

[54] CARBON DIOXIDE EXTRUDED PELLETS
[75] Inventor: John A. Scudder, Homewood, Ill.
[73] Assignee: Chemetron Corporation, Chicago, Ill.
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[52] U.S. Cl. 62/35, 62/10
[51] Int. Cl. F25j 1/00
[58] Field of Search..... 62/10, 35, 14

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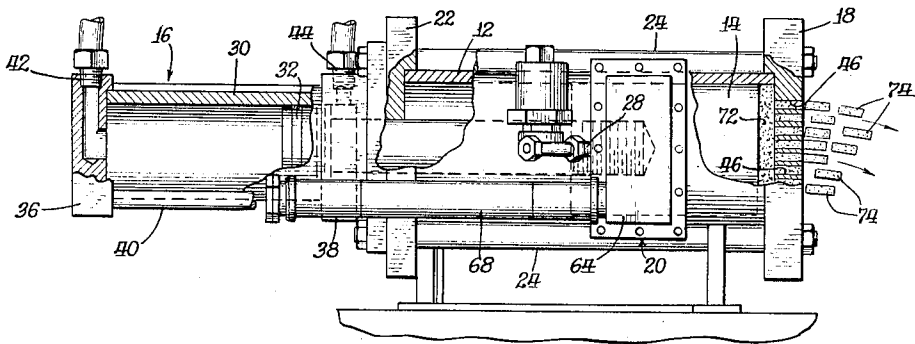
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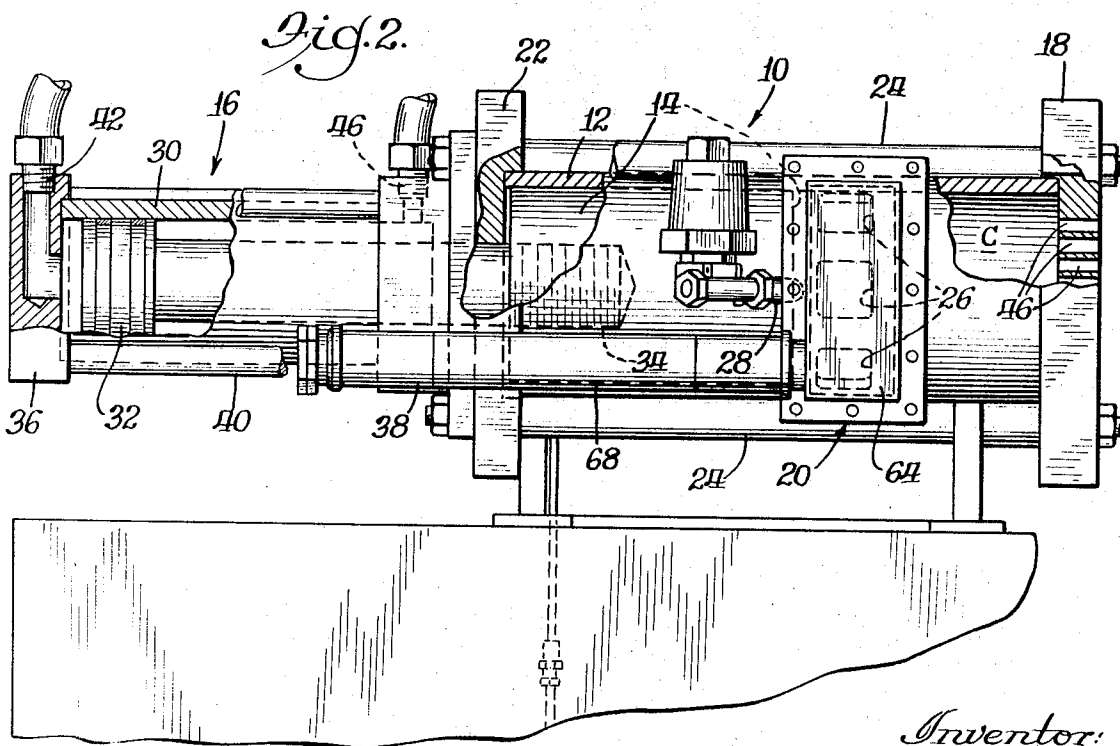
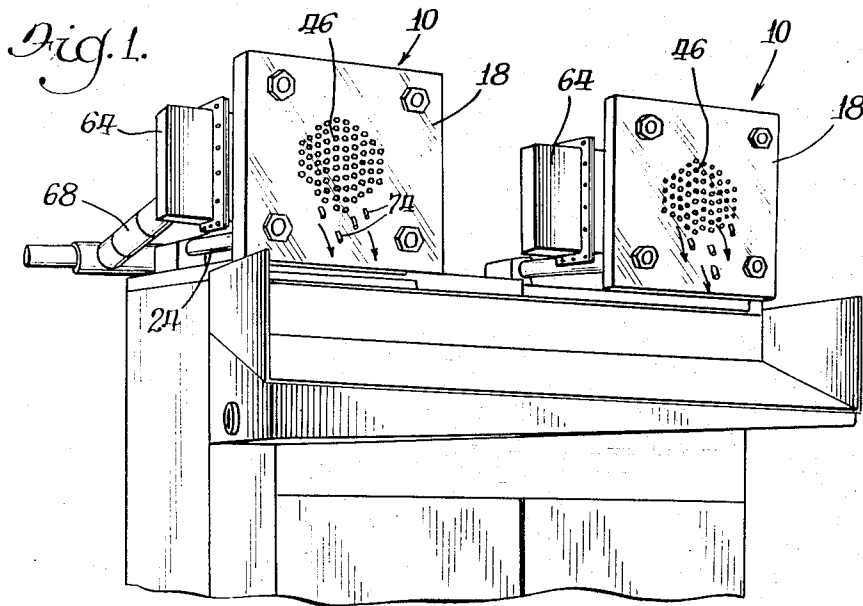
Primary Examiner—Norman Yudkoff
Attorney, Agent, or Firm—N. M. Esser

