Feb. 14, 1967 M. H. NICKERSON 3,304,219

ENERGY ABSORBING MATERIALS

Filed May 2, 1962

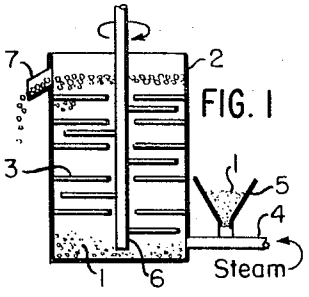


FIG. 1

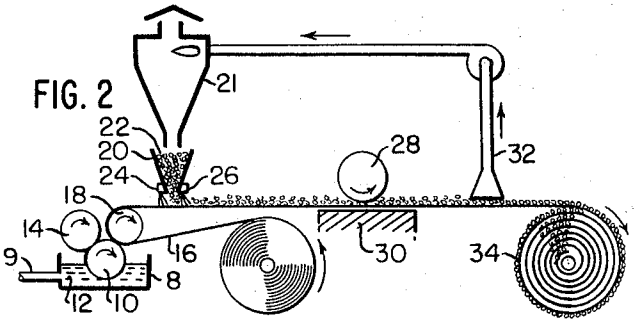


FIG. 2



FIG. 3

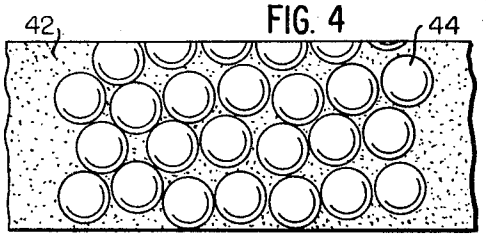


FIG. 4

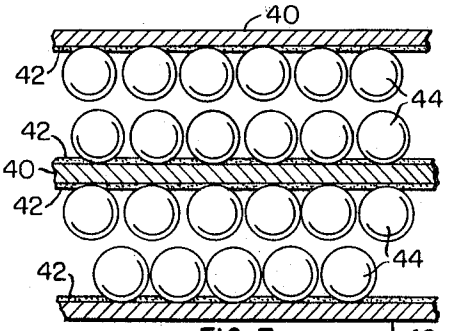


FIG. 7

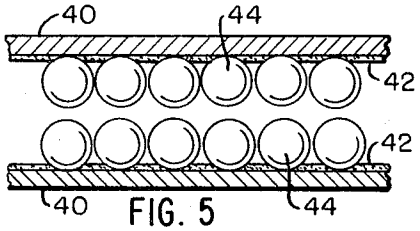


FIG. 5

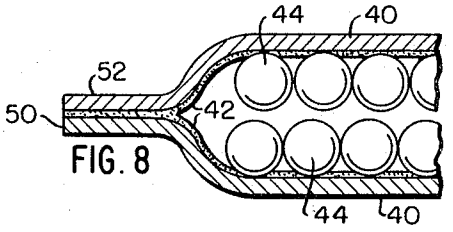


FIG. 8

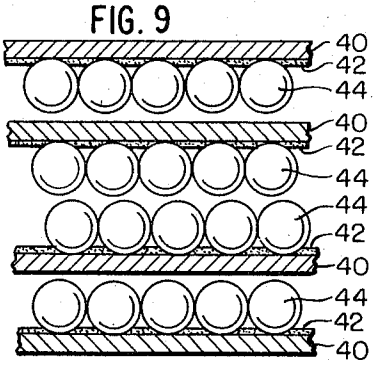


FIG. 9

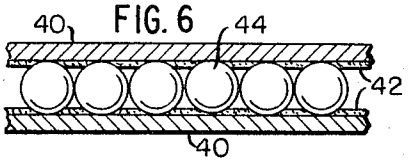


FIG. 6

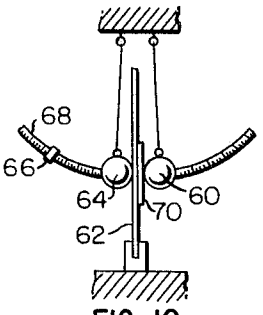


FIG. 10

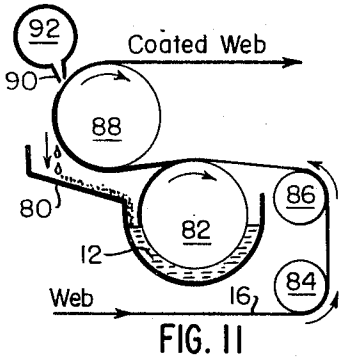


FIG. 11

INVENTOR.
MORTIMER H. NICKERSON
BY Kenway, Jenney & Hildreth
ATTORNEYS

United States Patent Office 3,304,219 Patented Feb. 14, 1967

3,304,219

ENERGY ABSORBING MATERIALS

Mortimer H. Nickerson, Winchester, Mass., assignor to Arthur D. Little, Inc., Cambridge, Mass., a corporation of Massachusetts

Filed May 2, 1962, Ser. No. 191,864
12 Claims. (Cl. 161—162)

My invention relates to packaging materials and more particularly to energy absorbing packaging materials.

