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MULTI-STAGE IGNITER CHARGE

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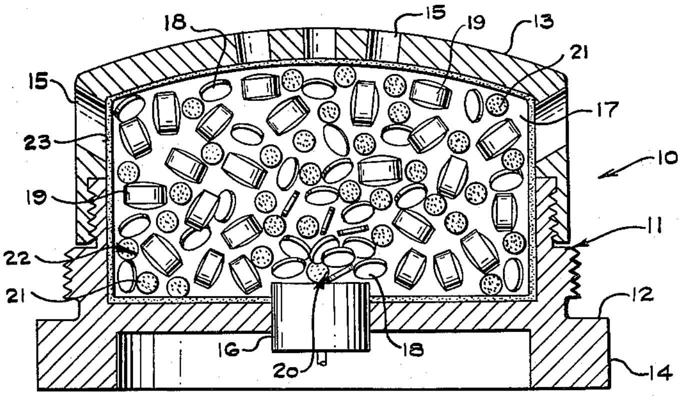

Fig. 1

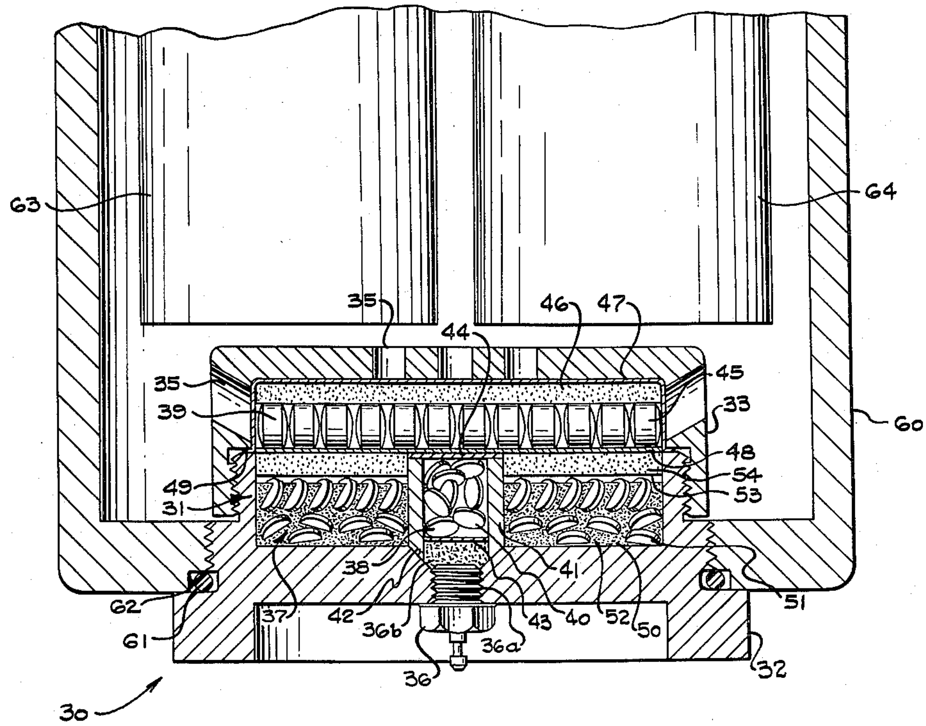

Fig. 2

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MULTI-STAGE IGNITER CHARGE

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This invention relates generally to igniters of the type having an igniter charge within a housing of sufficient strength to resist rupture during ignition combustion, and also having one or more nozzles for discharging igniting gases from said housing; such igniters are generally used for igniting bodies of solid propellant supported within rocket housings.

More particularly, this invention is concerned with an igniter of the type described in which the duration and pressure of the jets of igniting gas are controlled, at least in part, by an ignition charge comprised of an initial stage of rapid burning igniter material enclosed in or surrounded by a main ignition charge made up at least in major part of ignition pellets enveloped in slow burning or combustion resistant material.

In the preferred species of the invention, the main igniter charge is annular in shape and surrounds a core of initial igniter charge, into which a squib means discharges, with or without the aid of confining or directing barrier walls.

In rockets or missiles in which solid propellant is used, the propellant is ordinarily supported in a chamber inside a housing or case with free space around the propellant material. The means of support may be a spider or the like, but the present invention is not concerned with the nature of the propellant or of its support, or general structure, but only with the need for igniting it by means of hot igniting gases.

