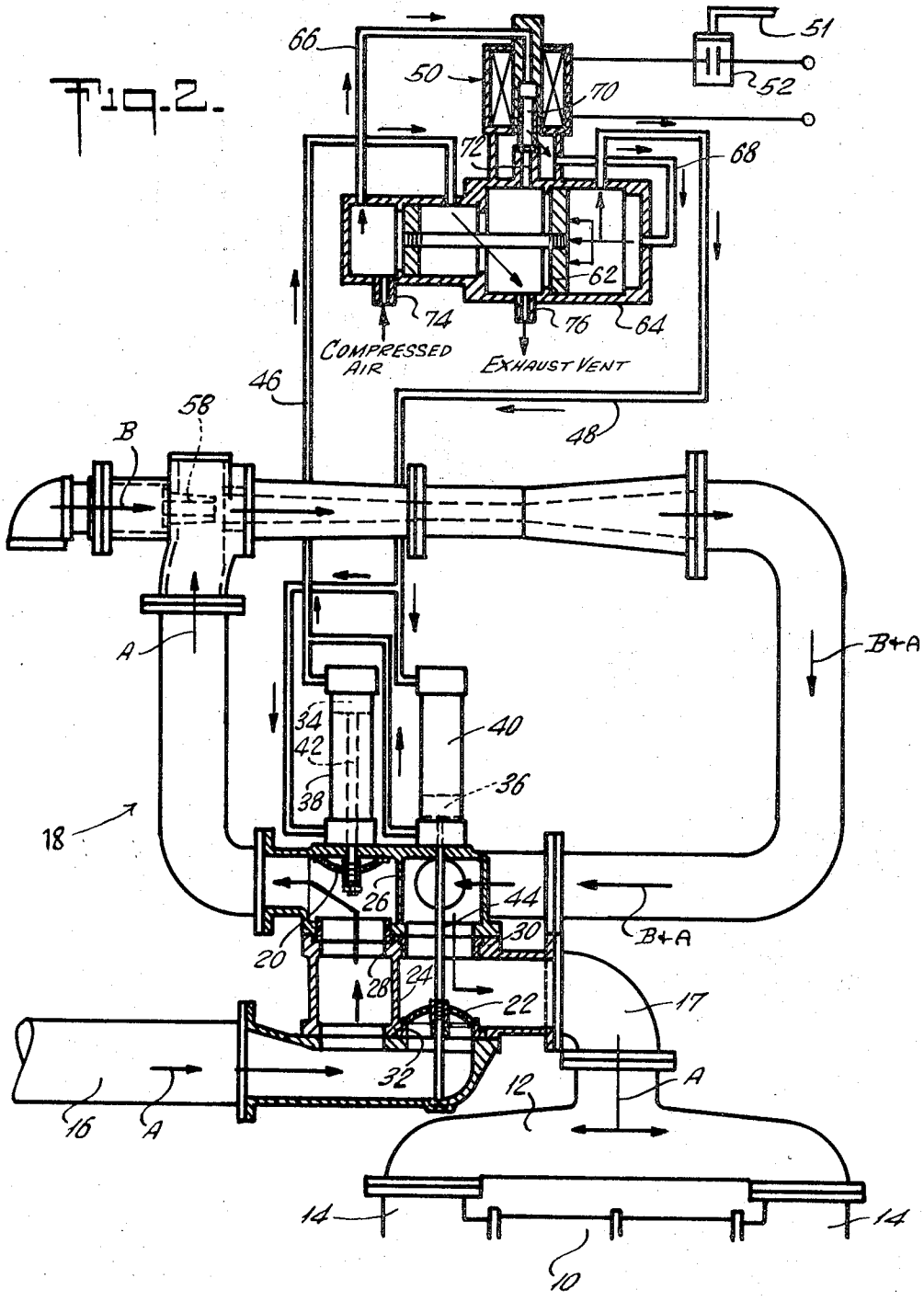
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Fig. 2.



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HIGH VACUUM PUMP WITH AIR JET HAVING AUTOMATIC CUT-IN VALVE

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ABSTRACT OF THE DISCLOSURE

A high vacuum pump provided with an air jet that is automatically cut into the system upon the attainment of a predetermined vacuum level. The valve arrangement includes pneumatically operated valves which bring the air jet assembly into operation, using the vacuum pump as a second stage. The pneumatic valves are made operative by a vacuum switch controlling a solenoid and a double-acting control valve.

BACKGROUND OF THE INVENTION

Prior U.S. Pats. Nos. 3,064,878 and 3,239,131 are directed to constructions in which high vacuum pumps are utilized and which incorporate cut-in valves after the "hogging" or "pull-up" operation of an evacuation system. Upon the attainment of a certain vacuum level in the system an air jet or a supersonic jet diffuser becomes operational.

