

May 26, 1970

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3,513,776

CONSUMABLE CARTRIDGE CASE

Filed April 11, 1968

2 Sheets-Sheet 1

FIG. 1

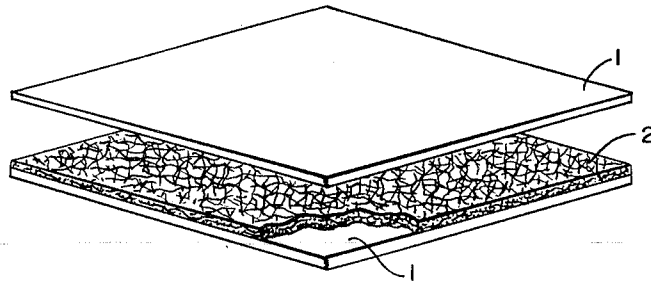


FIG. 2

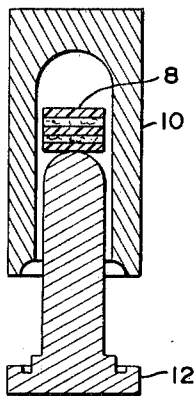
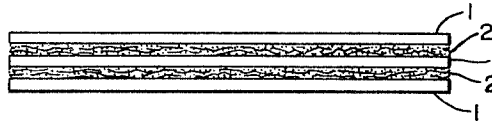


FIG. 3

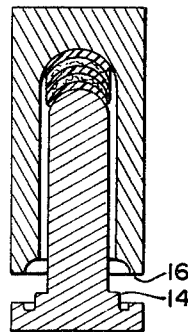


FIG. 4

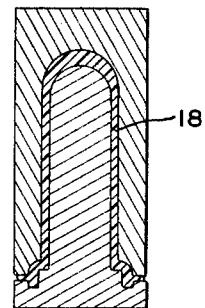


FIG. 5

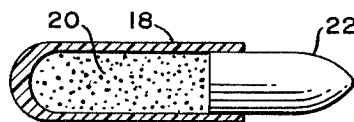


FIG. 6

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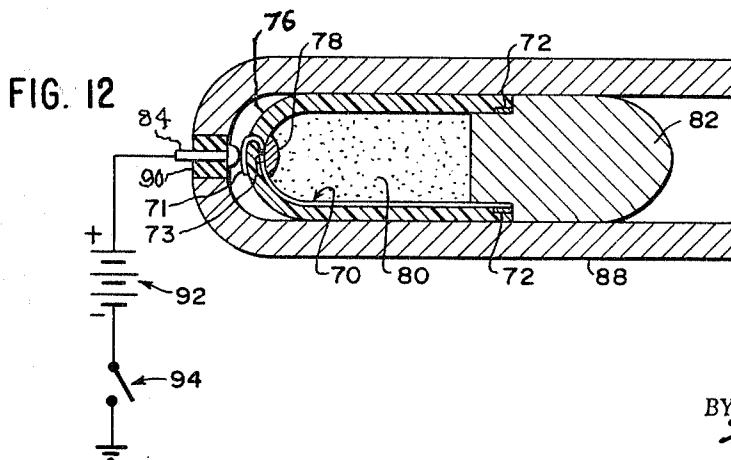
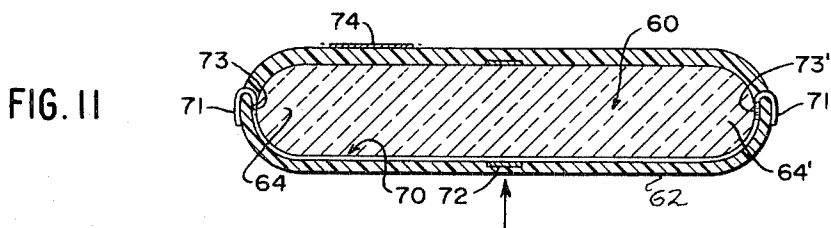
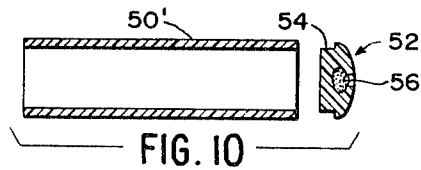
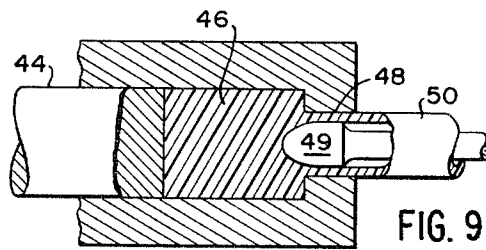
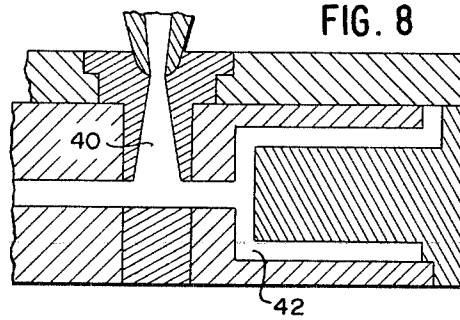
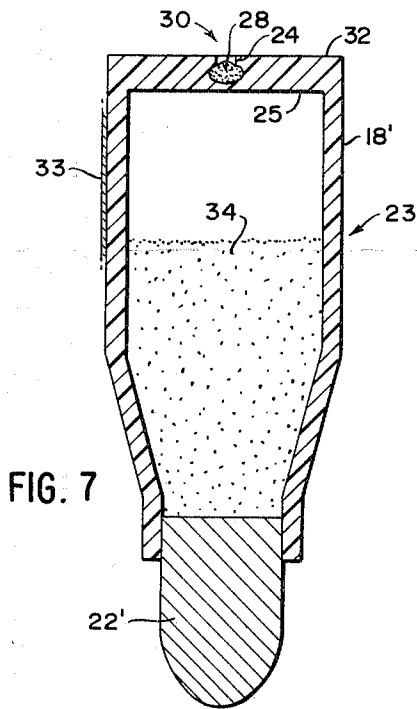
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2 Sheets-Sheet 2



