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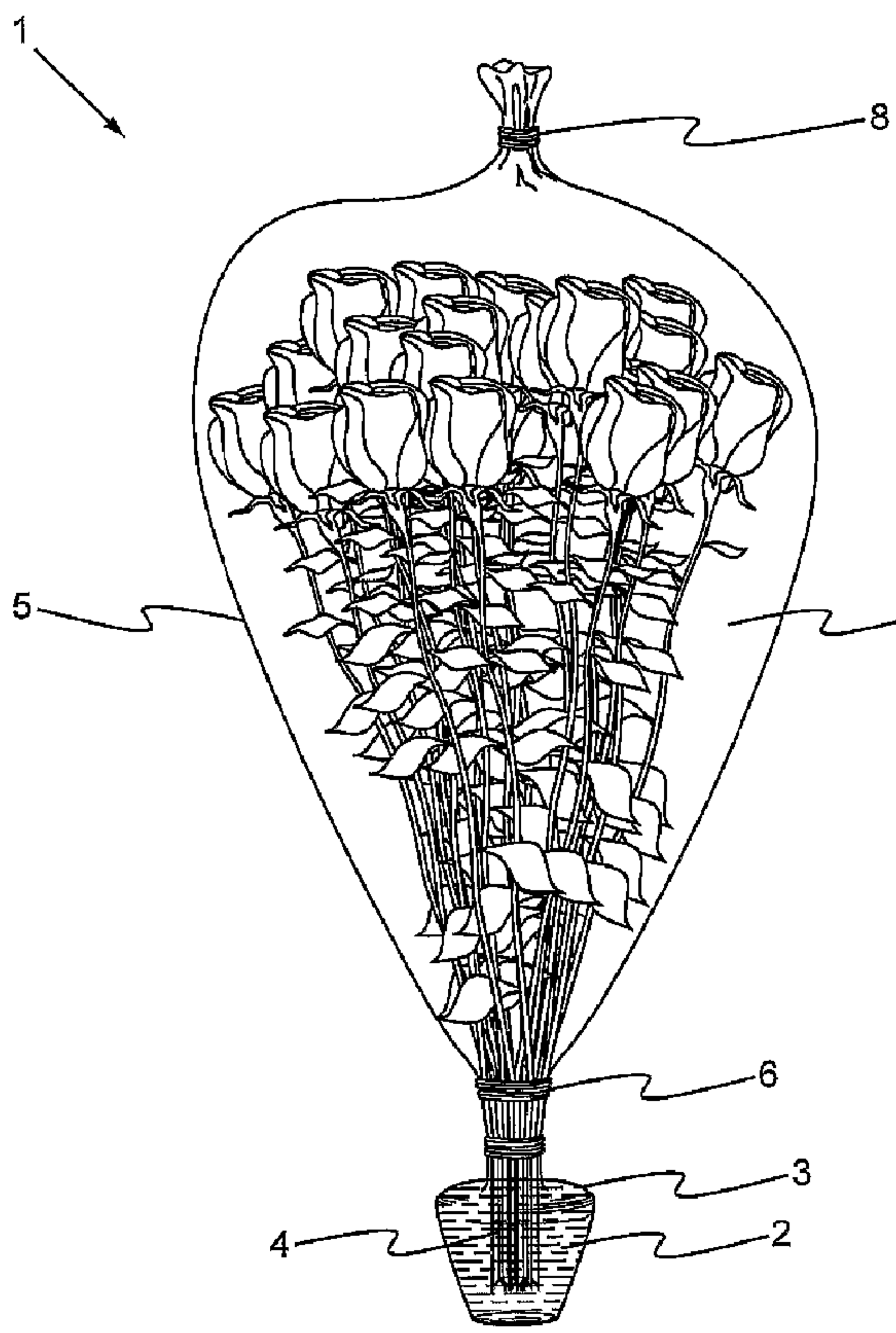
(54) Title: PLANT PRESERVATION SYSTEMS



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The present invention provides, e.g., methods, devices and compositions to preserve plants, such as cut flowers. The methods include, e.g., sealing cut stems (4) in antimicrobial preservative media (2) and sealing the flowers in an inert gas environment (7). The devices include, e.g., packaging materials (5) and media to vitalize and protect uprooted plants and/or cut flowers. The compositions of the invention provide, e.g., media which inhibit microbe growth and vitalize cut plants.

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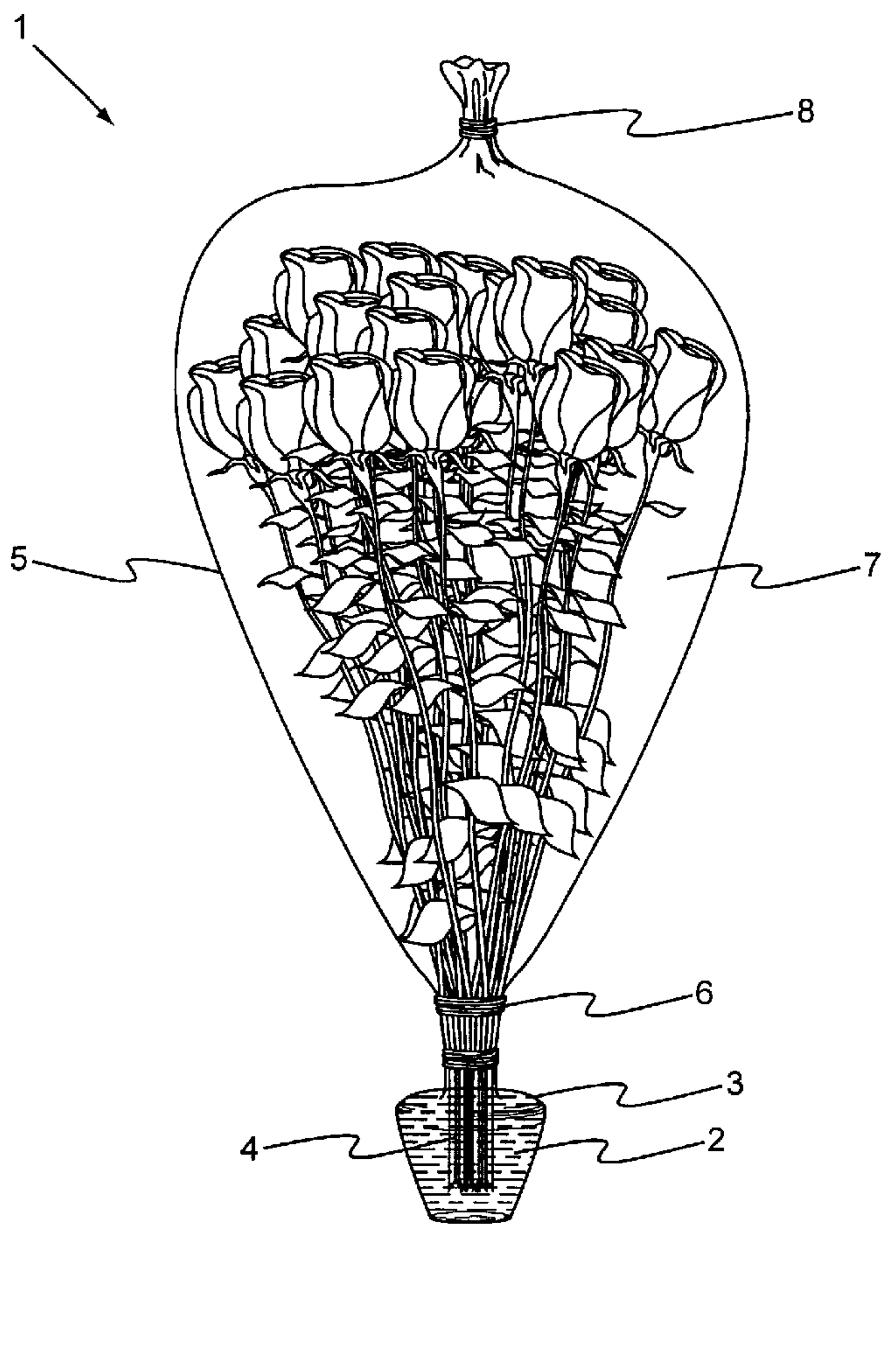

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PLANT PRESERVATION SYSTEMS

CROSS-REFERENCE TO PRIOR APPLICATIONS

[0001] This application claims priority to, and benefit of, prior U.S. provisional application number 60/362,002, "Sugar-Free Gelled Media in Specialized Packaging for Maintaining Freshness and Leakproof Transportability of Plants or Plant Parts Including Flowers" by Sudhir K. Jaiswal, filed March 5, 2002 and prior U.S. Utility application number 10/188,663, "Plant Preservation Systems" by Sudhir K. Jaiswal, filed July, 1, 2002.

FIELD OF THE INVENTION

[0002] This invention is in the field of methods, devices and compositions to preserve plants. The present invention relates to, e.g., methods to inhibit microbes by sealing roots or cut stems in a preservative media and/or sealing the plant aerial parts in an inert gas. The plant preservation devices of the invention include, e.g., a packaging system for spill-free retention of preservative media, and protection of plants in an inert gas environment. The composition of the invention provides, e.g., a thickener, an anti-wilting hormone, salts, and/or microbe inhibitors.

BACKGROUND OF THE INVENTION

[0003] The importance of preserving plants and cut flowers continues to increase as consumers demand a greater selection of plants and flowers from around the world. Consumers have come to expect florists to provide a variety non-indigenous plants, and out of season flowers, from around the world. Better plant and cut flower preservation can allow longer enjoyment of flowers by customers after jet transport, regional wholesaling, and retail display by the florist.

[0004] One requirement for preservation of most uprooted or cut plants is water. Many flowers and plant parts quickly lose turgidity and wilt without a ready supply of water at the cut stem. It is an ancient practice to increase the attractive life of the flowers by keeping cut stems in water. Provision of certain salts and sugars in the water, to maintain an appropriate osmotic balance, has also been known to forestall wilting of cut flowers. These approaches, though useful, provide only a short respite from wilting for many types of cut flowers. In addition, the presence of liquids in flower shipments has been forbidden by many airlines, due to the potential damage from spilled solutions on the aircraft and cargo.

[0005] Microbes can degrade the appearance of plants and cut flowers in storage and during transport. Systemic attacks by bacteria often originate in stem water and can cause the flowers to wilt early. Fungi can colonize the outside of the plants, making them appear rusty or moldy. A variety of methods have been used to combat microbial destruction of plants and cut flowers, such as the use of sterile technique, refrigeration, application of biocides, and the use of antibiotics.

[0006] Microbial load can be reduced through the practice of sterile technique. Sterilized fertilizer can be fed to the plants during the growth period. Plants can be grown in artificial, or sterile soil and harvested without contact by contaminated surfaces. Cut flowers can be packaged in particle controlled environments, such as within HEPA filtered rooms. Such practices can be expensive and may fail due to the large variety of microbes that normally populate plant surfaces, even with these precautions.

[0007] Refrigeration can slow the progress of microbe growth and cut plant deterioration in many cases. Colder temperatures slow metabolism and chemical reactions to delay degradation in the cut flowers. Again, this can be quite expensive. In addition, many types of flowers respond adversely to refrigeration by wilting, or losing petals and leaves.

[0008] The application of biocides, such as ozone, ethanol, or sodium hypochlorite, can kill microbes on the surface of plants. Still, many microbes, such as spore-forming bacteria and fungi, can survive the treatment. Biocide treatments are generally harsh and can harm plant surfaces or color of the flowers.

[0009] Antibiotics can be useful in preventing microbial infestation of cut flowers. Antibiotics, and anti-fungals, in stem water can stop microbial contamination of the water. The antibiotics can diffuse systemically to protect the entire cut plant. However, even broad spectrum antibiotics do not stop all microbes.

Widespread use of antibiotics can select for resistant microorganisms and should be avoided. Stem water with antibiotics may not be safe should it be consumed by children or pets.