Similarly in the present construction, the ejector pump is retained in a non-operative condition in the system until the vacuum therein has reached a predetermined degree. When the vacuum has reached this particular degree, the ejector pump becomes operative and thereby enables the over-all system to attain a higher degree of vacuum than that reached by the primary vacuum pump alone. It should be noted that at this point the primary vacuum pump becomes the secondary pump while the jet pump becomes the primary pump. Thus, when the ejector pump is brought into the system after the primary pump has evacuated the system to the aforesaid predetermined degree of vacuum, a supersonic fluid flow is produced in the system. This supersonic flow is a combination of a primary and secondary stream of fluid. In this case, the primary fluid is withdrawn from the container to be evacuated by the primary pump and a secondary stream is withdrawn from a source, such as the atmosphere, through the utilization of the vacuum produced by the primary pump. It is, therefore, apparent that a high efficiency evacuation system is provided by the present arrangement which includes automatic means for controlling the operation of the secondary ejector pump after a predetermined degree of vacuum has been attained by a primary pump. In the present case the automatic cut-in of the air jet is accomplished by means of a vacuum switch which operates a solenoid. The solenoid further controls a valve in the form of a double-acting piston which opens and closes the various lines to the pneumatic cylinders. The pistons in these pneumatic cylinders are connected to valves in the main line and an additional conduit circuit respectively. Thus, by the proper movement of the pistons and their associated valves, the main line and the additional conduit circuit may be interconnected at will. This interconnection takes effect automatically by means of the vacuum switch when a certain level of vacuum has been attained in the system. When this occurs, the jet diffuser comes into operation and as stated hereinabove the primary pump, that is the vacuum pump, then becomes the secondary stage of the present high vacuum pumping system.

It should be apparent that the present invention is

directed to a well known air ejector process in which an evacuator in the form of a conventional vacuum pump and at least one supersonic jet diffuser are arranged in a system for increasing the useful range of higher vacuum. Thus, the present system obtains higher vacuums than any comparable system and in addition, reduces strain on the apparatus, thereby avoiding irregular operation of the system and hence extending the normal life of the evacuator or the vacuum pump without expenditure of additional power.

BRIEF DESCRIPTION OF THE DRAWINGS

This invention is illustrated by way of example in the accompanying drawing which form part of this application and in which:

FIG. 1 is a partial elevation view and a partial sectional view of the high vacuum pumping system constructed in accordance with the teachings of the present invention, and in one condition thereof; and

FIG. 2 is a partial elevational and a partial sectional view of another condition of the present high vacuum pumping system constructed in accordance with the teachings of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference is now made particularly to the drawings, in which FIG. 1 discloses the apparatus that utilizes a standard primary vacuum pump **10** driven by a motor (not shown). The pump **10** may be a conventional liquid ring pump and an intake manifold **12** is connected to the dual inlets **14** thereof. The intake manifold **12** is in fluid connection with the conduit **16** and the latter may be connected to a condenser (not shown), or other apparatus to be evacuated.

An additional conduit circuit is referred to generally by the numeral **18** and becomes operative by means of the movement of valves **20** and **22** within their respective valve housings **24** and **26**. Valve housing **26** is provided with a valve seat **28** while housing **24** is provided with an upper valve seat **30** and a lower valve seat **32**.

The movement of valves **20** and **22** in their respective housings **24** and **26** are caused by the movement of pneumatic pistons **34** and **36** in their respective cylinders **38** and **40**. Piston **34** is connected to valve **20** by means of a piston rod **42**, while piston **36** is connected to valve **22** by means of piston rod **44**. The pistons **34** and **36** are operated by a compressed air supply in line **46** and the exhaust air is conducted through line **48**. It is within the scope of the present invention to use hydraulically-operated pistons to move valves **20** and **22** in place of the air-operated pistons.

A solenoid referred to generally by the numeral **50** is energized or de-energized by means of a diaphragm-operated vacuum switch **52**, the latter being connected through pipe **51** to a source of vacuum, for example, a condenser (not shown) in the system.

The solenoid **50** is operatively connected to a double-acting control piston **62**, the latter being slidably operated in cylinder housing **64**. Conduits **66** and **68** are connected from opposite ends of cylinder housing **64** to the solenoid **50**. Conduit **66** is directly connected to the top of plunger **70** in solenoid **50** and the cylinder housing **64** is provided with an opening **72** directly under the path of travel of plunger **70**. The cylinder housing **64** additionally is provided with a compressed air connection **74** and an exhaust vent **76**.

