July 5, 1960 D. F. MELTON 2,943,490

AIR SAMPLING DEVICE

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FIG. 1.

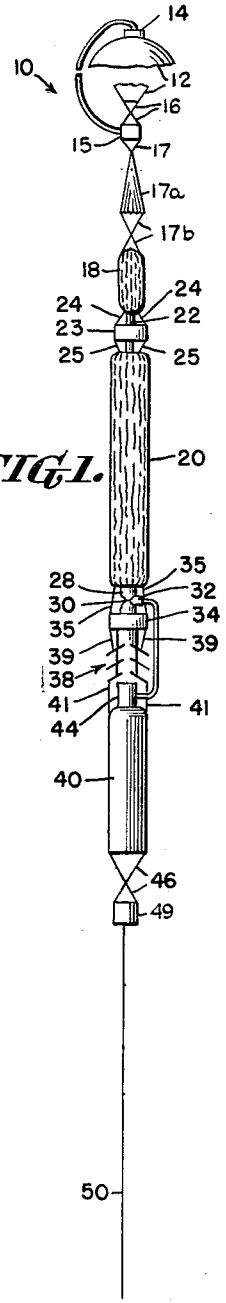


FIG. 2.

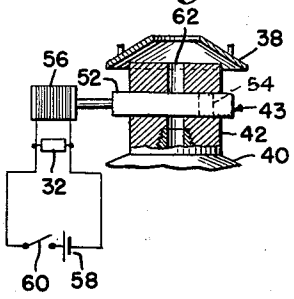


FIG. 3.

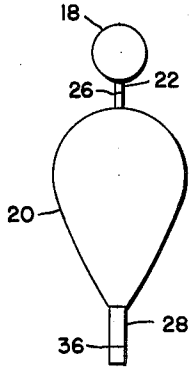


FIG. 4.

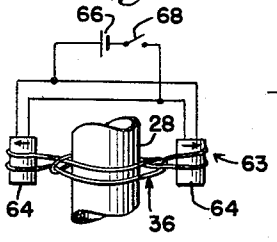


FIG. 5.

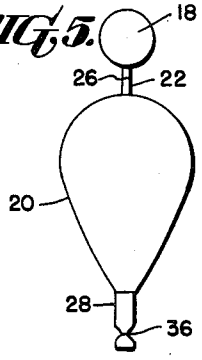


FIG. 6.

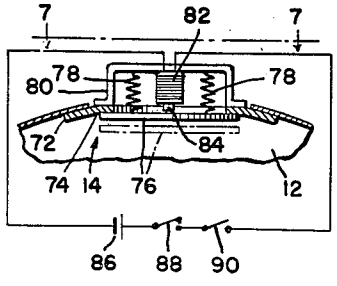
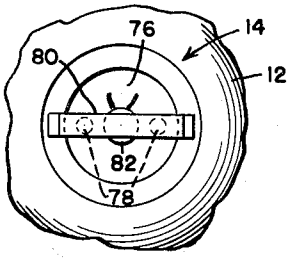


FIG. 7.



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FIG. 8.

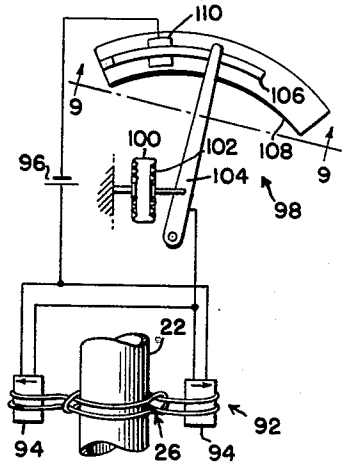


FIG. 9.

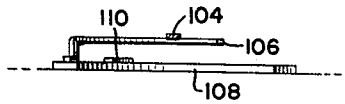


FIG. 10. FIG. 11.

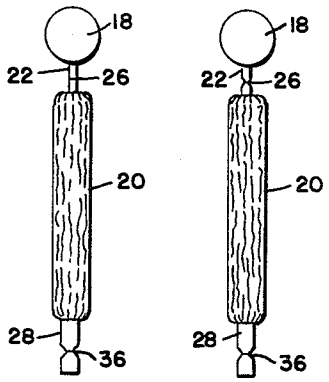


FIG. 12.