Most articles of commerce will at some time have to undergo shipment from their place of manufacture to the place where they will be used. During this shipment the article must be protected from physical damage. Traditionally, paper in one form or another has been one of the most widely used materials. In flat sheets, such as kraft paper, it provides reasonably adequate protection against soiling and a moderate resistance to abrasion but very little resistance to impact. To increase the impact resistance, paper has been built up into corrugated box board structures. Employing conventional corrugated box constructions, considerable impact resistance can be incorporated into a shipping container. However, it is still frequently necessary to provide additional protection for the article within the box.

One method of providing protection for the articles has been to pack the space surrounding the article in the shipping container with excelsior or other loose material such as macerated paper. While reasonably effective energy-absorbent packing can be achieved in this manner, the recipient of the packaged article is faced with a messy unpackaging operation. Furthermore, the packaging is basically unsuited for precision articles which might be damaged by foreign particles or excessive dust. To reduce the unpackaging problems, the macerated paper is sometimes packaged itself. However, such packaging pads are often punctured, either in transit or upon unpackaging, with the result that the macerated paper fibers are still a problem.

More recently a clean energy absorbent packaging medium has been achieved through the use of integral plastic foam structures. Normally, a mold is prepared which will produce a foam plastic structure proportioned to fit the article rather closely. While these plastic foam containers produce a clean and effective integral shipping assembly, they are of necessity rather expensive. Expensive, carefully engineered molds must be made for each article to be shipped. In addition, the molding machinery employed is complex and expensive, involving presses, injection nozzles, and control devices. These factors add substantially to the cost of the packaging structures. Thus, the integral foam structures are limited in their utility to articles of manufacture of relatively high value. With such articles, the additional packaging cost can be tolerated. However, for general packaging utility, the integral foam structures are at a severe economic disadvantage.

Accordingly, it is an object of the present invention to provide relatively inexpensive energy absorbing packaging material.

Another object is to provide energy absorbing packaging material which can be utilized with a wide variety of articles.

Still another object is to provide energy-absorbent material of very light weight.

A further object is to provide packaging material of increased cleanliness.

A still further object is to provide energy absorbing packaging material which can be easily fabricated to provide varying degrees of impact protection.

These and other objects of the present invention are achieved in a packaging assembly wherein energy absorbing particles are affixed to an adhesive layer applied to

the surface of a flexible web. A further feature is the use of expanded plastic beads to form a monoplanar layer adjacent to a flexible web. These and other features of the present invention will become apparent in the following description in conjunction with the drawings wherein:

FIG. 1 is a schematic view of apparatus for producing expanded beads;

FIG. 2 is a schematic view of machinery for producing energy absorbing packaging materials according to my invention;

FIG. 3 is a cross-section view of packaging material according to my invention;

FIG. 4 is a plan view of the material of FIG. 3;

FIG. 5 is a cross-section view of a double layer energy absorbing packaging material assemby according to my invention;

FIG. 6 is a cross-section view of a double web single layer energy absorbing packaging material assembly according to my invention;

FIG. 7 is a cross-section view of a quadruple layer energy absorbing packaging material assembly according to my invention;

FIG. 8 is a cross-section view of an energy absorbing pad assembly according to my invention;

FIG. 9 is a cross-section view of another four layer energy absorbing packaging material assembly according to my invention;

FIG. 10 is an elevation view of apparatus to test energy absorption; and

FIG. 11 is a schematic view of machinery for producing energy absorbing packaging materials according to my invention.