Thus, when the system is started up and operating in the "pulling-up" or "hogging" stage, the solenoid **50** is energized and the air pressure and exhaust of the system follow the paths indicated by the arrows for both lines **46** and **48** in FIG. 1. In this case, the air pressure

from the cylinder housing **64** is conducted through line **46** since the double-acting piston **62** has moved to the right thereby unblocking the line **46** and the compressed air then enters the top of the cylinder **38** and the bottom of cylinder **40**. Accordingly, valve **20** is moved downwardly to a position on valve seat **28** while valve **22** is moved upwardly to a position on valve seat **30**. The line **48** becomes the exhaust line and the compressed air is evacuated from the apparatus through the cylinder housing **64** and finally to the atmosphere through exhaust vent **76**. In this condition of the system, the additional conduit circuit **18** is blocked off and the primary fluid stream indicated by the arrows A flows from the system being evacuated through conduit **16** directly into the connection **17** and then into the intake manifold **12** of the pump **10**. The stream flows through pump **10** and is then vented to the surrounding atmosphere through an exhaust tube (not shown).

Referring now to FIG. 2, and the condition when a certain level of vacuum is attained during the aforesaid "pulling-up" or "hogging" operation, which is approximately 26 inches, the vacuum switch **52** becomes operative causing the plunger **70** of the solenoid **50** to drop to a location where it blocks the opening **72** of the cylinder housing **64**. When this occurs, compressed air is directed from conduit **66** through the plunger chamber to conduit **68** and into the right hand end of cylinder housing **64** thereby forcing the double-acting piston **62** to the left. Since line **48** is now unblocked compressed air is supplied through line **48** and the exhaust is evacuated through line **46**. Compressed air enters the top of cylinder **40** and the bottom of cylinder **38** and the piston **36** moves downwardly taking with it the valve **22** which moves from valve seat **30** to valve seat **32**. Simultaneously, the piston **34** is caused to move upwardly taking with it the valve **20** to abut the upper internal part of valve housing **26**.

With the valves **20** and **22** in the positions shown in FIG. 2 the additional conduit circuit is opened and the primary fluid stream is caused to flow around the additional circuit **18** in the manner indicated by the arrows A. When this occurs, a secondary or ejector pump **58** becomes operative and the ejector pump causes a fluid flow indicated by the arrows B which joins the primary fluid stream A. Thus, when the predetermined degree of vacuum has been achieved a supersonic fluid flow is produced in the pump. The two streams are mixed in the conduit circuit **18** where the mixed circuit is decelerated thereby increasing the pressure of the system and reducing the amount of work required to operate pump **10**. It should be noted that the pneumatically-operated valves **20** and **22** are operated automatically by means of the vacuum switch **52** and solenoid **50**, and the air jet assembly is entirely shut off from the system until a certain vacuum is reached therein.

What is claimed is:

1. A high vacuum evacuation system comprising a primary vacuum pump, a suction conduit connecting a device to be evacuated with said primary pump during the hogging operation of said primary pump, an additional conduit circuit, a plurality of co-acting valves for connecting and disconnecting said additional conduit circuit to said suction conduit, an ejector pump in communication with said additional conduit circuit for operating in series with said primary vacuum pump for enablng the system to attain a higher degree of vacuum than that reached by the primary pump alone, a vacuum-operated switch responsive to the vacuum in said device to be evacuated, a fluid-operated device constituting a pair of pistons each in respective cylinders, supply and exhaust lines for directing fluid to and from each cylinder, said fluid-operated device being operatively connected to said valves, means for supplying fluid to said fluid-operated device to move said valves, the latter being controlled by said switch whereby when said valves are in a predetermined position said additional conduit is connected to said suction conduit and said ejector pump becomes fully operative.

2. A high vacuum evacuation system as claimed in claim **1** wherein said pistons are pneumatically operated.

3. A high vacuum evacuation system as claimed in claim **1** further comprising a solenoid, a control valve arrangement for opening and closing said supply and exhaust lines controlled and said solenoid, and said vacuum-operated switch being connected to said solenoid for operating the latter whereby said valve arrangement is selectively operated to open and close said supply and exhaust lines to said fluid-operated device.

4. A high vacuum evacuation system as claimed in claim **1** wherein said pistons are moved in opposite directions in order to operate respective valves thereby selectively connecting said additional conduit circuit to said suction conduit.

5. A high vacuum evacuation system as claimed in claim **1** wherein said pistons are moved in the different directions in order to operate respective valves thereby selectively disconnecting said additional conduit circuit from said suction circuit.

6. A high vacuum evacuation system as claimed in claim **3** wherein the control valve arrangement is a cylinder having ports therein, and a double-acting piston in said cylinder, said piston being movable in said cylinder to open and close respective ports, and conduits connecting said valves to said ports whereby said fluid is selectively conducted and exhausted from said valves.

7. A high vacuum evacuation system as claimed in claim **6** wherein the cylinder is provided with an opening, said solenoid having a plunger positioned directly over said opening, said plunger being normally spaced from said opening but moved to block said opening upon the attainment of a predetermined amount of vacuum in the system.

8. A high vacuum evacuation system as claimed in claim **1** wherein said valves block off said additional conduit circuit from said system in one position thereof, and in another position thereof unblock said additional conduit circuit from said system in order to permit the connection of said additional conduit circuit to said suction conduit.

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