United States Patent

Mills et al.

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[54] **METHODS, APPARATUS, AND PRODUCTS FOR HANDLING BRITTLE MATERIALS**

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[52] **U.S. Cl.**.....**206/65 R,** 217/26.5, 229/2.5, 250/106 S

[51] **Int. Cl.**....**B65d 71/00,** B65d 81/02, B65d 85/62

[58] **Field of Search**.....250/106 S; 217/26.5; 53/28; 229/2.5; 206/56 A, 56 AB, 65 R, 46 FR, 46 P

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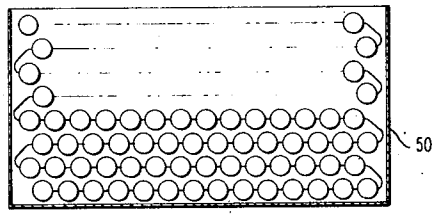
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[57] **ABSTRACT**

Methods and apparatus for automated packing, shipment, and unpacking of components of brittle material, such as uranium oxide pellets. Enclosures for individual pellets provide support over a substantial portion of a pellet with a minimum of contact on the pellet edges and provide cushioned protection for pellet surfaces and edges. Continuous wide belt packaging of pellets permits subdivision into flat slabs. Shipping containers conforming in length and width to the flat slab length and width dimensions accommodate a plurality of layers of pellets dependent upon safe density requirements of the material. This flat slab packaging method permits single-layer shipment of containers of flat-slab packaged uranium oxide without limitation because of safe density requirements on the area of the single-layer shipment.

17 Claims, 10 Drawing Figures



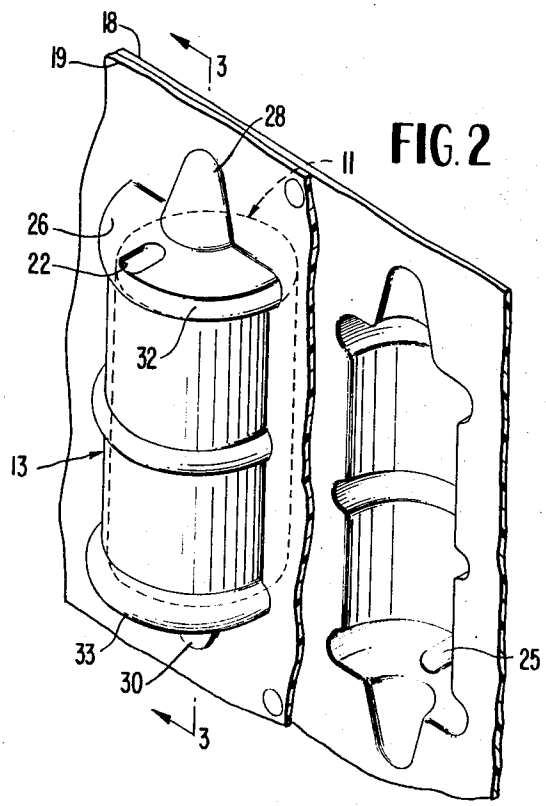
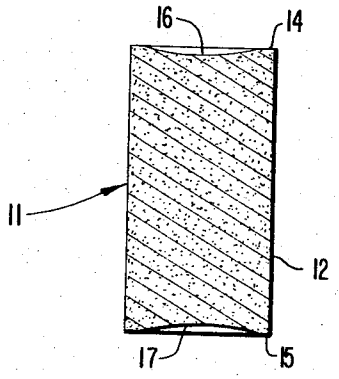