Referring now to FIG. 1, apparatus suitable for producing energy absorbent particles for use in my invention is shown. The container **2** is partially filled with spherical beads **1** of polystyrene. Such beads, approximately 0.05" in diameter, are readily available on the commercial market in a form containing a low boiling liquid. Steam is admitted to the container **2** through the aspirator pipe **4**. The supply of polystyrene beads **1** is contained in hopper **5**. These beads feed into the flow of steam in aspirator pipe **4** and thus provide a continuing supply of beads for expansion in container **2**. The steam raises the temperature of the beads **1** to about 100° C. At this temperature, the polystyrene beads are softened. The low boiling point liquid contained within the beads begins to vaporize, and this vaporization causes the heat softened beads to expand. A stirring assembly **6** rotates within the chamber between the fixed rods **3**. This rotation continually moves the beads so that they do not stick together as they expand. The result is a free flowing mass of discrete expanded beads. The expanded beads are lighter and rise to the top of container **2** where they are discharged through overflow chute **7**.

Apparatus such as that just described in connection with FIG. 1 is in general use commercially, but normally the beads produced are utilized solely as an intermediate product. These beads are used to make the integral foam plastic products previously discussed. In such processes, mold cavities are filled with the expanded beads, and moderate pressure at temperatures slightly above 100° C. causes the beads to fuse together to form a continuous uniform structure. I have found that the expanded polystyrene beads can advantageously be used as individual discrete energy absorbing units in structures according to my invention.

Apparatus suitable for producing energy absorbing packaging materials according to my invention is shown in FIG. 2. An adhesive mixture **12** is contained within the tank **8**. The heating element **9** controls the temperature of the adhesive mixture. A casting roller **10** rotates partially submerged within the adhesive **12**. A metering

roller **14** rotates in such a manner that its surface at the point of closest proximity is moving in the opposite direction to that of the surface of roller **10**, thus serving to provide a uniform layer of adhesive on roller **10**. The web material **16**, kraft paper for instance, passes over the face roller **18** which rotates in the direction of motion of the web material. The casting roller **10** rotates in the direction opposite to the motion of the web **16** with the result that an adhesive layer is transferred to the web **16** as it is pressed lightly against the surface by roller **18**. The rolls **10** and **14** may be heated to a desired temperature of adhesive application. Typically, rollers **10** and **14** may be fabricated of cast iron. Rubber is a suitable material for roller **18**. The web continues under hopper **20** which is filled with polystyrene beads **22**. The hopper **20** has brushes **24** and **26** which sweep the beads into essentially a monobead layer. The brushing action does not completely remove all unneeded beads so that a slight excess remains on the web **16** as it leaves the hopper **20**. The web then passes between a weighted roller **28** and a platen **30**. The weighted roller **28** presses the beads **22** into firm contact with the adhesive layer which has been transferred to the web **16**. A vacuum cleaner **32** situated after the weighted roller **28** removes any excess beads and returns them to a cyclone separator **21**. The cyclone separator **21** feeds these beads back into hopper **20**. The completed packaging material is now rolled up on a takeup roller **34**.

FIG. 3 shows an expanded view of the cross section of packaging material produced in the apparatus of FIG. 2. The web base **40** is coated on one side with adhesive layer **42**. This adhesive layer **42** is substantially continuously coated with a layer of expanded polystyrene beads **44**. As shown in plan view in FIG. 4, these polystyrene beads **44** form a substantially continuous monobead layer of discrete energy absorbing particles. Since the only application of adhesive is to the base web **40**, the beads touch adhesive only on the portion of their surface which is adjacent to the supporting web. The surfaces of the beads which touch other beads are not coated with adhesive. Therefore, the beads are free to move with respect to each other, although each bead remains affixed to its point of contact with the supporting flexible web.

By way of example, kraft paper of a weight of 40 pounds per ream was utilized in apparatus according to FIG. 2. The reverse roll coating assembly consisting of rolls **10**, **14** and **18** applied an adhesive layer at a weight of 50 pounds per ream. The adhesive used was a combination of GRS type rubber plasticized with a hydrocarbon oil such as that sold under the tradename of Dutrex and a resin based material such as Vinsol. The adhesive also contained a small amount of water to confer liquidity. The adhesive layer was applied at a temperature of about 215–220° F. At this temperature the adhesive was a viscous mass. Immediately after the web **16** had received the adhesive coating, the expanded polystyrene beads were distributed by the hopper **20**. The expanded beads had an apparent bulk density of 1.5 pounds per cubic foot. That is, a one cubic foot volume poured full of the beads would weigh 1.5 pounds. The paper was coated smoothly and without difficulty at speeds of 40 feet per minute.

