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PROCESS AND APPARATUS FOR THE TRANSFER OF LIQUID CARBON DIOXIDE

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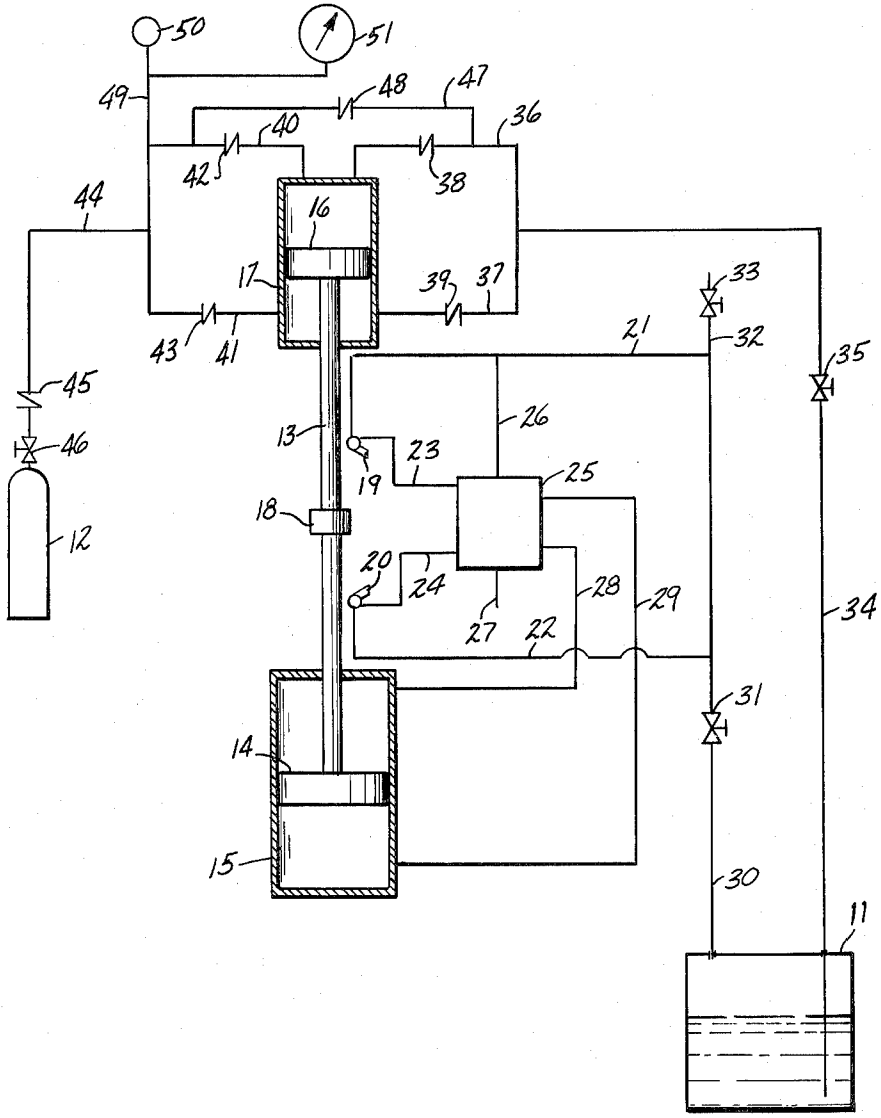

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PROCESS AND APPARATUS FOR THE TRANSFER OF LIQUID CARBON DIOXIDE

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This invention relates to a method and apparatus for the transfer of liquid carbon dioxide from a storage container to a second container, the carbon dioxide in the storage container having a maximum temperature of 10° F. and a maximum pressure of 350 p.s.i.g.

Carbon dioxide is commonly stored in bulk storage plants throughout the country under a pressure usually in the range of from 280 to 305 p.s.i.g. and at a temperature of about 0° F. The containers are insulated and refrigerated to maintain these conditions. Various pumps are known to the art for the purpose of transferring liquid carbon dioxide from such storage containers to smaller containers usually ranging from 5 to 150 pounds. The prior devices require a source of power, usually an electrically operated pump, and may cost from $1500 to $2000. The methods and apparatus of this invention provide a system for the transfer of liquid carbon dioxide using a compressed gas as motive power. Preferably, it is the gaseous carbon dioxide from the same storage container as the liquid carbon dioxide. The process of this invention requires a minimum gas pressure of 150 p.s.i.g. Pressures up to about 300 p.s.i.g. are ordinarily available in such storage containers. Alternatively, compressed air or steam, either of which is usually available from any conventional source, are suitable motive fluids. The system provided by this invention is simple, filling is rapid and the cost of the apparatus at present market prices is about $200.

