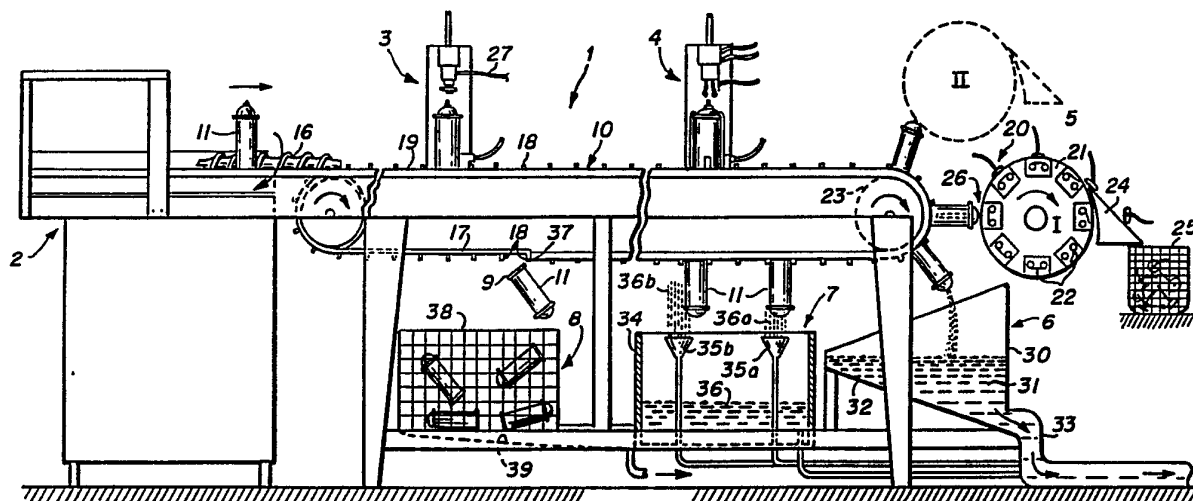




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(54) Title: AEROSOL CAN RECYCLING APPARATUS AND METHODS



(57) Abstract

A multi-stage, batch or continuous, manual or automated process and apparatus (1) for safely depressurizing, de-capping, and recycling aerosol cans (11), propellants, solvents, chemicals, dip tubes, and can tops (43). The apparatus includes a sorting and loading unit (2) for guiding the cans onto an advancing line (10). The cans are first depressurized by a vacuum head unit (3) comprising a vacuum seal and a reciprocable hollow needle (70) which punctures the top cap and removes the propellants by suction. The cans are advanced to a decapping unit (4) where the cap member is removed by decrimping. The decrimper/decapper head includes a plurality of specially adapted pincers (80) for gripping and radially inwardly deforming the cap nozzle neck. The method includes unloading cans bottom side down, passing them at preselected, indexed intervals and rate along a disassembly line for depressurization, removal and recovery of propellants, and decapping. The can top, plastic dip tube assemblies, and residual solvents and chemical contents are recovered for disposal or recycling. The cans are washed, rinsed and dried.

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Title: AEROSOL CAN RECYCLING APPARATUS AND METHODS

SPECIFICATION

5 This invention relates to methods and apparatus for recycling pressurized aerosol containers. More specifically, the invention relates to apparatus for safely de-pressurizing and removing the inset cap member of an aerosol can (de-crimping) in order to keep the can
10 in re-usable condition, and to methods for the recovery of the aerosol can contents, recycling of the contents, cleaning and re-use (repacking) of the can.

Aerosol cans which are disposed in trash are classified as hazardous wastes. They pose serious
15 environmental pollution problems in that they contain propellants, solvents and residual chemicals. The current common propellants range from propane, isobutane, butane, (hydrocarbon gases) and CO₂ to fluorocarbons (freons). Fluorocarbons have been proven
20 to be a major contributing factor in the deterioration of the ozone layer. Hydrocarbon gases and CO₂ are contributing to a dangerous rise of global average temperatures (otherwise known as the "Greenhouse Effect"). Many of the chemicals contained in the cans
25 are also hazardous.

Inability to recycle the cans represents a serious waste of the various raw materials, including the hydrocarbon/CO₂ or fluorocarbon propellants, the solvents, the chemicals, and the can materials. These
30 latter include aluminum or tin can materials, and various plastic parts such as high density polyethylene or polypropylene dip tubes.

As cans gradually corrode in landfills, they release the propellants into the atmosphere, and the solvents
35 and waste chemicals into the water table. In the US during only three years 1986-1988, the number of aerosol

cans produced in all product categories exceeded 8.145 billion cans. Since no can is completely emptied, for the years 1981-1988 this waste amounts to 129,935,000 liters (34,329,000 gallons), the vast majority of which
5 will be improperly disposed in land fill and discharged over the next 5-100 years as the cans deteriorate.

The recycle value of the cans is significant especially the 10% of which are aluminum. For every can recycled, there is also energy of production saved, and
10 a reduction in source pollution (e.g. reduction in fuel burned to produce electricity to refine bauxite to aluminum, and then to roll sheet and form cans).

Various U.S. Patents, such as: 3,835,768 (Kidson, 1974); 4,133,261 (Belfils, 1979); and 4,418,460 (Ruth,
15 1983), teach recycling non-aerosol cans by total destruction of the can by a process involving puncturing the side wall of one can at a time.

U.S. Patents 4,349,054 (Chipman et al., 1982); 4,407,341 (Feldt et al., 1983); 4,459,906 (Cound I,
20 1984); and 4,526,097 (Cound II, 1985) teach various multi-stage processes for the safe transfer of contents, disposal or recycling of aerosol cans due to the explosive nature of the contents. These patents employ an apparatus having an enclosed chamber wherein the
25 aerosol container is fixedly retained and the side wall punctured. Next, the contents are discharged into a receiving area to be recycled, and the ruined can is then cleaned and compacted (crushed).

These patents do not permit reuse of the original
30 aerosol containers, as the methods and apparatus used for reclaiming the contents effectively destroy the mechanical integrity of the can.

U.S. Pat. No. 2,423,708 (Keogh et al., 1947) teaches salvaging metal cans by cutting off the top end closure
35 of a single-closure type can. After the can is cleaned, it is subjected to further drawing action, which thins the walls and bottom portion while restoring the length of the can body to its original height. A new closure

is then installed on the thinner-walled can.

U.S. Patents 3,473,499 (Bishop, 1967) and 3,618,429 (Froeliger, 1969) disclose methods to remove a flanged metal container top by applying a downward axial force to the top of a drum-type non-pressurized container to bow it sufficiently to deformingly unseal the rolled flanges. These methods are unsafe for aerosol cans.

It is also known to use pincer-like tools in combination with a plunger device to remove closures of containers. U.S. Patents 2,612,065 (Packer et al., 1952) and 2,732,741 (Muller-Strobel, 1956) teach the use of side grippers or pincers that engage the perimeter of either a crown cap or insertable plug-type metal covered rubber container plug after which a plunger is actuated downward, whereby the cap or plug is released from the container. These methods work well for the bottle-type of enclosures for which they were designed, but they are not suited to remove the top cap from an inset cap type metal aerosol container without damaging the container.

SUMMARY OF THE INVENTION:

The present invention comprises apparatus and processes for safely depressurizing, de-capping (decrimping) and recycling aerosol cans by means of a pneumatically or electro-pneumatically driven assembly line at high speed comprising the following means (assemblies) and steps:

1. Unloading a batch of cans, bottom side down, onto a rotary disc or vibrating screen-type can feeder unit, or optionally employing a depalletizer;
2. Selectively advancing the cans in sequence from the can feeding machine onto a moving conveyor of the assembly line by means of a timed feeder means, such as a timing screw;
3. Safely depressurizing the aerosol can by lowering a vacuum head onto the can top, puncturing the can cap member by a hollow needle, rapidly removing the

propellants and other gaseous contents (product and/or solvent vapors) by means of a vacuum drawn through said hollow needle, and storing the propellants and other gases, preferably off-site for later reuse, use or proper disposal;

4. Removing the cap member from the can body without damaging or altering the can body or dome top by use of a special decrimper assembly comprising a decrimper head lowered onto the can top. The decrimper head includes a plurality of specially adapted pincers (preferably four pincers), which are sufficiently opened in a neutral position, to be directable over and around the can cap crown (stem) member. The pincers are then closed, thereby applying a uniform inwardly directed radial force to the cap crown (stem) at a plurality of equally spaced points about the crown stem. This causes the annular horizontal areas surrounding the cap crown stem medial of the pincer contact point to be drawn radially inwardly toward the crown (stem), thereby causing the cap flange to deform and unroll from the lip of the can without damage to the lip. The pincers and decrimper head are then raised vertically upward as a unit causing a further bowed-upward deformation to the cap member until any remaining bond between the cap and the can lip is broken. This complex process is termed "decapping" herein. The pincers are then opened, thereby releasing the cap member to rest loosely on top the can lip;

5. Removal and collection of the loosened cap and dip tube assemblies, for example by passing the cans adjacent a magnetized rotating disc which plucks the cap and connected plastic dip tube assemblies from the cans. The metal cap member and plastic dip tube assemblies are collected for later sorting and reclamation of the separate metal and plastic components;

6. Removal of any residual solid or liquid contents (chemicals and solvents) for later recycling for reuse, or proper disposal;

7. Washing and drying of the empty cans, and optionally de-lithoing (removal of painted-on text and logos) the cans;

5 8. Collection, storage and shipping of the undamaged de-pressurized, de-crimped, de-capped and cleaned aerosol cans (herein "reclaimed can bodies") for later reuse (repacking), reclamation or recycling; and

9. Optionally refilling (repacking) the reclaimed can bodies in an aerosol can filling line (including relabeling the refilled cans), or crushing damaged cans.

10 The entire line may be shrouded or surrounded by a hood to capture can content vapors. Alternately, a negative pressure travelling boot may be placed around the advancing cans in the process, preferably steps 2 through steps 5 or 6.

15 The process for bottom-plugged cans involves similar steps, except that the depressurizing needle may be directed upwardly through the rubber or plastic grommet plug in the bottom of the can, while simultaneously or sequentially thereafter the cap is decrimped as described. Alternately, the bottom-plugged can may be inverted in the depressurizing step (bottom up), and righted for the decrimping step.

20 The specific embodiments described below are with reference to a linear recycling line, but the line may be laid-out in a rotary configuration, and may involve multiple depressurizing and decrimping heads per line.

DRAWINGS:

Fig. 1 is a top plan view of a single index assembly line apparatus for recycling aerosol cans in accord with this invention;

Fig. 2 is a side elevation view of Fig. 1;

Fig. 3 is a side elevation view of the first, can depressurizing head station showing a vacuum head and a pressurized aerosol can in place;

35 Figs. 3A-3D are a sequence of four side elevation

views, partially in section, of the depressurizing vacuum head of Fig. 3;

Fig. 4 is an enlarged side elevation view of the second, can decapping head station;

5 Figs. 4A-4D are a sequence of four side elevation views, partially in section, of the decapper head;

Fig. 5 is a face view of the decapper (decrimper) head in the open position taken along line 5-5 of Fig. 4A;

10 Fig. 6 is a top view of a can cap with a puncture hole;

Fig. 7 is a side elevation view of Fig. 6;

Fig. 8 is a face view of the decapper head in the closed position;

15 Fig. 9 is a top view of a decrimped cap showing the direction of forces applied to the cap and the resulting arcuate deformations of the cap perimeter;

Fig. 10 is a side elevation view of the decrimped cap of showing the unrolling of the cap flanges due to the inwardly directed radial forces applied to the cap;

20 Fig. 11 is a partial cross section view of the pincers of the decapper head;

Fig. 12 is a schematic of the logic for the operation of the assembly line of this invention; and

25 Fig. 13 is a side elevation view, partially in section, showing an alternate embodiment of the vacuum head assembly adapted for bottom pressurized (plugged) aerosol cans.

