May 1, 1962 N. B. BOTSFORD 3,032,356

EXPLOSIVE MEANS TO SEPARATE CASING MEMBERS

Filed Jan. 26, 1960 3 Sheets-Sheet 1

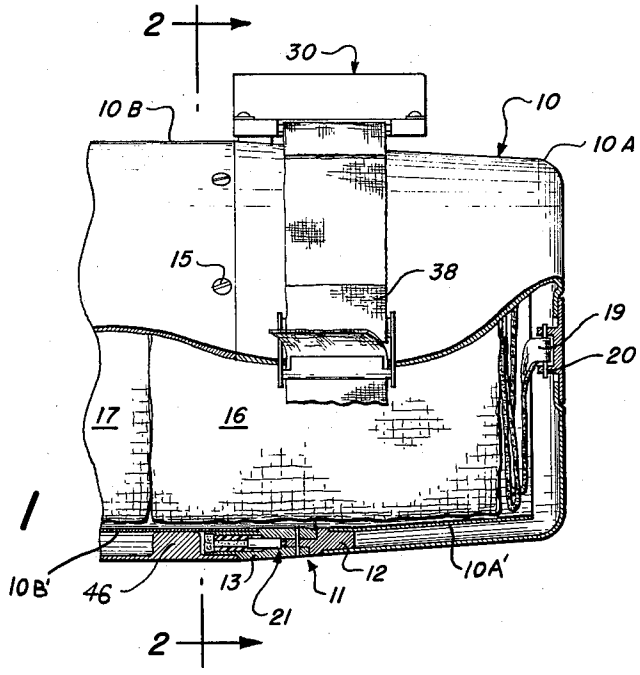


Fig. 1

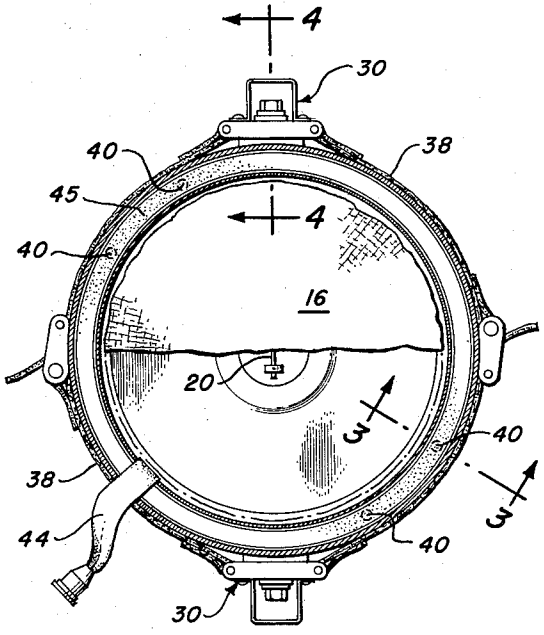


Fig. 2

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EXPLOSIVE MEANS TO SEPARATE CASING MEMBERS

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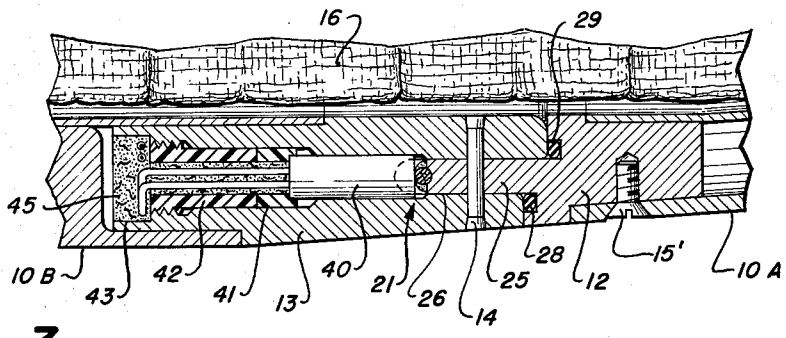