The kraft paper and expanded polystyrene bead packaging product just described was then utilized in two layers to provide an energy absorbing packaging material assembly of the type shown in FIG. 5. As shown in FIG. 5, a structure consisting of two layers of the product described in conjunction with FIG. 3 was utilized. Each layer has a base web **40** which is coated with an adhesive layer **42**. To this flexible adhesive coated web a monoplanar layer of expanded beads **44** is applied. The use of a compound structure incorporating two monoplanar layers of energy absorbing particles provides increased impact resistance.

To test the packaging material product according to the above example of my invention, tests were made with a double ball pendulum tester as shown in FIG. 10. In this test, a steel ball pendulum **60** swinging through a measured arc impacts a firmly clamped steel plate **62**. The energy is transmitted through the plate to a second steel ball pendulum **64** which then swings from its rest position against the plate. Since the two ball pendulums are identical in size and weight, the arc through which the second ball pendulum swings, when compared to the arc through which the first ball pendulum passed, provides an accurate measure of the energy transmitted through the plate. The arc is measured by a rider **66** on scale **68**. In the absence of any energy absorbing test specimen, the transmitted energy is very nearly 100%. When a sample of energy absorbing material **70** to be evaluated is placed over the steel plate on the impact side, the relative swing of the second pendulum **64** provides an accurate measure of the energy which was absorbed by the pad. In the tests discussed herein, the striking pendulum and the second ball pendulum were fabricated utilizing steel balls three inches in diameter and of 3.74 pounds weight. In the tests, the striking pendulum impact was 1.72 foot pounds of energy.

Utilizing the previously described construction of FIG. 5 comprising two flexible webs coated with monoplanar layers of 1.5 pounds per cubic foot bulk density beads, the energy absorption was 57.4%. If successive impacts were made at the same point, the energy absorption decreased to 27% upon the fourth impact.

As noted above, the beads themselves are not coated with adhesive and therefore are not bonded to one another but rather solely to the flexible web. Since the monoplanar bead layer is therefore discontinuous in the sense that the energy absorbent particles are not bonded to each other, the flexibility of the assembly is essentially that of the web itself. Therefore, there is little hindrance to the wrapping or folding of the combined assembly as may be required in packaging. It will be understood that the foamed particles provide impact energy absorption but contribute little, if anything, to abrasion resistance or protection against soiling. These latter functions, particularly the isolation of the packaged article from atmospheric particles, are performed by the flexible web. The following Table I gives energy absorption results with structures according to FIG. 5 utilizing various web materials. In each case, the same test apparatus, as previously described, was utilized. The beads were the same 1.5 pounds per cubic foot foamed polystyrene beads discussed in conjunction with the operation of the apparatus of FIG. 2. While the adhesive utilized is believed to have little effect on the energy absorption, the same plasticized rubber adhesive was utilized.

Table I

Composition of web:	Percent energy absorbed
1 mil "Mylar"	59.4
1 mil biaxially oriented polystyrene	54.0
Kraft paper (40 lbs. per ream)	57.4
2.25 mil polyethylene	61.5
Kraft paper coated ½ mil polyethylene	52.6
1 mil aluminum foil	55.1

It will be seen that the web material makes relatively little difference in the energy absorption. Tests on the web-adhesive combination in the absence of the expanded polystyrene beads showed virtually no energy absorption. The web material does, of course, make considerable difference in tear strength and moisture permeability. One of the valuable advantages of the present invention is the applicability of the structure to a wide variety of webs so that the best material for the application under consideration can be utilized.

The particular energy absorbent particles utilized can make a substantial difference in the performance of energy absorbing packaging materials produced according

to my invention. Table II tabulates results with two types of beads and with two packaging assembly configurations. These packaging assembly configurations are identified by reference to the drawing number in which that arrangement is illustrated. One of these is that previously discussed in conjunction with FIG. 5. The other is shown in FIG. 6 and consists of a flexible web **40** and an adhesive layer **42**, a monoplanar layer of beads **44** affixed to this layer, as previously described, and a second flexible web **40** with an adhesive layer **42** applied to the other surface of the monoplanar layer of beads. In all cases, the flexible web was 40 pounds per ream kraft paper. The expanded polystyrene beads utilized were of lighter density than those of the previous example, being 0.65 and 1.0 pound per cubic foot as indicated. Four successive impacts at the same point were utilized, and each of the four is tabulated in succession for each type assembly. It will be seen that the assemblies utilizing two layers of energy absorbing beads provided substantially more impact resistance. Furthermore, these assemblies retained their impact resistance well on successive impacts. However, even the single bead layers retained a substantial proportion of their impact resistance after four successive impacts with the steel pendulum ball.