FIG. 2

FIG. 1



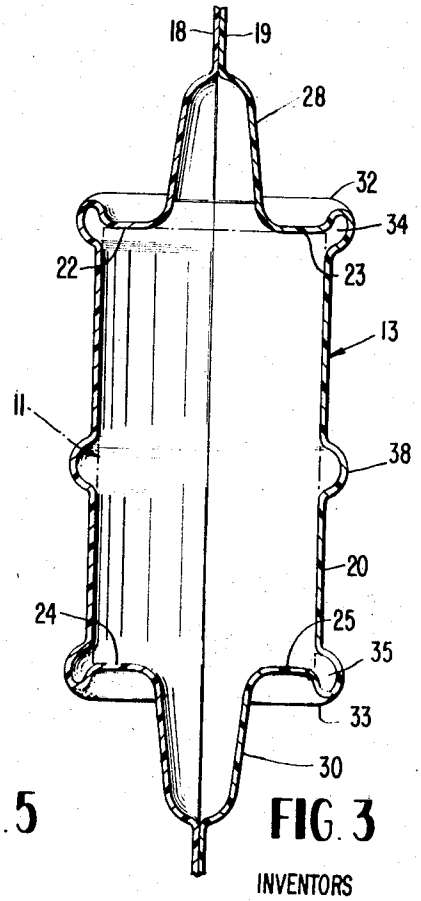


FIG. 3

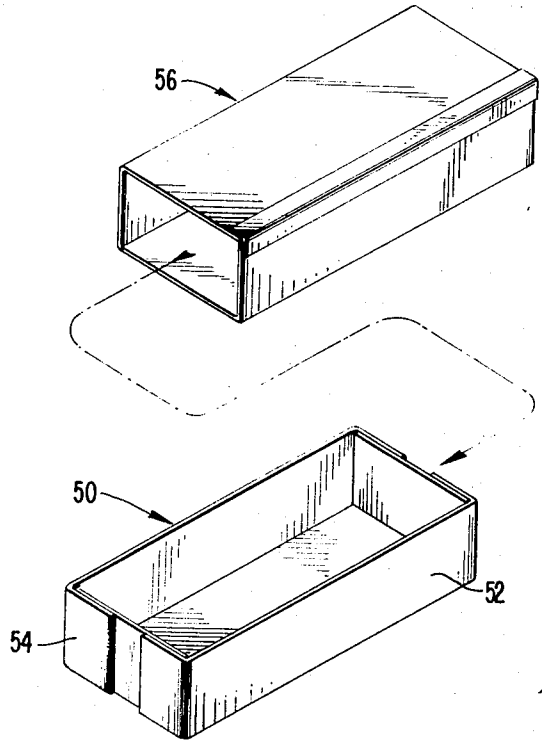


FIG. 5

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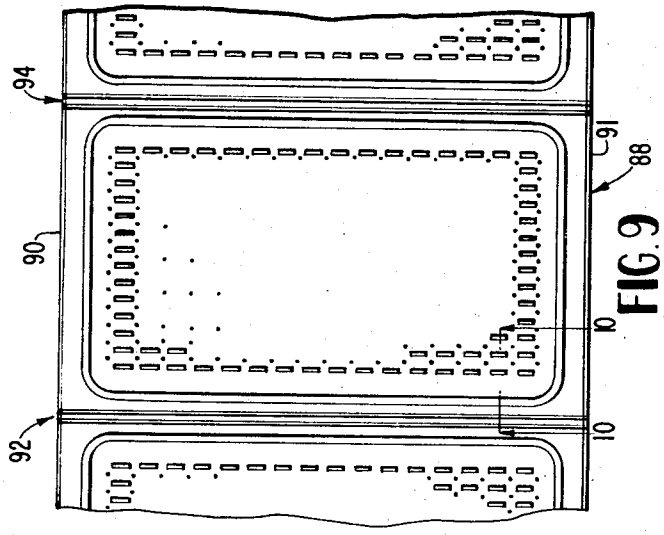
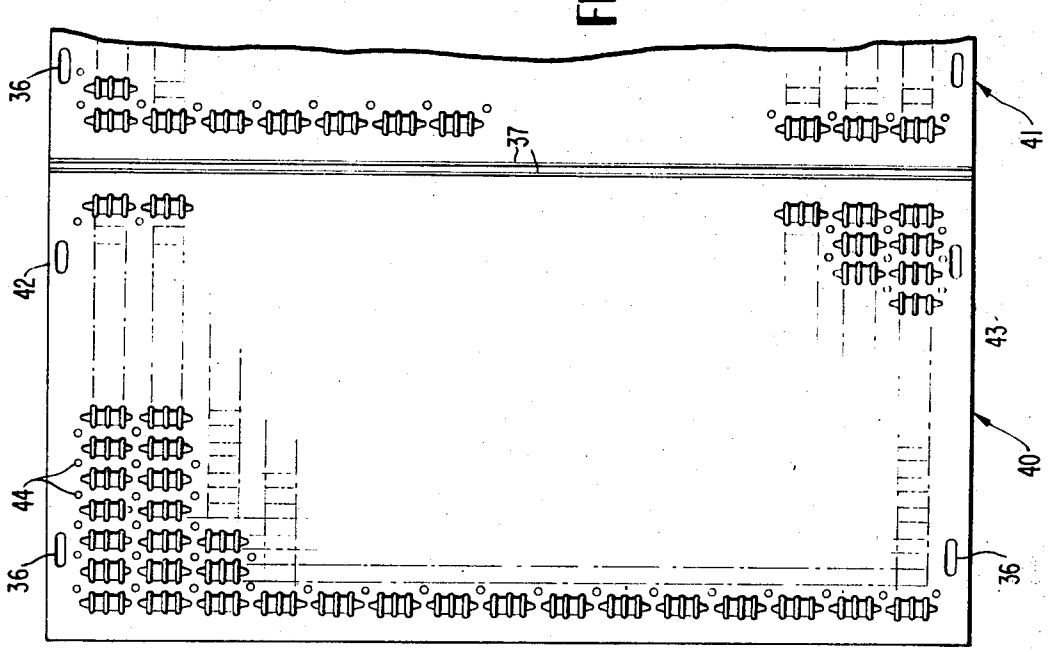


