United States Patent

Begleiter

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[54] COMPRESSED GAS SUPPLY SYSTEM

[72] Inventor: **Manny Begleiter**, Bronx, N.Y.

[73] Assignee: **Miner Industries, Inc.**, New York, N.Y.

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[58] **Field of Search** 137/111, 113, 112, 114; 141/167

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Primary Examiner—Samuel B. Rothberg
Assistant Examiner—William H. Wright
Attorney—Lewis H. Eslinger, Alvin Sinderbrand and Curtis, Morris & Safford

[57] **ABSTRACT**

In a compressed gas supply system, particularly for supplying helium under pressure to inflate balloons, as in balloon vending machines, two tanks containing gas under pressure are connected to a supply line through respective pressure regulating valves set to feed gas under relatively low pressures from the respective tanks to the supply line, and the regulating valve associated with one of the tanks is set to feed at a pressure slightly higher than that at which the other regulating valve is set to feed so that gas is initially supplied from the tank whose regulating valve is set at the slightly higher pressure and feeding of gas from the other tank commences automatically only when the pressure of gas in the first tank has been reduced substantially to the pressure setting of the regulating valve for that other tank.

5 Claims, 2 Drawing Figures

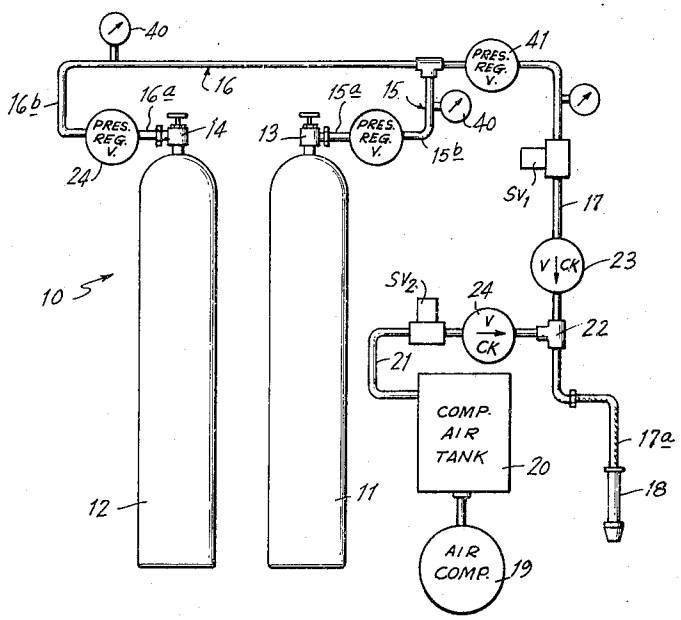
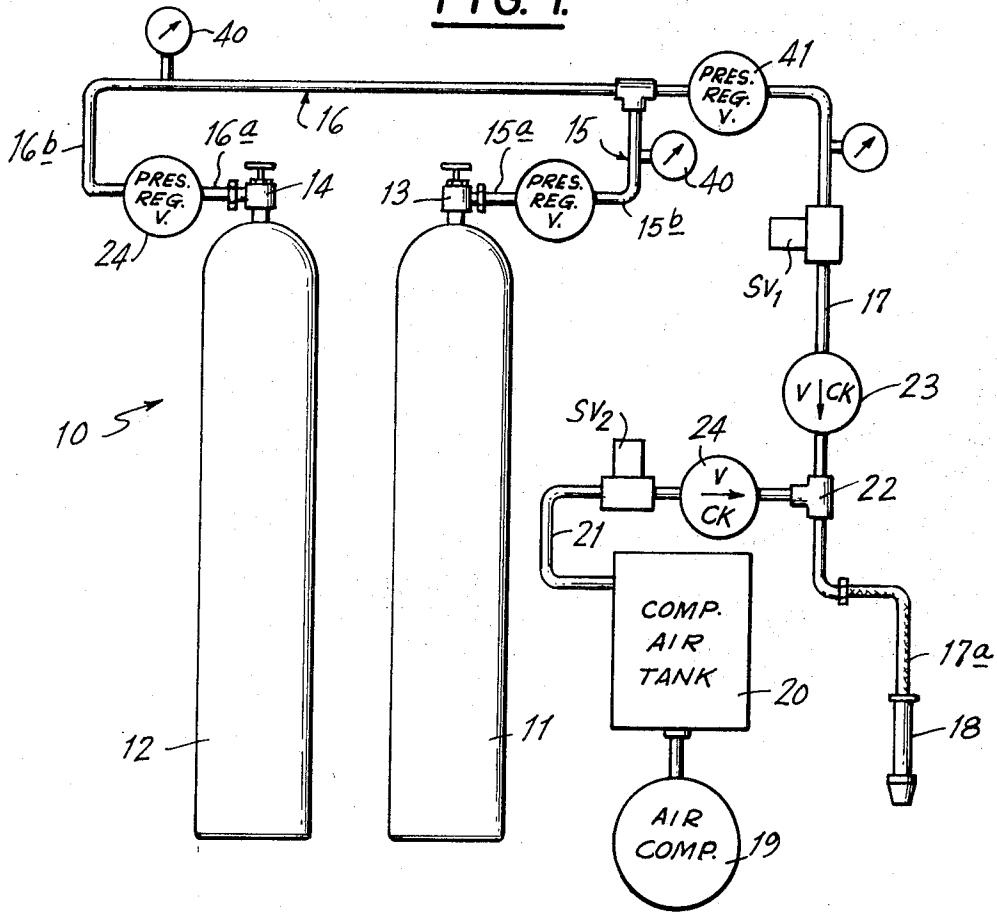


