

[54] VACUUM SKIN PACKAGING AND PACKAGES

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[51] Int. Cl. **B65d 75/30**, B65b 31/02

[58] Field of Search 53/22 A, 112 A; 206/80 A

[56] **References Cited**
UNITED STATES PATENTS

2,912,805	11/1959	Maynard	53/37
3,216,172	11/1965	Piazzè	53/22 B
3,634,993	1/1972	Pasco et al.	53/22 A
3,694,991	10/1972	Perdue et al.	53/22 A

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[57]

ABSTRACT

An object is packaged in a vacuum skin pack formed by evacuating space between a pair of heat-sealable sheets containing the object and by heat-sealing the sheets to each other about the object. The sheets are pore and cell-free; at least at the sealing surfaces. A multitude of convex protrusions is formed in one of the sheets for providing during the formation of the pack a multitude of collapsible and sealable evacuation channels extending between the sheets. The other of the sheets is heated and the object is provided between the sheets. After the evacuation channels have been formed, the space between the pair of sheets is evacuated essentially only through the latter evacuation channels. The flow of heat from the mentioned one sheet in a direction away from the heated other sheet is inhibited, and peripheral portions of the mentioned one sheet about the object are heated while the flow of heat from said one sheet is being inhibited. The mentioned other sheet is moved tightly against the object being packaged by continued evacuation essentially only through the evacuation channels between the sheets.