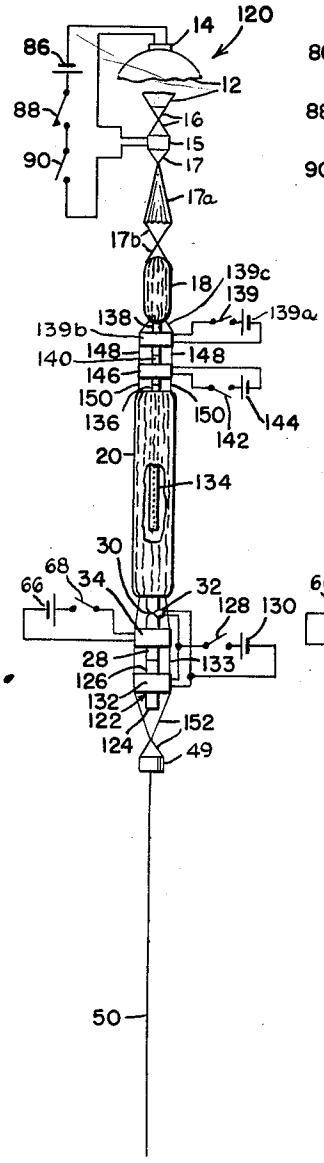
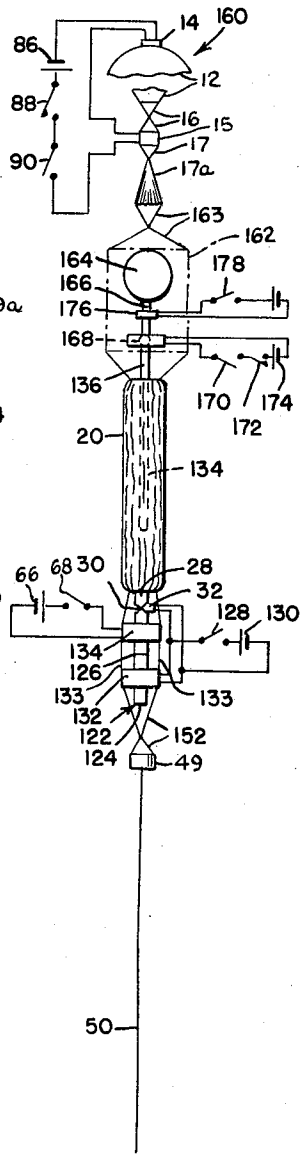


FIG. 13.



Donald F. Melton, INVENTOR

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AIR SAMPLING DEVICE

Donald F. Melton, Minneapolis, Minn., assignor, by mesne assignments, to the United States of America as represented by the Secretary of the Navy

Filed Feb. 17, 1959, Ser. No. 793,940

16 Claims. (Cl. 73—421.5)

This invention relates to the collection of high altitude atmospheric air samples.

It is an object of the invention to provide improved apparatus and methods for collecting an air sample at high altitude ambient pressure and bringing the sample intact to earth.

Another object is to collect a relatively large air sample at the collection altitude in a large container, tansfer the sample to a relatively small and rugged container, and deliver the latter to earth.

Further objects and advantages of the invention will appear as the description proceeds.

The invention will be better understood on reference to the following description and the accompanying schematic drawings, wherein:

Fig. 1 is an elevational view of a high altitude atmospheric air sample collecting system according to one form of the invention.

Fig. 2 shows the mechanism by which high altitude air is aspirated into the lower bag.

Fig. 3 shows the bags fully inflated with the mixture of bottle gas and high altitude air.

Fig. 4 shows mechanism for sealing the lower bag at the end of the inflation of the bags.

Fig. 5 shows the inflated bags with the lower one sealed at the bottom.

Fig. 6 shows the descent-control mechanism.

Fig. 7 is a top plan view taken as indicated by the line 7—7 in Fig. 6.

Fig. 8 shows mechanism for sealing the upper bag.

Fig. 9 is a sectional view taken as indicated by the line 9—9 in Fig. 8.

Fig. 10 shows the bags just before the upper one is sealed.

Fig. 11 shows the bags with the upper one sealed.

Fig. 12 shows a modified system.

Fig. 13 shows a further modified system.