[57] ABSTRACT

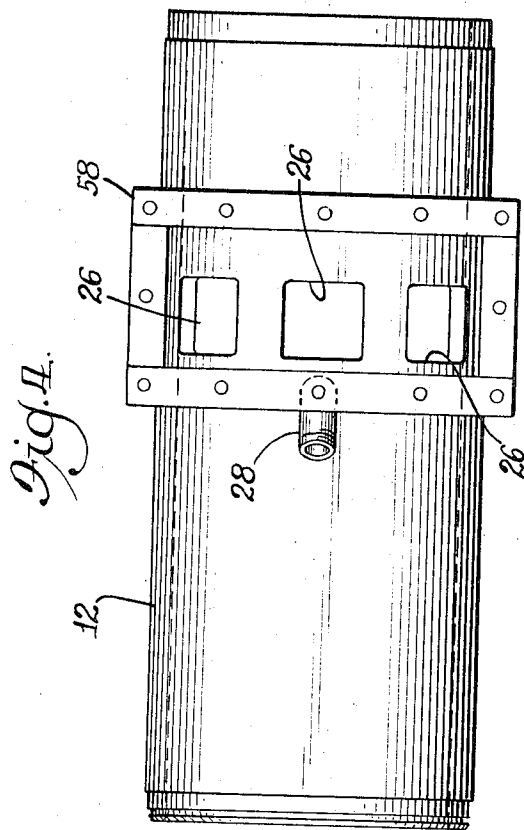
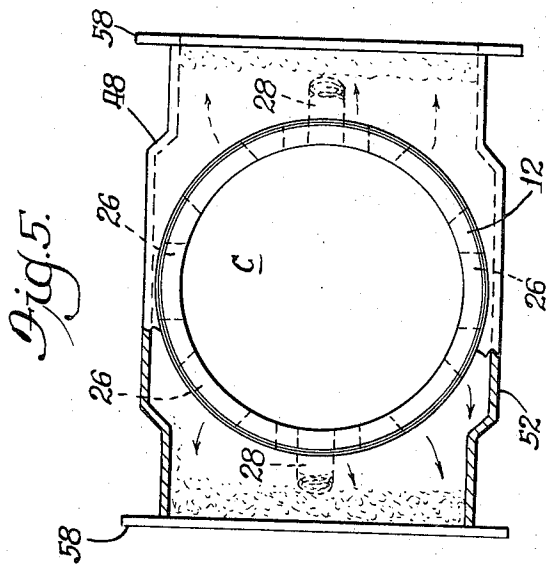
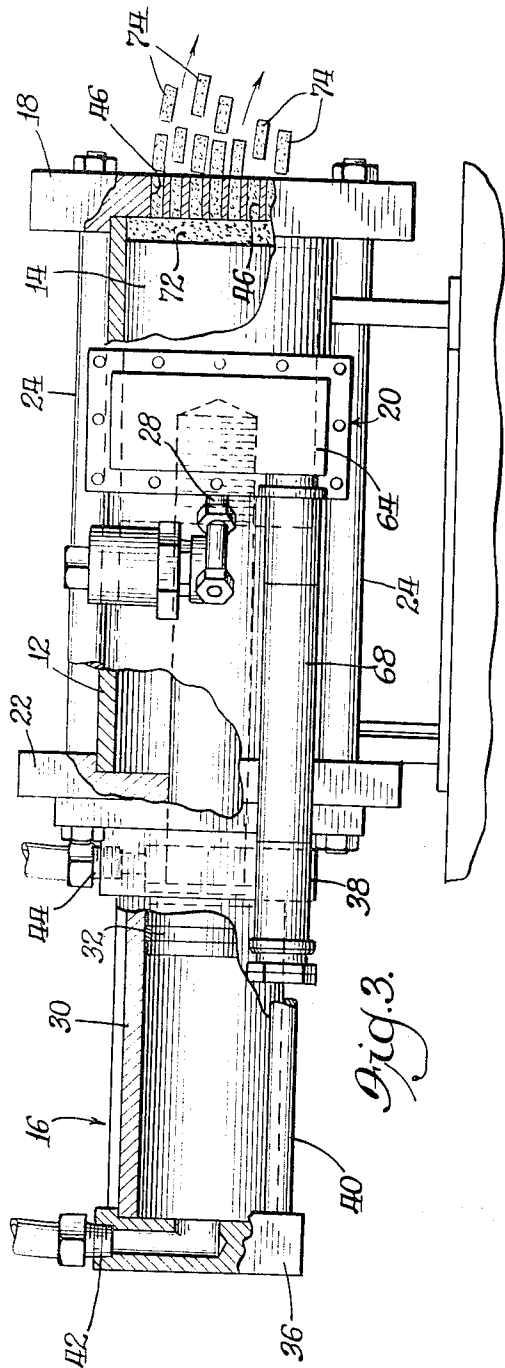
Apparatus for producing carbon dioxide extrusions such as pellets by flashing carbon dioxide liquid to form carbon dioxide snow and vapor in a chamber. A reciprocating piston in the cylinder compresses the snow material and extrudes compacted carbon dioxide snow through extrusion orifices at one end of the chamber. The chamber is constructed with openings in the lateral wall to permit part of the snow to be ejected therethrough into a snow retaining box, the snow in the box being employed as a porous filter to separate the vapor from the snow within the chamber.