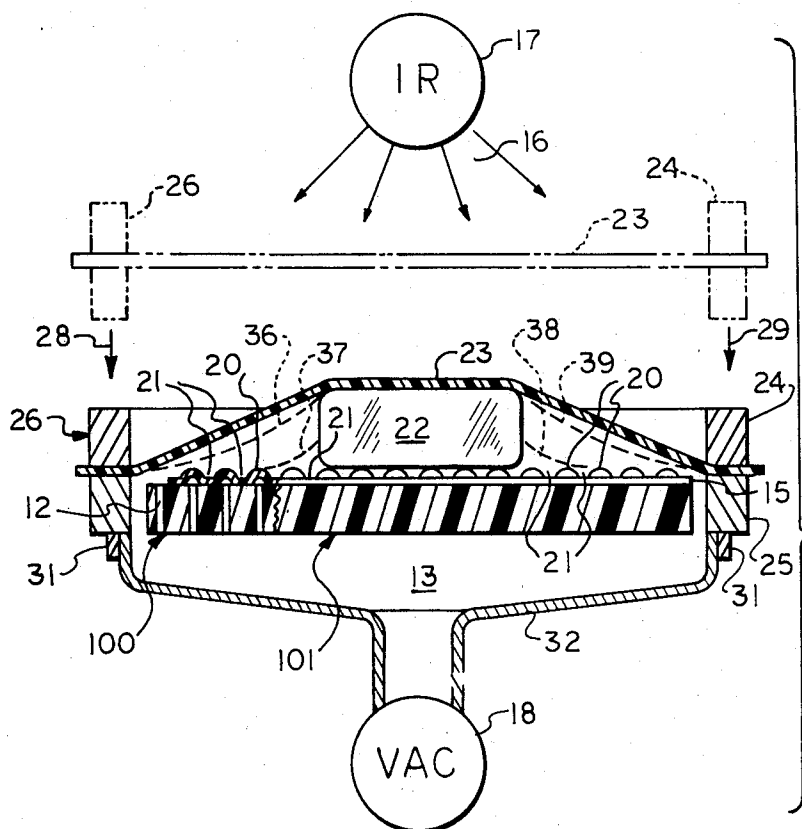
17 Claims, 10 Drawing Figures


FIG. 1

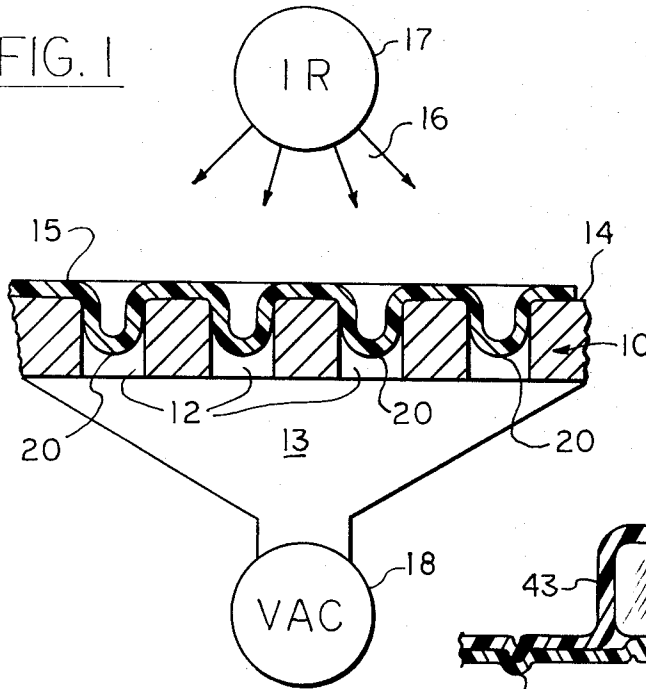


FIG. 2

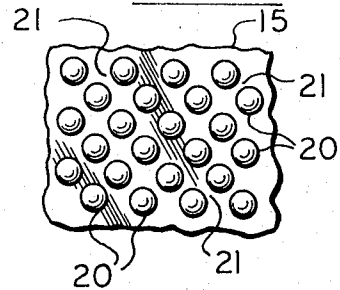


FIG. 4

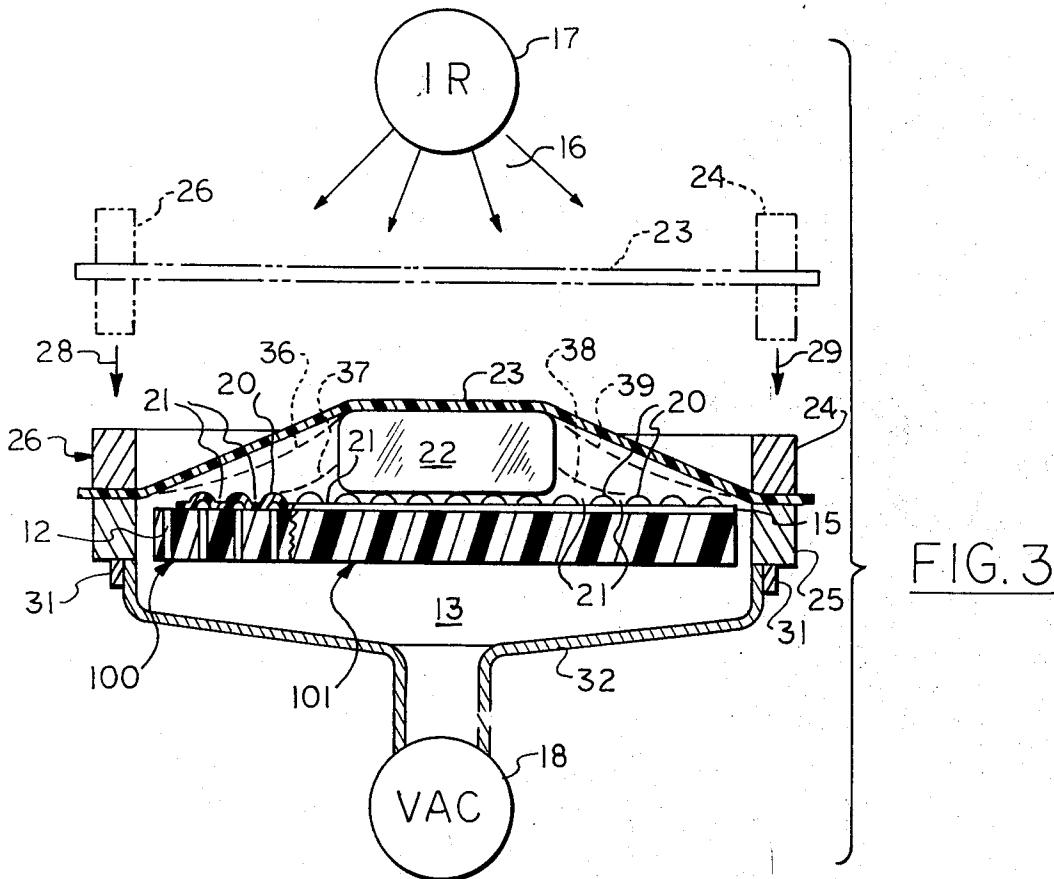
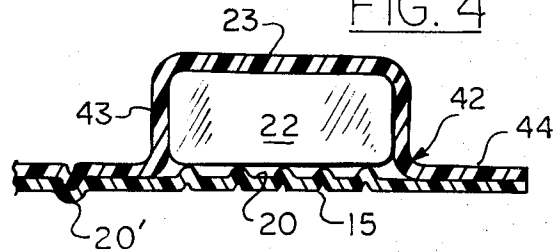


