NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO ATTN OF: GP

AUG 7 1973

TO: KSI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,944,738

Government or Corporate Employee : U.S. Government

Supplementary Corporate Source (if applicable) :

NASA Patent Case No. : KSC-10626

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

Yes ☐ No ☒

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

Elizabeth A. Carter

Elizabeth A. Carter
Enclosure
Copy of Patent cited above

United States Patent [19]

Howard

[11] **3,744,738**

[45] **July 10, 1973**

[54] **ZERO GRAVITY LIQUID TRANSFER SCREEN**

[75] Inventor: **Frank S. Howard**, Indian Harbor Beach, Fla.

[73] Assignee: **The United States of America as represented by the National Aeronautics and Space Administration**, Washington, D.C.

[22] Filed: **Sept. 16, 1971**

[21] Appl. No.: **180,963**

[52] **U.S. Cl.** ..... **244/1 SS**, 244/135, 222/414

[51] **Int. Cl.** **B64c 39/00**

[58] **Field of Search** ..... 244/1 SS, 135 A; 222/333, 367, 370, 410, 412, 413, 414; 198/213; 141/392

[56] **References Cited**

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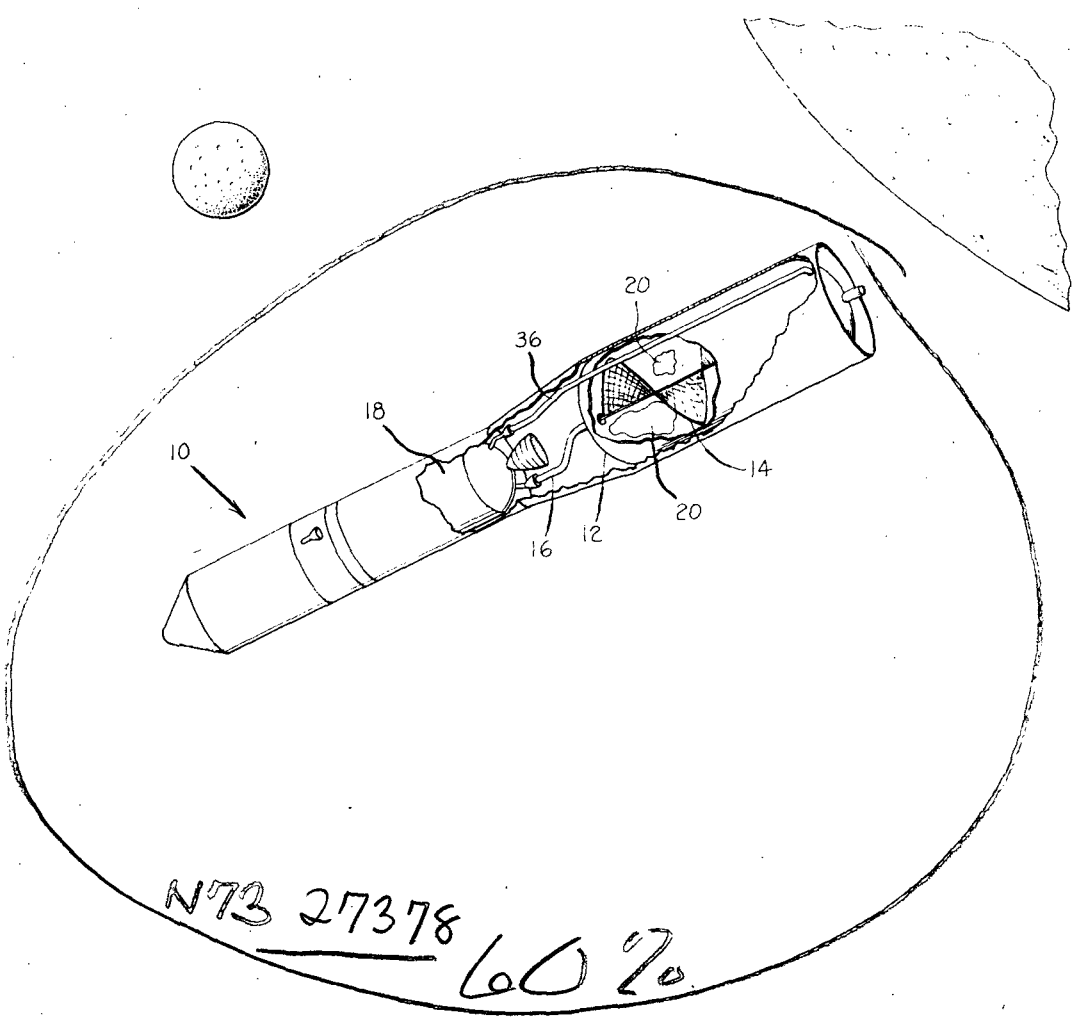
Primary Examiner—Robert B. Reeves
Assistant Examiner—Larry Martin
Attorney—James O. Harrell, John R. Manning et al.

