

March 10, 1931.

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DUAL EFFECT COMPRESSION METHOD AND APPARATUS
FOR PRODUCING CARBON DIOXIDE SNOW
Filed Aug. 11, 1928

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3 Sheets-Sheet 1

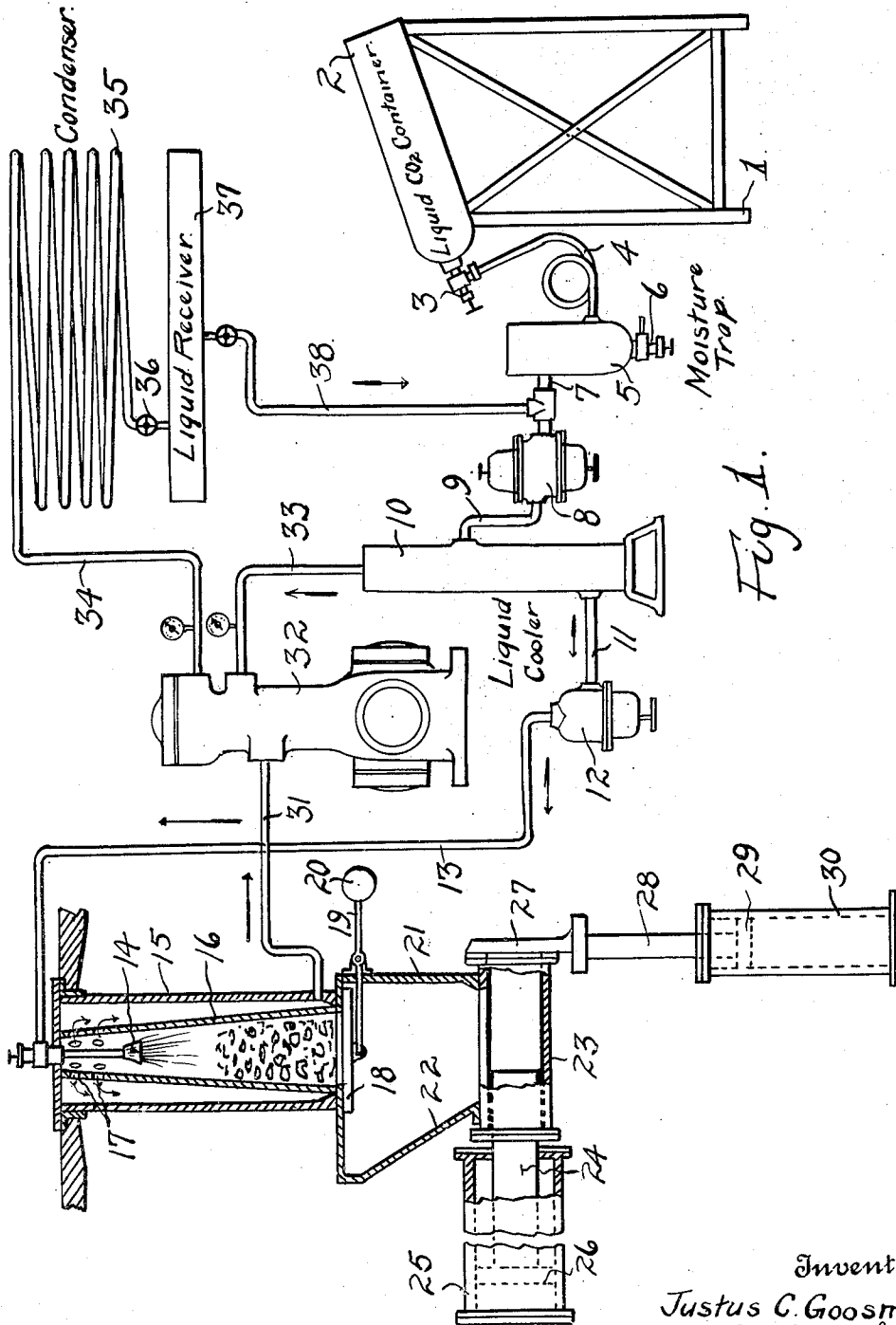


Fig. 1.