1 Claim, 9 Drawing Figures





Inventor:
John A. Scudder
By: *[Signature]*
Att'y: *[Signature]*



Inventor:
John A. Scudder
By: *[Signature]*
Atty.

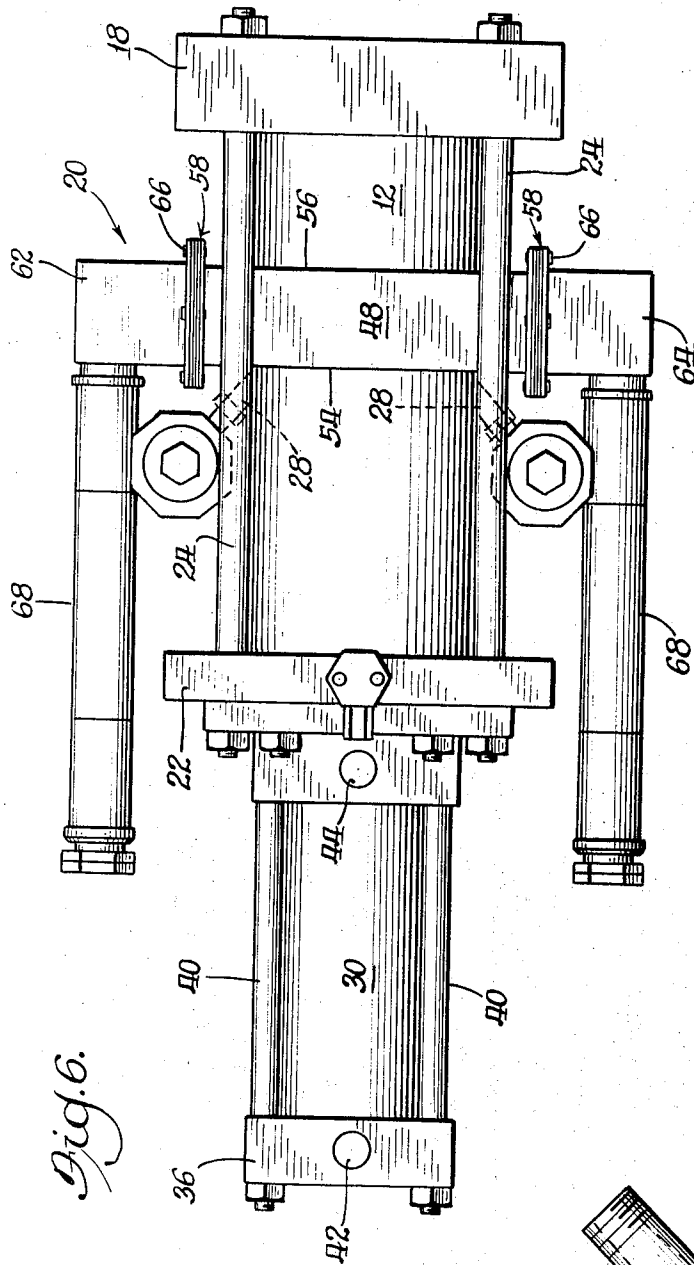


Fig. 6.

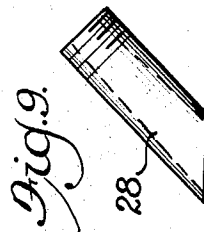


Fig. 9.

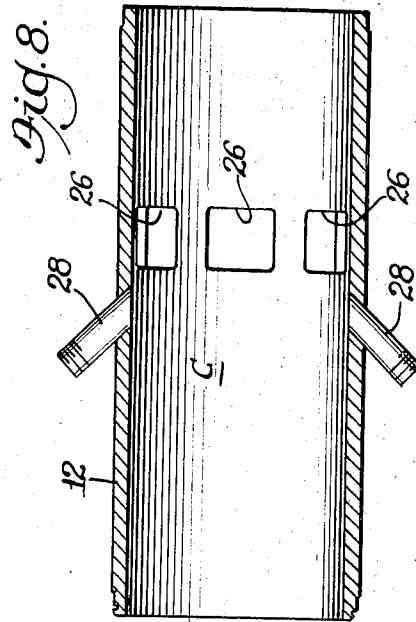


Fig. 8.

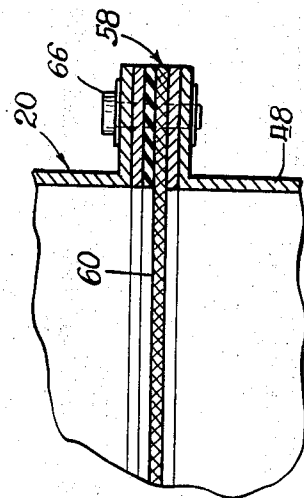


Fig. 7.

Inventor:
John A. Scudder
By: *McKee*
Att'y.

CARBON DIOXIDE EXTRUDED PELLETS

This invention relates to apparatus for making pellets, and particularly to apparatus for continuously making carbon dioxide pellets.

Prior art discloses apparatus for automatically making carbon dioxide extrusions such as pellets. The prior art also discloses apparatus wherein carbon dioxide snow is formed within a chamber by flashing carbon dioxide liquid into the chamber and a portion of the snow so formed serves as a porous filter. The invention disclosed herein is an improvement in such apparatus and in a related method for producing carbon dioxide extrusions, to make more efficient use of the snow itself as a porous filter than previously have been known to the art. U.S. Pat. No. 3,576,112 and United States Pat. No. 3,618,330, which are assigned to the assignee of this application, disclose carbon dioxide pellet making apparatus as referred to above.

Briefly summarized, the invention herein provides improved apparatus and an improved method for producing carbon dioxide extrusions and especially for making more efficient use of carbon dioxide snow as a medium for filtering carbon dioxide vapor also formed during the production of such extrusions. In the apparatus, one or more openings provided in a snow barrel communicate with a snow retaining box mounted externally of the snow barrel. Reciprocation of a piston in the snow barrel forces snow through the openings into the snow retaining box such that snow is compacted therein to form a porous filter. A porous matrix preferably in the form of a screen is included in a wall portion of the snow retaining box and permits carbon dioxide vapor to be vented.