The apparatus consists primarily of a double acting duplex pump with suitable fittings. The pump consists of two pistons and cylinders with a common piston rod. The motive piston and cylinder have a larger diameter than that of the driven piston and cylinder in order to utilize gaseous carbon dioxide from the storage container as the motive power under the same available pressure as the liquid to be moved. In a particularly advantageous form of the invention the diameter of the motive cylinder is 3 to 3½" and that of the driven piston cylinder is about 1½". The cylinders may be constructed of any suitable material, for example, brass or steel. A steel cylinder having a brass lining is especially suitable. The driven piston is composed of a heavy Teflon plate suitably ⅜" to 1" in thickness faced by aluminum plates 1/16" to ¼" in thickness. The driven piston can be similarly constructed or it may be of steel with steel piston rings or other material suitable for use with the motive fluid.

At substantially the mid-point of the piston rod, a cam is provided for operating the reversing valve which delivers motive fluid alternately to the top and the bottom of the cylinder for the driving piston. The cam actuates upper and lower control followers at the upper and lower ends of the stroke controlling the flow of actuating fluid, conveniently the same as the motive fluid, to effect operation of the reversing valve. The cam can be attached to the piston rod or to separate piston rods in any suitable manner, for example, it can be a standard shaft collar, held in place by one or more set screws.

Liquid carbon dioxide is supplied through check valves to the upper and lower ends of the cylinder containing the driven piston. Exit conduits are provided from the top and bottom of the same cylinder. Check valves in the exit conduits prevent back flow of the liquid carbon dioxide into the cylinder. The exit conduits are joined in a common delivery conduit. A bypass around the

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pump is provided from the liquid carbon dioxide supply line to the delivery line since the receiving cylinder can be quickly and partially filled with liquid without operating the pump. When the flow through the by-pass diminishes, the pump is started by admitting the motive and actuating fluids to the reversing valve. Suitable safety discs and gauges are also provided in the delivery line.

Although, for simplicity and convenience, reference herein is made to upper and lower parts and upward and downward strokes and although the figure shows the pump of this invention in a particular position, nevertheless the process of this invention can be operated with the pump in an inverted or any other position, the relation of each part to each other part being the same.

The figure shows a system according to the present invention for transferring liquid carbon dioxide from supply container **11** to receiving container **12**. In the pump, shaft **13** is connected at one end to driving piston **14** contained in cylinder **15**. At the opposite end of shaft **13** is driven piston **16** in cylinder **17**. At about the mid-point of shaft **13** is cam **18**. At the upper end of the stroke, cam **18** engages and moves upper control follower **19** and at the lower end of the stroke lower control follower **20**. Each of the cam-followers is spring loaded and suitably stopped so that it always returns to a position of rest. Actuating fluid is supplied via conduit **21** controlled by control follower **19** through line **23** to reversing valve **25**. Similarly actuating fluid is supplied via line **22** controlled by lower control follower **20** via line **24** to reversing valve **25**. Motive fluid to reversing valve **25** via line **26** and exhaust conduit **27** is supplied to reversing valve **25**. The motive fluid flows via line **28** and **29** to the upper and lower ends respectively of cylinder **15**. Motive fluid is supplied from supply container **11** via line **30** controlled by valve **31**. Alternatively, any other motive fluid can be supplied via line **32** controlled by valve **33**. Conduit **34** is the liquid carbon dioxide supply conduit controlled by valve **35**. This line is divided into lines **36** and **37** controlled by check valves **38** and **39** respectively to cylinder **17**. Conduits **40** and **41** are respectively the upper and lower liquid carbon dioxide delivery conduits controlled by check valves **42** and **43**. Conduit **40** and **41** combine in common conduit **44**. Liquid carbon dioxide is delivered through conduit **44** controlled by check valve **45** and supply container valve **46** to receiving container **12**. By-pass line **47** controlled by check valve **48** is provided for direct transfer of liquid carbon dioxide from supply container **11** to receiving container **12**. Conduit **49** leads from conduit **40** to safety disc **50** and gauge **51**.

In operation cylinder **17** is flooded with liquid carbon dioxide, valve **31** is opened to supply gaseous carbon dioxide as actuating fluid and motive fluid through reversing valve **25** alternately to the top and bottom of cylinder **15**. On the upward stroke cam **18** contacts follower **19** moving it to supply actuating fluid via line **23** to valve **25** reversing the flow of motive fluid from line **29** to line **28**. On the downward stroke cam **18** contacts and moves lower follower **20** supplying actuating fluid via line **24** to valve **25** reversing the flow of motive fluid from line **28** to **29**. On the upward stroke liquid carbon dioxide is supplied via line **37** to the underside of piston **16** while carbon dioxide is transferred from the upper side of piston **16** via line **40** and **44** to receiving cylinder **12**. On the downward stroke liquid carbon dioxide is supplied via line **36** to the upper side of piston **16** while liquid carbon dioxide is transferred from the lower side of piston **16** via line **41** and **44** to receiving cylinder **12**. The operation is initiated by transferring liquid carbon dioxide via by-pass **47** to cylinder **12** until the flow diminishes.