FIG. 9



FIG. 10

FIG. 4



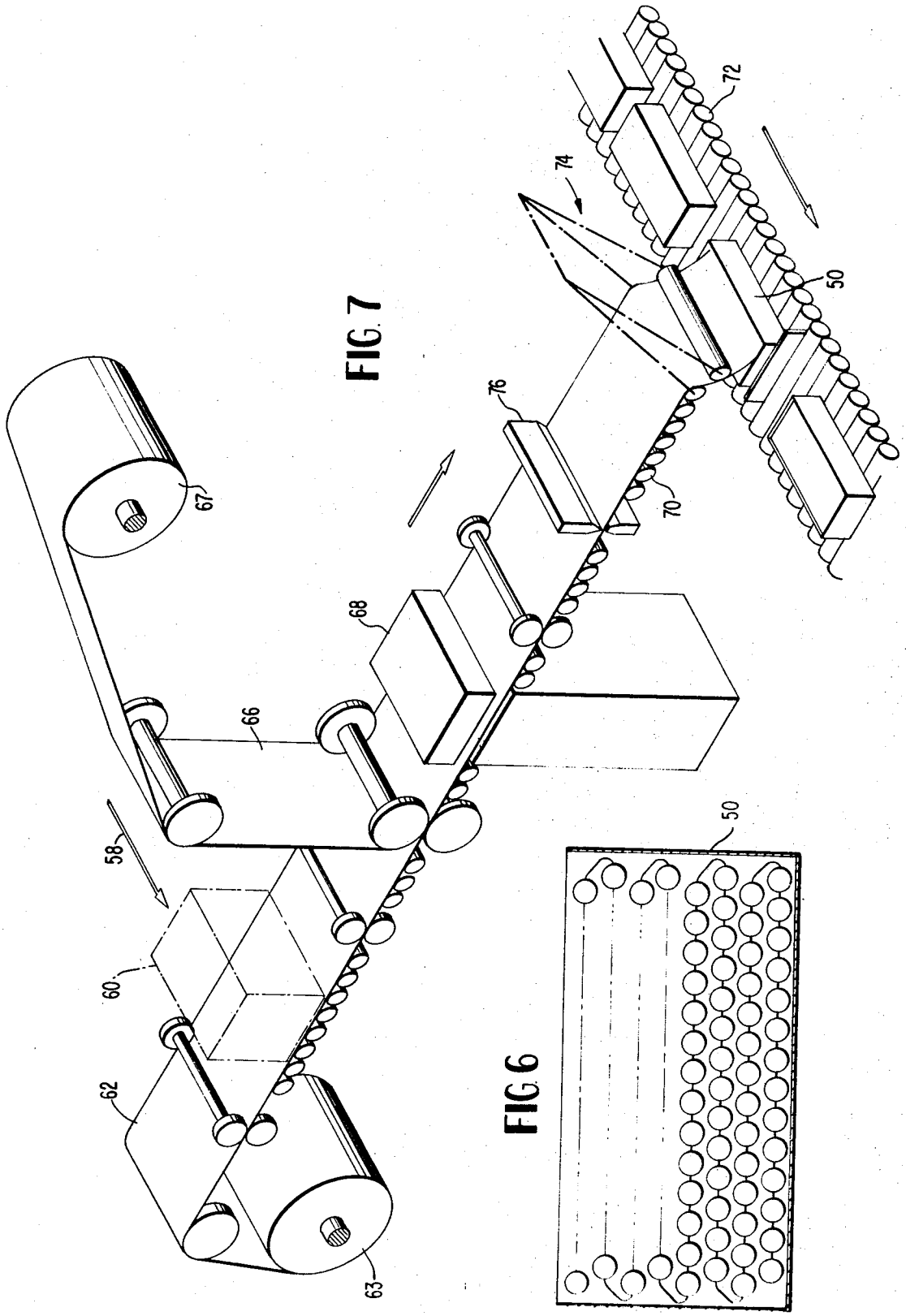


FIG. 7

FIG. 6

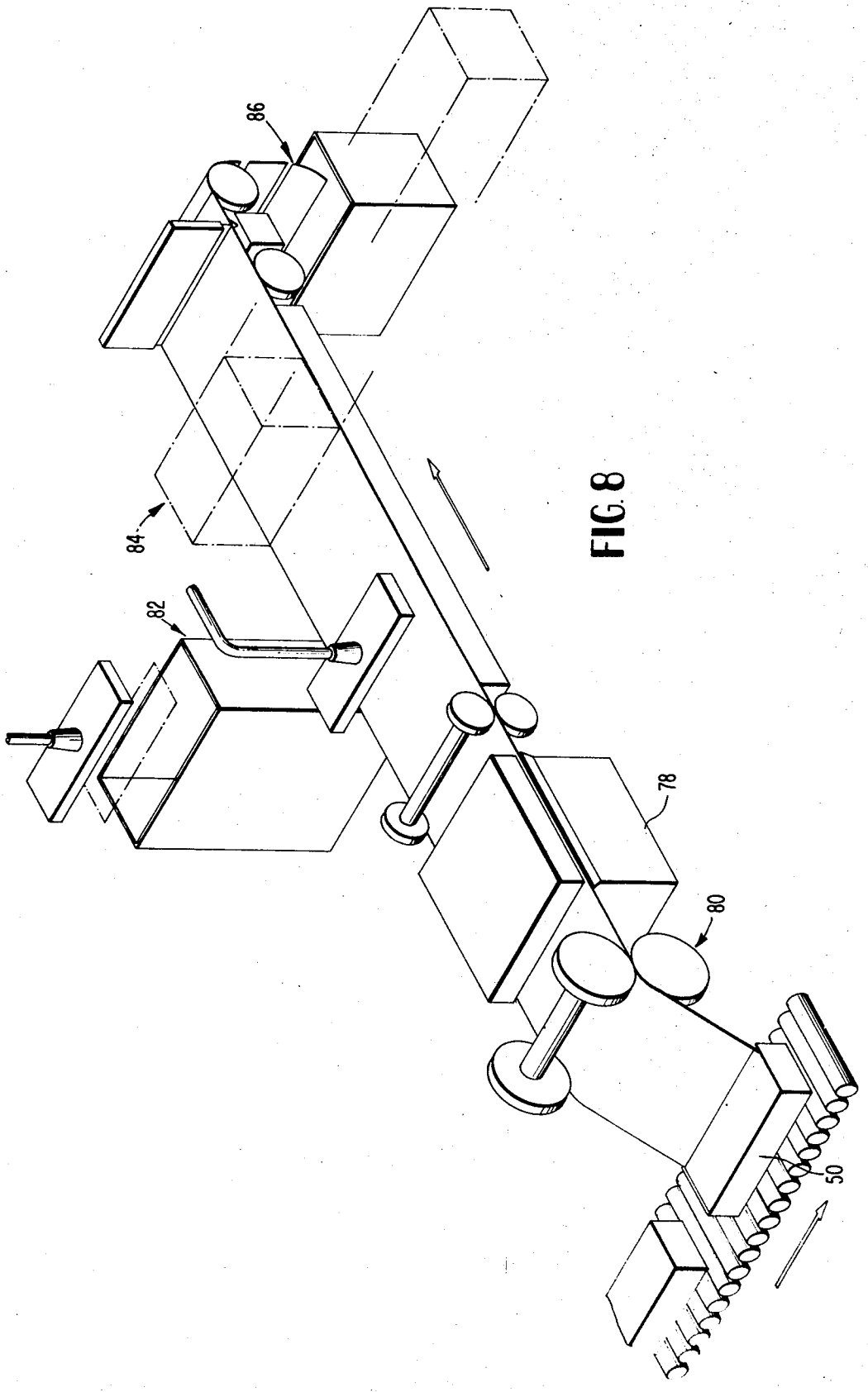


FIG. 8

METHODS, APPARATUS, AND PRODUCTS FOR HANDLING BRITTLE MATERIALS

This invention is concerned with handling of brittle materials in pellet form; in particular, the invention makes provision for completely automated handling, packaging for shipment, and unpackaging of such material.

The invention solves serious difficulties encountered in commercial production lines which convert enriched, depleted, or natural uranium sources to UO_2 pellets. While such lines have been set up for automatic production for a number of years, there has been no solution to the handling, packaging, and shipment problems which have prevented proper automation beyond the pellet manufacturing stage.