FIG. 1.



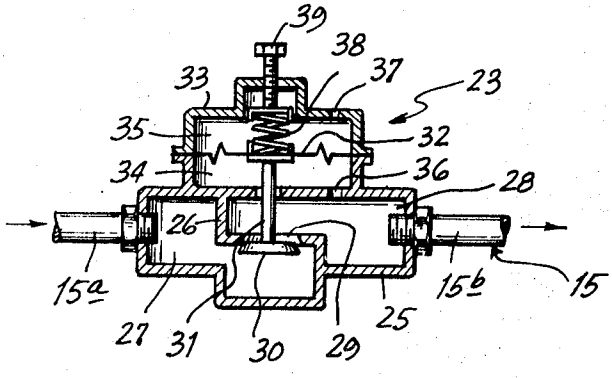


FIG. 2.

INVENTOR.
MANNY BEGLEITER
BY
ATTORNEY

COMPRESSED GAS SUPPLY SYSTEM

This invention relates generally to compressed gas supply systems, and more particularly is directed to gas supply systems of the type in which the compressed gas is stored in a plurality of tanks or bottles and is intended to be discharged therefrom in sequence.

In compressed gas supply systems which store the gas under pressure in tanks or bottles, it has become standard to employ two or more tanks from which the gas is discharged in sequence so that when the gas supply in one tank is exhausted, feeding can continue from another tank and the exhausted tank can be replaced by a filled tank without interrupting the gas supply. The foregoing arrangement is particularly advantageous when the site of the compressed gas supply system is remote from the storage depot for the compressed gas tanks so that only periodic service calls are feasible to determine the extent of the compressed gas supply that remains at the remote site. If a single tank is employed, the supply of compressed gas therein may not be fully exhausted at the time of a service call, in which case the existing options require either replacing the partly filled tank or running the risk that the supply of compressed gas will run out before the next service call. However, if two or more tanks discharging in sequence are provided, a tank has to be replaced at each regularly scheduled service call only if that tank is substantially empty, and assurance is thereby provided that at least one full tank is available after each service call to ensure an uninterrupted supply of the compressed gas until the next service call.

Although the above advantages of compressed gas supply systems having a plurality of tanks from which the gas is discharged in sequence have been long recognized, the existing systems of that type have used relatively complex and costly special crossover valves to achieve the discharge from the tanks in sequence.

Accordingly, it is an object of this invention to provide a compressed gas supply system in which the gas is stored in a plurality of tanks and the discharging of the gas from the tanks in sequence is achieved by an arrangement of readily available and relatively inexpensive pressure regulating valves.