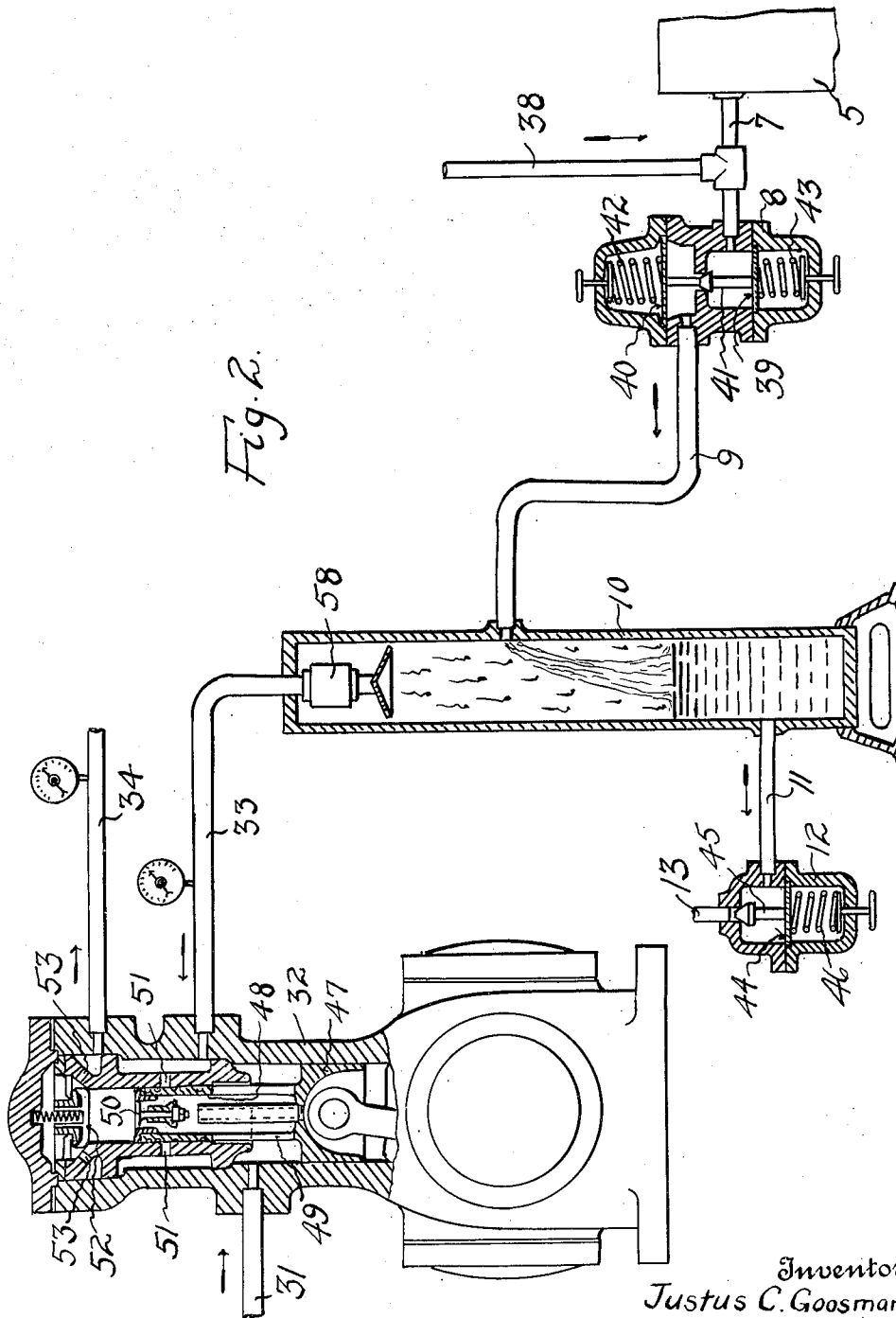
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