[57] **ABSTRACT**

A liquid transfer device for use in a zero gravity environment, such as outer space, for transferring liquid from one container to another. The device includes a spiral shaped screen type member which is carried in the container for collecting the randomly dispersed liquid in the container and transferring such to an exit port.

2 Claims, 4 Drawing Figures



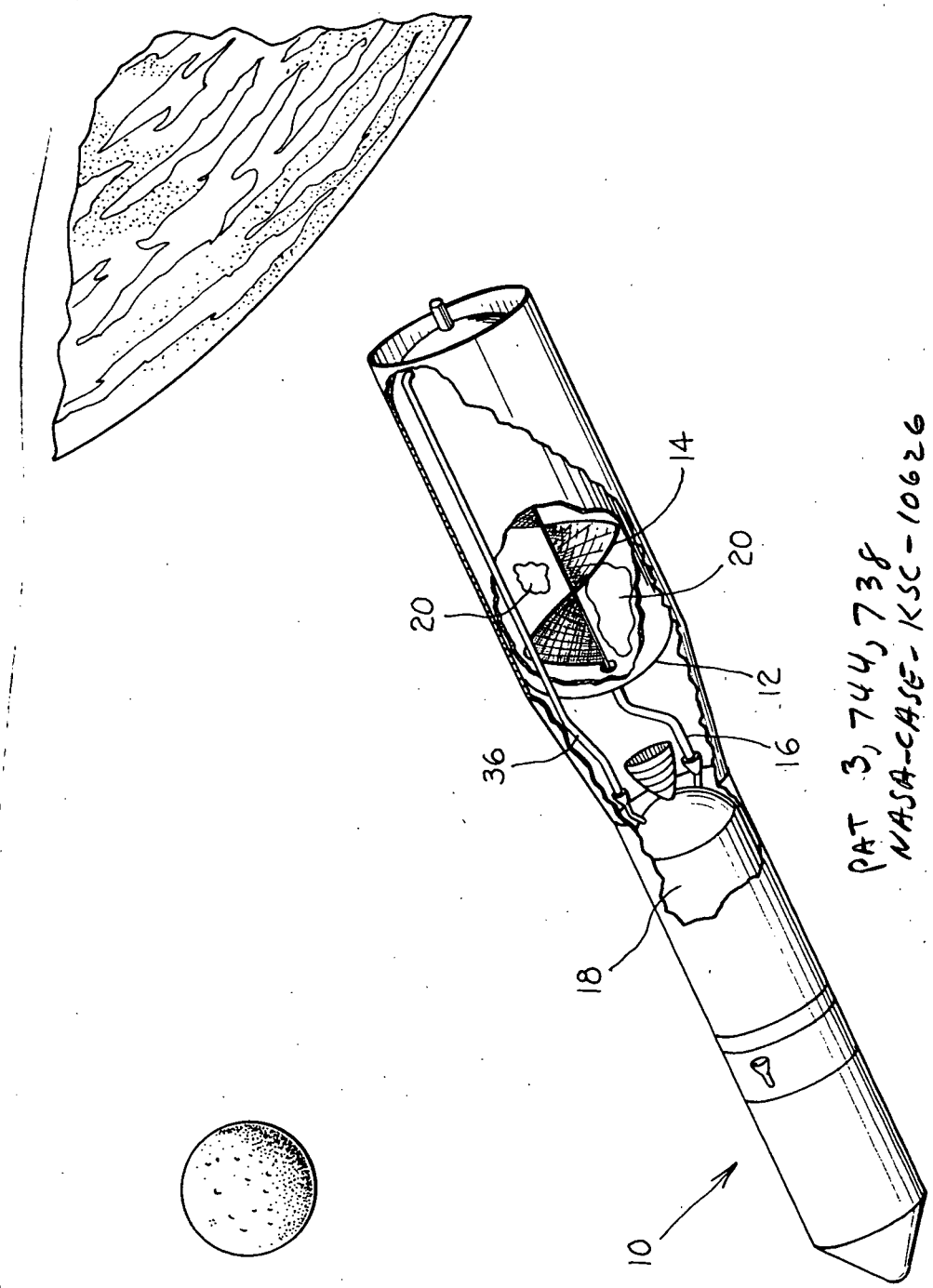


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Fig. 1.

INVENTOR.
FRANK S. HOWARD
BY James O. Harrell
ATTORNEY.

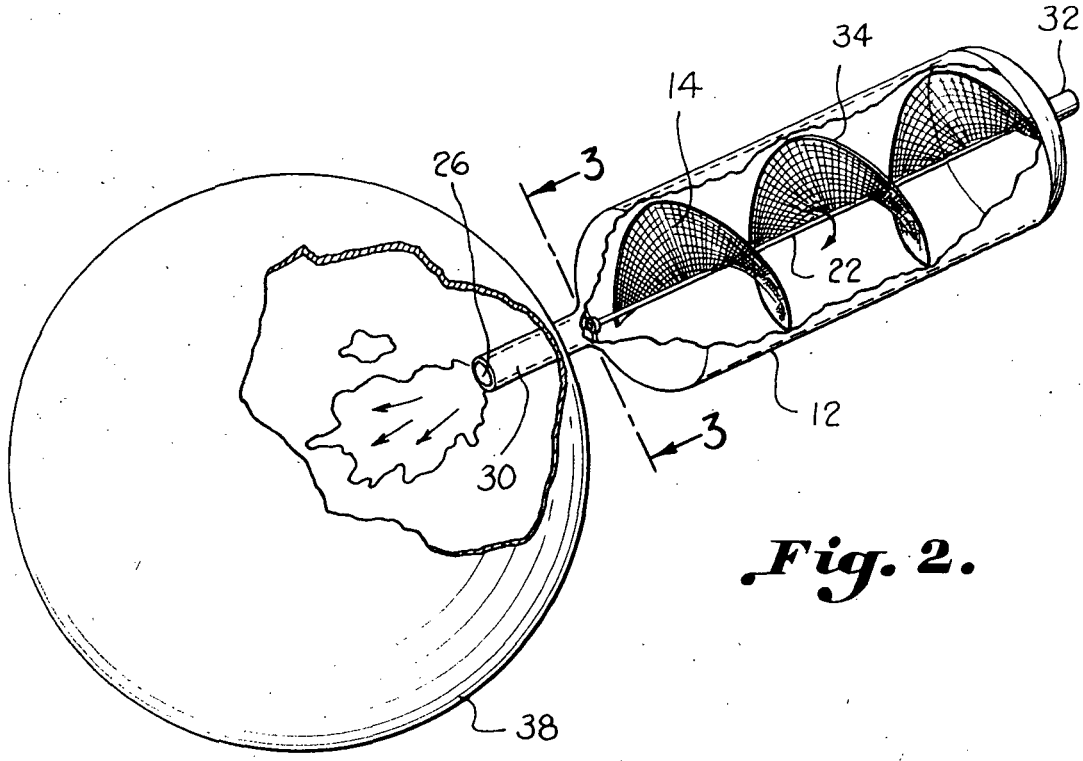

Fig. 2.

