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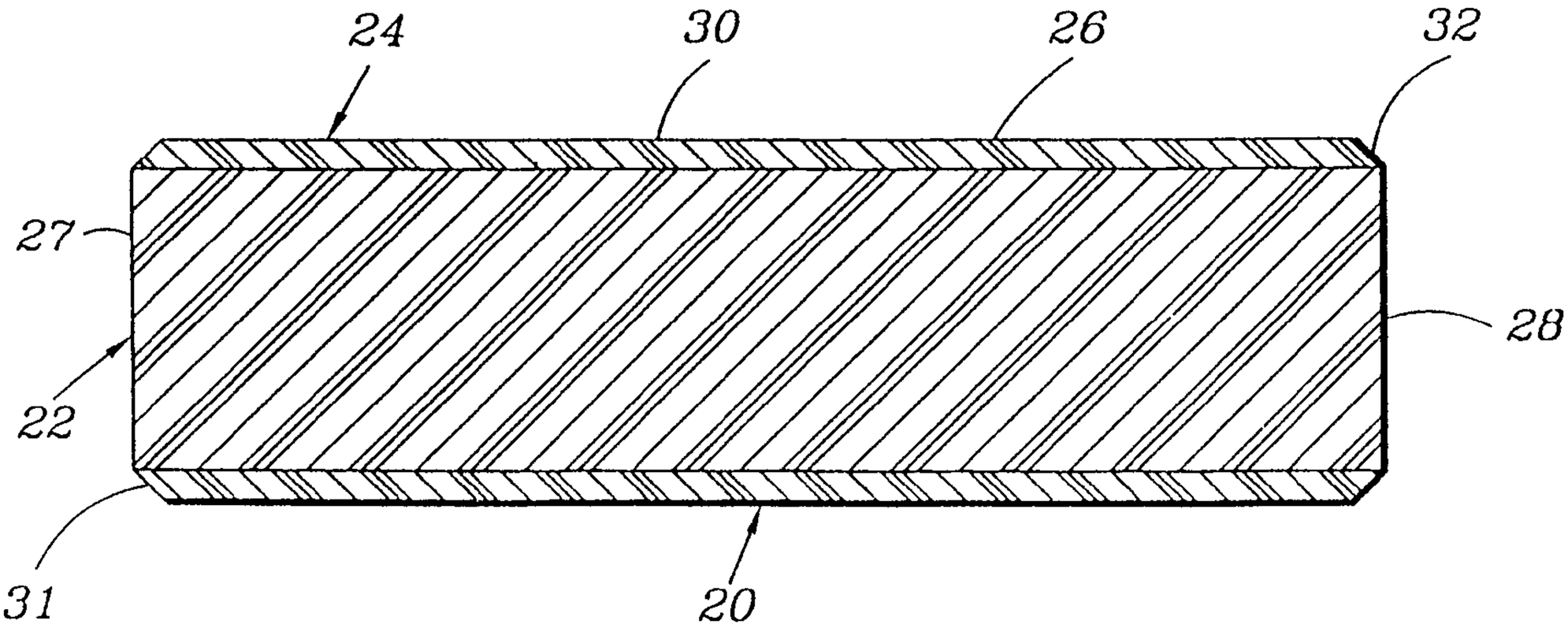

(57) Abrégé/Abstract:
By achieving an extruded, foamed core (22) formed from plastic material peripherally surrounded and integrally bonded with a cooperating synthetic, plastic, extruded, outer layer (24), a unique, multi-component, multi-layer synthetic closure (20) is provided which may be employed as a bottle closure or stopper for any desired product, whether the product is a liquid, a viscous material, or a solid distributed in a bottle or container and dispensed through the open portal of the container neck. The present invention achieves a mass producible, resilient, synthetic bottle closure (20) which is employable for any desired bottle, including wine. By employing the present invention, a multi-component or multi-layer synthetic closure (20) is attained which possesses physical properties substantially equal to or better than the physical properties found in cork material, which has caused such cork material to be the principal closure material for wine bottles.

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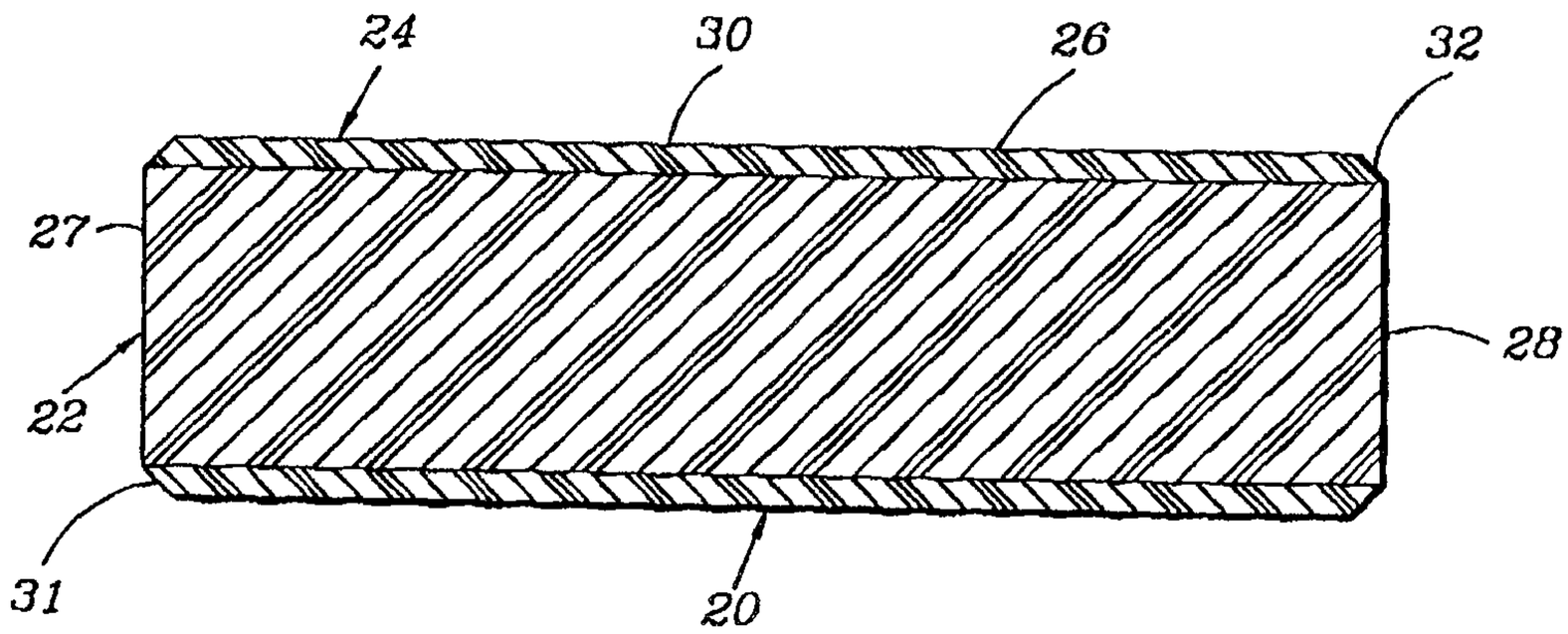


(57) Abstract

By achieving an extruded, foamed core (22) formed from plastic material peripherally surrounded and integrally bonded with a cooperating synthetic, plastic, extruded, outer layer (24), a unique, multi–component, multi–layer synthetic closure (20) is provided which may be employed as a bottle closure or stopper for any desired product, whether the product is a liquid, a viscous material, or a solid distributed in a bottle or container and dispensed through the open portal of the container neck. The present invention achieves a mass producible, resilient, synthetic bottle closure (20) which is employable for any desired bottle, including wine. By employing the present invention, a multi–component or multi–layer synthetic closure (20) is attained which possesses physical properties substantially equal to or better than the physical properties found in cork material, which has caused such cork material to be the principal closure material for wine bottles.

SYNTHETIC CLOSURE

TECHNICAL FIELD

This invention relates to closures or stoppers for containers containing liquids, low viscosity substrates, and small solids, and more particularly, to closures or stoppers formed from synthetic materials and employable as a bottle stopper for a container.

BACKGROUND ART

In view of the wide variety of products that are sold for being dispensed from containers, particularly containers with round necks which define the dispensing portal, numerous constructions have evolved for container stoppers or closure means for the portals. Generally, products such as vinegar, vegetable oils, laboratory liquids, detergents, honey, condiments, spices, alcoholic beverages, and the like, impose similar requirements on the type and construction of the closure means used for containers for these products. However, wine sold in bottles represents the most demanding product for bottle closure means, due to the numerous and burdensome requirements placed upon the closure means used for wine bottles. In view of these demands, most wine bottle closures or stoppers have been produced from a natural material known as "cork".

Although synthetic materials have been proposed for use as wine bottle stoppers or closures, such products have been unable to satisfy all of the stringent requirements. As a result, cork has remained the dominant material for wine closures, in spite of the numerous inherent problems that exist with cork.

Cork represents the bark of a particular variety of cork oak, quercus suber, a tree of the oak family characteristic of western Mediterranean countries, such as Portugal, Spain, Algeria, Morocco, France, Italy, and Tunisia, that has the ability to renew its bark indefinitely. Cork is a vegetable plant comprising tissue made up of dead microcells, generally 14-sided polyhedrons, slotting in one against the other, with the intercell space filled with a gaseous mixture, essentially atmospheric air but without the carbon dioxide. It is estimated that 1 cm^3 of cork numbers 15 to 40 million hexagonal cells with the thickness of the cellular membranes varying between 1 and 2.5 microns.

The suberose texture is not arranged in a uniform fashion. It is crisscrossed within its thickness by pores or ducts with walls more or less lignified, forming the lenticels. These are filled with powder of a reddish-brown color, rich in tannin.

The lenticels are permeable to gases and liquids and they are often invaded by molds and other microorganisms.

The unevenness, both in membrane thickness and in the height and diameter of the cell forming the suberose parenchyma, can affect some of the cork's mechanical and physical properties, namely its compressibility and elasticity. The cork oak being able to keep its physiological process active at all times, the difference in cell size and the thickness of the cellular membrane between cork produced in spring and the succeeding autumn leave discernible rings showing the extent of each year's growth.

The contents of newly formed cells disappear during growth and the subsequent process of suberization of the membranes, on completion of which all communication with the plant's living tissues ceases. The uniqueness of quercus suber is the achieved thickness of cork bark, up to several centimeters, which insulates the tree from heat and loss of moisture and protects it from damage by animals.

In order to harvest the thick cork bark for the first time, the growth cycle takes between 20 and 30 years, depending on location, weather conditions etc. yielding the so-called virgin cork. Afterwards, some 10 years are needed between each harvest of cork boards or reproduction cork in order to gain the necessary length for some corks. Due to this process, the cork used for the manufacture of bottle closures is a reproduction of cork that is formed again after several barking phases.

The properties of cork derive naturally from the structure and chemical composition of the membranes. Because 89.7% of the tissue consists of gaseous matter, the density of cork is extremely low, about 120 to 200 kg/m^3, which makes the cork light and a good insulator. Density differences can be explained by the humidity differences, the age and quality of the cork bark and the cork tree and its growth differences. The cellular membranes are very flexible, rendering the cork both compressible and elastic. Elasticity enables it to rapidly recover to its original dimensions after any deformation. Its chemical composition gives the cork the

property of repelling moisture. The walls of the cells are crusted with suberin, a complex mixture of fatty acids and heavy organic alcohols.

The value of cork is further increased by its low conductivity of heat, sound and vibration due to the gaseous elements sealed in tiny, impervious compartments. Cork is also remarkably resistant to wear and has a high friction coefficient, thanks to the honeycomb structure of the suberose surface. Cork does not absorb dust and consequently does not cause allergies nor pose a risk to asthma sufferers. It is fire resistant, recyclable, environmentally friendly and a renewable product.

These advantages have made natural cork the preferred bottle closure for wine storage, particularly for medium and high quality wines where tradition, the wine mystique and the bottle opening ritual with a corkscrew, are a very important, though intangible, aspect of the wine consumption. However, numerous disadvantages of natural cork also exists and derive naturally from the structure and chemical composition of the membranes.

Because cork is a natural product, it is a limited resource. Its limitations become even more obvious with the following facts: the natural growing of cork is geographically limited to the western Mediterranean countries; the world wide annual harvest of cork oak bark is 500,000 tons and can barely be increased, because of climatic and ecological reasons; and ten-year cycles are needed between each harvest of cork boards. In order to meet the rising worldwide cork demand, the pare cycles of cork have been shortened, leading to inferior qualities and constantly rising raw material prices.

The irregularities of the cork's structure due to geographic, climatic and ecological reasons causes many quality variances. This creates a complex categorization of qualities and standards. Through different types of washing processes, various chemical agents are combined in order to decontaminate the cork and to treat the appearance of the cork. High quality corks do not need washing. The cork quality is graded, based on the number of lenticels, horizontal and vertical cracks, their sizes, and other cork specific characteristics. The grading process is a

subjective task based on statistically significant populations which is difficult to perform due to its natural origin, since every cork looks, feels, functions and smells different.

Wine market experts estimate that 1% to 5% of all bottled wine is spoiled by cork taint. At least six chemical compounds have been associated with cork taint in wines. Most frequently, 2,4,6-trichloranisole (TCA) is the major culprit responsible for the offensive off-odor and impact on the flavor of the wine. TCA has an extremely low threshold for odor detection. It is detectable at concentrations as low as 1 ppt or 1.0 nanogram per liter.

In most cases, cork taint does not involve the wine-making process. Typically, the tainting chemical is not found in vineyards or in parts of the winery where the wine is produced. After the wine is bottled, the defect shows itself, thus spoiling the wine. It is almost exclusively associated with corks.