Table II

Structure	Apparent Density (lbs. per cubic foot)	Percent Energy Absorption at Indicated Impact			
		1	2	3	4
Fig. 6	0.65	37.0	30.0	24.0	22.8
Fig. 5	0.65	66.0	57.0	50.0	48.0
Fig. 6	1.0	34.5	27.5	23.5	21.6
Fig. 5	1.0	66.0	42.5	40.0	31.6

It is interesting to compare the impact resistance for packaging material assemblies in Tables I and II which utilize the same structure, that is the structure of FIG. 5. It will be noted that the results tabulated in Table II are superior. It is believed that this increased energy absorption results from the fact that the polystyrene beads utilized in the examples of Table II are larger in diameter than those utilized in the examples of Table I. Whereas the expanded beads in the structures of Table I averaged less than $\frac{1}{16}$" in diameter, those utilized in the structures of Table II averaged over $\frac{1}{16}$" in diameter. Furthermore, as will be noted from the apparent bulk densities, the expanded beads utilized in the examples of Table II are substantially lighter per unit volume.

Energy absorption with a structure according to FIG. 5 utilizing the small, relatively dense beads on a kraft paper web went from about 57% on the first impact to 27% at the fourth impact. Energy absorption with an equivalent structure utilizing large, intermediate density beads went from 66% to about 32% with four impacts. Energy absorption with an equivalent structure utilizing the lightest density beads went from 66% to 48% with four impacts. Since a package may receive repeated impacts at the same point during shipment, an ability to retain energy absorbing qualities enhances the breadth of the packaging applications for which these structures are suited. For the most difficult applications, the high energy absorbing structures can be combined with a web of substantial strength, such as a web of the plastic sheeting currently available from the Du Pont Company under the tradename of Mylar. Such structures will provide both high impact resistance and high tear resistance.

While a particular adhesive has been described in conjunction with the above embodiments, the adhesive used to bind the particles of foam to the web does not have critical requirements. There is little shearing action of the beads on the web, and the function of the adhesive is merely to keep the beads in place. When the packaging material is performing the principal function of impact energy absorption, no load at all is placed on the adhesive, since the particles and the web are in compression. A variety of adhesives have been used successfully, including solvent based rubber cements, aqueous latices of synthetic rubbers or polyvinyl acetate, and hot melts based upon plasticized coumarone-indene resins.

It is desirable that the adhesive layer retain some tack after drying or cooling, in order that foam particles which may be dislodged in use become reattached readily. The adhesive should be of the relatively soft and flexible type in order that it will not break up or deteriorate upon flexing of the carrying web. While reverse roll coating has been illustrated and described, any of the other conventional means of adhesive coating, such as air knife or doctor blade, may be used. For extremely fluid adhesives, such as latices, coating equipment incorporating an air knife may be preferable.

A suitable coating system incorporating an air knife is shown in FIG. 11. The adhesive **12** is contained within a pan **80**. A cast iron applicator roller **82** rotates partially submerged in the adhesive. The web **16** passes over idler rollers **84** and **86** and backup roller **88** is such that the web **16** is pressed lightly against the applicator roller **82**. The applicator roller **82** rotates in a direction opposite to the motion of the web **16**, and a generous coating of adhesive is wiped onto the surface of the web. As the web passes over the backup roller **88**, the air knife **90** removes excess adhesive from the web. The air knife **90** is continuously supplied with air under pressure through air duct **92**. The excess adhesive returns to the pan **80**. As noted above, this coating system is preferable to that of FIG. 2 if extremely fluid adhesives are utilized.

While foam polystyrene beads have been utilized in the described embodiments, other energy absorbent particles may be utilized. For example, particles obtained by dicing or granulating other types of plastic foam, such as cellulose acetate, polyurethane, and polyvinylchloride are also suitable. However, for many purposes the foam polystyrene bead is the most convenient since it is easily fabricated and handled. Expandable polystyrene beads are a standard article of commerce from a number of suppliers, and for general foam molding purposes are supplied unexpanded in diameters averaging about 0.05". When expanded by the usual process outlined in FIG. 1, these give beads averaging about $\frac{1}{8}$" in diameter.

By screening, one can obtain a fraction of expendable but unexpanded beads averaging 0.070" in diameter. When these beads are expanded by the usual process previously described, one obtains expanded beads averaging 0.220" in diameter, and further, such beads have a lower apparent bulk density that the smaller beads. While structures utilizing these larger beads produce a more bulky padding, the use of such large, low density beads offers advantages in efficiency of energy absorption, particularly in retention of energy absorbing power after repeated blows.

