June 6, 1967 G. L. GRIFFITH 3,323,455

EXPANSIBLE EXPLOSIVE CARTRIDGE

Filed Sept. 30, 1965 2 Sheets-Sheet 1

FIG. 1

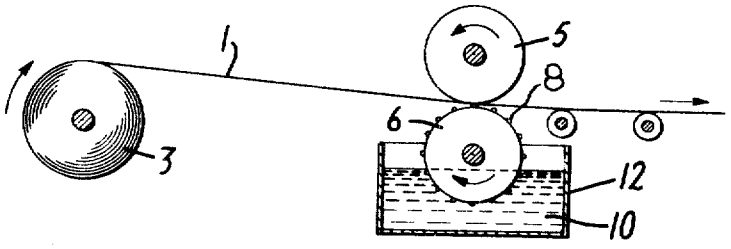


FIG. 2

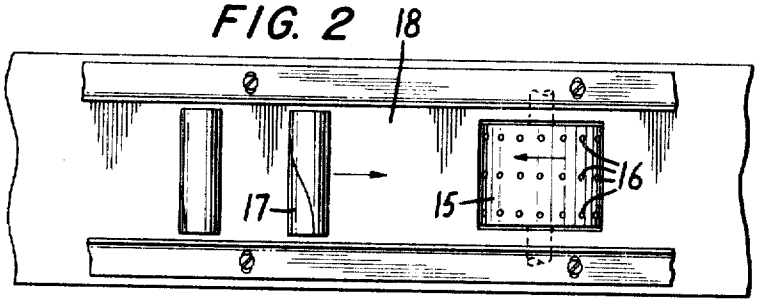


FIG. 3

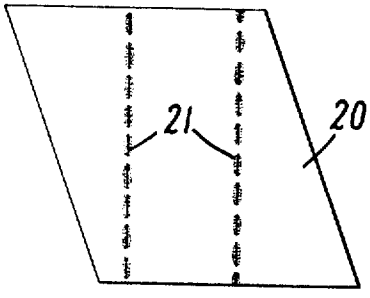


FIG. 5

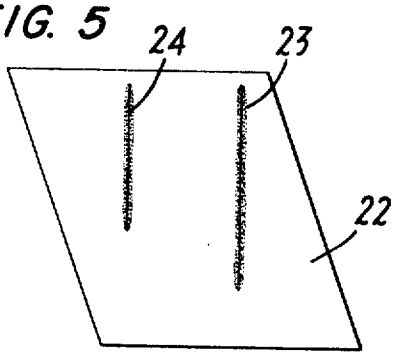


FIG. 4

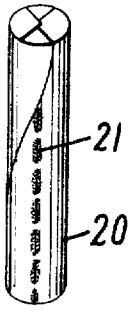
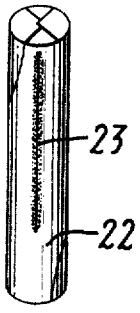


FIG. 6



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EXPANSIBLE EXPLOSIVE CARTRIDGE

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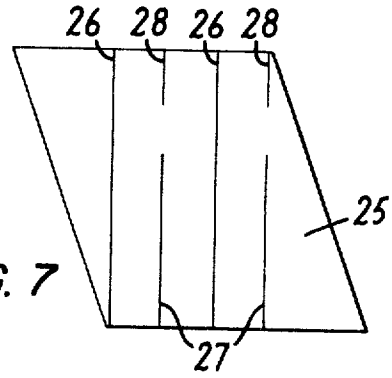