In the practice prior to the present invention, UO_2 pellets have been rolled, scroll fashion, in corrugated sheets forming cylindrical shapes which were held in cylindrical containers. Or, the pellets were packaged, end-to-end, in spiral wrap-form cardboard tubes and then held in cylindrical containers. Because of critical mass safety requirements for this material, the canisters, of about 10 inches in diameter, had to be held rigidly in spaced relationship, about 2 feet apart, on the shipping vehicle bed. Notwithstanding considerable attention and effort in the art, such prior art methods for handling UO_2 have not been adaptable to complete automation and have been recognized for some time as inefficient and uneconomical packaging and shipping techniques for use with commercial production facilities. The fragile sharp edges of UO_2 pellets have been a major problem and the cylindrical shipping configuration has helped forestall progress toward automated handling of this product to date. Protection for such fragile edges and use of a unique shipping configuration concept are basic contributions of this invention.

The invention provides specially formed enclosures which provide cushioned support for and protection of fragile pellets without contact of pellet edges. Further, "safe mass" limitations of prior packing techniques are greatly increased by continuous wide-belt, flat packaging of a plurality of individually compartmentalized pellets grouped for end usage. Also, a sectionalized continuous belt technique is combined with matching configuration shipping containers to provide automated packaging for shipment and to provide for automated unpacking of pellets for usage.

DESCRIPTION OF FIGURES

FIG. 1 is a cross-sectional configuration of a typical pellet handled by the present invention,

FIG. 2 is a perspective view, with portions cut away, of pellet enclosure structure embodying the invention,

FIG. 3 is a cross-sectional view along the line 3–3 of FIG. 2,

FIG. 4 is a partially-schematic plan view of a flat shipping configuration embodying the invention,

FIG. 5 is an exploded, perspective view of a shipping container forming part of the invention,

FIG. 6 is a partly schematic cross-sectional view of a packed shipping container forming part of the invention,

FIG. 7 is a schematic perspective view of packaging structure embodying the invention,

FIG. 8 is a schematic perspective view of unpacking structure embodying the invention,

FIG. 9 is a partially schematic plan view of a flat shipping configuration embodying the invention, and

FIG. 10 is an enlarged cross-sectional view taken along the line 10—10 of FIG. 9.

The cross-sectional configuration of a conventional UO_2 pellet is shown in FIG. 1. Elongated pellet 11 includes side wall surface 12 and end walls 14 and 15. The end walls 14 and 15 include a spherical radius 16 and 17 respectively. Typically such a pellet has a cylindrical configuration with a length between about 0.45 inch and 1 inch, a diameter of about 0.3 inch to 0.5 inch, and a weight between about 5 to 50 grams. UO_2 pellets are brittle and have fragile edges which require protection in all handling stages from production to ultimate use.

Edge protecting enclosure for individual pellets constitutes an important contribution of the invention. The enclosures are assembled from sheet material, e.g., deformable plastic sheets, having preformed pockets. A pair of plastic sheets are joined with preformed pockets in opposed registering relationship to form enclosures, indicated generally at 13. The enclosure configuration provided by the invention will provide required support for a pellet without contacting fragile edges of the pellet.

Referring to FIGS. 2 and 3, a plastic sheet 18 is joined to another plastic sheet 19 for encasing pellet 11. Each enclosure 13 presented by registering pairs of the preformed pockets of sheets 18 and 19 includes side wall portion 20 which conforms generally to the size and side wall shape of the pellet so that the pellet is contacted and supported over a substantial portion of its side wall surface by enclosure 13. The pellet is not, however, contacted at edge regions by the side wall portion 20.

The preformed pockets also form end wall structure at each longitudinal end of the encased pellet. Such end wall structure provides for contact with the pellet end walls in spaced relation to pellet edges, provides end wall cushioning, and can additionally provide protection against folding of the plastic sheet transversely to the longitudinal axis of the pellet.

Edge spaced contact with pellet end walls is obtained by at least one indenture in each end wall such as indentures 22, 25 shown in perspective in FIG. 2. Indentures 22 through 25, symmetrically disposed about the longitudinal axis of the enclosure, are shown in cross section in FIG. 3.

In the preferred embodiment, such indentures exist in an end wall portion which is otherwise spaced from the encased pellet along the longitudinal axis of the enclosure. As shown in FIG. 2, indenture 22 exists in spaced end wall portion 26. Such spaced end wall portion cushions the pellet by a flexing action in a direction along the longitudinal axis of the pellet.

Elongated protuberances 28 and 30, formed as part of the pocket means in the plastic sheets, are positioned along the longitudinal axis of the enclosure formed by the plastic sheets. These protuberances act as stiffening means to prevent edge damage to the pellet and provide for better handling in packaging and unpackaging as brought out more fully in subsequent description.