It is important for suitable ignition that the igniting gases be projected at or on the solid propellant in a desired manner for a suitable igniting time of a few milliseconds. It is desirable for reliable ignition, without failure and without irregular and improper burning of the propellant, that the igniting gases are supplied in a very roughly constant fashion for the brief but perceptible igniting period. Of course, the pressure of the gases will change substantially during the igniting period, but it is desirable to avoid very high peak pressures which then trail off to much lower pressures early in the ignition period.

One excellent solution for the problem has been to provide a strong igniter housing for the igniter charge, with a plurality of nozzle openings directed toward the propellant, and adapted to project a number of jets of hot igniting gases from the igniter housing, across the intervening space within the rocket or missile housing, to the exposed surfaces of the solid propellant. Such an igniter housing may be in the form of an ignition charge container mounted in the end of the rocket housing, and provided with an electrically controlled squib igniting means in its outer end, external to said rocket housing.

The present invention uses such a housing but only as one coacting part of a combination, the principal novel parts of which are the combustible igniter materials themselves, which are shaped into charges providing sustained and controlled ignition burning.

In the past, the igniter housing has had to be made heavy enough to withstand high peak pressures, or has been constructed of light materials which would blow out upon ignition, with resultant inferior quality of ignition.

Control of pressure and duration of ignition flame has been attempted by making use of heavier and more complex igniter housings, with more complex and expensive nozzle arrangements. Such complexity naturally increases expense and sometimes introduces sources of failure.

A practical form for the igniter charge material is in pellets rather than in powder. However, some failures in the past have been traced to attrition of said pellets within the igniter housing, during transport and storage prior to use. Although some of this attrition can be avoided by the introduction of cushioning materials, cushioning alone has proven ineffective to avoid substantial attrition, and failures resulting therefrom.

Other proposals have involved the use of slow burning powders, delayed ignition structures, various types of fuses, etc., but all have proven rather complicated and expensive for the purpose intended.

It is a major object of the present invention to provide an igniter producing propellant-igniting gases of controlled duration and limited pressure, by means of a novel structure of the combustible igniter material itself.

It is another object of the invention to provide an igniter charge structure which achieves the results of two or more stages of combustion, with extremely simple and economical arrangements of the charge materials, and the use in most instances of only one or two readily available combustible materials.

It is still another object of the invention to provide an igniter in which the ignition charge or charges are largely protected from attrition, without interfering with their quick and reliable ignition by standard squib ignition means.

The foregoing and other objects are accomplished with standard igniter materials. Any of the solid igniter materials ordinarily used in granular or pelletized form may be employed in the practice of the invention. Such igniter materials are generally much more readily ignited than the propellant employed as rocket fuel, which is to be ignited by the igniter. Also, such igniter materials ordinarily have a burning rate which is much higher than that of propellant materials or certain other solid oxidant compositions which can be used in association with the rapidly burning igniter materials.

In the present invention, at least two stages of igniter combustion are approximated by pellets of the same rapidly burning igniter material, some of said pellets being uncoated and unshielded from the squib ignition, and others being enveloped by a coating or a solid matrix bed of relatively slow burning material, which may be a slower burning igniter material, propellant material, or even a mere coating of combustible but combustion resistant material.

The application of the invention is illustrated by two very different specific embodiments described herein in connection with the accompanying drawings, in which:

FIGURE 1 is a sectional view through the housing of an igniter constructed according to the present invention, in one of its simplest forms; and

FIGURE 2 is a cross-sectional view of a rocket housing, and an igniter constructed according to the invention in a somewhat more elaborate form, approximating three-stage ignition burning.

In FIGURE 1, an igniter indicated generally by the numeral **10** is enclosed in a two-piece igniter housing **11**, which is generally cylindrical in shape, and is comprised of a lower cup **12** on to which is threaded an inverted cup shaped cover **13**.

The lower cup container **12** may be threadably received into the end of a rocket housing, in the same manner as is illustrated in FIGURE 2 for cup **32** which is received in a rocket housing **60**.

