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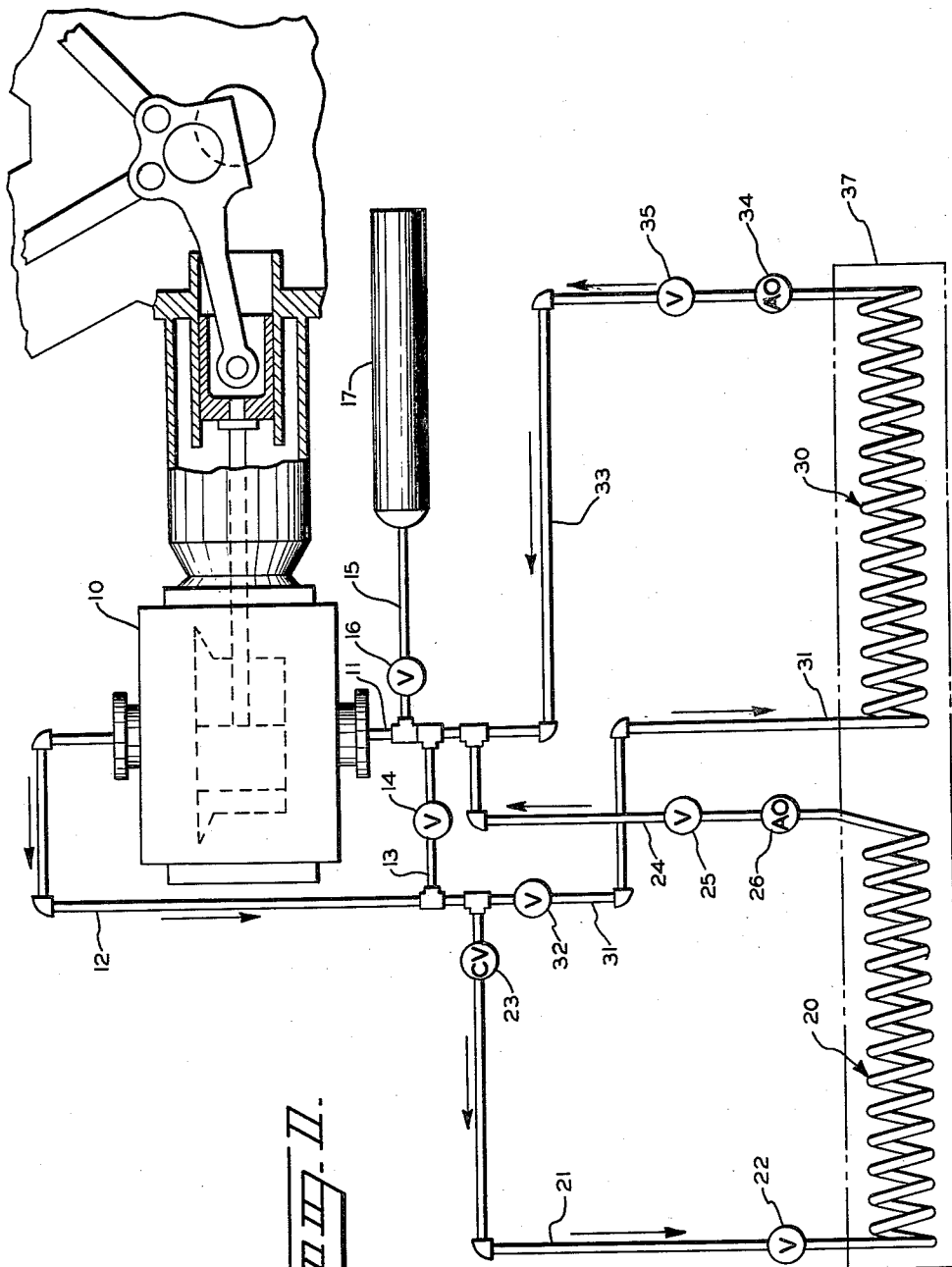


Fig. 11.

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1

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## METHOD AND APPARATUS FOR TESTING HIGH PRESSURE COMPRESSOR COMPONENTS AND THE LIKE

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This invention relates to a method and apparatus productive of very high pressures for testing the performance and strength of cylinders and other components of gas compressors at very high pressures.

At the present time the chemical industry utilizes multi-stage reciprocating compressors to compress ethylene gas to about 30,000 to 35,000 p.s.i.g. in the manufacture of polyethylene plastics. Theory and some development testing indicate that quality might be improved and the costs of the process reduced if the compression pressures at which polymerization takes place could be raised to nearer 100,000 p.s.i.g. The development of the higher pressure process has been slowed due to the mechanical limitations of compressors at these high pressures.