[0010] Flower wilting can be caused by exposure to ethylene, a gaseous natural plant hormone that can be generated in the cut flowers. Ethylene levels can be reduced by supplying ventilation. For example, in U.S. Patent number 4.515,266 to Meyers, "Modified Atmosphere Package and Process", produce is preserved by venting a storage container with a mixture of inert gasses. Another way to minimize the damage caused by ethylene is by addition of indol-3-acetic acid (IAA) which is known to inhibit ethylene production under certain conditions.

[0011] Aerobic bacteria and fungi can be inhibited by removing oxygen from the environment. For example, U.S. Patent number 5,564,225 to Quiding et al., "Method and Apparatus for Packaging and Preservation of Flowers and Other Botanicals", describes how cut flowers can be preserved by packaging them in a mixture of inert gasses under a partial vacuum. However, the equipment and packaging materials involved can be expensive. In addition, factors other than aerobic microbes can still deteriorate the uprooted plants and cut flowers.

[0012] In view of the above, a need exists for ways to minimize agricultural waste by extending the useful life of uprooted plants and cut flowers. It would be desirable to replace the need for aseptic practice and refrigeration with environmentally friendly alternatives. The present invention provides these and other features that will be apparent upon review of the following.

SUMMARY OF THE INVENTION

[0013] The present invention provides, e.g., media, devices and methods to preserve plants, such as cut flowers, by supplying the plants with vital substances while inhibiting the growth of microbes. The media of the invention can include, e.g., a sugar-free mixture of soil and/or a thickener, an auxin, a cytokinin, salts, and/or antibiotics. The devices of the invention can include, e.g., a flexible container filled with a substantially sugar-free media and sealed around plant stems with two spaced bands, and a sealable container enclosing an inert gas about the upper plant parts. The methods of the invention can include, e.g., filling a flexible container with medial from a dispensing device, inserting roots or cut plant stems into the media of the invention, and packaging the upper plant parts in a sealable container filled with an inert gas.

[0014] The media of the invention for preservation of cut flowers can include, e.g., about 0.1% to about 1% agar by weight, indole-3-acteic acid, salts, and anti-microbials. The media can be, e.g., substantially sugar-free and contain about 0.5% agar by weight. The indole-3-acteic acid can be present, e.g., in an amount ranging from about 1.5 mg/L to about 20 mg/L. The media can include, e.g., kinetin in an amount ranging from about 3.5 mg/L to about 15 mg/L, and/or a gibberellin in an amount ranging from about 0.3 mg/L to about 5 mg/L. The anti-microbials in the invention can be, e.g., hypochlorite, plant extracts, and/or kanamycin monosulfate in an amount ranging from about 50 mg/L to about 200 mg/L. Media of the invention can include, e.g., thickeners and/or soil.

[0015] The media of the invention can include, e.g., small molecules such as salts and vitamins. For example, the media can include ammonium nitrate, boric acid, calcium chloride, cobalt chloride, cupric sulfate, EDTA, ferrous sulfate, magnesium sulfate, sodium molybdate, potassium iodide, potassium nitrate, potassium phosphate, zinc sulfate, myo-inositol, nicotinic acid, pyridoxin, thiamine, and the like.

[0016] The present invention provides devices for preserving uprooted plants and cut flowers. The devices can include, e.g., a flexible container (e.g., a container formed by components of the plant preservation system with a flexible element useful in providing a seal, e.g., against media spillage) filled with preservative media and urged closed on plant stems with two or more bands, and a sealable container (e.g., a chamber formed by elements of the plant preservation system) sealing the upper plant parts, e.g., in an atmosphere of inert gas. The bands can be, e.g., elastic bands spaced 0.5 inches apart, or more, with the upper media surface captured between them. The sealable container can be fabricated, e.g., from a plastic, or other polymer, with a thickness of about 2 mil, 3 mil, or more. The sealable container can be assembled using a sleeve (i.e., a tube or cylinder shape) of plastic by sealing one or more end openings, e.g., by folding, twisting, banding, and/or the like. The sealable container can have, e.g., a textured inner surface to prevent wetting and browning of flower petals that contact the surface. The inert gas can include, e.g., nitrogen, helium, argon, and/or the like.

[0017] The media of the device can be, e.g., any suitable preservative media. The media can be, e.g., substantially sugar-free to reduce microbial growth. The media can have a thickener, such as an agar based gel, to reduce spilling from the flexible container. The media can contain, e.g., soil. The media can contain, e.g., one or more antibiotics, anti-fungals, anti-microbial plant composition, and/or anti-microbial plant extracts to help control the growth of microbes.

[0018] In one embodiment, the method of the invention for preservation of cut flowers can include, e.g., inserting cut flower stems into a preservative media, packaging the flowers in a sealable container, filling the sealable container with an inert gas, and sealing the sealable container.

[0019] In another embodiment, the method for preserving cut flowers can include filling a flexible container with a substantially sugar-free preservative media, inserting cut stems of the flowers into the preservative media, and sealing the opening of the flexible container around the stems with two or more bands spaced along the stems. A sealant thickener or gel and be applied to the stems between the bands to further ensure the integrity of the flexible container seal.

[0020] In still another method of the invention, plants can be preserved, e.g., by filling a flexible container with a substantially sugar-free preservative media, inserting roots of one or more plants into the preservative media, sealing an opening of the flexible container around the stems of the plants with two or more bands spaced along the stems, and packaging the upper parts of the plants in a sealable container. Plants of the method can include, e.g., fruit and vegetable plants.

[0021] The media in the methods of the invention can be, e.g., any suitable plant preservative media. For example, the media can be substantially sugar-free. The media of the method can include, e.g., a thickener, such as an agar and/or other gel. The media can include, e.g., soil. The media can contain one or more antibiotic such as kanamycin and/or ampicillin. The media can contain sodium hypochlorite. The media can contain, e.g., a fungicide. The media can include, e.g., one or more plant extracts or compositions, such as neem and/or eucalyptus. The neem (*Azadirachta indica*) of the media can be present, e.g., as ground leaves in an amount from about 0.01% to about 10% by weight, or about 1.5% by weight. The media of the method can include, e.g., one or more plant hormones, such as auxins, kinetin, IAA, 2iP and gibberellins. The preservative media of the methods can include, e.g., additives such as ammonium nitrate, boric acid, calcium chloride, cobalt chloride, cupric sulfate, EDTA, ferrous sulfate, magnesium sulfate, sodium molybdate, potassium iodide, potassium nitrate, potassium phosphate, zinc sulfate, myo-inositol, nicotinic acid, pyridoxin, and thiamine. The pH of the media in the methods of the invention can be adjusted, e.g., within the range of about pH 3 to about pH 8.

[0022] The methods of the invention include, e.g., perforating the cut stems with a series of holes through which media can enter. Plant hormone gradients and/or different ratios of hormones between plant parts can be provided, e.g., to induce growth of certain plant tissues, by use of hormones in media and by application of hormones on aerial parts. The methods of the invention can include, e.g., planting rerooted cut plant stems in soil.

[0023] The flexible container of the devices of the invention can be sealed, e.g., over media with substantially all the air removed. The flexible container can be sealed, e.g., with two or more bands spaced from each other and constricted around the flexible container and plant stems. The flexible container can be, e.g., an entirely flexible plastic bag, a rigid container with a flexible opening, or a rigid container without flexible parts and sealable with other flexible elements of the plaant preservation system (such as the lower section of a sealable container sleeve); the flexible container can be any appropriate media holding container with an opening to receive media and stems. A sealant can be applied, e.g., to plant stems above the first band to enhance the integrity of the seal.

[0024] The sealable container of the methods can be fabricated, e.g., from plastic or polymer material with a thickness of, e.g., 2 mil, 3 mil, or more. The sealable container can be a sleeve open at two ends or a bag like container open at one end. The sealable container can have a textured inner surface, e.g., on the upper third of the container to prevent wetting and browning of flower parts. The gas can be introduced into the sealable container by pouring liquid nitrogen, liquid helium, and/or liquid argon into the sealable container. The inert gasses can be filled into the sealable container by, e.g., purging air from the sealable container with a gaseous stream of nitrogen, helium, argon and/or the like. The inert gas atmosphere of the sealable container can be further secured by, e.g., packaging the sealable container inside an outer container filled with an inert gas.

DEFINITIONS

[0025] The term agar, as used herein, refers, e.g., to any of a variety of aqueous polysaccharide extracts from agarophyte sea weeds, such as *Gelidium, Gracilaria, Ceramium, Phyllophora, Pterocladia, Ahnfeltia, Campylaephora, Acanthopelitis*, and the like. Agar of the invention can include, for example, agar, agarose, phytagar, agar-agar, agarobiose, and phycocolloid. Agar can be, e.g., any member of the family of 1, 3-linked galactopyranose and 3, 6-linked 3,6-anhydro-L-galactopyranose polymers.

[0026] The term substantially sugar-free, as used in association with the media of the invention, refers to sugar concentrations below levels at which growth of contaminant microbes in the media is significantly stimulated. The term sugar free suggests a media without, e.g., significant monosaccharides or disaccharides readily available as an energy supply for microbes. As the media of the invention can include, e.g., thickeners that can be polysaccharides, some small amount of sugars can be present as a result of thickener hydrolysis.

[0027] The term anti-microbial includes, e.g., antibiotics, anti-fungal agents, antiseptics, anti-microbial plant compositions and extracts that can kill or slow the growth of microbes.

[0028] The term plant refers to, e.g., one or more whole plants, uprooted plants and/or cut plants, including cut flowers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] Figure 1 is a schematic diagram of cut flowers packaged in a cut flower preservation system, wherein the flexible container and sealable container are sections of a single packaging container.

[0030] Figure 2 is a schematic diagram of cut flowers packaged in a cut flower preservation system, wherein the flexible container and sealed container are fabricated from independent system elements.

[0031] Figure 3 is a schematic diagram of the flexible container redundant seal.

[0032] Figure 4 is a schematic diagram of cut flowers packaged in a cut flower preservation system with gas exchange perforations.

[0033] Figure 5 is a schematic diagram of a plant in a plant preservation system.

DETAILED DESCRIPTION

[0034] The present invention provides, e.g., media, packaging materials and methods to preserve plants. Roots or cut stems can be inserted into the media of the invention, which preserves the plants by, e.g., providing water, inhibiting growth of microbes, and/or providing plant hormones. Packaging materials of the invention can, e.g., retain the media without spills, physically protect the aerial plant parts, maintain humidity, minimize loss of water, and/or provide a substantially oxygen free environment. Methods of the invention can preserve plants, e.g., by providing necessary fluids, slowing plant metabolism, and by preventing growth of microbes.

[0035] In one embodiment of the invention, for example, preservative media containing agar, indole-3-acetic acid, and kanamycin, is poured into the narrow end (the "flexible container' section) of a generally conical plastic packaging container.

Flower stems are cut and inserted into the media. The cut stems and media are sealed without air, e.g., by constricting the sack onto the stems at the top of the media with two spaced rubber bands. About, e.g., 10 or more milliliters of liquid nitrogen is poured along the upper inside of the sack, and the top of the sack is twisted and banded to seal the flowers in the inert gas environment. Packaged in this fashion, the cut flowers can be transported and stored for extended periods, while retaining an attractive appearance and limiting the growth of microbes.

THE PRESERVATIVE MEDIA

[0036] The preservative media of the invention, e.g., provides inhibition of microbial growth while providing the plants with water and a favorable hormonal environment. The growth of microbes is inhibited, e.g., by the substantial absence of oxygen and CO_2 in the system, by the absence of sugar in the media and/or by the presence of anti-microbials in the media. Water, salts and hormones, e.g., help prevent abscission (dropping of leaves, fruit and petals) and wilting of the flowers. A thickener can be added to the media, e.g., to help limit spillage of the media during transport and handling. Soil can be added to the media, e.g., to provide soil constituents beneficial to some plants. In one embodiment, the media of the invention includes, e.g., about 0.5% agar, indole-3-acetic acid, salts and an antibiotic.