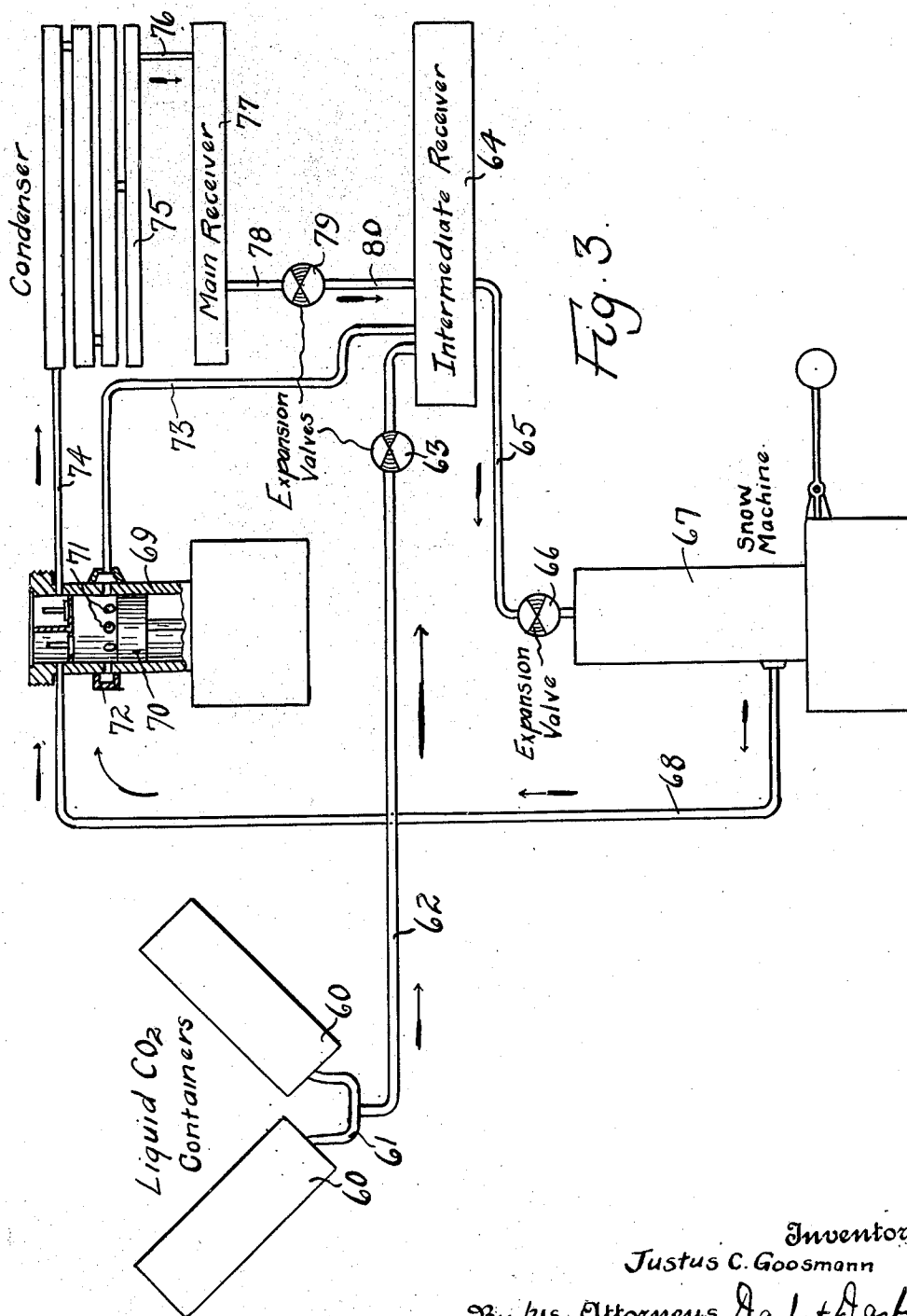


