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MISSILE CASING

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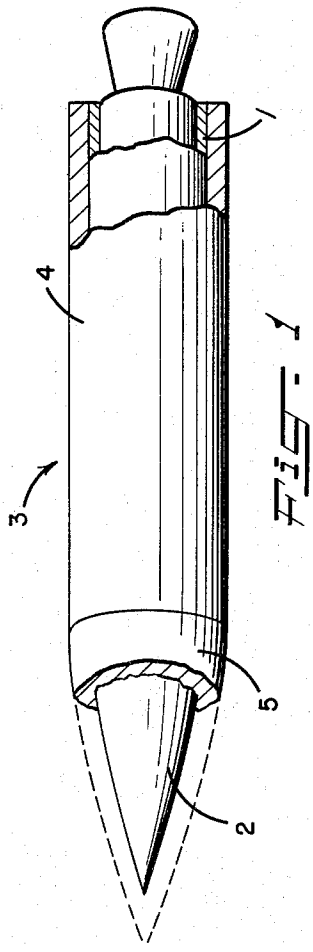
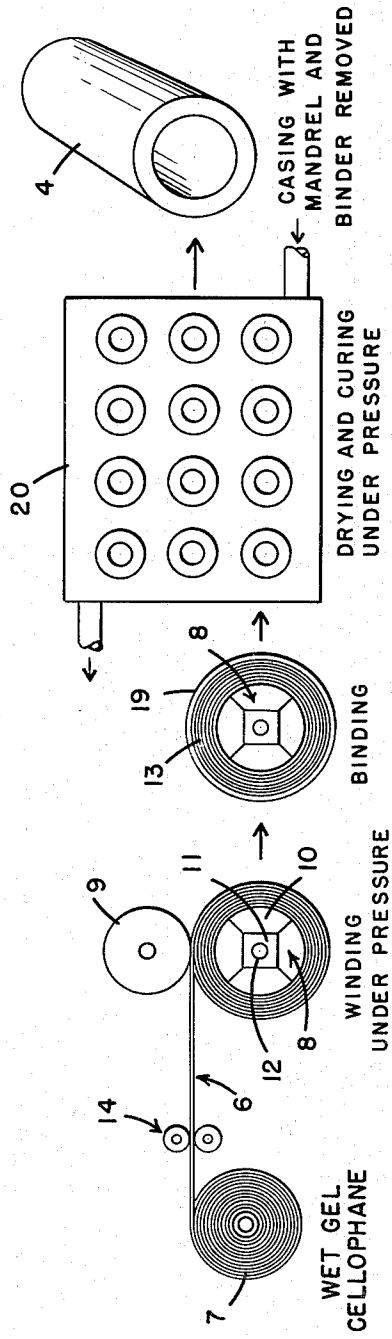



Fig. 1



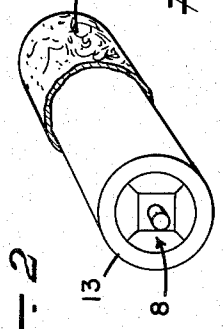




Fig. 2

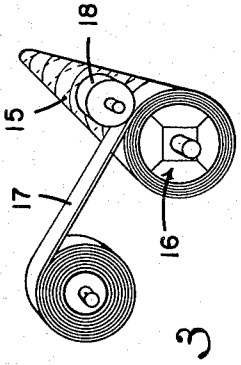



Fig. 3

Fig. 4

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# MISSILE CASING

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This invention relates to missiles, rockets, projectiles and similar ballistic devices and, more particularly, to expendable, protective casings therefor.

Missiles, rockets, projectiles and the like are now in existence which travel at extremely high velocities. Certain types of missiles are designed to be fired or projected through the earth's atmosphere into the stratosphere, travel through a predetermined space and then descend through the earth's atmosphere to reach a desired target. During the extremely brief period of travel through the atmosphere, very high temperatures are created or generated by the friction of the atmosphere on the outer surface of the missile. One of the troublesome problems in designing the high velocity missiles has been the construction of the device to protect the missile and the contents from the effects of these high temperatures as the missile travels at the high velocities. The exterior surfaces of these devices have been shaped to reduce to a minimum the friction of the atmosphere and considerable efforts have been expended, unsuccessfully, in attempts to develop a material which will resist the high temperatures created during the flight of the missile. Protective casings have been provided, some of which are intended to burn away during flight.