FIG. 7

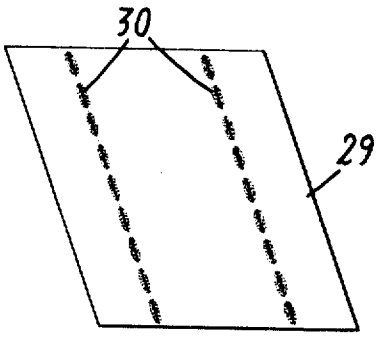


FIG. 9



FIG. 8

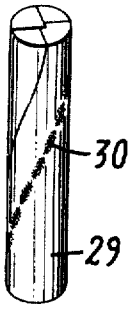


FIG. 10

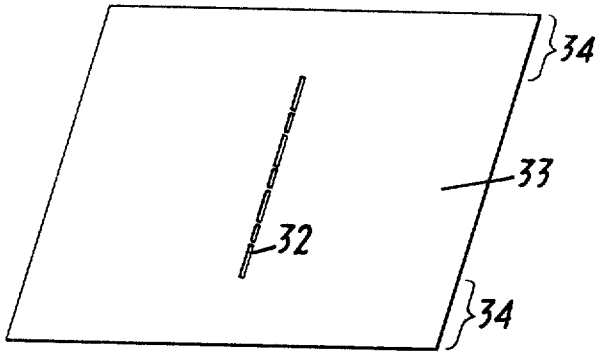


FIG. 11

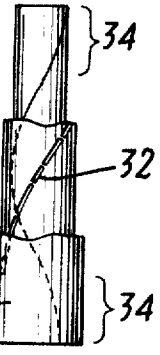


FIG. 13

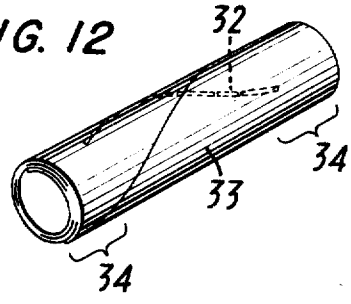


FIG. 12

United States Patent Office 3,323,455
Patented June 6, 1967

3,323,455

EXPANSIBLE EXPLOSIVE CARTRIDGE

George L. Griffith, Coopersburg, Pa., assignor to Trojan Powder Company, Allentown, Pa., a corporation of New York

Filed Sept. 30, 1965, Ser. No. 491,719
15 Claims. (Cl. 102—24)

This invention relates to an expansible explosive cartridge, and more particularly, to an expansible explosive cartridge whose walls are weakened by chemical action. This invention also relates to a process for the chemical weakening of an explosive cartridge, so that the cartridge at the time it is filled with explosive is strong enough to resist rupture, but can become weakened thereafter, and thereby develop expansibility by rupture.

Explosives for blasting purposes, as in the mining or construction industries, are usually packaged in sturdy cartridges made of tough, rigid, shape-retaining materials. Such cartridges are of convenient size or shape for insertion into a bore hole for mine and quarry blasting. When loading a train of cartridges into a bore hole, it is of course desirable, to obtain the maximum effectiveness from a given explosive, charge that the explosive cartridges in a train completely fill the hole; this increases the loading density of the explosive, and prevents the formation of an air cushion between the explosive and the rock. This is normally ensured by tamping the train of explosive cartridges after they have been filled into the bore hole, so as to rupture the cartridges, and pack the blasting explosive into all parts of the hole.

To facilitate packing in a bore hole, it is customary to manufacture cartridges which will rupture easily, by mechanically forming slits or perforations or expansible pleats in the cartridge blank. Expansible, easily ruptured, blasting explosive cartridges are disclosed in U.S. Patents No. 2,345,654 to Bowman and U.S. Patent No. 2,378,223 to Johnson. Bowman and Johnson each form slits or perforations in the blanks, which are then waxed to seal the openings, and rolled to form the cartridge. Although the slits may be formed and waxed after the cartridge is fitted and filled, it is obvious that, in an assembly line, slits are much more readily made in a flat blank than in a rolled cartridge. U.S. Patent No. 1,220,208 to Ellis discloses cartridges formed of fluted paper which can be expanded by tamping, to expand the cartridge wall into intimate contact with the sides of the bore hole.

The formation of slits or perforations prior to the filling of the cartridge with the explosive increases the complexity of the filling operation. The slits or perforations, even though closed with wax, can open during filling, which makes it necessary to avoid spilling the explosive and limit the pressure applied. Since it is necessary to pack the cartridges to a uniform density, the filling operation has to be very carefully carried out. As a practical matter, this is rather difficult.

According to this information, a container for explosives is provided, suitable for use in explosive cartridges, having structurally weak rupturable portions, formed by chemical action in situ on the container. The chemical action preferably does not weaken the container until after the container has been filled with explosive and tightly packed, but the chemical can be applied at any time before or after filling, at a sufficient time interval before use to develop structural weakness and easy rupturability.