Fig. 3.

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UNITED STATES PATENT OFFICE

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DUAL-EFFECT COMPRESSION METHOD AND APPARATUS FOR PRODUCING CARBON-DIOXIDE SNOW

Application filed August 11, 1928. Serial No. 298,991.

One of the objects of this invention is the provision of apparatus and a method to be employed therewith for the purpose of producing carbon dioxide snow.

Another object of this invention is the provision of a combination of instrumentalities in a particular manner for the purpose of providing a simple and efficient apparatus by means of which carbon dioxide in the form of snow or crystals may be rapidly produced from liquid carbon dioxide.

A still further object of this invention involves a method of producing carbon dioxide snow to be carried out with the apparatus of the above type.

A still further object of this invention is the use of a single compression machine by means of which the gas from two different sources at different pressure may be mixed therein and compressed thereby.

A still further object of this invention is the employment in connection with a compressor of this type of a machine connected therewith for forming the liquid carbon dioxide into snow and compressing it into blocks of suitable size and density.

A still further object of this invention involves the idea of mixing in the cylinder of a compressor the low pressure gases evolved during the snow forming operation and the higher pressure gases produced in a liquid cooler.

These and others as will appear from the following disclosure are secured by means of the invention comprising an apparatus and method.

This invention resides substantially in the combination, construction, arrangement, relative location of parts, steps and series of steps to provide a method as will become more apparent from the detailed disclosure given below in connection with the drawings.

Referring to the drawings, Figure 1 is a diagrammatic view of one form of apparatus employing the principles of this invention showing the snow forming machine in cross section;

Fig. 2 is a cross sectional view through the compressor liquid cooler and pressure

reducing valves employed in the apparatus of Fig. 1;

Fig. 3 is a diagrammatic view of a modified form of apparatus showing the compressor diagrammatically and partially in cross section.

As is known at the present time in this art carbon dioxide gas may be maintained in liquid form if confined under the proper temperature and pressure conditions. It is also now well established practice to convert liquid carbon dioxide under the proper conditions into snow or solid condition by suddenly reducing its pressure and then compacting the snow or particles thus formed into solid blocks for the purpose of producing a refrigerant. It is the purpose of this invention to provide apparatus and methods of effecting the formation of carbon dioxide snow in a new, novel and efficient manner.

For a fuller discussion of the temperature and pressure conditions and the precautions to be taken in producing snow from liquid carbon dioxide reference is hereby made to my co-pending application, Serial No. 298,992, filed August 11, 1928, in which these things have been discussed in greater detail.

For a clearer understanding of the present apparatus and method reference will now be made to the drawings. The system shown in Fig. 1 includes a liquid carbon dioxide container 2 supported on a suitable table 1. The carbon dioxide may be secured from any suitable source of which there are many now known and is reduced to a liquid state by well known methods. As shown in the drawings the liquid may be supplied to the system of this invention from a tank of the well known type in which liquid carbon dioxide is now stored and transported. The cylinder 2 is supported in an inclined position as shown in the drawings so that the liquid will collect at the end to which the valve 3 is attached. The valve 3 controls the delivery of the liquid from the cylinder 2 to the pipe 4 which is connected with a moisture trap 5 which may be cleared of moisture by means of an exhaust valve 6. In view of the fact that it is desirable to eliminate the moisture from the

gas to prevent its freezing in the system and clogging it, it is advisable to use as dry a gas as practically possible to secure and to also employ the moisture trap as a further precaution against the entry of moisture into the system. This trap may be of any well known construction such as the type employing a baffle plate therein. A pipe 7 leads from the moisture trap to the pressure reducing valve 8 which will be disclosed in more detail hereinafter. It may be pointed out that this pressure reducing valve is of the pressure ratio type and has been disclosed in structural detail and method of operation in my co-pending application referred to above. A pipe 9 establishes connection between the valve 8 and the liquid cooler 10 which likewise will be described in more detail hereinafter. The liquid cooler 10 is connected by means of a pipe 11 to a second pressure reducing valve 12 which in turn is connected by a pipe 13 to the spraying device 14 within the snow forming machine.