Also, there is evidence that once the corks have been treated with chlorine, and are brought into interaction with mold fungus through humidity, chloranisole is created. Other types of wine spoilage are caused by oxidation, hydrogen sulfide, volatile acidity, sulfur dioxide, brettanomyces, and mercaptans.

Another problem commonly found with natural cork is leaking bottles. Typically, the lack of tightness between the cork and the neck of the bottle causes 10% to 20% of bottle leakage. However, the majority of wine leakage is caused by passage of the wine through the cork body. These problems are most often found with lower quality cork material, which is typically porous, too soft, out of round, or out of the predetermined specifications.

In view of the fact that wine spoilage is caused by oxidation of the wine, any gas exchange between ambient conditions and the interior of the wine bottle must be avoided. However, many corks are deformed by the chops or jaws of the bottle corking equipment, which enables air exchange and oxidation to occur. Furthermore, when bottles are stored in an environment where ideal humidity is not maintained, optimum functionality of the cork is not achieved and the cork loses its

efficiency as a sealing medium by drying out, becoming brittle and/or losing its mechanical properties. These problems often cause the cork to break when pulled out of the bottle or enable wine spoilage to occur. In addition, natural cork absorbs liquids, depending on its structure and quality. This also results in breakage, while the cork is pulled out of the bottle.

Further problems or deficiencies found with natural cork is the propensity of cork worms to store or lay their eggs on the cork material, enabling the larvae to dig gullies into the cork. Consequently, enlarged apertures or channels are formed in the cork, unknown to the bottler, producing unwanted contamination. In addition to these drawbacks, cork powder and other cork impurities are often able to fall into the wine during the corking process, causing further problems for wine bottlers and unwanted surprises for the wine consumer.

In order to avoid some of the difficulties, bottlers have developed various coatings, such as paraffins, silicones and polymer materials, in an attempt to ease the movement of the cork into and out of the bottle, as well as to improve the permeability of the cork and fill imperfections in the cork surface. However, no ideal cork coating product has been developed to protect a wine corking member from all of the inherent difficulties or drawbacks of the material.

The vast majority of wine-containing bottles are currently being sold with natural cork stoppers. However, due to the inherent problems existing with natural cork, various other products have been developed to close liquid bearing containers, such as wine bottles. These other closures principally comprise structural synthetic plastics, crown cap metal stoppers, aluminum caps, plastic caps and combinations thereof.

In spite of these prior art efforts, a universally applicable closure has not been developed which satisfies all bottlers and consumer requirements. Particularly, the substantially burdensome requirements imposed upon closure means used in the wine industry have generally been employed as the standard that must be attained by a bottle closure that will be accepted by the industry. As a result of these stringent

requirements, these prior art products have been incapable of satisfying the requisite needs of the industry.

In particular, one of the principal difficulties to which any bottle closure is subjected in the wine industry is the manner in which the closure is inserted into the bottle. Typically, the closure is placed in a jaw clamping member positioned above the bottle portal. The clamping member incorporates a plurality of separate and independent jaw members which peripherally surround the closure member and are movable relative to each other to compress the closure member to a diameter substantially less than its original diameter. Once the closure member has been fully compressed, a plunger moves the closure means from the jaws directly into the neck of the bottle, where the closure member is capable of expanding into engagement with the interior diameter of the bottle neck and portal, thereby sealing the bottle and the contents thereof.

In view of the fact that the jaw members must be independent of each other and separately movable in order to enable the closure member to be compressed to the substantially reduced diameter, each jaw member comprises a sharp edge which is brought into direct engagement with the closure member when the closure member is fully compressed. Depending upon the composition of the closure member, score lines are frequently formed on the outer surface of the closure member, which prevents a complete, leak-free seal from being created when the closure member expands into engagement with the bottle neck.

As a result of this sealing system, closure members other than cork have not been accepted by the wine industry, due to their inability to withstand this conventional bottling and sealing method. Furthermore, many cork sealing members also incur damage during the bottling process, resulting in leakage or tainted wine.

Another problem inherent in the wine industry is the requirement that the wine stopper must be capable of withstanding a substantial pressure build up that occurs during the storage of the wine product after it has been bottled and sealed. Due to natural expansion of the wine during hotter months, pressure builds up,

imposing a burden upon the bottle stopper that must be resisted without allowing the stopper to be displaced from the bottle. As a result, the bottle stopper employed for wine products must be capable of secure, intimate, frictional engagement with the bottle neck in order to resist any such pressure build up.

A further problem inherent in the wine industry is the requirement that secure, sealed engagement of the stopper with the neck of the bottle must be achieved virtually immediately after the stopper is inserted into the neck of the bottle. During normal wine processing, the stopper is compressed, as detailed above, and inserted into the neck of the bottle to enable the stopper to expand in place and seal the bottle. However, such expansion must occur immediately upon insertion into the bottle since many processors tip the bottle onto its side or neck down after the stopper is inserted into the bottle neck, allowing the bottle to remain stored in this position for extended periods of time. If the stopper is unable to rapidly expand into secure, intimate, frictional contact and engagement with the walls of the neck of the bottle, wine leakage will occur.

Therefore, it is a principal object of the present invention to provide closure means for containers which is manufacturable from synthetic materials and effectively closes and seals any desired bottle, container, package and the like.

Another object of the present invention is to provide a synthetic closure having the characteristic features described above which is manufacturable on a continuing production basis, thus providing lower manufacturing costs compared to natural or synthetic (structured) closures and satisfying industry requirements for a removable bottle stopper which is producible substantially more economically than cork closure/stoppers.

Another object of the present invention is to provide a synthetic closure having the characteristic features described above which meets or exceeds all of the requisite physical characteristics found in natural closures or stoppers such as cork.

A further object of the present invention is to provide a synthetic closure or stopper having the characteristic features described above which is capable of

simulating all of the visually aesthetic and tactile characteristics found in natural stoppers, such as cork, so as to be effectively a substitute for cork stoppers or closures for the wine industry, particularly its ends users in both appearance and feel.

Another object of the present invention is to provide a synthetic closure or stopper having the characteristic features described above which is capable of being employed in conventional bottling equipment for being inserted into a bottle container without experiencing any unwanted physical damage.

Another object of the present invention is to provide a synthetic closure or stopper having the characteristic features described above that can be substituted for a cork stopper in wine bottles, providing all of the desirable characteristics of conventional cork stoppers while also being removable from the bottle in the conventional manner without breaking.

Another object of the present invention is to provide a synthetic closure or stopper having the characteristic features described above, which is physiologically neutral, capable of being sterilized, as well as capable of being formed to visually simulate any desired classification of natural cork.

A further object of the present invention is to provide a synthetic closure or stopper having the characteristic features described above which is odorless, remains odorless in position, is tasteless, and only absorbs limited amounts of water.

Another object of the present invention is to provide a synthetic closure or stopper having the characteristic features described above which is unaffected by diluted acids and bases as well as unaffected by most oils.

Another object of the present invention is to provide a synthetic closure or stopper having the characteristic features described above which does not shrink, does not age, does not absorb mold or fungus, and resists damage from insects.

Another object of the present invention is to provide a synthetic closure or stopper having the characteristic features described above which can be mass

produced on a continuing basis and eliminates any spoilage of wine due to cork taint.

Other and more specific objects will in part be obvious and will in part appear hereinafter.

SUMMARY OF THE INVENTION

By employing the present invention, all of the difficulties and drawbacks found in the prior art have been completely overcome and a mass producible, resilient, synthetic bottle closure is realized by achieving a synthetic, extruded, foamed polymer core peripherally surrounded and integrally bonded with a cooperating synthetic, extruded, outer layer. The present invention can be employed on any desired product, whether the product is a liquid, a viscous material, or a solid distributed in a bottle or container and dispensed through the open portal of the container neck.

As will become evident from the following detailed disclosure, the multi-component, multi-layer synthetic closure of the present invention may be employed as a bottle closure or stopper for any desired product. However, for the reasons detailed above, wine products impose the most burdensome standards and requirements on a bottle closure. Consequently, in order to clearly demonstrate the universal applicability of the multi-component/multi-layer synthetic closure of the present invention, the following disclosure focuses on the applicability and usability of the multi-component/multi-layer synthetic closure of the present invention as a closure or stopper for wine containing bottles. However, this discussion is for exemplary purposes only and is not intended as a limitation of the present invention.

As discussed above, a bottle closure or stopper for wine must be capable of withstanding the pressure build up due to temperature variations during storage, as well as preventing any seepage or leakage of the wine from the bottle. Furthermore, a tight seal must also be established to prevent unwanted gas exchange between ambient conditions and the bottle interior, so as to prevent any unwanted oxidation or permeation of gases from the wine to the atmosphere. In addition, the unique corking procedures employed in the wine industry also impart substantial restrictions on the bottle closure, requiring a bottle closure which is highly com-

pressible, has high immediate compression recovery capabilities and can resist any deleterious effects caused by the clamping jaws of the bottle closure equipment.

Although prior art synthetic products have been produced in an attempt to satisfy the need for alternate bottle closures employable in the wine industry, such prior art systems have been incapable of meeting all of the stringent requirements and demands imposed upon a bottle closure for wine products. However, by employing the present invention, all of the prior art inabilities have been obviated and an effective, easily employed, mass-produced synthetic closure has been realized.

The present invention overcomes all of the prior art problems by achieving a multi-component or multi-layer synthetic closure which possesses physical properties substantially equal to or better than the physical properties found in cork material, which has caused such cork material to be the principal closure material for wine bottles. In the present invention, the prior art failings have been overcome by achieving a multi-component or multi-layer synthetic bottle closure which incorporates a central core member peripherally surrounded by and integrally bonded to an outer peripheral layer imparting additional, desirable physical characteristics to the effective outer surface of the synthetic bottle closure. By employing multi-components or multi-layers to form the synthetic bottle closure of the present invention, all of the prior art difficulties and drawbacks have been eliminated and an effective, multi-purpose, easily employed and economically mass produced synthetic closure is realized.

The multi-component/multi-layer synthetic bottle closure of the present invention comprises, as its principal component, the core member which is formed from extruded, foamed, plastic polymers, copolymers, or homopolymers. Although any known foamable plastic material can be employed in the extrusion process for developing the bottle closure of the present invention, the plastic material must be selected for producing physical properties similar to natural cork, so as to be

capable of providing a synthetic closure for replacing natural cork as a closure for wine bottles.

By employing the present invention, a synthetic bottle closure is produced in a highly automated, high-tech extrusion or molding process with product tolerances being closely maintained. As a result, various prior art difficulties encountered with cork products being out of round or having improper diameters are completely eliminated.

In addition, the multi-component/multi-layer synthetic bottle closure of the present invention is manufacturable in any desired color or with any desired markings or indicia placed on the outer surface thereof. Consequently, if desired, the synthetic bottle closure of the present invention may be manufactured with a visual appearance substantially identical to the visual appearance of a cork stopper. In addition to the natural, wood-grain cork appearance, the synthetic closure of the present invention may also be produced with any desired indicia, colors, stripes, logos, etc. formed on the surfaces thereof. These desired indicia can be formed on either the side or ends of the synthetic closure of the present invention using conventional printing techniques, embossing techniques, laser printing, laser etching, etc. as known in the printing industry.

Depending upon the sealing process employed for inserting the synthetic closure of the present invention in a desired bottle, additives, such as slip additives, may be incorporated into the outer, peripherally surrounding layer of the synthetic closure of the present invention to provide lubrication of the synthetic closure during the insertion process. In addition, other additives typically employed in the bottling industry may also be incorporated into the synthetic closure of the present invention for improving the sealing engagement of the synthetic closure with the bottle as well as reducing the extraction forces necessary to remove the synthetic closure from the bottle for opening the bottle. Furthermore, if desired, a unique combination of additives selected from the group consisting of antimicrobial agents, antibacterial compounds, and oxygen scavenging materials can be incorporated into the synthetic

closure of the present invention in order to impart unique, heretofore unattainable desirable attributes .

In the present invention, the unique synthetic bottle closure is realized by forming an outer layer peripherally surrounding the core member in intimate, bonded, interengagement therewith. The outer, peripheral layer of the synthetic closure is formed from plastic material which is integrally bonded to the cylindrical surface of the core member by applying the outer layer to the core member by extrusion or molding. However, the outer, peripherally surrounding layer is formed with a substantially greater density in order to impart the desired physical characteristics to the synthetic bottle closure of the present invention.

By achieving a multi-component, multi-layer synthetic bottle closure in accordance with the present invention, a bottle closure is realized which is capable of satisfying all requirements imposed thereon by the wine industry, as well as any other bottle closure/packaging industry. As a result, a synthetic bottle closure is attained that can be employed for completely sealing and closing any desired bottle for securely and safely storing the product retained therein.

The invention accordingly comprises an article of manufacture possessing the features, properties, and relation of elements which will be exemplified in the article hereinafter described, and the scope of the invention will be indicated in the claims.

THE DRAWINGS

For a fuller understanding of the nature and objects of the invention, reference should be made to the following detailed description taken in connection with the accompanying drawings, in which:

FIGURE 1 is a perspective view of the multi-component or multi-layer synthetic bottle closure of the present invention;

FIGURE 2 is a cross-sectional side elevation view of the multi-component or multi-layer synthetic bottle closure of the present invention;

FIGURE 3 is a test data diagram depicting the effect of temperature on oxygen absorption over time;

FIGURE 4 is a test data diagram depicting the effect of humidity on oxygen adsorption over time; and

FIGURE 5 is a test data diagram depicting the change in oxygen content in the wine bottle headspace over time with and without oxygen scavengers.

