

[54] OVERHEAD GARAGE DOOR SECTIONS

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[51] Int. Cl. **E04b 2/10**

[58] Field of Search 160/201, 229, 232, 236; 264/46, DIG. 14, 48, 54; 52/309; 161/159, 166

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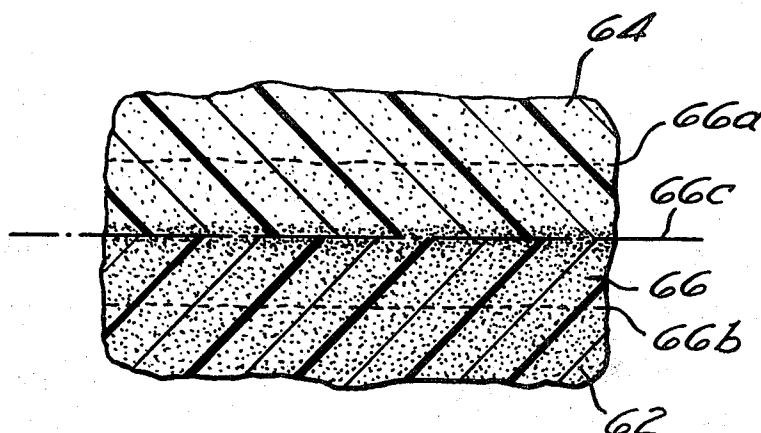
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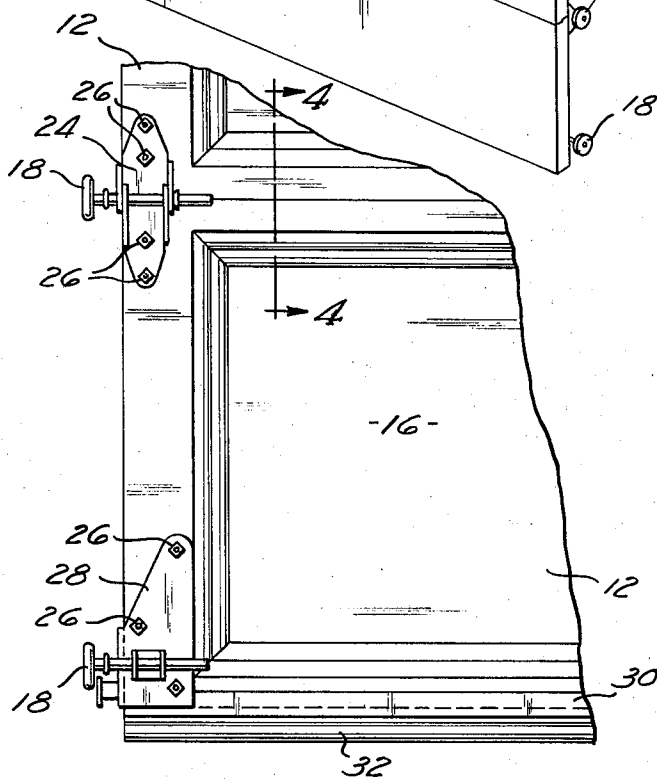
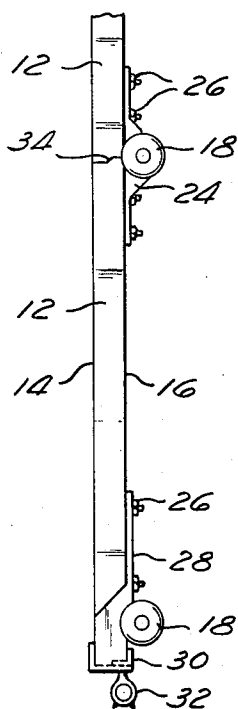
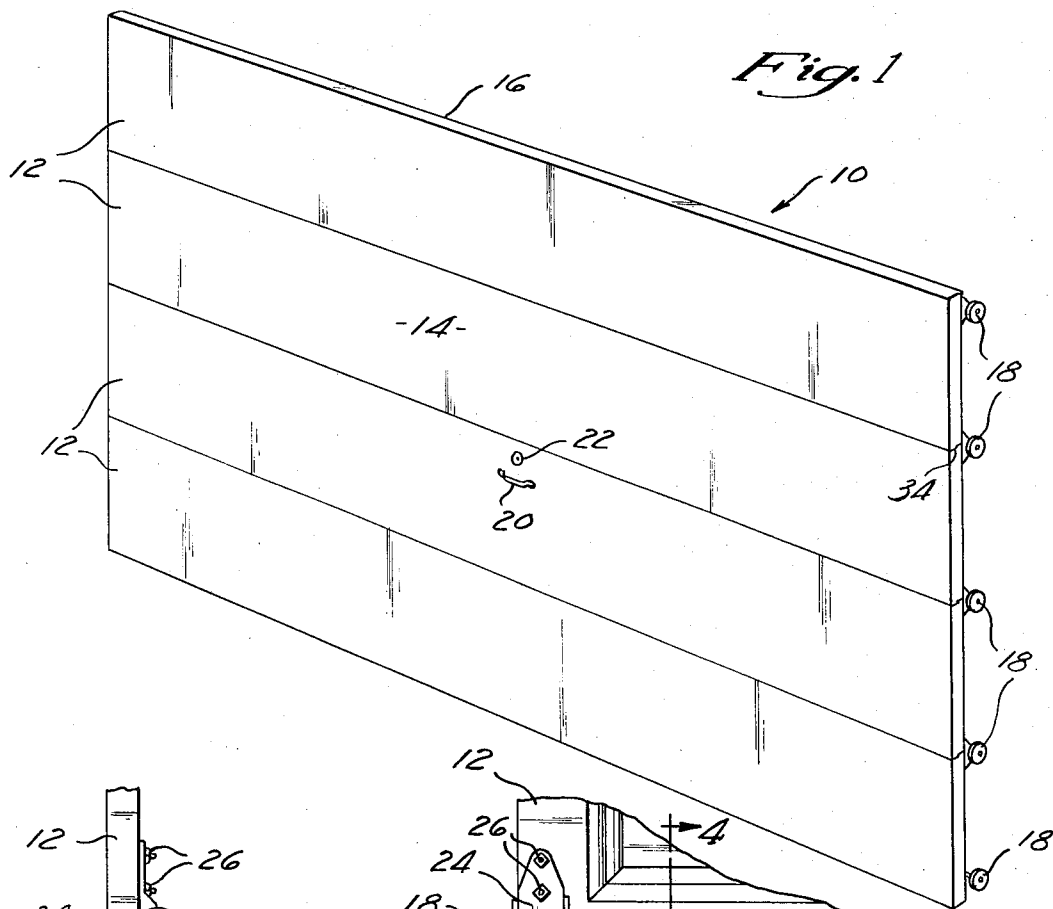
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ABSTRACT