Media Thickener

[0037] A thickener can be added to the media of the invention, e.g., to retain water in a form available to the cut stems and to minimize spillage of the media while the packaged plants are being handled. The thickeners of the intention can be any substance, compatible with the plants and packing materials, which increases the viscosity of the media. For example, the thickener of the invention can be any of a variety of hydrophilic natural and/or synthetic polymers. Thickeners of the invention can be, e.g., agar, alginate, carrageenan, gellan gum, pectin, a cellulose derivative plant gums, and/or the like. Biodegradable thickeners can be selected, e.g., where sewage or compost disposal of the media is desirable after use.

[0038] Thickeners can be added to media of the invention, e.g., in amounts required to provide a viscous or gelled composition that reduces spills in a particular packaging system during transport and handling. Media of the invention can include one or more thickeners in an amount ranging, e.g., from about 0 weight percent to about 5 weight percent, from about 0.05 weight percent to 1 weight percent, from about 0.3 weight percent to about 0.7 weight percent, or about 0.5 weight percent.

[0039] In one aspect of the invention, for example, the thickener can be an agar. Agars can include, e.g., agar, agarose, phytagar, agar-agar, agarobiose, phycocolloid, and the like. Agars are generally polymers of, e.g., 1, 3-linked galactopyranose and 3, 6-linked 3,6-anhydro-L-galactopyranose. Agars can be, e.g., crude or purified aqueous extracts of algae or seaweed, such as *Gelidium*, *Gracilaria*, *Ceramium*, *Phyllophora*, *Pterocladia*, *Ahnfeltia*, *Campylaephora*, *Acanthopelitis*, and the like.

[0040] Agar solutions and gels can be prepared by, e.g., adding dehydrated agar to water and heating to near boiling, until the agar is dissolved. The agar can be sterilized, e.g., by autoclaving at 120°C for about 15 minutes. The agar solution will, e.g., form a gel on cooling which can be repeatedly melted and solidified for pouring or addition of other media components.

Soil

[0041] Soil can be added to the media of the invention, e.g., to supply beneficial soil constituents to plants. Soil of the invention can be, e.g., clay, loam, humus, kaolin, sand, peat, top soil, potting soil, a mixture of soils, and/or the like. The soil of the invention can be, e.g., contain normal soil microbes or can be sterilized. Soil can be incorporated in to the media of the invention, e.g., in amounts ranging from about 0 weight percent to about 100 weight percent, 30 weight percent to about 80 weight percent, e.g., at about 60 weight percent.

[0042] Soil can be present, e.g., as an additive to the media or as the main matrix of the media. When soil is present, e.g., as a media constituent of about 10%, it can act as a source of normal flora and trace elements. When soil is present in the media, e.g., as a water saturated mud at about 60% of the media, it can act as a thickener to prevent spillage and provide a wholesome environment for uprooted plants.

[0043] Without being bound to any particular theory, it is believed that soil in the media of the invention can provide, e.g., beneficial microbes, minerals, trace elements, rooting surfaces, and nutrients to the plants. Anti-microbial agents in the media, reduced oxygen and substantial lack of sugar can, e.g., prevent excessive growth of microbes in media of the invention including media containing unsterilized soil.

Anti-microbials

[0044] Bacteria and/or fungi can infest whole plants and cut flowers to degrade their appearance and reduce their shelf-life. Anti-microbials, such as antibiotics, anti-fungals, hypochlorite salts (e.g., bleach), silver nitrate, plant extracts, and 8-hydroxyquinoline citrate (8-HQC), can be added to the media of the invention, e.g., to inhibit growth or these microbes. The choice of anti-microbials depends on, e.g., the threat associated with a particular plant (such as the normal surface microbes) and the presence of other anti-microbial factors in the preservation system (such as anaerobic conditions or the lack of sugars in the media). For example, where the plants are packaged in an anaerobic container, anti-fungals and antibiotics against aerobic bacteria may not be necessary.

[0045] Antibiotics are molecular agents that can kill bacteria or inhibit bacterial growth. Antibiotics often inhibit bacteria by interfering with their metabolic processes, such as cell wall formation; as compared to antiseptics, such as chlorine bleach, which destroy microbes by chemical attack. Antibiotics of the invention include, e.g., kanamycin and ampicillin. Other antibiotics, known in the art, such as broad spectrum antibiotics, and/or antibiotics targeted to particular problem microbes, can be beneficially included in the media of the invention. Antibiotics of the invention can be, e.g., incorporated into slow release polymeric compositions to ensure adequate concentrations in the media over time.

[0046] Fungi can be common saprophytes, pathogens, or contaminants on plant surfaces. Fungicides can be, e.g., added to the media of the invention to minimize the growth of fungi in the media and plants. Fungicides of the invention include, e.g., calcium polysulfide, benomyl, chlorothaloni, sulfur, mycobutanil alfa 4-chlorophenyl 1H 1, 2, 4-triazole-1 propanenitrile, triforine, thiphanate-methyl, nystatin, and the like. The fungicides of the invention can be, e.g., topically applied to the plant or media surface. The fungicides can be, e.g., incorporated into the media and/or systemically distributed within the cut flower.

Plant Compositions and Extracts

[0047] Media of the invention can include, e.g., anti-microbial compositions and/or extracts of plants. For example many plants such as neem, eucalyptus, lobelia, wintergreen, hops, juniper, chaparral, thyme, rosemary, and myrrh are known to have anti-microbial properties. Compositions of such plants can be prepared, e.g., by chopping or grinding the roots, stems, leaves, flowers and/or fruits. Extracts of such plants can be prepared, e.g., by effusion of ground plant parts in aqueous or organic solvents to obtain active antimicrobial agents from the plants. Many plant compositions and extracts in the invention can, e.g., provide benefits by controlling insect or nematode pests that can harm the plants.

[0048] Extracts and/or compositions of antimicrobial plants can be incorporated into media of the invention in amounts adequate to provide the desired microbe control for a particular media or plant. For example, ground neem leaves, or other plant compositions, can be incorporated into media of the invention in amounts ranging from about 0.1 weight percent to about 10 weight percent, or at about 1.5 weight percent.

[0049] Many of the plant compositions and extracts of the invention can be, e.g., employed on edible plants and/or are environmentally friendly. The natural anti-microbials of the invention can be disposed of, e.g., in compost, land fill and sewage systems without harm to the environment. Many of the anti-microbial plant compositions and extracts can be, e.g., applied to media or plant surfaces without rendering the plant unsuitable for consumption by animals or humans.

Absence of Sugars

[0050] Media of the invention can be, e.g., substantially sugar-free. Whereas, preservation media in the cut flower industry usually include one or more sugars (e.g., see Quinding, cited above, and U.S. Patent number 5,536,155, "Preservative of Cut Flowers" to Futaki, et al.), media of the invention can be provided, e.g., without added sugars. Although sugars can provide some nutritional benefit to some cut plants, they can also stimulate growth of bacteria and fungi that can destroy the plants. Without being bound to a particular theory, plants in the media and/or inert gasses of the invention, e.g., appear to receive adequate metabolic sugars from internal starch storage, and/or photosynthetic mechanisms, to retain a vital appearance and a long storage life without requiring sugar from the media.

Plant Hormones

[0051] Exposure of plants to plant hormones in the media and devices of the invention can affect the quality of the plants. Plant hormones can include certain small molecules such as, e.g., auxins, cytokinins, gibberellins, ethylene, and the like. The right combination of hormones in the media and/or devices of the invention can, e.g., control flower bud opening, increase stem turgidity, and prevent abscission. Such combinations can be different from one type of plant to the next. Plant hormones can be constituents of the media of the invention and/or can be applied to the surface of plants, e.g., by dipping or spraying.

[0052] Indole-3-acetic acid (IAA) can be added to the media of the invention, e.g., to help maintain an attractive appearance in the cut flowers. IAA is an auxin associated with stem growth. IAA is also known to affect ethylene production in some plants at certain concentrations. Ethylene (C_2H_2) is a volatile organic compound generated by plants which acts as a plant hormone stimulating plants to ripen fruit and/or to drop leaves. Without being bound to any particular theory, addition of IAA to the media of the invention may, e.g., inhibit production of ethylene thus delaying flower bud opening, and/or dropping of petals and leaves. The media of the invention can include auxins, such as IAA, in an amount ranging from about 0 mg/L to about 20 mg/L, in an amount ranging from about 3 mg/L to about 10 mg/L, or at a concentration of about 5 mg/L. The optimal concentration can vary, e.g., with plant type, plant age, combinations with other hormones, etc. Beneficial concentrations can be determined, e.g., empirically under a variety of conditions with cut flowers in the media of the invention.

[0053] Other plant hormones useful in controlling the appearance and shelf-life of plants in the invention include, e.g., cytokinins and gibberellins. Cytokinins, such as kinetin and 2iP, are known to influence, e.g., cell division and cell elongation in plants. Gibberellins are thought to be important in, e.g., normal plant height, leaf maturation, flower development and fruit development. The proper combination of cytokinin and gibberellin concentrations, e.g., in combination with IAA, can provide extended plant survival and improved appearance in storage. Media of the invention can include, e.g., cytokinins, such as kinetin, in an amount ranging from about 0 mg/L to about 20 mg/L, in amount ranging from about 3.5 mg/L to about 15 mg/L, or at a concentration of about 7 mg/L. Media of the invention can include gibberellins, such as GA_3, in an amount ranging from about 0 mg/L to about 5 mg/L, ranging from about 0.3 mg/L to about 2 mg/L, or at a concentration of about 1 mg/L. The actual optimum concentrations can vary, e.g., with plant type, plant age, combinations with other hormones, etc. Beneficial concentrations can be determined, e.g., empirically under a variety of conditions with plants in the media of the invention.

[0054] In another aspect of the invention, for example, aerial portions of cut plants can be treated with cytokinins and/or gibberellins to stimulate root propagation and/or floral budding. Without being bound to any particular theory, it is believed that gradients with different ratios of plant hormones between regions of a plant can strongly influence induction of growth. For example, increasing concentrations of auxins towards a cut stem and increasing concentrations of cytokinins towards aerial tips provides a high ratio of auxins to cytokinins at the cut stem that can induce root growth. In the invention, such gradients can be generated, e.g., in a cut flower by providing auxins in the preservative media and by spraying a solution of cytokinins onto the aerial plant parts. Root growth can be further stimulated, under these conditions, by providing a series of holes in the cut stem.

Other Media Ingredients

[0055] Salts, buffers and other small molecules can be added to the media of the invention to provide osmotic balance, pH control, trace elements, cofactors, nutrients, and the like. Plant tissue culture salt formulations, known in art, can provide, e.g., useful supplements to the media of the invention. For example, Murashige and Skoog's salts, Gamborg's vitamins, White's salts, and the like, can be incorporated into the media. Aqueous solutions can be formulated, e.g., from commonly available plant media components, such as ammonium nitrate, boric acid, calcium chloride, cobalt chloride, cupric sulfate, EDTA, ferrous sulfate, magnesium sulfate, sodium molybdate, potassium iodide, potassium nitrate, potassium phosphate, zinc sulfate, myo-inositol, nicotinic acid, pyridoxin, thiamine, and/or the like. The final media preparation can have a pH adjusted, e.g., within the range from about 3 to about 8, or to about pH 5.6. Some ingredients may have to be dissolved separately in a special solvent, at a certain temperature, and/or at a particular pH, before addition to the media.

Cut Rose Preservation Media

[0056] The preservation media of the invention can be, e.g., adjusted to formulations well suited to particular types of cut flowers. For example, a media formulation well adapted to preservation of cut roses can include, e.g., Murashige and Skoog's salts, Gamborg's vitamins, 7 mg/L kinetin, 5 mg/L IAA, 5 mg/L 2iP, 1 mg/L gibberellin, 100 mg/L kanamycin monosulfate, and 5.5 g/L phytagar. Final salt concentrations of about 1000 mg/L ammonium nitrate, 200 mg/L calcium chloride, 100 mg/L magnesium sulfate, 1000 mg/L potassium nitrate, and/or 100 mg/L monobasic potassium phosphate can provide favorable results in cut rose preservation media.

[0057] Cut rose preservation media can be prepared, for example, by dissolving the salts in water. The solution can be adjusted, e.g., to pH 5.6. The phytagar can be, e.g., added to water, dissolved and heated separately to prepare a melted solution. The salt solution and melted agar can be, e.g., mixed together with a quantity of additional water to obtain the desired final component concentrations.