DETAILED DESCRIPTION - OVERVIEW OF THE ASSEMBLY LINE:

30 The general layout of the invention is best illustrated in Figs. 1 and 2. The recycling machine 1 of this invention recycles aerosol cans 11 by employing, in a continuous process, several timely linked sub-assemblies (herein "stations") spaced along conveyor belt 10, including can feeder 2, vacuum head assembly 3 (depressurizing station), a decrimper/decapper head
35 assembly 4 (de-capping station), dip tube and cap

collection assembly 5, product dump station 6, can washing/drying station 7, and can recovery station 8. A separate can drying station (not shown) may be used between the can washing station 7 and the can recovery station 8.

A hood (not shown) may be placed over the entire recycling machine 1 for the collection of excess chemical vapors and propellants that may escape from the cans during the depressurizing and de-capping stages, or until the cans are completely emptied of their contents and washed and rinsed.

More or fewer of the stations 2-7 could be positioned in either orientation, that is, along the topside or underside of the conveyor belt 10. A second assembly line may be added to handle the secondary process steps, such as dip tube removal and recovery assembly 5, product dump station 6, can washing station 7, and can recovery station 8. They may be strung together on an independent secondary process step assembly line that is interfaced with or separate from the primary process step assembly line.

While the recycling machine 1 shown is a single index, single lane, in-line machine having a capacity of 24 cans per minute, a greater can processing capacity can be achieved by using a double, triple, or even quadruple index arrangement (i.e. multiple heads 3 and 4), and/or by using one or more lanes (parallel line operation).

The operation of the recycling machine 1 begins with the loading of pressurized aerosol cans 11, bottom side down, onto a rotary disk 12 of the can feeder 2. The pressurized cans 11 are then guided into the lane 13 by the feeder guide 14 and prevented from falling off the rotary disk by the guard rail 15.

The cans are selectively positioned onto the conveyor belt 10 by advancing along threads of the rotating timing screw 16. The conveyor belt 10 preferably comprises a slotted stationary track 17 along which a chain, having uniformly spaced upstanding pusher links

18, is driven. The links move the cans down the lane 13 from one station to the next. Spaced-apart guide rails 19 positioned along opposed sides of the track 17 are adapted to restrain tipping or vertical movement of the travelling cans by means of a lip 19a (Fig. 3) that engages the lateral protrusion of the can bottom flange 9. This also permits retaining the cans 11 so they can travel upside down to the product dump station 6 and can washing/drying station 7 (see Fig. 2).

At the depressurizing station 3, the cans 11 are depressurized and the propellant is removed by a vacuum line 27. The cans then proceed to the de-capping station 4 which includes a decrimper head assembly 4 which serves to separate the dip tube and inset cap assembly 20 from the individual cans. The cans then proceed to the cap/dip tube removal and recovery assembly 5. At this point the assembly line drive chain rotates about wheel 23 (clockwise in Fig. 2) thereby reversing the direction of can travel 180°.

The cap/dip tube removal and recovery assembly 5 comprises a rotatable disk 21 having solenoid switches 22 selectively spaced along its perimeter, a scraper ramp 24, and a basket 25. The disk 21 rotates in a clockwise direction as shown by arrow I in Fig. 2, and its period of rotation is coordinated with that of the chain advance so that the individual solenoids 22 coincide with the oncoming cans 11 at a suitable point of intersection 26. At intersection the solenoid is activated, magnetically attracting the dip tube and cap assembly 20 to the magnetic wheel 21 by virtue of its ferrous elements. After the activated solenoid has rotated past top dead center, it is deactivated and the dip tube and cap assembly 20 falls off or is removed by scraper ramp 24. The extracted dip tube and cap assemblies 20 are then deposited in basket 25 for parts recovery processing or disposal. If the cap is non-magnetic, wheel 21 may employ spaced fingers to grasp the stem 40 or exterior lip 50 (see Fig. 10).

Alternately, an inclined screen above liquid level 31 in reservoir 39 can collect the cap/dip tube assembly.

After removal of the dip tube and cap assembly 20, cans continue to product dump station 6 where they are inverted, causing any residual liquid and/or chemical product 31 (e.g. solvent and product) to empty into the product dump reservoir 30. The bottom wall 32 of the product dump reservoir 30 is preferably elevated at one end to aid in the removal of product 31 to the recovery pipeline 33. The recovered product 31 may then be recycled or otherwise properly disposed.

The empty cans 11 then proceed to the can washing station 7 where they are subjected to one or more jets of bath solution 36a emanating from one or more spray heads 35a. The bath solution 36 may be a hot soap and water combination or any other solvent required to thoroughly clean the inside of a particular run of cans. Optionally, forced air 36b from head 35b may be used to dry the can interior. Microswitching (not shown) may be mounted along the track 17 just before and after each of the spray heads 35a and 35b, which upon engagement with an approaching can sends a signal to activate or deactivate the spraying activity. As the cans pause at stations 3 and 4, they also pause at the washing/drying station 7 for a time sufficient to effectively scrub the cans.

The washed or/and dried cans 11 then proceed to the can recovery station 8. The bottom flange 9 of each can 11 is no longer restrained by the guide rails 19 once the individual cans 11 are pushed by its corresponding upstanding chain link 18 beyond the terminal end 37 of the guide rails 19. The cans fall from the track into the storage receptacle 38. A drip tray 39 is positioned beneath the storage receptacle 38. The guide rails 19 are adjustably fastened to and positionable on the table plate 41 by fastening screws 42.

DEPRESSURIZING HEAD ASSEMBLY

Operation of the depressurizing (vacuum head degassing) assembly 3 is shown in Fig. 3 and the four sequential operational cross-section views Figs. 3A-3D. As the cans 11 move into position under vacuum head 51, arm microswitch 52 of table-mounted pneumatic sensor 53 is activated by the can, thereby sending a signal to vacuum head assembly 3 to stop the conveyor belt travel and begin operation. Air is injected into cylinder 54 via injection line 65 filling cylinder 54 and causing shaft 55 and vacuum head 51 to be lowered as an entire unit onto the can 11 (as indicated by downward direction arrow A in Fig. 3B). The isolation bell 56 is positioned to cover cap 43, and an air tight seal is created by the engagement of pliable rubber ring-like vacuum seal member 57 onto raised dome 44 of can 11 around cap 43.

Functioning of vacuum head 51 involves two distinct reciprocating motions controlled by feedback signals generated by pneumatic sensors 66 and 67 positioned along post 59, and by vacuum shut-off valves in vacuum line 27, for a completion of one operating cycle. The first reciprocation is triggered by the activation of pneumatic sensor 66 by lower contact 68 of the mushroom contactor head 58 disposed on top of shaft 55.

Referring now to Fig. 3C, a first unit assembly comprising: (a) the vacuum sleeve and casing 61; (b) collet 62; (c) vacuum top housing 63; and (d) shaft 55, reciprocates vertically downward with respect to the isolation bell 56 (as indicated by downward direction arrow B). This first reciprocation is biased against spring 64, and is completed when the bottom end of vacuum sleeve and casing 61 is positioned substantially horizontally even with the midsection end of vacuum seal 57 and hollow needle 70 has come to rest just above the top outer surface 48 of can cap assembly 43. This position is intermediate Figs. 3B and 3C. In the first reciprocation, an airway is created whereby port 73 of isolation bell 56 is in communication with port 74 of

vacuum sleeve and casing 61 via annular space 72. Annular space 72 becomes fully developed upon the first downward reciprocation. Thus an exit route for pressurized propellants from isolation bell chamber 75
5 to vacuum line 27 is created.

Fig. 3D shows the second reciprocating movement where shaft 55, having a hollow or grooved needle 70 disposed at its lower end and attached integral therewith, is plunged downwardly (as indicated by Arrow C) relative to
10 the rigidly held four-piece assembly comprising: (a) the vacuum sleeve and casing 61; (b) collet 62; (c) vacuum top housing 63; and (d) isolation bell 56. This second reciprocation causes the hollow needle 70 to pierce the top surface 48 of cap 43 and de-pressurize (degas) the
15 can 11 by draw-off of the propellant by a vacuum pump connected to line 27. The downward plunging shaft 55 is biased against spring 79 and has a hollow relieved area 60 adjacent its bottom end with sufficient annular depth and lateral clearance to permit full downward reciprocal
20 movement of shaft 55 without damaging the spray nozzle unit 28 or stem 40 of the aerosol can 11.

Once the shaft is fully extended downward, the pneumatic sensor 66 is engaged by upper contact 69 of mushroom head 58 thereby activating vacuum line 27. The
25 propellants are removed by suction from the can 11 through the exit route created by the first reciprocation as seen by direction arrow D including port 73 and annular passage 76. Four O-rings, 71a-71d, are included in the assembly of the vacuum head 51 to
30 prevent "blow by" of gasses, and/or loss of vacuum pressure between the vacuum sleeve and casing 61, isolation bell 56, collet 62 and shaft 55.

Once depressurizing (degassing) is complete, a shut-off valve (not shown) in the vacuum line 27 is triggered
35 (e.g. by can pressure drop) sending a signal to exit line 77 (see Fig. 3) causing the pressure in cylinder 54 to be bled off. The compressed springs 64 and 79 thereupon reverse the two reciprocating processes,

ultimately raising the vacuum head 51 back up to the original position. A full upward extension of the shaft 55 causes the mushroom head contactor 58 to trigger the pneumatic sensor 67, which restarts the chain 18, releasing the now de-pressurized can 11 to be sent on down the assembly line to the decrimper/decapper head station assembly 4.

The depressurizing vacuum head assembly 3 may be manually adjusted vertically by operating a hand wheel 46 and pinion gear (not shown) to raise or lower the head mounting casting 45 along the track 47a of the adjustment post 47 in order to compensate for a run of cans of a different height.

It should be understood that mechanical or photo-optical can height sensors may be positioned in association with the vacuum head assembly, e.g. just before it, to activate the casing 45 or shaft 47 to raise or lower the assembly 3 (preferably hydraulically or pneumatically) to compensate for different can heights. Thus, cans of different heights can be run continuously on line 1. The entire machine may be microprocessor controlled and adjusted as to timing, sensor activation of the various movements, rates of travel, height, stroke(s) etc.

25 **DECRIMPER/DECAPPER HEAD ASSEMBLY:**

Operation of the decrimper head assembly is now described with reference to Fig. 4 and the four sequential views, in partial cross-section, (Figs. 4A-4D) of the decapper head 78.

The lowering sequence of the decapper head onto the can assembly cap relies on the additional cylinder 98 for pneumatic reciprocation of the decrimper head assembly 4 relative to the adjustment post 147 and head mounting casting 145. Upon engagement of the micro-switch arm 152 of pneumatic sensor 153 with the side wall of the moving can 11, pneumatic air line 110 is

activated (pressurized). This fills cylinder 98 forcing the plunger 197 downward and causing the entire decrimper unit comprising: (a) the decapper head 78; (b) cylinder 154; (c) shaft 155; (d) post 159; and (e) bracket 160, to be lowered so that the pincers 80 are positioned over the cap 43 (as indicated by downward direction Arrow E of Fig. 4). Movement of bracket 160 with respect to the stationary head mounting casting 145 is facilitated by means of a sliding bearing or keyway 161 having bearing surfaces along substantially the entire length of the contact area.

In the fully downwardly extended position, the pincers 80 come to rest against or just above the top surface 48 of cap 43 and partially enclose or surround the crown (stem) 40 (see Fig. 4B). At this moment, upper contact 195 triggers switch 196 thereby sending a signal to begin injecting air into cylinder 154 via injection line 165. This, in turn, forces shaft 155 to reciprocate downwardly, Arrow F in Fig. 4C.