Another object is to provide a helium supply system having a plurality of tanks containing helium under pressure and from which the helium is discharged in sequence, that is, from one tank until the supply of helium therein is substantially exhausted and then from another tank.

Still another object is to provide a helium supply system, as aforesaid, which is particularly suited for inflating balloons, as in a balloon vending machine.

In accordance with an aspect of this invention, a compressed gas supply system particularly for supplying helium under pressure to inflate balloons, as in a balloon vending machine, comprises first and second tanks containing gas under high pressure and being connected to a supply line through respective first and second pressure regulating valves set to feed the gas under relatively low pressures from the respective tanks to the supply line, and the first pressure regulating valve is set to feed at a pressure slightly higher than that at which the second pressure regulating valve is set to feed, so that gas will be initially supplied, on demand, from the first tank whose regulating valve is set at the slightly higher pressure and feeding of gas from the second tank will commence automatically only when the pressure of gas in the first tank has been reduced substantially to the pressure at which the second pressure regulating valve is set to feed.

In a preferred embodiment of the invention, a compressed gas supply system, as described above, is further provided with an additional pressure regulating valve interposed in the supply line downstream from the first and second pressure regulating valves and set to feed gas at a pressure below that at which either of the first and second regulating valves is set so that the pressure of the gas discharged from the supply line will be uniformly at the pressure setting of such additional regulating valve whether such gas originates in the first or the second tank.

The above, and other objects, features and advantages of this invention, will be apparent in the following detailed description of an illustrative embodiment which is to be read in connection with the accompanying drawing, in which:

FIG. 1 is a diagrammatic view showing a compressed gas supply system according to this invention; and

FIG. 2 is a schematic sectional view of one of the pressure regulating valves included in the system of FIG. 1.

Referring to the drawing in detail, and initially to FIG. 1 thereof, it will be seen that a compressed gas supply system **10** according to this invention, as there shown, comprises first and second containers **11** and **12**, for example, in the form of metal tanks or bottles, containing a gas such as helium which is initially under a relatively high pressure, for example, a pressure of 2,200 p.s.i. The tanks or bottles **11** and **12** have the usual outlet assemblies which include shutoff valves **13** and **14** and are separably connected to branch conduits **15** and **16**, respectively, extending to a supply conduit **17**. The supply conduit **17** may be connected, for example, through a flexible hose extensions **17*a***, to a device for utilizing the gas under pressure to be supplied thereto through conduit **17**. Such device, as shown, may be in the form of a nozzle **18** through which balloons may be inflated with the gas fed thereto, for example, as in balloon vending machines disclosed in either of U.S. Pat. No. 3,191,801, and No. 3,380,490, or in the copending application for a U.S. Pat. identified as Ser. No. 746,168, filed July 19, 1968, now U.S. Pat. No. 3,535,927, and all having a common assignee herewith.

In such balloon vending machine, successive balloons are inflated with a mixture of helium under pressure and compressed air. Thus, when the compressed gas supply system according to this invention is to form part of a balloon vending machine of the described type, the supply of helium for inflating the balloons is contained in tanks or bottles **11** and **12**, and the system further comprises a source of compressed air which may be constituted by an electric motor-driven air compressor **19** having its outlet connected to a compressed air tank or air pressure accumulator **20** from which there extends a compressed air supply line or conduit **21** connected, as by a Tee **22** with the supply conduit **17**. The supplying of helium under pressure and compressed air to nozzle **18** may be selectively controlled, as by solenoid valves SV_1 and SV_2 respectively interposed in conduits **17** and **21** and being normally closed to block the passage of helium and compressed air through the respective conduits. The solenoid valves SV_1 and SV_2 may be selectively energized through suitable electric circuits (not shown) which form no part of the present invention. When energized, valves SV_1 and SV_2 open to permit the passage of helium under pressure and compressed air, respectively, through the associated conduits **17** and **21** to the nozzle **18** for inflating a balloon engaged with the latter. Thus, by controlling the periods of energization of valves SV_1 and SV_2, one can select the proportions of helium and compressed air in the mixture thereof to be employed for inflating each balloon. Where the system is intended to supply compressed air as well as helium under pressure, as shown check valves **23** and **24** may be interposed in conduit **17** between valve SV_1 and Tee **22**, and in conduit **21** between valve SV_2 and Tee **22**, respectively.