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CONSUMABLE CARTRIDGE CASE

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16 Claims

ABSTRACT OF THE DISCLOSURE

A consumable cartridge case fabricated from consumable materials reinforced by consumable filaments so that a high strength case of a combustible or consumable nature is provided.

Caseless cartridges have been in use in at least rudimentary form for over 100 years, but they have always, particularly in the case of small arms ammunition, been handicapped by their innate fragility. Therefore, military and sporting weapons have consistently used metallic cases for weapons producing high chamber pressures and metallic and plastic or metallic and paper combinations for weapons such as shotguns which have somewhat lower chamber pressures. These metallic cartridges create operating problems for the weapons designer because a metallic case remains after the round has been fired and must be extracted from the weapon mechanism before another round can be chambered and fired. While some attempt has been made to use consumable cartridges, the fragile nature of consumable cartridges has led designers to incorporate at least a rudimentary metallic structure or reinforcing components so that extraction and ejection problems, while somewhat minimized, still remain.

Consumable or combustion cartridges date from the early paper cartridges. These were little more than a handy container to provide the required amount of black powder along with a bullet. In more modern times, combustible or consumable cartridge proposals normally consist of cartridges constructed from a material which will be consumed under conditions of firing. Cartridges of the early paper type would be utterly unsuited for modern firearms mechanisms. They are suited only to hand manipulation of cartridges. Modern consumable cartridge cases are better, but still not up to the severe requirements of modern, high rate of fire mechanisms. The addition of metal inserts at critical points gives rise to the extraction problems noted above and similarly the addition of reinforcing components complicate production.

I have found that all of the above problems can be solved if one uses a cartridge reinforced by filaments of consumable materials of high strength, such as carbon. Such filaments provide extremely strong cases when embodied in a combustible matrix. In fact, case strength can substantially exceed that of modern metallic cartridges. Therefore, the present invention does not merely minimize the problems of the prior art consumable cartridges, but provides superior case characteristics. The cases of this invention may be fabricated by impregnating filaments wrapped around a mandrel, by extruding fibers in a propellant matrix, by forming a combustible impregnated fiber cloth, by compression molding a fiber-propellant mix or by casting a fiber-propellant mixture.