Fig. 3

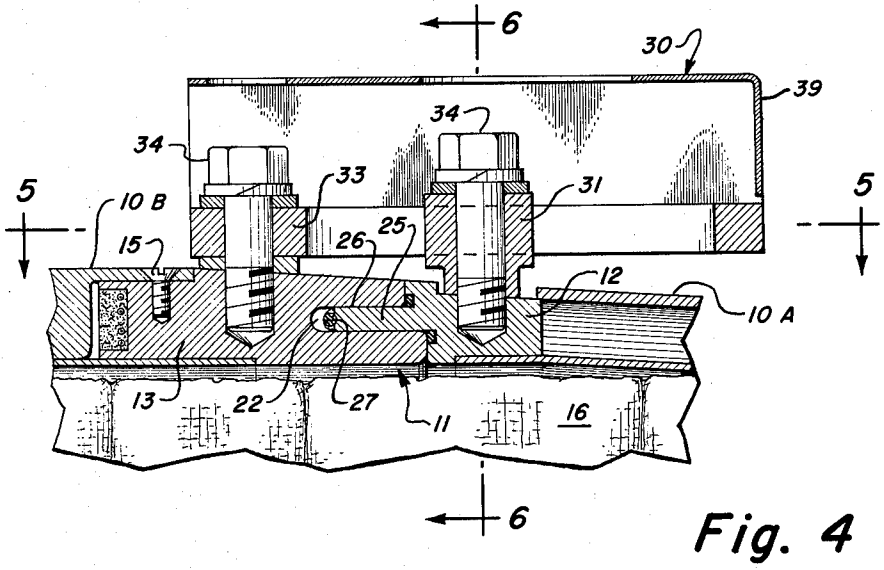


Fig. 4

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EXPLOSIVE MEANS TO SEPARATE CASING MEMBERS

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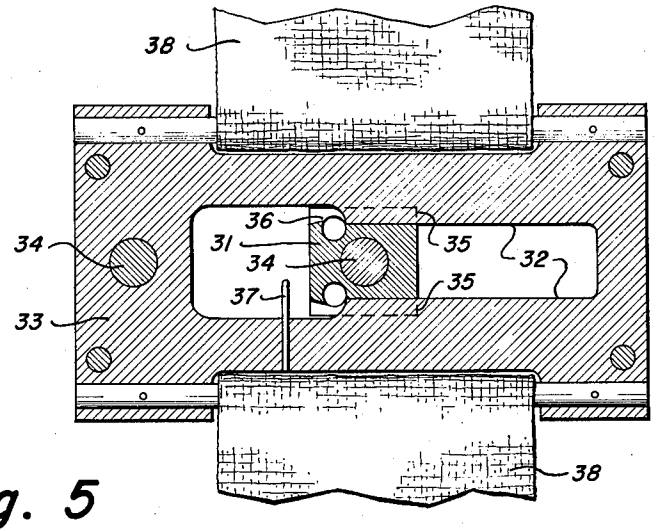


Fig. 5

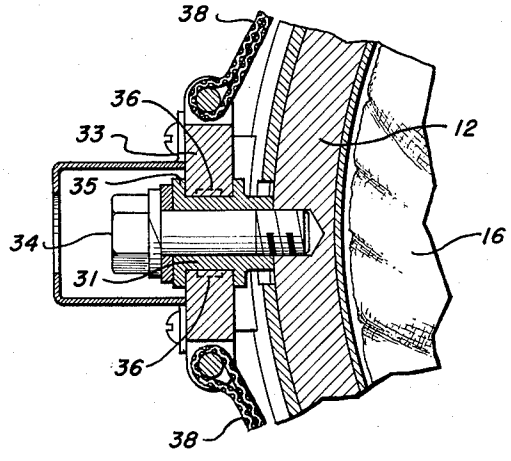


Fig. 6

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3,032,356

EXPLOSIVE MEANS TO SEPARATE CASING MEMBERS

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2 Claims. (Cl. 285—3)

This invention relates in general to improved separable case sections or case separation means which may be employed to disjoin portions of a case, airframe, or fuselage in a predetermined manner and more particularly to such means as are self-powered and adapted for remote initiation, as by an electrical circuit. Case or fuselage sections or separation means of this type may be utilized, for example, in rocketry for jettisoning burned-out stages from the payload portion of a rocket or for deployment of a parachute to ease the descent of a store.

An ideal means of this type should function to effect a reliable separation wherein only straight line relative movement is involved, i.e., with no objectionable tumbling movement imparted to either case portion in separation. Further, such an ideal means should be light in weight. This latter requirement is greatly facilitated by utilizing an explosive as a power source because of the inherently low weight to power ratio of explosives as compared to other presently known power sources.

Prior separable case sections or separating means of this general type, i.e., utilizing explosive power, have not obtained these ideals because of associated difficulties which have detracted from reliability and have tended to impart a tumbling motion to the case portions in the process of separation.

The present improved separable case sections, separating means or device may be described in connection with a missile or rocket fuselage or case but it is to be understood that the invention applies to cases or fuselages of all types. Also, for purposes of description and simplicity, the case or fuselage may be considered as having two main parts: One the payload body and the other the separable body. The separable body comprises that part of the case which is ejected for purposes of deploying a parachute, for example, and the payload body comprises a payload carrier and other parts which may be mounted thereon.