Referring now more particularly to the drawings, an illustrative embodiment of the invention is shown schematically in Figs. 1 to 11 and comprises a balloon system **10** including a tow balloon envelope **12** having at the top a descent-control valve **14** (Figs. 1, 6, and 7) controlled by mechanism carried by a box **15** suspended by load lines **16** from the envelope. Suspended by load lines **17** from the box **15** is a drag chute **17***a* which, by load lines **17***b*, suspends a small bag **18** by which the high altitude (100,000 ft. more or less) air sample is to be delivered to the ground. A large bag **20** is connected to the small bag **18** by a flexible tubular neck **22**, the three constituting a receptacle. A box **23** suspended by load lines **24** from the bag **18**, and suspending the bag **20** by load lines **25**, contains a cord noose **26** (Figs. 3, 5, 8, 10, and 11) about the neck **22**, and mechanism for tightening the noose to choke the neck closed. The bottom of the bag **20** has a flexible tubular inlet **28** choked closed by a cord loop **30** (Fig. 1) passing through a squib **32**. The inlet **28** passes through

a box **34** suspended at **35** from the bag, the box containing a cord noose **36** (Figs. 3, 4, 5, 8, 10, and 11) about the inlet, and mechanism for tightening the noose to choke the inlet closed. An injector **38** (Figs. 1 and 2) which may be formed of connected truncated hollow cones is suspended by load lines **39** from the box **34** and at its upper end projects into the bottom of the inlet **28**. A high pressure gas bottle **40** (Figs. 1 and 2) is suspended at **41** from the bottom of the injector **38** and has a nozzle **42** projecting into the bottom of the injector **38**, and a valve **43** controlled by mechanism in a box **44** which may also carry the control mechanism for the squib **32**. Suspended by load lines **46** from the bottle **40** is a box **49** containing a radio beacon for tracking. An antenna **50** is suspended from the box **49**.

In preparation for launching the system **10**, the descent-control valve **14** is closed, the noose **26** is loose about the neck **22**, the bags **18** and **20** are deflated at the launching site or have arrived there in deflated condition, the inlet **28** is choked closed by the loop **30** and is loosely surrounded by the loop **36**, and the bottle valve **43** is closed. Enough lift gas is introduced into the envelope **12** in any suitable manner (as by means of an inflation tube (not shown) which is then tied closed) to give the system **10** the desired rate of ascent (for example, 1000 ft./min.) enabling the system to reach collection altitude promptly. Fig. 1 shows the appearance of the soaring system **10** at about collection altitude just before collection starts.

When the system **10** reaches the desired collection altitude, which may be its ceiling (floating) altitude, (*a*) the squib **32** is caused to fire, cutting the loop **30** so that the inlet **28** is unchoked, and (*b*) the bottle valve **43** is caused to open, whereupon gas issues from the nozzle **42**, entering the injector **38** and aspirating atmospheric air through the inlet **28** and into the bags **20** and **18**. The flow continues until both bags **18** and **20** are full (the excess gas of course overflowing into the atmosphere) (Fig. 3), whereupon the noose **36** (Fig. 4) is caused to contract, choking the inlet **28** closed (Fig. 5), and then the descent-control valve **14** is caused to open (dot-dash lines, Fig. 6), allowing lift gas to escape from the envelope **12** to initiate descent of the system **10**.

As the descent progresses, the mixture of high altitude air and bottle gas trapped in the bags **18** and **20** is progressively compressed by the increasing ambient atmospheric pressure, so that the lower bag **20** becomes increasingly slack as the part of the mixture which is therein is forced upward into the upper bag **18** due to the natural tendency of the lower bag to collapse and the dynamic pressure of ambient air against the lower part of the lower bag, and also due to the solar heat which warms and therefore tends to render the mixture less dense than the outside (ambient) air. This transfer from the large bag **20** to the small bag **18** can be enhanced by using a lighter-than-air bottle gas, such as helium, so that even in the absence of solar heat the mixture will be less dense than the outside air.

At some relatively low altitude (for example, 10,000 ft.), when all or substantially all of the mixture is in the small bag **18** so that the bag **20** is collapsed (Fig. 10), the noose **26** is caused to contract, choking the neck **22** closed (Fig. 11), thereby sealing the mixture in the small bag. When the system **10** reaches the ground, the small bag **18** may be cut free and transported to the laboratory, where the air sample can be separated from the mixture by standard laboratory techniques and analyzed.

Inasmuch as the volume of a given mass of atmospheric

air varies approximately inversely with atmospheric pressure, and atmospheric pressure decreases with increasing altitude, a given mass of air occupies a much larger volume at high altitudes than it does at sea level. The size of the large (lower) bag **20** is therefore determined by the volume of the predetermined mass of air to be collected at the collection altitude, and the size of the smaller (upper) bag **18** is such as to hold the same mass of air at ground level.