The details of the invention are more fully set forth in the following description to be read in conjunction with the drawings wherein:

FIG. 1 is a schematic exploded view of a laminated sheet of propellant material in accordance with my invention in the course of its manufacture;

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FIG. 2 is a cross-sectional elevational sketch of a completed laminated sheet of propellant material in accordance with my invention;

FIGS. 3, 4 and 5 are diagrammatic illustrations, with parts shown in cross-section, of a sequence of steps in the manufacture of a consumable cartridge case in accordance with my invention;

FIG. 6 is a diagrammatic cross-sectional view of a completed cartridge in accordance with my invention, suited for use in externally primed firearms;

FIG. 7 is a diagrammatic cross-sectional view of a completed primed cartridge in accordance with a modification of my invention;

FIG. 8 is a diagrammatic cross-sectional view of an injection mold adapted for use in the manufacture of cartridge cases in accordance with my invention;

FIG. 9 is a diagrammatic cross-sectional view of an extrusion die assembly illustrating the formation of a portion of a cartridge case in accordance with my invention;

FIG. 10 is a diagrammatic cross-sectional view of a modified form of cartridge case in accordance with my invention;

FIG. 11 is a diagrammatic cross-sectional view of a mandrel and propellant material disposed on the mandrel, illustrating another method of manufacturing cartridge cases in accordance with my invention; and

FIG. 12 is a diagrammatic cross-sectional view of an electrically discharged firearm and a cartridge in accordance with my invention disposed in loaded position therein.

Before considering the various embodiments of my invention illustrated in the drawings, the composition of the cartridge material of my invention, and the manner in which it is prepared, will be described. The principal stress-resisting element of a cartridge in accordance with my invention consists of fine carbon filaments embedded in a matrix of conventional propellant material. This composition may be laminated or coated with other materials, in a manner to be described, to contribute desirable bulk and surface properties.

Carbon filaments useful in the practice of my invention may be obtained in the form of commercially available carbon or graphite filaments or yarns, such as those sold by the Union Carbide Company under the trade name "Thornel," including "WYB" graphite yarn and "VYB" carbon yarn. Such materials are made by carbonizing spun or woven textile fibers, such as rayon or the like, at high temperatures. One of these materials that is well suited to the practice of my invention is a carbon filament having a tensile strength of 180,000 pounds per square inch, a density of 1.42 grams per cubic centimeter, an elastic modulus of 25×10^6 pounds per square inch, an equivalent diameter of 7.4 microns, and a carbon assay of 99.1 percent by weight. If desired, up to ten percent by weight of the fibers may be glass fibers of the type used to fill epoxy resins.

The carbon filaments may be chopped to lengths of a few millimeters, or, for some purposes, used in lengths up to 2 inches or so. Depending upon whether a preferred or a random orientation of the fibers in the final product is desired, various techniques, to be described below, may be employed for embedding the filaments in the propellant matrix. Broadly, however, the preferred approach involves liquefying, or at least softening, the propellant material to permit the introduction of the filaments into the propellant. For example, if the desired propellant is sufficiently thermoplastic, at temperatures at which it is stable, heat may be employed. Alternatively, a solvent for the propellant may be employed.

The chemical nature of the propellant material is not important, except that unstable explosives would obviously

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ly be unsuitable. The necessary physical properties are characteristic of a number of available conventional propellants. Specifically, the material must be a solid over the range of temperatures to be encountered in the use and storage of the final product. To permit admixture with the carbon fibers, the material should be sufficiently thermoplastic for that purpose, or should be soluble in a convenient volatile solvent with which it will not react chemically. For example, many conventional propellants are soluble in acetone.

Satisfactory structures have been made using two conventional propellant compositions. In one case, a solution of a conventional ammonium perchlorate-rubber rocket propellant composition in sufficient acetone to dissolve it was mixed with 25 percent by volume of carbon filaments. Upon evaporation of the solvent, a solid possessing high mechanical strength was formed. The material was burned and found to leave a negligible residue.

A second suitable material was prepared by mixing 20 percent of the same filaments, by volume, in a solution of "Hercules Smokeless" powder, a commercially available double-base powder containing nitroglycerin and nitrocellulose, in sufficient acetone to dissolve the powder. The carbon filaments were chopped to five millimeter lengths. Again the resulting matrix, formed upon evaporation of the solvent, was found to have high mechanical strength and to burn to a negligible residue.

For some purposes cartridge cases may be fabricated from the material made as described above, by simply mixing carbon filaments with a solution of a conventional propellant and allowing the solvent to evaporate. However, the carbon filaments in that material contribute great strength to the matrix only when completely embedded in the softer propellant material, and may contribute to high localized stresses at the surfaces of the matrix. In addition, the chemical properties of the matrix surface may require it to be protected from exposure to air or moisture. Thus, it is preferred to employ a composite construction, such as that next to be described.