FIG. 5

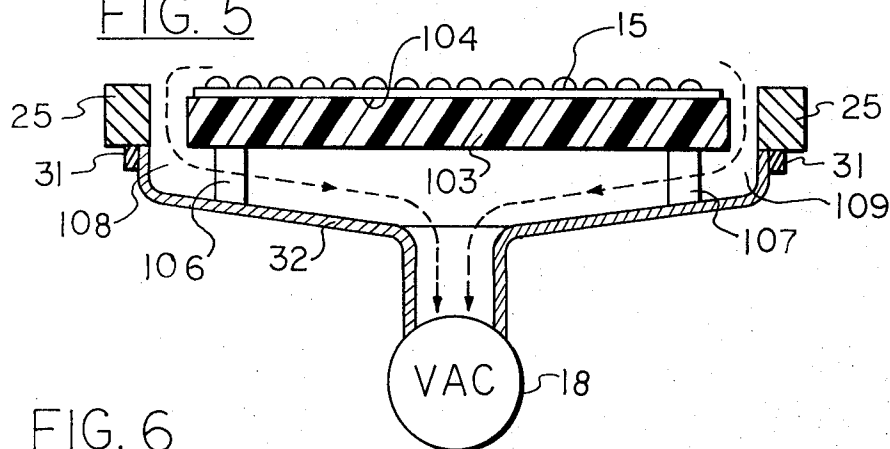


FIG. 6

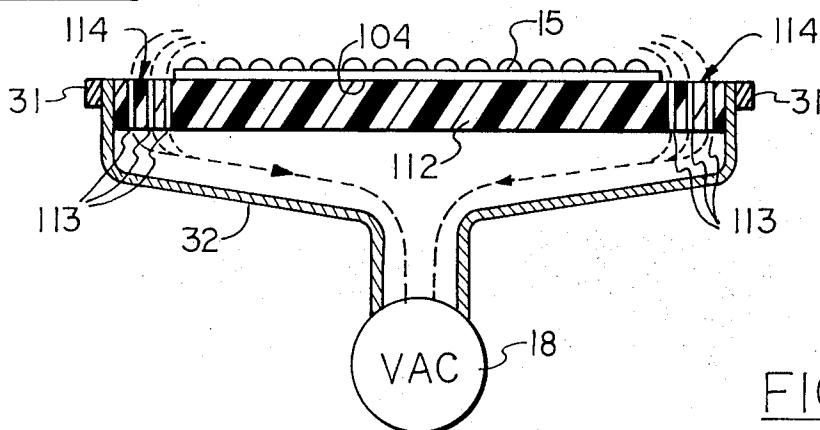


FIG. 7

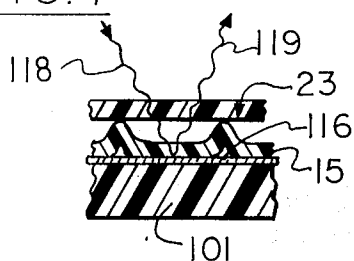


FIG. 8

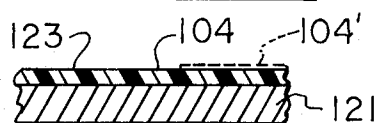


FIG. 9

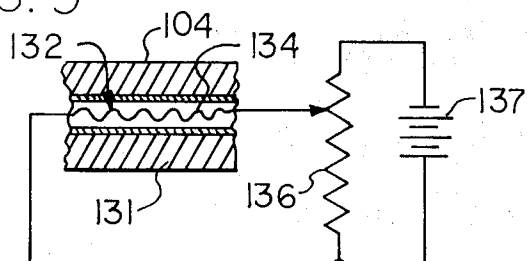
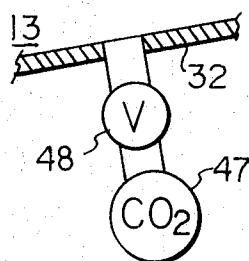


FIG. 10



VACUUM SKIN PACKAGING AND PACKAGES

CROSS-REFERENCE TO RELATED APPLICATION

Certain subject matter herein disclosed is claimed in U.S. Patent application Ser. No. 256,524, filed May 24, 1972 by Richard L. Levor, as a continuation-in-part of U.S. Patent application Ser. No. 163,157 now abandoned, entitled Vacuum Skin Packaging and Packages, filed July 16, 1971 by said Richard L. Levor, said patent applications are assigned to the subject assignee, and are herewith incorporated by reference herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The subject invention relates to packaging and, more specifically, to vacuum skin packaging and vacuum skin packs.

2. Description of the Prior Art

Packaging of goods historically has been a major concern of mankind. Most of this aspect of human history has been spent with the development of better packaging materials. With the progress of the industrial age, human effort has branched into the quest for better packaging techniques.

A substantial improvement of packaging materials and packaging techniques came in the wake of the development of plastics. These efforts have yielded techniques in which containers are vacuum pre-formed for subsequent reception of goods. Even where such containers were made expandable by a provision of corrugations or pleats (see U.S. Pat. No. 3,497,059), the utility of these techniques still depended on the uniformity of the shape and size of the goods being packaged.

In other prior-art proposals, the object to be packaged is, in some manner, placed in an evacuable space. For instance, the object may be inserted into a plastic bag which, in turn, is inserted into a vacuum chamber. Upon evacuation of that chamber, the bag collapses against the object and can then be sealed. Similar prior-art proposals provide conduits, tubes, and the like devices for drawing air out of the bag (see U.S. Pat. Nos. 2,750,719, 3,010,262, 3,216,832, 3,347,011, 3,358,415, 3,481,101).

The major drawback of these proposals is the considerable apparatus effort involved in providing the requisite vacuum chambers or the specialized package preforming and holding equipment as well as the specialized tooling involved in the provision and operation of evacuation conduits and tubes.

In techniques known as vacuum skin packaging, the object to be packaged is placed on a substrate. A thermally softened plastic skin is moved onto the object and substrate and is drawn against object and substrate by an evacuation step, and is then sealed to the substrate. The major stumbling block in the development of practical vacuum skin packaging techniques has been the evacuation step, since this necessitated a removal of gas or gases (typically air) from in between the substrate and top skin.

A review of prior-art proposals shows that the price so far paid for the evacuation step can only be called exorbitant. In order to evacuate the space between substrate and top skin, porous or perforated substrates were used (see U.S. Pat. Nos. 2,855,735, 2,931,495, 2,989,827, 3,583,129, Canadian Pat. No. 555,219, by

L. J. Moncrieff, issued Apr. 1, 1958, and Modern Plastics Encyclopedia, Vol. 45, No. 14A [McGraw-Hill, Oct. 1968] page 567). Use of a porous backing severely limited the utility of the process, since intruding moisture, fungi, oxidizing agents or other contaminants frequently destroyed the packaged goods. Techniques for sealing the pores were either not too effective or then not generally practical. The prior-art vacuum package was thus a "vacuum package" in name only, since the vacuum which was used to form the package did not persist in the formed package. Also, since useful porous backing materials are opaque or translucent at best, permitting no or only scattered passage of light, difficulties were encountered in producing packages through which the packaged objects are visible from all sides.

In an effort to avoid the drawbacks of porous substrates, the U.S. Pat. No. 3,154,898, by E. F. Engles, issued Nov. 3, 1964, proposed the use of a heat shrinkable foamed backing, notably a backing or substrate of polystyrene foam, polyethylene foam and polyvinyl foam. The idea behind this proposal probably was that thermoplastic foamed backings would be generally non-porous because of their closed cell structure. Intensive tests have proved that packages produced according to this proposal provide no sufficient vapor barrier and little or no effective water or moisture protection for the packaged goods. In fact, it was found that a considerable amount of the air was evacuated through the backing, thereby placing these thermoplastic foam backings into the same class as porous cardboard backings.

In retrospect, these test results are not too surprising, since all good plastics handbook lists the relatively high water absorption and vapor transmission of foamed plastics. Also, the gas-bubble-permeated structure and cellular nature of foamed plastics, even those of the closed-cell type, does not lend itself to a maintenance of the degree of non-porosity required of high-quality food or goods packages.

Tests also indicated that only few plastic materials will provide a heat seal between a backing of a foamed version of the plastic material and a top skin of an unfoamed version thereof. The few plastic materials that do seal, generally seal so well that peripheral portions of the package are sealed before the air around the packaged object is evacuated. Air evacuation then proceeds through the supposedly non-porous backing.

Another effect that was observed in testing heat-shrunk thermoplastic backings was the formation of air inclusions around raised portions of the shrunk backing. These air inclusions militate against continued maintenance of a sealed package. This also is believed to have been the chief reason for the manifest preference of porous base sheets in the above mentioned Canadian patent.