In general, the highest temperatures are reached during the very brief period that the device travels through the atmosphere in its fall to the earth. The outer protective casing, therefore, is in effect, only required to protect the inner structure of the device for a brief period of time to avoid damage to the fuel, explosive charge and enclosed instruments from the excessive temperature rise. It has been proposed to provide missiles with outer, burnable casings formed of a relatively hard wood such as maple. While wood is a fairly good heat-insulator, its burning rate is too high so that the entire outer casing is burned away before the missile reaches its target and exposes the missile housing itself to high temperatures resulting from the friction of the atmosphere.

The term "missile" is used herein and in the claims to designate ballistic devices either projected or propelled by an external force or by a self-contained means such as a rocket engine or motor.

One of the principal purposes of this invention is to provide a ballistic device or missile having an outer or exterior expendable casing which will protect the device from elevated temperatures generated during flight.

Another object of this invention is to provide a ballistic device or missile with a protective casing which is characterized by having a high thermal-insulating property and a slow burning rate.

Other objects and advantages of this invention will become apparent from the description and claims which follow.

In the drawings,

FIGURE 1 is an elevational view, partly in section, of a missile formed in accordance with the present invention;

FIGURE 2 is a diagrammatical illustration of a method of forming the missile casings;

FIGURE 3 is a diagrammatical perspective view illustrating a method of building up the casing element for the nose of a missile; and

FIGURE 4 is a perspective view illustrating one detail in one step of making the casings of this invention.

In accordance with the present invention, a ballistic device or missile having a generally cylindrical configuration is provided with an exterior, expendable, cylindrical casing comprising non-fibrous cellulosic material. The expendable casing is formed by winding upon itself under pressure a thin film of wet gel cellulosic material which has been impregnated with an aqueous dispersion of a thermosetting resin and, preferably, the aqueous dispersion also contains a flame-retarding substance. After building up a desired wall thickness, the structure is dried and the resin cured or set under pressure to form a seamless, cylindrical casing having a low burning rate and a high thermal-insulating property. Devices of this nature and having such a casing are protected from the effects of high temperatures created by the atmospheric friction when such devices are caused to travel through the atmosphere at the high velocities. When a device or missile including such an exterior casing travels through the atmosphere at the high velocities, the outer non-fibrous cellulosic casing becomes charred and burns away slowly although it simultaneously protects the missile housing and its contained instruments.



As illustrated in FIGURE 1, the missile formed in accordance with this invention comprises a housing consisting of a cylindrical body section **1** terminating in a forward conical nose section **2** and an outer expendable, protective casing **3** of non-fibrous cellulosic material conforming to the missile housing and consisting of a cylindrical section **4** and a conical section **5**. The usual explosive charge, fuel, instruments and the like, depending upon the nature of the missile, are contained within the housing.

Various methods may be employed in forming the expendable casing. For example, as illustrated in FIGURE 2, a film of wet gel cellulosic material **6**, such as wet gel regenerated cellulose film impregnated with a thermosetting resin, for example, an aminotriazine-aldehyde type resin, such as melamine-formaldehyde, urea-formaldehyde, ammeline-formaldehyde, guanamine-formaldehyde and the like is supplied from a roll **7** or any other desired source. The wet gel film is wound upon itself on a collapsible mandrel **8** under pressure. The pressure is preferably applied by means of a roller or drum **9**. The collapsible mandrel may be formed of a plurality of segments **10** and a tapered core **11**. The tapered core may be provided with an axle **12** to which the core is secured. The core is preferably coextensive with the segments so that upon assembly, the core and segments form a cylindrical body of a desired diameter and length. Further details of the collapsible core are not included herein because the core forms no part of this invention and any conventional collapsible core may be used. It is essential that during the winding operation the roller or drum **9** exert sufficient pressure to prevent entrapment of air between successive layers of the film and also to press any excess liquid from the tubular casing **13** as it is built up on the collapsible mandrel. To further insure removal of excess liquid from the film as it is wound upon the mandrel, the film may be passed between squeeze rolls **14** before it reaches the mandrel.

In order to form a cone-shaped section **15** adapted for the nose of a missile, a collapsible conical mandrel **16** is employed as shown in FIGURE 3. A narrow strip or band **17** of wet gel cellulosic material impregnated with a resin is wrapped about the mandrel in overlapping spiral relationship. The wet gel strip is traversed over the conical mandrel in building up a layer of the desired thickness. A roller **18** also traverses over the conical mandrel and exerts pressure on the tape **17** as it is laid on the mandrel. It is obvious that the conical mandrel may be formed as part of the cylindrical mandrel, if desired.