The resultant mixture can be, e.g., autoclaved (this is often not necessary since the media, devices and methods of the invention can inhibit microbial growth without the requirement of absolute media sterility). Phytohormones and anti-microbials can be, e.g., dissolved in special solvents, at suitable pHs, and filtered, as necessary. After the media mixture has cooled, e.g., to about 45°C, or less, the hormone and/or anti-microbial solutions can be mixed into the final media. The media can be, e.g., poured immediately into plant storage containers, or heated later for pouring.

Strawberry Plant Preservation Media

[0058] The preservation media of the invention can be, e.g., adjusted to formulations well suited to particular types of whole rooted plants. For example, a media formulation well adapted to preservation of whole strawberry or grape plants can include, e.g., 150 ml (about 250g) of sandy soil, 75 ml water, 5 g ground neem leaves, and 200 ppm 8-HQC. The soil can act, e.g., as a buffer and source of nutrient salts. More water can be included, e.g., if the sealable container is perforated; less if the sealable container is sealed with inert gas.

PLANT PRESERVATION DEVICES

[0059] The plant preservation devices of the invention can, e.g., inhibit growth of microbes, prevent media spilling, retain the vitality of uprooted plants, and retain the appealing appearance of cut flowers over an extended period of time. The devices can include, e.g., a flexible container of media and a sealable container enclosing upper plant parts (such as, e.g., stems, leaves, flowers and fruit) in an inert gas environment.

[0060] For example, as shown in Figure 1, plant preservation system **1** can include preservation media **2** retained within flexible container section **3**. The cut stems of cut flower bouquet **4** is inserted into the media and sealed from sealable container section **5** of the system with two spaced bands **6** constricted over flexible container **3** and the cut stems. The interior of sealable container **5** is filled with inert gas **7**. The top of the sealable container is twisted, then sealed by constriction with closure band **8**.

The Flexible Container

[0061] The flexible container of the invention, e.g., seals roots or cut stems of flowers within media of the invention. The flexible container preferably employs a redundant seal of two or more bands to retain media and restrict entry of air.

[0062] The flexible container can be, e.g., the lower section of a packaging container which also includes an upper sealable container section, as shown in Figure 1. The flexible container can be, e.g., a separate container, as shown in Figure 2. The opening at the top of the flexible container can be, e.g., flexible to comply with the constrictive force of the spaced bands to seal media within the flexible container. Optionally, the flexible container can be a rigid container with a flexible seal provided by lower sections of the plastic film packaging container.

[0063] The flexible container can be filled, e.g., with the media of the invention. After roots or cut stems are introduced into media **2**, first band **6a** can be, e.g., constricted at, or just below, the media top surface **10** so that no air remains below the band in the flexible container, as shown in Figure 3. Second band **6b** can be constricted, e.g., about 0.5 inches or more above the first band to form a redundant seal between the media and the exterior of the flexible container. Additional bands can be added to increase seal security, e.g., when a flower bouquet is particularly thick, when expected handling is aggressive, when the media is especially thin, when plants have odd shaped stems, and/or the like.

[0064] Filling the flexible container can include, e.g., dispensing media into the container by use of a dispensing device, as can be appreciated by those skilled in the art. For example, a dispensing device can include, a container of known volume for manually pouring media into the flexible container section of the packaging system, a valve to control flow of gravity fed media from a mixing container, pumping media from a container, and/or the like. Preferred pumps are peristaltic pumps. Specialized dispensers are commercially available, e.g., with manual and/or automated systems for receiving media concentrate, adding water for reconstitution, blending the water and concentrate mixture, controlling the temperature of the mixed media, and/or dispensing the media preparation. Such systems can include, e.g., liquid volume controllers, known in the art (such as those available from, e.g., Inline Filling Systems, Inc. 216 Seaboard Avenue, Venice, FL 34292, and others), to control mixture dilution and/or media mixture dispensing volumes. Such volume controllers can be manual or automated and can include, e.g., graduate marked containers, discrete or variable stroke valved piston pumps, syringes driven by stepper motors, calibrated peristaltic pumps, positive displacement pumps, and/or the like.

[0065] A sealant can be entrapped in the space between the bands sealing the flexible container opening, e.g., to further enhance the seal integrity. The sealant can be, e.g., viscous or gelatinous to inhibit the flow of liquids across the sealed space. The sealant can be, e.g., a natural thickener, such as agar, and/or synthetic, such as PVC. In one embodiment, 5 ml of warm agar is poured, e.g., over the stems above the first band before sealing the second band to provide a substantially impenetrable seal to liquid between the bands.

[0066] The flexible container can be fabricated, e.g., from any suitable material known in the art. For example, the flexible container and/or associated flexible sealing sections thereof, can be formed from polyethylene, or other polymer, film 2 mil thick, 3 mil thick, or more. Such a container can be conveniently formed, e.g., by heat sealing a container shape through two layers of film and cutting the container from the film, as is commonly practiced in the art. Optionally, the flexible container can be, e.g., a rigid media container sealed to a flexible lower section of the main plastic film packaging container of the plant preservation system. Other polymers useful in fabrication of the flexible container of the invention can include, e.g., polypropylene, poly-vinyl chlorides, poly-ethersulfones, polycarbonate, poly-ethyleneoxides, and/or copolymers thereof.

[0067] The media held in the flexible container can be, e.g., as described in the Preservative Media section, above. The media can have, e.g., a thickener to help reduce seepage of media past the first seal. The media can be, e.g., degassed under vacuum or by heating to reduce the oxygen available to microbes.

The Sealable Container

[0068] The sealable container of the invention can, e.g., protect plants from damage and/or enclose them in an inert atmosphere. The sealable container can, e.g., allow visual inspection of the packaged plants and provide a final barrier to media spillage.

[0069] The sealable container can be, e.g., an upper section of a packaging container which also includes a lower flexible container section, as shown in Figure 1. The sealable container can be, e.g., a separate container constrictively sealed about the plant stems, or a separate container sealed to or enclosing both the plant and the flexible container, as shown, e.g., in Figure 2.

[0070] As cut flowers, and many plants, are generally wider at the top than the bottom, the sealable container can have, e.g., a tapered or conical shape. The top of the sealable section can have, e.g., an opening about 1 inch wide, or more, to receive a single small plant. The top of the sealable section can have, e.g., an opening about 4 inches wide, or more, to receive a bouquet of flowers or a bushy plant. In one example embodiment, for preservation of a dozen flowers, the packaging container is a 26 inch long tapered shape with a 3 inch wide base and a 14 inch wide top, sealed and cut from 2 layers of 3 mil polyethylene film. In another embodiment, the sealable container can be, e.g., a cylindrical sleeve of plastic film with a top end opening and a bottom end opening; in such a case, e.g., the bottom opening can be sealed to or around a rigid media container to form the flexible container of the invention, while the top opening end can receive, e.g., flowers into the sealable container section of the packaging system.

[0071] The opening at the top of the sealable container can be flexible to aid in sealing the container. For example, the sealable container can be fabricated from low density plastic 2 mil thick or less, 3 mil thick, 4 mil thick, or more. The top of the sealable container can be gathered, e.g., by folding or twisting, then bent back on itself and fixed in place with a tape, band, or clip to form a substantially gas impermeable seal. Other sealable container constructions and seals can be readily appreciated by those skilled in the art.

[0072] All or part of the sealable container inner surface can be textured to, e.g., reduce flower petal wetting and browning from moisture trapped between the petal and the container. A textured surface can, e.g., reduce surface tension forces that can allow moisture condensate to adhere flower petals to the inner sealable container surface. Flower petals "stuck" to the container surface by moisture can become, e.g., wetted, soggy or poorly oxygenated resulting in discoloration and drooping of the flower petal. Provision of a textured (i.e., rough, patterned) inner surface can, e.g., trap gasses and/or substantially reduce the surface contact can promote surface tension phenomenon, thus reducing sticking and damage to the petals.

[0073] The sealable container can, e.g., seal an atmosphere of one or more inert gases about the upper sections of plants. The inert gas can be, e.g., nitrogen, helium, argon, and the like. The gas can fill the sealable container by, e.g., pouring liquefied gas into the container, where it quickly changes to the gas state and displaces air from the container. The gas can fill the sealable container by, e.g., purging air out of the container with a stream of the gas from a pressurized gas cylinder. For embodiments of the invention using helium as the inert gas, the sealable container can have, e.g., thicker walls, metal foil layers and/or high quality seals to prevent diffusion from the container.

[0074] To further ensure an inert atmosphere in the sealable container, the entire cut flower preservation system can be, e.g., sealed in an outer container, thus creating an outer space between the sealable container and the outer container. The outer space can be, e.g., filled with an inert gas to minimize diffusion from the sealable container, and to protect the sealable container from punctures.

[0075] The sealable container of the invention can be, e.g., transparent to allow inspection of packaged plants and/or to allow the plants to receive light. A transparent sealable container can, e.g., allow handlers to detect media leakage before it escapes the container or harms the appearance of the plants. A transparent sealable container can, e.g., allow wholesale, retail and final purchasers to examine the quality of the plants without breaking the seal. Some cut plants and flowers can, e.g., retain a more pleasant appearance if light is allowed to shine on them through the container.

[0076] The sealable container of the invention can, e.g., protect plants from physical damage. The sealed container can, e.g., form a protective boundary against intrusion of sharp or abrasive objects that can damage delicate plants. The pneumatic pressure of the gases within the container can, e.g., repel certain blunt or crushing forces the container might experience in transit and handling.

[0077] The sealable container of the invention can, e.g., decrease the loss of moisture and increase the humidity around the aerial plant parts. Sealing water vapor inside the sealable container and, e.g., allow plants can remain packaged longer with less preservative media in the flexible container. A high humidity in the sealable container can, e.g., minimize transpiration and lower plant metabolism for a longer packaged shelf life.

[0078] The sealable container of the invention can be, e.g., perforated or imperfectly sealed to allow gas exchange with the external atmosphere in some situations. As shown in Figure 4, for example, sealable container **5** can have one or more gas exchange perforations **9**. The perforations can number, e.g., from about 3 to about 100, or more, depending on the size of the container and the gas exchange requirements of the plants. The perforations can range in size, e.g., from about 0.1 mm to about 2 mm, or more. Perforations in the small size range can be, e.g., more numerous for adequate gas exchange, while small enough so that liquids, such as condensate or media, can not drain through. Optionally, gas exchange can be promoted by, e.g., provision of an imperfect closure or seal of the sealable container.

<u>METHODS OF PRESERVING PLANTS</u>

[0079] Methods of the invention employ, e.g., preservative media, liquid sealable containers, and/or gas sealable containers to preserve plants. In one embodiment, for example, cut stems of flowers are inserted into a preservative media and the flower buds are enclosed within an inert gas environment for preservation. In another embodiment, the cut stems are inserted in a substantially sugar-free media without air and sealed with multiple separated bands. In still another embodiment, whole plants, freed of soil, are preserved with their roots sealed in the media of the invention and the their upper sections protected in the sealable containers of the invention.

[0080] The methods of the invention preserve plants by, e.g., combining plant sustenance techniques with microbial inhibition techniques. For example, the preservative media can supply plants with water and auxins, while the media and packaging can deny sugar and oxygen to the microbes. The plants can thereby, e.g., retain a fresh appearance without being attacked by bacteria and/or fungi.

Sustaining the Cut Flowers

[0081] When flowers are cut, they can rapidly lose their attractive appearance. Most immediately, water lost to transpiration from the leaves can not be replaced, so the flower wilts. Later, even if the cut flower stems have been placed in water, hormonal and enzyme systems can degrade the flower so it becomes discolored and loses flower petals and leaves. The degraded appearance can be aggravated by bacterial or fungal infestations of the cut flower. The degradation of cut flowers can be delayed by providing conditions that can help sustain vitality.