Also, the cup **12** may be surrounded at its base with an outwardly projecting flange **14** which may serve to seat against an O-ring recessed in the end of the rocket housing, as is shown for O-ring 61 placed in recess 62, in connection with igniter cup 32 in FIGURE 2.

The cover 13, which may be referred to as the inner end of the igniter housing 11, since it projects into the interior of the rocket housing with which it is used, is provided with a number of openings 15, which serve as nozzles, and may project jets of igniting gases in a number of directions, as desired, when the igniter 10 has been ignited. The outer end of the cup 12, which is normally exposed outside the rocket housing, is provided with any suitable squib means 16. The commonest type of squib will be comprised principally of a readily combustible powder packed around an electrical heating element which is connected by means of leads to a suitable source of igniting power and control switch. However, the invention is not limited as to squib means, and any fuse squib device or the like which meets the engineering requirements of a particular case may be employed.

The interior 17 of the igniter housing 11 is filled with an assortment of three kinds of small pellets forming the igniter charge. These pellets may be identified as rapid burning pellets 18, which are preferably relatively small, and are uncoated and unprotected from the fire of squib 16. These pellets serve to insure initial firing of the igniter charge, and a few of them may be scattered through the entire charge, if desired, to insure continued burning. Their only essential location, however, is in the immediate vicinity of the squib 16. Some must be concentrated in that region in order to assure initial firing, even if there are no rapidly burning pellets 18 in the remainder of the interior 17.

Slow burning pellets, which may also be referred to as sustaining pellets, are preferably, although not necessarily, substantially larger than the rapid burning pellets. Their essential difference is that they are covered over all or a large part of their exterior surface with a thin coating of a silicone paint or the like. In the embodiment illustrated, the slow burning pellets illustrated at 19, have been entirely covered with a spray coating of silicone paint, although their interior composition is identical to that of the rapid burning pellets 18. It is an essential feature of the invention that the slow burning coated pellets 19 be distributed around or enclosing the central concentration 20 of rapid burning pellets 18.

Typical pellet size for most igniters is about ⅛ inch in diameter by ⅛ inch long for the smaller pellets, up to ½ inch in diameter and ¼ inch long for the larger pellets, particularly those which are coated and are to serve as the sustained burning stage of the igniter. The pellets may range in weight from only a few grams up to over one hundred grams. They should be sufficiently numerous so as to provide a readily distributable structure, usually fifteen to two hundred pellets, and over fifty percent of the material should be concentrated in the coated sustaining pellets.

Coating of the pellets 19 has been found to have a beneficial effect on the prevention of attrition, in addition to the suppression of combustion rate which produces the ignition of desirable duration and pressure limitation. However, in the particular embodiment described herein in connection with FIGURE 1, close packing of the pellets 18 and 19 are achieved without much attrition resulting by random scattering of many chunks of cushioning material 21, which may be referred to as cushion "pellets," although it is not compressed or pelletized in any sense, but it is very soft.

The entire igniter charge, which may be referred to collectively by the numeral 22, may appear at first to be packed as an entirely random assortment of rapid burning pellets 18, slow burning coated pellets 19, and cushioning material 21. However, as previously pointed out, it is actually packed as a more or less annular pack comprised predominantly or exclusively of slow burning uncoated pellets 19, so far as igniter material is concerned, enclosing a core 20 of rapid burning pellets 18 disposed immediately adjacent to the igniter 16.

The entire charge 22 is enclosed in a moisture-impervious film, which protects it from the moisture or other airborne impurities which might otherwise enter through the nozzle openings 15 during storage prior to use. The film is indicated generally by the numeral 23, and may be understood to be any of a variety of suitable materials. For example, the film may be aluminum foil, a sheet of plastic such as Mylar plastic, or even paper impregnated with some suitable moisture resistant impregnating material. Also, the film 23 may be a painted coating applied to the igniter charge after its formation, and before or after insertion into the igniter housing 11. It should also be understood, that the film 23 may be actually somewhat thicker than an ordinary film and may actually be comprised not only of a waterproofing material but a cushioning lining of such materials as felt, plastic foam, or the like.

The operation of the igniter of FIGURE 1 will be obvious to those skilled in the art of igniters. The igniter housing 11 is constructed of sufficient strength to resist rupture at the igniter combustion pressures. Consequently, when the squib 16 is fired, the central core 20 which is comprised of a concentration of the relatively small and uncoated rapid burning pellets 18, is ignited as the first stage of ignition.