IN THE DRAWINGS

FIG. 1 is a perspective view showing a pair of apparatus for producing carbon dioxide extrusions;

FIG. 2 is an elevation view of one of the apparatus of FIG. 1, partially broken away, showing a piston in a retracted position;

FIG. 3 is a view, similar to FIG. 2, showing the piston in an advanced position;

FIG. 4 is a view of a cylinder or snow barrel of said apparatus with a snow retaining box mounted thereon;

FIG. 5 is an end view of the snow barrel and snow retaining box of FIG. 4;

FIG. 6 is a plan view of the apparatus of FIGS. 2 and 3 showing the snow retaining box and attached filter covers;

FIG. 7 is an enlarged sectional view of a detail of FIG. 6 showing the filter screen arrangement;

FIG. 8 is a detail of the snow barrel showing injectors and their position in relation to openings in the cylinder wall; and

FIG. 9 is a detail of an injector of FIG. 8.

Referring now to the drawings, in which like reference characters in the several views designate similar parts, the numeral 10 designates generally apparatus for producing carbon dioxide extrusions such as pellets. The apparatus 10 includes a cylinder or snow barrel 12, an extrusion piston 14 disposed in the snow barrel, hydraulic piston-actuating mechanism 16, an orifice plate or head 18 secured at one end of the cylinder through which compacted carbon dioxide snow is extruded and a filter manifold 20 associated with the snow barrel. One or more apparatus 10 may be mounted on a cabi-

net as shown, adapted to house controls associated with the apparatus 10 for its or their operation.

The cylinder or snow barrel 12 is secured between the orifice plate 18 at one end and a cylinder mounting plate 22 at the other end by a plurality of tie rods 24. The plate 22 forms the back face of the snow barrel 12. Plural openings 26 are arranged circumferentially around the lateral wall of the snow barrel 12 for a purpose to be hereinafter explained. As shown, the openings 26 extend over major portions of the circumference of the lateral wall of the snow barrel 12. Injector tubes 28, which extend through the lateral wall of the snow barrel 12, are adapted to be connected to a source of carbon dioxide liquid for injection into the chamber C in the snow barrel 12. The extrusion piston 14 is disposed in the snow barrel 12 for reciprocating movement therein.

The hydraulic piston-actuating mechanism 16 is arranged to provide timed actuation of the piston 14 in the snow barrel. The piston-actuating mechanism herein illustrated includes a cylinder 30 and a double acting ram 32 therein which extends through the cylinder mounting plate 22 and is secured to the piston 14 preferably at a threaded connection as shown at 34. The cylinder 30 is secured between mounting plates 36 and 38 by a plurality of tie rods 40 with the mounting plate 38 being secured to the cylinder mounting plate 22. Hydraulic fluid connections 42 and 44 are provided to communicate with respective ends of the cylinder 30 whereby actuation of the ram 32 and the extrusion piston 14 connected thereto is achieved.

The orifice plate 18 secured at one end of the snow barrel 12 has formed therein a plurality of orifices 46 through which compacted carbon dioxide snow is extruded. The filter manifold 20 includes a snow retaining box 48 mounted to the outside of the snow barrel 12 to enclose the openings 26 in the snow barrel 12. The snow retaining box 48 comprises a substantially rectangular box-like structure including upper and lower plates 50 and 52 and interconnecting side plates 54 and 56 through which the snow barrel 12 extends. Wall portions respectively comprising a frame 58 and a porous matrix preferably in the form of a filter screen 60 therein are disposed at each end of the snow retaining box to complete the box-like structure. Box-like filter covers 62 and 64 are attached by suitable means such as bolts 66 to the snow retaining box 48 to complete the manifold 20. Vent tubes 68 attached to each of the filter covers provide means whereby the filtered vapor may be conducted to appropriate apparatus (not shown) for reliquefaction as described in the above referred to U.S. patents. The snow retaining box 48 retains carbon dioxide snow which acts as a porous filter for carbon dioxide vapor formed in the chamber C. As the piston 14 reciprocates in the snow barrel 12, the piston 14 forces carbon dioxide snow formed in the chamber C through the openings 26 to compact the snow in the snow retaining box 48.