That Canadian patent at one point mentions the use of non-porous or but slightly porous coarsely rough or granular or scored backings, referring to coarse glass paper or other granule-coated abrasive paper. With the kind of rigid granules or permanent scores contemplated by the Canadian patent, air inclusions or imperfect bonds are left about the granules or at the scores. It is thus not surprising that the Canadian patent reverts to porous backings in the further course of its disclosure.

Another example of prior-art thinking is apparent from the U.S. Pat. No. 3,216,172, where air evacuation channels between raised projections or dimples are left intact after the evacuation process has been completed, except for a small annular portion which is sealed by a special heat sealing tool. Also, the general arrangement of that prior-art proposal is such that a special conduit is necessary to evacuate the air.

Since the prior art has not been able to evolve a generally acceptable solution, recent prior-art efforts have concentrated on reducing the requisite size of the pores in porous backings, as may be seen in U.S. Pat. No. 3,583,129. Of course, even small pores render vacuum skin packages unsatisfactory in many applications.

In U.S. Pat. No. 3,491,504 the space above the wrapping top sheet is evacuated to maintain that top sheet away from the substrate during evacuation of the space about the object to be packaged. Top sheet and substrate are then sealed and atmospheric pressure is restored above the top sheet to provide for a wrapping of the object. Evacuation of the space above the top sheet on the side removed from the object necessitates the provision, manipulation and control of special vacuum chambers which vary substantially complicate and increase the cost of the packaging process and machinery. Also, the dimensions of extra vacuum chambers in practical installations in some manner have to be tailored to the typical objects to be packaged, whereby the versatility of the packaging machine is necessarily limited.

A revealing example of how an industry learns to resign itself to a seemingly insurmountable obstacle is seen in U.S. Pat. No. 3,358,829. That proposal starts out with the use of a perforated or porous substrate of cardboard, wood, plastic or polyethylene foam. Recognizing the above mentioned drawbacks of a perforated or porous substrate, the proposal in question employs a nonperforated plastic sheet on the substrate. This, of course, obstructs the perforations or pores to a large extent. In consequence, the accomplishment of a tight fit between the top sheet and the object being packaged becomes impossible, since the top sheet seals too rapidly to the bottom sheet that obstructs the perforations or pores.

There thus remains a fillet between the top sheet and the object. This fillet extends around the object, typically to its entire height. This fillet is, of course, a manifestation of the fact that the space inside the package has not been substantially evacuated. In the case of packaged produce and the like, unsightly juices accumulate in the fillet. The package is vulnerable to damage, since the part of the sheet forming the fillet is suspended in air, rather than being backed up by the object. Due to the presence of the fillet the object can shift around in the package. Worse yet, the space taken up by the fillet diminishes the width of the seal between top sheet and substrate.

The typical material for vacuum platens in prior-art skin packaging machines is metal. This provides a heat sink at the substrate which initially retards premature sealing where the substrate is non-porous or only slightly porous. Unfortunately, a metal platen, while cold, will also retard the desired sealing process. Furthermore, a metal platen eventually brings about premature sealing when the metal platen becomes hot in the course of continuous operation.

Another platen material, such as wood, is tolerated when the sealing is to take place after the wrapping process. This is, for instance, the case in U.S. Pat. No. 3,024,579 where an acetone bath is used to seal a vacuum-drawn package. Premature sealing is thus avoided at the expense of extra handling steps and potentially inadequate seals.

Although the above mentioned U.S. Pat. No. 3,358,829 does not teach any deviation from established prior-art practice to use a metal vacuum platen, the coincidence in that patent of large fillets, with their above mentioned disadvantages, and cardboard, wood, plastic and polyethylene foam backings is in retrospect seen as an illustration of a case of premature sealing of the top sheet and substrate.

SUMMARY OF THE INVENTION

In retrospect it may be said that the subject invention synergistically combines a first method which retards the sealing between two sheets of the vacuum pack with a second method which, by itself, would promote premature sealing. The two methods are carefully chosen whereby the first method does not impair, but rather promotes, the quality of the evacuation step and of the resulting seal, while the former premature sealing effect of the second method is, by the synergistic combination, converted to a substantial improvement of the resulting seal and thus of the quality of the entire package.

It is broadly an object of the subject invention to provide novel vacuum skin packaging methods and vacuum skin packs.

It is a further object of the subject invention to provide vacuum skin packaging methods which avoid the above mentioned disadvantages of prior-art techniques.

It is a related object of the invention to provide improved vacuum skin packaging methods and vacuum skin packs in which the formation of air or gas pockets between substrate and top skin and the formation of large fillets are essentially eliminated.

It is a further object of the invention to provide vacuum skin packs having improved sealing properties.

From one aspect thereof, the subject invention resides in a method of packaging an object in a vacuum skin pack formed by evacuating space between a pair of sheets containing the object and sealing the sheets to each other about the object. This method is characterized by the improvement comprising, in combination, the steps of providing a pair of heat-sealable sheets, each being pore and cell-free at least at the sealing surface, forming a multitude of convex protrusions in one of said sheets for providing during the formation of said pack a multitude of collapsible and sealable evacuation channels extending between said sheets and being delimited on opposite sides by said sheets, heating the other of said sheets, providing said object between said sheets and said sheets in proximity to each other, inhibiting the flow of heat from said one sheet in a direction away from said heated other sheet, evacuating the space around said object and between said sheets until said evacuation channels have been formed and continuing said evacuation essentially only through said evacuation channels while said sheets form gas barriers on said opposite sides, heating peripheral portions of said one sheet about said object while said flow of heat from said one sheet is being inhibited, moving said

other sheet tightly against said object by continuing said evacuation essentially only through said evacuation channels, and collapsing said evacuation channels and sealing said evacuation channels by sealing said sheets to one another.

The expression "essentially only" as herein employed is intended to distinguish the subject invention from the above mentioned prior-art technique in which the space inside the package is evacuated through a porous or cellular backing or through evacuation tubing distinct from the sheets.