The pressure of the hot gases produced breaks through the light film 23 and jets from the nozzle openings 15 to begin ignition of propellant. Within a short time, the increased pressure and temperature within the igniter housing 11 advances combustion to the second ignition charge 22, comprised of the coated and relatively slower burning pellets 19 distributed in an annulus around the central core 20.

FIGURE 2 illustrates a three-stage embodiment of the igniter of the invention. The three-stage igniter indicated generally by the numeral 30 has its charge enclosed in a housing indicated generally by the numeral 31, comprised of a cup 32 and a cap 33, cup 32 being threadably received in the end of the housing 60, seating against the O-ring 61, in the annular recess 62.

Cup 33 is provided with a plurality of nozzle openings 35 by means of which the igniter 30 projects jets of igniting gases against the propellant charges 64 and 63 during ignition. Propellant charges 64 and 63 are supported within the rocket housing 60 with a substantial region of clear space between them and the igniter 30, and between each other. Such support may be made within the housing 60 by means of support spiders, housing structure or the like, all in the manner well known to those familiar with the construction of rockets, and not illustrated herein since they form no part of the present invention. It should only be noted that the spacing illustrated in FIGURE 2 is not proportionate to actual dimensions; the spacing has actually been reduced very much in order to make illustration convenient.

An electrical squib means 36 is threadably received in a threaded bore 36*a* in the center of the outer end of the igniter housing cup 32.

The igniter means 36 is used to ignite an igniter charge identified generally by the numeral 37, and comprised principally of small uncoated pellets 38 and large coated pellets 39, corresponding approximately to the pellets 18 and 19 described in connection with the embodiment of FIGURE 1. However, the embodiment of FIGURE 2 employs additional igniter material and features of construction not found in FIGURE 1.

A first-stage ignition charge is in the form of a core 40, comprised of relatively rapid burning uncoated pellets 38, and housed in a tubular housing 41, which is disposed coaxially with the cup 32, and has its lower end received in a central recess 42 in the inner wall of the bottom of the cup 32. Tubular container 41 may be either of metal or of relatively combustion resistant nonmetallic material, such as certain impregnated papers, or certain plastics. It is necessary that the walls of the tubular container 41 delay combustion of that part of the ignition charge 37 which surrounds the exterior of the container 41.

The first-stage ignition charge is supported within the container 41 between transverse barriers 43 and 44, which may be referred to as upstream and downstream barriers relative to the direction of ignition burning. The barriers 43 and 44 may be of any suitable supporting construction, such as fiberboard, metal screen, foil discs or the like. The downstream barrier 44 is a cap which actually covers the inner end of tubular container 41, at a plane transverse to the igniter housing 31 substantially flush with the inner opening of the igniter housing cup 32.

The second-stage ignition charge 45 is comprised of coated pellets 39 and substantially fills the ignition housing cap 33 except for a thick layer of plastic foam (such as Styrofoam) cushioning 46 between the second-stage ignition charge 45 and the interior wall surface of the inner end of the ignition housing cap 33. Both the second-stage ignition charge 45 and the cushioning layer 46 are enclosed in a moisture-impervious liner 47 and a disc shaped sheet 48 covering the contents of the cap 33 and protecting them from exposure. It will be seen that the liner 47 extends into a flange 49 which serves as a gasket between the threaded cap 33 and the externally threaded cup 32.

The third-stage ignition charge 50 is comprised of a large number of relatively small uncoated rapidly burning pellets 51 embedded in a solid matrix 52 of combustible material which may be the same as propellant 63 and 64 or have burning properties intermediate between the propellant fuel and that of the ignition pellets 51. It will be seen that the matrix 52 is an annular body filling the lower part of the space between the exterior of the tubular container 41 and the interior surface of the cup 32. The most convenient method of manufacture is to place the tubular container 41 in position, and fill the annular space in cup 32 to the desired depth with the matrix material in liquid form. The combustible pellets 51 are then inserted into the liquid matrix material, which is then permitted to solidify into the third-stage ignition charge 50.

It is a preferred species of the invention to insure the proper ignition of the third-stage ignition charge 50 by placement of the upper layer of the pellets 51 with exposed edges 53 projecting above the upper surface of the solid matrix 52.