The side wall portion of the enclosure is joined to the end wall portions of the enclosure by bubble-contour projections 32, 33 which extend outwardly from the enclosure. These projections define cavities 34, 35 within

the enclosure at the opposite ends of the pellet so that all sharp edges of the pellet are surrounded by cavity-spacing and do not contact the walls of the enclosure. The cavity-spacing also provides cushioned protection against contact with other pellets and shipping containers regardless of the packing technique employed so that handling stresses are not transmitted to pellet edges.

A similar outward projection, cushioning ring **38**, located in the side wall surface **20** along the length of the elongated enclosure provides protection for the pellet intermediate its end walls.

With the cavity-spacing structure shown, the fragile edges of the pellet are protected at all times in handling, packaging, and unpacking. The elongated protuberances **28, 30** along the longitudinal axis of the enclosure inhibit folding of the plastic strip in a direction transverse to the longitudinal axis of the enclosure. Other protrusion means contiguous to edge portions of enclosures, e.g., strengthening ribs in at least one of the plastic sheets, can be used to inhibit longitudinal folding. Additionally, staggered rows of enclosures can be utilized to prevent longitudinal folding without sacrificing edge protection because of the enclosure features described above.

Continuous, automated packaging of uranium oxide pellets, free of manual operations, is made possible by the present invention. This contribution stems from a continuous-belt concept which is carried out by using longitudinally continuous strip having preformed pockets as shown in FIGS. **2** and **3**. These are symmetrically arranged, e.g., in rows as shown diagrammatically in FIG. **4**. Joining a pair of longitudinally continuous strips with their preformed pocket means in opposed relationship produces a continuous belt of enclosures. Alignment of the pair of longitudinally continuous strips with their preformed pockets in opposed relationship is facilitated by index means, such as **36**, positioned along the length of the strips, as described in more detail later.

The continuous belt is subdivided longitudinally into flat slabs sealed along a continuous line around the periphery to make a moisture-proof section. As shown in FIG. **4**, a double seal **37** is provided between sections **40** and **41** so that the sections can be severed intermediate the pair of transverse seal lines without destroying the moisture-proof seal of either section. Edge sealing is provided at **42, 43**. Longitudinal sealing lines can also be placed inwardly of the longitudinal edges and register holes, or other indexing means, positioned contiguous to the edges beyond the longitudinal seals. In addition, the strips are joined at numerous points located inwardly with relation to the peripheral moisture-proof seal. For example, spot welds can be provided intermediate each pellet enclosure or selectively distributed. Spot welding prevents spreading apart or "ballooning" of the strips and maintains firm support and protection for pellets within their individual compartments.

The invention includes a unique shipping configuration in which the continuous wide belt technique coacts with predetermined configuration shipping containers to make possible automation of packaging for shipment and unpacking for use. Within safe thickness requirements, which are dependent on the degree of uranium enrichment, the area covered by packed containers on a single tier vehicle is not limited and the horizontal spacing of containers on a shipping vehicle bed as required by the prior art is eliminated. These teachings of the invention more than double the shipping capacity of a single tier vehicle.

Forming part of the unique shipping concept are receptacles for the continuous-belt sections having length and width dimensions conforming to those of a continuous belt section. Referring to FIG. **5**, receptacle **50** has a side wall **52** having a length approximately equal to the width of the continuous belt, e.g., about 18 inches. The end wall **54** is approximately equal to the dimension of a section or slab of pellets measured along the direction of movement of the continuous belt, e.g., 7 inches. The height of the container will vary dependent on the number of sections, or flat slabs, to be packed in the container as determined by density requirements. The number of layers will generally be in the range of from six to 12. Sections of the continuous belt are reverse folded and packed in layers as shown in FIG. **6**. Safe shipment thicknesses for these layers are about 5 (5.1) inches for 3 percent enriched uranium and slightly less than 4 (3.85) inches for 5 percent enriched uranium.

The following example is typical of the increase in shipping capacity brought about by the present invention. Assuming an effective trailer area of 281.25 sq. ft. and utilizing a 5-inch thickness permitted for 3 percent enriched uranium, 118.2 cu. ft. of space is available. With 25 percent of this volume pellets, 18,600 pounds of product can be shipped. A standard shipment of cylindrical containers on the same vehicle would handle approximately 7,000 pounds of product.

A protective covering member **56** for receptacle **50** is shown adjacent to the receptacle. Covering member **56** encloses the receptacle **50** by relative longitudinal movement along the longitudinal axis of the receptacle.