After the desired number of laps has been applied to the mandrel, the film or tape is cut and an elastic or

shrinkable binding **19** is applied over the wet gel, laminated cellulosic tube while on the mandrel. The wrapped tube while on the mandrel is transferred to a suitable curing chamber **20** wherein the wet gel cellulosic material is dried and the temperature is gradually increased and maintained at the required temperature to effect a curing of the specific resin contained in the cellulosic material. For purposes of illustration, FIGURE 4 only depicts a tubular casing enclosed in an elastic or shrinkable wrapper, but it is to be understood that the conical section is also similarly enclosed before drying. In order to maintain the internal diameter of the tube and to prevent distortion, it is essential that the tube be dried on the mandrel. Where the casing is to be dried on its mandrel, the mandrel is preferably porous to allow the moisture to escape from the interior as well as the exterior surface. It is well known that wet gel cellulosic material, such as regenerated cellulose, shrinks appreciably as the moisture is removed and unless means is provided to prevent a radial shrinkage, the tube or cone becomes radically distorted. During drying, the contractile forces exerted by the successive laps is so great that each successive lap exerts considerable pressure on the underlying lap and to provide pressure on the exterior lap, the wet gel tube or cone is enclosed in a suitable binding, such as unimpregnated wet gel regenerated cellulose or with a porous elastic sleeve. It is essential that the binder or wrapper be porous to permit escape of the moisture and that it have sufficient elasticity or shrinkability so as to follow the shrinkage of the wall of the tube or cone. One convenient form of elastic tube is formed of a web of rubber fibers which are bonded together at their points of intersection. The wrapper or binder should have a high degree of shrinkability or elasticity because the wet gel cellulosic material will shrink in cross-section as much as 60% or more.

After drying and curing under pressure as described, the tube or casing **4** is extremely rigid and hard and cannot be delaminated. The tube grips extremely tightly the underlying mandrel. It is therefore necessary that the mandrel be a collapsible mandrel to permit separation of the tube from the mandrel. The tube is substantially transparent and appears to be more or less homogeneous throughout its thickness.

In forming the casing whether a substantially straight cylinder or whether a conical section, additional laps may be applied to the mandrel so as to provide additional wall thickness thereby allowing a finishing operation. The dried casing material can be sawed and machined as by turning or milling to bring it to final exterior size and to provide a smooth exterior surface and reduce air friction of the casing to a minimum.

The casing is applied to the missile by first applying the cylindrical section and finally the conical section covering the nose of the missile where the casing has been formed in sections. In order to insure a tight grip between the casing and the missile, the casing material may be subjected to high humidity conditions to absorb moisture after application to the missile. The casing material possesses a high moisture absorption characteristic and, upon subsequent removal of absorbed moisture as by drying, additional shrinkage of the cellulosic material occurs to provide an extremely tight fit over the missile.

It is not essential that the casing be formed on a separate mandrel, dried and the surface finished before application to the missile housing. The wet gel cellulosic material film **6** may be wound upon the mandrel **8** and the tape **17** may be wound upon the conical mandrel **16** to form the casing sections, as described hereinbefore. The sections may then be removed from the collapsible mandrels, applied to the missile housing and then enclosed in the shrinkable or elastic wrapper. The housing and casing are then transferred to the drying and curing chamber.

As a further alternative, the housing may constitute



the mandrel upon which is wound the wet gel cellulosic material. The film **6** and the tape **17** are wound directly on the missile housing under pressure as described. Alternatively, the entire casing may be formed from tape wound upon the housing in overlapping relationship. After the desired number of layers or laps have been applied to the housing, the wet gel cellulose casing is enclosed in a shrinkable or elastic wrapper and the assembly then transferred to the drying and curing chamber.

Because of the high degree of shrinkage of wet gel cellulosic material as it is dried, the dried casing is so tightly fitting that it is impossible to remove it from the missile housing without destroying the casing.

The casing may be formed from wet gel cellulosic materials such as regenerated cellulose and alkali-soluble, water-insoluble cellulose ethers, for example, the hydroxyethyl cellulose ethers, carboxymethyl cellulose ethers, cellulose ether-esters and the like. The term "wet gel" is employed in its conventional sense to designate the coagulated and regenerated or coagulated cellulosic material after formation and prior to initial drying. A wide variety of flame-retarding substances may be incorporated in the wet gel film by passing the wet gel film through a solution thereof. For example, the wet gel film after passing through an aqueous dispersion of the resin may be passed through a 6% to 10% aqueous solution of a mixture of four parts of ammonium bromide and one part of diammonium hydrogen phosphate.