An annular cushion 54 of plastic foam (such as Styrofoam) covers the exposed edges 53 of the third-stage ignition pellets 50 and cushions them from the intermediate stage coated pellets 39.

In operation, the igniter is actuated by the heating of the squib means 36. The heat in turn flash ignites squib powder charge 36*b* contained in the recess 42 under the upstream barrier 43. The first-stage ignition charge 40 is rapidly ignited, and rapidly burns through the downstream barrier 44 to ignition of the second-stage ignition charge 45. Combustion of the second-stage ignition charge 45 is prolonged because it is comprised of relatively large coated ignition pellets 39.

As ignition of the second-stage ignition charge 45 proceeds, the cushions 46 and 54 are rapidly consumed and ignition of the exposed edges 53 of the third-stage ignition charge 50 occurs. The burning of the third ignition stage 50 is most prolonged of all the stages because of the envelopment of the pellets 51 in the solid matrix of relatively slow burning material 52. The precise nature of its burning can be determined by the mixture of solid matrix 52 and quick burning pellets 51.

It will be seen from the foregoing that I have provided an igniter which functions as if it had three stages of ignition charge, by virtue of the construction of the igniter charge. The multi-stage effect is achieved by enveloping at least some of the pellets of the ignition charge in relatively less combustible material. In the embodiment of FIGURE 1, the suppression of combustion in order to achieve a prolonged burning at a lower and flatter pressure peak is achieved by coating the pellets which are not in the immediate vicinity of the starting squib 16. In the embodiment of FIGURE 2, the envelopment of the third-stage pellets is accomplished by embedding them in a relatively less combustible solid matrix.

Although the envelopment of stages subsequent to the first or starting stage in relatively less combustible material is one essential part of the invention, it is to be understood that a second essential feature is the structural distribution of the different types of pellet materials. They are not placed at random, but are arranged with a first-stage readily ignitible core enclosed in, or surrounded by, or at least partially surrounded by a second-stage or several later stages of enveloped material.

The preferred form makes use of the core and annulus arrangement.

Furthermore, it is a preferred species to employ the arrangement of FIGURE 2 in which the solid annular matrix is actually separated from the first-stage ignition charge 40 by a metal combustion resistant tube 41. However, it will be appreciated, that tube 41 might be constructed of material which had very little resistance, or might be dispensed with entirely if no intermediate-stage 45 were used; in that event, the combustion would spread from the igniter core 40 directly to the solid matrix 52, and the pellets 51 therein, in the same manner as occurs in the embodiment of FIGURE 1.

Although I have described and illustrated two specific embodiments of my invention, it will be understood that those skilled in the engineering arts of ordnance and explosives will be able to conceive of many variations of the invention without departing from its spirit. I therefore intend that the scope of the invention be defined not by the detailed limitations set forth in the description of the embodiments of FIGURES 1 and 2, but by the terms of the following claim.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

A propellent igniter for projecting a stream of hot igniting gas onto propellant, which igniter includes: a substantially cylindrical igniter housing having a nozzle end and a squib end, said housing having sufficient bursting strength to remain intact during burning of igniter materials in its interior; walls defining a plurality of nozzle openings in said nozzle end for directing ignition gases toward the propellant to be ignited; a tubular initial stage charge container extending into the interior of said igniter housing from the central part of said squib end, and having an opening for discharge toward the interior of said nozzle end; said container having an annular space between its exterior walls and the interior side walls of said igniter housing; an initial igniter charge of rapidly burning igniter material located in said tubular container; squib means mounted in the squib end of said igniter housing for ignition of said initial igniter charge; a middle stage charge of pellets slower-burning than said initial charge, said middle stage charge being located in the nozzle end of said igniter housing and in the path of ignition gases issuing from the discharge opening of said tubular container; a final stage igniter charge in the form of an annular ring located in said annular space between said tubular container and the inner side walls of said igniter housing, said final stage igniter charge being comprised of a large number of rapid burning igniter pellets embedded in a solid matrix of material slow burning relative to said embedded pellets, with many of said rapid burning igniter pellets having exposed portions projecting from the surface of said solid matrix toward said middle stage igniter charge; and a layer of cushioning material between said middle stage charge and said final stage igniter charge.

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