An articulated closure comprising a plurality of hingedly connected sections adapted to be positioned adjacent a structural opening is provided. The sections cooperate to define reversible closure surfaces facing opposite sides of the structural opening. Each of the sections is integrally formed of a closed-cell, rigid polyurethane foam which provides a central core substantially enclosed within an integrally connected, substantially continuous skin of increased density. According to one aspect of the invention, the section further includes a case structure which is integrally molded with the low density core and has a relatively higher density. The case is chemically and mechanically bonded to the core at an interface zone having a higher average density than the core and the case so that the interface zone serves as an inner reinforcement for the section. According to another aspect of the invention, the case is provided with reinforcing means substantially embedded therein and comprising a net-type structure or randomly oriented glass fibers. In addition, methods of forming such sections are provided.

10 Claims, 10 Drawing Figures





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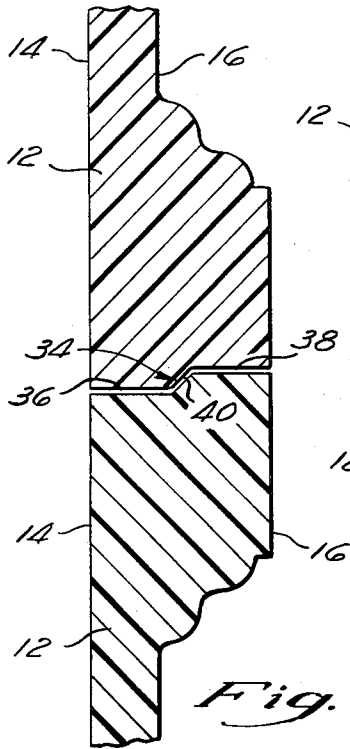