To merely illustrate the formation of casings of the type herein disclosed, a wet gel film of cellophane was passed through an aqueous dispersion of a melamine-formaldehyde resin (Parez 607) and wound on a collapsible mandrel of the type hereinbefore described. The wet gel film was about nine inches in width and of a thickness normally formed in the production of cellophane having a thickness of about 0.003 inch. The impregnated wet gel film was wound under pressure on the mandrel to form a tube having a thickness in the wet gel condition of about one-half inch. The mandrel was constructed of maple. After this wrapping of the cellophane was completed, an unimpregnated wet gel regenerated cellulose film was wrapped around the tube. The wrapped tube was then allowed to air dry at normal room temperatures. In practice, however, the mandrel is preferably formed of a porous material to allow escape of the moisture vapors through the interior of the tube as well as the exterior and thereby hasten the drying of the tube. After drying, the assembly was hated to about 300° F. in order to cure and complete the polymerization of the melamine-formaldehyde resin. The wall thickness of the dried tube was approximately 59% of its original thickness and the length of the tube was approximately 80% of the original length. The tube was hard, substantially transparent, very rigid and appeared to be homogenous when an end was sawed from the tube. It is obvious that any desired wall thickness may be obtained by regulating the thickness of the wet gel wall thickness.

Under high temperature conditions such as are developed in the extremely high speed flight of missiles, the action of the casings of this invention are entirely distinct from that of wood such as has been employed. It is recognized that temperatures are reached in the flight of some of the high speed missiles which are sufficiently high to melt or render metals, such as steel, plastic. In order to illustrate the difference in action between the missile as formed in accordance with this invention and a missile having a wood outer casing, a sample of maple wood and a sample of a casing as formed in accordance with this invention were subjected to an oxyacetylene flame. Each sample was of the same thickness, namely, five-sixteenth inch thick. The samples were mounted in a vertical plane with the grain of the wood running vertically and the laminations of the regenerated cellulose running vertically. The oxyacetylene torch tip was approximately four inches from the samples and the flame was directed

horizontally against each sample with the blue cone playing on the sample. A thermocouple was mounted on each sample in close contact with the sample on the side directly opposite the point of impingement of the flame. In the case of the maple wood, it was noted that the temperature on the opposite side began to increase almost as soon as the flame touched the sample. The temperature rose through a ten Fahrenheit degree rise in forty-five seconds. In the case of the casing of the present invention, no temperature change was noticeable for about sixty seconds and the ten Fahrenheit degree rise required a period of seventy-five seconds. Upon inserting an asbestos shield between the wood sample and the gas torch, the wood continued to support combustion and continued to burn. In the case of the casing of the present invention, no combustion was noted and those portions of the regenerated cellulose which were glowing at the time the asbestos shield was inserted between the sample and the torch ceased to glow in a matter of a few seconds. The burned and charred portion of the wood had the characteristic appearance of a piece of wood which had been ignited and then extinguished. In the instance of the casing of the present invention, it was noted that there was a successive rupturing and flaking-off of each layer of the casing. There appeared to be a slight expansion or bubble effect of each succeeding layer of regenerated cellulose and it is believed that this may account for the appreciably greater time delay in the temperature rise on the opposite surface of the casing. As each layer puffed and ruptured, small bits of the charred layer sloughed-off with the gas blast.

The foregoing specific data illustrates the totally different action of the casings of the present invention as compared to casings which have been employed. Missiles formed pursuant to this invention may be provided with housings of lesser thickness because of the increased protection afforded by the wound external casings. A decided advantage of the structure of this invention is that as the missile becomes heated due to air friction on the casing, there is a uniform, progressive sloughing-off of the



burned cellulosic material because of the structure of the casing, while in the case of wood with an inherently non-uniform structure the burning of the casing is also non-uniform.

Since variations and modifications may be made in carrying out the invention, without departing from its spirit and scope, it is to be understood that the invention is not to be limited except as defined in the appended claims.

We claim:

1. A ballistic device having means for propelling the device through the earth's atmosphere and into the stratosphere comprising, in combination, a housing and an outer protective casing on the housing, said casing being capable of burning and flaking at a slow rate when subjected to elevated temperatures without, by itself, sustaining combustion to thereby protect the housing from heat generated during flight of the device through the earth's atmosphere, said casing comprising a smooth, seamless, substantially cylindrical body formed of multiple layers of a non-fibrous cellulosic film material impregnated with a thermosetting resin which adheres said layers to each other and provides an integral structure.

2. A ballistic device as defined in claim 1 wherein the cellulosic material is regenerated cellulose and the resin is a melamine-formaldehyde resin.

3. A ballistic device as defined in claim 1 wherein the cellulosic material is an alkali-soluble, water-insoluble cellulose ether and the resin is a melamine-formaldehyde resin.

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