The lack of test facilities and production equipment operative at these very high pressures does not allow compressor manufacturers to conduct research on compressor components suitable for the very high pressures and has delayed the availability of compressors to the plastics industry as well as to others for whom a machine of this nature might be useful.

Up to the present time, testing of valves and cylinders in high pressure compressors has been largely a matter of building the components, assembling them into working units without prior testing, and noting their behavior when the compressor is on stream.

Due to gas compressibility from a large volume at atmospheric pressure to a relatively minute volume at very high pressures, the compressor at one stroke or operation cannot sufficiently reduce the volume to obtain the desired pressure.

A compressor is further limited by the difference between its supply and exhaust pressures in conjunction with gas compressibility. Thus, in commercial practice several compressors are staged with the first compressor discharging to the supply of the second, with the second discharging to the supply of the third, with the third discharging to the supply of the fourth, etc. with the final compressor discharging to a vessel.

The heat of compression in this process must be liberated and this adds a further difficult problem to be handled as lowering the temperature of the compressed gas also lowers the pressure. Testing of any one compressor is therefore difficult and the multi-stage process is prohibitive costwise for test purposes.

Without test equipment, the building of new equipment and components assumes the aspect of a dangerous gamble and the present invention solves this problem by furnishing test equipment economically which can reach test pressures far higher than available commercially thereby enabling progress in equipment based on actual test at very high pressures under actual working conditions not possible heretofore.

The primary object of the present invention is to provide a method and apparatus for testing the performance and strength of components of high pressure gas compressors apart from a complete, multi-stage machine.

Another object of the invention is to substitute two or more vessels as pressure staging means effective to eliminate staging compressors to gain the desired suction pressure.

2

Another object of the invention is to provide pressure vessels which can be easily cooled and inexpensively constructed to contain the very high pressures under test with maximum safety.

Another object of the invention is to provide vessels having a low volume so that only minimal supply of test gas is consumed, making the test very economical.

Another object of the invention is to provide such a method and apparatus which is inexpensive to operate and construct and which will give definite results in a minimum of test time.

Briefly, the present invention, in its method aspects includes charging a compressor cylinder under test with a quantity of inert gas, such as from a previously pressurized bottle source, compressing the gas and discharging it into at least two independent, closable vessels, successively isolating one of the said vessels from the other, using the isolated vessel as an intermediate pressure supply in the suction circuit for the compressor while discharging into the other remaining load vessel, recharging the isolated vessel, and repeating the steps until the pressure in the remaining load vessel equals or exceeds the rated working pressure of the compressor. Thereafter, the remaining load vessel which contains gas at working pressure is connected as a closed circuit to the compressor, a manually or automatically controlled valve being utilized to permit expansion of the trapped gas down to a predetermined suction pressure, while the compressor continues to discharge at high pressure into the same circuit.

In the accompanying drawings forming a part of the application:

FIG. 1 is a diagrammatic view of an apparatus, with parts in section, embodying the present invention, and capable of carrying out my new method.

Referring to the drawing, the present invention is shown in conjunction with the performance and strength testing of a compressor cylinder 10 and its associated valves, the compressor having a conventional close-fitting high pressure plunger or piston. The valves are not shown in detail. A line leading to the suction valve is indicated generally at 11 and a line leading from the discharge valve generally by the reference numeral 12. A purge connection 13 having a shutoff valve 14 interconnects the lines 11 and 12 during the start of a test as hereinafter described.

Provision is made for charging the compressor cylinder as well as the remainder of the system with an inert gas such as nitrogen. The charging line is indicated at 15 and is connected to the suction line 11 or cut off therefrom by a valve 16. The charging gas may be stored in a conventional bottle 17 under pressure of, for example, 1000 p.s.i.g.

A plurality of isolated vessels, two in the form shown, are provided, and at first both may be connected to the compressor to act as receivers for the compressor discharge; then one vessel acts as a source of supply for the compressor suction while the compressor continues to discharge into the other vessel as a receiver.

One of the vessels, designated 20, may conveniently comprise a coil of heavy wall tubing capable of withstanding an internal pressure equal to or greater than the highest pressure to which the compressor will be tested. For example, if the test pressure is to be 100,000 p.s.i.g. the tubing may have an inside diameter of 1/4 inch and an outside diameter of 1 1/4 inches. Such tubing will readily hold the desired pressure.