DETAILED DESCRIPTION

By referring to FIGURES 1 and 2, along with the following detailed disclosure, the construction of the multi-component or multi-layer synthetic bottle closure of the present invention can best be understood. In FIGURES 1 and 2, as well as in the following detailed disclosure, the multi-component or multi-layer synthetic closure of the present invention is depicted and discussed as a bottle closure for wine products. However, as detailed above, the present invention is applicable as a synthetic closure for use in sealing and retaining any desired product in any desired closure system. However, due to the stringent and difficult demands and requirements placed upon a closure for wine products, the following detailed disclosure focuses on the applicability of the synthetic bottle closure of the present invention as a closure for wine bottles. However, it is to be understood that this detailed discussion is provided merely for exemplary purposes and is not intended to limit the present invention to this particular application and embodiment.

As shown in FIGURE 1, multi-component or multi-layer synthetic bottle closure 20 comprises a generally cylindrical shape having an outer diameter larger than the diameter of the portal-forming neck of the bottle into which the closure is to be inserted. In general, the overall diameter of multi-component, multi-layer synthetic closure 20 is slightly greater than the diameter of the portal into which bottle closure 20 is to be inserted. In this way, assurance is provided that secure sealed contacting interengagement is attained between synthetic closure 20 and the portal within which it is employed.

As depicted in FIGURES 1 and 2, multi-component/multi-layer synthetic bottle closure 20 comprises core member 22 and peripheral layer 24 which peripherally surrounds and is integrally bonded to core 22. In the preferred embodiment, core

member 22 comprises a substantially cylindrically shaped surface 26 terminating with substantially flat end surfaces 27 and 28.

In the preferred embodiment, surrounding layer 24 is intimately bonded directly to core member 22, peripherally surrounding and enveloping surface 26 of core member 22. Peripheral layer 24 incorporates exposed surface 30, which comprises a substantially cylindrical shape and forms the outer surface of multi-component/multi-layer synthetic bottle closure 20 of the present invention, along with flat end surfaces 27 and 28.

In order to assist in assuring entry of synthetic bottle closure 20 into the portal of the bottle into which closure 20 is inserted, terminating edge 31 of peripheral layer 24 may be beveled or chamfered. Similarly, terminating edge 32 of peripheral layer 24 also may comprise a similar bevel or chamfer. Although any desired bevel or chamfered configuration can be employed, such as a radius, curve, or flat surface, it has been found that merely cutting ends 31 and 32 with an angle of about 45, the desired reduced diameter area is provided for achieving the desired effect.

By incorporating chamfered or beveled ends 31 and 32 on synthetic bottle closure 20, automatic self-centering is attained. As a result, when synthetic bottle closure 20 is compressed and ejected from the compression jaws into the open bottle for forming the closure thereof, synthetic bottle closure 20 is automatically guided into the bottle opening, even if the clamping jaws are slightly misaligned with the portal of the bottle. By employing this configuration, unwanted difficulties in inserting bottle closure 20 into any desired bottle are obviated. However, in applications which employ alternate stopper insertion techniques, chamfering of ends 31 and 32 may not be needed.

In order to produce the attributes required for use in the wine industry, core 22 is formed from foam plastic material using a continuous extrusion process. Although other prior art systems have employed molded foamed plastic material, these processes

have proven to be more costly and incapable of providing a final product with the attributes of the present invention.

In the preferred embodiment, core member 22 is formed as an extruded, medium or low density closed cell foamed plastic comprising one or more plastics selected from the group consisting of inert polymers, homopolymers, and copolymers. The preferred plastic material is preferably selected from the group consisting of polyethylenes, metallocene catalyst polyethylenes, poly-butanes, polybutylenes, polyurethanes, silicones, vinyl based resins, thermoplastic elastomer, polyesters, ethylene acrylic copolymers, ethylene-vinyl- acetate copolymers, ethylene-methyl acrylate copolymers, ethylene-butyl-acrylate copolymers, ethylene-propylene-rubber, styrene butadiene rubber, ethylene-ethyl-acrylic copolymers, ionomers, polypropylenes, and copolymers of polypropylene and copolymerizable ethylenically unsaturated commoners, as well as ethylenic acrylic copolymers, ethylene-vinyl-acetate copolymers, ethylene-methyl-acrylate copolymers, thermoplastic polyurethanes, thermoplastic olefins, thermoplastic vulcanizates, flexible polyolefins, fluorelastomers, fluoropolymers, polyethylenes, teflons, ethylene-butyl-acrylate copolymers, ethylene-propylene-rubber, styrene butadiene rubber, ethylene-ethyl-acrylic copolymers and blends thereof. Furthermore, if a polyethylene is employed, it has been found that the polyethylene may comprise one or more polyethylenes selected from the group consisting of high density, medium density, low density, linear low density, ultra high density, and medium low density.

Regardless of the foamable plastic material selected for forming core member 22, the resulting extruded foam product must have a density ranging between about 100 kg/m^3 to 500 kg/m^3. Although this density range has been found to provide an effective core member, the density of the extruded foam core member 20 preferably ranges between about 200 kg/m^3 to 350 kg/m^3.

Since core member 22 is substantially closed cell in structure, additives are intermixed with the plastic material to form a closed cell foam with minute cells. The resulting core member 22 of the present invention has average cell sizes ranging from between about .02 millimeters to 0.50 millimeters and a cell density ranging between about 25,000,000 cells/cm^3 to 8,000 cells/cm^3. Although this cell configuration has been found to produce a highly effective product, it has been found that the most desirable product possesses an average cell size ranging between about .05 and 0.1 millimeters with a cell density ranging between about 8,000,000 cells/cm^3 to 1,000,000 cells/cm^3. Furthermore, in order to assure that core member 22 possesses inherent consistency, stability, functionality and capability of providing long-term performance, the cell size of core member 22 is homogeneous throughout its entire length and diameter.

In order to control the cell size of core member 22 and attain the desired cell size detailed above, a nucleating agent is employed. In the preferred embodiment, it has been found that by employing a nucleating agent selected from the group consisting of calcium silicate, talc, clay, titanium oxide, silica, barium sulfate, diamatious earth, and mixtures of citric acid and sodium bicarbonate, the desired cell density and cell size is achieved.

In this regard, it has been found that cell size and cell density is most advantageously realized in the formation of core member 22 by employing between about 0.1 and 5 parts by weight of the nucleating agent for every 100 parts by weight of the plastic foam. In this way, the desired physical characteristics of core member 22 are realized along with the desired control of the cell size and cell density. This leads to product consistency currently not available with natural and synthetic materials.

As is well known in the industry, a blowing agent is employed in forming extruded foam plastic material. In the present invention, a variety of blowing agents can be employed during the extruded foaming process whereby core member 22 is

produced. Typically, either physical blowing agents or chemical blowing agents are employed. Suitable blowing agents that have been found to be efficacious in producing the core member of the present invention comprise one or more selected from the group consisting of: Aliphatic Hydrocarbons having 1-9 carbon atoms, Halogenated Aliphatic Hydrocarbons having 1-9 carbon atoms and Aliphatic alcohols having 1-3 carbon atoms. Aliphatic Hydrocarbons include Methane, Ethane, Propane, n-Butane, Isobutane, n-Pentane, Isopentane, Neopentane, and the like. Among Halogenated Hydrocarbons and Fluorinated Hydrocarbons they include Methylfluoride, Perfluoro-methane, ethyl Fluoride, 1,1-Difluoroethane (HFC-152a), 1,1,1-Trifluoroethane (HFC 430a), 1,1,1,2-Tetrafluoroethane (HFC 134a), Pentafluoroethane, Per-fluoroethane, 2,2-Difluoropropane, 1,1,1-Trifluoropropane, Perfluoropropane, Perfluorobutane, Perfluorocyclobutane. Partially Hydrogenated Chlorocarbon and Chlorofluorocarbons for use in this invention include Methyl Chloride, Methylene Chloride, Ethyl Chloride, 1,1,1-Trichlorethane, 1,1-Dichloro1-Fluoroethane (HCFC-141b), 1-Chloro1, 1-Difluoroethane (HCFC142b), 1,1-Dichloro-2,2,2-Trifluoroethane (HCFC-123) and 1-Chloro-1,2,2,2-Tetra-fluoroethane (HCFC124). Fully Halogenated Chlorofluorocarbons include Trichloromonofluoromenthane (CFC11), Dichlorodifluoromenthane (CFC12), Trichlorotrifluoroethane (CFC113), Dichlorotetrafluoroethane (CFC114), Chloroheptafluoropropane, and Dichlorohexafluoropropane. Fully Halogenated Chlorofluorocarbons are not preferred due to their ozone depiction potential. Aliphatic alcohols include Methanol, Ethanol, n-Propanol and Isopropanol. Suitable inorganic blowing agent is useful in making the foam of the present invention include carbon dioxide, nitrogen, carbon, water, air, nitrogen, helium, and argon.

Chemical blowing agents include Azodicarbonamic, Azodiisobutyro-Nitride, Benzenesulfonhydrazide, 4,4-Oxybenzene Sulfonylsemicarbazide, p-Toluene Sulfonylsemicarbazide, Barium Azodicarboxlyate, N,N'-Dimethyl-N,N'-Dinitrosoterephthalamide and Trihydrazinotriazine.

Preferably, in order to produce the desired product, the blowing agent is incorporated into the plastic melt in a quantity ranging between about .005% to 10% by weight of the weight of the plastic material.

As detailed above, either a physical blowing agent or a chemical blowing agent can be employed as part of the extrusion process for forming core member 22 of the present invention. However, it has been found that the selection of a physical blowing agent is preferred since physical blowing agents allow core member 22 of synthetic bottle closure 20 to be achieved with a lower density, which is closer to natural cork.

In this regard, a blowing agent which is inert is preferred. Although any desired inert blowing agent may be employed, the blowing agent is preferably selected from the group consisting of nitrogen, carbon dioxides, sulphur dioxide, water, air, nitrogen, helium, and argon. In addition, hydrocarbons can be employed as the blowing agent which are preferably selected from the group consisting of butane, isobutene, pentane, isopentane and propane.

In addition to attaining core member 22 which possesses a construction with physical characteristics similar to nature cork, multi-component or multi-layer synthetic bottle closure 20 of the present invention also comprises peripheral layer 24. Peripheral layer 24 is of particular importance in attaining synthetic bottle closure 20 which is capable of meeting and exceeding all of the difficult requirements imposed upon a closure or stopper for the wine industry.

As discussed above, the wine industry incorporates corking machines which incorporate a plurality of cooperating, movable jaws which move simultaneously to compress the bottle stopper to a diameter substantially smaller than the diameter of the portal into which the stopper is inserted. Then, once fully compressed, the stopper is forced out of the jaws directly into the bottle, for expanding and immediately closing and sealing the bottle.

Due to the operation of the cooperating jaws which are employed to compress the stopper for insertion into the bottle, sharp edges of the jaw members are forced into intimate contact with the outer surface of the stopper. Although cork material has been successful in resisting permanent damage from the jaw edges in most instances, other prior art synthetic stoppers have been incapable of resisting these cutting forces. As a result, longitudinal cuts, score lines or slits are formed in the outer surface of the stopper, enabling liquid to seep from the interior to the exterior of the bottle.

Multi-component/multi-layer synthetic bottle closure 20 of the present invention eliminates this inherent problem, existing with prior art cork and synthetic closures, by incorporating peripheral layer 24 which surrounds and envelopes substantially the entire outer surface 26 of core member 22. In addition, by forming peripheral layer 24 from high density, rugged, score-resistant material, synthetic bottle closure 20 overcomes all of the prior art difficulties and achieves a bottle closure having physical properties equal to or superior to conventional cork material.

In the preferred embodiment, peripheral layer 24 is formed from plastic material identical or similar to the plastic material employed for core member 22. However, as detailed below, the physical characteristics imparted to peripheral layer 24 differ substantially from the physical characteristics of core member 22.

In the preferred construction, peripheral layer 24 comprises a thickness ranging between about 0.05 and 5 millimeters and, more preferably, between about 0.1 and 2 millimeters. Although these ranges have been found to be efficacious to producing synthetic bottle closure 20 which is completely functional and achieves all of the desired goals, the preferred embodiment for wine bottles comprises a thickness of between about 0.1 and 1 millimeter.

In producing peripheral layer 24 and achieving the desired tough, score and mar-resistant surface for core member 22, peripheral layer 24 preferably comprises a density ranging between about 300 kg/m^3 to 1,500 kg/m^3. Most ideally, it has been

found that the density of peripheral layer 24 ranges between about 750 kg/m^3 to 1,000 kg/m^3.

In accordance with the present invention, multi-component or multi-layer synthetic bottle closure 20 of the present invention must be formed with peripheral layer 24 intimately bonded to substantially the entire surface 26 of core member 22. If any large unbonded areas exist, flow paths for gas and liquid could result. Consequently, secure, intimate, bonded interengagement of peripheral layer 24 with core member 22 is required for attaining a bottle closure for the wine industry.

In order to achieve this integral bonded interconnection between peripheral layer 24 and core member 22, peripheral layer 24 is formed about core member 22 in a manner which assures intimate bonded engagement. Preferably, the desired secure, intimate, bonded, interengagement is attained by simultaneous co-extrusion of core member 22 and peripheral layer 24 or by applying peripheral layer 24 to core member 22 after core member 22 has been formed. By employing either process, intimate bonded interengagement of peripheral layer 24 to core member 22 is attained.

By using equipment well known in this industry, multi-component/multi-layer synthetic bottle closure 20 of the present invention can be produced by co-extruding core member 22 simultaneously with peripheral layer 24 to provide a final product wherein peripheral layer 24 is intimately bonded to core member 22 in a single, continuous operation. If co-extrusion process is employed, once the continuous elongated co-extruded layers forming synthetic bottle closure 20 have been completely formed and are ready for final processing, the elongated dual component material produced is cut to the precise length desired for forming synthetic bottle closures 20.