The snow forming machine comprises an outer casing 15 and an inner conical wall 16 which is supported with its smaller end at the top and which forms a gas tight seal with the bottom of the casing 15 as shown. The members 15 and 16 are supported upon a chamber 21 and open thereinto as shown through an opening which is normally closed by a gate 18 supported on the pivoted lever 19 and normally maintained raised by means of the weight 20 adjustably secured to the arm 19. The upper portion of the member 16 is provided with a series of holes 17 to establish communication between the inside of member 16 and the space between members 15 and 16. As shown the casing or chamber 21 is provided with an inclined wall 22 opposite the end of the gate from which the snow will ordinarily fall when the gate is opened. The conical member 16 increasing in area downwardly permits the easy discharge of the snow therefrom when the gate 18 opens. By adjusting the position of the weight 20 on arm 19 it is possible to have the gate open when any predetermined weight of snow has collected thereon. Attached to the lower end of chamber 21 is a cylinder 23 which opens into the chamber as clearly shown. A plunger 24 slidably operates in the cylinder 23 and is controlled by a piston 26 acting within the cylinder 25. The end of cylinder 23 opposite to that in which the plunger 24 operates is open and a movable gate 27 is arranged to close it when desired. This gate is moved into and out of alignment at the open end of cylinder 23 by means of piston 26 rod 28 piston 29 and cylinder 30.

When the weight of the snow collected on gate 18 is sufficient to open it the snow falls into cylinder 23 and is then compressed to a suitable size and density by means of plunger 24 with gate 27 closed. When sufficiently

compressed gate 27 is withdrawn and plunger 24 advanced to eject the block of carbon dioxide snow. It is, of course, apparent that the finished block will be of a shape determined by the shape of cylinder 23.

The formation of snow in the machine during the spraying operation results also in the formation of carbon dioxide gas which is at a pressure of about 4 or 5 pounds gauge. This gas escapes through the holes 17 into the space between members 15 and 16 and is delivered through pipe 31 to the compressor 32. This compressor will be described in detail later. Likewise the gas formed in the liquid cooler is delivered through pipe 33 to the compressor 32 where it mixes with the gas coming through pipe 31. This mixture of gases is compressed and delivered through pipe 34 to the coils 35 of a condenser. This condenser may be of any well known type and is preferably a water cooled type in which cold water surrounds the coils 35. The pressure and temperature of the gas within the condenser is such as to convert it into a liquid which liquid is delivered through control valve 36 to a liquid receiver 37. The liquid is then delivered through pipe 38 to pipe 7 and pressure reducing valve 8 whence it travels through the system as described before in connection with the liquid coming from cylinder 2.

Reference is now made to Fig. 2 where the various elements of the system will be described in greater detail. The pressure reducing valve 8 is shown in cross section having two flexible diaphragms 39 and 40 of which the diaphragm 40 has the largest area. These diaphragms are controlled by means of springs 42 and 43 whose pressure on the diaphragms may be varied by means of the hand wheels shown. Mounted between the diaphragms is a valve stem 41 which contacts with each and controls a valve opening as shown. The liquid coming from pipes 38 and 7 are delivered into the lower chamber of which diaphragm 39 forms one wall. The pressure of the liquid depresses diaphragm 39 to permit valve 41 opening. This permits the delivery of the liquid into the upper chamber of which diaphragm 40 forms one wall. The liquid suffers a reduction in pressure as it passes through the valve and it is for this reason that the diaphragm 40 is larger. Under normal operating conditions the springs are so adjusted that if the liquid is at the proper pressure the valve will be open. Should the liquid pressure fall below a predetermined amount the valve will close to prevent undue depletion of the liquid source. The liquid now somewhat reduced in pressure is delivered to the liquid cooler comprising a casing 10. The liquid falls to the bottom of the casing 10 and any gas formed during the pressure reducing operation travels upwardly and out through the member 58 to pipe 33. The

pressure within casing 10 is of the order of 150 to 200 pounds gauge. The conical construction of member 58 serves to separate out any liquid vapor which might be in the gas as it passes pipe 33. The liquid then travels through pipe 11 to valve 12 which is shown comprising a diaphragm 44 upon which an adjustable spring 46 presses. The diaphragm 44 controls the valve 45. Should the pressure of the liquid being delivered to valve 12 fall below a predetermined amount spring 46 will close the valve 45 to prevent undue depletion of the liquid from the source. The liquid then travels through pipe 13 to the snow forming machine as described above.