The vessel 20, referred to as a "load vessel" hereinafter is connected to the compressor discharge line 12 by a line 21 having a shutoff valve 22 therein, in series with a check valve 23 opening in the direction of the vessel 20. The load vessel 20 is also connected to the suction side

3

of the compressor by a line 24 having a shutoff valve 25 and an adjustable orifice 26 therein in series. Valve 25 is capable of operation either manually or automatically to enable gas contained in the load vessel 20 at high pressure to expand down to a predetermined suction pressure. If the valve 25 is closed, the load vessel 20 is isolated from the compressor suction side.

A second intermediate pressure transfer vessel 30, referred to hereinafter as a "storage vessel," is connected to the compressor discharge line 12 by line 31 having a shutoff valve 32 therein, and to the suction line 11 of the compressor by a line 33 having an adjustable orifice 34 and a shutoff valve 35 in series. By manipulation of the valves as hereinafter described, the present invention provides for the accumulation of gas under an intermediate pressure such as 16,000 to 20,000 p.s.i.g. in the storage vessel 30. Tubing having an inside diameter of 1/2 inch and an outside diameter of 1 1/4 inches will withstand these pressures.

Because of the substantial energy imparted to the gases by compression, provision is made for water cooling the vessels 20 and 30, for example by immersion in a suitable tank 37 through which water may be circulated.

From the foregoing it can be seen that the vessels 20 and 30 may be selectively connected to suction and discharge and selectively isolated from suction and discharge, singly and in combination, as desired to accomplish accumulating the very high test pressure in stages.

The operation of the parts so far described is as follows:

All of the valves are opened and the system purged in any suitable manner so that all air therein is replaced with nitrogen (or other process gas such as ethylene), either from the bottle 17 or some low pressure source. After purging, the valve 14 in line 13 directly between suction 11 and discharge 12 is closed and valve 16 remains opened feeding gas from the bottle 17 via line 15 to the compressor 10. Valves 25 and 35 in the lines 24 and 33, respectively, leading to compressor suction 11 are closed and all other valves are open so that both vessels 20 and 30 received compressed gas from the discharge line 12 via lines 21 and 31 respectively. The compressor is now operating with a suction pressure equal to the bottle pressure, for example 1000 p.s.i.g. If the compression ratio of the compressor is 10 to 1, the discharge pressure will be 10,000 and pumping continues until both vessels 20 and 30 contain gas at nearly this pressure. (There will be some drop in pressure due to the drop in temperature.)

The next step is to disconnect the bottle 17 and use the storage vessel 30 as a supply source for the compressor suction at increased suction pressure while the compressor continues to discharge into the load vessel 20.

Valve 16 in the line 15 is now closed to cut off the bottle 17; valve 25 in line 24 remains closed to isolate the high pressure load vessel 20 from the suction line 11; valve 32 in line 31 is closed to isolate storage vessel 30 from the compressor discharge 12. Valve 22 in line 21 remains open between the discharge line 12 and the load vessel 20.

Valve 35 is opened to connect the storage vessel 30 with the compressor suction line 11.

The compressor is now operating with a suction pressure in the neighborhood of 10,000 p.s.i.g. supplied by storage vessel 30 via line 33 and discharging into the load vessel 20 via line 21 at nearly ten times this pressure. Due to the small volume capacity of the storage vessel 30, a large volume of gas at the high discharge pressure is not required; however, the discharged gas will expand down somewhat in the now twice pressurized load vessel 20.

The next step in the process is to isolate the load vessel 20 and recharge the storage vessel 20 with a fresh supply of gas at intermediate pressure so that the storage vessel can later act again as a source of such supply at a

4

high intermediate pressure. Thus, when the pressure in the storage vessel 30 is down to some intermediate pressure, for example 5000 p.s.i.g., valve 35 is closed to the suction side and valve 32 is opened to the discharge side and valve 16 in the bottle line 15 is reopened. Valve 25 remains closed in line 24 between suction line 11 and load vessel 20. The compressor once again takes gas at the bottle pressure from line 15, compresses it into line 31 and recharges the storage vessel 30 to approximately 10,000 p.s.i.g. When this vessel is again filled to the desired pressure, valve 16 from the bottle is closed, valve 32 in line 31 from discharge line 12 is closed, valve 35 in line 33 to suction 11 is reopened so that the recharged storage vessel 30 again becomes the supply for the suction side of the compressor system.

The charging and partial exhaustion of the storage vessel 30 continues until the high pressure vessel 20 contains gas at the desired test pressure, such as 100,000 p.s.i.g. Thereafter, the storage vessel 30 inlet valve 32 and outlet valve 35 are closed, and the high pressure load vessel 20 adjustable orifice 26 and outlet valve 25 is manipulated to give a suction pressure in lines 24 and 11 of about 10,000 p.s.i.g., the gas being taken from the high pressure load vessel 20. The compressor will thereafter discharge gas back into the load vessel 20 through line 21, check valve 23, and valve 22. It will be seen that the gas is now circulating from and to the load vessel 20 and that all of the compressor components are operating at the desired high pressure which may be equal to or greater than those encountered in service.