Referring now to FIG. 1, a sandwich construction suitable for cartridge fabrication is shown. Essentially, the construction comprises outer layers 1 of solid propellant material, between which are layers such as 2 of propellant-carbon fiber matrix made as described above. The layers such as 1 may be made by rolling, extruding or calendaring conventional propellant, softened by heat or with the aid of a solvent such as acetone, into sheets of desired thickness for most purposes. Such sheets may be conveniently stored by interleaving them with sheets of polyethylene film.

The intermediate matrix layers 2 may be made in sheet form in the same manner, from softened or dissolved propellant mixed with carbon fibers. A composite laminate, as shown in FIG. 2, is then formed by rolling the superposed sheets 1 and 2 with heat and pressure, or by first softening the confronting surfaces of the sheets with acetone and rolling under pressure. About 20 millimeters is the practical minimum for the total thickness of the finished laminate shown in FIG. 2. That thickness would be appropriate for the manufacture of small arms cartridges; i.e., in calibers from .22 to .30.

Referring again to FIG. 1, an alternate process for the manufacture of laminated cartridge case material comprises softening the confronting surfaces of the sheets 1 with acetone, sprinkling a layer of chopped, 0.5 millimeter lengths of carbon fibers over the surface of one of sheets 1, and then rolling the sheets 1 and the intermediate fibers 2 into a composite laminate relatively rich in carbon fibers in the center but having no carbon fibers in the outer surfaces.

Still another approach is to mix the carbon fibers with an acetone solution of propellant, and flow the mixture over the surface of one of the sheets 1 to form a layer of desired thickness. After substantial hardening of the

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matrix layer by solvent evaporation, the composite can be completed by the addition of the other sheet 1 in the manner described above. A suitable matrix mixture for the purpose is made from 20 parts by weight of 4 millimeter long filaments of 9.5 micron diameter, and 80 parts by weight of conventional propellant, in sufficient acetone to dissolve the propellant.

Referring now to FIG. 3, a die suitable for forming a cartridge from the material of FIG. 2 is shown. The sheet of sandwich material 8 is placed in the die. The mold will preferably be slightly warmed to facilitate forming. The die cavity 10 and plunger 12 are then mated under heat and pressure or solvent and pressure, to cause the layers of propellant sheet to flow and conform to the die configuration. The mill portion of the die is provided with a sheering ring 14 which mates with a matching cavity 16 to pinch off and trim the end of the case.

FIG. 4 illustrates the operation as the dies are forced together.

FIG. 5 shows the dies as the molding operation is completed. The dies are then separated and the completed case 18 removed. If a cartridge were being prepared for an externally primed firearm, such as a cap-and-ball type weapon primed with an external percussion cap, a case formed exactly as described above in conjunction with FIGS. 3 through 5 would be entirely suitable. Additional propellant material 20 would be placed in the case and a projectile 22 inserted into the open end. If long storage under adverse conditions is anticipated, the assembled cartridge would be coated with a combustible waterproof material, such as lacquer or one of the waterproof synthetic resins. The coating may be applied simply by spraying or dipping and will provide a waterproof seal both to the combustible cartridge case and to the joint between the case and the projectile.

If the cartridge is to be used in modern firearms adapted to combustible cartridges, then a suitable cartridge may be made by a method very similar to that set forth in the above description of FIGS. 3 through 5. In this case, however, the female die will have a shape to provide a cartridge base suitable for use in such firearms. As shown in FIG. 7, the cartridge case 23 is molded with a recess 24 at the base 25 which serves to provide a pocket for a pellet of priming composition 28.

In order to provide a completely consumable cartridge, the primer pellet 28 may be made in the same manner as the case. For that purpose, a suitable priming composition filled with carbon fibers to provide sufficient mechanical strength so that no metallic reinforcing components need be included.

The surface 30 of the priming composition 28 is preferably slightly recessed from the surface 32 of the case to avoid accidental detonation of the primer. A sealing coating 33 may be applied to the case to serve to waterproof the case and primer and assist in holding the primer in place.

As shown in FIG. 7, a projectile 22' and additional propellant 34 are added to the case to form a complete round. This round may be fired in conventional firearms suited to the firing of combustible cartridges. Since there are no metallic inserts, the entire cartridge is consumed, because the only non-combustible component is the projectile which will leave the muzzle of the weapon. Moreover, since the case is formed in a simple, one step molding operation, it may be cheaply fabricated in quantity. The filament reinforced matrix formed in the case provides extremely high strength, so that the case will stand normal handling and the stresses involved in modern firearms having a high rate of fire.