After each bottle closure 20 has been formed with the desired length, the desired chamfer, if needed, is formed at each end of peripheral layer 24 in order to provide the benefits detailed above. Once the chamfer or radius has been achieved, synthetic bottle

closure 20 is ready for distribution to the desired consumer, unless appropriate coatings and/or printing will be applied.

In the alternate construction, core member 22 is formed as an elongated, continuous, extruded foam product and is cooled or allowed to cool until ready for subsequent processing. Then, whenever desired, the continuous elongated length forming core member 22 is fed through a cross-head machine which enables peripheral layer 24 to be formed and positioned in the desired location peripherally surrounding core member 22 in intimate bonded interengagement therewith. Once the dual component product has been completed, the elongated length of material is cut to the desired length for forming bottle closure 20, as detailed above, with the desired chamfer or radius being formed in peripheral layer 24, attaining the final product.

In a further alternate embodiment, synthetic bottle closure 20 of the present invention is formed by employing generally conventional injection molding techniques. As is well known, injection molding is a manufacturing process where plastic is forced into a mold cavity under pressure. The mold cavity is essentially a negative of the part being produced, and the cavity is filled with plastic, and the plastic changes phase to a solid, resulting in a positive. Typically, injection pressures range from 5,000 to 20,000 psi. Because of the high pressures involved, the mold must be clamped shut during injection and cooling.

By employing this process, a plurality of separate and independent bottle closures 20 are simultaneously formed in a multi-cavity mold having the precisely desired shape and configuration. Consequently, if beveled or chamfered edges are desired, the desired configuration is incorporated into the mold, thereby producing a product with the final shaped desired.

Typically, injection molding is employed to produce products having a single composition. However, if desired core member 22 may be formed with outer peripheral layer 24 surrounding and intimately bonded thereto using alternate techniques such

as multi-step molding and multi-component molds, or subsequent coating operations, such as spray coating, tumble coating, or immersion coating. By employing these procedures, synthetic bottle closures 20 of the present invention are formed in an injection molding process, as desired, achieving the unique, multi-layer, multi-component synthetic bottle closure of the present invention.

As discussed above, intimate bonded interengagement of peripheral layer 24 to core member 22 is required for providing a synthetic bottle closure 20 capable of being used in the wine industry. In this regard, although it has been found that the processes detailed above provide secure intimate bonded interengagement of peripheral layer 24 to core member 22, alternate layers or bonding chemicals can be employed, depending upon the particular materials used for forming core member 22 and peripheral layer 24.

If desired, well known bonding agents or tie layers can be employed on the outer surface of core member 22 in order to provide secure intimate bonded inter-engagement of peripheral layer 24 therewith. If a tie layer is employed, the tie layer would effectively be interposed between core member 22 and peripheral layer 24 to provide intimate bonded interengagement by effectively bonding peripheral layer 24 and core member 22 to the intermediately positioned tie layer. However, regardless of which process or bonding procedure is employed, all of these alternate embodiments are within the scope of the present invention, providing a synthetic bottle closure capable of overcoming all of the prior art difficulties and drawbacks.

As detailed above, a wide variety of plastic materials can be employed to produce the extruded multi-component, multi-layer synthetic bottle closure 20 of the present invention. Although each of the plastic materials detailed herein can be employed for both core member 22 and peripheral layer 24, the preferred plastic material for forming both core member 22 and peripheral layer 24 comprises one or more selected from the group consisting of medium density polyethylenes, low density polyethylenes, metallocene catalyst polyethylenes, polypropylenes, polyesters, ethyl-

ene-butyl-acrylate copolymers, vinyl-acetate copolymers, ethylene-methyl acrylate copolymers, and blends of these compounds.

It has also been discovered that the outer peripheral layer or skin layer 24 may comprise a thermoplastic composition which differs from the thermoplastic composition employed for the core member. In this regard, the outer peripheral layer 24 may comprise one or more selected from the group consisting of foamable or non-foamable thermoplastic polyurethanes, thermoplastic olefins, thermoplastic vulcanizates, flexible polyolefins, fluoroelastomers, fluoro-polymers, polyethylenes, teflons, and blends thereof. In addition, peripheral layer 24 may be formed from thermoplastic olefinic elastomers such as petrothene TPOE, thermoplastic urethanes thermoplastic polyesters, and other similar product formulas.

The particular composition employed for peripheral layer 24 is selected to withstand the compression forces imposed thereon by the jaws of the corking machine. However, many different polymers, as detailed above, are able to withstand these forces and, as a result, can be employed for peripheral layer 24. In this regard, one principal feature of the present invention is the type of material used for layer 24, as well as the discovery that a substantially solid, non-foamed or foamed plastic-based outer peripheral layer or skin is securely affixed about a foamed plastic center core, to produce a multi-layer synthetic closure which is able to withstand the forces of a cork machine. The ability of the present invention to withstand these forces, without product leakage, exists even if cork dust filler is present between the core and the peripheral layer.

In order to form synthetic bottle closure 20 with all of the desirable inherent physical and chemical properties detailed above, one compound that has been found to be most advantageous to employ for outer peripheral layer 24 is metallocene catalyst polyethylene. As detailed below, outer peripheral layer 24 may comprise 100% metallocene catalyst polyethylene or, if desired, the metallocene catalyst polyethylene

may be intermixed with a polyethylene. In this regard, it has been found that outer peripheral layer 24 preferably comprises between about 25% and 100% by weight based upon the weight of the entire composition of one or more polyethylenes selected from the group consisting of medium density polyethylenes, medium low density polyethylenes, and low density polyethylenes.

In order to demonstrate the efficacy of this embodiment of the present invention, a supply of synthetic closures 20 were produced employing 100% by weight of metallocene catalyst polyethylene for outer peripheral layer 24. This supply of synthetic bottle closures 20 were identified as Synthetic Closure A and were tested in combination with natural cork bottle closures and synthetic bottle closures 20 in accordance with the present invention, using alternative formulations for outer peripheral layer 24. The formulations employed for these comparative samples are detailed below, along with the test data demonstrating the efficacy of all of the alternate embodiments of the present invention.

Another formulation which has been found to be highly effective in providing an outer peripheral layer 24 which meets all of the required physical and chemical attributes to attain a commercially viable synthetic bottle closure 20 is a polyether-type thermoplastic polyurethane.

By employing this material and forming the material in peripheral, surrounding, bonded engagement with any desired foamed core member 22, a highly effective, multi-layer synthetic closure is attained which is able to meet and exceed all requirements for a wine bottle closure.

In the preferred construction of this embodiment, the particular polyether-type thermoplastic polyurethane employed for forming outer peripheral layer 24 comprises Elastollan LP9162, manufactured by BASF Corporation of Wyandotte, Michigan. As detailed below in the test data provided, this compound, referred to as Synthetic Closure B, has been found to produce an outer layer in combination with core member

22 which provides all of the physical and chemical characteristics required for attaining a highly effective synthetic closure 20 for the wine industry.

In addition to employing the polyether-type thermoplastic polyurethane detailed above, another compound that has been found to be highly effective in providing all of the desirable attributes required for outer peripheral layer 24 is a blend of thermoplastic olefins and thermoplastic vulcanizates. In the preferred embodiment, the blend of thermoplastic olefins and thermoplastic vulcanizates comprises between about 10% and 90% by weight based upon the weight of the entire composition of the thermoplastic olefin and between about 10% and 90% by weight based upon the weight of the entire composition of the thermoplastic vulcanizate. As detailed below in the test data, the construction of synthetic closure 20 using an outer peripheral surface 24 formed from this blend, referred to below as Synthetic Closure C, provides a wine bottle closure which exceeds all requirements imposed thereon.

Another compound that has also been found to provide a highly effective outer peripheral layer 24 for synthetic closure 20 of the present invention comprises flexible polyolefins manufactured by Huntsman Corporation of Salt Lake City, Utah. These compounds are sold under the trademark REXflex FPO, and comprise homogeneous reactor-synthesized polymers, produced under proprietary technology which attains polymers having unique combinations of properties.

In a further alternate embodiment, a highly effective synthetic bottle closure 20 is attained by employing metallocene catalyst polyethylenes, either independently or in combination with one selected from the group consisting of low density polyethylenes, medium density polyethylenes, and medium low density polyethylenes. In this embodiment, these materials are preferably employed for both core member 22 and peripheral layer 24.

Still further additional compounds which have been found to provide highly effective outer peripheral surfaces 24 for forming synthetic bottle closures 20, in

accordance with the present invention, comprise Teflon, fluoroelastomeric compounds and fluoropolymers. These compounds, whether employed individually or in combination with each other or with the other compounds detailed above have been found to be highly effective in producing an outer peripheral layer 24 which is capable of satisfying all of the inherent requirements for synthetic bottle closure 20.

Any of the compounds detailed herein for providing outer peripheral layer 24 can be employed using the extrusion processes detailed above to produce an outer layer which is securely and integrally bonded to core member 22, either as a foamed outer layer or a non-foamed outer layer. In addition, these compounds may also be employed using the molding processes detailed above to produce the desired multi-component, multi-layer, synthetic bottle closure 20 of the present invention.

In addition, it has also been found that additives may be incorporated into outer peripheral layer 24 in order to further enhance the performance of the resulting synthetic bottle closure 20. As detailed above, these additional additives include slip resistant additives, lubricating agents, and sealing compounds.

It has also been discovered that further additional additives may be incorporated into either core member 22 and/or outer layer 24 of synthetic closure 20 in order to provide further enhancements and desirable performance characteristics. These additional additives incorporate antimicrobial agents, antibacterial compounds, and or oxygen scavenging materials.

The antimicrobial and antibacterial additives are incorporated into the present invention to impart an additional degree of confidence that in the presence of a liquid the potential for microbial or bacterial growth is extremely remote. These additives have a long term time release ability and further increases the shelf life without further treatments by those involved with the bottling of wine. This technology has been shown to produce short as well as long term results (microbial and bacterial kills in as little as ten minutes with the long term effectiveness lasting for tens of years) which cannot be

achieved with a natural product. An additional additive employed in the present invention is an oxygen scavenging system. Since oxygen is the worst enemy for wine, this system will for all intent and purposes eliminate the possibility of wine oxidation.

Free diatomic oxygen has an antagonistic effect on still wine. Oxidation occurs over a period of time to render the beverage undrinkable. However, during the bottling process, there is a chance that oxygen is trapped in the headspace between the wine and the closure, oxygen is solublized and released from the wine, and/or oxygen is released from or permeates through the closure.

In order to reduce the possibility of this oxidation in wine, an oxygen scavenger is incorporated into the synthetic closure to extend and preserve the freshness and shelf life of the product. Oxygen scavenger concentrates such as sodium ascorbate, sodium sulfite, edetate dipotassium (dipotassium EDTA), hydroquinone, and similar substances are used to actively bind free oxygen unlike passive barrier layers such as glass and/or barrier polymers. Oxygen residing in the headspace after bottling and dissolved oxygen in the wine are unaffected by the passive barriers, but the concentration is reduced in the presence of the oxygen scavengers.

With an oxygen scavenger, the closure system can be designed with both active and passive protection from oxidation and result in a prolonged shelf life and an improved wine quality. The oxygen scavenging capability of the closure remains dormant throughout the bottling process until the mechanism is activated in the presence of moisture. One other major advantage of this oxygen scavenging capability is the possibility to eliminate the need for vacuum in the headspace before closure insertion; therefore, eliminating one variable in the still wine bottling operation.

Oxidation in wine is also expedited by elevated temperatures. Because the kinetics of the reaction mechanism of the scavenging system also increase with temperature, closures containing oxygen scavengers provide heightened levels of protection against oxidation. By referring to FIGURES 3, 4, and 5, the highly effective, advanta-

geous results attained by employing an oxygen scavenger in the present invention are fully detailed.

By employing any desired combination of these agents or additives, a further enhanced synthetic closure is realized which is capable of providing a product performance which has heretofore been incapable of being provided by either cork closures or conventional synthetic closures.

In order to attain the desired chemical and physical properties for multi-component/multi-layer synthetic closure 20, core member 22 preferably comprises between about 0% and 75% by weight of metallocene catalyst polyethylene, and between about 25% and 100% by weight of one or more polyethylenes as detailed above. In forming peripheral layer 24 in secure, bonded interengagement therewith, it has been found that any of the formulations detailed above may be employed, with the selected formulations being affixed to core member 22 by co-extrusion or cross-head extrusion methods.

In order to demonstrate the efficacy of the present invention, a plurality of samples of multi-component/multi-layer synthetic bottle closures 20, manufactured in accordance with the present invention, were produced and tested. These sample products were produced by employing metallocene catalyst polyethylene and low density polyethylene intermixed with each other in the ranges detailed above to form core member 22. In forming core member 22 of each sample product, the two compounds were intermixed and formed using conventional foam extrusion equipment. In forming peripheral layer 24, the various compounds detailed above were employed to produce alternate embodiments of synthetic closure 20 of this invention and identified as Synthetic Closure A, Synthetic Closure B, and Synthetic Closure C. These separate embodiments were each tested and the results thereof are detailed below.

In the forming process, peripheral layer 24 was foamed in the extrusion equipment peripherally surrounding core member 22 and being intimately bonded

thereto. The resulting products were cut in lengths suitable for forming bottle closure 20, followed by a chamfer being formed in edges 31 and 32. The resulting closures were then employed in a plurality of tests to prove the ability of the present invention to overcome the prior art difficulties and provide a bottle closure which is equivalent to or better than the properties and performance characteristics provided by cork.

In producing the synthetic bottle closure 20 of the present invention in the manner detailed above, blowing agents and nucleating agents detailed above were employed as previously disclosed. These additives were employed using standard procedures well known in the foam extrusion process.