The present invention in its method aspects includes initially supplying inert gas at the lowest supply pressure to the suction side of a compressor, compressing the gas in the compressor and discharging at a higher intermediate pressure to at least two pressure accumulating vessels. It includes disconnecting initial gas supply to the compressor, isolating said vessels from one another, connecting one vessel to the compressor suction as supply as an intermediate pressure transfer means, connecting the other vessel to the compressor discharge as final load pressure accumulator means, compressing the gas from the transfer means to the final load means.

It includes the final load means, again connecting the transfer means to the compressor discharge, again furnishing initial gas supply to the compressor suction, again compressing the gas into the transfer means, again disconnecting initial gas supply to the compressor, again connecting the transfer means to the compressor suction as supply, again connecting compressor discharge to the final means, and again compressing the gas from the transfer means to the final means.

It includes then repeating the steps as stated until the final pressure accumulation load means is at the desired very high pressure thereby producing a very high pressure load under which the compressor and other equipment receives actual test.

The invention contemplates having as many intermediate pressure transfer means or vessels as desired such as six or more wherein the first compression from the initial gas source raises all the vessels such as six to an intermediate pressure. The first vessel is then used as supply for the next five wherein the working pressure rises; the second is then used as supply for the next four wherein the pressure rises again; and the vessels are cut off sequentially until the fifth is used as supply for the last vessel wherein the pressure rises to the final very high load pressure.

It will thus be seen that the vessels represent steps in pressure and upon recharging the first vessel from the original supply, gas in the first can be compressed to the second, from the second to the third, and so on to obtain the final very high load pressure.

The invention includes means whereby the testing of high pressure cylinders is economical and it is to be particularly noted that only a small volume of gas is re-

5

quired to operate the cylinder 10 under actual load conditions as the coils of the storage vessels 20 and 30 may be as short and their inside diameter as small as desired commensurate with the volume needed for testing the cylinder or other equipment under test.

Up to the present time testing has not been possible economically as pressurizing the gas circuit up to suction pressure has required many staged compressors with as many as six stages being required to supply 8000 p.s.i.g. suction pressure for cylinders having only 35,000 p.s.i.g. discharge pressure.

While only one embodiment of the invention has been disclosed and described in detail, it is obvious that many changes may be made in the size, shape, detail, and arrangement of the various parts and steps of the invention within the scope of the appended claims.

I claim:

1. Apparatus for testing high pressure fluid compressors and like equipment under conditions and pressures at least equal to normal working conditions and pressures comprising,

- (a) a suction line leading to the equipment under test,
- (b) a discharge line leading from said equipment,
- (c) an ultimate pressure load vessel,
- (d) at least one intermediate pressure accumulator storage vessel,
- (e) a source of gas under relatively low initial pressure,
- (f) lines leading from said discharge line to all of said vessels,
- (g) lines leading from all of said vessels to said suction line,
- (h) a charging line leading from said source to said suction line,
- (i) separately operable and closable valves in all said lines for selectively connecting and isolating said source of gas relative to said suction line and for selectively connecting and isolating said vessels relative to each other and fluid compressors and like equipment, and

6

(j) a pressure reducing valve interposed in the line between said ultimate pressure load vessel and said suction line,

- (1) disposed to reduce the high pressure of gas in said load vessel to a predetermined suction pressure for said equipment when said load vessel is connected to both said suction line and said discharge line in a high pressure circuit.
- 2. A method of testing a high pressure compressor and like equipment at pressures at least equal to normal working pressures comprising,
  - (a) compressing gas from a source into a system including at least two vessels to establish in said vessels an intermediate pressure,
  - (b) isolating one of said vessels from the remaining vessels,
  - (c) compressing gas from said isolated vessel into said remaining vessels,
  - (d) recharging said isolated vessel to said intermediate pressure,
  - (e) repeating steps (c) and (d) until the pressure in said remaining vessels equals or exceeds the normal working pressure,
  - (f) connecting said remaining vessels with said compressor in a closed circuit to act as a source for said compressor and to receive gas discharged therefrom, and
  - (g) reducing the pressure of gas flowing from said load vessel to substantially the normal suction pressure of said compressor.
- 3. A method of testing a high pressure compressor in accordance with claim 2 and the additional step of removing heat from said vessels during operation.

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