Fig. 4

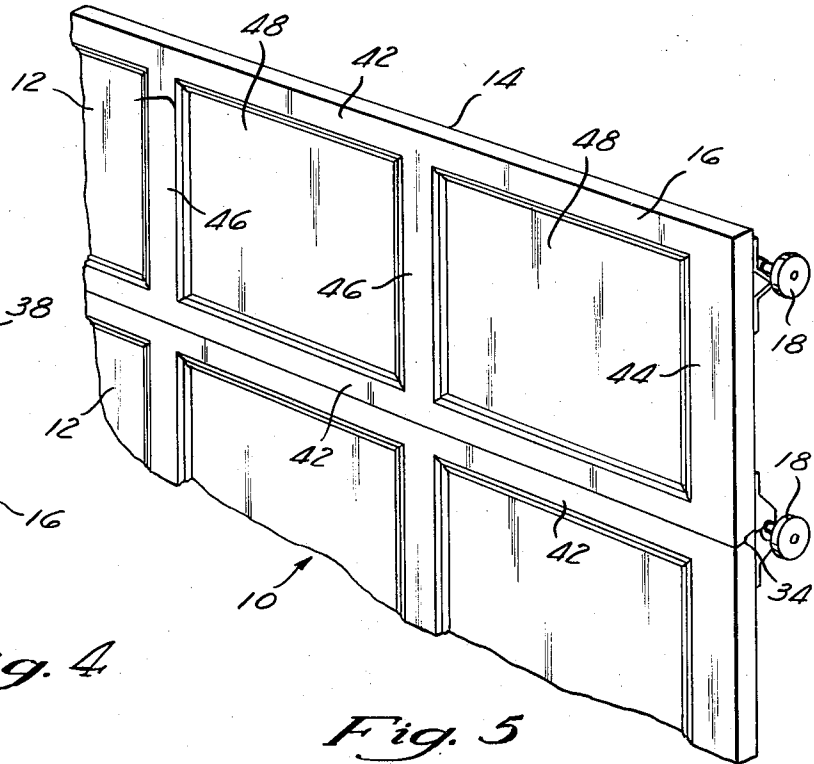


Fig. 5

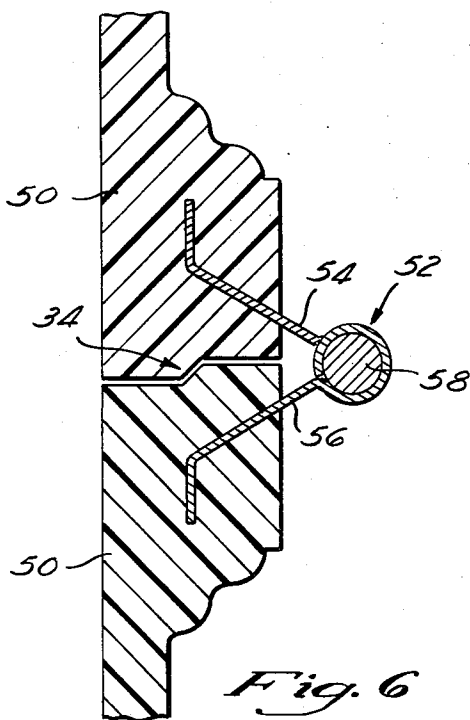
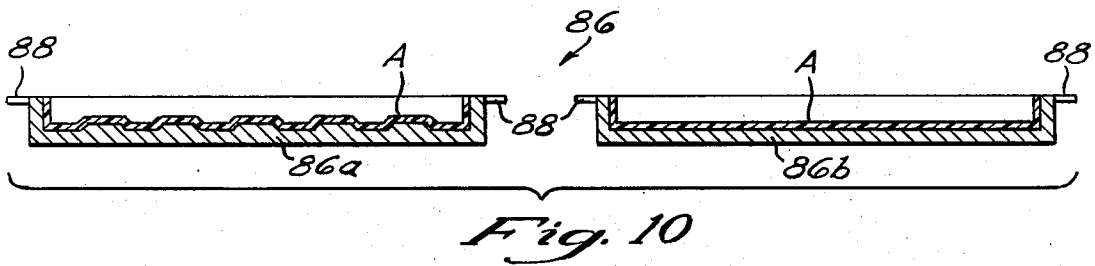
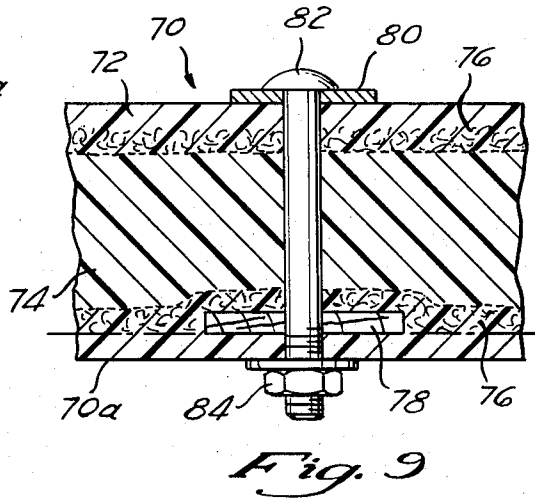
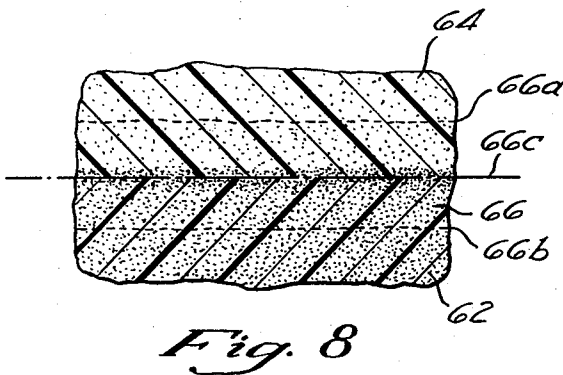
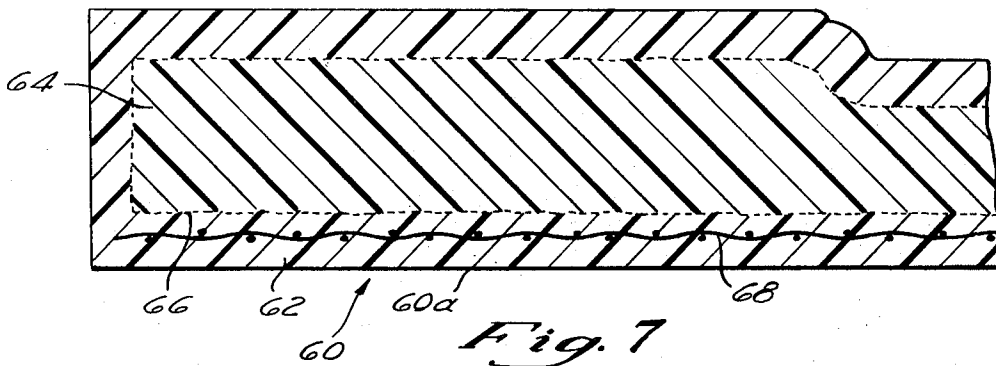


Fig. 6

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OVERHEAD GARAGE DOOR SECTIONS

This application is a continuation-in-part of our co-pending application, Ser. No. 70,839, filed Sept. 9, 1970 now abandoned.

FIELD OF INVENTION

This invention generally relates to articulated closures such as overhead garage doors, having a plurality of hingedly connected sections, and, more particularly, to a novel and improved closure wherein the sections are formed of a rigid polyurethane foam having an integral exterior skin of increased density and provide interchangeable closure surfaces.

PRIOR ART

Overhead garage doors of the general type with which this invention is concerned are formed of flexibly articulated sections which are adapted to be guided from an overhead storage position to a vertical closed position adjacent a door opening. Such doors may be spring-tensioned or power-driven to facilitate the opening and closing thereof, and are employed in both residential and commercial structures. The door sections are desirably formed of sturdy but lightweight materials which have good insulating and weather-resisting properties.

In the past, garage doors have been typically made of materials such as wood, wood laminates, hardboard, solid plastic materials reinforced with woven glass fiber cloth, or metal, as well as combinations of these materials. In addition, the use of cellular plastic materials to form an inner lamina or core which is bonded to oppositely disposed, wood reinforcing laminae is known in the prior art. Although such materials are generally adequate for some structural purposes, they are not entirely satisfactory when used to form garage doors.

The wood compositions are highly susceptible to weathering, and particularly, moisture absorption. In order to avoid rapid and excessive moisture damage, it is necessary to periodically paint the wood surfaces with various types of weather-resistant paints and varnishes. Even though these wood surfaces may be regularly treated with paints and varnishes, the wood compositions are frequently subject to moisture damage.

The moisture damage to wood compositions includes warpage and distortion of the door, which may result in misalignment of the door with the door opening and with a track and roller system in which the door sections are mounted. Consequently, it may be necessary to realign the door and/or replace the door sections when severe warpage or distortion occurs.

When a hardboard material supported by a wood frame is employed, moisture absorption tends to cause the unsupported or exposed hardboard sections to flex in a convex or concave fashion with respect to the wood frame. This permanent deflection is aesthetically displeasing and structurally undesirable, since the rigidity of the door is diminished.

The wood composition laminates frequently tend to delaminate as a result of moisture absorption. In this case, the outermost lamina tends to separate from the body of the laminate. This separation is exceptionally harmful, since the weather-resistant paint or varnish is only applied on the outermost lamina. Consequently, the exposed interior laminae may deteriorate at an even greater rate due to the moisture absorption. Ac-

cordingly, it is frequently necessary to replace entire door sections because of delamination.