The structurally weak portions, according to the process of this invention, are formed by a disintegrating chemical action upon the container material by a chemical substance corrosive thereto. The corrosive substance can partially or completely eat away or dissolve the container, as desired. A partial eating away or disintegration usually will suffice to form a structurally weak area, rupturable under tamping stress without an undesirable, premature breakthrough of the wall of the container.

The explosive cartridge of this invention comprises a container enclosing a charge of explosive material and having applied to predetermined portions to be weakened a substance capable of deteriorating or disintegrating the said portions by chemical action thereof. After completion of the action of the substance in situ with the container, substantially weaker portions are formed, which will open when the cartridge is placed under compression, as by tamping. The said portions can have a sufficient amount of the chemical substance applied to eat holes through, or dissolve out, the wall. Preferably, however, the cartridge is impervious and moistureproof along the entire exposed outer surface, including the weakened areas. The weakened portions to which the corrosive chemical is applied are generally in the form of dots or elongated lines extending along the surface of the cartridge.

This invention also includes a blank of sheet material for the forming of an explosive cointainer, having applied to portions of its surface to be made relatively structurally weak a chemical substance capable of deteriorating or disintegrating or dissolving the sheet material.

According to the process of this invention, a container for explosive material having structurally weak portions therein, to facilitate rupturing of the cartridge by the application of compressive stress or force, is obtained by applying a corrosive or disintegrating chemical substance to selected portions of the surface at some stage of its manufacture: before, during or after the filling of the container with explosive. Where the container is formed from a blank of sheet material, cut to the proper shape and then folded, the chemical substance is preferably applied to the blank prior to its being formed into the cartridge. If applied before the container is filled, the substance preferably has a slow corrosive or disintegrating action, and will not eat through or weaken the container wall until after the container has been filled with explosive.

The chemical substance can also be applied in an inactive form or inactivated in situ and the weakening action thus stayed until the desired time, at which time the corrosive or disintegrating chemical action is begun by application of an activating agent, such as a catalyst or other chemical activating agent, or heat. For example, the chemical can be applied in an inactive state or inactivated after application, to the blank or container during the rolling, initial crimping or printing operation. The resulting container can be stored indefinitely, and shipped to the field for loading when desired. After the cartridge has been filled and crimped, without danger of the cartridges being too weak to withstand filling, the activator can then be applied to the cartridge, and weakening proceeds.

To facilitate application of the activator, the chemically treated areas can be given a distinctive mark or color. The activator can then be applied exclusively to the indicated areas.

The activator can be applied by rolling, dipping, or spraying, and can be combined with a treating operation, such as wax dipping, by adding an actuator to the wax.

A cartridge container should be sufficiently strong to carry the explosive all the way into a bore hole without rupture and to withstand the strain of normal careful handling before use, and sufficiently non-porous to prevent moisture from entering and explosive from leaking out before use; however, at the same time it should have a bursting strength of a sufficiently low value to rupture

easily upon being tamped without the application of dangerously high compressive force. Preferably, the corrosive substance acts slowly, so that the container can be filled and sealed before it becomes rupturable. The corrosive substance can alternatively and with equal effect be applied at any time during the formation of the container, even after the completed cartridge has been filled and sealed, and will thus become chemically weakened in situ.

In the preferred embodiment, the process of this invention comprises applying the corrosive substance onto the surface of the cartridge container wall material while it is a blank of flat stock. The corrosive substance can be applied before the stock is cut into the proper size blanks. The earlier the corrosive substance is applied before filling, the longer should be the period necessary to effect the chemical weakening, to prevent weakening before filling.

Chemically weakened portions formed by a corrosive or disintegrating chemical substance are of a different nature from the physically weakened portions formed by scoring or perforating, as in the prior art. Generally, a chemically weakened portion will be less sharply defined, and will affect a larger area. When such a chemical is applied to a container wall, it will act on the wall relatively equally sideways as well as down. As a result, the weakened portion will be of a generally hemispheric cross-section, whose width at the top is equal to two radii, and whose depth at the bottom is equal to one radius. A container having a wide but shallow weakened area will rupture as easily under compression as a container having a narrow but deeper scored line, and at the same time will be more moistureproof, and less likely to rupture accidentally under a short sharp shock. In addition, the chance of the substance's accidentally eating all the way through the material is less than the chance of accidentally scoring too deeply, cutting the paper through.