Suitable molding times are in the order of 45 seconds for a temperature of 300 degrees Fahrenheit and a pressure of 500 to 1,000 pounds per square inch. In general, molding temperatures would be in the 200 to 300 degrees Fahrenheit temperature range. If there is a temperature differential of about 10 degrees Fahrenheit between the

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two halves of the mold, curing and shrinking will start at the hotter half. This produces a higher gloss and a more even surface. Thus, if the female half of the die is approximately 10 degrees hotter, a glossy external case surface will be produced. Since shrinkage will also begin at the hotter half, the formed case will release easily from the mold and will be withdrawn on the male side. It may then be readily handled for further processing, such as the application of the priming pellet.

After a cartridge case with primer pellet is provided, further operations can be identical to those in normal cartridge manufacture.

In addition to the sandwich molding technique described above, other forming techniques are suitable for making cartridge cases according to the present invention. For example, an injection molding process, illustrated in FIG. 8, may be employed. In that case, a configuration substantially identical to the closed die assembly of FIG. 5 is provided, but the matrix to be molded is injected through an opening 40 to fill the cavity 42. The configuration of the resulting case will depend on the mold design and can be identical to that shown in FIG. 8. For the injection molded cartridge case, any of the fiber-propellant matrix mixtures described above are suitable; laminated cases would require a series of molding steps to form the layers of different composition. As discussed above, two suitable mixes for single stage molding, or for the matrix layers in a laminate, are carbon filaments in an ammonium perchlorate binder, and carbon fibers in a nitroglycerine, nitrocellulose binder.

Cylindrical cartridge case material may be extruded in the die assembly shown in FIG. 9. In that case, a plunger 44 expels the matrix mixture 46 through an annular die 48 to form a combustible cylindrical tubing 50 comprising carbon fibers in a combustible binder. As shown in FIG. 10, cartridge cases may be made employing sections of this tubing 50' plugged at one end with a molded plug 52 of the same material, having cylindrical section 5A to close one end. A primer pellet 56 may be provided in the plug 52.

While molding operations will normally be more economical for large scale manufacture, suitable cartridge cases according to my invention can also be produced by winding the material on a mandrel. Referring now to FIG. 11, a mandrel 60 suitable for producing combustible cartridges to be utilized in the electrically fired gun of FIG. 12 is shown. Layers of carbon yarn impregnated with propellant material are wound on the mandrel 60 to produce a cocoon 62. Alternatively, the carbon yarn may be wound on the mandrel and then impregnated with an acetone solution of propellant. The mandrel 60 has a slight taper from its midpoint 61 toward the rounded ends 64 and 64'.

As shown in FIG. 11, provision may be made for producing electrically fired cases. For that purpose, a consumable conductive strip 70, of magnesium foil or the like, is laid over the mandrel 60 before the cocoon 62 is put in place. The ends 71 and 71' of the strip are brought out as shown to form external electrical contacts. A conductive ring 72, of magnesium foil or other suitable conductive and consumable material, is wound about the mandrel 60. The ring 72 may be over the strip 70, as shown, or under it.

Carbon filament yarn impregnated with propellant material is then wound around the mandrel to produce the filament cocoon 62. The completed cocoon may be coated with a sealing plastic layer 74. The cocoon is then cut into two halves where indicated by the arrow, and forms two filament reinforced cartridge cases.

FIG. 12 illustrates a possible weapon suitable for use with, and loaded with, a cartridge having a case fabricated in accordance with FIG. 11. The cartridge case 76 is one-half of the impregnated fiber cocoon 62 produced on the mandrel 60 of FIG. 12.

A projectile 82 is inserted in the open end of the case

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76. A pellet 78 of prier composition is in contact with the conducting strip 70. The strip 70 may be notched or otherwise reduced in area at 73 so that electrical current flowing through the strip 70 will fuse the strip at that point and ignite the primer 78. As shown at 80, a supplemental charge of propellant may be placed inside the case 76.

As schematically indicated, the gun may comprise a barrel 88 suitably formed with a chamber at one end to receive the cartridge. A contact 84 at the closed end of the barrel 88, and insulated therefrom by suitable means 90, is connected to one terminal of a suitable voltage source, here shown as a battery 92. A trigger switch 94 completes the circuit through the battery 92, contact 84, strips 70 and 72, and the barrel 88, and energizes the primer pellet 78 to fire the cartridge.