As previously mentioned, it is a principal object of this invention to ensure that, in the compressed gas supply system **10**, the helium or other gas under pressure contained in the tanks or bottles **11** and **12** will be initially supplied from only one of the tanks, for example, from the tank **11**, and that gas will be supplied from the other tank **12** only when the supply of gas in the first tank **11** has been substantially exhausted. In accordance with the present invention, the foregoing objective, that is, the supplying of the gas under pressure from the tanks **11** and **12** in sequence, is achieved simply by providing pressure regulating valves **23** and **24** respectively interposed in the branch conduit **17**. Each of pressure regulating valves **23** and **24** may be of a commercially available type, for example, as is obtainable from Air Products and Chemical, Inc., Allen-

town, Pennsylvania, under the designation Style 2200, Comm. No.-231-6-222035, and is operative to maintain a preselected relatively low pressure in the respective conduit **15** or **16** at the downstream side of the pressure regulating valve and to open for feeding of gas from the respective tank **11** or **12** only when a demand for such gas causes the pressure at the downstream side of the valve **23** or **24** to fall below its preselected pressure.

For example, as shown on FIG. **2** which schematically represents pressure regulating valve **23**, each of pressure regulating valves **23** and **24** may comprise a housing **25** having a partition **26** extending thereacross to divide the interior of housing **25** into compartments **27** and **28** which are respectively connected with the upstream and downstream sections of the respective conduit, for example, the sections **15***a* and **15***b* of conduit **15**. An opening **29** is provided in partition **26** to afford communication between compartments **27** and **28** and the periphery or edge of opening **29** defines a seat for a valve member **30**. A valve stem **31** extends from valve member **30** and is connected to a flexible diaphragm **32** which extends across an extension **33** of housing **25** so as to divide the interior of housing extension **33** into chambers **34** and **35** which are isolated from each other. Chamber **34** is vented to compartment **28**, as by the vent opening **36**, so that the pressure in the downstream conduit section **15***b* acts in chamber **34**. The other chamber **35** is vented to the atmosphere, as by the vent opening **37**. It will be apparent that the pressure differential between the gas pressure in downstream conduit section **15***b*, which acts in chamber **34**, and the atmospheric pressure acting in chamber **35** will act on diaphragm **32** so as to urge valve member **30** against its seat in opening **29**. On the other hand, a compression spring **38** adjustably loaded by a screw **39** acts against diaphragm **32**, and hence against stem **31** of valve member **30**, to urge the latter away from its seat defined by the edge of opening **29**. Thus, by adjusting screw **39**, one can preselect the relatively low pressure at which gas will be fed from the respective tank **11** or **12** through the pressure regulating valve **23** or **24** to the downstream section of the respective conduit **15** or **16** and then to the supply conduit **17**.

If the gas pressure in downstream conduit section **15***b* is equal to or greater than the preselected pressure established by adjustment of screw **39**, such downstream pressure acting in chamber **34** will be sufficient to overcome the force of spring **38** and thereby maintain valve member **30** in its closed or seated position. However, if the downstream pressure falls below the preselected value, for example, when solenoid valve SV_1 is opened to feed helium under pressure to nozzle **18**, then the force of spring **38** is dominant with respect to the pressure in chamber **34** acting on diaphragm **32** and valve member **30** is opened or unseated sufficiently to return the downstream pressure to the preselected value by the feeding of gas under pressure from the respective tank.

In accordance with the present invention, the pressure at which one of the pressure regulating valves, for example, the valve **23**, is operative to feed gas from the respective tank **11** to supply conduit **17** is made slightly greater, for example, 5 p.s.i. greater, than the pressure at which the other pressure regulating valve **24** is operative to feed gas from its tank **12** to supply conduit **17**. For example, when the tanks **11** and **12** initially contain helium under a pressure of 2,200 p.s.i., as previously mentioned, pressure regulating valves **23** and **24** may be desirably set or arranged to feed gas from their respective tanks **11** and **12** only when the pressures in the downstream sections **15***b* and **16***b* of conduits **15** and **16** decline below pressures of 40 and 35 p.s.i., respectively.