Example

In a pump and transfer system according to the present invention, an upper and lower cylinder were formed of steel having a brass liner. The top cylinder was 1½" in internal diameter and the lower cylinder 3½" in diameter. A cam was attached at the center of a 12" piston rod and a ½" thick Teflon head faced on each side by a ⅛" thick sheet of aluminum was bolted to one end of the piston rod to form the driven piston. The driving piston was a 3½" diameter standard steel piston fitted with suitable piston rings and connected to the opposite end of the piston rod. The lower end of the upper cylinder and the upper end of the lower cylinder were closed by packing nuts around the shaft. The packing nuts were lined internally with Teflon sleeve packing. Two diametrically opposite holes were tapped and threaded near the top of the upper cylinder for inlet and exit conduits. Similarly inlet and exit conduits were provided at the bottom of the upper cylinder. Check valves were installed in the upper and lower inlet lines to the upper cylinder and the two lines were in turn connected to the supply container of carbon dioxide. It provided liquid carbon dioxide to the driven piston and gaseous carbon dioxide to the driving piston at a pressure of 300 p.s.i.g. and a temperature of 0° F. The two exit openings of the upper cylinder were provided with check valves to prevent back flow and these exit lines were combined in a delivery conduit to the container to be filled. A by-pass line was provided directly from the inlet conduit to the delivery conduit. Suitable safety discs and gauges were installed in the delivery conduit. A reversing valve was connected to the gaseous supply of carbon dioxide in the storage container and to upper and lower exit conduits in the lower cylinder. The reversing valve was actuated by cam followers located near each end of the stroke of the cam. The cam follower actuated by the came in turn reversed the reversing valve and the flow of motive fluid was directed to the opposite end of the driving cylinder.

The first of several small cylinders to be filled was connected to the delivery conduit, the cylinder valve was opened and the delivery conduit was opened. The by-pass line was opened and the receiving cylinder was partially filled with liquid. The gaseous carbon dioxide conduit to the reversing valve was then opened starting the pump. In about 1½ minutes the 20 pound cylinder was substantially filled with liquid carbon dioxide. The delivery conduit valve and the cylinder valve were closed and the cylinder disconnected. Additional cylinders were similarly filled.

What is claimed is:

1. Method for transferring liquid carbon dioxide from a supply container in which carbon dioxide is stored as liquid and gas at a maximum temperature at 10° F. and a maximum pressure of 350 p.s.i.g. to a receiving container by means of double acting duplex pump using a motive fluid at superatmospheric pressure to move liquid carbon dioxide from said supply container to said receiving container, said method consisting of supplying said motive fluid alternately to a first side and to a second side of a driving piston to induce reciprocating motion to said piston and to a driven piston having a smaller cross-sectional area than said driving piston and connected to said driving piston by a connecting rod, supplying liquid carbon dioxide from said supply container alternately to a first side and to a second side of said driven piston and simultaneously transferring to said receiving container the liquid carbon dioxide alternately from the second side and from the first side, respectively, of said driven piston.

2. Method of claim 1 in which said motive fluid is steam.

3. Method of claim 1 in which said motive fluid is air.

4. Method of claim 1 in which said motive fluid is carbon dioxide gas.

5. Method of claim 4 in which said motive fluid is carbon dioxide gas derived from said supply container.

6. Apparatus for transferring liquid carbon dioxide from a supply container in which carbon dioxide is stored as liquid and gas at a maximum temperature of 10° F. and a maximum pressure of 350 p.s.i.g. to a receiving container, said apparatus comprising:

(1) a double-acting duplex pump having a driving piston in a motivating cylinder and a driven piston in a pump cylinder, said pistons connected by a connecting rod acting over a reciprocating stroke, said driving piston having a larger cross-sectional area than said driven piston;

(2) a cam on said rod located at substantially the midpoint of said stroke;

(3) a reversing valve for directing a motive fluid to said motivating cylinder;

(4) conduits for supplying a motive fluid to said reversing valve and for supplying said motive fluid from said reversing valve to each side of said driving piston;

(5) a control follower positioned adjacent each end of the stroke of said cam for actuation by contact with said cam;

(6) a pair of control valves alternately actuated by said follower at each end of said stroke, each of said control valves on actuation directing the flow of said motive fluid to reverse said reversing valve;

(7) an inlet conduit having two branches conducting a supply of liquid carbon dioxide to both ends of said pump cylinder from said supply container, each branch of said inlet conduit having a check valve permitting flow to said pump cylinder while preventing back flow to said supply container;

(8) an outlet conduit having two branches connecting both ends of said pump cylinder to a delivery conduit, each branch of said delivery conduit having a check valve permitting flow to said delivery conduit while preventing back flow to said pump cylinder, said delivery conduit being connectable to said receiving container.

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