The expression "pore and cell-free" refers to a freedom from cells, such as the cells of foamed plastics or other cellular materials, as well as to a freedom from pores through which significant amounts of air or gas would be drawn during the evacuation step. No exact dictionary equivalents could be found for these expressions, so that "solid" is herein employed for "pore-free" while "homogeneous" is herein employed for "cell-free". Because of their pore and cell-free structure at least the sealing surfaces, the sheets will form gas barriers on opposite sides of the evacuation channels so that no significant amount of gas (air or other gas mixture or gas) can be drawn through either of the sheets during the evacuation process.

The expression "convex" as herein employed is not intended to be limited to outwardly rounded or curved shapes, but also is meant to cover configurations for the protrusions with curved or slanted sides, wherein the cross-sectional dimension of each protrusion is largest at the base of the protrusion.

The above mentioned step of collapsing the evacuation channels may typically be integral with the evacuation process, in that the evacuation channels are advantageously collapsed by pressure generated by progressive evacuation. In further synergistic operation of the steps of the inventive method, the inhibition of the mentioned flow of heat and the mentioned heating of one sheet are effective to bring about not only a collapse of the evacuation channels, but, if desired, also a collapse of the convex protrusions and a resulting improvement of the sealing effect and quality.

The expression "sealing surface" used in conjunction with the pore and cell-free condition of each sheet is intended to refer not only to the surface at which the sheet is actually sealed to the other sheet, but also to the remainder of the surface which will contact the object. This remainder, too, is a potential sealing surface as the size of the objects to be packaged can be widely varied in accordance with the subject invention.

That the protrusions providing the evacuation channels are made convex is an essential feature which minimizes a formation of gas pockets around or at a location of the protrusions in the sealed package. This solves a cumbersome prior-art problem without resort to disadvantageous porous backings.

As to the broad aspect of the invention, no critical limitation is intended with respect to the manner in which the object to be packaged is placed between the sheets and in which the sheets are provided in proximity to each other. For instance, the object may be placed onto one of the sheets and the other sheet may then be lowered onto the object and toward the other sheet. Or, the one sheet with the object may be raised toward the other sheet.

A preferred embodiment of this invention includes the step of providing thermal insulation adjacent said

one sheet for inhibiting said flow of heat from said one sheet in a direction away from said heated other sheet to aid said other sheet in heating said peripheral portions of said one sheet.

5 A further preferred embodiment of this invention includes the step of driving heat into said one sheet in a direction toward said other sheet to heat at least peripheral portions of at least said one sheet.

Another preferred embodiment of this invention includes the step of reflecting thermal radiation into said one sheet in a direction toward said other sheet to heat said peripheral portions of said one sheet.

A further preferred embodiment of this invention includes the step of providing a heated body adjacent at least said peripheral portions of said one sheet for inhibiting said flow of heat from said one sheet in a direction away from said heated other sheet.

No limitation to any particular method of forming the convex protrusion is intended. For instance, the protrusions may be mechanically preformed or vacuum-formed prior to the evacuation process. Alternatively, the protrusions may, for instance, be vacuum formed or otherwise provided during the packaging process, such as with the aid of an apertured or deformed platen.

25 From another aspect thereof, the subject invention resides also in articles of manufacture made by the methods of the subject invention. These articles of manufacture or vacuum skin packs are superior in quality to prior-art vacuum packs having a porous or cellular backing or large fillets, and are at least more economical than the vacuum packs produced with the aid of special tooling, such as distinct evacuation tubing or special vacuum chambers.

35 Nevertheless, the articles of manufacture of the subject invention are not believed fully susceptible to definition in terms of structure, as far as the inventive features are concerned.

Accordingly, the articles of the subject invention are defined by their method of manufacture.

40 From yet another aspect thereof, the subject invention resides in vacuum pack apparatus employing the methods of the subject invention.

BRIEF DESCRIPTION OF THE DRAWINGS

45 The subject invention will be more readily apparent from the following detailed description of preferred embodiments thereof, illustrated by way of example in the accompanying drawings, in which like reference numerals designate like or functionally equivalent parts, and in which:

50 FIG. 1 is a section through essential parts of equipment for forming protrusions in a plastic sheet, together with a diagrammatic showing of requisite components, in accordance with a preferred embodiment of the subject invention;

55 FIG. 2 is a top view, on a smaller scale, of a fraction of the sheet produced by the method and equipment of FIG. 1;

60 FIG. 3 is a section through a vacuum forming apparatus and illustrates a packaging method in accordance with a preferred embodiment of the subject invention;

65 FIG. 4 is a section through a vacuum skin pack in accordance with a preferred embodiment of the subject invention;

FIG. 5 is a sectionalized detail view of a modification of the apparatus and method of FIG. 3, in accordance

with a further preferred embodiment of the subject invention;

FIG. 6 is a diagrammatic detail view of a further modification of the apparatus and method of FIG. 3, in accordance with yet another preferred embodiment of the subject invention.

FIGS. 7, 8 and 9 are fractional views of modifications of the apparatus and methods of FIGS. 3, 5 or 6 in accordance with further preferred embodiments of the subject invention; and

FIG. 10 is a diagrammatic view of a further modification.

DESCRIPTION OF PREFERRED EMBODIMENTS

The subject invention may be practiced with various types of heat-sealable top and bottom sheets including, by way of example, sheets of ionomer resin, such as those sold by E. I. duPont de Nemours & Company under the registered trademark SURLYN, sheets of polyvinyl chloride, sheets of polyethylene, or sheets of unsaturated polyester resin. If desired, either or both of the sheets may be in the form of a laminate.

Suitable laminates may also be formed in a conventional manner by reinforcing thermoplastic sheets with NYLON or other materials possessing special properties required of the package. NYLON may be incorporated in plastic sheets or laminates for rupture resistance.

According to the subject invention, both sheets are pore and cell-free at least at the sealing surfaces.