The envelope **12**, the large bag **20**, the neck **22**, and the inlet **28** may be made of a suitable film material such as polyethylene. The small bag **18** is preferably tough, to withstand impact and ground abrasion and contact with sharp objects, and handling, and may be suitably made of some such material as "Fiberthin," a neoprene-coated nylon.

The bottle nozzle valve **43** may comprise a valve plate **52** having a passage **54** and connected to the plunger of a solenoid **56** in series with a battery **58** and a low pressure switch **60** (Fig. 2), all preferably carried in the box **44**. Until the solenoid **56** is energized, the plate **52** closes the nozzle **42**. The squib **32** may be controlled by its own low pressure switch and battery, or may be connected in parallel with the solenoid **56** as shown. The switch **60** is set to close when collection altitude is reached, to fire the squib **32** and pull the valve plate **52** to the position in wihch its passage **54** registers with the nozzle bore **62**, releasing gas from the bottle **40**.

The noose **36** may comprise linked cords (Fig. 4), and the noose-actuating mechanism **63** may comprise motor-driven drums **64** connected to the respective cords and powered by a battery **66** and controlled by a switch **68**. The switch **68** could be a timer switch set to close when the predetermined bag-inflating period has terminated, or it could be a pressure switch set to close when the bottle **40** is exhausted. When the switch **68** closes, the drums **64** are turned in directions to contract the noose **36** tight about the inlet **28**.

The descent-control valve **14** may be of the form illustrated in Figs. 6 and 7. The envelope **12** has a top opening at which is fastened a ring **72** providing at its under surface a valve seat **74**. A valve disc **76** below the seat **74** is biased into closed position against the seat by springs **78** connecting the disc to a bracket **80** over and secured at its ends to the ring. Insulated from and supported by the bracket **80** is a solenoid **82** having a plunger **84** over the disc **76**. The solenoid **82** is connected in series with a battery **86**, a rate-of-descent sensor switch **88**, and a timer switch **90**, the latter three being carried in the box **15**, and the wiring from the solenoid extending outside the envelope **12** (Fig. 1). The timer switch **90** is preset to remain open until after the system **10** reaches the predetermined ceiling altitude and enough time has elapsed to insure that the bags **18** and **20** are filled. The sensor switch **88** is set to open only in the case of excessive rate of descent, so that it is normally closed. Once the timer switch **90** closes, it remains closed. When the timer switch **90** closes, and the sensor switch **88** is closed, the solenoid circuit closes, whereupon the solenoid plunger **84** is thrust downward, unseating the disc **76** (see dot-dash lines, Fig. 6), opening the valve **14**, and thus initiating the descent of the system **10**.

The noose **26** may comprise linked cords (Fig. 8), and the noose-actuating mechanism **92** may comprise motor-driven drums **94** connected to the respective cords and powered by a battery **96** and controlled by a delayed action high pressure switch **98**, such as that illustrated in Figs. 8 and 9. The switch **98** may comprise an aneroid bellows **100** to whose movable wall **102** is connected a pivoted arm **104** which, until a high altitude is reached, rides on a bar **106** connected to an insulator plate **108** having at its low altitude end a conductor surface **110**. When the high altitude is reached, the **104** snaps down onto the plate **108** and then rides thereon, and, at the predetermined low altitude, at which all or practically all of the mixture is contained in the upper bag **18** (Fig. 10), the arm makes contact with the surface **110**, closing the drum motor circuit, whereupon the drums **94** turn in directions to contract the noose **26** (Fig. 11).

A modified system, shown at **120** in Fig. 12, resembles the system **10** except that: the injector, bottle, and control therefor are replaced by a centrifugal blower **122** whose intake **124** communicates with the atmosphere and whose discharge end **126** is secured in the bottom of the inlet **28**, a blower-controlling timer or low pressuer switch **128** which is preset to close when the system reaches collection altitude, and may control the squib **32**, and a battery **130**, all housed with the squib control mechanism in a box **132** suspended by load lines **133** from the box **34**; and the single neck connecting the bags, and the neck control, are replaced by a perforated hose **134** secured at its upper end to the top of and extending a substantial distance down in the bag **20**, a lower neck **136** extending up from the hose, an upper neck **138** depending from the bag **18** and surrounded by a noose **26** hidden by, and controlled by a timer switch **139** and battery **139***a* housed in, a box **139***b* suspended by load lines **139***c* from the bag **18**, a centrifugal blower **140** whose intake and discharge ends are respectively connected to the necks **136** and **138**, a delayed action high pressure switch **142**, of the same type as that shown at **98**, for controlling the blower, and a battery **144**, the blower, switch **142**, and battery **144** being carried in a box **146** suspended by load lines **148** and suspending, by load lines **150**, the bag **20**. The box **49** is suspended by load lines **152** from the box **132**.