Similar delamination and distortion problems have been found to occur when laminates of different types of materials are employed. Such problems are encountered when a foamed resin core is adhesively bonded to exterior laminae. Since the different materials may have wide variations in their coefficients of thermal expansion, the delamination and distortion problems are accentuated. In this case, changes in temperature may result in the stressing of the bonds between the laminae and rupture thereof. In addition, the variations in thermal expansion may cause separations and gaps to occur between the different materials of the door sections. Such separations permit the relatively unimpeded penetration of moisture, which accelerates the rate and increases the severity of the resulting moisture damage.

It should be appreciated that all such laminate structures involve costly step-wise production techniques necessitated by the layered structure which may involve intermediate curing steps. Further, it is often necessary to include multiple adhesive applying steps wherein the uniform application of the adhesive must be maintained to assure uniform bonding so as to avoid the formation of stress concentration points at unbonded sites. Even though uniform adhesive application and bonding may be achieved, it should be appreciated that such an adhesive bonding layer frequently constitutes a plane of weakness in the overall structure.

Since wood composition materials are subject to a relatively high degree of moisture absorption, variations in weather conditions and moisture exposure also tend to cause the weight of door sections to fluctuate. In some cases, the door sections tend to absorb moisture in a random manner so as to result in an uneven weight distribution. Consequently, it is difficult to maintain the proper spring balance in a spring-tensioned door system. In the case of a power-driven door system, an uneven weight distribution tends to cause irregular movement of the door by the power drive and excessive wear of the drive as well as the door supporting structure.

In order to eliminate the problem described above, a variety of metal materials have been employed for such door structures. Although metal doors eliminate some of those problems, they are more expensive than some of the non-metal materials. Since metal doors are generally heavier than comparable wooden structures, it is necessary to provide a stronger, more expensive door mounting structure for metal doors. Since metal doors are subject to corrosion and/or rust due to continuous moisture exposure, it is also necessary to periodically paint metal doors with protective paints. In addition, the relatively high coefficient of thermal conductivity of metal, as compared to wood, has resulted in additional insulation problems in some instances. Thus, the use of metal doors has been limited by their cost and they still have serious disadvantages.

SUMMARY OF THE INVENTION

The present invention provides an articulated closure comprising a plurality of hingedly connected sections adapted to be guided to a position adjacent a structural opening. The sections cooperate to define reversible closure surfaces which face opposite sides of the open-

ing. The sections are molded plastic bodies comprising a closed-cell, rigid polyurethane foam core and integral outer skin of increased density which completely surrounds the lower density core and imparts additional toughness to the exterior surfaces of the closure.

In one of the illustrated embodiments, each door section is provided with a high density foam case which substantially, completely encases a foam core. The case is integrally connected to the core at an interface zone having a cellular structure characterized by the chemical bonding and mechanical interengagement or interlocking so as to contiguously unite the case and core without the use of additional adhesive materials. The interface zone has a higher average density than the case and the core so that it serves as an internal reinforcing means for the molded section.

When it is desirable to provide additional strength and rigidity, additional reinforcing means may be completely encased within the section. The encasement of the reinforcing means within the section results in the achievement of reinforcing strength and rigidity without the prior art disadvantages of a laminate structure as described more fully hereinafter.

The integral skin, the closed-cell structure, and the inherent tendency of polyurethanes to repel water cooperate to substantially eliminate moisture absorption and the associated problems encountered in the prior art. For example, the polyurethane foam door section is not subject to warpage, deterioration, such as rotting or corrosion, delamination, or weight variation due to moisture absorption.

As indicated above, the integral structure of each of the door sections also eliminates delamination problems as well as the problems associated with the different degrees of thermal expansion and contraction displayed by the various laminae of laminated prior art structures. In particular, since the door section of the present invention is primarily formed of an integrally joined, single material having varying densities, there is no tendency for delamination or distortion to occur.

The primary structural material of the closure, polyurethane foam, displays a very low coefficient of thermal expansion over a broad range of temperatures. For example, such foams undergo no dimensional changes at temperatures as low as -20°F. , and only slight dimensional changes at temperatures as high as 160°F. Consequently, the foam door sections of the closure substantially eliminate the prior art problems associated with thermal dimensional changes.

Since the sections cooperate to provide reversible or interchangeable closure surfaces, the sections can be structured to provide two visually different closure surfaces. For example, in one of the illustrated embodiments, one closure surface is essentially planar and the other surface is nonplanar, geometrically configured pattern. In this manner, the same set of door sections is adaptable for use with either of two different styles of architecture.

The present invention also provides methods of forming such sections, with or without additional reinforcing materials, which is semi-continuous and eliminates the prior art step-wise, laminate assembly techniques which require intermediate curing steps in some cases. The method of the present invention utilizes the chemical and mechanical bonding of a contiguously disposed, compressively retained foam forming solution and a partially cured foam layer to provide an integrally

formed section of exceptional strength. Thus, the method eliminates the prior art use of adhesives to bond individual laminae and the possible formation of undesirable planes of weakness as well as stress concentration points between laminae.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective, front view of an overhead garage door according to one aspect of the present invention;

FIG. 2 is a plan view on an enlarged scale of a portion of the back of the door shown in FIG. 1;

FIG. 3 is a side elevational view of a portion of the door shown in FIGS. 1 and 2;

FIG. 4 is a sectional view on an enlarged scale, taken along the line 4—4 of FIG. 2;

FIG. 5 is a fragmentary, perspective, front view, on an enlarged scale, of the door shown in FIG. 1, with the sections reversed;

FIG. 6 is a sectional edge view of another aspect of the present invention, having integrally molded hinges connecting adjacent sections;

FIG. 7 is a sectional edge view of yet another aspect of the present invention, having an inner core surrounded by an outer case with reinforcing means comprising a net-type structure embedded therein;

FIG. 8 is an enlarged, fragmentary, sectional view illustrating the interface zone between the inner core and outer case portions of the door section shown in FIG. 7;

FIG. 9 is a sectional edge view of still another aspect of the present invention using randomly oriented fibrous reinforcing material; and

FIG. 10 is a schematic illustration of a split mold useful in forming a door section according to the teachings of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, there is illustrated an overhead garage door 10 comprised of hingedly connected door sections 12. The door sections 12 cooperate to define a front door surface 14 and a back door surface 16. The door 10 includes track rollers 18 which are adapted to travel in spaced trackways (not shown) so as to guide the door from an overhead storage position to a substantially vertical closed position adjacent a doorway opening (not shown).