The blank is usually formed into a cylindrical cartridge container by rolling on a mandrel; there are, however, many alternative ways of forming the cartridge, and the cartridge can be formed into any shape desired. For example, the blank may be scored and folded into a cube, cone, octahedron, tetrahedron, sphere, or any other shape desired.

In one common method for forming a cylindrical or tubular container, the blank is rolled on a mandrel to form a cylinder, and the ends are crimped for sealing. Although a tubular cartridge can be formed with a single layer of wrapping or with many layers of wrapping, it has been found preferably to form it from at least two complete layers, up to 3½ layers, i.e. where up to one half of the circumference of the cylinder is formed of four layers. One end is capped and crimped in the rolling operation, and the tube is then ready to be filled. The methods of forming containers of different shapes are well known, and are not part of this invention. The container is filled with explosive material, generally in a fluent form, such as by being poured in the molten state and then allowed to set, poured in a slurry or gelatinous condition, or in a powdered or granulated form. The opening is then sealed.

The material used for forming the cartridge container is generally a strong and preferably water-resistant cardboard or heavy paper, such as kraft or manila of approximately sixty to one hundred pounds weight. Other materials suitable for use in forming cartridge containers include polymeric synthetic resin materials such as polyethylene, polypropylene, polyvinyl butyrate, cellulose acetate butyrate, cellulose acetate propionate, cellulose acetate, ethyl cellulose, polyvinyl chloride, vinyl chloride-vinyl acetate copolymer, polyvinylidene chloride, polyacrylonitrile, ethylene glycol-terephthalic acid polymers, and nylon, as well as metal foils such as aluminum. Materials not inherently moistureproof, such as paper, can be coated with wax or other water-repellent coatings, or otherwise treated at any stage in the manufacturing process, but usually after the corrosive substance has completed its action.

Corrosive or disintegrating substances which are suitable for cellulosic, e.g. paper, container materials include alkaline materials such as caustic soda and caustic potash; acids such as sulfuric acid, hydrochloric acid, phosphoric acid, nitric acid, aqua regia, acetic acid, and formic acid; and enzymes having strong cellulytic activity such as derivatives of the *Aspergillus niger* and *Trichoderma viridens* microorganisms. These materials are sold under various trade names as celluloses or hemi-celluloses. Acids and bases can be applied as weak or concentrated aqueous solutions. Substances suitable for use with polymeric materials include solvents such as acetone, methyl ethyl ketone, nitroethane, ethyl lactate, glycol diformate, glycol diacetate, furfural, and cyclohexanone.

An active chemical that is effective only in aqueous solution can be made inactive by removing the water, and then activated for weakening action by wetting the portions of the container impregnated with such a chemical. Substances in this category include sodium hydroxide and potassium hydroxide.

An organic compound that is a solid at atmospheric temperature but is melted to liquid form whereupon it can exert a solvent or corrosive action on the container material is also a suitable inactivatable chemical. Such substances include acetamide, 2,2-dimethyl-propanol-1, aryl benzene sulfonic acid.

Some enzymes are active only in acid media, and some only in alkaline media. Such enzymes can be applied, and then activated when desired by application of the appropriate media.

The pattern in which the corrosive substance can be applied to the surface of the blank or container is not critical to the invention but can be in any pattern. Generally, the pattern comprises lines running lengthwise of the cartridge such as shown and described in the patents to Bowman and Johnson discussed above. Other patterns include helical lines, lines circumscribing the container, cross lines, grid networks of lines and patterns of dots, dashes, triangles, squares, rhomboids and other shapes. The patterns selected will conform to the rupture lines desired for spilling out the contents of the cartridge into the bore hole.