In order to demonstrate the ability of the synthetic bottle closure 20 of the present invention to possess physical properties similar to or better than natural cork, a comparative analysis of natural cork and synthetic closure 20 of the present invention was made using the sample products produced as detailed above. By referring to Table I, the ability of the synthetic bottle closure 20 of the present invention to achieve physical properties that are equivalent to or better than natural cork is clearly demonstrated.

TABLE I

Property	Natural Cork	Synthetic Closure
Compressive strength to 15.5 mm radial Max load (LBF)	591	581
Compressive strength to 15.5 mm Radial Max stress (psi)	113.6	126.4
Compressive strength (36%) rectangular Max stress (psi)	280.4	300.4
Compressive recovery instantaneous (%)	94.79	94.12
Compressive recovery 1 hour (%)	98.33	97.88
Compressive recovery 24 hours (%)	99.58	98.35

In order to demonstrate the ability of the multi-component/multi-layer, synthetic bottle closure of the present invention to meet or exceed the physical qualities possessed by natural cork when employed as a bottle closure or stopper for wine, numerous tests were conducted directly comparing the synthetic bottle closure of the present invention to natural cork stoppers. However, natural cork varies in quality from an ultra low quality to an ultra high quality. Typically, the quality of the cork is determined by price in accordance with the following schedule:

ultra low quality corks are below $90 per 1,000 pieces

low quality natural corks range from $95 to $120 per 1,000 pieces

medium quality natural corks range from $125 to $180 per 1,000 pieces

high quality natural corks range from $175 to $250 per 1,000 pieces

ultra high quality natural corks are above $250 per 1,000 pieces

As detailed below, most test comparisons were made using medium quality natural cork. In this regard, since the price for medium quality natural cork ranges between about $125 to $180 per 1,000 pieces, the samples tested in the following comparisons were made using medium quality natural cork found in the highest price range for this category.

Before being used as a test sample, each of the natural cork stoppers were inspected to assure high quality and eliminate obvious flaws that might exist. As a result, all of the natural cork stoppers employed in these tests met the following standards.

Each natural cork stopper was 45mm in length, 24mm in diameter and, upon visual inspection, had no visual or functional flaws. Furthermore, natural cork stoppers tested to possess a maximum of three very shallow or narrow lenticels, and were free of dust particles. In addition, the stoppers had no holes or pores in excess of 2mm, possessed a maximum of one crack, which was classified as being very tight and less than 8% of the cork length. Furthermore, no worm activity was visible, as well as no bellyspots or greenwood. The ends of each cork were relatively clean and possessed very little chance of chipping on the edges. Finally, no cracks originated from the ends, and growth rings were uniform and substantially equidistant.

In conducting the following tests, a supply of synthetic bottle closure of the present invention were manufactured in the manner detailed above. In addition, a separate supply of each different type of natural cork stoppers was established. In

conducting each test, a plurality of samples were randomly selected from each supply and tested in accordance with the procedures detailed herein. The results for each test were computed and are provided in Tables II, III, IV, and V.

Compression Tests

In this test, the force required to compress each closure or stopper from its original diameter to a diameter of 15.5mm was determined. In conducting this test, 6 random samples were selected from the supply of medium quality natural cork stoppers and six random samples were selected from the supply of synthetic bottle closures of the present invention manufactured in the manner detailed above.

Each sample was separately positioned on a radial compression device, which was installed onto an Instron 1011 Material Tester. When positioned on the radial compression device, each sample was compressed from its normal diameter, typically 24.0mm, to a compressed diameter of 15.5mm. The force value required for compressing each test sample was recorded. The overall average resulting force values for each sample type were computed and are reported in Table II as the maximum compression force in pounds.

TABLE II

Compression Tests

Test / Sample	Max. Radial Compression Force to 15/5 mm (LBF)	Compression Recovery Instanta-neous	Compression Recovery After 15 min.	Compression Recovery After 1 Hour	Compression Recovery After 24 Hrs.	Compression Set
Synthetic Closure A	481.7	94.90%	97.45%	97.77%	98.09%	17.49%
Natural Cork Medium Quality	483.75	93.86%	96.44%	96.72%	97%	28.78%
Synthetic Closure B	398.00	93.5%	97.1%	97.5%	97.7%	
Synthetic Closure C	329.42	92.2%	95.4%	95.9%	96.3%	

Another compression test was conducted to determine the recovery rate for the closures or stoppers at different time intervals. In conducting this test, six random samples were selected from the supply of synthetic bottle closures of the present invention, manufactured in the manner detailed above, and six random samples were selected from the supply of medium quality natural cork closures. This test was designed to determine the recovery rate for each of the closures after compression to 13.0mm and release therefrom.

In conducting this test, each of the selected samples was positioned in a commercially available hand corker having a capability to compress the closures from their original diameter to a diameter of 13.0mm, and then allow each of the stoppers to be released by pushing them out of the compression jaws with a plunger. In each case, the original diameter of each sample was recorded.

Thereafter, the diameter of each test sample was recorded immediately after being ejected from the compression jaws, fifteen minutes after ejection, one hour after ejection, and twenty-four hours after ejection. The percent recovery for each measurement was calculated by employing the following formula:

$$\% \text{ Recovery} = \frac{Dm}{Do} \times 100$$

where Dm is the measured diameter at the different time interval and Do is the original diameter. The average percent recovers was computed for each sample type and the results are shown in Table II.

The final compression test conducted was a determination of the compression set, which is a determination of the ability of each stopper to recover after being exposed to a prolonged 50% linear compression. In conducting this test, three random samples were selected from the supply of medium quality natural cork stoppers and three random samples were selected from the supply of synthetic bottle closures of the present invention manufactured in the manner detailed above.

The diameter of each sample was recorded. Then, following the method detailed in ASTM Method D-3575 Suffix B, each sample was linearly compressed to 50% of its original diameter and maintained at this compression for 22 hours. The test device consisted of two flat, surface ground plates capable of securing the samples at the desired 50% compression. At the end of the 22 hours, the samples were allowed to recover for 2 hours, after which the diameter of each sample was measured in the compression direction and the measurements recorded.

The compression set was determined for each sample using the following formula: Percent Compression Set = 100 -[(diameter after compression)÷ (original diameter) x 100]. The overall average percent compression set for each sample type was determined by averaging the individual values calculated for each test sample. This overall average result is provided in Table II.

Extraction Force

Another comparative test which was conducted was an extraction force test to determine the amount of force required to extract each type of closure from a properly corked bottle. In conducting this test, six random samples were selected from the supply of medium quality natural corks, and six random samples selected from the supply of synthetic bottle closures of the present invention manufactured in the manner detailed above. The device used for testing was an Instron Model 1011 Material Tester, which was outfitted with a corkscrew fixture to perform the extraction and measure the forces.

In conducting this test, each of the test samples were inserted into a 750 ml bottle filled with water to the 55mm fill level, using the procedure described in Practical Aspects of Wine Corkage by Jean Michel Riboulet and Christian Alegoet, Bourgogne Publications, Chaintre, France, pages 148-157. The corkscrew was inserted into the corked bottle and the cork removed, while recording the forces required to extract the cork. For each sample, both the maximum force and the average force

required for its extraction was recorded. In Table III, the overall average for both the maximum extraction force and the average extraction force for each sample type is detailed.

TABLE III

Extraction Force

Sample Type	Maximum Extraction Force (lbs)	Average Extraction Force (lbs)
Synthetic Closure A	44.50	25.89
Natural Cork - Medium Quality	39.80	23.05
Synthetic Closure B	51.5	25.32
Synthetic Closure C	45.083	24.76

Sealing Behavior

The next performance test conducted was a sealing behavior test which determines the ability of the closure or stopper to resist compromising the integrity of the seal when the closure is subjected to elevated pressures inside the bottle. In conducting this test, six random samples were selected from the supply of high quality natural corks, six random samples were selected from the supply of medium quality natural corks, six random samples were selected from the supply of low quality natural corks, and six random samples were selected from the supply of the synthetic bottle closure of the present invention, manufactured in the manner detailed above. The device used for testing each of the samples was a conventional 750 ml bottle, which was modified to allow the pressure in the bottle to be regulated from 0 psi to 30 psi.

In conducting this test, each sample closure was inserted into a bottle and allowed to recover in the bottle for one hour prior to testing. Thereafter, the samples

were inverted and connected to the pressure device. The samples were subjected to four elevated pressure levels for two-minutes at each level. The pressure levels were 10 psi, 15 psi, 22.5 psi and 30 psi. At the end of the two-minute interval at each pressure level, each sample was individually observed and rated on the following scale:

- 10 = closure did not move from its original location and no dampness detected
- 8 = closure moved from its original location without popping out of the bottle and no dampness detected
- 6 = closure did not move from its original location and dampness was detected, but no dripping
- 4 = closure moved from its original location without popping out of the bottle and no dampness detected, but no dripping
- 2 = closure did not move from its original location and drips
- 1 = closure moved from its original location without popping out of the bottle and drips
- 0 = closure popped out of bottle
- -40 = test pressure is lost

The evaluations for each sample were recorded at each interval and the results for each sample at the four different test intervals were totalled. Any sample receiving a total score less than 40 was considered a failure. With six closures being tested of each sample type, a total score of 240 represented the maximum score attainable and was employed as the standard for passing this test. When fully evaluated, the synthetic bottle closure A of the present invention, the high quality natural cork stoppers, and the medium quality natural cork stoppers all scored 240 points, synthetic bottle closure B

and C both scored 260 points thereby passing this test. The low quality natural cork stoppers received a total point score of 224, resulting in a failure of this test.

Temperature Test

The next performance test was a temperature test to compare the ability of the closures to resist any compromising sealing integrity at elevated temperatures. In conducting this test, two random samples were selected from the supply of medium quality natural cork and two random samples were selected from the synthetic bottle closure of the present invention manufactured in the manner detailed above. 750 ml bottles were filled with water to a level of 55mm from the bottle lip and 63mm from the bottle lip. This filling was done in accordance with the disclosure found in Practical Aspects of Wine Corkage, as detailed above.

Each sample type was inserted into both the 55mm and 63mm fill levels and when sealed in position, the bottle was placed horizontally in an oven at 38 C for twenty-four hours. The samples were observed after twenty-four hours for leakage and movement of the closure. Any leakage or movement was considered a failure. The results of this test are shown in Table IV.

TABLE IV

Sample	55mm Fill Level		63mm Fill Level	
	Leaking	Movement	Leaking	Movement
Natural Cork - Medium Quality - 1	Fail	Pass	Fail	Pass
Natural Cork - Medium Quality - 2	Fail	Pass	Fail	Pass
Synthetic Closure - A	Pass	Fail	Pass	Pass
Synthetic Closure - B	Pass	Fail	Pass	Pass
Synthetic Closure - C	Pass	Fail	Pass	Pass

Aroma Absorption

In the next performance test, the ability of the closures to resist absorption of aromas were performed. In this test, eighteen random samples were selected from the supply of medium quality natural corks and eighteen random samples were selected from the supply of synthetic bottle closures of the present invention manufactured in the manner detailed above. Each of the closures were individually soaked in a white wine solution for a period of 24 hours. After soaking, each wine solution sample was analyzed for retained odors. The overall results revealed the synthetic closures of the present invention had an aroma which was described as very consistent, neutral, and light woody. The medium quality natural cork closures had aromas which were described as vanilla, woody, cardboardy, and papery.

Capillarity

Another test performed on the closures was a capillarity test, which is designed to determine the ability of the materials tested to resist the absorption of red wine above the level of the hydrostatic head of the liquid. In conducting this test, three random samples were selected from the supply of medium quality natural cork stoppers and three random samples were selected from the supply of synthetic bottle closures of the present invention manufactured in the manner detailed above. The device used for testing was a flat-bottom vessel capable of holding red wine at a constant level of 5mm.

Each of the samples were vertically positioned on the flat-bottom vessel submerged in 5mm of wine for twenty-four hours. Thereafter, the samples were removed from the holding tank and blotted dry. Then, the length of the wine stain on the exterior of each of the closures was measured and recorded in millimeters. Due to variations in the rate of absorbency over the cross-section of the closures, particularly the natural cork closures, the maximum capillarity or maximum length of the wine stain was measured as well as the overall average capillarity or wine stain length. The

overall average of each of these results for each of the sample types tested is shown in Table V.

TABLE V

Capillarity

Sample	Maximum Capillarity	Average Capillarity
Synthetic Closure A	0.00	0.00
Natural Cork - Medium Quality	20.03	6.60
Synthetic Closure B	0.00	0.00
Synthetic Closure C	8.0	7.7

Water Absorption

Another test conducted was a water absorption test to compare the amount of water absorbed by each of the sample types. In conducting this test, three random samples were selected from the supply of medium quality natural cork stoppers and three random samples were selected from the synthetic bottle closures of the present invention manufactured in the manner detailed above. The water absorption test conducted was in compliance with ASTM Method D-570. In conducting this test, the device used was a water-tight vessel capable of holding enough water to completely submerse each sample. The vessel also contained a screen with enough weight to submerge all of the samples simultaneously.

Each sample was weighed to the nearest 1/10,000 of a gram and submerged in the tank for 24 hours. Thereafter, the samples were removed from the tank and blotted dry. Then, the samples were weighed to the nearest 1/10,000 of a gram and the amount of water absorbed determined as the difference between the weight of the

sample before and after submersion. The water absorption for each sample was computed in accordance with the following formula:

$$\text{Water Absorption} = \frac{\text{Weight of Water}}{\text{Original Weight of Sample}} \times 100$$

The resulting average absorbency for the synthetic bottle closure A of the present invention was 0.27%,for synthetic closure B.0.215%,and for synthetic closure C 0.491%, while the average of water absorbency for the medium quality natural cork stopper was 13.06%.