[0082] Placing the cut ends of flower stems in water can help maintain turgor pressure and delay wilting. For many flowers, it is important to place the cut stems immediately into water, or to make the cut under water, to avoid transpiration drawing air bubbles into the stem vasculature and blocking the flow of fluids. The methods of the present invention provide water to the cut stems, e.g., in the form of preservative media. Cut stems can be, e.g., immediately dipped into the media and held within the flexible container filled with media. The flexible container can be sealed with bands, as described above in the Flexible Container section, so that no air can reach the cut stem ends. As the preservative media is transported up into the flowers, the flexible container can, e.g., collapse so air is not drawn in. The stem can be cut at a diagonal to increase the surface exposed to media and the cut ends can be suspended away from container walls to avoid flow blockage by the container inner surface.

[0083] A series of puncture holes can be optionally made, e.g., in the sides of the stem near the cut end, to provide a route of water entry into the stem vasculature even if the cut ends become blocked. The holes can be, e.g., placed longitudinally and/or radially along the stem where there is contact with the media. The holes can range in size, e.g., from about 0.1 mm to about 2 mm, and number from about 3 to about 100 per stem.

[0084] Small molecule additives to the media, such as, e.g., salts and vitamins, can help maintain the vitality of cut flowers, as is known in the art. Salts, vitamins and trace elements can help the living cut plants to continue normal plant metabolism and physiology, although roots are lacking. The proper balance of salts can provide, e.g., a beneficial pH and osmotic balance.

[0085] Having a thickener in the media can help supply water to the cut flowers. For example, the thickener can prevent media from being shaken off the cut end during handling so that air does not enter the stem. The viscosity of thickeners can stop media from leaking out of the flexible container so it remains available to the cut ends. The thickener can keep media from spilling onto flowers in the sealable container where it can foul the appearance of the flowers and promote the growth of microbes.

[0086] Plant hormones in the media, such as, e.g., auxins, cytokinins, and/or gibberellins, can extend the attractive shelf life of cut flowers by providing chemical messages of vitality and/or reducing messages that promote wilting and abscission. For example, the presence of the auxin, IAA, in the media of the invention can send a hormonal message promoting growth and delaying blossoming of flowers, while at the same time it delays abscission by limiting the generation of ethylene. Consequently, flowers can, e.g., appear fresh and remain in bud-state longer.

[0087] Some plants can develop roots, e.g., in the presence of media of the invention, particularly with media containing hormones, such as IAA. In such cases, e.g., the vitality of the cut flower can be improved. Application of a cytokinin, e.g., to the aerial portions of the plant can further stimulate root development. The value of the cut flowers to the end customer, e.g., can be increased, since the flower can be planted in soil for continued enjoyment.

[0088] In one aspect of the invention, the sealable container is perforated, e.g., to allow exchange of gasses with the external atmosphere. This venting can have certain advantages for preserving some cut flowers. Venting can reduce ethylene levels, e.g., for cut flowers that generate large amounts of ethylene or which are particularly sensitive to ethylene. Venting can, e.g., lower the humidity inside the container so that water condensation does not saturate flower parts or provide an environment for growth of microbes. Venting can, e.g., prevent injury to flower parts caused by expansion and contraction of the container volume caused by air pressure changes experienced in the cargo hold of a jet aircraft.

[0089] In another aspect of the plant preservation methods of the invention, e.g., the inner surface of the sealable has a texture. Such a texture can inhibit sticking of flower petals to the sealable container surface, as described in the Sealable Container section above, e.g., to reduce water damage to the petals.

Sustaining Whole Plants

[0090] Whole plants, which retain their roots, can be maintained in a vital state for extended periods by using the media and packaging techniques of the invention. Whole plants can be sustained, e.g., using the media and packaging described in the Sustaining Cut Flowers section above. However, whole plants can be more hardy because, e.g., they can exclude air and microbes that would injure cut plants. On the other hand, certain hormones and anti-microbials, e.g., may not effectively penetrate whole plants. Although whole plants can thrive, e.g., in cut flower media, they can have distinctly different optimal media conditions.

[0091] As the root interface with media can, e.g., control exchange of salts, the liquid of whole plant media can have less stringent buffer and osmotic control parameters than for cut flower media. Necessary nutrients, such as salts and trace elements, can be absorbed, e.g., from media with low concentrations of the nutrients or simply from water which has leached nutrients from soil of the media.

[0092] The root interface with the media can, e.g., provide a barrier to gasses. Air in the media of the invention will not, e.g., be drawn into the vasculature of the plant to block flow of fluids. Whole plants can therefore tolerate, e.g., absorption of water from a soil media beyond the point where gasses enter the media.

[0093] Plants can, e.g., senesce in the media and devices of the invention so that vitality can be extended. For example, a plant kept out of direct sunlight and sealed in an inert gas will have a lowered metabolism and transpire less water. The lowered metabolism, e.g., requires less nutrients and water. Plants sustained by the methods of the invention can, e.g., exist in a semi-senescent state that extends the usable life of the plant in shipping, handling and storage.

Inhibiting Microbial Growth

[0094] Bacterial and fungal infestation are a significant cause of product waste in the cut flower industry. The methods of the invention can prevent such infestations, e.g., by creating environments unfavorable to growth of microbes. The media and container systems of the invention, e.g., limit the availability of surfaces, oxygen, and nutrients, necessary to the growth of the microbes.

[0095] Fungi and aerobic bacteria need oxygen to grow and multiply. The media and gasses of the invention can, e.g., deny oxygen to microbes present in the cut flower preservation system. Media of the invention can be degassed, e.g., under vacuum or by heating before pouring into the flexible container. Thickeners can, e.g., reduce transport of oxygen from the air into the in the media caused by liquid mixing. As sealing bands are placed at the opening of the flexible container, media can, e.g., be squeezed up to the seal so that no air space remains in the container. Air in the sealable container can be, e.g., substantially eliminated by introduction of inert gasses, as described in the Sealable Container section, above. The oxygen reduction methods of the invention can, e.g., mitigate the need to protect cut flowers with anti-fungals and antibiotics.

[0096] Media of the invention are, e.g., substantially sugar-free. Sugars are a ready source of the energy necessary for the growth of many microbes. Sugars are not required in media for many plants since they can obtain adequate energy from carbohydrate storage and/or photosynthetic processes. The substantial lack of sugar in media of the invention can, e.g., significantly reduce the microbial infestation of uprooted plants and cut flowers.

[0097] Some bacteria and fungi use surfaces to grow and spread. For example, some fungi require a surface to raise sporangium into the air for spreading of spores. The methods and devices of the invention can, e.g., deny surfaces to the microbes. Sealing the flexible container, e.g., without an air space can substantially eliminate the media/air interface. The redundant band seal of the invention can, e.g., prevent media spillage and creation of media surfaces within the sealable container. In one aspect of the invention, perforations in the sealable container can, e.g., prevent condensation and formation of water surfaces in the container.

[0098] Media of the invention can, e.g., limit the availability of water to microbes. The thickeners, gels, salts, and/or soil of the media can absorb or complex with water of the media, e.g., making it unavailable to undesirable microbes. Limited availability of water can inhibit growth of some bacteria and fungi so they can not damage packaged plants.

[0099] Antimicrobials, such as antibiotics, antiseptics and anti-fungal agents, e.g., as described in the Preservative Media section, can be used to limit microbial infestations of cut plants. These anti-microbials can be added to the media of the invention or, on some cases, applied to flower surfaces. Natural anti-microbial agents, such as, e.g., plant compositions and plant extracts, can be used where plant consumption by humans is contemplated. The need for anti-microbials can be, e.g., reduced or eliminated by practicing the oxygen reduction, sugar reduction and surface reduction methods of the invention.

EXAMPLES

[0100] The following examples are offered to illustrate, but not to limit the claimed invention. One of skill will recognize a variety of parameters that can be altered while obtaining substantially similar results.

Preservation of Cut Roses

[0101] A plant preservation system for cut roses includes a preservative media in a flexible container section redundantly sealed from a sealable container section filled with an inert gas. The process of assembling cut flowers into a preservation system of the invention can be, e.g., simple and inexpensive.

[0102] A packaging container is prepared by heat sealing and cutting a tapered pattern from two layers of 4 mil low density polyethylene film. The 26 inch long tapered container is 3 inches across at the bottom and 14 inches across at the top, as measured with the container laid out flat.

[0103] A preservative media is prepared having salts (e.g., 1000 mg/L ammonium nitrate, 200 mg/L calcium chloride, 100 mg/L magnesium sulfate, 1000 mg/L potassium phosphate), 7 mg/L kinetin, 5 mg/L IAA or 1.25 mg/L gibberellin, 100 mg/L kanamycin monosulfate, and 5.5 g/L phytagar. While the media is still warm, 100 milliliters is poured into the bottom of the packaging container (flexible container section).

[0104] The stems of a dozen roses are cut at a diagonal and immediately inserted into the media in the flexible container. A rubber band is positioned around the stems and the flexible container section while media is squeezed to force air out. The rubber band is allowed to constrict around the flexible container section and stems at, or below, the top of the media surface. A second rubber band is positioned one inch above the first rubber band and allowed to constrict around the top of the flexible container section and the stems, thus forming a redundant seal between the flexible container section and the sealable container section.

[0105] Ten milliliters of liquid nitrogen is poured down the inside of the sealable container section. As the nitrogen rapidly converts to the gas state, the top of the sealable container is twisted and folded back on itself to form a substantially gas impermeable seal. A rubber band is constricted around the folded twist seal to fix it in place.

[0106] The cut roses are ready for arrangement in racks and/or boxes for international shipment, wholesale handling or retail display. The roses will retain a fresh appearance for about six to twenty days at room temperature.

[0107] After use, media of the invention can often be, e.g., disposed of without harm to the environment. Thickeners, salts, and hormones of the media are, e.g., generally biodegradable. The methods and devices of the invention can, e.g., reduce or eliminate the need for antibiotics in the media. Media of the invention can, e.g., be disposed of in sewer systems or composted.

Preservation of Strawberry Plants

[0108] A plant preservation system for strawberry plants includes a preservative media in a flexible container section redundantly sealed from a sealable container section filled with an inert gas. The preservation system of the invention can, e.g., reduce the metabolism of the plant while inhibiting the growth of microbes that can damage the plant.

[0109] A packaging container is prepared by heat sealing and cutting a tapered pattern from two layers of 4 mil low density polyethylene film. The 26 inch long tapered container is 5 inches across at the bottom and 14 inches across at the top, as measured with the container laid out flat.

[0110] The plant is prepared by digging out the plant with an intact root ball, from the original growing site. The entrapped dirt is removed from the root ball by rinsing with water to leave the uprooted whole plant with exposed roots.

[0111] A preservative media is prepared by mixing 250 grams of sandy soil with 75 ml of water and 5 grams of ground neem leaves. 8-HQC is added to 200 parts per million. The soil can be previously sterilized, or not.

[0112] The plant is packaged into the container by placing the roots into the bottom flexible container section, followed by the preservative media. The plant is held raised somewhat off the bottom of flexible container **3** so media **2** can flow into spaces between roots **11**, as shown in Figure 5. The top of the flexible container section is constricted around the plant stem at the top of the media and held in place with an elastic band **6a**. Second band **6b** is placed 1 inch above the first band to form a redundant seal. Excess air is pressed gently out of sealable container **5** and a cannula of nitrogen gas, flowing at about 3 cubic feet per minute, is inserted into the container. The top of the container is squeezed around the cannula so the container will inflate with the gas. After the container is inflated, the gas is allowed to flow and escape for several moments to purge residual oxygen from the sealable container section. The cannula is withdrawn and the top of the container is sealed by twisting and folding the excess material before binding it with another elastic band. Multiple plants can be packaged in this way given adequate container space.

[0113] The packaged plants can be arranged in racks and/or boxes for international shipment, wholesale handling or retail display. The strawberries will remain viable for up to about 3 months before replanting.

[0114] After use, the soil media of the invention can be disposed of without harm to the environment. All the ingredients of the media are biodegradable. Media can be composted or disposed of at a waste management facility.