In the example given above, and assuming that tanks **11** and **12** are both full, that is, contain helium under a pressure of approximately 2,200 p.s.i., pressure regulating valve **23** will establish a pressure of 40 p.s.i. in downstream section **15***b* of branch conduit **15** and also in downstream section **16***b* of branch conduit **16** by reason of the mutual connection of conduits **15** and **16** to supply conduit **17**. When solenoid valve SV_1 is opened to create a demand for helium under pressure, the pressure in conduit section **15***b* will decline and, in response to such pressure drop, pressure regulating valve **23** will open in order to maintain the pressure of 40 p.s.i. in conduit section **15***b* and also in conduit section **16***b*. Since the pressure of 40 p.s.i. in conduit section **16***b* at the downstream side of pressure regulating valve **24** is greater than the preselected pressure of 35 p.s.i. at which valve **24** is operative to feed gas from its associated tank **12**, pressure regulating valve **24** will remain closed, and thus the demand for helium under pressure will be satisfied by the feeding of gas from tank **11** alone.

However, when the supply of helium in tank **11** is almost exhausted, that is, when the pressure of helium in tank **11** has been reduced to the pressure at which the pressure regulating valve **24** associated with tank **12** is operative to feed gas from the latter, then pressure regulating valve **23** can no longer maintain a pressure in conduit sections **15***b* and **16***b* which is in excess of the pressure at which valve **24** opens. Thus, in the example mentioned above, when the pressure in tank **11** has been reduced to 35 p.s.i., the further opening of solenoid valve SV_1 to create a demand for helium drops the pressure in conduit section **16***b* below 35 p.s.i. and, in response to such pressure drop, pressure regulating valve **24** opens sufficiently to supply the demanded helium from tank **12** at the preselected pressure of 35 p.s.i. Thereafter, any further demand for helium under pressure is satisfied by the feeding of such gas from tank **12** and, although pressure regulating valve **23** remains open, a pressure of approximately 35 p.s.i. is maintained in tank **11**, that is, a relatively small quantity of helium remains in tank **11**.

If desired, a pressure gauge **40** may be connected with one, or each of conduit sections **15***b* and **16***b* to indicate the pressure existing therein. It will be apparent that, when gauge **40** indicates the pressure for which valve **23** has been set, such indication establishes that feeding of helium is still taking place from the supply in tank **11** and, therefore, that tank **12** still contains a supply of helium. On the other hand, if gauge **40** indicates the pressure for which valve **24** has been set, then such indication establishes that tank **11** has been substantially exhausted and that feeding of helium is then occurring from the second tank **12**. In the latter case, tank **11** may be replaced with a filled tank in order to ensure that there will remain an adequate supply of helium until the next inspection of the balloon vending machine or other device with which the compressed gas supply system is associated. The fact that a minimum pressure of helium is maintained in tank **11** when feeding of helium from tank **12** commences is desirable in that the small amount of helium that thus remains in tank **11** avoids the necessity of cleaning or purging of the tank before its refilling.

With the system **10** to the extent described above, the pressure of helium supplied to nozzle **18** would be greater, for example, by 5 p.s.i., when such helium is being supplied from the tank **11** than when the helium supply is coming from tank **12**. When the compressed gas supply system **10** is provided in a balloon vending machine, as mentioned above, such differential pressure in the supply of helium to nozzle **18** would be undesirable in that it would alter the pressures with which the balloons are inflated and thereby vary the sizes of the inflated balloons. Therefore, in the system **10** intended for use in balloon vending machines, a third pressure regulating valve **41**, which may be similar to the valves **23** and **24**, is interposed in supply conduit **17** between solenoid valve SV_1 and the end of conduit **17** to which branch conduits **15** and **16** are joined. The third or additional pressure regulating valve **41** is adjusted or otherwise made operative to feed helium to conduit **17**, at the downstream side of valve **41**, at a pressure that is less than the lowest of the pressures at which the valves **23** and **24** are operative to feed. For example, when valves **23** and **24** are respectively operative to feed at pressures of 40 and 35 p.s.i., pressure regulating valve **41** may be made operative to feed so as to maintain a pressure of 7 p.s.i. at the downstream side thereof. With the foregoing arrangement, it will be apparent