A conventional handle 20 may be secured adjacent the front door surface 14 for purposes of opening and closing the door 10. A similar handle (not shown) may be provided adjacent the back surface 16 of the door 10. In addition, the door 10 may be provided with a lock 22 of conventional construction.

Referring to FIGS. 2 and 3, a portion of the back surface 16 of the door 10 is illustrated. As there shown, the upper track roller 18 is supported by a conventional residential hinge 24. The hinge 24 is secured to each of the adjacent door sections 12 by bolt and nut fasteners 26. Thus, the hinge 24 pivotally connects the adjacent door sections 12 and secures the track roller 18 to the door.

The roller 18, located adjacent the lower extremities of the door 10, is secured thereto by a conventional bottom bracket 28. The bottom bracket 28 may also be secured to the door by bolt and nut fasteners 26. A bottom expander 30 is provided adjacent the closing or abutting edge of the door 10 and secured thereto by

bolt and nut fasteners 26. The bottom expander 30 is formed of metal and it is designed to protect the door when it is inadvertently closed upon objects lying within the opening of the doorway.

The bottom expander 30 is adapted to retain a seal 32 which is formed of a rubberlike material. The seal 32 extends across the entire width of the door 10, and it is adapted to form a weatherseal with the abutting doorway opening surface. Since the seal 32 is formed of a rubberlike material, it also serves as a bumper or cushion for the closing impact of the door 10.

As best shown in FIG. 4, the adjacent door sections 12 form a ship lap joint 34 having a step-shaped cross section. The ship lap joint 34 is formed of a first portion 36 extending to a second portion 38. The two portions 36 and 38 are connected by an intermediate portion 40 which is upwardly inclined when the door is in a closed position. Thus, the second portion 38 adjacent the back surface of the door 16 is elevated with respect to the first portion 36, which is adjacent the front surface 14 of the door. Consequently, the step-shaped cross section of the ship lap joint 34 substantially eliminates the flow of water or moisture therethrough to the interior of the garage.

Referring to FIG. 5, a portion of the door 10 is shown with the door sections 12 reversed in the sense that each of them is rotated 180 degrees about a horizontal axis so as to interchange the front door surface 14 and the back door surface 16 from the arrangement shown in FIGS. 1 through 4 so that the surface 16 is now the front or exposed outside surface of the door 10. Thus, the door sections may be initially assembled so as to expose either of their panel surfaces to the outside. As may be noted by a comparison of FIGS. 4 and 5, the ship lap joint 34 has the same inwardly and upwardly stepped cross section in both cases so as to impede the penetration of water therethrough.

The door sections 12 are structured to provide two visually different closure surfaces 14 and 16. As illustrated, the surface 14 is substantially planar and provides an appearance suitable for a contemporary style home. By contrast, the surface 16 is provided with geometrically configured recessed panels 48 formed by horizontally extending rails 42, vertical stiles 44, and vertical muntins 46. The closure surface 16 is designed for use with a colonial style home. Thus, a single set of sections 12 may be assembled to provide either of two different architectural styles. Accordingly, the manufacturer and the distributor are able to reduce their inventories of such closure units without limiting the variety of architectural effects obtainable.

As indicated above, the door sections 12 are formed of a molded closed-cell, rigid polyurethane foam and each of the sections includes an integrally formed, thin outer skin 12a which has an increased density. The types of polyurethanes which are useful in the present invention are formed by the exothermic reaction of an isocyanate with a polyhydroxy material or polyol. Although both polyether and polyester polyols are useful, polyether polyols are preferable from a cost standpoint. The rigidity and degree of closed cells present are influenced by the polyol selected. For example, low molecular weight polyols which display a high degree of branching are useful in forming closed-cell rigid foams of the type employed in the present invention.

During the course of the urethane-forming isocyanate-polyol reaction, a foam structure is imparted to

the polyurethane by the production of a gaseous compound within the reaction mixture. For example, a foam structure may be provided by generating carbon dioxide by the reaction of water with isocyanate during the urethane forming reaction. Another known method of providing at least part or all of the foam structure involves the addition of volatile liquid which is subsequently vaporized by the heat of reaction developed during the course of the exothermic urethane forming reaction.

In the latter method, the preferred class of volatile materials are the alkanes and the fluoro-substituted alkanes. Specific examples of such materials include trichlorofluoromethane, dichlorofluoromethane, dichlorotetrafluoroethane, trichlorotrifluoroethane, ethyl chloride, methane and ethane. When a closed-cell foam structure is produced and such blowing agents are employed, the closed cells retain the blowing agents in the gaseous state (where the blowing agent is a gas at room temperature) for at least a considerable period of time. This retention is especially useful where the blowing agent is a fluoroalkane or a chlorofluoroalkane, since it tends to enhance the insulation value and the fire-resistant properties of the foam.

The structure and physical properties of the urethane foam are also influenced by a variety of other factors, including the incorporation of surfactants, catalysts, and fire-retardancy agents. The incorporation of fire-retardancy agents renders the foam nonburnable or self-extinguishing. This is highly desirable for safety reasons, and a clear advantage over prior art wooden composition door materials.

Although rigid polyurethane foams can be produced with a wide range of densities, the door sections are preferably provided with an average core density of from about 2 to about 10 pounds per cubic foot. Rigid foams within this density range have provided satisfactory insulation, sound deadening, and strength properties. In addition, the door produced of such a rigid foam is approximately one-third the weight of a conventional wood door. Accordingly, the door supporting structure and other hardware necessary for installation are relatively less expensive.