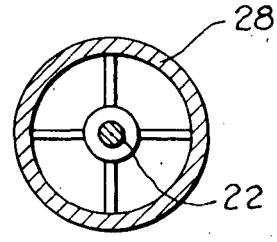

Fig. 3.

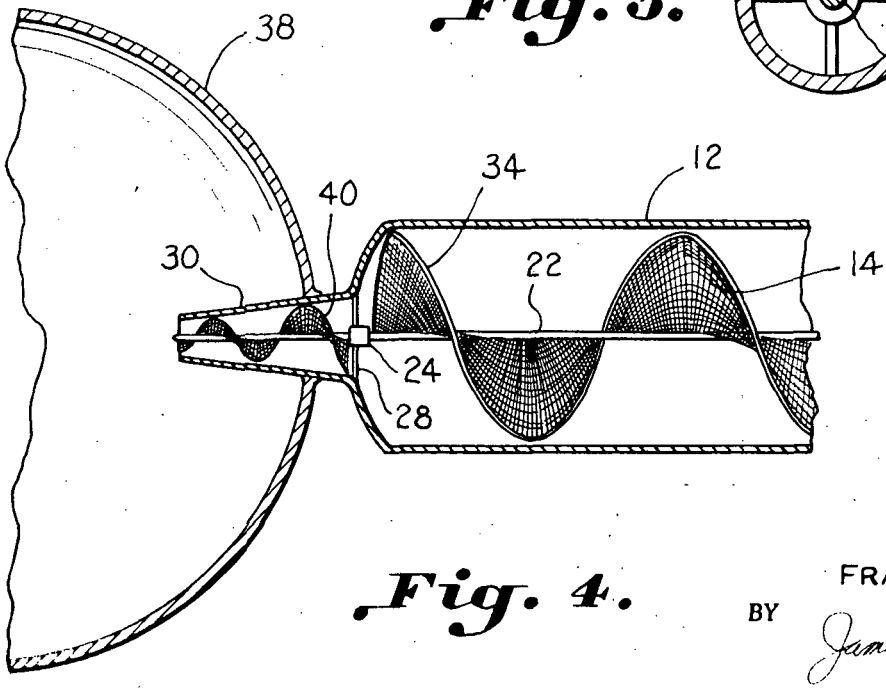

Fig. 4.

INVENTOR.
FRANK S. HOWARD
BY James O. Harrell
ATTORNEY.

ZERO GRAVITY LIQUID TRANSFER SCREEN

This invention described herein was made by an employee of the United States Government, and may be manufactured and used by or for The Government for Govenrmental purposes without the payment of any royalties thereon or therefor.

This invention relates to a liquid transfer device for containers and the like, and in particular to a device which utilizes a spiral shaped screen for collecting and dispersing liquid from the container.

Heretofore, the transfer of liquid from one container to another has not been accomplished in a zero gravity environment except by use of a bladder. Bladders are not considered suitable for cryogenic liquids because of insufficient flexibility at cryogenic temperatures. Transfer can also be accomplished in a zero gravity environment where the container is being accelerated by rocket engines and the tank is being pressurized with gas to force the liquid out. However, this known pressurization technique will not work satisfactorily when the container is not experiencing acceleration because, without any gravitational or acceleration force, globules of the liquid would merely collect in various areas of the container and not be forced out by the inert gas.

Another disadvantage of utilizing inert gas to force the liquid from the container is that such added to the weight of the container due to the requirement of the storing of the inert gas. There also has to be some means of regulating the pressurized gas in order to prevent over pressurization of the containers.

Conventional pumps utilized on earth do not work satisfactory in outer space for the reason that generally they rely on gravity feed to the input of the pump. If such pumps were utilized in a zero gravity environment, globules of liquid would collect throughout the container preventing complete evacuation thereof.