If the case 76 is made by methods discussed above other than in the manner illustrated in connection with FIG. 11, the primer pellet 78 may be placed at the base of the projectile 82. The strip 70 could then be brought up into contact with the projectile 82 at its center, with the reduced portion 73 occurring in the region of the pellet 78. The primer pellet and firing circuit may also be arranged as disclosed in my copending U.S. application Ser. No. 680,935, filed on Nov. 6, 1967, and assigned to the assignee of this application. The reinforced consumable cartridge case of my invention is well suited for use in the firearms also disclosed in application Ser. No. 680,935.

The electrical conductivity of the carbon reinforced material of my invention is in the range between that of metallic conductors and insulators, i.e., typically about 35.3 ohm-cm. Thus, while the conductivity should be kept in mind, it presents no problem in the design of a practical firing circuit.

While the above description has set forth certain preferred embodiments of my filament reinforced cartridge, those skilled in the firearms art will recognize that various modifications may be made without departing from the scope of the present invention.

Having thus described my invention, what I claim is:

1. A cartridge comprising a projectile and a consumable case mounted on said projectile, said case comprising a stress resisting shell of carbon filaments embedded in a matrix of solid propellant.

2. A cartridge according to claim 1 wherein said carbon filaments

have a diameter in the order of 10 microns.

3. A cartridge according to claim 1 wherein said carbon filaments have a length of from 1 to 50 millimeters.

4. A consumable cartridge case, comprising a tubular body portion open at one end to receive a projectile, closed at an opposite end by a base portion, and comprising as the chief stress resisting element carbon filaments embedded in a matrix of a solid propellant.

5. A cartridge case according to claim 4 wherein carbon filaments

have a diameter in the order of 10 microns.

6. A cartridge case according to claim 4 wherein said carbon filaments

have a length of from 1 to 50 millimeters.

7. A composition useful in the manufacture of combustible structural elements,

comprising carbon filaments,

said filaments having longitudinal and transverse dimensions,

the longitudinal dimensions being substantially greater than the transverse dimensions of said filaments, said filaments being embedded in a combustible matrix propellant.

8. A combustible structural material, comprising approximately 20 parts of carbon yarn filament particles, said filaments having longitudinal and transverse dimensions, the longitudinal dimensions being substan-

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tially greater than the transverse dimensions of said filaments,

said filaments being dispersed and imbedded in a matrix, of approximately 80 parts of a combustible propellant.

9. The process of manufacturing a consumable cartridge case, comprising the steps of dissolving a combustible propellant in a volatile solvent, mixing carbon yarn filaments with the solution so formed, said filaments having longitudinal and transverse dimensions, the longitudinal dimensions being substantially greater than the transverse dimensions of said filaments, and evaporating the solvent.

10. A laminar combustible structural material, comprising alternate interdiffused layers of combustible propellant and of carbon filaments imbedded in a matrix of propellant, said filaments having longitudinal and transverse dimensions, the longitudinal dimensions being substantially greater than the transverse dimensions of said filaments, in which at least one surface of the laminar material comprises a layer of propellant substantially free of carbon filaments.

11. The process of manufacturing laminated combustible structural material comprising the steps of interspersing sheets of solid propellant material with sheets of carbon filaments, said filaments having longitudinal and transverse dimensions, the longitudinal dimensions being substantially greater than the transverse dimensions of said filaments, said filaments being imbedded in a matrix of solid propellant material, and pressing said sheets together, while at least the confronting surfaces of the sheets are maintained in a softened state, to form a unitary laminated construction.

12. The process of claim 11, in which the confronting surfaces of said sheets are softened by heating.

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13. The process of claim 11,

in which the confronting surfaces of said sheets are softened by the absorption of a solvent for the propellant material.

14. In the manufacture of consumable cartridge cases from solid propellant material, the improvement comprising the step of dispersing carbon filaments, said filaments having longitudinal and transverse dimensions, the longitudinal dimensions being substantially greater than the transverse dimensions of said filaments, said filaments being dispersed throughout at least the stress resisting portion of the consumable solid propellant material from which the cases are made.

15. A cartridge comprising a projectile and a consumable case on said projectile, said case comprising a stress resisting shell of carbon filaments imbedded in a matrix of solid propellant and containing additional propellant material within said shell.

16. A consumable cartridge case, comprising a tubular body portion open at one end to receive a projectile, closed at an opposite end by a base portion, said base providing a volume for the receipt of additional propellant material and comprising as a chief stress resistant element carbon filaments imbedded in a matrix of a solid propellant.

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U.S. Cl. X.R.

102—43, 97; 149—19