The workings of the decapper head 78 is seen in Figs. 4A and 4C. As shaft 155 is lowered into the decapper head 78, the tapered edges 86 of the conical tip 92 of shaft 155 come into wedging contact with the mating surfaces of the conical inner walls 87 of the upper portion 88 of pincers 80. The outward, splaying movement of the upper pincer portion 88 causes a reverse, closure-type movement in the lower pincer portion 89 of pincers 80. The mechanical sequence is facilitated by a ball pivot 90 disposed at the central intersection of the four pincher fingers 80. One continuous hemispherical pivot surface 93 is disposed along the exterior surfaces of each pincher finger 80 at approximately its midpoint, and functions to retain and permit the pincher fingers to remain within base member (ring) 91. The downward movement of the shaft 155 is translated into a lateral closure movement of the pincers 80 about the stem 40 through the mechanical workings of the upper pincer portion 88, lower pincer

portion 89, center ball pivot 90, and torroidal pivot 93.

When firmly engaged and fully closed about the stem 40, the pincers 80, having a tremendous mechanical advantage, radially and inwardly deform the stem 40 and stress the top portion 49 in radially inward tension (arrow H in Fig. 4C). Stressing the cap 43 in this manner results in a partial unrolling of crimped flange 50, causing it to at least partly break the seal between flange 50 and the lip 81 of the can 11 (see Fig. 4C).

Upon full downward movement of shaft 155, as indicated by downward direction arrow F in Fig. 4C, pneumatic sensor 166 (see Fig. 4) is activated by engagement with lower contact 168 of mushroom head 158, thereby sending a signal to begin releasing pressure on the line 110 side of cylinder 98 and raising plunger 197 by pressurizing air line 111. The entire unit (decapper head 78, cylinder 154, shaft 155 and post 159) reciprocates upward with respect to the head mounting casting 145 and adjustment post 147. The now deformed cap 43, while still being firmly engaged by the pincers 80 since the downward pressure (arrow F in Figs. 4C and 4D) is still applied, is subjected to an upward pull by this reciprocation.

As best seen in Fig. 4D, prior to the upward deformation exerted on the cap 43, the rolled flange 50 may be still partially secured to lip 81 e.g. by the curl of crimped flange 50 over the bead lip 81. Then, the upward pulling force exerted on cap 43 and crown 40, by raising the entire decrimper head, produces a bowed-upward deformation of the central portion of cap 43 until the resistance of the seal between rolled flange 50 and lip 81 is completely broken, resulting in the cap 43 becoming completely separated from the can 11. This is called "decapping".

Optional additional opposed restraining members 84a, 84b overlappingly engage flange 82 of the can 11 to assist the guide rail members 19 (see Fig. 4) to firmly

hold the can 11 down during the upward pulling phase of the decrimper assembly operation. The restraining members 84 are adjustable both vertically and laterally for cans of different sized diameters, or even spun aluminum cans (i.e., a can having no upper rolled flange). These restraining members, as well as the entire decrimper head assembly, may be adjustable vertically and horizontally from can to can by use of photo-optical sensors and microprocessors. In the case of a spun aluminum can, the restraining members 82 may be positioned further inward and appropriately shaped to matingly engage the curved area of the raised dome 44.

Upon plunger 197 extending upwardly out of cylinder 98, upper contact 194 engages sensor switch arm 196, thereby sending a signal to pressurize air line 177 while simultaneously depressurizing line 165 thereby causing shaft 155 to be raised upwardly through the cylinder 154. This, in turn, removes the tapered edge 86 of the shaft tip 92 from mating engagement with inner wall 87 of the upper pincer portion 88. A donut-type closure spring means 102 (shown only in Figs. 4B and 4C) now forces the upper pincer portion 88 closed, thereby opening the lower pincer portion 89 to the original open position. Pincers 80 now release the loosened cap 43 which drops and rests loosely on top of the can, typically on head 81.

The decrimper sequence is completed upon full upward extension of shaft 155. Pneumatic sensor 167 is triggered by engagement with mushroom head 158 sending a signal that restarts chain line 18, releasing can 11 so that it may proceed to the next station along the assembly line.

Figs. 5-10 are an example of a "before and after" illustration showing the functioning of pincers 80 on cap 43. In Fig. 5, a bottom view (plan view or face-on view) of the pincers in the open position, the gap 101 left in the center of the pincers 80 is sufficient to receive the stem 40 of cap 43 (see Fig. 6). While Fig.

5 shows the use of a four pincer arrangement, it is understood that anywhere from two to twenty pincers may be utilized in the decrimper head assembly. An increase in the number of pincers used results in a like increase in number of contact points between pincer 80 and crown (stem) 40, resulting in a more even deformation to the rolled flange 50 of cap 43. Figs. 6 and 7 show top plan and side elevation views of a normal undeformed cap 43 and stem 40 crimped in position as it would be on a can (can not shown). Hole 29 is left by hollow needle 70 during the depressurizing step. Multiple hollow, solid or grooved needles may be used. Indeed, any means for piercing the cap to permit the can pressure to release into an evacuated or contained space from which the can propellant may be employed without damaging the can body or top cap rim. A hollow needle is not required.

Fig. 8 shows the pincers 80 in the "closed" position. The four pincers 80 engage the stem 40 at four distinct points, as is generally indicated by radially inwardly directed arrows H_1 - H_4 in Fig. 9. Note how the rolled flange 50 is uniquely deformed along portions of the flange 151 angularly between the four points of contact. In a four pincer arrangement, the greatest areas of deformation of the rolled flange 50 are at the four arc regions between the four pincer contact points, which deformation regions are spaced 90 degrees relative to each other and offset from the four pincer contact points by 45 degrees. Likewise, in a three pincer arrangement where the points of applied force contact the crown 40 are at 0, (360), 120, and 240 degrees, the greatest unrolling deformation of the rolled flange would occur at 60, 180, and 300 degrees.

Fig. 10 shows how the inwardly directed radial forces of the pincers (denoted by the opposed horizontal arrows H), combined with the upward pulling force (denoted by the single vertical arrow G) cause the rolled flange 50 to unroll or slightly flatten out (as generally indicated by curved arrows J). A critical aspect of

this invention is the unrolling effect on the crimped (rolled) flange 50 of the cap 43 as a result of the inwardly applied radial force of the pincers 80 to the insert (stem) 40. This result was not previously anticipated, as evidenced by the prior art methods which deformed both the cap and the can, thereby rendering both useless for immediate repackaging. The subsequent upward pulling stage of Fig. 4 is usually required to finally break any remaining bond and separate the cap 43 from the lip 81, but with appropriate number of pincers, and/or sufficient unrolling or unpeeling of cap flange 50 from can bead or lip 80 the upward pull may be minimal or unnecessary. Where that is not required the vertical reciprocation is not required and the operating cycle can be simplified (and speeded up) by eliminating or vertically restricting this motion.

Fig. 11 is a cross section view of the pincers 80 which shows the teeth 85 of the pincers 80. The teeth 85 function to engage and grip the nozzle neck (insert or stem) 40 at its base just above the surface 48 of the cap 43.

The additional upward pulling force causes the cap 43 to bow upwardly, further causing the inner shoulder 83 adjacent the rolled flange 50 (see Fig. 4D) to pull inwardly resulting in a further unrolling or flattening of the rolled flange 50 and breaking its sealing contact with the lip or bead 81. Deformation ribs 183 may (usually) form in the surface 48 of the can cap 43 during the upward pull. The upper end 140 of the can stem mushrooms out laterally slightly upon pinching to help prevent the can cap 43 from slipping out of the pincer teeth 85.

It is important to note that the lip 81 of the can 11 is not harmed or deformed in any way in this process; the can bodies may be cleaned and recycled and all wastes (propellant, solvent, chemicals, can top and dip tubes) recovered for disposal or recycle. Thus, the only hole in the can is needle hole 29 in the relatively

inexpensive and replaceable top 40. The tops may be trashed or smelted to recover the metal values. Alternately, the needle hole can be plugged and the can caps reused.

5 **PNEUMATIC LOGIC FOR THE INVENTION:**

Fig. 12 shows the pneumatic logic diagram of this invention. The air flow sequence of the diagram will be described with cross reference to the elements previously discussed in the detailed description of
10 **Figs. 1-4.** The description will begin with a discussion of the pneumatic logic of a first loop where only the vacuum head assembly 3 is involved, followed by a discussion of how the air signals flow through the main cluster 115, the chain index drive 125, and the manifold
15 table switch 120. Then the second loop involving both the depressurizing head assembly 3 and the decrimper/decapper head assembly 4 will be described.

PNEUMATIC LOGIC FOR THE FIRST LOOP INVOLVING ONLY THE DEPRESSURIZING HEAD:

20 Looking at the center right of Fig. 12, as the first can advances along the assembly line it will trip the table-mounted pneumatic sensor 53 of the vacuum head assembly 3. This sends a signal to a 1/4" double pilot "versa valve " 133 via intermediary shuttle valve 134a.
25 The versa valve 133 injects air into the cylinder 54 via line 65 thereby forcing shaft 55 and mushroom head contact 58 downward. This begins the vacuum process of removing the can's gaseous contents. For the sake of clarity, all lines in Fig. 12 are pneumatic.

30 Referring also to Figs. 3 and 3A-3D, vacuum line 27 disconnected to a vacuum source in order to remove the can's pressurized contents through the aperture made in the can top (e.g.) hollow needle 70 and the airway created within the vacuum head 51 during full downward

extension of shaft 55. Full downward extension of shaft 55 also results in the activation of pneumatic sensor 66 which, in turn, sends a signal to begin raising the shaft 55 upward by depressurizing air line 65 and by
5 injecting air into the cylinder 54 via the air circuit comprising air line 171, shuttle valve 134b, versa valve 133, and air line 77.

In order to assure that the vacuum process is complete before the shaft 55 is raised, a delay switch (not
10 shown) may be incorporated into the line between pneumatic sensor 66 and versa valve 133. Otherwise, premature raising of the shaft 55 would result in the can's pressurized contents escaping into the atmosphere. The delay switch may be an independent electro-pneumatic
15 control, a synchronized mechanical timer, a check valve/mechanical assembly or other like means for delaying the air signal to line 77 to begin filling the cylinder 54 and raise the shaft 55.

After the degassing step is complete the vacuum
20 developed in isolation chamber 75 and the interior of the can 79 needs to be broken or else the can will be lifted when the isolation bell 56 with the seal 57 is raised. A check valve in the vacuum line 27 or at the vacuum pump (not shown) provided bleed air to equalize
25 pressure so the seal 57 lifts off dome 44 easily. Alternately, a check valve can be provided in the side wall of the bell 56.

Where sufficiently low vacuum is not developed in can 79 via line 27, as determined by a vacuum sensor (not
30 shown), that means the can is a "leaker" and should not be recycled (repacked). The can may be tagged at that stage, by labeling with a spot of fluorescent color spray paint, and removed by hand or automatically ejected by ejector means (not shown) downstream of the
35 dump station 5 after the cap has been removed.

After the degassing step is complete, the pressure equalized, and the shaft 55 has reached full upward extension, pneumatic sensor 67 is activated by mushroom

head contact 58. This sends an air signal through air line 172 to a three way air pilot 116a of the main cluster 115. The main cluster 115 is the pneumatic "brain" of the entire assembly as it collects and ranks
5 the order of the air signals from the various assemblies of the present invention before sending the signal to the chain index drive 125 to further advance the can down along the assembly line.

The assemblies include the degassing head assembly 3
10 and the decrimper/decapper head assembly 4. They are connected to three-way pilots 116a and 116b of the main cluster 115 by their respective air lines 172 and 170. Any greater number of assemblies may be attached to and regulated by the main cluster 115 by merely adding
15 additional three-way air pilots. Air pilot 116c is such an additional member which permits the connection of another assembly to the main cluster 115 via line 176.