Referring to FIG. 6, another aspect of the present invention is illustrated. As there shown, the door sections 50, which are similar to the door sections 12 and include an integrally molded thin external skin 50a, are connected by an integrally molded hinge 52. The hinge 52 is securely retained within the sections, since urethanes adhere tightly to metal as well as a wide variety of other structural materials. Although any type of hinge may be employed, the hinge 52 is a double-leaf piano hinge having its associated leaves 54 and 56 integrally molded in the adjacent sections. The piano hinge 52 may extend along the entire horizontal length of the door sections 50, or suitable portions thereof. The associated leaves 54 and 56 are retained in an interlocked condition by a pivot bar 58.

Although the embodiment illustrated in FIG. 6 does not provide reversible closure surfaces, it should be noted that multiple hinges may be provided on opposite sides of the door sections so as to permit reversibility. In this instance, a decorative appearing hinge would be employed. The oppositely disposed hinges which are not being employed to connect the sections would be operatively disconnected. For example, the pivot bar

58 would be removed from the hinge 52 so as to permit independent movement of the leaves 54 and 56.

Referring to FIGS. 7 and 8, there is shown another aspect of the present invention. According to this aspect of the invention, a door section 60 is provided with an outer case portion 62 and an integrally connected inner core portion 64. The case and core are both formed of a rigid polyurethane foam and they are integrally connected at an interface zone 66 disposed between hypothetical zone boundary lines 66a and 66b. These boundary lines are not subject to precise location based upon visual observations and they are depicted herein as shown for convenience and clarification in describing the interface zone. It should be understood that the zone 66 is continuous and it exists at all locations intermediate the adjacent regions of the inner core and outer case.

The outer case 62 is formed of a high density rigid polyurethane foam and it provides a covering structure for the section. A relatively thin face skin 60a of significantly higher density and substantially less thickness is provided adjacent the exterior surface of the case. The average density of the case excluding the skin 60a and the interface zone 66 is in the range of from about 15 pounds per cubic foot to about 60 pounds per cubic foot. Satisfactory results have been obtained when the case is provided with an average density ranging from about 20 pounds per cubic foot to about 30 pounds per cubic foot.

In a typical garage door installation, the outer case 62 is provided with a thickness ranging from about one-sixteenth inch to about three-sixteenths inch. Generally, it has been found that a case thickness of about one-eighth inch provides the door section with adequate rigidity and strength.

The core 64 is formed of a relatively lower density rigid polyurethane foam and average density varies within the range of from about 1.2 pounds per cubic foot to about 12.0 pounds per cubic foot have been found to provide suitable door section structures. The optimum thickness and density of the core is a function of the overall dimensions of the door section and the thickness of the case.

The physical characteristics of the interface zone 66 are primarily determined by the method by which it is formed, as will become more apparent hereinafter. The density of the interface zone has a maximum value adjacent an intermediate planar location therein, which is indicated by hypothetical line 66c for convenience, and decreasing values at planar locations spaced therefrom which ultimately correspond with the average densities of the adjacent outer case and inner core. Accordingly, the density of the zone increasingly varies from the opposite, outer regions thereof to a maximum value adjacent the intermediate planar location 66c.

The region adjacent the hypothetical intermediate plane 66c is characterized by a cellular structure which is not susceptible to planar delamination in destructive testing, thus indicating the strength of the interface zone adjacent the intermediate plane 66c to be greater than that of the opposed inner core and outer case. Generally, the failure occurred in the low density core portion during the destructive tests.

A uniting of the case and core portions occurs within the interface zone and is characterized by mechanical interengagement of the portions and chemical bonding therebetween. The mechanical interengagement and

chemical bonding phenomena, which are defined and discussed more fully below, cooperate to unite the portions without the formation of an adhesion plane between disjuncted laminae as known in the prior art, since the uniting of the portions occurs throughout the interface zone which provides a continuity of structure not clearly susceptible to physical location by precise boundaries.

The mechanical interengagement of the inner core and outer case portions relates to the mechanical adhesion or bonding resulting from the physical interlocking developed by contacting an irregular surface with a flowable material which is subsequently cured. In this instance, the mechanical interengagement is further enhanced by the positive pressures developed during the molding process which assure the contiguous relationship of the ultimate portions formed and tend to promote the physical interlocking thereof.

With regard to the chemical bonding between the portions, this phenomenon includes both the intermolecular forces of adhesion and/or cohesion and chemical reaction bonding. With regard to the latter, such bonding may include both polymer chain extension and cross linking which assure a continuous structure.

The interface zone 66, therefore, is a zone of relatively high density material which constitutes an inner reinforcement means which is not subject to chipping or spalling as would a purely external reinforcement means.

The door section 60 may be provided with reinforcing means of a net-type structure having openings therethrough, such as metal netting 68, embedded within the outer case 62 of the door section when additional strength and rigidity are desired. The metal netting may be treated to enhance the adhesion between it and the rigid foam. However, it should be appreciated that the ultimately cured foam structure is essentially continuous through the openings of the net structure, and the metal netting is substantially embedded and enclosed within the case 62.

A suitable metal netting has been provided by the use of one inch mesh, poultry netting of 20 gage galvanized steel wire. This metal netting material is particularly suitable for commercial uses where security is an important consideration.

Although the net-type structure may be disposed throughout the case so as to surround the inner core, satisfactory results have been obtained with the net structure disposed in the outer case adjacent only one of the closure surfaces. Consequently, it has been found convenient to limit the disposition of the net structure to the outer case adjacent a planar exterior surface of the section.

Although metal netting has been found particularly useful in commercial applications, it should be appreciated that other net-type materials have been found to provide satisfactory results. For example, a known, continuous filament, glass fiber, woven netting has also provided suitable rigidity and impact strength for such door sections. For this purpose, a relatively open, square woven, glass fiber netting having a fiber or strand count per inch of 10 by 20 is suitable. Of course, a broad range of such nettings having various types of weaves and strand counts may be employed. However, it is preferable to utilize a relatively open weave pattern so as to insure complete "wetting" of the reinforcement.