In the molding of integral structures, the smaller beads are preferred since they pass through small gates and runners in the molding equipment more readily. However, the larger beads are preferred for use with my invention and may be obtained at no premium in cost. In fact, they are presently less expensive than the smaller beads.

FIG. 7 illustrates another assembly configuration suitable for use with any of the above materials in severe packaging situations where increased impact resistance is necessary. A flexible web **40** is coated on both surfaces with adhesive **42**. The energy absorbent particles **44** are applied to both adhesive coated surfaces. Two operations with the apparatus of FIG. 2 will produce such a

structure. Then on each side of that central structure, an additional monoplanar layer of beads affixed to a flexible support web in the manner of FIG. 3 is utilized. The resulting structure includes three flexible webs and four layers of energy absorbent particles. Such an assembly provides very substantial impact resistance and also provides a high degree of tear protection. The same degree of tear protection, but less impact resistance, can be achieved if the two outermost layers of energy absorbent materials are eliminated and the two outer flexible webs are adhered to the central monoplanar layers of absorbent material.

A preferred structure which provides four layers of energy absorbent particles is shown in FIG. 9. This structure can be assembled from a plurality of single layer structures of the type shown in FIG. 3. Thus, a single coating operation, such as that shown in FIG. 2 or FIG. 11, can be utilized. Moreover, it is unnecessary to coat both surfaces of any of the webs with adhesive. In each case, the web has an adhesive coating applied to only one surface. The central portion of the structure set forth in FIG. 9 consists of two facing layers of energy absorbent particles **44** applied to flexible web **40** coated on one surface with adhesive **42**. In other words, the central portion of the FIG. 9 structure corresponds with the structure of FIG. 3. Two additional layers of energy absorbent particles are provided, each layer being applied to a flexible web **40** coated on one surface with adhesive **42** in the manner of the structure of FIG. 3 These additional layers are applied on each side of the central structure so that each exterior surface is formed by a web **40**.

If still greater energy absorption is required, additional layers constructed according to the structure of FIG. 3 can be utilized with the structure of FIG. 9. Thus, packaging structures of differing energy absorption characteristics can be produced from one supply of particle coated web material. Table III tabulates the energy absorption obtained with such structures. The number of layers of energy absorbing beads varies from one to five.

Table III

Structure	Number of Impacts	Percent Energy Absorbed	
		Pcf. Beads 0.9	Pcf. Beads 1.5
One ply with web (Fig. 6)	1	52.8	36.4
	2	27.3	14.0
	3	20.0	10.5
	4	17.0	9.8
Two ply, web outside (Fig. 5)	1	76.5	68.0
	2	58.3	38.3
	3	46.2	29.4
	4	42.4	24.5
Three ply, web outside (Fig. 5 plus Fig. 3).	1	98.0	93.9
	2	91.2	72.2
	3	85.1	59.7
	4	81.6	52.9
Four ply, web outside (Fig. 5 plus two of Fig. 3).	1	98.1	96.8
	2	95.3	93.9
	3	95.4	91.4
	4	95.7	85.7
Five ply, web outside (Fig. 5 plus three of Fig. 3).	1	----------	97.6
	2	----------	96.9
	3	----------	95.0
	4	----------	92.0

It will be noted that, as in the previously discussed results, the lighter density beads (0.9 as compared to 1.5 pounds per cubic foot) provide greater energy absorption and retain their energy absorption characteristics better. In fact, the four-ply structures with low density polystyrene foam beads absorb substantially all impact energy even on the fourth successive impact. With five layers of energy absorbing particles, the structure utilizing the more dense beads also absorbs substantially all the energy even on the fourth impact.

While the above described packaging materials according to my invention can be used directly in sheet form, it is desirable for some applications to fabricate the materials into bags or pads. My invention is readily adapted to such operations by leaving sections of the adhesive coated flexible web free from the monoplanar layer of energy absorbing particles. For example, as shown in FIG. 8, a structure according to FIG. 5 can be assembled with terminal portions **50** and **52** free from energy absorbing particles. If the entire surface has been coated with the adhesive layer **42**, these portions may be simply pressed together to form a pad. Performing the same operation on all edges can produce a completely sealed pad. Alternatively, one edge can be left open for the insertion of the article to be protected.

Inasmuch as the polystyrene foamed beads are themselves thermoplastic and will collapse under heat and pressure to form an adhesive, in some cases it may be desirable to use sheet material which is entirely coated with beads. The edges may then be sealed by the application of heat and pressure, utilizing both the melted polystyrene and the adhesive layer already existing to form the bond.