The continuous automated packaging concept of the present invention depends on the cooperative combination of method steps and apparatus for protective packaging of individual pellets in a continuous belt and packing intermediate lengths of the continuous belt for shipment. The combination of machine components required for carrying out this concept is shown schematically in FIG. **7**. Pellets from a production line flow as indicated by arrow **58** to pellet loader **60**, details of which form no part of the present invention. Preformed continuous strip **62**, from coil **63**, forms the bottom layer of the continuous belt. The pellet loader **60** is indexed to the symmetrically arranged rows of pockets in strip **62** to deposit a pellet in each pocket or a preselected number of pockets in each section of the continuous belt. After loading pellets into the pockets of the continuous strip **62** this bottom layer of the continuous belt is covered with upper layer, preformed continuous strip **66** being fed from coil **67**. The conveyor guide rolls shown provide indexed feeding of both top and bottom layers in order to ensure proper alignment for formation of the enclosures about each pellet. Alternately, or in connection with this indexing arrangement, both continuous strips **62** and **66** can include indexing means. The continuous belt is also indexed for sealing purposes. The indexed continuous belt is fed to package sealer **68** for moisture-proof edge

sealing of sections and spot welding intermediate enclosure.

The continuous belt of encased pellets travels along conveyor **70** toward a packaging station located at receptacle conveyor **72** which travels transversely to the continuous belt conveyor **70**. Receptacles are loaded with a predetermined number of alternating layers as shown in FIG. **6**. Support mechanism **74** has a reciprocal movement and guides the belt sections to form the alternating layers. Transverse stiffening means, such as protuberances **28** and **30**, play an important function at this stage of the continuous line in loading the belt into receptacles and also along the line by helping to keep the belt planar and preventing longitudinal folding.

Cutter **76** is indexed to cut the continuous belt into intermediate lengths containing the predetermined number of sections required for prescribed filling of each receptacle and at the same time to cut the continuous belt between the moisture-proofing seal lines **37** which run transversely of the belt.

The elimination of manual operations made possible by the teachings of the present invention also extends to the unpacking of pellets. The intermediate lengths of continuous belt from a shipping receptacle are fed onto the conveyor of the unpacking line shown in FIG. **8**. The indexing required for unsealing at seal removal station **78** is provided at feed roll station **80** and conveyor guide rolls along the path of the conveyor. From seal removal station **78**, the intermediate length of continuous belt feeds along the conveyor to sheet removal station **82** for removal of the top layer of sheet material from each section. At pellet removal station **84** individual pellets are removed. The enclosures are checked by this mechanism to determine that no pellets remain and the enclosures are vacuumed to remove any loose particles of uranium oxide. After unloading the bottom layer of plastic sheet is cut or rolled at station **86** for accumulation and disposal.

In order to facilitate the unpacking operation, a modification of the belt illustrated in FIG. **4** is proposed. This modification is shown in FIGS. **9** and **10**. In section **88** of the belt shown in FIG. **9**, a wide, planar, marginal portion surrounds the grouping of pellet enclosures. The section is sealed entirely along its longitudinal edges **90** and **91** and transverse edge seals are provided at **92** and **94**. A border element **96** is positioned intermediate the section edge seals and the pellet enclosures. Border element **96**, shown in cross section in FIG. **10** consists of a continuous bubble. This bubble border extends entirely around a section and is located within the moisture-proof edge seal of such section. Also the continuous-line seal for moisture proofing of each section may be located at the border allowing use of longitudinal edges for indexing indentations.

For unpackaging in the seal remover station, the bubble border **96** is slit along its upper edge around the entire border of the section. Spot welds are punched from the continuous belt. After this operation in seal remover station **78**, the top layer of plastic sheeting can be readily removed at station **82**, e.g., by vacuum, without disturbing pellets in the remaining portions of the enclosures and while maintaining the bottom layer continuous for indexing purposes.

As will be obvious to those skilled in the art, the continuous belt teachings of the present invention lend themselves readily to indexing for various packaging and unpacking rates encountered in production and end usage of the pellets. Indexing of elongated strips for forming the continuous belt of enclosures can be carried out by utilizing male and female matching configurations in otherwise identically preformed strips. Also the strips and intermediate length of belt can be indexed by register holes preferably located along longitudinal edge portions of the strips. Such register holes can then be utilized for indexing the continuous belt.

A suitable plastic sheet material for carrying out the teachings of the invention is a moisture-proof polyethylene film having a thickness of fifteen mils. Well known heat sealing or adhesive sealing techniques for this film may be used in forming the continuous belt taught.

Various modifications can be made in the specific embodiment disclosed while still relying on the teachings of the invention. Therefore other dimensions, sheet materials, pellets, sealing techniques, registering means, and transverse stiffening means than those set forth above are within the scope of the appended claims.