Referring to FIG. 9, there is shown another embodiment of the present invention comprising a door section 70 including a case 72 and a core 74 similar in structure to that of the door section 60. In this embodiment, the reinforcing means comprise randomly oriented, chopped glass fibers 76. The chopped fibers are embedded within an interior region of the case 72 adjacent the core 74 throughout the entire extent of such region so as to completely surround the inner core of the section. The fibers may be of any suitable length and satisfactory results have been obtained with fibers having lengths in the range of from about one-half inch to about 2 inches.

It should be appreciated that the chopped fibers are preferably but not necessarily limited to disposition in the interior region of the case. This disposition of the chopped fibers is preferable for a number of reasons.

Initially, the chopped fibers are spaced from the exterior surfaces of the door section for aesthetic purposes. Specifically, their presence adjacent the exterior surfaces may detract from the provision of a simulated wood grain exterior appearance and otherwise provide a somewhat non-uniform finished surface. In addition, the substantial encasement of the chopped fibers within the interior regions of the case 72 eliminates the possibility of moisture transfer to the interior portion of the door section by way of capillary action.

The embodiment shown in FIG. 9, also illustrates the use of additional, substantially disjuncted, local reinforcing means such as the elongated wood slat member 78. Such reinforcing means are disposed to provide local reinforcement adjacent hinge sites and, therefore, they typically coincide with the stiles or muntins in a patterned door section.

Although the reinforcing member 78 comprises a wood slat, it should be understood that any material providing a sufficiently rigid structure could be utilized. For example, the reinforcing member may be formed of metal, a compatible solid plastic material, or an integral layer of high density foam. It should be appreciated that such reinforcing means could also be employed in the previously discussed embodiments of the present invention with or without the use of reinforcing net-type structures or chopped glass fibers.

As shown in FIG. 9, the wood slat 78 is disposed adjacent a hinge 80 which is secured to the door section by means of a bolt 82 and a threadedly engaged nut 84. During the installation of the door, an appropriate bore for the bolt 82 may be provided by means of drilling a hole through the section and the reinforcing slat.

The door sections 12, 50, 60 and 70 are molded within a closed, split half mold 86 including halves 86a and 86b, as schematically shown in FIG. 10. Each of the mold halves includes interior surfaces which cooperate to define the section to be formed when the mold halves are closed.

The mold is formed of a metal or like material having a relatively high coefficient of thermal conductivity and conventional release agents are employed. The exothermic heat of the urethane reaction, which promotes the generation and/or volatilization of cell-forming gases, is rapidly dissipated by walls of the mold.

In practice, the mold is generally preheated to retard the heat dissipation and assure flowability and/or wetting-out of the interior surfaces of the mold by the liquid foam resin. However, the temperature of the poly-

urethane reaction is reduced in the regions adjacent to the interior walls of the mold. Consequently, thin integral skins 12a, 60a, 50a and 70a are formed at the external surfaces of the door sections. The skin is a less cellular, higher density layer of polyurethane which provides a tough surface for the door section, as well as a barrier against moisture penetration.

A conventional barrier coat for urethanes may be applied over the release agent previously applied to the mold surfaces. The barrier coat is retained on the surface of the molded product or door section to protect the polyurethane against ultraviolet degradation.

The door sections can be provided with uniquely in-laid designs which are either not available or are economically impractical in prior art structures, since each section is integrally molded as a single unit. As illustrated by the closure surface 16, multiplanar designs can be provided without combining separate pieces. Furthermore, such intricate designs can be formed without a significant increase in the manufacturing costs.

In the case of the door sections illustrated in FIGS. 1 through 6, there is provided a single deposition of foam within the mold halves. The mold halves are then closed and secured to one another by clamp means or the like (not shown) locking the mating flanges 88 of the mold halves together. The section is then cured and removed from the mold.

When it is desirable to provide a case such as outer case portions 62 and 72, the split half mold 86 is utilized in a somewhat different manner. In this instance, it is of course necessary to utilize foam forming solutions formulated to provide cured foams having two different, predetermined average densities. The variation in density may be achieved by conventional means such as utilizing polyols of different molecular weights as well as adjusting the amount of blowing agent.

A high density foam forming solution A which ultimately forms the case of the door section is initially applied to the inner mold surfaces of the mold halves 86a and 86b. The deposition of the foam forming solution may be achieved in any manner, although the use of conventional urethane spray apparatus has been found satisfactory. The deposited foam solution forming the case of the section is permitted to freely expand or blow until its rise is completed. As previously indicated, the blowing of the foam is an exothermic reaction and the heat generated results in temperatures ranging upwards from room temperature initially to about 190°F. as measured at the surface of the foam portion being formed.

Subsequent to the completion of the rise of the solution A, which ultimately forms the case, but prior to any significant degree of curing of the foam and while the surface temperature thereof is still above room temperature, a low density foam forming solution which ultimately forms the core portion of the section is deposited over the solution A or the semi-cured outer portion in at least one of the mold halves. The deposition of the low density foam solution may also be achieved by means of conventional apparatus. The mold halves are immediately closed and secured following the deposition of the low density foam forming solution.

It should be appreciated that the low density foam forming solution is deposited while the semi-cured outer portion is still at an elevated temperature, as a re-

sult of the exothermic reaction, in order to achieve the desired flow of the low density solution as well as a maximum surface wetting-out thereby so as to provide a uniform density. Thus, the exothermic heat of reaction of the case is somewhat analogous to the preheating of the mold 86 with regard to the wetting-out of the low density, core forming foam solution.

The low density core forming solution is deposited at about 25 percent excess or overpour based upon the calculated amount of foam solution required to form the inner portion of the section with the predetermined average density. The deposition of excess foam results in packing and the development of positive molding pressures upon the closing of the mold halves. It should be understood that the percentage excess or overpour may range from about 10 to about 30 percent in order to achieve a good fill and provide the positive pressures necessary for the mechanical and chemical interengagement and bonding of the case and the core as previously discussed.