After all the signals have been received by the main cluster 115, a pneumatic signal is sent via air line 173
20 to switch 126a, which, in turn, relays the signal to the 1/4" double pilot versa valve 133. The versa valve 133 directs air into cylinder 132 via air line 178. The cylinder 132 is used to activate a ratcheted drive chain and crank assembly to advance the individual cans one
25 space at a time as it receives signals from the main cluster 115. The stroke length of the cylinder 132 can be set for the desired index, whether it is single, double, triple index (i.e. 1, 2 or 3 cans at a time), etc., by graduating the limit 138 along the drive chain
30 139. The drive chain 139 is indexed forward by ratchet drive sprocket 128 and is biased by ratchet drive chain return 130.

The chain index drive process is complete when end-of-stroke switch 126b has been activated by limited 138,
35 thereby sending a signal to inject air through air line 179 into the cylinder 132. Through air line 175, shuttle valve 134 and versa valve 133. Impulse switch 131 is also activated, thereby sending a signal through

air line 180 to the special N.O. safety switch 127. Safety switch 127 of the chain index drive 125 waits for the last signal sent by pneumatic sensors 67 and 167 during a can operating sequence before relaying the signal to the manifold switch 120. This is a safety precaution to prevent the manifold table switch 120 from prematurely sending a signal via lines 121 and 122 to all the pneumatic sensors of the various assemblies (pneumatic sensors 53 and 153 of Fig. 12) to release the cans before the depressurizing and decrimping stages have been completed. In the present discussion, only the degassing head assembly 3 is operating on a can, thus the last signal to the main cluster 115 comes from pneumatic sensor 67 via line 172.

PNEUMATIC LOGIC FOR THE SECOND LOOP INVOLVING THE VACUUM AND DECRIMPER/DECAPPER HEAD ASSEMBLY:

The air logic for the decrimper/decapper head assembly 4 is similar to the vacuum head assembly 3, but includes an additional circuit involving the approach cylinder 98. As the first can comes into contact with the table mounted pneumatic sensor 153, a signal is sent through air line 110 to begin filling the approach cylinder 98 via shuttle valve 134 and 1/4" double pilot versa valve 137. This causes plunger 197 to be lowered until upper contact 195 engages pneumatic sensor 196. The lowering of the plunger 197 into approach cylinder 98 corresponds to the lowering of the decapper head 78 on top of the can (see Fig. 4B). Contact of sensor 196 sends a signal through the air circuit comprising air line 198, shuttle valve 134, versa valve 133, and air line 165 to begin filling cylinder 154 and thereby cause shaft 155 to be forced downward. This corresponds to the pincers 80 engaging the crown 40 of Fig. 4C.

Upon full downward extension of the shaft 155, pneumatic sensor 166 is engaged by the mushroom head contact 158 to send a signal to begin raising the

plunger 197 out of the approach cylinder 98 by depressurizing air line 110 and by pressurizing air line 111 with air injected through the air circuit comprising on-off three-way safety valves 135, air line 139, shuttle valve 134 and versa valve 137. This sequence corresponds to the raising of the decapper head 78 with the crown (stem) 40 still being engaged by the pincers 80 (see Fig. 4D).

Upon full upward extension of the plunger 197, pneumatic sensor 196 is activated by engagement with lower contact 194, thereby sending a signal via air line 199, on-off three way safety switch 135, shuttle valve 134, and versa valve 133, to begin raising shaft 155 by depressurizing air line 165 and pressurizing air line 177. This corresponds to the release of the stem 40 by the pincers 80.

When the shaft 155 is fully upwardly extended, the mushroom head contact 158 engages pneumatic sensor 167, thereby sending a signal through air line 170 to the main cluster 115. This corresponds to the completion of one "decrimping/decapping" cycle. The main cluster 115 ranks the incoming signals from pneumatic sensor 167 of the decrimper/decapper head assembly 4 via line 170, and pneumatic sensor 67 of the vacuum head assembly 3 via line 172, before sending them along to the chain index drive 125 via line 173 to sequentially advance the next can(s) along the line.

Fig. 13 shows a variation of the system of this invention wherein a modified vacuum head assembly 186, having a hollow needle 188 is used to pierce, or push into the can, the rubber seal 18 to release and recover (e.g. by vacuum) the propellants. A boot and plunger assembly 185 is used to vertically restrain the can 187 during bottom depressurization and also to hold the valve actuator 190 open during depressurization so that a back vacuum in space 181 created by drop of piston 189 does not form. Any back pressure in space 181 is equalized by pathway 210, which pathway 210 connects the

opened aperture within actuator 190 (the apparatus is opened during actuation) to the ambient. This boot and plunger assembly 185 with pathway 210 leading to the ambient permits "bleeding in" air to equalize pressure in space 181. The bottom circular edge of the can 187 rests upon a sealing ring 191 so that the space 200 within the can bottom edge will be sealed from the atmosphere when the can is pressed downwardly by the boot and plunger assembly 185. Similarly, vacuum seals 192 and 193 are also used to keep the depressurization operation air tight. As an alternate to passage 210, a one-way check valve 182 may be employed in plunger assembly 185 to permit air to enter can space 181 via actuator 190.

The operation of vacuum head assembly 186 is the same as before except for the additional step of first lowering the boot and plunger assembly 185 on top of the can. The plunger 215 is reciprocated downward in the direction of Arrow I to depress the actuator 190, thus bleeding off any back pressure that may result during bottom depressurization. Alternately, bleeding off back pressure within space 181 may be accomplished by addition of a cap top puncturing needle (not shown) on the bottom of plunger 215. Propellant exhaust path is through bore 203 in shaft 55, holes 204, 205 and 206 which are aligned when shaft 55 is reciprocated upwardly for needle to pierce plug 184. Where the needle 188 is hollow, passage 203 is axially aligned with it to provide a continuous degassing passageway.

Once the propellant has been removed from space 201, and the piston 189 drawn downwardly by the differential pressure to the bottom of the can, the can is sent to the decrimper assembly for removal of the cap 43 as before, and thence to the cap retrieval, wash/dry and can collection stations.

The conveyor chain may be designed to provide axial rotational twist so that the recycle line may be kept moving linearly in the same direction (rather than

reversed) yet permit the cans at the cap recovery and wash/dry stations to be inverted, and thereafter returned to the upright position for refilling in a second line or a continuation of the recycle line, all on the same can advance chain. The chain may also be provided with lateral flexibility so the second refill line can be spaced laterally. Alternately multiple chains or other can moving means, guide-ways, and the like, may be employed. While it is preferred to keep the cans separated (spaced apart) the cans may be permitted to move along the line in contact. The cans may also be moved by rolling, pulled along by moving magnets (for ferrous cans), blown by air impulses, etc.

In the case of bottom pressurized, piston-type cans, where it is not desired to reuse (refill) the can with the piston, the piston-type can may be converted to a dip tube-type can, whereby the bottom plug is withdrawn and replaced with a rigid plug if needed. Optionally a self-curing sealant may be employed to fill any needle hole left by needle 188. The piston 189 can be removed through the cap mouth defined by rim 81 (see Fig. 4D) in the cap dome. The piston 189 can be cut up with a centrifugal rotary cutter, the diameter of which expands upon rotation after lowering into the can through the cap aperture. The cutter shreds the plastic piston, and the shreds are flushed out and collected upon inversion, washing and drying.

It is also understood that other modifications, such as the integration of a robotic system to manipulate and position the cans as needed, is also within the scope of this invention without departing from the spirit thereof. For example, a multiple-needle depressurizer head may be employed, with one or more removing gas, and another simultaneously or sequentially providing bleed-in air.

CLAIMS

1 1. Aerosol can depressurizing apparatus comprising
2 in operative combination:

3 a) means for depressurizing said can comprising
4 a depressurizing head assembly;

5 b) means for isolating a propellant evacuation
6 zone disposed in an end surface of an aerosol can
7 associated with said depressurizing head assembly means;

8 c) means for aligning an aerosol can to be
9 depressurized and said head assembly into position so
10 that said end surface of said can is engageable by said
11 isolation means;

12 d) means for puncturing a hole in said
13 propellant evacuation zone to permit release of
14 pressurized gas from said can when said isolation means
15 is engaged with said can end.

1 2. Apparatus as in claim 1 wherein:

2 a) said isolation means is adapted to isolate
3 at least a portion of the top surface of said claim;

4 b) said can has a cap member on said isolated
5 end; and

6 c) said isolated top surface portion is said
7 can cap.

1 3. Apparatus as in claim 2 wherein:

2 a) said can cap is crimpingly joined to said
3 can along a rim;

4 b) said can has a dome top; and

5 c) said isolation means engages said can end on
6 said dome adjacent and exterior of said crimped rim.

1 4. Apparatus as in claim 1 which includes:

2 a) means for reciprocatingly moving said can
3 and said head assembly relative to each other so that
4 said isolation means engages said can end.

1 5. Apparatus as in claim 4 wherein:

2 a) said depressurizing head is reciprocable
3 from a first, retracted position relative to said can to
4 a second, extended propellant removal position.

1 6. Apparatus as in claim 4 wherein:

2 a) said puncturing means is reciprocable from
3 a first, retracted non-puncturing position to a second,
4 extended puncturing position; and

5 b) said puncturing means is disposed in
6 telescoping association with said depressurizing head
7 and is reciprocable between said first and second
8 positions while said depressurizing head is in its
9 second, propellant removal position.

1 7. Apparatus as in claim 6 wherein:

2 a) said puncturing means includes a hollow
3 needle; and which includes:

4 b) means for collecting gas exiting said can
5 upon puncturing disposed in association with said
6 depressurizing head assembly.

1 8. Aerosol can decapping apparatus for non-
2 destructively removing the top cap assembly from an
3 aerosol can of the type having a top cap with a central
4 actuator stem member, which top cap is crimp-sealed to
5 a rimmed opening at one end of said can, comprising in
6 operative combination:

7 a) means for removing the top cap containing
8 said actuator stem member including a decapping head
9 assembly;

10 b) means for positioning said can top stem in
11 alignment with said decapping head assembly; and

12 c) said decapping head assembly including means
13 for engaging said stem member adjacent its juncture with
14 said planar medial portion with a pincher assembly with
15 sufficient radial inward force to provide sufficient
16 inward tension on at least one portion of said medial

17 portion to cause arcuate deformation of said cap crimp
18 effecting said partial unrolling from said rim and at
19 least partial breakage of said seal between said cap
20 crimp and said can opening rim, so that said can body is
21 non-destructively separated from said cap permitting
22 recovery of can chemical contents and recycling of said
23 can body.

1 9. Apparatus as in claim 8 which includes:

2 a) means for vertically, linearly reciprocating
3 said pinchers relative to said can body while grasping
4 said actuator assembly stem to complete the breaking of
5 said seal between said cap crimp and said can opening
6 rim.

1 10. Apparatus as in claim 9 which includes:

2 a) means for restraining movement of said can
3 body during said pincher reciprocation;

4 b) said pincher means includes means for moving
5 said pinchers from a first, open position to a second,
6 closed position to grasp said can stem assembly adjacent
7 said stem base; and

8 c) said decapping head assembly top removal
9 means includes means for synchronizing the opening and
10 closing of said pincher means so that said pincher means
11 closes when said reciprocating means positions said
12 pincher means adjacent said can stem base, and maintains
13 said pincher means closed during withdrawing motion from
14 said second reciprocated position to said first
15 reciprocated position and thereafter opens said pinchers
16 to release said removed can top.

1 11. Aerosol can recycling apparatus for non-
2 destructively removing top caps from propellant-
3 pressurized aerosol cans of the type having a top cap
4 with a central actuator stem member, which top cap is
5 crimp-sealed to a rimmed opening at one end of said can
6 body, comprising in operative combination:

- 7 a) a first station including means for
8 depressurizing said aerosol can;
9 b) a second station including means for
10 decapping said aerosol can by breaking the seal between
11 said cap crimp seal and non-destructively separating
12 said cap from said can;
13 c) means for sequentially feeding said aerosol
14 cans from said first station to said second station;
15 d) means for collecting said propellant in
16 communication with said first station.