It will be apparent that all of the above embodiments provide extreme cleanliness. Furthermore, they can utilize foam plastic material of the least expensive type. Since the best performance is obtained with the lightest density materials, the packaging structure will have extremely small total weight. Thus, the transportation costs can be minimized. This light weight is particularly important for small precision parts where the absolute cleanliness obtained with my invention is most useful. Such parts are often sent by air transport.

The particular embodiments described above are intended to be illustrative only and do not serve to limit my invention. Those skilled in the packaging arts will be able to make modifications without departing from the scope of my invention which utilizes energy absorbent particles in the production of a flexible packaging assembly.

Having thus described my invention, I claim:

1. An article of manufacture comprising a flexible web, said web having first and second surfaces, first and second adhesive layers applied to said first and second surfaces respectively, a first group of particles of expanded polymeric material affixed to said first adhesive layer, and a second group of particles of expanded polymeric material affixed to said second adhesive layer whereby each of said particles is contacted by adhesive solely in the area of contact between the particle and web and thus is affixed only to an adhesive layer but is free to move with respect to adjacent particles, said first and second group of particles forming first and second essentially monoplanar layers.

2. An article of manufacture comprising a flexible web, said web having first and second surfaces, first and second adhesive layers applied to said first and second surfaces respectively, a first group of particles of expanded polystyrene material affixed to said first adhesive layer, and a second group of particles of expanded polystyrene material affixed to said second adhesive layer whereby each of said particles is contacted by adhesive solely in the area of contact between the particle and web and thus is affixed only to an adhesive layer but is free to move with respect to adjacent particles, said first and second group of particles forming first and second essentially monoplanar layers.

3. An article of manufacture comprising a flexible web, said web having first and second surfaces, first and second adhesive layers applied to said first and second surfaces respectively, a first group of particles of expanded polystyrene material affixed to said first adhesive layer, and a

second group of particles of expanded polystyrene material affixed to said second adhesive layer whereby each of said particles is contacted by adhesive solely in the area of contact between the particle and web and thus is affixed only to an adhesive layer but is free to move with respect to adjacent particles, said polystyrene material being in the form of beads with a mean diameter greater than approximately one sixth inch, said first and second group of particles forming first and second essentially monoplanar layers.

4. An article of manufacture comprising first and second flexible webs, a group of particles of expanded polymeric material between said layers, said group of particles forming an essentially monoplanar layer, the surfaces of said webs adjacent said monoplanar layer serving as first and second interior surfaces, and an adhesive layer applied to at least one of said interior surfaces whereby each of said particles is contacted by adhesive solely in the area of contact between the particle and web and thus is affixed only to an adhesive layer but is free to move with respect to adjacent particles, said monoplanar layer being adhered to said adhesive layer.

5. An article of manufacture comprising first, and second and third flexible webs, first and second groups of particles of expanded polymeric material, said groups of particles forming first and second essentially monoplanar layers, said first monoplanar layer disposed between said first and second flexible webs, adjacent surfaces of said first and second webs forming a first group of interior surfaces, said second group of particles disposed between said second and third flexible webs, the adjacent surfaces of said second and third webs forming a second group of interior surfaces, and adhesive layers applied to at least one surface of each interior surface group whereby each of said particles is contacted by adhesive solely in the area of contact between the particle and web and thus is affixed only to an adhesive layer but is free to move with respect to adjacent particles, said monoplanar layers being adhered to adjacent adhesive layers.

6. An article of manufacture comprising first and second flexible webs, a group of particles of expanded polystyrene material between said layers, said group of particles forming an essentially monoplanar layer, the surfaces of said webs adjacent said monoplanar layer serving as first and second interior surfaces, and an adhesive layer applied to at least one of said interior surfaces whereby each of said particles is contacted by adhesive solely in the area of contact between the particle and web and thus is affixed only to an adhesive layer but is free to move with respect to adjacent particles, said monoplanar layer being adhered to said adhesive layer.

7. An article of manufacture comprising first, second and third flexible webs, first and second groups of particles of expanded polystyrene material, said groups of particles forming first and second essentially monoplanar layers, said first monoplanar layer disposed between said first and second flexible webs, the adjacent surfaces of said first and second webs forming a first group of interior surfaces, said second group of particles disposed between said second and third flexible webs, the adjacent surfaces of said second and third webs forming a second group of interior surfaces, and adhesive layers applied to at least one surface of each interior surface group, said monoplanar layers being adhered to adjacent adhesive layers whereby each of said particles is contacted by adhesive solely in the area of contact between the particle and web and thus is affixed only to an adhesive layer but is free to move with respect to adjacent particles.