At the collection altitude the switch **128** closes, firing the squib **32** and thus unchoking the inlet **28**, and starting the blower **122** to drive atmospheric air into the lower bag **20**. When the bag **20** is filled, the switch **68** (Fig. 4), which in this case is preferably a timer switch, is closed, whereupon the drums **64** are operated to choke the inlet **28** closed, and the descent-control valve **14** opens to initiate descent of the system **120**. As the descent progresses, the air in the bag **20** proceeds to compress as noted above in connection with the system **10**. When the system **120** reaches some selected low altitude, say 10,000 ft., the high pressure switch **142** closes, starting the upper blower **140**, which transfers the air from the large bag **20** to the small bag **18**. The volume of the small bag **18** is tailored to hold at this transfer altitude all of the sample contained in the large bag **20**. On the completion of the transfer, the timer switch **139** closes, causing the drums **94** to operate to choke the upper neck **138** closed.

Inasmuch as a centrifugal blower is inherently self-by-passing, there is no need for turning it off when its work is done. It can be allowed to run until the battery is exhausted.

The purpose of the hose **134** is to prevent the film material of the lower bag **20** from being sucked by the upper blower **140**. The hose **134** is of a character which may flex but will not collapse to the extent of shutting off flow therethrough.

A further modified system is shown at **160** in Fig. 13, and comprises, in addition to the envelope **12** and descent control valve **14** and control therefor, a box **162** (dot-dash lines) suspended by load lines **163** from the drag chute **17***a* and carrying a rigid high compression container **164** connected by a tube **166** to a high pressure compressor **168** controlled by a delayed action high pressure switch **170**, of the type shown at **98**, and a cut-off timer switch **172**, and powered by a battery **174**, the tube having a valve **176** controlled by a high pressure switch **178**. The intake of the compressor is secured to the lower neck **136**, the structure therebelow being the same as in the system **120**.

In the system **160**, the container **164** and bag **20** are evacuated and the inlet **28** is choked closed by the squib loop **30** prior to launching. At the collection altitude the squib **32** is fired to unchoke the inlet **28**, and the

blower **122** is started. When the bag **20** is filled, the drums **64** (Fig. 4) are operated to choke the inlet **28** closed. Then the valve **14** opens and the system **160** descends. During the descent the air sample in the bag **20** is progressively compressed. At some suitable low altitude, say 10,000 ft., the switch **170** closes, the cut-off timer switch **172** being then closed, starting the compressor **168**, which proceeds to transfer the air sample from the bag **20** to the container **164**. The compressor **168** is stopped by the timer switch **172** when the transfer is complete shortly before impact, whereupon the switch **178** closes, to close the valve **176**, preventing escape of the air sample from the container **164**.

The container **164** is made tough and rugged to withstand impact, ground abrasion, contact with sharp objects, and handling.

Blowers and compressors inherently have a maximum compression ratio which is considerably less than the ratio required to compress high altitude air into a required small volume, for example, 10,000 to 1. Inasmuch as the ambient pressure is low at high altitudes, many stages of compression, of great weight and requiring a large amount of power, would be necessary at high altitude to compress the sample into a small container. Where the compressor is used, the compressor is able to operate at nearly ground pressure, so that the weight and power required are relatively small.

Where bags are used in the several systems disclosed it is necessary to move air into the bags with only enough pressure to fill out the bags.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

I claim:

1. Apparatus for capturing a sample of high altitude atmospheric air, comprising an exhausted receptacle having a small compartment and a relatively large compartment, the large compartment having a closed inlet, means for carrying the receptacle from the ground to a predetermined high altitude, maintaining it at that altitude, and carrying it back to the ground, means for opening the inlet when the receptacle is at the high altitude, means for inflating the large compartment with a sample of atmospheric air at the high altitude, means for closing the inlet when the sample is in the large compartment, means for transferring the sample to the small compartment at predetermined low altitude, and means for sealing the small compartment from the large compartment when the transfer is substantially complete.