According to FIG. 1, a vacuum platen 10 has a multitude of apertures 12 leading from a plenum chamber 13 to the top surface of the platen. A sheet 15 of the desired material, such as an ionomer sheet or another of the above mentioned sheets, laminates or coextrusions, is placed on the top surface 14 of the platen 10. The sheet 15 is heated by thermal radiation and/or convection 16 from a conventional heat source 17 until the sheet material softens. By way of example, suitable heat sources include infrared heat sources, heat lamps, forced hot air equipment, and the like.

A conventional vacuum pump 18, which is connected to the plenum chamber 13, is then actuated. The resulting evacuation of the chamber 13 and apertures 12 will draw parts of the sheet 15 into the apertures 12. In this manner, a multitude of protrusions 20 are formed in the sheet 15. These protrusions are convex because of the action of air pressure during the evacuation process on the softened sheet portions at the apertures. Reference may in this connection be had to pages 776 et seq. of the above mentioned *Plastics Encyclopedia*, containing an article on thermoforming. FIG. 2B of that article shows in dotted lines how a vacuum-drawn softened plastic sheet will assume convex configurations. That article also describes various techniques for making articles or protrusions with slanted sides being within the definition of convex outlined above.

As shown on a somewhat reduced scale in FIG. 2, the protrusions 20 are spaced from each other to provide a multitude of collapsible and sealable evacuation channels 21 to be more fully described in connection with FIG. 3. The protrusions may be offset relative to each other to contort the evacuation channels 21. For instance, as seen in FIG. 2, the protrusions 20 are offset relative to each other to provide contorted evacuation channels as seen in a horizontal and in a vertical direc-

tion. Contorted evacuation channels have the advantage of diminishing the effect of local leaks on the evacuation process during formation of the package.

As seen in FIG. 3, the sheet 15 is placed on a vacuum platen 100 in an inverted position wherein the protrusions 20 project upwardly. An object 22 to be packaged is placed on the sheet 15. As further shown in FIG. 3 in dotted outline, a thermoplastic top sheet 23 is inserted and held between top and bottom portions 24 and 25 of a frame structure 26. This frame structure may be of a conventional type shown in the above mentioned U.S. Pat. Nos. 2,855,735, 2,989,827 or 3,024,579, all incorporated by reference herein, or the above mentioned *Modern Plastics Encyclopedia* issue, at page 567, for instance. The top sheet 23 is heated by the source 17. Upon having attained a sufficient softening temperature, the sheet 23 is moved downwardly. This is preferably accomplished by moving the frame structure 26 in the direction of the arrows 28 and 29 until the frame structure 26 is in the solidly illustrated position shown in FIG. 3. Such frame structure movement may be effected along conventional rails or guides (not shown). It is also within the contemplation of this invention to have the vacuum platen 10 move upwardly towards the sheet 23, rather than have the sheet 23 move downwardly towards the platen.

In the solidly illustrated position, the lower element 25 of the frame structure 26 abuts a vacuum seal 31 around the top of the enclosure 32 of the plenum chamber 13. The softened top sheet 23 is draped over the object 22 as shown in FIG. 3.

In accordance with an essential feature of the subject invention, the flow of heat from the lower sheet 15 in a direction away from the heated top sheet 23 is inhibited. In the illustrated preferred embodiment of FIG. 3, for instance, this is accomplished by the use of thermal insulation. More particularly, the platen used in the apparatus and method of FIG. 3 is made of thermally insulating material, such as low-density wood, thermally insulating ceramics, natural or synthetic felt, or various plastics materials. Once the subject invention has been understood, various suitable materials for the platen become apparent to those skilled in the art. In some of our prototypes we covered the thermally insulating material with a higher-density layer, such as a Dacron or Nylon fabric, to protect the insulating core of the platen and facilitate removal of the formed packs from the platen (see top layer 104' shown in dotted outline in FIG. 8).

The activated vacuum pump 18 evacuates the space 34 occupied by and surrounding the object 22 between the sheets 15 and 23. The resulting vacuum draws portions of the sheet 23 about the object 22 progressively downwardly as indicated by the dotted lines 36, 37, 38 and 39.

In the position indicated by the dotted lines 37 and 38, peripheral portions of the sheet 23 about the object 22 are placed on top portions of the protrusions 20. Despite this close proximity of the sheets 15 and 23, evacuation channels 21 are still provided by the protrusions 20 from space adjacent the object 22 to the periphery of the sheet 15. Accordingly, the evacuation provided by the pump 18 progresses essentially only through the latter evacuation channels while the sheets 15 and 23 form gas barriers on opposite sides of the evacuation channels.

Peripheral portions of the substrate 15 about the object 22 are heated while the flow of heat from the substrate 15 is being inhibited as herein disclosed. By way of example, peripheral portions of the substrate 15 are heated by the source 17 by way of the sheet 23. Unlike the method of the above mentioned U.S. Pat. No. 3,358,829 and other prior-art proposals, the top sheet 23 is moved tightly against the object 22 by continuing the evacuation essentially only through the evacuation channels 21 (see also FIG. 4). There are no large fillets or other voids about the object 22. Premature sealing between the top sheet 23 and substrate 15 is avoided by the protrusions or dimples 20.

The evacuation continuing through the evacuation channels draws top film 23 into conformity with the substrate 15. Owing to the curved or laterally slanted configuration of the convex protrusions 20, an ideal conformity between the top sheet 23 and substrate 15 is possible, and air or gas inclusions and imperfect bonds between top sheet and substrate are minimized.

The drawing of the top sheet 23 into conformity with the substrate 15 progresses continuously toward a sealing of the sheets 15 and 23 to each other about the object 22. This progressively collapses and closes the evacuation channels 21 until the sheets become sealed to each other at the end of the evacuation process and throughout the contacting surfaces of the sheets 15 and 23. An interesting effect due to an essential feature of the subject invention has been noted in practice. Because of the above mentioned inhibition of heat flow from the substrate 15 in a direction away from the top sheet 23, sufficient heat energy is provided and conserved to collapse not only the evacuation channels 21, but, if desired, also the protrusions 20 themselves. This improves the quality of the resulting seal and vacuum pack very substantially.