8. An article of manufacture comprising first and second flexible webs, a group of particles of expanded polystyrene material between said layers, said polystyrene material being in the form of beads with a mean diameter greater than approximately 1/6 inch, said group of particles forming an essentially monoplanar layer, the surfaces of said webs adjacent said monoplanar layer serving as first and second interior surfaces, and an adhesive layer applied to at least one of said interior surfaces, said monoplanar layer being adhered to said adhesive layer whereby each of said particle is contacted by adhesive solely in the area of contact between the particle and web and thus is affixed only to an adhesive layer but is free to move with respect to adjacent particles.

9. An article of manufacture comprising first, second and third flexible webs, first and second groups of particles of expanded polystyrene material, said polystyrene material being in the form of beads with a mean diameter greater than approximately 1/6 inch, said groups of particles forming first and second essentially monoplanar layers, said first monoplanar layer disposed between said first and second flexible webs, the adjacent surfaces of said first and second webs forming a first group of interior surfaces, said second group of particles disposed between said second and third flexible webs, the adjacent surfaces of said second and third webs forming a second group of interior surfaces, and adhesive layers applied to at least one surface of each interior surface group, said monoplanar layers being adhered to adjacent adhesive layers whereby each of said particles is contacted by adhesive solely in the area of contact between the particle and web and thus is affixed only to an adhesive layer but is free to move with respect to adjacent particles.

10. An article of manufacture comprising a flexible web, said web having first and second surfaces, first and second edhesive layers applied to said first and second surfaces respectively, a first group of particles of expanded polystyrene material affixed to said first adhesive layer, and a second group of particles of expanded polystyrene material affixed to said second adhesive layer whereby each of said particles is contacted by adhesive solely in the area of contact between the particle and web and thus is affixed only to an adhesive layer but is free to move with respect to adjacent particles, said polystyrene material being in the form of beads having an apparent bulk density less than approximately 4 pounds per cubic foot, said first and second group of particles forming first and second essentially monoplanar layers.

11. An article of manufacture comprising first and second flexible webs, a group of particles of expanded polystyrene material, said polystyrene material being in the form of beads having an apparent bulk density less than approximately 4 pounds per cubic foot, said group of particles forming an essentially monoplanar layer, the surfaces of said webs adjacent said monoplanar laying serving as first and second interior surfaces, and an adhesive layer applied to at least one of said interior surfaces, said monoplanar layer being adhered to said adhesive layer whereby each of said particles is contacted by adhesive solely in the area of contact between the particle and web and thus is affixed only to an adhesive layer but is free to move with respect to adjacent particles.

12. An article of manufacture comprising first, second and third flexible webs, first and second groups of particles of expanded polystyrene material, said polystyrene material being in the form of beads having an apparent bulk density less than approximately 4 pounds per cubic foot, said groups of particles forming first and second essentially monoplanar layers, said first monoplanar layer disposed between said first and second flexible webs, the adjacent surfaces of said first and second webs forming a first group of interior surfaces, said second group of particles disposed between said second and third flexible webs, the adjacent surfaces of said second and third webs forming a second group of interior surfaces, and adhesive layers applied to at least one surface of each interior surface group, said monoplanar layers being adhered to adjacent adhesive layers whereby each of said particles is contacted by adhesive solely in the area of contact between the particle and web and thus is affixed

only to an adhesive layer but is free to move with respect to adjacent particles.

References Cited by the Examiner

UNITED STATES PATENTS

196,531	10/1877	Long	161—211
2,719,100	9/1955	Banigan	161—231
2,736,679	2/1956	Nickerson	161—239
2,783,568	3/1957	Robinson	117—33 X
2,797,201	6/1957	Veatch et al.	260—2.5
2,806,509	9/1957	Bozzacco et al.	161—162 X
2,827,727	3/1958	Lipsius	117—33 X

2,862,834	12/1958	Hiler	260—2.5
3,116,349	12/1963	Immel	260—2.5

FOREIGN PATENTS

292,846	2/1932	Italy.
533,200	9/1955	Italy.

MORRIS SUSSMAN, *Primary Examiner.*

EARL M. BERGERT, ALEXANDER WYMAN, *Examiners.*

A. J. SMEDEROVAC, *Assistant Examiner.*