2. The structure of claim 1, characterized in that the small compartment is of rugged construction capable of withstanding impact, ground abrasion, and handling.

3. The structure of claim 1, characterized in that the receptacle is formed of film and is collapsed when exhausted.

4. The structure of claim 1, characterized in that the inflating means comprises means for aspirating air into the inlet.

5. The structure of claim 1, characterized in that the inflating means comprises a blower.

6. The structure of claim 1, characterized in that the large compartment is formed of film and is collapsed when exhausted.

7. The structure of claim 1, characterized in that the transferring means comprises a blower.

8. The structure of claim 1, characterized in that the large compartment is formed of film and is collapsed when exhausted, together with baffle means connected to and projecting into the large compartment for preventing the film from being sucked by the transferring means to a position in which the film would block the transfer.

9. The structure of claim 1, characterized in that the receptacle is formed of film and is collapsed when exhausted, and the inflating and transferring means are blowers.

10. Apparatus for capturing a sample of high altitude atmospheric air, comprising a collapsed exhausted film receptacle comprising an upper compartment and a lower compartment several times larger than the upper compartment, the lower compartment having a closed bottom inlet, a balloon connected to the receptacle for carrying it to and maintaining it at a predetermined high altitude, means for opening the inlet at the high altitude, means for inflating the receptacle through the inlet with a sample of atmospheric air at the high altitude, means for closing the inlet at the high altitude when the receptacle contains the sample, means for causing the balloon to descend when the receptacle contains the sample, the weight of the lower compartment and the dynamic drag of the ambient atmospheric air against the downwardly facing part of the lower compartment being operative during descent to collapse the lower compartment and transfer the part of the sample therein into the upper compartment, the ratio of the volumetric capacity of the receptacle to that of the upper compartment being substantially equal to the ratio of the atmospheric pressure at the low altitude to the atmospheric pressure at the high altitude, so that at the low altitude the transfer is substantially complete, and means for sealing the upper compartment from the lower compartment when the transfer is substantially complete, the upper compartment being of rugged construction to withstand impact, ground abrasion, and handling.

11. Apparatus for capturing a sample of high altitude atmospheric air, comprising exhausted communicating upper and lower compartments, the upper compartment being a relatively small rigid high pressure container of rugged construction to withstand impact, ground abrasion, and handling, the lower compartment being formed of film and being collapsed and having a closed inlet, a balloon for carrying the compartments to and maintaining them at a predetermined high altitude, means for opening the inlet at the high altitude, means for inflating the lower compartment with a sample of the high altitude air through the inlet when the inlet is open, means for closing the inlet when the lower compartment contains the sample, means for causing the balloon to descend when the lower compartment contains the sample, a high pressure compressor between the compartments for transferring the sample to the upper compartment at a low altitude, and means for sealing the upper compartment from the lower compartment when the transfer is substantially complete.

12. The structure of claim 11, characterized in that the volumetric capacity of the upper compartment is a small fraction of the volume of the sample at the high altitude.

13. The structure of claim 11, together with baffle means extending from the exit of and a substantial distance into the lower compartment for preventing the film of the lower compartment sucked by the compressor from obstructing the exit.

14. Apparatus for capturing a sample of high altitude atmospheric air, comprising an exhausted receptacle having a closed inlet, means for carrying the receptacle from the ground to and maintaining it at a predetermined high altitude and carrying it back to the ground, means for opening the inlet when the receptacle is at the high altitude, means for inflating the receptacle with a sample of atmospheric air at the high altitude, means for closing the inlet when the receptacle contains the sample, and means for sealing an intermediate part of the receptacle at predetermined low altitude, the ratio of the volumetric capacity of the entire receptacle to that of the portion of the receptacle above said intermediate part being substantially equal to the ratio of the atmospheric pressure

at the low altitude to the atmospheric pressure at the high altitude.

15. The structure of claim 1, characterized in that the large compartment is formed of film and is collapsed when exhausted, and baffle means extending from the exit of and a substantial distance into the large compartment for preventing the film from collapsing into exit-obstructing position before the transfer is substantially complete.

16. In a method of the character described, the steps of collecting a sample of air at high altitude, carrying the sample to a lower altitude where the volume of the sample is a small fraction of its volume at the collection altitude, sealing the sample in close confinement at the lower altitude, and carrying the sealed sample to the ground.

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