As is evident from a review of the test results detailed above, the multi-component/multi-layer synthetic bottle closure of the present invention has been clearly demonstrated as possessing physical characteristics which are either equivalent to or better than the physical characteristics possessed by bottle stoppers formed from natural cork. As a result of these test procedures, as well as the foregoing detailed disclosure regarding the synthetic bottle closure of the present invention, it is immediately apparent that all of the inherent problems, difficulties, and drawbacks existing with natural cork stoppers have been completely overcome by the present invention, and a uniform, consistent, easily manufactured and comparatively inexpensive synthetic bottle closure has been achieved which can be employed for sealing products in bottles, such as wine, without incurring any loss or unwanted change in the physical characteristics of the product.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above article without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of

the scope of the invention which, as a matter of language, might be said to fall therebetween.

Particularly, it is to be understood that the in said claims, ingredients or compounds recited in the singular are intended to include compatible mixtures of such ingredients wherever the sense permits.

Having described my invention, what I claim is new and desire to secure by Letters Patent is:

THE CLAIMS

1. A synthetic closure/stopper for a product retaining container constructed for being inserted and securely retained in a portal forming neck of the container, said closure/stopper comprising:

A. an elongated, cylindrically shaped core member formed from foamed plastic material; and

B. at least one layer

a. enveloping substantially the entire peripheral surface of the cylindrically shaped core member, and

b. comprising at least one plastic material selected from the group consisting of polyethylenes, metallocene catalyst polyethylenes, polybutanes, polybutylenes, polyurethanes, silicones, vinyl-based resins, thermoplastic elastomers, polyesters, ethylenic acrylic copolymers, ethylene-vinyl-acetate copolymers, ethylene-methyl-acrylate copolymers, thermoplastic polyurethanes, thermoplastic olefins, thermoplastic vulcanizates, flexible polyolefins, fluorelastomers, fluoropolymers, polyethylenes, teflons, and blends thereof, ethylene-butyl-acrylate copolymers, ethylene-propylene-rubber, styrene butadiene rubber, ethylene-ethyl-acrylic copolymers, ionomers, polypropylenes, and copolymers of polypropylene and copolymerizable ethylenically unsaturated comonomers;

wherein the cylindrically shaped core member includes substantially flat terminating surfaces forming the opposed ends of said cylindrically shaped core member, said at least one layer is defined as enveloping substantially the entire peripheral surface of the cylindrically shaped core member, and wherein said flat terminating surfaces are devoid of said at least one layer; and whereby a multi-layer/multi-component synthetic closure is attained which is capable of completely sealing any desired product in a container, retaining the product in the container for any desired length of time without any degradation of the product or degradation of the closure.

2. The synthetic closure/stopper defined in Claim 1, wherein the plastic material forming the core member is further defined as comprising medium density or low density, closed cell, foamed plastic comprising one or more materials selected from the group consisting of inert polymers, homopolymers, and copolymers.

3. The synthetic closure/stopper defined in Claim 2, wherein said closed cell foam plastic material is further defined as comprising one or more materials selected from the group consisting of polyethylenes, metallocene catalyst polyethylenes, polybutanes, polybutylenes, polyurethanes, silicones, vinyl-based resins, thermoplastic elastomers, polyesters, ethylenic acrylic copolymers, ethylene-vinyl-acetate copolymers, ethylene-methyl-acrylate copolymers, ethylene-butyl-acrylate copolymers, ethylene-propylene-rubber, styrene butadiene rubber, ethylene-ethyl-acrylic copolymers, ionomers, polypropylenes, and copolymers of polypropylene and copolymerizable ethylenically unsaturated comonomers, as well as ethylenic acrylic copolymers, ethylene-vinyl-acetate copolymers, ethylene-methyl-acrylate copolymers, thermoplastic polyurethanes, thermoplastic olefins, thermoplastic vulcanizates, flexible polyolefins, fluorelastomers, fluoropolymers, polyethylenes, teflons, and blends thereof, ethylene-butyl-acrylate copolymers, ethylene-propylene-rubber, styrene butadiene rubber, ethylene-ethyl-acrylic copolymers.

4. The synthetic closure/stopper defined in Claim 2, wherein said closed cell, foamed plastic material is further defined as comprising one or more polyethylenes selected from the group consisting of high density, medium density, low density, linear low density, ultra high density, and medium low density.

5. The synthetic closure/stopper defined in Claim 1, wherein said core member is further defined as comprising a density ranging between about 100 kg/m^3 to 500 kg/m^3.

6. The synthetic closure/stopper defined in Claim 5, wherein said core member further comprises a density ranging between about 200 kg/m^3 to 350 kg/m^3.

7. The synthetic closure/stopper defined in Claim 5, wherein said core member is further defined as comprising closed cells having an average cell size ranging from between about .02 millimeters to 0.50 millimeters and a cell density ranging between about 8,000 cells/cm^3 to 25,000,000 cells/cm^3.

8. The synthetic closure/stopper defined in Claim 7, wherein said core member is further defined as comprising cell size ranging between about 0.05mm and 0.1mm and a cell density ranging between about 1,000,000 cells/cm^3 to 8,000,000 cells/cm^3.

9. The synthetic closure/stopper defined in Claim 1, wherein said peripheral layer is further defined as comprising one or more compounds selected from the group consisting of foamable or non-foamable thermoplastic polyurethanes, thermoplastic olefins, thermoplastic vulcanizates, flexible polyolefins, fluoroelastomers, fluoropolymers, polyethylenes, teflons, and blends thereof.

10. The synthetic closure/stopper defined in Claim 9, wherein said peripheral layer is further defined as comprising one material selected from the group consisting of foam plastics and non-foamed plastics.

11. The synthetic closure/stopper defined in Claim 9, wherein said peripheral layer comprises one material selected from the group consisting of polyether-type polyurethanes, thermoplastic polyolefins, thermoplastic polyvulcanizates, flexible polyolefins, and blends thereof.

12. The synthetic closure/stopper defined in Claim 11, wherein said peripheral layer further comprises between about 10% and 90% by weight based upon the weight of the entire composition of a thermoplastic olefin and between about 10% and 90% by weight based upon the weight of the entire composition of a thermoplastic vulcanizate.

13. The synthetic closure/stopper defined in Claim 1, wherein said core member is formed by injection molding.

14. The synthetic closure/stopper defined in Claim 13, wherein said peripheral layer is integrally affixed to the surface of the core member by employing one process selected from the group consisting of injection molding, spray coating, roll coating and bath coating.

15. The synthetic closure/stopper defined in Claim 14, wherein said peripheral layer is formed in an injection molding die during the formation process for the core member.

16. The synthetic closure/stopper defined in Claim 1, and further comprising at least one additive selected from the group consisting of lubricating agents, slip-enhancing compounds, antimicrobial agents, antibacterial agents, and oxygen scavenging compounds.

17. The synthetic closure/stopper defined in Claim 16, wherein said additives are blended into one material selected from the group consisting of the core member, the peripheral layer and both the core member and the peripheral layer.

18. The synthetic closure/stopper defined in Claim 1, wherein said peripheral layer is further defined as comprising a thickness ranging between about 0.05mm and 5mm.

19. The synthetic closure/stopper defined in Claim 18, wherein said peripheral layer is further defined as comprising a thickness ranging between about 0.1mm and 2mm.

20. The synthetic closure/stopper defined in Claim 1, wherein said peripheral layer is further defined as comprising a tough, score and mar resistant surface and a density ranging between about 300 kg/m^3 and 1,500 kg/m^3.

21. The synthetic closure/stopper defined in Claim 20, wherein the density of the peripheral layer is further defined as comprising between about 750 kg/m^3 and 1,000 kg/m^3.

22. The synthetic closure/stopper defined in Claim 1, wherein the core member and the peripheral layer are both further defined as being formed from one or more foamable plastic materials selected from the group consisting of medium density polyethylenes, low density polyethylenes, metallocene catalyst polyethylenes, polypropylenes, polyesters, ethylene-butyl-acrylate copolymers, vinyl-acetate copolymers, and ethylene-methyl acrylate copolymers.

23. The synthetic closure/stopper defined in Claim 22, wherein said core member is further defined as comprising:

a. between about 0% and 75% by weight based upon the weight of the entire core member of metallocene catalyst polyethylene, and

b. between about 25% and 100% by weight of one or more polyethylenes selected from the group consisting of medium density polyethylenes, medium low density polyethylenes, and low density polyethylenes.

24. The synthetic closure/stopper defined in Claim 1 wherein said core member and said peripheral layer are further defined as being formed by extrusion.

25. The synthetic closure/stopper defined in Claim 24, wherein said core member and said peripheral layer are further defined as being extruded simultaneously.

26. The synthetic closure/stopper defined in Claim 24, wherein said core member is further defined as being extruded separately and subsequent thereto said peripheral layer is formed in extrusion equipment peripherally surrounding and enveloping the preformed core member.

27. The synthetic closure/stopper defined in Claim 24, wherein said extrusion process is further defined as incorporating one or more blowing agents selected from the group consisting of carbon dioxide, sulphur dioxide, nitrogen, carbon, water, air nitrogen, helium, and argon, Azodicarbonamic Azodiiso-butyro-Nitride, Benzenesulfonhydrazide, 4,4-Oxybenzene Sulfonylsemicar-bazide, p-Toluene Sulfonylsemi-carbazide, Barium Azodicarboxlyate, N,N'-Dimethyl-N,N'-Dinitro-soterephthalamide, Trihydrazinotriazine, Aliphatic Hydrocarbons having 1-9 carbon atoms, Halogenated Aliphatic Hydrocarbons having 1-9 carbon atoms, Aliphatic Hydrocarbons having 1-9 carbon atoms, Aliphatic alcohols having 1-3 carbon atoms and partially Hydrogenated Chlorocarbon and Chlorofluorocarbons.

28. The synthetic closure/stopper defined in Claim 27, wherein said blowing agent is further defined as comprising between about .005% and 10% by weight of the weight of the plastic material and comprises an inert blowing agent selected from the group consisting of nitrogen, carbon dioxide, sulphur dioxide, water, air, nitrogen, helium, and argon.

29. The synthetic closure/stopper defined in Claim 25, wherein a nucleating agent is employed in the extrusion process and said nucleating agent is selected from the group consisting of calcium silicate, talc, clay, titanium oxide, silica, barium sulfate, diamatious earth, and mixtures of citric acid and sodium bicarbonate.

30. The synthetic closure/stopper defined in Claim 29, wherein said nucleating agent is further defined as comprising between about 0.1 and 5 parts by weight for every 100 parts by weight of the plastic material.

31. The synthetic closure/stopper defined in Claim 1, wherein said peripheral layer is further defined as comprising indicia formed on the outer surface thereof.

32. The synthetic closure/stopper defined in Claim 31, wherein said indicia comprises one or more selected from the group consisting of letters, symbols, colors, graphics, and wood tones.

33. A synthetic closure/stopper for a fluid product retaining container constructed for being inserted and securely retained in a portal forming neck of the container, said closure/stopper comprising:

A. an elongated, solid cylindrically shaped member dimensioned for insertion in the neck of the fluid product retaining container for closing and sealing the fluid product in the container, comprising at least two components concentrically mounted to each other and integrally bonded together in the manner which prevents passage of the fluid therebetween;

B. said first component comprising an elongated, solid, cylindrically shaped core member formed from extruded foamed plastic material comprising a density ranging between about 100 kg/m^3 to 500 kg/m^3 and constructed for sealing the fluid product retained in the container and preventing transfer of the fluid product from the container prior to removal; and

C. said second component

a. enveloping substantially the entire peripheral surface of the first component,

b. comprising a plastic material in peripheral surrounding, intimate, bonded engagement with the peripheral surface of the cylindrically shaped core member of the first component and comprising one or more materials selected from the group consisting of polyethylenes, metallocene catalyst polyethylenes, polybutanes, polybutylenes, polyurethanes, silicones, vinyl-based resins, thermoplastic elastomers, polyesters, ethylenic acrylic copolymers, ethylene-vinyl-acetate copolymers, ethylene-methyl-acrylate copolymers, thermoplastic polyurethanes, thermoplastic olefins, thermoplastic vulcanizates, flexible polyolefins, fluorelastomers, fluoropolymers, polyethylenes, teflons, and blends thereof, ethylene-butyl-acrylate copolymers, ethylene-propylene-rubber, styrene butadiene rubber, ethylene-ethyl-acrylic copolymers, ionomers, poly-propylenes, and copolymers of polypropylene and copolymerizable ethylenically unsaturated comonomers; and

c. having an exposed surface constructed for frictionally engaging a

surface of the portal formed in the neck of the container and being securely engaged therewith until forcibly removed therefrom, sealing the fluid product in the container and resisting all forces generated by the fluid product when retained in said container;

wherein the cylindrically shaped core member includes substantially flat terminating surfaces forming the opposed ends of said cylindrically shaped core member, said second component is defined as enveloping substantially the entire peripheral surface of the cylindrically shaped core member of the first component, and wherein said flat terminating surfaces are devoid of said second component; and

whereby a multi-layer/multi-component synthetic closure is attained which is capable of completely sealing any desired fluid product in a container, retaining the product in the container for any desired length of time without any degradation of the fluid product or degradation of the closure.

34. The synthetic closure/stopper defined in Claim 33, wherein the plastic material forming the core member is defined as comprising medium density or low density, closed cell, foamed plastic comprising one or more materials selected from the group consisting of inert polymers, homopolymers, and copolymers.