The main problem in transferring a liquid in outer space is that the liquid will separate into globules and float throughout the tank. While it is possible to accelerate and decelerate the container in order to collect and transfer the liquid, such is not practical in that it requires the use of the engines of the space vehicle and consumption of fuel for operating such.

In accordance with the present invention, it has been found that difficulties encountered in transferring liquid from one container to another in outer space may be overcome by providing a novel zero gravity liquid transfer screen. This transfer screen, includes the following basic parts: (1) A spiral shaped member carried in a container having a longitudinal axis in alignment with the exit port of the container from which the liquid is being carried, (2) constructing a spiral shaped member of a screen having a diameter corresponding to the internal diameter of the container, and (3) means for rotating the spiral shaped member so that the surface tension created between the liquid in the container and the spiral shaped member directs the liquid out an exit port. The perforated screen is utilized so that when a back pressure is created greater than the pressure created by the spiral shaped member engaging the liquid, such allows the liquid to pass through the spiral shaped member, minimizing the back-pressure.

Accordingly, it is an important object of the present invention to provide a liquid transfer device for transferring liquid in a zero gravity environment, and in particular, outer space.

Another important object of the present invention is to provide a liquid transfer device which utilizes a lightweight perforated spiral shaped member for transferring the liquid from one container to another.

Another important object of the present invention is to provide a liquid transfer device which minimizes the pressure build-up in the container into which liquid is being transferred.

Another important object of the present invention is to provide a simple and lightweight liquid transfer device which collects randomly dispersed liquid carried in a tank and transfers such out an outlet port of the tank.

Still another important object of the present invention is to provide a liquid transfer device which adds very little heat to the liquid being transferred, minimizes the amount of venting required during transfer, and rapidly evacuates the tank.

Other objects and advantages of this invention will become more apparent from a reading of the following detailed description and appended claims taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a perspective view illustrating a space vehicle in outer space coupled to a transfer tank provided with a zero gravity liquid transfer screen constructed in accordance with the present invention,

FIG. 2 is a perspective view with parts broken away to show the interior of the tank, illustrating a tank equipped with a zero gravity liquid transfer screen transferring liquid into another tank,

FIG. 3 is a transverse sectional view taken along lines 3—3 in FIG. 2 illustrating a support for the liquid transfer screen of FIG. 2, and

FIG. 4 is a longitudinal sectional view illustrating a modified form of the liquid transfer screen.

Referring in more detail to the drawings, FIG. 1 illustrates a space vehicle, generally designated by the reference character **10**, located in outer space docked with a refueling container **12** provided with a spiral shaped member **14** which collects the fuel in the container **12** and transfers such through a transfer pipe **16** into a tank shown by the reference character **18** associated with the space vehicle. The space vehicle and the refueling container are provided with conventional coupling mechanisms (not shown) for maintaining such in fixed relation relative to each other during the fuel transfer operation. The refueling container **12**, illustrated in FIG. **1**, is shown partially empty with the fuel **20** taking the form of globules, such as occurs when the tank is partially evacuated of fuel and is located in a zero gravity environment, such as outer space. By rotating the spiral shaped member such collects the randomly dispersed globules in the tank **12** and forces them out of the transfer pipe **16**.

The spiral shaped member **14** is constructed of a material having small perforations, and in one particular embodiment consist of woven stainless steel wire. The size of the perforations in the screen and the speed of rotation of the screen may vary according to the type liquid being transferred. One suitable screen is constructed of 0.025 inch diameter woven stainless steel wire using ten strands of wire per linear inch. Such provides a percentage of open area of 56.3 percent. A tighter woven screen could be utilized, such as provided by a weave of 325 × 325 strands per inch.

One edge of the woven steel wire is attached to a rod **22** by any suitable means, such as welding. The rod **22** is journalled in bearings **24** supported at opposite ends

of the tank in alignment with the longitudinal axis thereof. The bearing **24** which supports the end of the rod **22** adjacent an exit port **26** of the tank is supported in a spoke circular collar **28.** The collar **28** is suitably mounted in the throat of the tank **12.** In FIG. **1** the throat takes the form of a transfer pipe **16,** while in FIG. **2** the throat is tubular in shape. The modified form of the invention illustrated in FIG. **4** utilizes a frusto-conical shaped throat **30.** The other end of the rod **22** is attached to a rotating shaft of an electric motor **32** carried adjacent the end of the tank. The motor **32** may be powered by self-contained batteries, or in some applications plugged into a source of energy carried by the space vehicle which is being refueled.