By way of summary, it will thus be recognized that the evacuation process is prolonged by a retardation of the sealing of the sheets due to the presence of the protrusions 20. In this manner, a sudden cessation of the evacuation process due to a premature contact and sealing of the sheets 15 and 23 is avoided by the subject invention. However, the quality and strength of the resulting seal is at the same time promoted by the disclosed heat flow inhibition.

The vacuum pump 18 is deactivated after the sheets 15 and 23 have become heat sealed to one another at peripheral portions around the object 22. The frame element 24 may then be lifted away from the element 25 and the vacuum skin pack may be removed from the apparatus. Circumferential portions of the sheets 15 and 23 may be trimmed in a conventional manner.

A vacuum skin pack 42 containing the packaged object 22 located on the backing sheet 15 and provided with an outer skin 43 by the top sheet 23 is shown in FIG. 4. The pack 42 has been formed by the method shown in FIG. 3. When a platen 100 having apertures 12 over its area is employed in the method and apparatus of FIG. 3, the upward protrusions 20 are typically drawn downwardly as indicated in FIG. 4 at 20' during the evacuation and sealing process. On the other hand, when a solid platen 101 is employed, the protrusions 20 may be collapsed as mentioned above. The sealed peripheral portions of the substrate 15 and top sheet 23 are then essentially flat as shown at 44, which may not

only improve attainable sealing properties, but also the appearance of the pack 42.

The apertures or channels 12 can be eliminated and a solid platen 101 as in part shown in FIG. 3 may be employed because of the fact that evacuation takes place according to the subject invention through the channels 21 provided by the protrusions 20 between and along the sheets 15 and 23. In accordance with the principles of the subject invention, a solid platen, moreover, can be used, since the disclosed inhibition of heat flow enables a collapsing of the protrusions 20 and a smoothing of the peripheral sheet portions. Downward drawing of the protrusions as shown at 20' in FIG. 4 thus becomes unnecessary.

The vacuum skin pack 42 may be described as having two sheets 15 and 23 containing at least one packaged object 22 and being sealed to one another around the object 22. The sheets 15 and 23 are pore and cell-free at least at the sealing surfaces, including the inner surfaces where the sheets contact the object 22. The sheets 15 and 23 have intimately sealed surfaces where they contact each other and all evacuation channels between the sealed sheets are collapsed and sealed, and the protrusions 20 also may be collapsed and smoothed in peripheral sheet portions.

In the illustrated preferred embodiments, the protrusions 20 are in the form of raised nodes which are spaced from each other to provide the evacuation channels 21. These nodes may also be designated as dimples and the sheet 15 may be designated as dimpled. The requisite convex protrusions may alternatively be provided by corrugating or otherwise deforming either or both of the sheets to form the requisite collapsible evacuation channels 21. On the basis of practical tests, the provision of raised, substantially circular nodes is, however, the best mode presently contemplated. Methods and tools other than those shown in FIG. 1 (such as dimpled rollers) may be employed for forming the convex circular nodes or dimples prior to the packaging process or in situ in the evacuation apparatus.

The sheets 15 and 23 are of light-transparent material if a visibility of the packaged object 22 from all sides of the pack 42 is desired.

In accordance with a preferred embodiment of the subject invention, the substrate 15 is supported by a perforation-free surface while the evacuation channels 21 and the protrusions 20 are collapsed. As a result, the peripheral package portions are essentially flat as seen at 44 in FIG. 4.

According to FIG. 5, a solid platen 103 provides a supporting surface 104 of the latter type. In other words, the means for supporting the sheet 15 include a platen 103 having a perforation-free support surface for the sheet 15. In FIG. 5, the platen comprises or is of a thermal insulating material which may be the same as the material of the platen 101 of the apparatus of FIG. 3. As shown by way of example in FIG. 5, the platen 103 is supported by posts 106 and 107.

The enclosure 32 and adjacent parts of the apparatus define evacuation channels 108 and 109 laterally of the platen 103. The remainder of the apparatus of FIG. 5 may be identical or similar to that of FIG. 3.

As seen in FIG. 6, the requirement that the platen have a perforation-free support surface for the substrate 15 does not exclude the optional presence of marginal perforations. More specifically, the thermally

insulating platen 112 of FIG. 6, which may be of the same material as the platen 101 or 103, has perforations 113 in marginal regions 114 about the perforation-free support surface 104. The perforations 113 do not essentially impair the perforation-free character of the substrate supporting surface 104, since they are outside such supporting surface. In this manner, the peripheral portions of the sheets 15 and 23 will be flat as shown at 44 in FIG. 4.

According to FIG. 7, the above mentioned solid platen 101 (or one of the other perforation-free platens disclosed herein) is provided with a layer of reflective material 116. Materials, such as gold or polished aluminum, which reflect thermal radiation, may be used for the layer 116. As diagrammatically indicated in FIG. 7, thermal radiations 118, which may for instance be provided by the heat source 17, are reflected by the layer 116 to reenter the substrate 15 as reflected thermal radiations 119.

The reflective layer 116 thus constitutes a means for inhibiting the flow of heat from the substrate 15 in a direction away from the top sheet 23, since the layer 116 reflects the thermal radiations back into the substrate 15 in a direction toward the top sheet 23.

According to FIG. 8, a metal supporting platen 121 may be employed in lieu of the platen 101, 103 or 112 of thermally insulating material. The requisite means for inhibiting the flow of heat from the substrate 15 then include a layer of insulating material 123. The layer 123 may be of the same material as the platen 101, 103 or 112.

In the preferred embodiment of FIG. 8, the perforation-free surface 104 for supporting the substrate 15 is formed or defined by the layer 123.