The container may consist of more than one thickness or convolution of material. In this instance, the areas of predetermined weakness in each layer of material can be positioned so as to lie directly over each other or to show any desired degree of offset. It is preferable to avoid the leakage of moisture into the container or the leakage of explosive material out of the container. The lines of weakness should be offset in the circumstances where a rupture may accidentally occur prior to use. Although the coating of a water-proofing material over the surface of the container, following the chemical weakening of the container material, will help to prevent the leakage in or out through the cartridge container, the offsetting of the areas of weakness would still be preferable as the coating would of course have very little structural strength and an accidental jarring or rubbing against another surface could very readily remove the coating and perhaps cause an accidental leak.

By forming the weakened areas as serrated lines, or rows of dots and dashes, which do not extend entirely along the length of the cartridge, or by providing two overlying lines of serrations, one perhaps longer than the other, but neither one extending completely along the length of the cartridge, the strength of the container is improved and its storability and its ability to withstand rough handling prior to use are markedly increased, while its ability to be easily ruptured under compressive force in the bore hole is not in any substantial degree lessened. The predetermined areas of weakness formed in the blank container material prior to its being formed into the cartridge container should be so positioned that the lines of weak-

ness in the final product will be as desired. This is quite easily accomplished by properly spacing the areas along which the rupture will be facilitated in the blank by simple geometric calculations based on the size of the blank and the size and shape of the container to be formed from the blank material. It is evident that if the corrosive substance is applied to the finished container, and if the finished container has several thicknesses or convolutions of container material, the outer convolution will be the layer initially weakened, and depending upon the strength and amount of corrosive substance applied to the surface of the outer convolution, the inner layers may also be weakened chemically. The term "outer layer" refers to the layers on the exterior of the container as well as the layer on the interior of the container depending on how the corrosive substance is applied. Usually, however, when forming the areas of weakness on a finished contained, the corrosive substance will be applied to the exterior surface of the container rather than to the interior wall.

It is obvious that when the container material is coated with a waterproofing substance, the waterproof coating should have a lower mechanical bursting strength under compressive force than the container material itself. This is especially true when the coating is applied after the chemical weakening has been carried out. This is true of most of the usual coatings for container materials, such as wax and synthetic resinous materials such as polyethylene. However, in addition to these resinous coatings, the outer surface of the container material may be covered with a ply or layer of a weaker material such as a thin sheet of cellophane or any of the synthetic polymeric resins. This material, which should have a lower bursting strength than the container material and indeed should have the same bursting strength as the chemically weakened areas, will be waterproof and may be bonded to the container material as supplied. In this case, of course, the corrosive substance will be applied to the uncovered side of the container material and the chemically weakened areas will then preferably be in the interior of the container, with the bonded layer being on the exterior. Alternatively, the sheet of waterproof material may be bonded onto the container material after the corrosive substance is applied.

The invention also includes apparatus for the formation of the expansible explosive cartridge. The apparatus comprises means for applying a corrosive substance in a desired pattern onto the container wall material, in combination with means for forming and cutting a blank stock for forming the walls of a container, and/or means for forming the blank stock into a container of the desired shape, and/or means for filling the container with the explosive mixture and/or means for sealing the filled container.

Means for applying the corrosive substance onto the surface of the container wall material are varied and will generally be determined by the stage at which the corrosive substance is applied. For example, flat stock, either before or after it is cut into the proper size for forming a container, or the container before or after filling, can be passed between pairs of rollers, as shown in FIGURE 1, one or both of which are dimpled or ridged, i.e., having raised areas or lines on its surface, which will imprint the corrosive substance in a pattern onto the surface of the container material. In addition, the corrosive substance can be imprinted by means of die plates, by sponges pressed against the surface, or with brushes. The corrosive substance can also be applied by passing the blank or container over a roller or belt, as shown in FIGURE 2.

The following drawings represent in the opinion of the inventor the best embodiments of apparatus and containers of the invention:

FIGURE 1 is a diagram of apparatus suitable for applying a corrosive substance onto a flat blank of the container wall material;

FIGURE 2 is a diagram of apparatus for applying a corrosive substance onto the walls of a formed container;

FIGURES 3, 5, 7, 9 and 11 are plane views of blanks suitable for forming tubular cartridges showing weakened areas in the form of lines;

FIGURES 4, 6, 8, 10 and 12 are isometric drawings of cartridges formed from the blanks of FIGURES 3, 5, 7, 9 and 11; and

FIGURE 13 is a partial cut-away view of the cartridge of FIGURE 12.