35. The synthetic closure/stopper defined in Claim 34, wherein said closed cell foam plastic material is further defined as comprising one or more materials selected from the group consisting of polyethylenes, metallocene catalyst polyethylenes, polybutanes, polybutylenes, polyurethanes, silicones, vinyl-based resins, thermoplastic elastomers, polyesters, ethylenicacryliccopolymers, ethylene-vinyl-acetatecopolymers, ethyl-ene-methyl-acrylate copolymers, ethylene-butyl-acrylate copolymers, ethylene-propylene-rubber, styrene butadiene rubber, ethylene-ethyl-acrylic copolymers, ionomers, polypropylenes, and copolymers of polypropylene and copolymerizable ethylenically unsaturated comonomers as well as ethylenic acrylic copolymers, ethylene-vinyl-acetate copolymers, ethylene-methyl-acrylate copolymers, thermoplastic polyurethanes, thermoplastic olefins, thermoplastic vulcanizates, flexible polyolefins, fluorelastomers, fluoropolymers, polyethylenes, teflons, ethylene-butyl-acrylate copolymers, ethylene-propylene-rubber, styrene butadiene rubber, ethylene-ethyl-acrylic copolymers and blends thereof.

36. The synthetic closure/stopper defined in Claim 34, wherein said closed cell, foamed plastic material is further defined as comprising one or more polyethylenes selected from the group consisting of high density, medium density, low density, linear low density, ultra high density, and medium low density.

37. The synthetic closure/stopper defined in Claim 33, wherein said peripheral layer is further defined as comprising one or more compounds selected from the group consisting of foamable or non-foamable thermoplastic polyurethanes, thermoplastic olefins, thermoplastic vulcanizates, flexible polyolefins, fluoroelastomers, fluoropolymers, polyethylenes, teflons, and blends thereof.

38. The synthetic closure/stopper defined in Claim 38, wherein said peripheral layer is further defined as comprising one material selected from the group consisting of foam plastics and non-foamed plastics.

39. The synthetic closure/stopper defined in Claim 37, wherein said peripheral layer comprises one material selected from the group consisting of polyether-type polyurethanes, thermoplastic polyolefins, thermoplastic polyvulcanizates, flexible polyolefins, and blends thereof.

40. The synthetic closure/stopper defined in Claim 39, wherein said peripheral layer further comprises between about 10% and 90% by weight based upon the weight of the entire composition of a thermoplastic olefin and between about 10% and 90% by weight based upon the weight of the entire composition of a thermoplastic vulcanizate.

41. The synthetic closure/stopper defined in Claim 33, wherein said peripheral layer is further defined as comprising a thickness ranging between about 0.05mm and 5mm.

42. The synthetic closure/stopper defined in Claim 41, wherein said peripheral layer is further defined as comprising a thickness ranging between about 0.1mm and 2mm.

43. The synthetic closure/stopper defined in Claim 33, wherein said peripheral layer is further defined as comprising a tough, score and mar resistant surface and a density ranging between about 300 kg/m^3 and 1,500 kg/m^3.

44. The synthetic closure/stopper defined in Claim 43, wherein the density of the peripheral surface is further defined as comprising between about 750 kg/m^3 and1,000kg/m^3.

45. A synthetic closure/stopper for a wine-retaining container constructed for being inserted and securely retained in a portal forming neck of the container, said closure/stopper comprising:

A. an elongated, solid, cylindrically shaped member dimensioned for insertion in the portal of the neck of the wine retaining container for closing and sealing the wine in the container; comprising two components concentrically mounted to each other and integrally bonded together in a manner which prevents passage of any fluid therebetween;

B. said first component comprising an elongated, solid, cylindrically shaped core portion formed from extruded foamed plastic material, comprising a density ranging between about 100 kg/m^3 and 500 kg/m^3 and constructed for sealing the wine retained in the container and preventing transfer of the wine and any gases produced thereby out of the container prior to removal thereof; and

C. said second component

a. enveloping substantially the entire peripheral surface of the first component,

b. comprising plastic material in peripheral surrounding, intimate, bonded engagement with the peripheral surface of the cylindrically shaped core member of the first component comprising one or more materials selected from the group consisting of polyethylenes, metallocene catalyst polyethylenes, polybutanes, polybutylenes, polyurethanes, silicones, vinyl-based resins, thermoplastic elastomers, polyesters, ethylenic acrylic copolymers, ethylene-vinyl-acetate copolymers, ethylene-methyl-acrylate copolymers, thermoplastic polyurethanes, thermoplastic olefins, thermoplastic vulcanizates, flexible polyolefins,

fluorelastomers, fluoropolymers, polyethylenes, teflons, and blends thereof, ethylene-butyl-acrylate copolymers,ethylene-propylene-rubber, styrene butadiene rubber, ethylene-ethyl-acrylic copolymers, ionomers, polypropylenes, and copolymers of polypropylene and copolymerizable ethylenically unsaturated comonomers,

c. having a density ranging between about 300 kg/m^3 and 1,500 kg/m^3, and

d. having an exposed surface comprising a tough, score and mar resistant construction for resisting the compressive force of a corking machine employed for inserting the closure/stopper into the portal of a wine retaining bottle, and constructed for frictionally engaging a surface of the portal formed in the neck of the container and being securely engaged therewith until forcibly removed therefrom, sealing the wine in the container and resisting all forces generated by the wine retained in said container; and

wherein the cylindrically shaped core member includes substantially flat terminating surfaces forming the opposed ends of said cylindrically shaped core member, said second component is defined as enveloping substantially the entire peripheral surface of the cylindrically shaped core member of the first component, and wherein said flat terminating surfaces are devoid of said second component.

46. The synthetic closure/stopper defined in Claim 45, wherein said peripheral layer is defined as being formed from extruded plastic material comprising one material selected from the group consisting of foamed plastics and non-foamed plastics.