According to FIG. 9, a platen 131 includes means 132 for heating the platen. The platen 131 may be used instead of the platen 101, 103, 112 or 121 in the embodiment of FIGS. 3, 5, 6, 7 or 8. The heating means 132 heat the platen 131 to a temperature at which flow of heat from the substrate 15 in a direction away from the top sheet 23 is inhibited. For instance, the heating means 132 may heat the platen to a temperature which is higher than, or equal to, the temperature to which the substrate 15 is heated by heat from the heated top sheet 23.

As shown in FIG. 9, the heating means 132 may include an electrical heating element 134 which is energized by way of a potentiometer 136 by an electric power source 137. This renders adjustable the temperature of the platen 131.

The heated platen 131 may be of metal or it may, as before, be of a thermally insulating material. The perforation-free surface 104 for supporting the substrate 15 may be provided by the heated platen itself, or by a sheet of insulating material 123 which is located on the platen as shown in FIG. 8.

According to FIG. 10, the packaging process is carried out in a special gas atmosphere. To this end, a supply 47 of an inert gas such as carbon dioxide or nitrogen or highly reactive gas such as ethylene oxide, for instance, is connected to the plenum chamber 13 by a valve 48. There are several possible methods by means of which the gas from the supply 47 may be provided in the space 34 between the sheets 15 and 23. In one preferred embodiment, the space 34 (see FIG. 3) is first pre-evacuated by the pump 18 and the valve 48 is then opened so that the gas from the supply 47 will per-

meate the space 34. Alternatively, the space between the sheets 15 and 23 may be flushed with the desired gas shortly before the frame structure 27 has moved downwardly past the platen 10. In either case, at least a portion of the gas is evacuated through the channels 21 prior to sealing.

The scope of the present invention extends also to methods in which at least one of the sheets is preformed in the manner known, for instance, from conventional blister packs. In that case, the sealing of the top sheet 23 to the backing sheet 15 may generally proceed in the manner described above.

Various other modifications within the spirit and scope of the subject invention will suggest themselves or become apparent from the subject disclosure to those skilled in the art.

I claim:

1. In a method of packaging an object in a vacuum skin pack formed by evacuating space between a pair of sheets containing said object and sealing said sheets to each other about said object, the improvement comprising in combination the steps of:

providing a pair of heat-sealable sheets, each being pore and cell-free at least at the sealing surface;

forming a multitude of convex protrusions in one of said sheets for providing during the formation of said pack a multitude of collapsible and sealable evacuation channels extending between said sheets and being delimited on opposite sides by said sheets;

heating the other of said sheets;

providing said object between said sheets and said sheets in proximity to each other;

inhibiting the flow of heat from said one sheet in a direction away from said heated other sheet;

evacuating the space around said object and between said sheets until said evacuation channels have been formed and continuing said evacuation essentially only through said evacuation channels while said sheets form gas barriers on said opposite sides;

heating peripheral portions of said one sheet about said object while said flow of heat from said one sheet is being inhibited;

moving said other sheet tightly against said object by continuing said evacuation essentially only through said evacuation channels; and

collapsing said evacuation channels and sealing said evacuation channels by heat-sealing said sheets to one another.

2. A method as claimed in claim 1, including in said combination the step of:

providing thermal insulation adjacent said one sheet for inhibiting said flow of heat from said one sheet in a direction away from said heated other sheet.

3. A method as claimed in claim 1, including in said combination the step of:

driving heat into said one sheet in a direction toward said other sheet to heat said peripheral portions of said one sheet.

4. A method as claimed in claim 1, including in said combination the step of:

reflecting thermal radiations into said one sheet in a direction toward said other sheet to heat said peripheral portions of said one sheet.

5. A method as claimed in claim 1, including in said combination the step of:

providing a heated body adjacent at least said peripheral portions of said one sheet for inhibiting said flow of heat from said one sheet in a direction away from said heated other sheet.

6. A method as claimed in claim 1, wherein: said provision of said object between said sheets includes the steps of locating said object on said one sheet and draping said heated other sheet over said object.

7. A method as claimed in claim 1, wherein: both of said sheets are made of light transparent material.

8. A method as claimed in claim 1, wherein: the sealing of said sheets to each other about said object is retarded by said protrusions to prolong the evacuation of said space; and said sealing of said sheets to one another is intensified by said inhibition of said flow of heat to improve the resulting seal between said sheets.

9. A method as claimed in claim 8, wherein: said convex protrusions are collapsed in said peripheral portions of said one sheet with the aid of heat flowing from said heated other sheet while said flow of heat from said one sheet is inhibited.

10. A method as claimed in claim 1, wherein: said convex protrusions are collapsed in said peripheral portions of said one sheet with the aid of heat flowing from said heated other sheet while said flow of heat from said one sheet is inhibited.

11. A method as claimed in claim 10, wherein: said one sheet is supported by a perforation-free surface while said evacuation channels and said pro-

trusions are collapsed.

12. A method as claimed in claim 1, wherein: said protrusions are provided by forming a multitude of convex raised nodes in said one sheet, said nodes being spaced from each other to provide said evacuation channels.

13. A method as claimed in claim 12, wherein: said raised nodes are offset relative to each other to contort said evacuation channels.

14. A method as claimed in claim 1, wherein: said space is provided with a substantially inert atmosphere prior to evacuation thereof.

15. A vacuum skin pack containing at least one packaged object and comprising two sheets sealed to one another around said object and being pore and cell-free at least at surfaces where said sheets are sealed and at inner surfaces where said sheets contact said object, said vacuum skin pack having been made by a method as claimed in claim 1.

16. A vacuum skin pack as claimed in claim 15, wherein:

the sealing of said sheets to each other about said object is retarded by said protrusions to prolong the evacuation of said space; and

said sealing of said sheets to one another is intensified by said inhibition of said flow of heat to improve the resulting seal between said sheets.

17. A vacuum skin pack as claimed in claim 15, wherein:

said sheets have essentially flat sealed peripheral portions around said object.

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