In FIGURE 1, paper stock **1** from roll **3** passes between the opposing kissing rollers **5** and **6**. The lower roller **6** is driven by means (not shown). The upper roller **5** is a smooth faced roller. The lower roller **6** is dimpled in a raised pattern **8** of dots, in two parallel rows. Roller **6** is partially immersed in a bath of corrosive solution **10** contained in pan **12**.

In operation, as the rollers **5** and **6** rotate, the dimpled surface of roller **6** picks up corrosive substance in bath **10** and imprints it onto the surface of the stock **1** as it passes between the rollers in the pattern of rows on roller **6**. The stock is then cut into blanks of the proper size, and these are formed into containers, which are filled with explosive before the corrosive substance has sufficiently weakened the container as to present a rupture hazard during filling.

The device of FIGURE 2 also includes a dimpled roller belt **15** rotated by drive means (not shown) in the direction indicated by the arrow. The belt has a raised pattern of three rows of dots **16** on its surface. Belt **15** passes through a bath of corrosive substance (not shown) as it rotates (as in the roller of FIGURE 1). Cylindrical containers **17** are rolled down inclined ramp **18** and pass over belt **15**. As the containers pass over the belt **15**, the corrosive substance is imprinted on their surface in the pattern on the surface of the belt.

In FIGURE 3, blank sheet **20** of container wall material, in this instance 80 weight light kraft paper, is cut in the form of a rhombic parallelogram and imprinted with aqueous caustic soda, using a die plast, to form the rows of dashes **21**. The rows of dashes **21** are perpendicular to the top and bottom of the cartridge blank, and form straight weakened portions **21** on the sides of the formed container as shown in FIGURE 4. Then the blank is rolled on a mandrel to form a container of two thicknesses of paper of the blank. The caustic solution is of a low enough concentration to allow sufficient time to roll and fill the tubular container with the explosive before deterioration of the paper fibers makes it difficult to pack the container with explosive without rupturing.

In FIGURE 5, **22** is the cartridge paper, in this instance manila paper of 100 weight, and **23** and **24** are areas of potential weakness formed by applying a continuous line of aqueous hydrochloric acid. Lines **23** and **24** are perpendicular to the top and bottom of the blank and of the container made therefrom, but are of different lengths, and do not extend the full length of the blank or container side wall, as shown in FIGURE 6. In forming the finished container, the blank of FIGURE 5 is wrapped twice around the mandrel. The longer line of weakness **23** is in the outer layer of wrapping. Using a line of weakness that does not extend the full length of the cartridge avoids accidental rupture in handling during storage or shipment.

FIGURE 7 shows a blank of container wall material **25**, in this case a 160 pounds weight manila paper having a coating of wax upon both sides. The lines **26**, **27** and **28** on the surface of the blank were scored through the wax coating on one side exposing the paper along the score. Lines **27** and **28** are discontinuous. Aqueous 50% sulfuric acid was then applied by dipping the blank into a sulfuric acid bath and wiping off the excess. The acid disintegrated the paper in the scored portions. Wax is inert to the acid and thus protected the paper in the other areas.

When the blank was wrapped two times around the mandrel to form the container shown in FIGURE 8, the weakened areas **27** and **28** were in the top layer of material, and area **26** in the under layer.

FIGURE 9 represents a blank of polyethylene sheet ten mils thick. The lines **30** represent the potential lines of structural weakness, formed by applying perchloroethylene with a marking pen to the surface of the blank. In this example the lines **30** are at an angle to the top and bottom of the blank, and form helical weakened areas on the container formed from the blank, as shown in FIGURE 10, in a single thickness of sheet.

FIGURE 11 represents a blank **33** of 140 pounds weight of kraft paper wherein a 50% aqueous solution of caustic soda was applied in a single line **32** along the approximate center of the blank parallel to a pair of sides of the parallelogram. The solution was applied in this case, in discrete portions to form a segmented linear pattern of weakened areas. The line or pattern **32** does not extend the entire length of the blank. The top and bottom sections **34** of the blank are the portions crimped to form the ends of the cartridge.