The gas formed in the snow machine is delivered at 4 or 5 pounds gauge about minus 100° F. through pipe 31 to the dual compressor 32. The compressor consists of a sliding member 47 attached in any suitable manner to an operating mechanism and has formed thereon a hollow piston 48 provided with slots as shown at 49. The upper end of the piston 48 is provided with a valve 50 which opens outwardly on the suction stroke of the piston and closes on the compression stroke. The casing of the compressor 32 is provided with an inner liner in which piston 49 operates which liner is provided with a series of holes 51. The liner is constructed with a flange at right angles thereto on its outer surface and a flange extending at an angle thereto to form in connection with the outer casing of the compressor a small chamber. The lower end of the liner is provided with a flange which co-operates with the outer casing of the compressor to form a chamber into which pipe 31 delivers. Pipe 34 is connected with the upper chamber. The two flanges on the liner nearest the lower end form in the casing of the compressor another chamber to which pipe 33 connects. The operation of this compressor is as follows. On the suction stroke of piston 48 which is downwardly the gas formed in the snow machine is delivered at 4 or 5 pounds gauge and minus 100° F. through pipe 31 and through the slots 49 in the hollow piston and through valve 50 into the cylinder or chamber formed by the liner.

When the piston 48 has moved downwardly a sufficient distance to uncover the holes 51 the gas from pipe 33 which is at a pressure from 150 to 200 pounds gauge and a temperature of minus 35° to minus 20° F. is delivered into the volume or space formed by the liner. Thus the two gases at different pressures and temperatures are mixed and the pressure within the cylinder is built up to the order of 150 to 200 pounds gauge. On the compression stroke of piston 48 the gas in the cylinder is compressed to a predetermined pressure sufficiently high so that the gas on delivery to the condenser 35 will be changed into a liquid by the cooling action thereof.

When the gas has been compressed to the desired predetermined temperature on the compression stroke of the piston valve 52 opens and the carbon dioxide is delivered through holes 53 to pipe 34 which is connected to the condenser coil 35. This dual effect compressor in reality effects a compound compression in one compressor cylinder. The result is the elimination of the necessity of two or more compressors to compress the gas to the proper amount.

Reference is now made to Fig. 3 in which a somewhat modified system is disclosed. The carbon dioxide containers or cylinders are shown at 60 and are connected by means of a pipe 61 to a pipe 62. The liquid from the cylinders are passed through a pressure reducing valve 63 by any suitable construction as, for instance, the type shown in Fig. 2. The liquid then travels into the intermediate receiver 64 and is delivered through pipe 65 and expansion valve 66 to the snow machine 67 where it is formed into snow. This snow machine 67 may be of the type clearly disclosed in Fig. 1.

The gas formed during the snow forming operation is delivered through pipe 68 to the dual effect compressor 69 which has been diagrammatically illustrated since this compressor is the same as that shown in Figs. 1 and 2. The gas from the snow machine is drawn into the compressor during the suction stroke at 4 or 5 pounds gauge and mixes with the gas coming from the receiver 64 through pipe 73 when holes 71 are uncovered by piston 70. In order to make the diagrammatic disclosure of the compressure accurate a chamber 72 to which pipe 73 connects is shown enclosing the openings 71. As indicated the upper left-hand valve of the compressor opens on the suction stroke to admit the gas into the cylinder at 4 or 5 pounds pressure from pipe 68. The gas from the receiver 64 is at a pressure of 150 to 200 pounds pressure. On the compression stroke of piston 70 the left-hand valve closes and the right-hand valve opens upon the creation of a predetermined pressure to deliver the gas to pipe 74 which is connected to condenser 75. The compressor is so adjusted that the gas delivered to the condenser is of such temperature and pressure that it will upon being cooled in the condenser be converted to a liquid. The liquid is then delivered through pipe 76 to the main receiver 77. As needed the liquid flows from receiver 77 through pipe 78, expansion valve 79 and pipe 80 to the intermediate receiver 64. Expansion valve 79 is adjusted so that the liquid is delivered from the main receiver to the intermediate receiver of the proper pressure. As a result of the reduction of the liquid pressure partial evaporation occurs and the gas formed is delivered from receiver 64 to pipe 73 as and for the purpose described. It will be seen that this system dif-