A metal band **34** runs along the outer edge of the screen **14** for adding rigidity thereto. Other suitable reinforcing members could be utilized if desired. The diameter of the spiral shaped screen is substantially equal to the internal diameter of the tank **12** so that when such is rotated substantially all of the liquid globules in the tank are collected and moved to and out of the throat **30** of the tank. Since the perforations in the spiral shaped screen **14** are small, the overall surface area of the screen is large. When this large surface area contacts the liquid as the screen rotates, the surface tension and frictional forces therebetween cause the liquid to be set in motion and move out through the throat or exit port **30.** In a zero gravity environment, these surface tension and frictional forces are substantial enough to impart the motion of the liquid needed to dispense it from the tank. If, however, a back-pressure is created by the liquid being transferred will overcome the surface tension and frictional forces, the screen rotating too fast or a restriction in the flow through the throat **30,** the and pass through the perforations in screen, minimizing a pressure build-up. Another advantage of utilizing a spiral shaped screen is that the liquid transfer is accomplished with a minimum addition of hardware weight to the liquid transfer system and tank **12.**

Referring again to FIG. **1,** in some instances it may be desirable to vent the receiving tank, and such is accomplished by running a vent tube **36** from the receiving tank **18** back to the far end of the sending tank **12.** Normally, however, the venting tube can be eliminated since the liquid is being moved by a perforated screen which in itself allows a back-flow of pressure therethrough if the back pressure created during transfer exceeds the surface tension forces produced by the rotating spiral shaped member moving the liquid into the receiving tank.

In FIG. **4** as previously mentioned, a frusto-conical shaped spout **30** is provided on the end of the sending tank **12** which extends into the receiving tank **38.** In order to prevent the liquid from being transferred from collecting in the spout **30** the rod **22** is extended to the end of the spout. The spiral shaped member **14** has a tapering portion **40** which extends from adjacent the spoke collar **28** to the end of the spout **30,** and has a diameter corresponding to the inner diameter of the spout. It is desirable both in the main sending tank and in the spout **30** to minimize the space between the spiral shaped screens **14** and **40,** and the inner wall of the sending tank **12** so as to insure complete collection of the liquid being transferred from the sending tank.

Since it is not necessary to utilize a receiving tank **38** that is to be used in outer space structurally as strong as a tank that would be used on earth, it is important to be aware of the problem of possibly rupturing the receiving tank by over pressurization. In applicant's device such is minimized since when there is a pressure build-up such is relieved by the liquid passing through the screen **14** as it is rotated.

While a preferred embodiment of the invention has been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the spirit or scope of the following claims. It is also to be understood that the coupling mechanism between the sending tank **12** and the receiving tank **38** have not been shown for purposes of clarity, since such does not form a part of this invention.

I claim:

1. In combination with a liquid container in a zero gravity environment such as outer space, a device for transferring liquid from said container through an exit port provided therein, comprising:

A. a spiral shaped member rotatably mounted in said container along a longitudinal axis in alignment with said exit port;

B. said spiral shaped member being constructed of a material having small perforations therein normally capable of imparting a motion to said liquid by surface tension and frictional forces created therebetween when said material contacts said liquid;

C. means for rotating said spiral shaped member to impart said motion of said liquid to direct said liquid out through said exit port;

D. said material being constructed so as to permit the passage of said liquid through said small perforations if the pressure buildup created by said spiral shaped member engaging said liquid becomes greater than said surface tension and frictional forces, thereby minimizing undesirable back pressures in said container.

2. The device as set forth in claim **1** wherein:

A. said material consists of a woven metallic wire defining a perforated screen.

* * * * *