FIGURE 12 represents the tubular container formed by rolling the blank of FIGURE 5 but before crimping the ends **34**. The ends **34** show that the container has three layers of material around a portion of its periphery and at least two elsewhere.

FIGURE 13 is a sectional cut-away view, and shows the position of the helical line of weakness **32** in the middle layer of the portion of the container having three layers.

In the situation where the corrosive substance will completely eat through the container wall material at the point of application, so as to form holes or slits through the wall, it has been found preferable, to form the lines of potential weakness in the blank such that in the finished container, the holes or slits are beneath a protective continuous outer layer of wrapping. This prevents leakage of the contents and the seeping in of moisture.

Although the blanks can be made to any size and shape to form a cartridge of any desired configuration, the usual cartridges in commercial use are cylindrical and have a diameter of between one and two inches. Cylindrical cartridges, however, have been manufactured between ¾ inch and eight inches in diameter, and up to thirty inches in length.

The ends of the cartridge, rather than being sealed by crimping of the tube as explained above, can be closed by fitting a cap over, or a cup into, each end, and sealing the cap or cup to the tube. Any other system of closure is also suitable for use in this invention.

The container of this invention can be used for any type of explosive, and the explosive filler used will not substantially affect either the final cartridge or the process for manufacturing it, except as necessary for accommodating the explosive as to amount, form, or chemical properties.

The containers of this invention are suitable for use with both primary explosives and secondary explosives, such as the straight dynamites, the extra dynamites, the gelatins, the extra gelatins, semi-gelatins, the various nitrated explosives such as nitrostarch and pentaerythritol tetranitrate.

The order of carrying out the process steps in forming the cartridge may be determined according to the particular explosive to be packaged. For example, it would not be suitable to dip a filled cartridge into a bath of molten wax, which could be at a temperature in excess of 60° C., when the explosive contained therein is highly heat sensitive. In this case, the container can be coated prior to filling with the explosive.

The preferred embodiments described are merely exemplary of the invention, and the full scope is to be determined by the claims, as set forth below.

Having regard to the foregoing disclosure, the following is claimed as the inventive and patentable embodiments thereof:

1. In the process for forming an explosive cartridge comprising forming a container from sheet material, filling the container with explosive, and closing the container, the improvement which comprises applying a corrosive substance to predetermined limited portions of the surface of the container material, to chemically weaken the material in such portions, forming areas of structural weakness therein.

2. The process of claim **1** wherein the corrosive substance is applied to the surface of the blank for forming the container.

3. The process of claim **1** wherein the corrosive substance is applied to the empty container.

4. The process of claim **1** wherein the corrosive substance is applied to the container filled with explosive.

5. The process of claim **1** wherein the container is coated with a waterproofing substance.

6. A process in accordance with claim **1** in which the corrosive substance is inactive when initially applied, and is activated at a later time.

7. The process of claim **6** wherein the substance is activated by heating.

8. The process of claim **6** wherein the substance is activated by reaction with another chemical substance.

9. In the process for forming an expansible container for explosives, the step which comprises chemically weakening predetermined limited portions of the container material after the container is filled with explosive, thereby facilitating rupture of the container under compressive force.

10. An explosive cartridge comprising a container, an explosive in the container, said container having limited areas of its imperforate surface at least partially weakened chemically by action of a corrosive substance, and having a lower structural strength than the remaining portions of the container, but of sufficient structural strength to retain the explosive in the container until the container is ruptured by compressive force.

11. An explosive cartridge in accordance with claim **10** wherein the weakened areas are disintegratable, due to such action.

12. An explosive cartridge in accordance with claim **10** wherein the weakened areas are in the form of lines.

13. An explosive cartridge in accordance with claim **10** wherein the container is of a tubular shape and the weakened areas are in the form of a helix spiraling around the container.

14. In an apparatus for forming an expansible explosive cartridge, which comprises means for forming a sheet material into a container, means for filling the container with explosive, and means for closing the container, the improvement which comprises means for applying a corrosive substance to predetermined limited portions of the container to chemically weaken the material in such portions.

15. An apparatus in accordance with claim **14**, wherein the means for applying the corrosive substance comprises means for depositing the substance onto the container material in a predetermined pattern.

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