Carbon dioxide liquid under pressure is flashed into the chamber C through the injectors 28. Thus, carbon dioxide snow and vapor are formed in the chamber C. As the piston 14 is reciprocated by the piston actuating mechanism 16, the piston 14 advances from a retracted position as shown by dotted lines in FIG. 2 to a fully advanced position as shown in FIG. 3. It will be observed from FIG. 2 that piston 14 in its fully retracted position leaves the openings 26 in the cylinder

12 fully exposed. As snow forms in the chamber C upon the flashing of carbon dioxide liquid, a portion of the snow is forced through the openings 26 into the snow retaining box 48, and the snow is compacted in the snow retaining box. Thus, the snow therein forms a porous filter 70 for the vapor formed in the chamber C. As the piston 14 advances, it forms adjacent the orifice plate 18 a plug 72 of compressed carbon dioxide snow. The plug 72 provides a seal between the atmosphere and the chamber C. Thus carbon dioxide vapor in the chamber C is removed from the chamber C by passing through the snow filter in the snow retaining box 48 and then through the filter screens 60 and into the vent conduits 68. Also, as the piston 14 advances, the snow in chamber C is compacted, and a portion of the compacted carbon dioxide snow is extruded through the orifices 46. Then, the remaining compacted carbon dioxide snow reforms the plug 72.

In the apparatus 10, the preferred orientation is for the central axis of the snow barrel 12 to be horizontal, as shown. However, the arrangement of the snow filter in the apparatus 10 enables the apparatus 10 to be operated, as described, without reference to gravity.

It has been found that the presence of carbon dioxide liquid in the chamber C should be avoided. Particularly, it has been found that such liquid flashes to carbon dioxide vapor as the compacted snow is being extruded and thus tends both to fragment the pellets and to eject fragmentary pellets explosively from the orifices 46. Thus, it has been found highly desirable to operate the apparatus 10 to insure that the vapor pressure within the chamber C does not exceed the triple-point pressure as carbon dioxide liquid is flashed to form carbon dioxide snow and vapor in the chamber C.

The venting of carbon dioxide vapor is restricted at the openings 26, at the compacted snow in the snow box 48, at the filter screens 60, and downstream of the filter screens 60. These restrictions tend to cause the vapor pressure to be increased in the chamber C as carbon dioxide liquid is flashed to form carbon dioxide snow and vapor in the chamber C.

The vapor pressure within the filter covers 62 and 64 downstream of the filter screens 60 may be measured by conventional means (not shown) and in the apparatus 10 generally is approximately equal to atmospheric pressure. The pressure of the hydraulic fluid which actuates the ram 32 and thereby actuates the piston 14, may be measured by conventional means (not shown). Such pressure serves as a measure of the compacting pressure within the chamber C. Also, it provides an indication of the compacting pressure within the snow box 48 so long as the openings 26 are exposed.

It has been found that the permeability of carbon dioxide snow to carbon dioxide vapor is related to the density of the snow and thus to the pressure with which the snow is compacted. Thus, in order to operate the apparatus 10 such that the vapor pressure within the chamber C does not exceed the triple-point pressure as carbon dioxide liquid is flashed to form carbon dioxide snow and vapor in the chamber C, it has been found necessary to control the maximum density of the snow in the snow box 48 by controlling the maximum compacting pressure within the snow box 48.

From the drawings, it is evident that the advancing piston 14 compacts the snow both in the chamber C and in the snow box 48 so long as the openings 26 are exposed and that it compacts the snow only in the

chamber C once the openings 26 are blocked by the piston 14. Thus, the position of the openings 26 along the snow barrel 12 controls the compacting pressure within the snow box 48 and thus controls the density of the snow in the snow box 48 such that the vapor pressure within the chamber C does not exceed the triple-point pressure as carbon dioxide liquid is flashed to form carbon dioxide snow and vapor in the chamber C. Also, while the apparatus 10 is operating with compacted snow in the snow box 48, the filter covers 62 and 64 and the filter screens 60 may be removed, as for cleaning or replacement, without loss of the compacted snow in the snow box 48.

Moreover, from the drawings, it is evident that the total area of the openings for the filter screens 60 is larger than the total area of the openings 26. Thus, the pressure increase caused by the filter screens 60 is less than it would be if smaller screens (not shown) of the same micron-size were to be employed merely to cover the openings 26.