What is claimed is:

1. Protective encasement for enclosing, supporting and providing cushioned edge protection for a sharp edge configuration pellet to prevent normal handling and shipping stresses from being transmitted to edge portions of an enclosed pellet comprising

a pair of sheets of deformable material having preformed pocket means, the pair of sheets being joined together peripherally of the pocket means with the pocket means in opposed relationship defining an enclosure for receiving and supporting a pellet,

the enclosure including main body, end wall, and bubble contour portions,

the main body portion of the enclosure having a configuration substantially conforming to the size and shape of the pellet so as to contact and support an enclosed pellet over a substantial portion of its exterior side wall surface in spaced relationship from pellet edge portions,

the end wall portions of the enclosure including indenture means for contacting an encased pellet to provide pellet end wall support, such end wall contact being in spaced relationship from pellet edges with remaining surface of the end wall portions being spaced from the pellet end walls to provide end wall cushioning,

the main body and end wall portions of the enclosure being joined by the bubble contour portion with the bubble contour portion protruding outwardly from the main body portion of the enclosure defining cavity means within the enclosure, such cavity means preventing contact between edge portions of the pellet and the enclosure.

2. The protective encasement of claim **1** in which the enclosure is elongated and the main body portion includes cushioning means projecting outwardly from the enclosure and located along the side wall portion intermediate end wall portions of the enclosure.

3. The protective encasement of claim 1 further including protrusion means contiguous to end wall portions of the enclosure, such protrusion means inhibiting folding over of sheet material peripheral to the enclosure adjacent to edge portions of an encased pellet.

4. The encasement of claim 2 further including protrusion means extending from end wall portions of the enclosure along its longitudinal axis.

5. The encasement of claim 1 in which the pairs of sheets comprise deformable plastic in combination with a uranium oxide pellet.

6. Protective encasement for a plurality of sharp edge configuration pellets comprising

a pair of elongated strips having preformed pocket means, the strips being joined together in overlying relationship peripherally of the pocket means to form an elongated belt with the preformed pocket means in one strip being arranged in opposed relationship to preformed pocket means in the remaining strip so as to define a plurality of individual enclosures for receiving and supporting individual pellets,

each enclosure having an internal configuration for contacting and supporting an encased pellet along side wall and end wall portions of such pellet, such contact being spaced from sharp edge portions of such pellet with the enclosures defining a cavity surrounding each sharp edge portion of such pellet.

7. The protective encasement of claim 6 further including means acting intermediate individual enclosures to inhibit folding of the elongated belt along its longitudinal axis.

8. The protective encasement of claim 7 in which the means for inhibiting longitudinal folding of the elongated belt comprises protrusions formed in at least one of the elongated strips contiguous to the preformed pocket means.

9. The protective encasement of claim 8 in which the protrusions are elongated and extend transversely of the elongated strip.

10. The protective encasement of claim 6 in combination with a plurality of sharp edge configuration pellets encased individually in the enclosures defined by the preformed pocket means of the elongated strips.

11. The protective encasement of claim 10 in which the enclosures are arranged symmetrically permitting the elongated belt to be subdivided longitudinally into sections of predetermined dimensions containing a plurality of pellets, with the pair of elongated strips forming the elongated belt being secured together along a continuous-line circumscribing each section.

12. The protective encasement of claim 11 in which the pair of strips are further secured together at a plurality of locations within the continuous-line circumscribing each such section and distributed intermediate individual enclosures of each such section.

13. The protective encasement of claim 10 for protective packaging of and spacing a plurality of pellets of radioactive material within safe density requirements in which the encased pellets comprise elongated pellets of uranium oxide with the enclosures being arranged in substantially parallel relationship with longitudinal axes of the elongated pellets extending transversely of the elongated belt permitting the elongated belt to be subdivided longitudinally into a plurality of sections of predetermined length and width dimensions with each section including a predetermined number of pellets.

14. The protective encasement of claim 11 further including

circumferential slitting means for each such section located inwardly with relation to the continuous-line securing the elongated strips together and circumscribing the plurality of pellets in each section; the circumferential slitting means permitting that portion of one of the elongated strips overlying the plurality of pellets in a section to be removed from the elongated belt while maintaining the remaining elongated strip longitudinally continuous.

15. The protective encasement of claim 14 in which the circumferential slitting means comprises a bubble configuration formed in at least one of the elongated strips.

16. The combination of claim 13 in which an intermediate length of the elongated belt including a plurality of such sections of predetermined length and width dimensions is combined with receptacle means having substantially planar bottom and side walls, the cross-sectional length and width dimensions of the receptacle means conforming to the length and width dimensions of individual sections of the elongated belt, with the elongated belt being folded transversely of its longitudinal axis between individual sections.

17. The combination of claim 16 in which the plurality of sections of elongated belt form a plurality of layers within the receptacle means, such layers being disposed in planes substantially parallel to the bottom wall of the receptacle means.

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