Dispensing Media

[0115] Dispensing of media into the containers of the invention can be practiced, e.g., by adaptation of processes and apparatus commercially available and known in the art. For example, technologies common in food processing, canning, coffee vending machines, and/or the like, can be employed to scale up and/or enhance the efficiency of media dispensing in the invention.

[0116] In one example of a media preparation and dispensing device, a container is provided with a media concentrate inlet, a water inlet, and a media dispensing outlet. The media concentrate inlet has a hopper and valve to meter a desired amount of media concentrate into the container. The water inlet has a volume metering device to add a selected volume of water into the container. The volume of water added can also be monitored by observing the liquid level relative to volume gradations marked on the container walls. The water is preheated before introduction to the container but the temperature of media in the container is adjustable by a thermostatically controlled heating element associated with the container. The container has a blender impeller driven by a shaft from an electric motor through a sealed bushing in the bottom of the container. The dispensing outlet includes a valve to introduce an antimicrobial into the media during dispensing (alternately, the antimicrobial can be added from a prealiquoted packet in the flexible container of media), a sanitary shroud, and a volumetric dispenser device. In use, a desired amount of hot water (about 90°C) is introduced into the container from the water inlet. An appropriate amount of dry powder media mix, including phytagar, kinetin, IAA, and GA3, is added from the concentrate inlet while the mixture is blended by the impeller. The thermostat holds the mixture at 90°C for several minutes until the mixture is homogenous and the phytagar is expanded to a gel. The thermostat is reset to about 45°C and the media is allowed to cool. Once the media has cooled, it can be dispensed through the dispensing outlet, along with an appropriate amount of a desired antimicrobial, into the flexible container of a plant preservation system.

[0117] It is understood that the examples and embodiments described herein are for illustrative purposes only and that various modifications or changes in light thereof will be suggested to persons skilled in the art and are to be included within the spirit and purview of this application and scope of the appended claims. All publications, patents, and patent applications cited herein are hereby incorporated by reference in their entirety for all purposes.

CLAIMS

What is claimed is:

1. A method for preserving cut flowers, the method comprising:
inserting one or more cut stems of the flowers into a preservative media;
packaging the flowers in a sealable container;
filling the sealable container with an inert gas; and,
sealing the sealable container.

2. The method of claim **1**, further comprising filling a flexible container with the preservative media by dispensing the media from a dispensing device.

3. The method of claim **1**, wherein the media is substantially sugar-free.

4. The method of claim **1**, wherein the media comprises soil.

5. The method of claim **1**, wherein the media comprises a thickener.

6. The method of claim **5**, wherein the thickener comprises a gel.

7. The method of claim **5**, wherein the thickener comprises an agar.

8. The method of claim **1**, further comprising perforating the cut stem with a series of holes.

9. The method of claim **1**, wherein the preservative media comprises an antibiotic, anti-fungal, an anti-microbial plant extract, or an anti-microbial plant composition.

10. The method of claim **9**, wherein the antibiotic comprises kanamycin or ampicillin.

11. The method of claim **9**, wherein the extract comprises neem extract or eucalyptus extract.

12. The method of claim **9**, wherein the plant composition comprises neem leaves in an amount ranging from about 0.01 weight percent to about 10 weight percent.

13. The method of claim **1**, wherein the preservative media comprises a hypochlorite, silver nitrate, or 8-hydroxyquinoline.

14. The method of claim **1**, wherein the preservative media comprises one or more plant hormones.

15. The method of claim **14**, wherein the hormone comprise kinetin, 2-iP, IAA or gibberellin.

16. The method of claim **14**, further comprising applying cytokinins or gibberellins to one or more plant aerial parts.

17. The method of claim **14**, further comprising planting the stems in soil.

18. The method of claim **1**, wherein the preservative media comprises additives selected from the group consisting of ammonium nitrate, boric acid, calcium chloride, cobalt chloride, cupric sulfate, EDTA, ferrous sulfate, magnesium sulfate, sodium molybdate, potassium iodide, potassium nitrate, potassium phosphate, zinc sulfate, myo-inositol, nicotinic acid, pyridoxine, thiamine, kinetin, auxin, IAA, and gibberellin.

19. The method of claim **1**, wherein the media ranges from about pH 3 to about pH 8.

20. The method of claim **1**, wherein the media is contained in a flexible container.

21. The method of claim **20**, further comprising substantially removing air from the flexible container.

22. The method of claim **20**, further comprising sealing an opening of the flexible container around the stems with two or more bands spaced along the stems.

23. The method of claim **22**, further comprising applying a sealant in a space between the bands.

24. The method of claim **1**, wherein the sealable container comprises a plastic with a thickness of 2 mil, or more.

25. The method of claim **1**, wherein the sealable container comprises a textured surface.

26. The method of claim **1**, wherein the sealable container is a sleeve comprising plastic film.

27. The method of claim **1**, wherein filling the sealable container comprises introducing liquid nitrogen, liquid helium, or liquid argon into the sealable container.

28. The method of claim **1**, wherein filling the sealable container comprises purging air from the sealable container with a gaseous stream of nitrogen, helium, or argon.

29. The method of claim **1**, further comprising packaging the sealable container in an outer container and filling the outer container with an inert gas.

30. A method for preserving cut flowers, the method comprising:

filling a flexible container with a substantially sugar-free preservative media;

inserting one or more cut stems of the flowers into the preservative media; and,

sealing an opening of the flexible container around the stems with two or more bands spaced along the stems.

31. The method of claim **30**, wherein the filling comprises dispensing the media from a dispensing device.

32. The method of claim **30**, wherein the media comprises soil.

33. The method of claim **30**, wherein the media comprises a thickener.

34. The method of claim **33**, wherein the thickener comprises an agar based gel.

35. The method of claim **30**, further comprising perforating the cut stem with a series of holes.

36. The method of claim **30**, wherein the preservative media comprises an antibiotic, antiseptic, anti-fungal, an anti-microbial plant composition, or an anti-microbial plant extract.

37. The method of claim **36**, wherein the antibiotic comprises kanamycin or ampicillin.

38. The method of claim **36**, wherein the extract comprises neem extract or eucalyptus extract.

39. The method of claim **36**, wherein the anti-microbial plant composition comprises neem in an amount ranging from about 0.01 weight percent to about 10 weight percent.

40. The method of claim **30**, wherein the preservative media comprises a hypochlorite, silver nitrate, or 8-hydroxyquinoline.

41. The method of claim **30**, wherein the preservative media comprises one or more plant hormones.

42. The method of claim **41**, wherein the hormone comprise kinetin, 2-iP, IAA or gibberellin.

43. The method of claim **41**, further comprising applying cytokinins or gibberellins to one or more plant aerial parts.

44. The method of claim **41**, further comprising planting the stems in soil.

45. The method of claim **30**, wherein the preservative media comprises additives selected from the group consisting of ammonium nitrate, boric acid, calcium chloride, cobalt chloride, cupric sulfate, EDTA, ferrous sulfate, magnesium sulfate, sodium molybdate, potassium iodide, potassium nitrate, potassium phosphate, zinc sulfate, myo-inositol, nicotinic acid, pyridoxine, thiamine, kinetin, auxin, IAA, and gibberellin.

46. The method of claim **30**, wherein the media ranges from about pH 3 to about pH 8.

47. The method of claim **30**, further comprising substantially removing air from the flexible container.

48. The method of claim **30**, further comprising applying a sealant in a space between the bands.

49. The method of claim **30**, wherein further comprising packaging the flowers in a sealable container comprising one or more perforations.

50. The method of claim **49**, wherein the sealable container comprises a plastic material with a thickness of 2 mil, or more.

51. The method of claim **49**, wherein the sealable container comprises a textured surface.

52. A method for preserving plants, the method comprising:

filling a flexible container with a substantially sugar-free preservative media;

inserting roots of one or more plants into the preservative media;

sealing an opening of the flexible container around one or more stems of the plants with two or more bands spaced along the stems; and,

packaging one or more upper parts of the plants in a sealable container.

53. The method of claim **52**, wherein the filling comprises dispensing the media from a dispensing device.

54. The method of claim **52**, wherein the plant is a fruit plant or a vegetable plant.

55. The method of claim **52**, wherein the media comprises soil.

56. The method of claim **52**, wherein the media comprises a thickener.

57. The method of claim **56**, wherein the thickener comprises a gel.

58. The method of claim **56**, wherein the thickener comprises an agar.

59. The method of claim **52**, wherein the preservative media comprises an antibiotic, anti-fungal, an anti-microbial plant composition, or an anti-microbial plant extract.

60. The method of claim **59**, wherein the antibiotic comprises kanamycin or ampicillin.

61. The method of claim **59**, wherein the extract comprises neem extract or eucalyptus extract.

62. The method of claim **59**, wherein the anti-microbial plant composition comprises neem in an amount ranging from about 0.01 weight percent to about 10 weight percent.

63. The method of claim **52**, wherein the preservative media comprises a hypochlorite, silver nitrate, or 8-hydroxyquinoline.

64. The method of claim **52**, wherein the preservative media comprises one or more plant hormones.

65. The method of claim **64**, wherein the hormone comprise kinetin, 2-iP, IAA or gibberellin.

66. The method of claim **64**, further comprising applying cytokinins or gibberellins to one or more plant aerial parts.

67. The method of claim **52**, wherein the preservative media comprises additives selected from the group consisting of ammonium nitrate, boric acid, calcium chloride, cobalt chloride, cupric sulfate, EDTA, ferrous sulfate, magnesium sulfate, sodium molybdate, potassium iodide, potassium nitrate, potassium phosphate, zinc sulfate, myo-inositol, nicotinic acid, pyridoxine, thiamine, kinetin, auxin, IAA, and gibberellin.

68. The method of claim **52**, further comprising applying a sealant in a space between the bands.

69. The method of claim **52**, wherein the sealable container comprises plastic material with a thickness of 2 mil, or more.

70. The method of claim **52**, wherein the sealable container comprises one or more perforations.

71. The method of claim **52**, wherein the sealable container comprises a textured surface.

72. The method of claim **52**, further comprising filling the sealable container with an inert gas.

73. The method of claim **52**, further comprising packaging the sealable container in an outer container and filling the outer container with an inert gas.

74. A device for preserving plants, the device comprising:

a flexible container comprising an opening and filled with a preservative media;

a sealable container defining a space between the flexible container opening and external air; and,

one or more inert gases substantially filling the space within the sealable container;

whereby roots or cut stem ends of one or more plants, can be inserted into the media, and upper plant parts can be preserved within the space of the sealable container.

75. The device of claim **74**, wherein the media is substantially sugar-free.

76. The device of claim **74**, wherein the media comprises soil.

77. The device of claim **74**, wherein the media comprises one or more thickener.

78. The device of claim **77**, wherein the thickener comprises an agar based gel.

79. The device of claim **74**, wherein the media comprises one or more antibiotics.

80. The device of claim **74**, wherein the media comprises one or more anti-microbial plant extracts or an anti-microbial plant composition.

81. The device of claim **80**, wherein the plant composition comprises neem in an amount ranging from about 0.01 weight percent to about 10 weight percent.

82. The device of claim **74**, further comprising two or more bands around the opening of the flexible container, whereby the opening is urged to close.

83. The device of claim **82**, wherein the bands comprise elastic bands.

84. The device of claim **82**, wherein the bands are spaced 0.5 inches apart, or more.

85. The device of claim **84**, wherein an surface interface of the media is located above a lower band.

86. The device of claim **82**, further comprising a sealant in a space between the bands.

87. The device of claim **74**, wherein the sealable container comprises plastic with a thickness of about 2 mil, or more.

88. The device of claim **74**, wherein the sealable container comprises a textured surface.

89. The device of claim **74**, wherein the sealable container is a sleeve comprising plastic film.

90. The device of claim **74**, wherein the inert gas comprises nitrogen, helium or argon.

91. A preservation media for cut flowers, the media comprising:
about 0.1 weight percent to about 1 weight percent agar;
indole-3-acteic acid;
one or more salts; and,
one or more anti-microbial.

92. The media of claim **91**, wherein the agar is present in an amount of about 0.5 weight percent.

93. The media of claim **91**, wherein the media is substantially sugar-free.

94. The media of claim **91**, wherein the indole-3-acteic acid is present in an amount ranging from about 1.5 mg/L to about 20 mg/L.