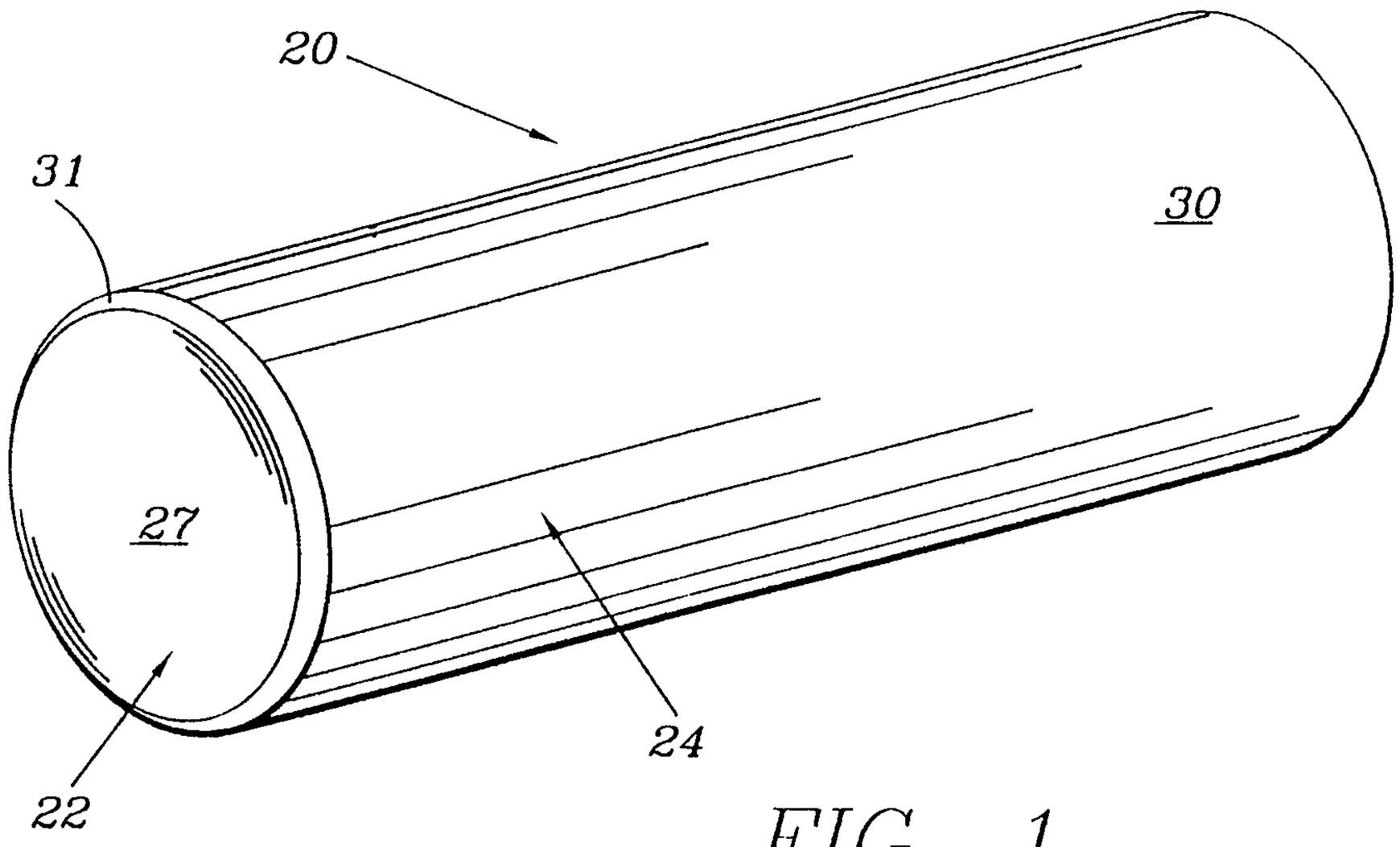


FIG. 1

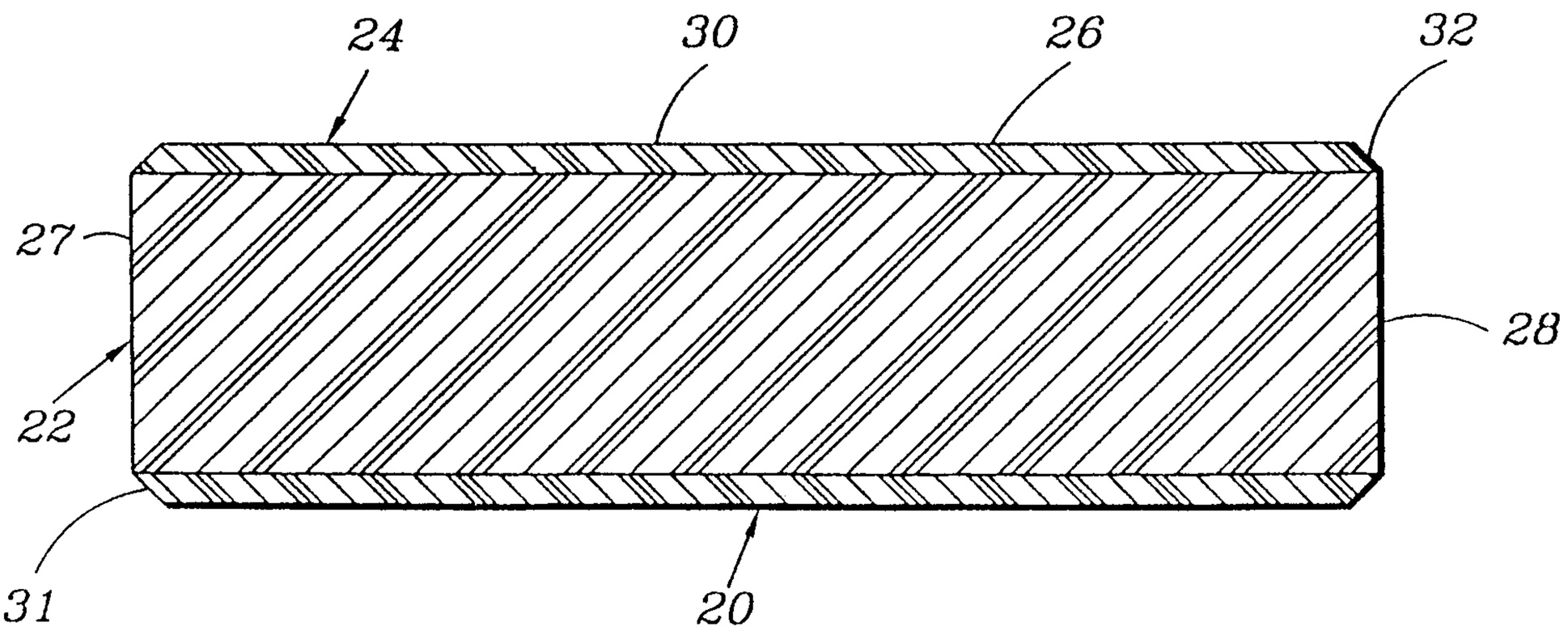


FIG. 2

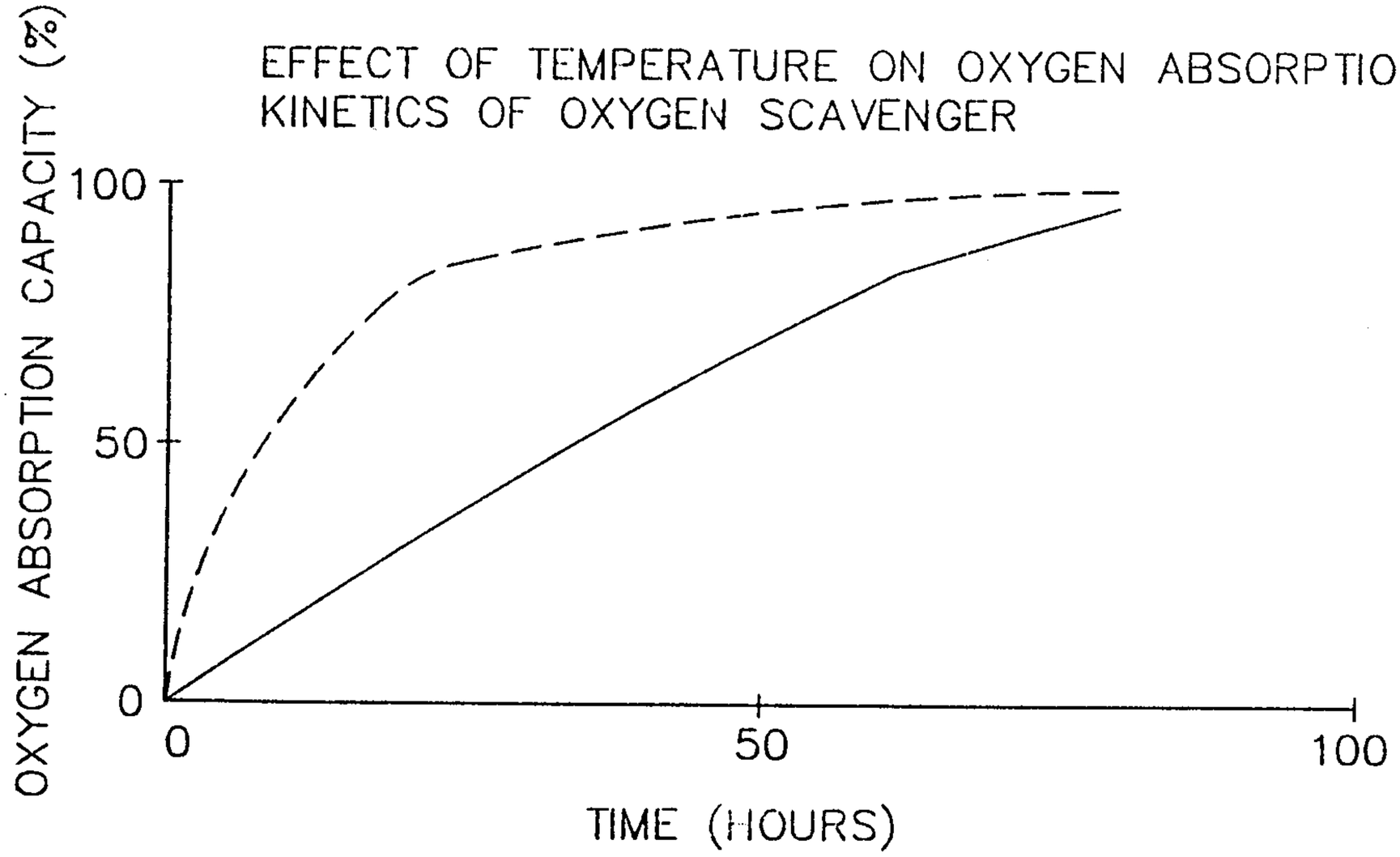

EFFECT OF TEMPERATURE ON OXYGEN ABSORPTION KINETICS OF OXYGEN SCAVENGER
OXYGEN ABSORPTION CAPACITY (%)
100
50
0
0
50
100
TIME (HOURS)

FIG. 3

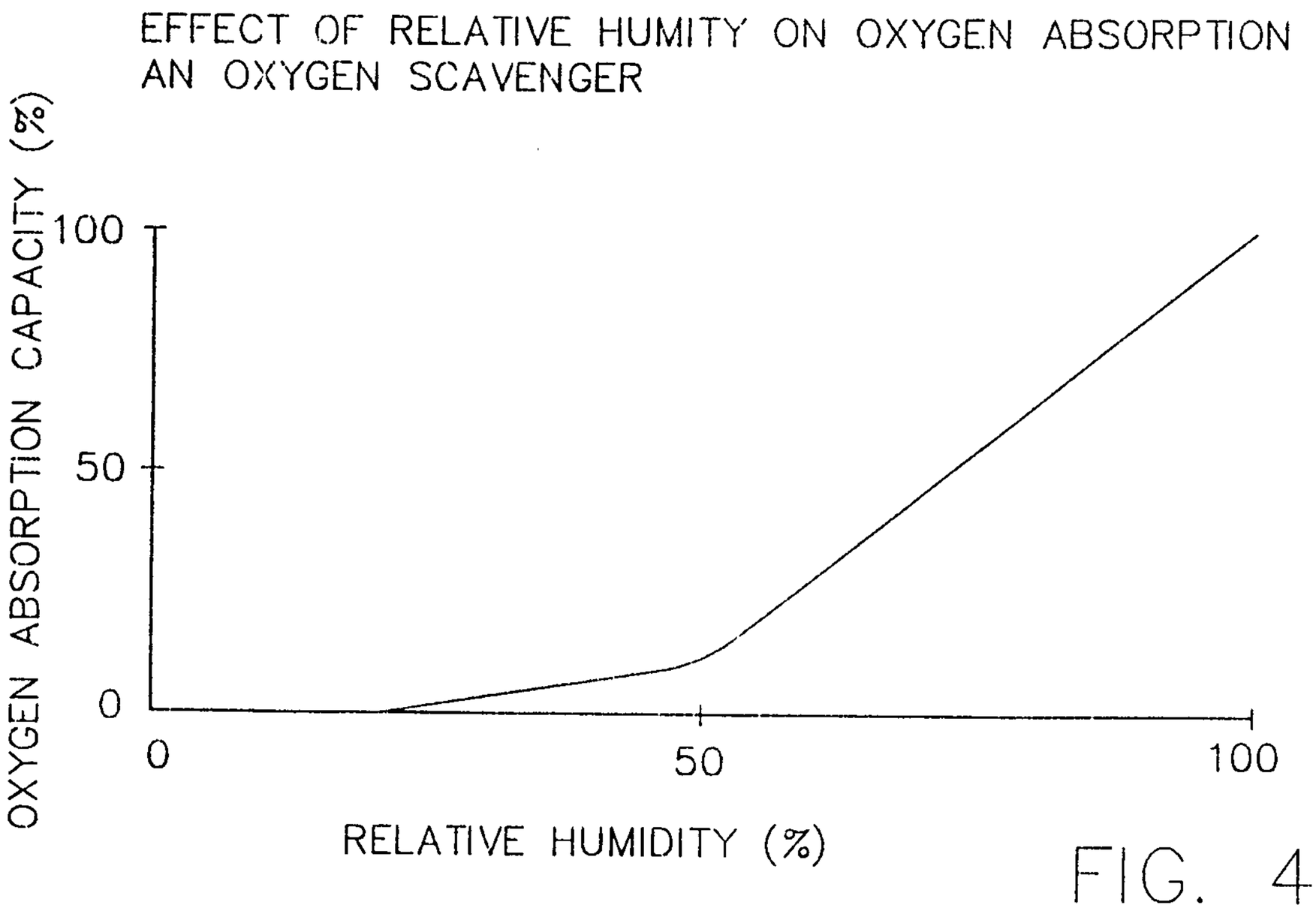

EFFECT OF RELATIVE HUMITY ON OXYGEN ABSORPTION OF AN OXYGEN SCAVENGER
OXYGEN ABSORPTION CAPACITY (%)
100
50
0
0
50
100
RELATIVE HUMIDITY (%)

FIG. 4

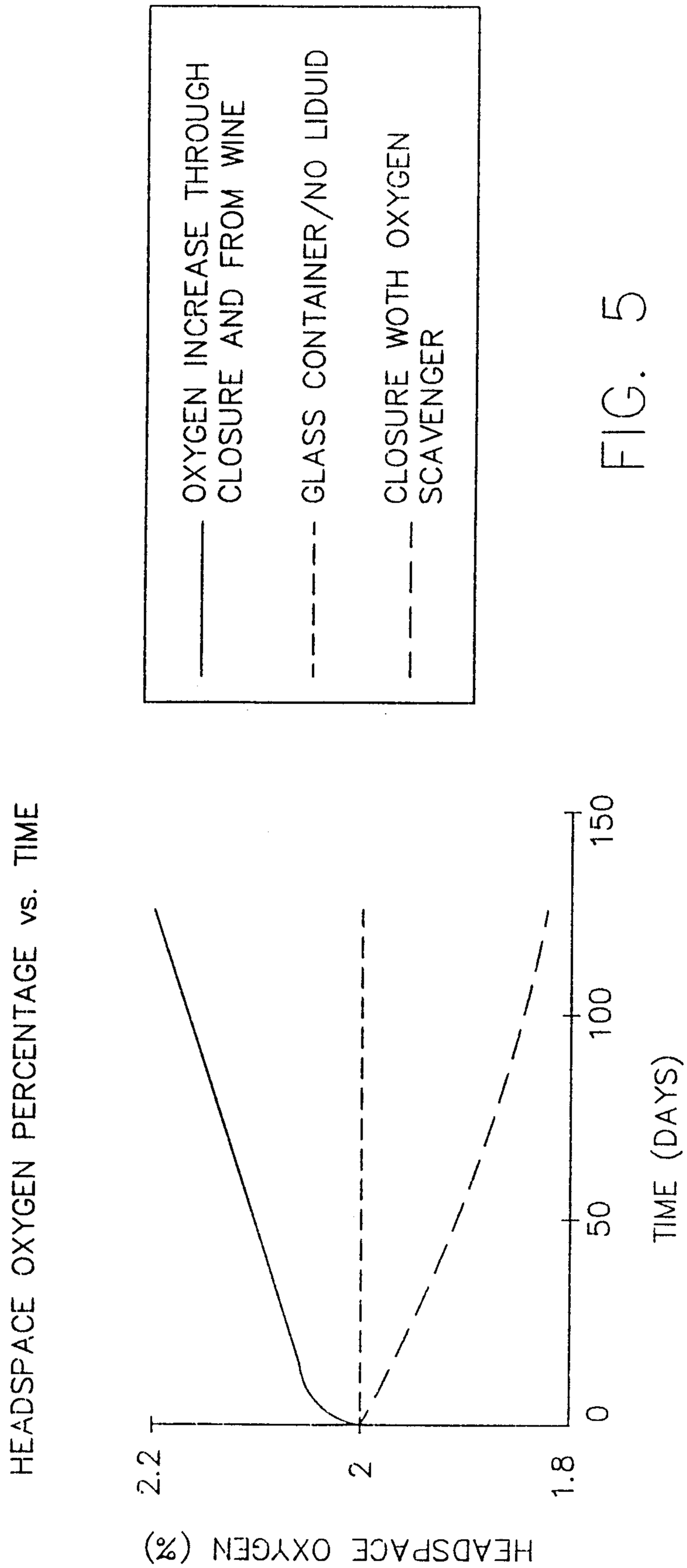
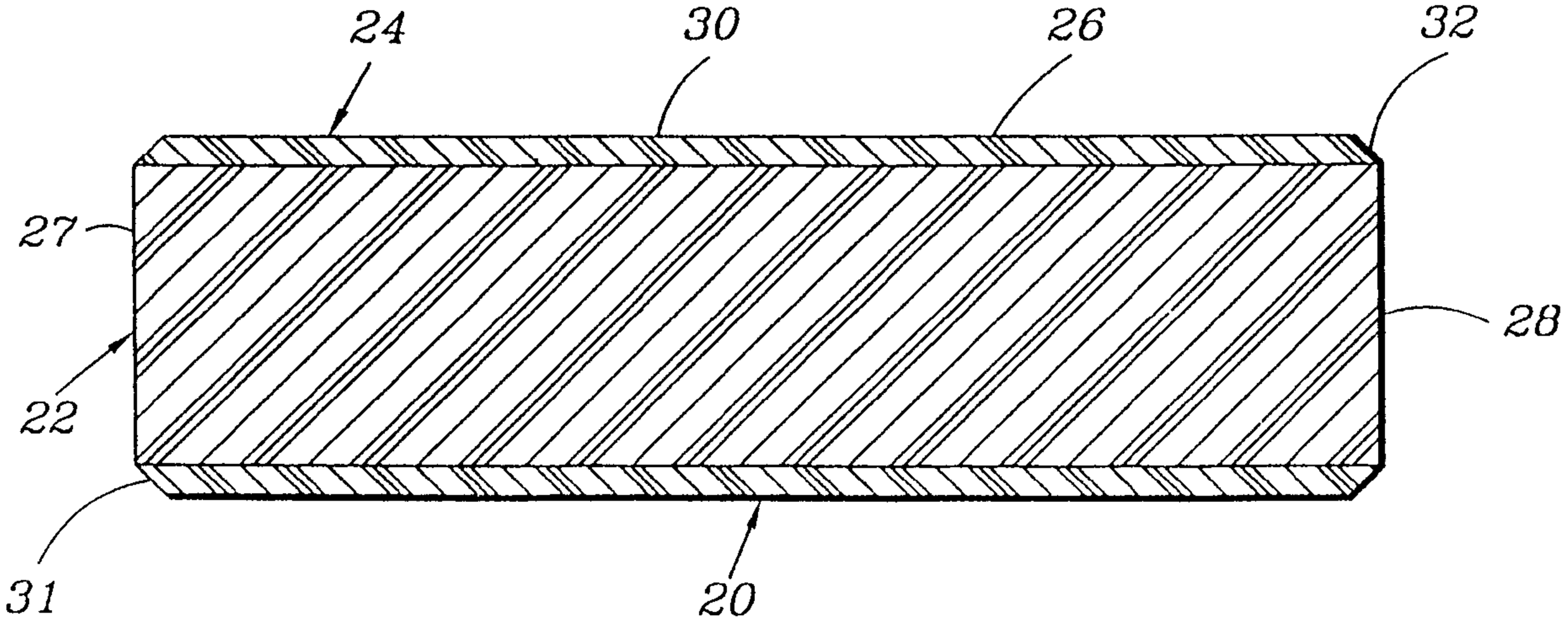

OXYGEN INCREASE THROUGH CLOSURE AND FROM WINE
GLASS CONTAINER/NO LID
CLOSURE WOTH OXYGEN SCAVENGER
HEADSPACE OXYGEN PERCENTAGE vs. TIME
HEADSPACE OXYGEN (%)
2.2
2
1.8
0
50
100
150
TIME (DAYS)

FIG. 5


24
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