By way of an example, an apparatus similar to the apparatus 10 has been constructed and successfully operated with the following approximate dimensions:

Piston: 8 inches dia. $\times$ 11 $\frac{7}{8}$ inches length, 10 inches travel;

Snow barrel: 8 inches inner dia. $\times$ 22 $\frac{1}{2}$ inches length;

Openings (8) from snow barrel to snow box: 2 $\frac{1}{2}$ inches sq., back edges 12 $\frac{3}{4}$ inches from back face of snow barrel;

Injection Orifices (2): center lines 11 $\frac{1}{8}$ inches from back face of snow barrel (at outside of snow barrel), five-sixteenths inch inner dia. at inlet, 2 $\frac{1}{2}$ inches long, 6° taper, 40° angle to axis of snow barrel;

Extrusion Orifices (86): $\frac{1}{2}$ inch dia. (nominal)

Snow Box: 13 $\frac{5}{8}$ inches screen-to-screen, (2) screen openings 8 $\frac{3}{4}$ $\times$ 4 inches ea., 32 micronsize stainless steel cloth filter screens.

(Note: figures in parentheses refer to the quantities of the features.)

Such apparatus was successfully operated at one cycle per 48 seconds, with the hydraulically driven piston advancing 10 inches in 16 seconds and reacting fully in 8 seconds. Carbon dioxide liquid at 200 psi—, -10°F, was injected throughout a 24-second period during which the piston was in its retracted position, at a rate of 17 pounds-total per cycle, to form about 50 percent snow and about 50 percent vapor in the chamber of the snow barrel, the vapor pressure within the chamber remaining below 50 psig. The snow barrel achieved an average temperature of -110°F. Snow sublimed in the snow box was replenished from compacted snow in the chamber. (The foregoing data are illustrative.)

During the advance of the piston, the data of TABLE I was obtained as illustrative of the novel timed sequence of this invention.

TABLE I

TIME	EXTRUDER OPERATION		
	PISTON TRAVEL	PRESSURE ₁	PRESSURE ₂
1	.615	0	0
2	1.25	0	0
3	1.875	0	0
4	2.5	0	0
5	3.125	0	0

TABLE I-Continued

TIME	EXTRUDER OPERATION		
	PISTON TRAVEL	PRESSURE ₁	PRESSURE ₂
6	3.75	0	0
7	4.375	0	0
8	5.000	300	261
9	5.625	500	695
10	6.25	2500	2180
11	6.875	3000	2616
12	7.500	2800	2441
13	8.125	2600	2267
14	8.750	2600	2267
15	9.375	2600	2267
16	10.000	2600	2267

Legend

Time in seconds, piston travel in inches, pressures in psig; PRESSURE₁=hydraulic fluid pressure measured; PRESSURE₂= pressure of the piston on the snow in the chamber, calculated from $P_1A_1=P_2A_2$, where A_1 and A_2 are the areas respectively of the ram and the piston.

(Note: A block was applied externally to seal the extrusion orifices until a plug of compacted carbon dioxide snow was formed internally at these orifices.)

Thus, it will be appreciated that all of the recited objects, advantages and features of this invention have been demonstrated as obtainable in a highly practical apparatus and one that is simple and positive in operation. It will be further understood that although this invention has been described with respect to certain specific embodiments thereof, this invention is not limited thereto, since various modifications of said invention will suggest themselves from the aforesaid description and are intended to be encompassed within the scope

of the appended claims wherein there is claimed.
I claim:

1. In apparatus for producing carbon dioxide extrusions of the type comprising a barrel having a generally tubular lateral wall and defining a generally cylindrical chamber adapted to receive carbon dioxide snow and vapor, said chamber having at least one extrusion orifice, means for flashing carbon dioxide liquid to form carbon dioxide snow and vapor in said chamber, means including a piston reciprocable in said chamber for compacting carbon dioxide snow in said chamber to extrude a portion of the compacted snow through the extrusion orifice, and means for removing carbon dioxide vapor from said chamber, the improvement wherein said means for removing carbon dioxide vapor from said chamber comprises a snow retaining box mounted externally of and to the lateral wall of said barrel to enclose plural openings in said lateral wall, said openings being arranged circumferentially around and extending over major portions of the circumference of said lateral wall, said box being adapted to receive and retain carbon dioxide snow, an outer wall portion of said box including a porous matrix larger in area than the openings in the lateral wall of said barrel and disposed externally of said lateral wall, said matrix being adapted to retain carbon dioxide snow in said box and to pass carbon dioxide vapor from said box, and a filter cover removably mounted on said box so that said cover and said matrix may be removed from said box without loss of snow from the apparatus, said cover being disposed over said matrix to receive the vapor passing from said box.

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