95. The media of claim **91**, further comprising kinetin or gibberellin,

96. The media of claim **95**, wherein the kinetin is present in an amount ranging from about 3.5 mg/L to about 15 mg/L.

97. The media of claim **95**, wherein the gibberellin is present in an amount ranging from about 0.3 mg/L to about 5 mg/L.

98. The media of claim **91**, wherein the salts are members of the group consisting of ammonium nitrate, boric acid, calcium chloride, cobalt chloride, cupric sulfate, EDTA, ferrous sulfate, magnesium sulfate, sodium molybdate, potassium iodide, potassium nitrate, potassium phosphate, and zinc sulfate.

99. The media of claim **91**, wherein the anti-microbial comprises kanamycin monosulfate present in an amount ranging from about 50 mg/L to about 200 mg/L.

100. The media of claim **91**, wherein the anti-microbial comprises a plant extract or a plant composition.

101. The media of claim **100**, wherein the plant composition comprises neem in an amount ranging from about 0.01 weight percent to about 10 weight percent.

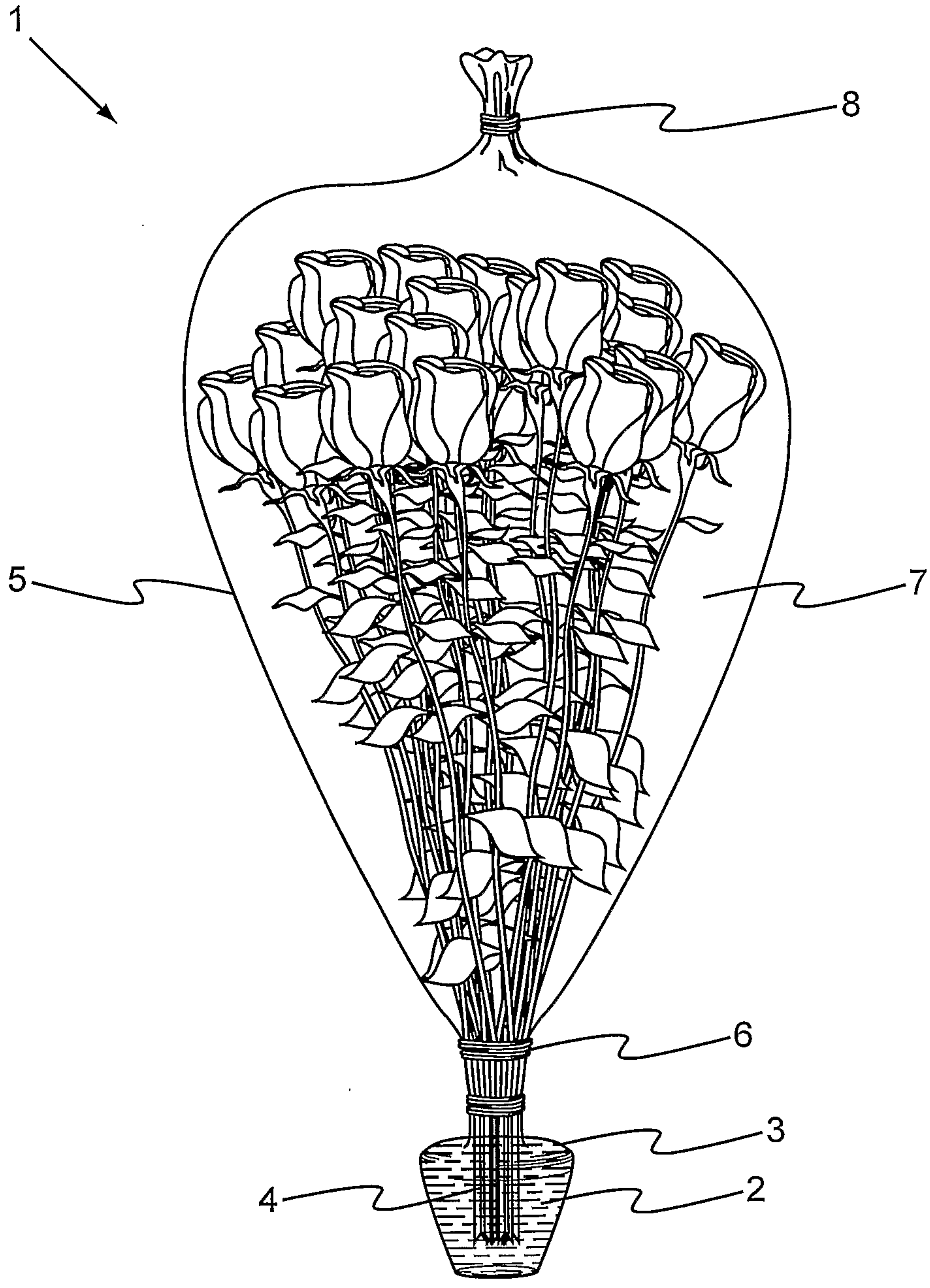

Fig. 1

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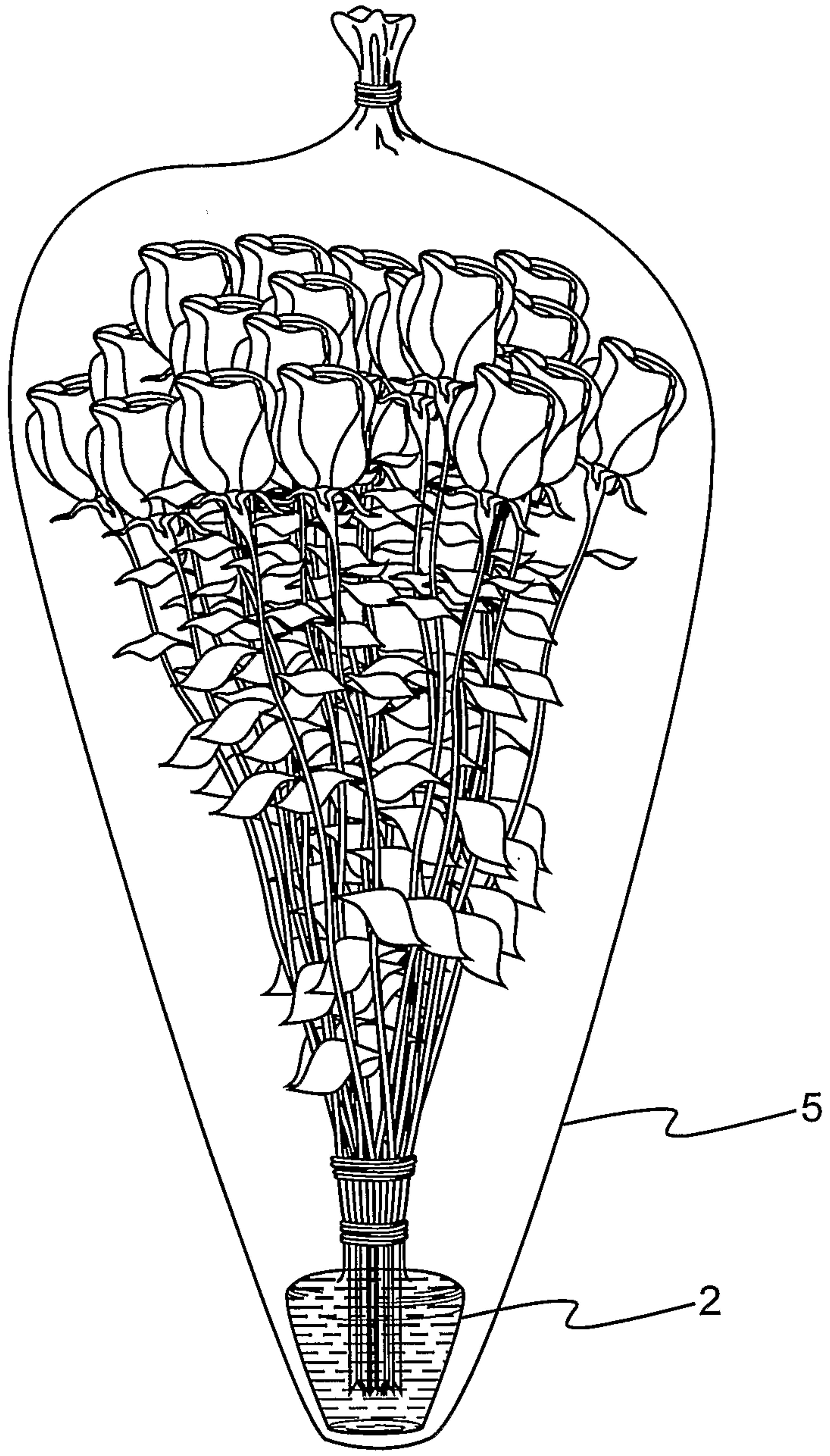
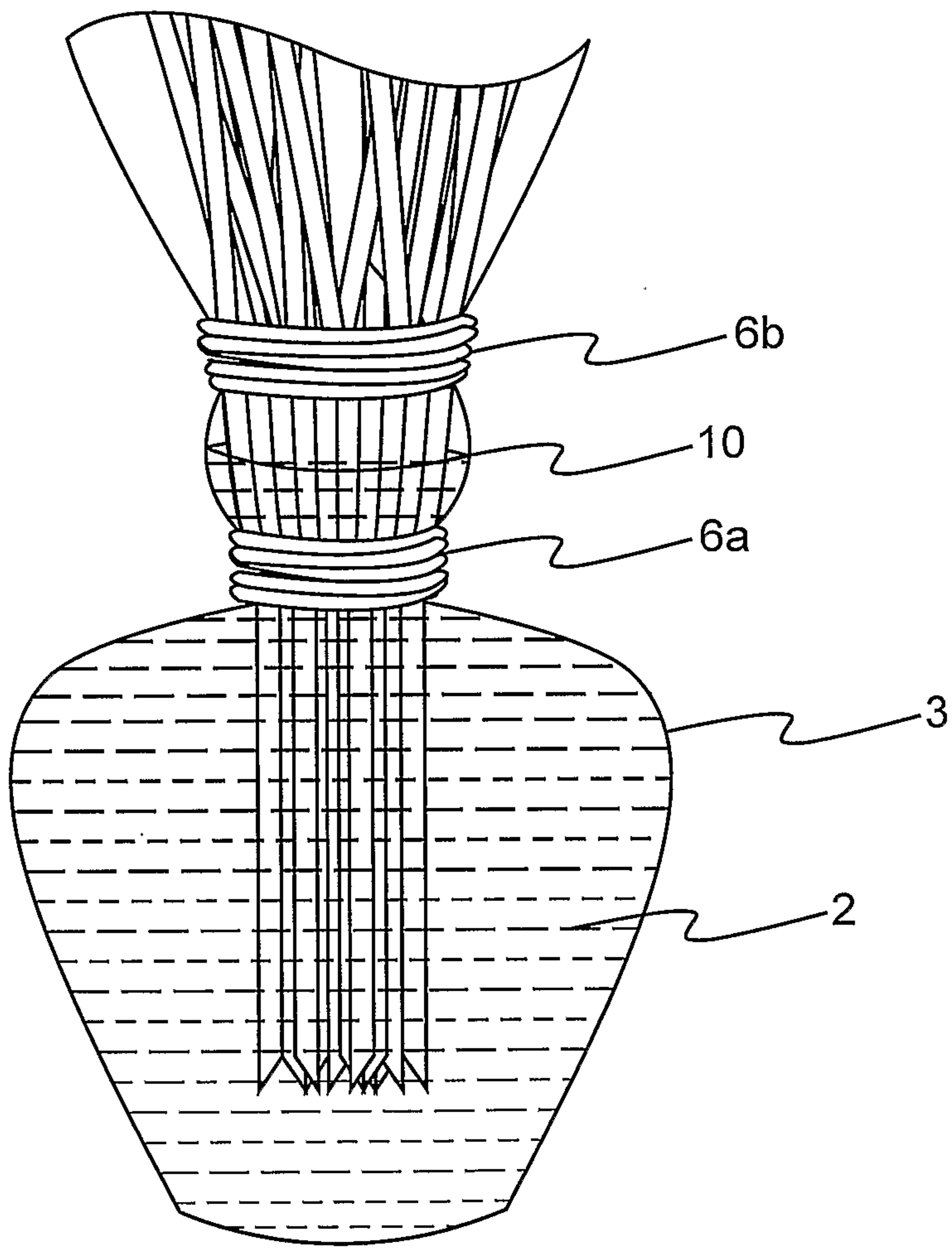