- 1 12. Apparatus as in claim 11 which includes:
2 a) a third station including means for
3 separating the contents of said cans from said can body
4 and said can top; and
5 b) means for separately collecting said
6 contents and said can bodies;
7 c) said feeding means feeds can bodies from
8 said second station to said third station;
9 d) a fourth station including means for
10 cleaning the interior of said can bodies; and
11 e) said feeding means feeds can bodies from
12 said third to said fourth station.

- 1 13. Apparatus as in claim 11 which includes:
2 a) means for repacking said cans bodies
3 disposed downstream of said second station; and
4 b) said feeding means transfers said can bodies
5 to said repacking means.

- 1 14. Apparatus as in claim 13 which includes:
2 a) means for depalletizing said pressurized
3 cans in association with said marshalling means; and
4 b) means for palletizing said refilled cans
5 associated with said repacking means at the downstream
6 end thereof.

- 1 15. Apparatus as in claim 11 wherein:

2 a) said depressurizing means and said decapping
3 means include means for pneumatic operation;
4 and which includes:

5 b) means for pneumatically actuating said
6 depressurizing and decapping means; and

7 c) said propellant collecting means includes a
8 vacuum line in communication with said depressurizing
9 means.

1 16. Apparatus as in claim 11 wherein:

2 a) said depressurizing means includes:

3 i) means for isolating a propellant
4 evacuation zone disposed in an end
5 surface of an aerosol can associated
6 with said depressurizing head assembly
7 means;

8 ii) means for positioning an aerosol can to
9 be depressurized into alignment with
10 said depressurizing means with said end
11 surface of said can engageable by said
12 isolation means;

13 iii) means for puncturing a hole in said
14 propellant evacuation zone to permit
15 release of pressurized gas from said
16 can when said isolation means is
17 engaged with said can end; and

18 b) said decapping means includes:

19 i) means for decrimping which at least
20 partially radially unrolls the cap
21 crimp from said rim to at least
22 partially break the seal between said
23 cap assembly and said cap rim.

1 17. Apparatus as in claim 16 which includes:

2 a) means for reciprocatingly moving said can
3 and said depressurizing means relative to each other so
4 that said isolation means engages said can end;

5 b) said depressurizing means is reciprocable

6 from a first, retracted position relative to said can to
7 a second, extended propellant removal position;

8 c) said puncturing means is reciprocable from
9 a first, retracted non-puncturing position to a second,
10 extended puncturing position;

11 d) said puncturing means is disposed in
12 telescoping association with said depressurizing means
13 and is reciprocable between said first and second
14 positions while said depressurizing means is in its
15 second, propellant removal position;

16 e) said puncturing means includes a hollow
17 needle;

18 and which includes:

19 f) means for collecting gas exiting said can
20 upon puncturing disposed in association with said
21 depressurizing means; and wherein:

22 g) said cap member includes a generally planar
23 medial portion between said outer rim and said central
24 actuator stem member;

25 h) said decrimping means includes means for
26 deforming at least a portion of said planar medial
27 portion of said cap radially inwardly toward said stem
28 member to at least partially unroll said cap crimp from
29 selected arcuate portions of said can rim opening to at
30 least partially break said seal along said arcuate
31 portions;

32 i) said deforming means comprises means for
33 pinchingly engaging said stem member adjacent its
34 juncture with said planar medial portion with sufficient
35 radial inward force to provide sufficient inward tension
36 on at least one portion of said medial portion to cause
37 arcuate deformation of said cap crimp effecting said
38 partial unrolling from said rim and at least partial
39 breakage of said seal between said cap crimp and said
40 can opening rim;

41 and which includes:

42 j) means for reciprocating said pincher means
43 relative to said can body while pinchingly grasping said

44 actuator assembly stem to complete the breaking of said
45 seal between said cap crimp and said can opening rim.

1 18. Apparatus as in claim 17 wherein:

2 a) said gas collection means includes means for
3 forming a vacuum;

4 b) said depressurizing means includes a vacuum
5 pathway from adjacent said can puncturing means to said
6 gas collection means, said pathway being open to flow of
7 said gas exiting said can when said needle is in its
8 second, can puncturing position;

9 c) said isolation means includes a flexible
10 sealing member adapted to form a seal with said can end;
11 and which includes:

12 d) means for restraining movement of said can
13 body during said pincher reciprocation;
14 and wherein:

15 e) said reciprocation comprises relative
16 movement of said pincher means away from said can end a
17 distance sufficient to complete breaking of said seal;
18 and wherein:

19 f) said reciprocating means moves said pincher
20 means from a first position separated from said can stem
21 assembly in axial alignment therewith to a second
22 position adjacent said can stem assembly base where said
23 can stem assembly is joined to said can top medial
24 portion;

25 g) said pincher means includes means for moving
26 said pinchers from a first, open position to a second,
27 closed position to grasp said can stem assembly adjacent
28 said stem base; and

29 h) said decapping head assembly top removal
30 means includes means for synchronizing the opening and
31 closing of said pincher means so that said pincher means
32 closes when said reciprocating means positions said
33 pincher means adjacent said can stem base, and maintains
34 said pincher means closed during withdrawing motion from
35 said second reciprocated position to said first

36 reciprocated position.

1 19. Aerosol can depressurizing method for safely and
2 non-destructively depressurizing aerosol cans of the
3 type pressurized with propellant through a plugged hole
4 in the bottom can wall to drive a piston within the can
5 for dispensing product contained in the can volume above
6 the piston upon manual operation of an actuator adjacent
7 a top opening of the can, comprising the steps of:

8 a) positioning the bottom of said can relative
9 to a depressurizing head having an airtight seal and
10 means for providing propellant release so that said
11 propellant release means is aligned with said can
12 bottom;

13 b) reciprocating said propellant release means
14 relative to said can to pierce said can bottom to
15 establish communication with the propellant volume
16 between said piston and said bottom wall; and

17 c) equalizing pressure on said piston while
18 permitting said propellant to release from said can.

1 20. Aerosol can reclamation method for non-
2 destructively disassembling propellant-pressurized
3 aerosol cans of the type having a top cap with a central
4 actuator stem joined to a cap rim by a generally planar
5 intermediate annular member, which top cap is crimp-
6 sealed to a rim opening at one end of the body of said
7 can, and collection of the can contents and can parts,
8 comprising in any operative sequence the steps of:

9 a) isolating at least a portion of one end of
10 said can to confine gases released therefrom in a first
11 zone;

12 b) piercing said isolated can end to release
13 can propellant into said confined zone;

14 c) decrimping said can top cap to at least
15 partially break said seal between said can top cap and
16 said rim;

17 d) removing said can top cap from said rim

18 without substantial damage to said can body; and
19 e) recovering said can body, said propellant,
20 and said can contents.

1 21. Method as in claim 20 wherein:

2 a) said isolating step includes providing a
3 boot sealable against said can end to prevent degassing
4 to atmosphere.

1 22. Method as in claim 21 wherein:

2 a) said can end is pierced with a hollow member
3 providing a passageway for release of said gas;
4 and which includes the step of:

5 b) providing a vacuum connected to said
6 released gas passageway to assist in collecting said
7 propellant gas.

1 23. Method as in claim 20 wherein:

2 a) said decrimping step includes pinching said
3 actuator stem adjacent its base to at least partially
4 unroll said can top crimp by radially inwardly deforming
5 portions of said intermediate annular member to cause at
6 least partial release of arcuate portions of said can
7 top crimp without deforming said can opening rim.

1 24. Method as in claim 23 wherein:

2 a) said removing step includes
3 i) maintaining the pinching of said
4 actuator stem; and
5 ii) moving said actuator stem axially
6 sufficiently to completely break said
7 crimp seal by further unrolling and
8 axial deformation of said planar
9 intermediate annular member.

1 25. Aerosol can depressurizing method for non-
2 destructively removing propellant from pressurized
3 aerosol cans of the type having a top cap with a central

4 actuator stem joined to a cap rim by a generally planar
5 intermediate annular member, which top cap is crimp-
6 sealed to a rim opening at one end of the body of said
7 can, comprising in any operative sequence the steps of:
8 a) isolating at least a portion of one end of
9 said can to confine gases released therefrom in a first
10 zone;
11 b) piercing said isolated can end;
12 c) releasing can propellant into said isolated
13 zone; and
14 d) recovering said propellant.

1 26. Method as in claim 25 wherein:

2 a) the isolated end of said can is at least a
3 portion of said top cap planar member.

1 27. Method as in claim 26 wherein:

2 a) said can end is pierced with a hollow member
3 providing a passageway for release of said gas;
4 and which includes the step of:
5 b) providing a vacuum connected to said
6 released gas passageway to assist in collecting said
7 propellant gas.

1 28. Aerosol can top disassembly method for non-
2 destructively disassembling aerosol cans of the type
3 having a top cap, with a central actuator stem joined to
4 a cap rim by a generally planar intermediate annular
5 member, which top cap is crimp-sealed to a rim opening
6 at one end of the body of said can, comprising in any
7 operative sequence the steps of:

8 a) decrimping said can top cap to at least
9 partially break said seal between said can top cap and
10 said rim;
11 b) removing said can top cap from said rim
12 without substantial damage to said can body;
13 c) said decrimping step includes pinching said
14 actuator stem adjacent its base to at least partially

15 unroll said can top crimp by radially inwardly deforming
16 portions of said intermediate annular member to cause at
17 least partial release of arcuate portions of said can
18 top crimp without deforming said can opening rim; and
19 d) said removing step includes
20 i) maintaining the pinching of said
21 actuator stem; and
22 ii) moving said actuator stem vertically
23 axially and only linearly to
24 sufficiently to completely break said
25 crimp seal by further unrolling and
26 axial deformation of said planar
27 intermediate annular member.