that the pressure of helium reaching nozzle **18** for inflating balloons is always at a pressure of 7 p.s.i. whether such gas is being fed from tank **11** or from tank **12**. A further advantage of providing the additional pressure regulating valve **41**, as shown on FIG. **1**, resides in the fact that a two-stage reduction of the pressure is thereby obtained, that is, a first reduction of pressure by the valve **23** or the valve **24** from the high pressure in tank **11** or **12**, and a final reduction of pressure by the valve **41** to the relatively low pressure required for balloon inflation. It has been found that such two-stage reduction of pressure is desirable in that, in the absence of the second pressure reduction by valve **41**, it is difficult to accurately obtain the necessary pressure reduction from the high pressure in tank **11** or **12** to the low pressure required for inflating balloons.

It will be apparent that, in the system embodying this invention, the desired feeding of gas from tanks **11** and **12**, in sequence, is achieved through the use of conventional pressure regulating valves, and that the described system eliminates the necessity of specially designed, and hence costly crossover valves for achieving the sequential discharge of gas from the tanks.

The system **10** described above with reference to FIG. **1** employs two tanks **11** and **12** as the source of helium or other gas under high pressure. However, systems according to this invention may include three or more of such tanks connected through respective branch conduits to the supply conduit **17**, and with pressure regulating valves, such as **23** and **24**, being interposed in the respective branch conduits and being operative to feed gas at progressively different pressures.

Although an illustrative embodiment of the invention has been described in detail herein with reference to the drawing, it is to be understood that the invention is not limited to that precise embodiment, and that various changes and modifications may be effected therein by one skilled in the art without departing from the scope of spirit of the invention.

What is claimed is:

1. A compressed gas supply system comprising at least first and second containers of gas under relatively high pressure, supply conduit means, first and second branch conduit means extending from said first and second containers and opening at all times into said supply conduit means, first pressure regulating valve means interposed in said first branch conduit means and operative to open to feed gas from the first container to said supply conduit means at a first predetermined relatively low pressure only when the pressure in said first branch conduit means between said first pressure regulating valve means and said supply conduit means declines to the value of said first predetermined low pressure, and second pressure regulating valve means interposed in said second branch conduit means and operative to open to feed gas from said second container to said supply conduit means at a second predetermined relatively low pressure, which is slightly lower than said first predetermined low pressure, only when the pressure in said second branch conduit means between said second pressure regulating valve means and said supply conduit means declines to the value of said second predetermined low pressure, whereby gas is fed only from said first container until the pressure of gas therein is reduced to said second predetermined low pressure at which said second pressure regulating valve means is operative to feed and, thereafter, gas is automatically fed from said second container.

2. A compressed gas supply system according to claim **1**, in which third pressure regulating valve means is interposed in said supply conduit means and is operative to feed gas therethrough at a pressure lower than either of said first and second low pressures at which said first and second pressure regulating valve means are operative to feed, whereby said supply conduit means delivers gas at said pressure at which said third pressure regulating valve means is operative to feed irrespective of the container from which the gas is being fed.

3. A compressed gas supply system according to claim **2**, further comprising a nozzle to which said supply conduit means extends and through which balloons may be inflated with the gas fed thereto, and control valve means interposed in said supply conduit means to normally block the feeding of gas to said nozzle and being operable to permit the feeding of gas to said nozzle.

4. A compressed gas supply system according to claim **3**, in which said gas under relatively high pressure in said containers is helium, and further comprising a source of compressed air and second supply conduit means extending from said source of compressed air to the first-mentioned supply conduit means at a location along the latter between said control valve means and said nozzle so that balloons may be inflated through said nozzle with a mixture of helium and air under pressure.

5. A compressed gas supply system according to claim **4**, further comprising second control valve means interposed in said second supply conduit means to normally block the feeding of compressed air through said second conduit means to said nozzle and being operable to permit the feeding of compressed air, so that, by selective operation of the first mentioned control valve means and said second control valve means, the proportions of helium and compressed air in said mixture can be controlled.

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