Fig. 2



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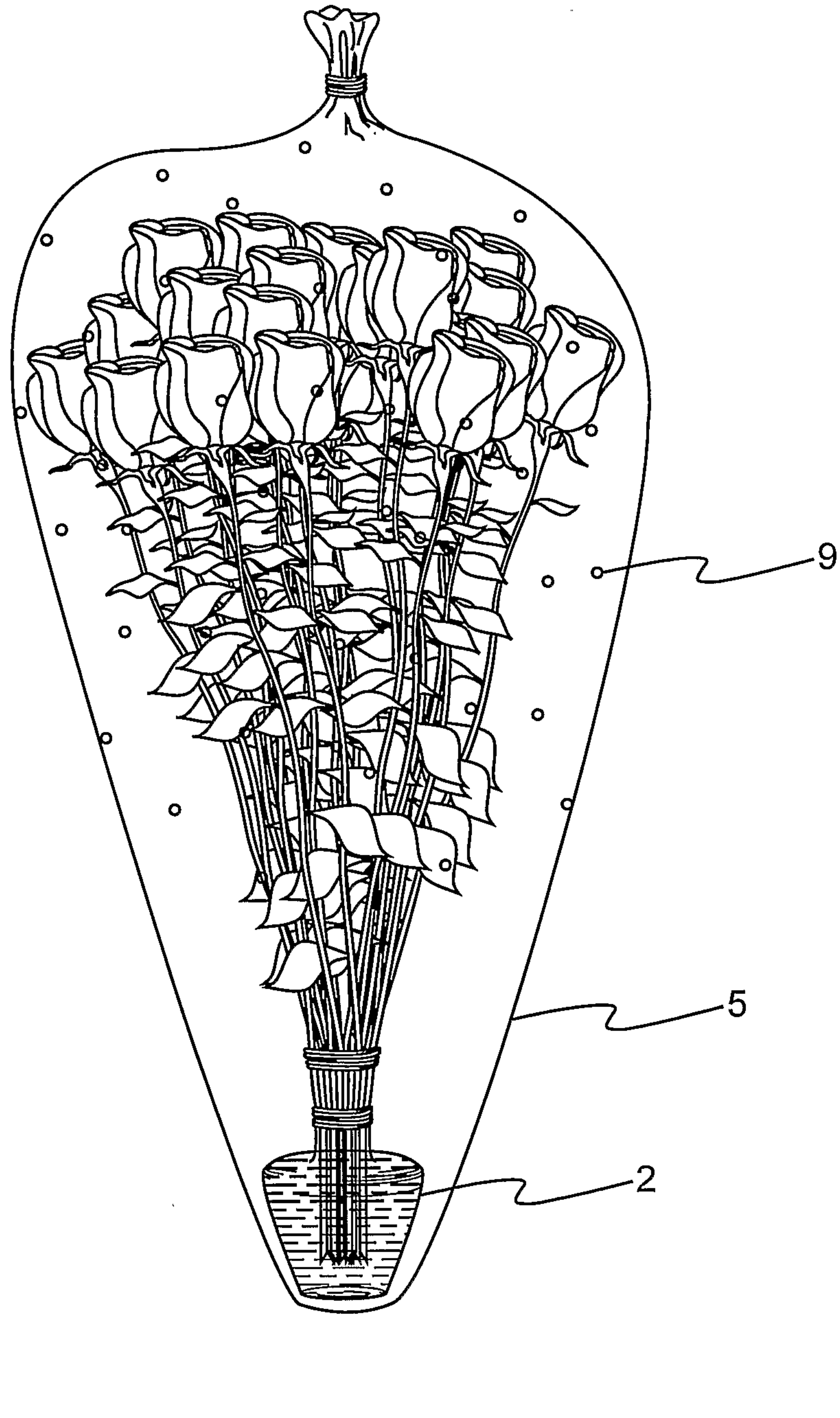

Fig. 4

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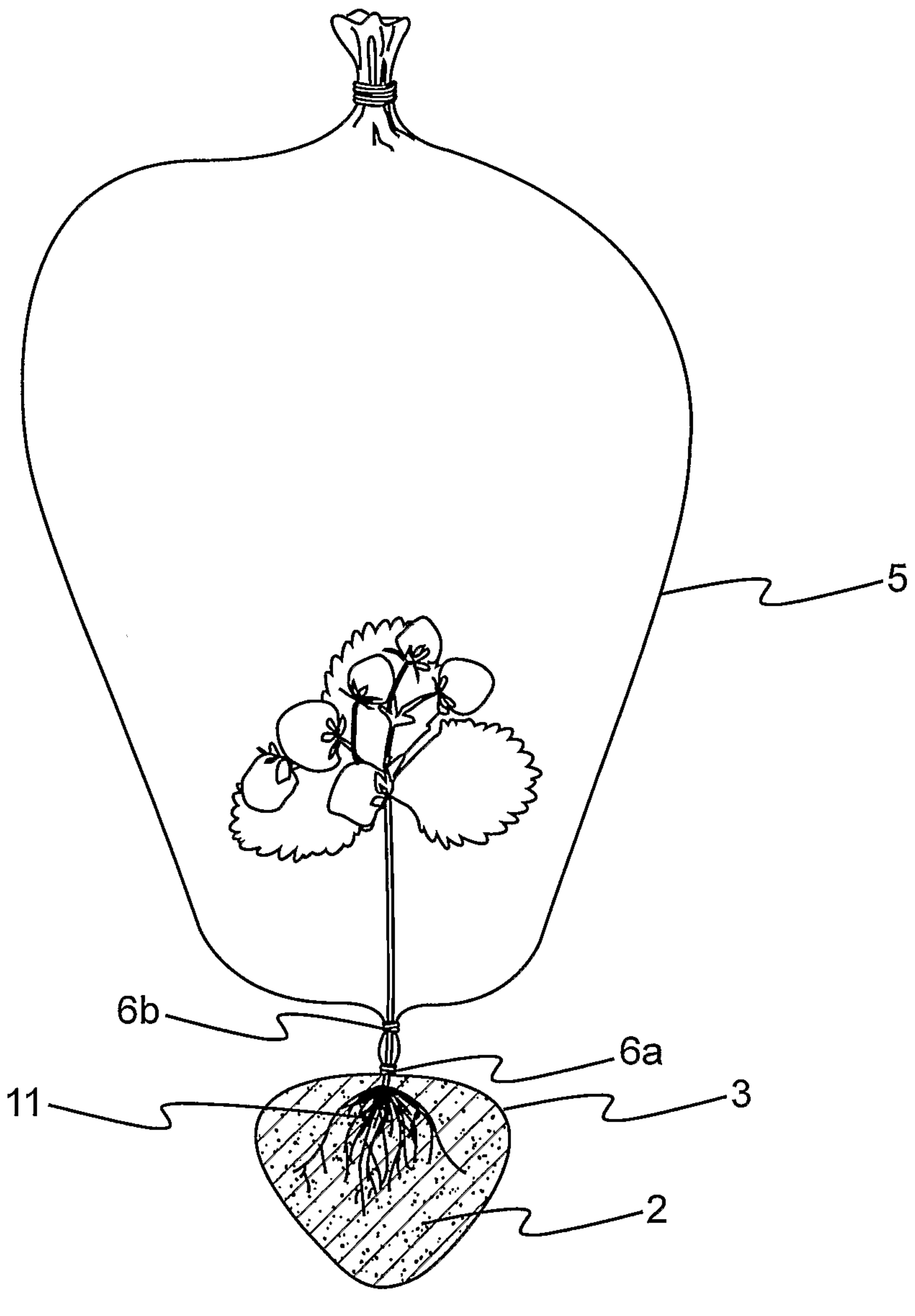
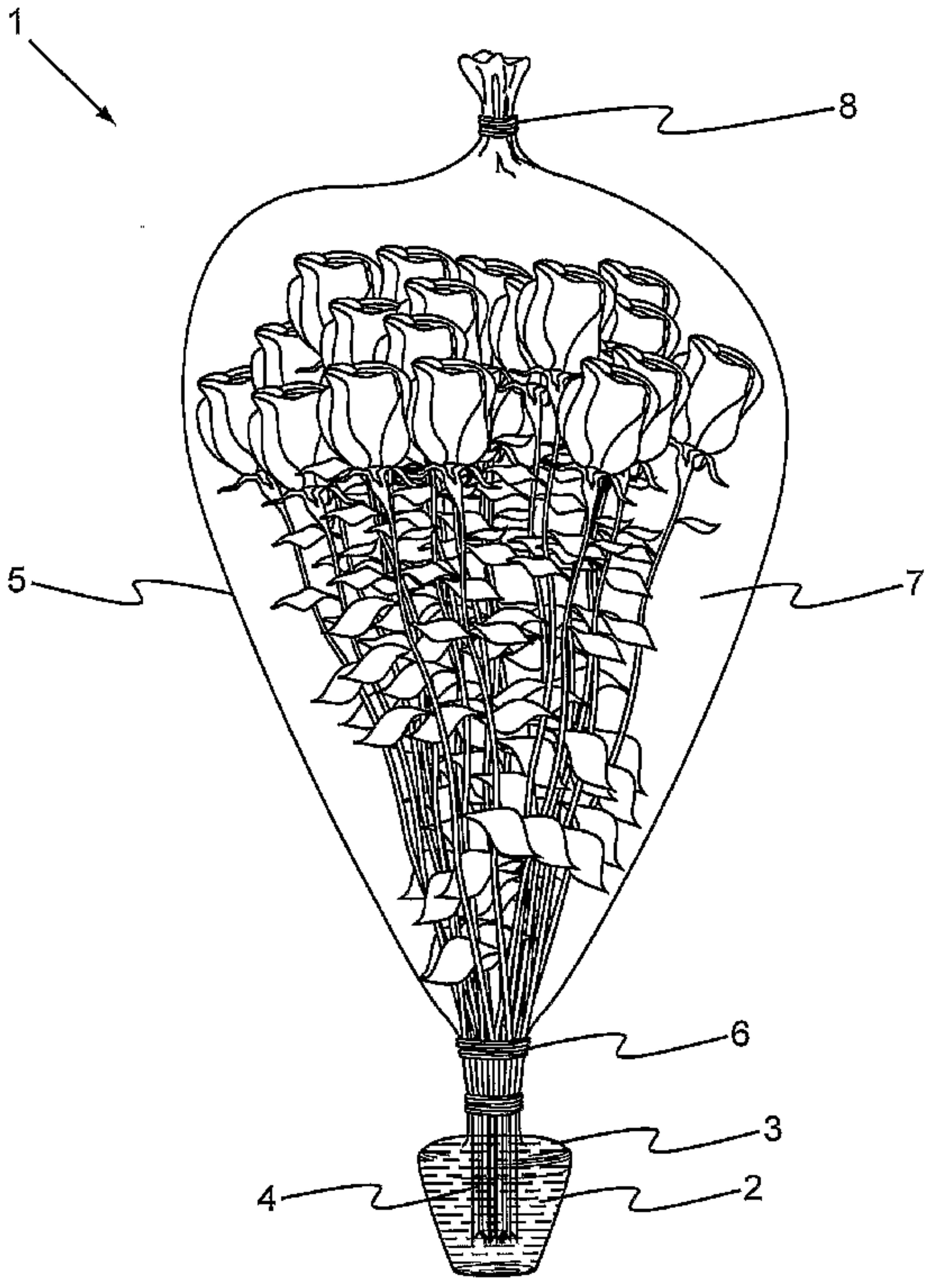


Fig. 5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