The time lapse between the completion of the rise of the case and deposition of the foam solution forming the core is a primary factor in the achievement of an interface zone having the mechanical interengagement and chemical bonding characteristics previously described. This time relationship is illustrated by the three test samples discussed below. In each of the test samples, the same rigid, polyurethane foam forming solutions were used, namely; a high density, 20 pound per cubic foot, case foam solution and a low density, 2 pound per cubic foot, core foam solution. Further, equal volumes of foam forming solutions were employed in identically sized molds.

In the first test sample, the time lapse following completion of rise was about 20 seconds and the surface temperature of the case was about 140°F. when the low density, core foam solution was deposited. In the second test sample, the time lapse was about 3½ minutes and the surface temperature of the case was about 110°F. In the third test example, the time lapse was about 19½ minutes and the surface temperature of the case was about 72°F. Each of the test samples was thereafter cured for a period of 24 hours.

Each of the cured samples was tested for delamination between the core and the case. The first and second test samples did not show a plane of delamination upon destructive testing but rather resulted in fracture substantially limited to the low density core indicating achievement of the interface zone described above.

The third test sample did result in actual delamination at a plane which formed between the case and the core. In addition, the core did not provide a sufficient fill although the same volumes of foam solution were employed in each of the test samples. The latter is believed to be related to the relatively low temperature (72°F.) of the outer portion at the time of the deposition of the core and an insufficient wetting-out by the foam core forming solution.

With regard to the wetting-out of the core foam forming solution, the surface temperature of the case at the time of the core deposition should be in the range of from about 100°F. to about 140°F. However, in practice, it may be desirable to maintain a lower temperature limit of about 120°F. to provide an interface zone of optimum strength.

When it is desirable to provide the door section with additional strength and rigidity through the use of rein-

forcing means of a net-type structure, such as metal netting 68, the above described method is slightly modified to permit the incorporation of the net-type structure in the section. Specifically, the deposition of the foam solution forming the case of the section is interrupted and performed in two steps.

In the first step, about one half of the foam solution A is initially deposited on the inner surfaces of the split mold half 86b. The foam deposition is then interrupted and the netting is disposed on the solution already disposed within the mold. If the netting does not assume a satisfactory planar configuration, it may be provided with such by means of mechanical tensioning thereof or magnetic forces provided by disposing appropriate magnetic means below the mold half. Of course, when a glass fiber net-type structure is employed for reinforcing means, it generally assumes a planar configuration or it may be mechanically tensioned to provide the same.

Subsequent to the positioning of the net-type structure, the remaining portion of the foam solution A is deposited over the net and the initial portion of the foam solution previously deposited. This step is performed as soon as possible to assure the formation of a substantially continuous case having the net-type structure embedded therein. The remaining steps of the method are essentially identical to those described above.

When it is desirable to employ reinforcing means comprising randomly oriented fibers, such as glass fibers 76, the case is similarly deposited within the mold in two steps. In this instance, the fibers may be simultaneously introduced in the second step of the case foam deposition by incorporation of the fibers within the foam forming solution being deposited. In practice, this method has been satisfactorily achieved by means of conventional urethane spray apparatus including means to introduce the chopped fibers at the spray mixing head.

The provision of local reinforcing means such as the member 78 is also achieved by means of a two step deposition of the foam solution A which forms the case of the section. In this instance, the reinforcing members are disposed upon the initial coating of the solution A and the remaining steps of the method are the same as those described above. Of course, additional reinforcing means such as net-type structures or chopped fibers may also be utilized with the local reinforcing members.

The specific details of the preferred form and method of the invention as described and shown herein are merely illustrative and may be modified in various ways within the scope of the invention as defined in the appended claims.

What is claimed is:

1. An articulated closure adapted to be guided into a position adjacent a structural opening, including closure surfaces disposed adjacent opposite sides of said opening, comprising a plurality of hingedly connected sections, each of said sections having a thickness substantially less than its width or length and including first and second section surfaces cooperating to define said closure surfaces, each of said sections being a single molded plastic material comprising a closed-cell rigid polyurethane foam of varying densities, having a relatively low density core, an integrally formed external case of increased density, and a cellular reinforcing in-

13

terface zone between the core and case having an average density higher than the average core density and the average case density, portions of said interface zone being substantially coextensive with each of said section surfaces and spaced apart by the thickness of said core.

2. An articulated closure adapted to be guided into a position adjacent a structural opening, including closure surfaces disposed adjacent opposite sides of said opening, comprising a plurality of hingedly connected rectangular sections, each of said sections including first and second section surfaces cooperating to define said closure surfaces, each of said sections being a single molded plastic material comprising a closed-cell rigid polyurethane foam of varying densities, having a relatively low density core, an integrally formed external case of increased density substantially surrounding and enclosing said core, and a cellular reinforcing interface zone between the core and case having an average density higher than the average core density and the average case density.

3. An articulated closure as set forth in claim 1 wherein said case substantially, entirely surrounds and encloses said core.

4. An articulated closure as set forth in claim 3 wherein the density of said interface zone progressively increases through its thickness from opposed regions thereof located adjacent said core and said case to a maximum value at an intermediate location within said interface zone.

5. An articulated closure as set forth in claim 4

14

wherein said interface zone provides both mechanical interengagement and chemical bonding between said core and said case.

6. An articulated closure as set forth in claim 1 wherein said case includes reinforcing means substantially, completely embedded therein, and said reinforcing means is substantially coextensive with the planar extent of each of said sections.

7. An articulated closure as set forth in claim 1 wherein said case includes local reinforcing means substantially, completely embedded therein, said reinforcing means comprising substantially disjuncted members which are more rigid than said case and core.

8. A closure as set forth in claim 6 wherein said reinforcing means comprise a net-type reinforcing member having openings therein, and said case substantially, entirely fills said openings to provide said case with a substantially continuous structure having said net-type member embedded therein.

9. A closure as set forth in claim 6 wherein said reinforcing means comprise randomly oriented, glass fibers, and said fibers are embedded substantially, completely within the regions of said case adjacent to said core, said regions being spaced from the exterior surfaces of said sections.

10. An articulated closure as set forth in claim 2 wherein said closure surfaces are reversible and said first and second section surfaces cooperate to define said reversible closure surfaces, each of said sections forming an interlocking joint with adjacent sections.

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