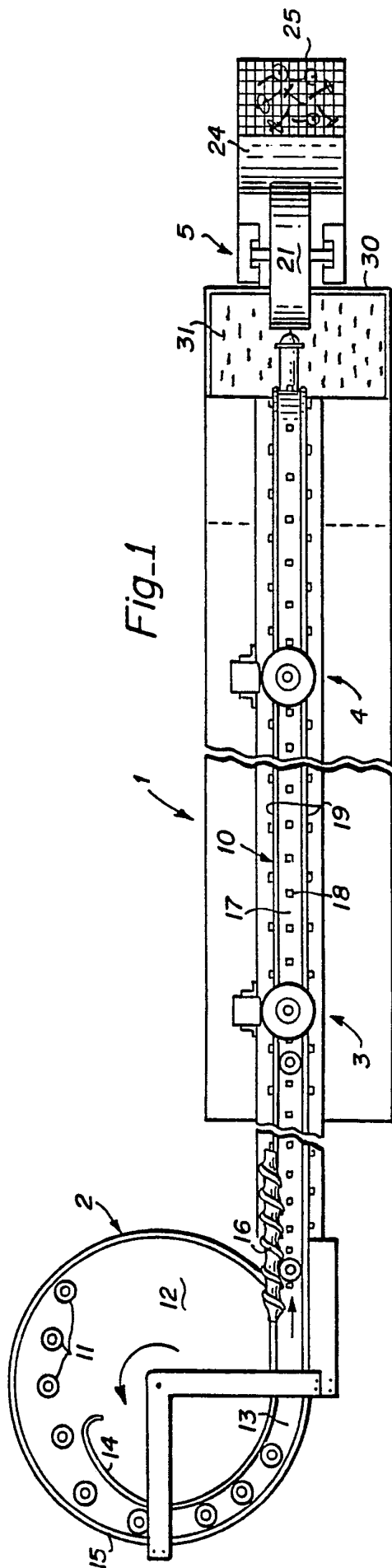


Fig-1

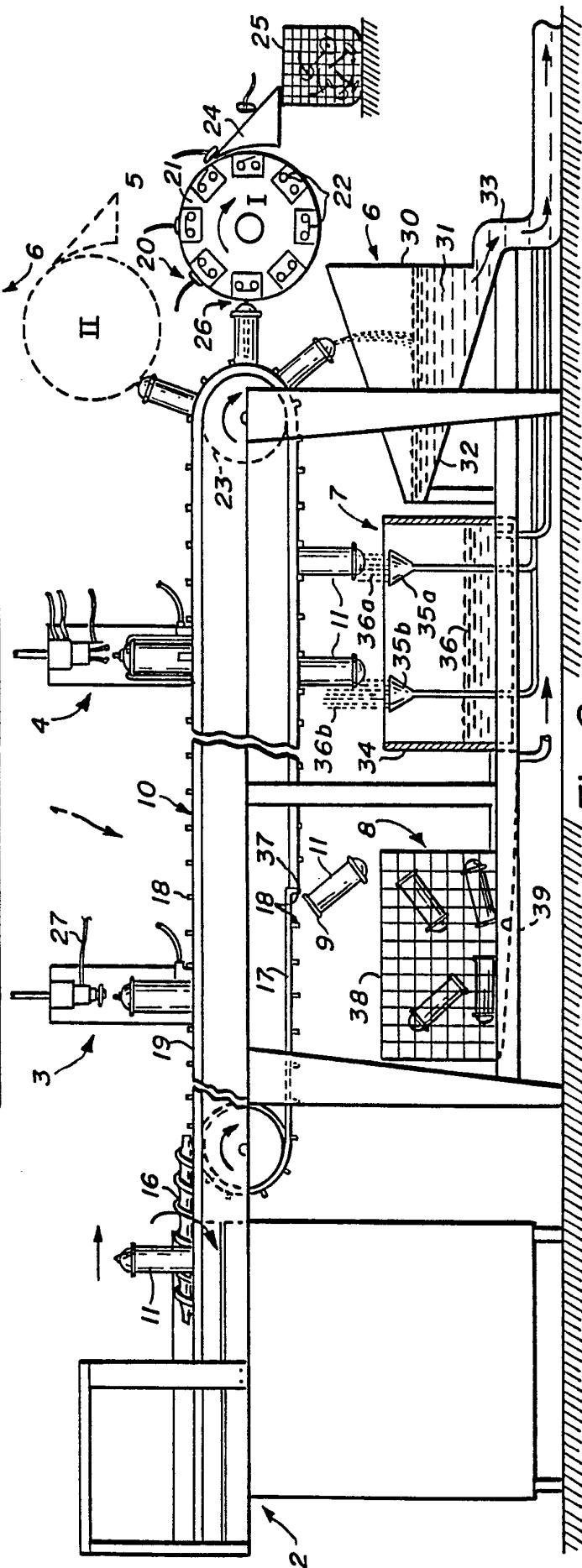


Fig-2

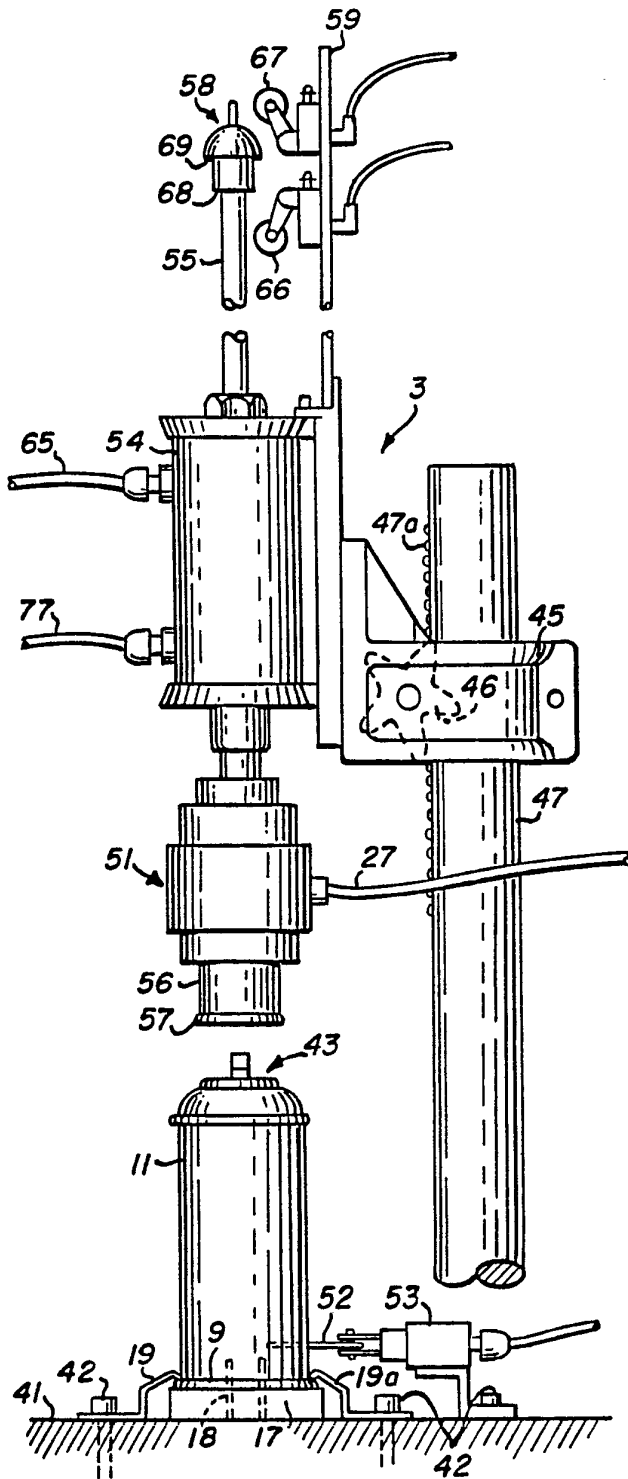


Fig. 3

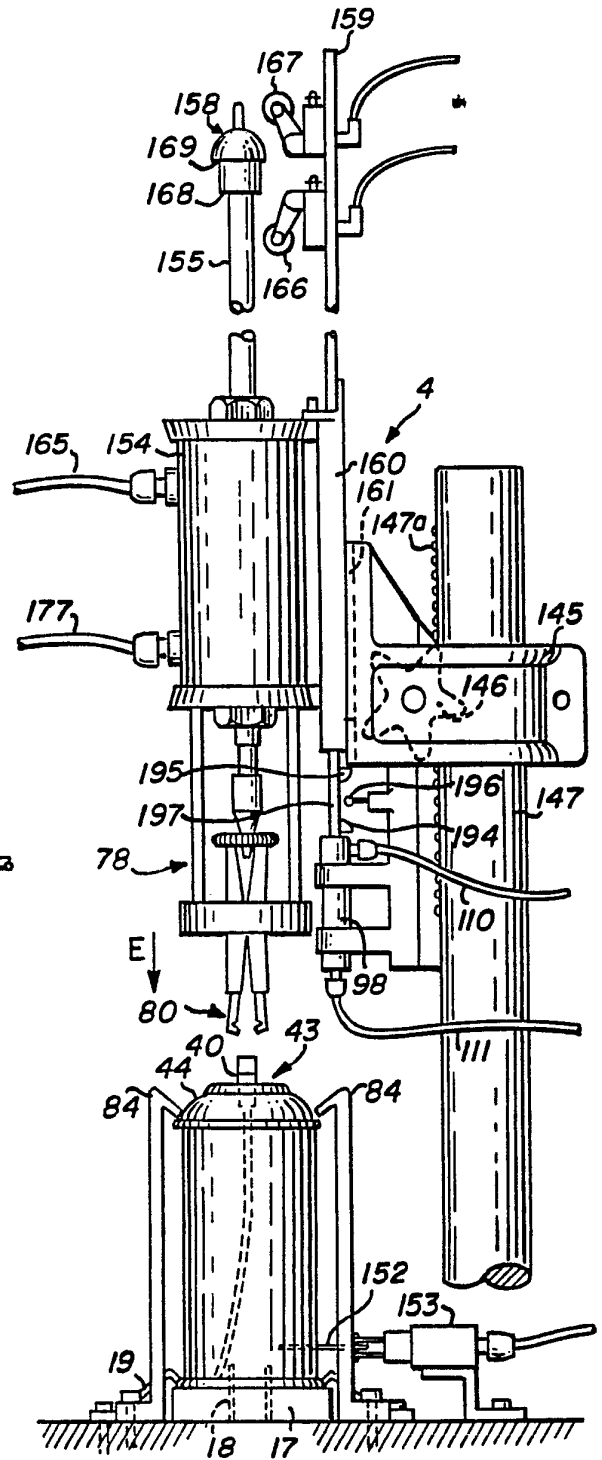


Fig. 4

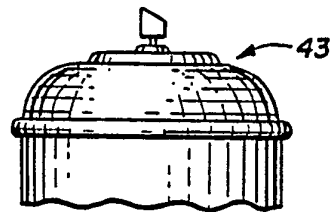
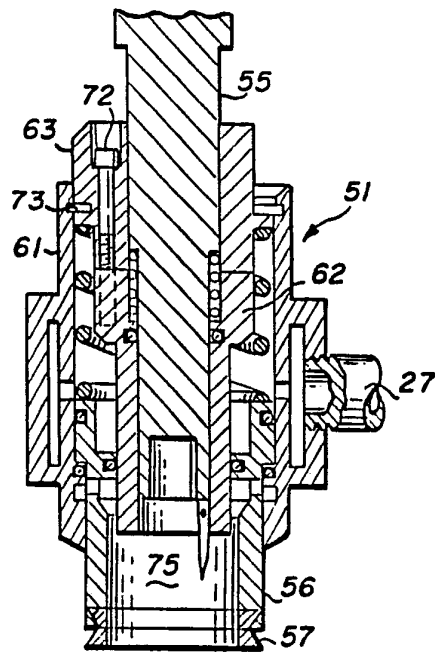