fers from the system in Fig. 1 in that two liquid receivers are provided instead of one. Thus the liquid is delivered from the original containers to the intermediate receiver and from the main receiver to the intermediate receiver.

I am, of course, aware of the many changes in the details and construction of the parts and the apparatus as well as their relative arrangement and the method of operation that may be made without departing from the principles of this invention. I do not therefore desire to be strictly limited to the disclosure in the specification and drawings given for the purpose of illustrating these principles, but rather to the scope of the invention as it is defined in the appended claims.

What I seek to secure by United States Letters Patent is:

1. In an apparatus of the type described, the combination comprising a source of liquid carbon dioxide, an intermediate receiver connected to said source, an expansive valve in the connection, a snow forming machine connected to said intermediate receiver, a compressor connected to said snow forming machine so that the gas formed in said machine is delivered to said compressor, a connection between the intermediate receiver and the compressor so that the gas in the intermediate receiver is delivered to said compressor, the gases from the snow machine and the intermediate receiver being mixed in said compressor and compressed thereby, a condenser and a connection for delivering the compressed gases to the condenser, a main receiver connected to the condenser for holding the liquid formed in the condenser, and a connection between the main receiver and the intermediate receiver including an expansion valve whereby the liquid is delivered from the main receiver to the intermediate receiver at the pressure of the gas and liquid in the intermediate receiver.

2. The method of forming carbon dioxide gas into snow comprising confining the gas under sufficient pressure to form it into a liquid, reducing the temperature of the liquid to cool the liquid and form some gas, reducing the pressure of the liquid sufficiently to form it into snow and gas, mixing the gas from the temperature reducing and snow forming operations, compressing the mixed gas to a predetermined temperature, and cooling the gas sufficiently to form a liquid so that the liquid can again be reduced in pressure sufficiently to form more snow.

3. The method of changing carbon dioxide gas into snow, comprising confining the gas in a liquid state, reducing the pressure of the liquid and delivering it to a cooler, reducing the pressure of the liquid sufficiently to form some of it into gas and the rest into snow, delivering the gas formed during the

snow forming operation and the gas formed in the cooler to the cylinder of a compressor and mixing them, compressing the mixed gases to a predetermined pressure, cooling the compressed gases sufficiently to liquefy them, and delivering the liquid to the cooler where it is mixed with fresh liquid from the source.

4. In an apparatus of the type described, the combination comprising a source of liquid carbon dioxide, means for cooling the liquid by partial evaporation, a dual effect compressor having a cylinder with a high pressure and a low pressure inlet port, connections between said source, said means for cooling the liquid by partial evaporation, and said dual effect compressor, means connected to said means for cooling the liquid by partial evaporation for solidifying the cooled liquid, a connection from said means for solidifying the cooled liquid to the low pressure port of the cylinder, and a connection from the means for cooling the liquid by partial evaporation and the high pressure port of the cylinder, the gases flowing through the connections to said cylinder being mixed and then compressed.

5. The method of changing carbon dioxide gas into solid form, including the steps of confining the carbon dioxide under liquefying conditions, reducing the temperature of the liquid by heat exchange in a cooler, reducing the pressure of the liquid to change it partly into solid form and partly into gaseous form, delivering the gas thus formed mixed with other gas to the cylinder of a compressor and mingling them therein, compressing the mixed gases in said cylinder, cooling the compressed gases sufficiently to liquefy them and delivering the liquid to the cooler to be mixed with fresh liquid.

In testimony whereof I have hereunto set my hand on this 10th day of August, A. D. 1928.

JUSTUS C. GOOSMANN.