Fig. 3A

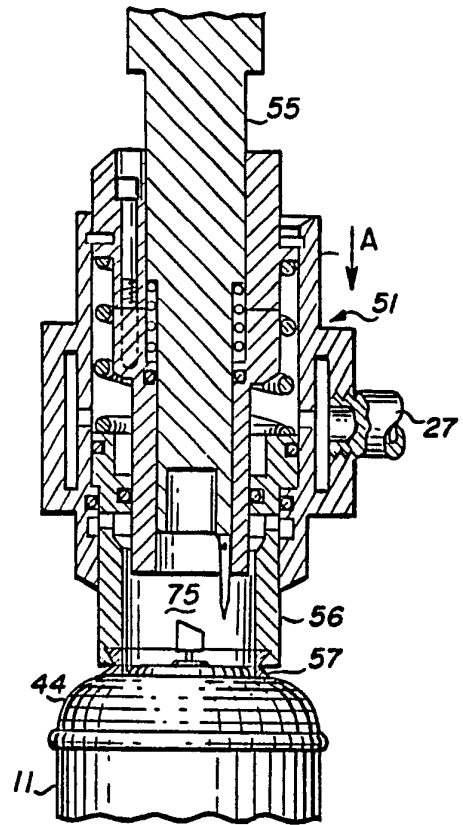


Fig. 3B

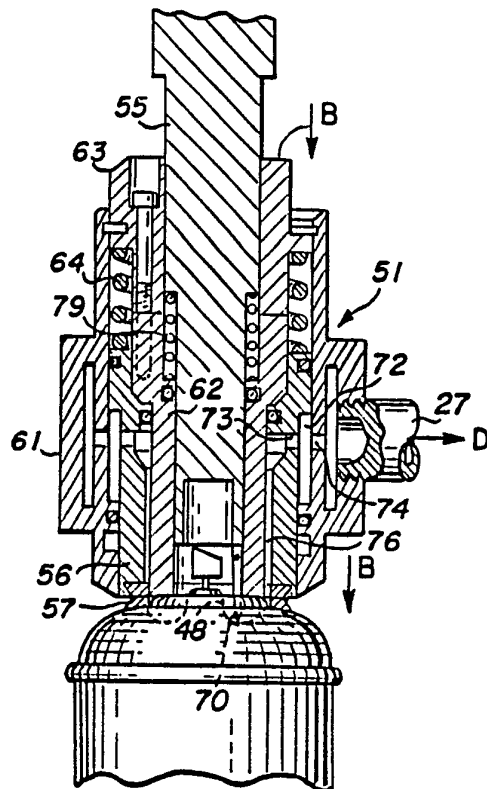


Fig. 3C

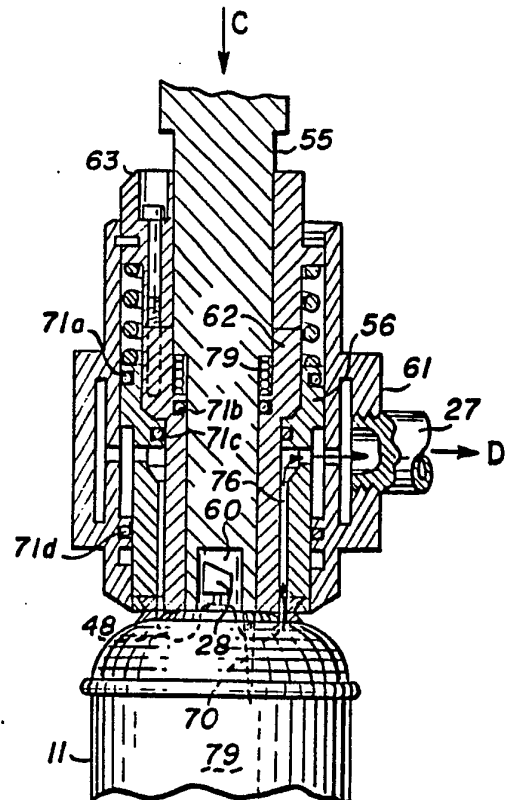


Fig. 3D

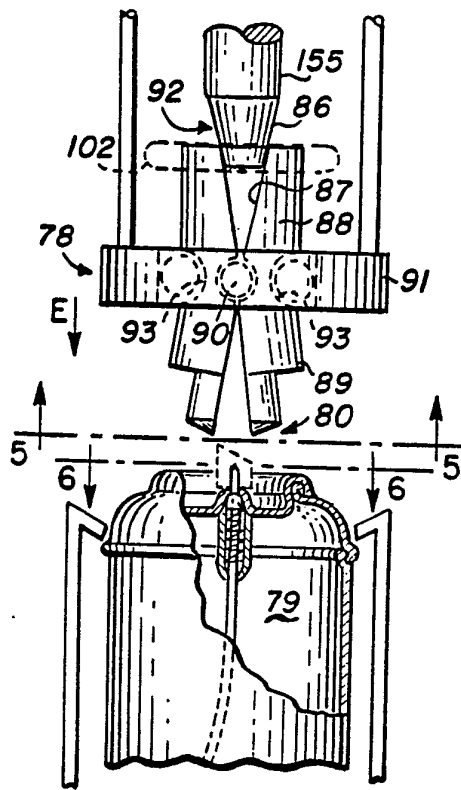


Fig. 4A

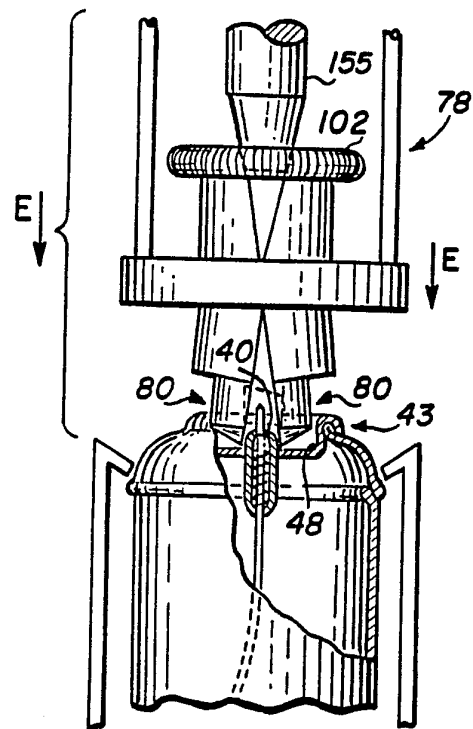


Fig. 4B

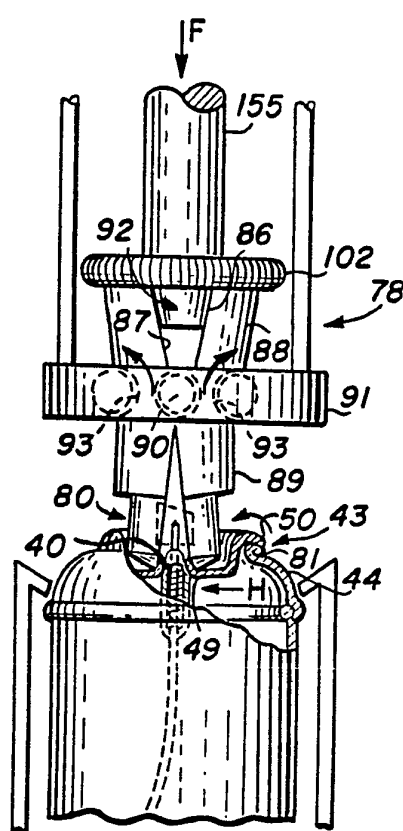


Fig. 4C

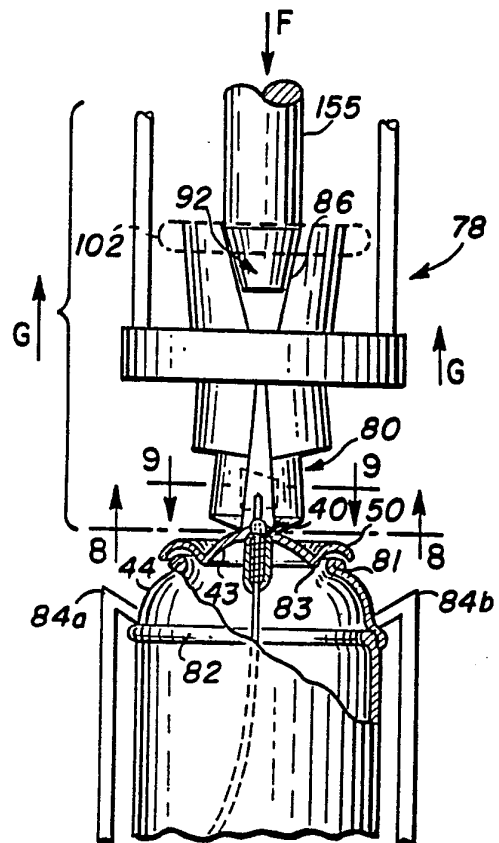


Fig. 4D

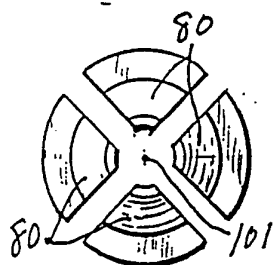


Fig-5

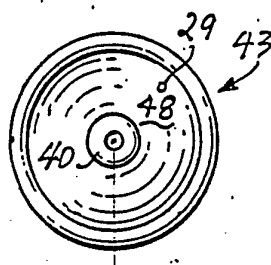


Fig-6

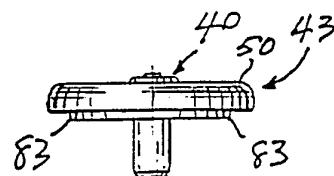


Fig-7

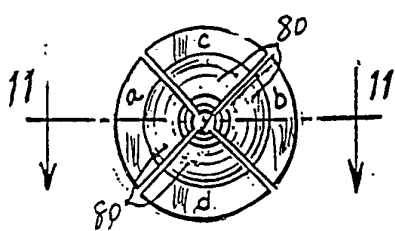


Fig-8

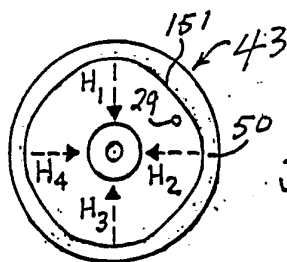


Fig-9

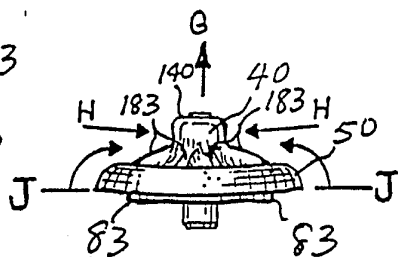


Fig-10

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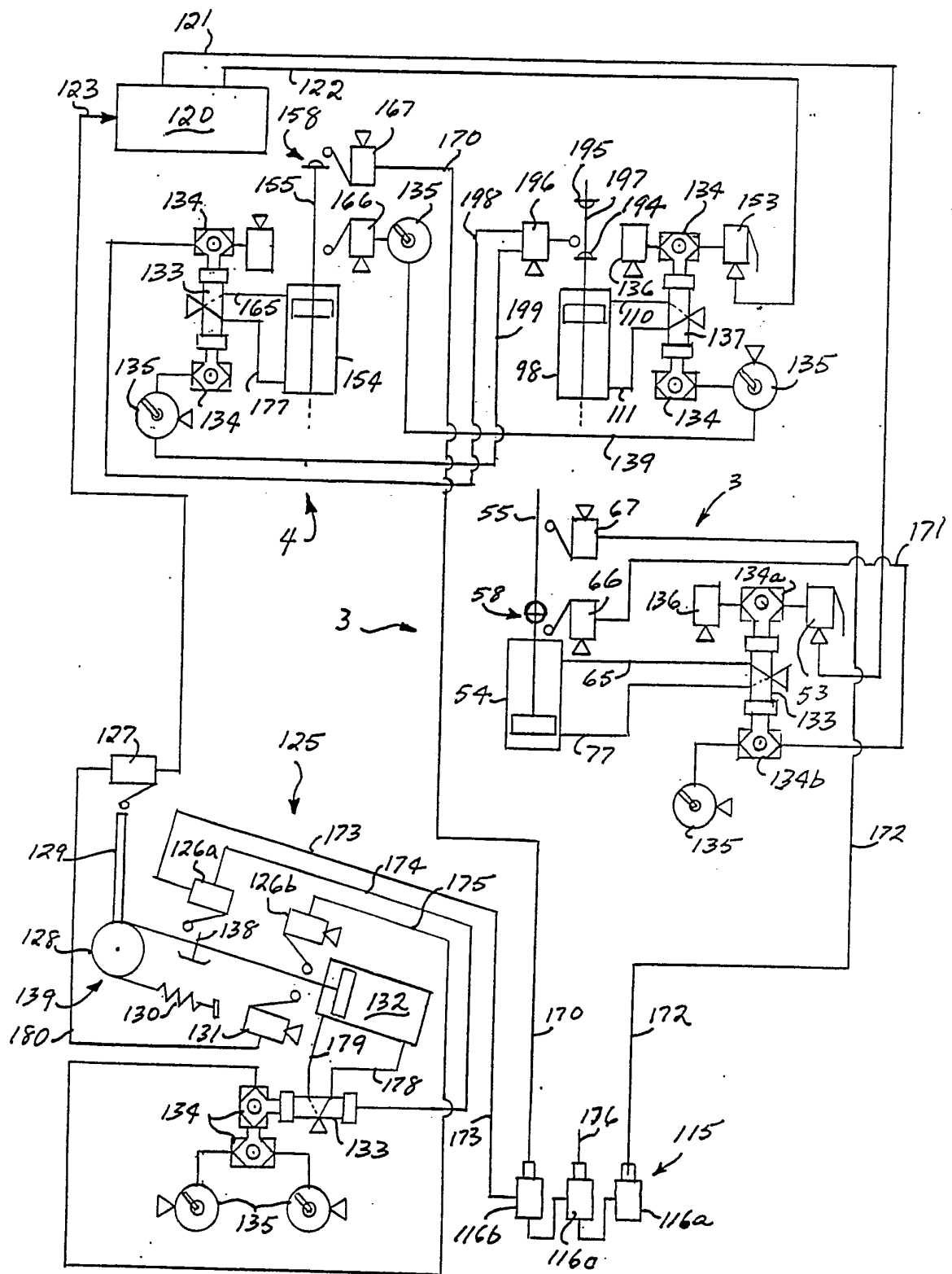
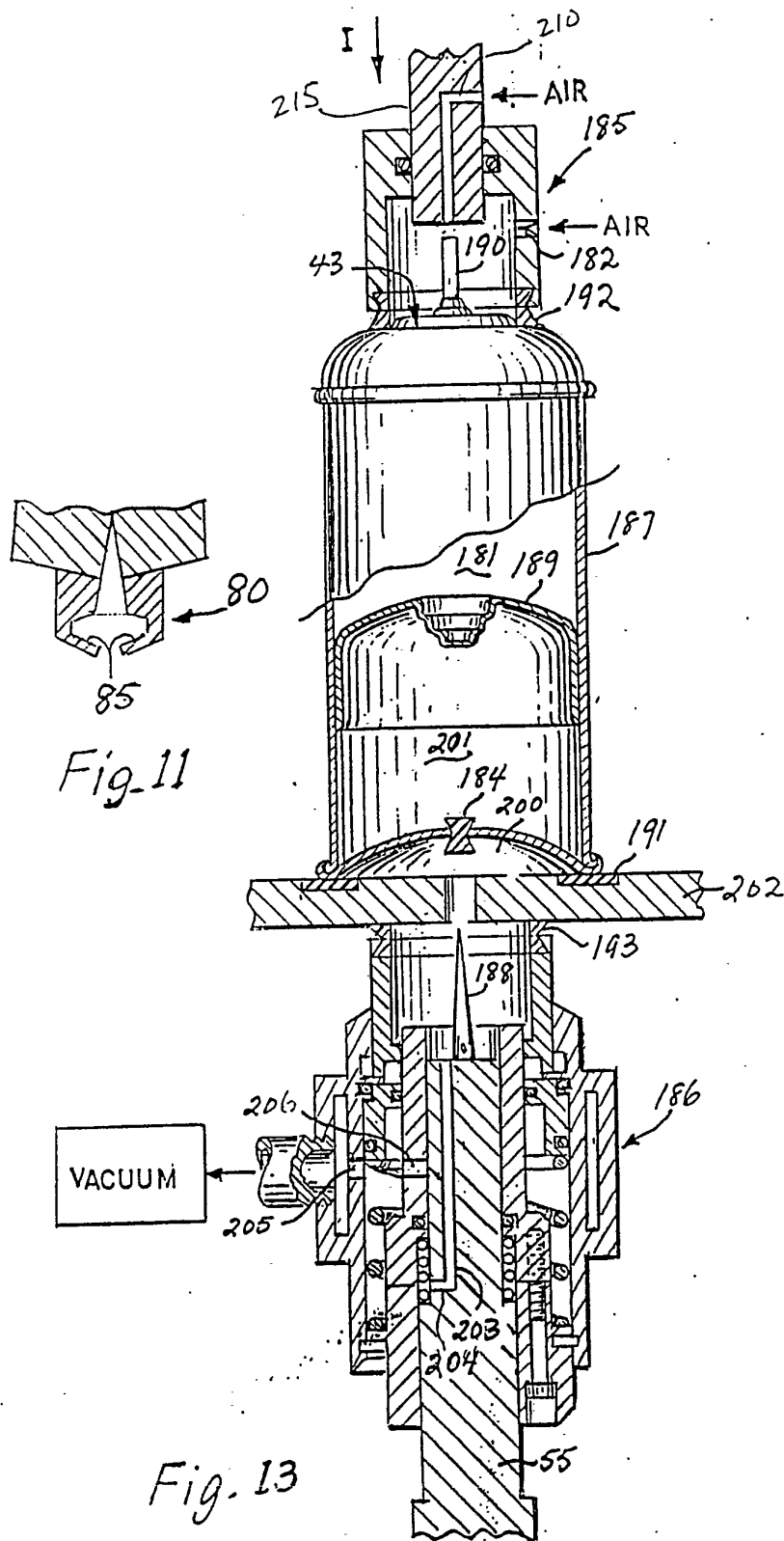


Fig-12



INTERNATIONAL SEARCH REPORT

International Application No PCT/US90/06295

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ³ According to International Patent Classification (IPC) or to both National Classification and IPC JPC (5) B65B 31/00, 31/04; U.S. Cl 141/51, 65, 329, 368; 414/412; 30/448; 222/83.5, 86, 397																													
II. FIELDS SEARCHED Minimum Documentation Searched ⁴ <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%; border-bottom: 1px solid black;">Classification System</td> <td style="border-bottom: 1px solid black;">Minimum Documentation Searched ⁴</td> </tr> <tr> <td style="border-bottom: 1px solid black;">U.S. Cl</td> <td style="border-bottom: 1px solid black;">141/1, 7, 65, 51, 98, 97, 89, 92, 165, 329, 330 100/902, 104 29 /403.1, 403.3, 426.1, 426.3, 426.4, 426.5, 801 222/80, 81, 86, 87, 397, 81/3.09, 3.2</td> </tr> </table> Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵			Classification System	Minimum Documentation Searched ⁴	U.S. Cl	141/1, 7, 65, 51, 98, 97, 89, 92, 165, 329, 330 100/902, 104 29 /403.1, 403.3, 426.1, 426.3, 426.4, 426.5, 801 222/80, 81, 86, 87, 397, 81/3.09, 3.2																							
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III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴ <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 10%; border-bottom: 1px solid black;">Category [*]</th> <th style="width: 70%; border-bottom: 1px solid black;">Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷</th> <th style="width: 20%; border-bottom: 1px solid black;">Relevant to Claim No. ¹⁵</th> </tr> <tr> <td style="border-right: 1px solid black; text-align: center; vertical-align: top;">X</td> <td style="border-right: 1px solid black; vertical-align: top;">U.S., A 4,349,054 (Chipman et al.) 14 September 1982</td> <td style="vertical-align: top;">1, 4-7</td> </tr> <tr> <td style="border-right: 1px solid black; text-align: center; vertical-align: top;">A</td> <td style="border-right: 1px solid black; vertical-align: top;">U.S., A 2,732,741 (Muller - Strobel) 31 January 1956</td> <td></td> </tr> <tr> <td style="border-right: 1px solid black; text-align: center; vertical-align: top;">A</td> <td style="border-right: 1px solid black; vertical-align: top;">U.S., A 4,500,015 (Penney) 19 February 1985</td> <td></td> </tr> <tr> <td style="border-right: 1px solid black; text-align: center; vertical-align: top;">A</td> <td style="border-right: 1px solid black; vertical-align: top;">U.S., A 3,473,499 (Bishop) 21 October 1961</td> <td></td> </tr> <tr> <td style="border-right: 1px solid black; text-align: center; vertical-align: top;">A</td> <td style="border-right: 1px solid black; vertical-align: top;">U.S., A 3,000,097 (Hartz) 19 September 1961</td> <td></td> </tr> <tr> <td style="border-right: 1px solid black; text-align: center; vertical-align: top;">A</td> <td style="border-right: 1px solid black; vertical-align: top;">U.S., A 4,526,097 (Cound) 02 July 1985</td> <td></td> </tr> <tr> <td style="border-right: 1px solid black; text-align: center; vertical-align: top;">A</td> <td style="border-right: 1px solid black; vertical-align: top;">U.S., A 3,993,221 (Boynton et al.) 23 November 1976</td> <td></td> </tr> <tr> <td style="border-right: 1px solid black; text-align: center; vertical-align: top;">A</td> <td style="border-right: 1px solid black; vertical-align: top;">U.S., A 3,835,768 (Kidson) 17 September 1974</td> <td></td> </tr> </table>			Category [*]	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁵	X	U.S., A 4,349,054 (Chipman et al.) 14 September 1982	1, 4-7	A	U.S., A 2,732,741 (Muller - Strobel) 31 January 1956		A	U.S., A 4,500,015 (Penney) 19 February 1985		A	U.S., A 3,473,499 (Bishop) 21 October 1961		A	U.S., A 3,000,097 (Hartz) 19 September 1961		A	U.S., A 4,526,097 (Cound) 02 July 1985		A	U.S., A 3,993,221 (Boynton et al.) 23 November 1976		A	U.S., A 3,835,768 (Kidson) 17 September 1974	
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* Special categories of cited documents: ¹⁸ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family																													
IV. CERTIFICATION <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; border-bottom: 1px solid black;">Date of the Actual Completion of the International Search ²</td> <td style="width: 50%; border-bottom: 1px solid black;">Date of Mailing of this International Search Report ²</td> </tr> <tr> <td style="border-bottom: 1px solid black;">11 January 1991</td> <td style="border-bottom: 1px solid black; text-align: center;">08 MAR 1991</td> </tr> <tr> <td style="border-bottom: 1px solid black;">International Searching Authority ¹</td> <td style="border-bottom: 1px solid black;">Signature of Authorized Officer ¹⁹</td> </tr> <tr> <td style="border-bottom: 1px solid black;">ISA/US</td> <td style="border-bottom: 1px solid black; text-align: center;">Ernest G. Cusick, dal</td> </tr> </table>			Date of the Actual Completion of the International Search ²	Date of Mailing of this International Search Report ²	11 January 1991	08 MAR 1991	International Searching Authority ¹	Signature of Authorized Officer ¹⁹	ISA/US	Ernest G. Cusick, dal																			
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ISA/US	Ernest G. Cusick, dal																												

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

A	U.S., A 4,133,261 (Belfils) 09 January 1979	1, 4-7
X	U.S., A 4,459,906 (Cound et al.) 17 July 1984	
A	U.S., A 4,418,460 (Ruth) 06 December 1983	
A	U.S., A 4,703,875 (Malek) 03 November 1987	
A	U.S., A 3,618,429 (Froeliger) 09 November 1971	
A	U.S., A 2,423,708 (Keogh et al.) 08 July 1947	
A	U.S., A 3,360,844 (Wowneman) 02 January 1968	

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE¹

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers _____, because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers _____, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers _____, because they are dependent claims not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING²

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

- ☐ The additional search fees were accompanied by applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No ¹⁸
A	U.S., A 2,612,065 (Packer et al.) 30 September 1952	
A	U.S., A 3,897,672 (Scheindel) 05 August 1975	
X	DE, A 1,607,991 (Ramms) 01 October 1970	1, 4-7
A	U.S., A 4,944,333 (Gold et al.) 31 July 1990	
A	U.S., A 4,690,180 (Gold) 01 September 1987	
A	U.S., A 4,166,481 (Farris et al.) 04 September 1979	
A	U.S., A 4,274,453 (Lee) 23 June 1981	
A	U.S., A 3,662,791 (Roschetti) 16 May 1972	
A	U.S., A 4,407,341 (Feldt et al.) 04 October 1983	
A	U.S., A 4,126,160 (Gurtler) 21 November 1978	