The present invention aims to overcome the various shortcomings of prior case separation devices and to provide a case separation means which approaches ideal standards of performance, lightness of weight, and reliability.

An object of the invention is to provide new and improved generally complementary case sections which are adapted to separate from each other smoothly and without cocking to one side, when subjected to a separating force.

Another object of the invention is to provide case separation means which is economical of both weight and space.

Still another object of the invention is to provide a self-powered case separation means which reliably actuates after receiving an initiation signal.

A further object of the invention is to provide case separation means which is ideally adapted for parachute deployment.

A still further object of the invention is to provide case separation means which is adapted to be positively safe during handling and storage of the case or fuselage.

Another further object of the invention is to provide a self-powered case separation means wherein the payload of the case or fuselage is protected from damage.

Still another object of the invention is to provide case separation means, with self-contained power supply, adapted to impart substantially only irrotational relative movement to the case components upon separation.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described, or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

A preferred embodiment of the invention and various modifications thereof have been chosen for purposes of illustration and description. The preferred embodiment and the modifications are not intended to be exhaustive nor to limit the invention to the precise forms disclosed. They are chosen and described in order to best explain the principles of the invention and their application in practical use to thereby enable others skilled in the art to best utilize the invention in various embodiments and modifications as are best adapted to the particular use contemplated.

In the accompanying drawings:

FIG. 1 is an elevational view of a portion of a fuselage or case having parts thereof broken away;

FIG. 2 is an end view of the right hand extending portion of the fuselage or case taken along line 2—2 of FIG. 1;

FIG. 3 is an enlarged sectional view taken along line 3—3 of FIG. 2;

FIG. 4 is another enlarged sectional view taken along line 4—4 of FIG. 2;

FIG. 5 is a sectional view taken along line 5—5 of FIG. 4; and

FIG. 6 is a sectional view taken along line 6—6 of FIG. 4.

With reference to the drawings, the invention is illustrated as being incorporated in a fuselage or case generally indicated by the reference character 10. As illustrated in FIG. 1, the case 10 generally comprises right and left hand case portions 10A and 10B respectively, connected along a separable zone or joint 11 comprised of tongue and groove joint portions 12 and 13 respectively. Joint portions 12 and 13 normally interfit and are normally so maintained by a number of shearable or cuttable fastening means such as the pin shown at 14 in FIG. 3. However, upon reception of a suitable electrical signal or firing pulse the joint portions 12 and 13 and their respectively associated case portions 10A and 10B are adapted to be separated by power means to be described hereinafter. The case 10 is shown to comprise a compartment containing a parachute assembly comprised of a sleeve-packed pilot chute 16 and a sleeve-packed drag chute 17.

Assuming a certain case or fuselage velocity toward the left and actuation of the separation power means, the right hand case portion 10A is adapted to be projected to the right with respect to the left hand case portion 10B and to forceably extract pilot chute 16 from the compartment by means of a "static line" 19 which interconnects case portion 10A with the packaging sleeve of pilot chute

16. This action continues to pull or separate the pilot chute sleeve from pilot chute 16, which then deploys in a well known manner to exert, in turn, sufficient force to extract the drag chute 17 from the compartment and in addition to separate the drag chute packaging sleeve therefrom. Thus freed, the drag chute 17 then, in turn, may deploy to decelerate the left hand case portion 10B in a known manner.

With further reference to the drawings (FIGS. 1–4), the invention is shown comprising separable case joint 11 including in addition to tongue and groove joint portions 12 and 13 joint separation power means generally indicated at 21 and safing means comprised of safing devices 30 for assuring against complete inadvertent separation.

As may best be seen in FIGS. 3–4 the case 10 generally includes tongue or projecting joint portion 12 having a tongue 25 and groove joint portion 13 having an appropriately extending groove 26 therein for receiving tongue 25; a power means 21 comprised of a power chamber 22 enclosed by the deepermost portions of channel or groove 26 and the distal end of tongue 25 and a length of mild detonating fuse 27 serving as a power source inside the chamber; and joint safing means comprised of two safing devices 30 which are in turn comprised of a cutting block 31 and a cutting guideway plate 33 and adapted to be secured or installed with respect to joint 11 so as to dissipate kinetic energy of relative movement as between joint portions 12 and 13 and thereby assure against the production of free flying missiles of case portions in event of an inadvertent joint separation.

Although the particular exemplary joint 11 is shown extending along a belt line or circumferential zone of a generally cylindrical fuselage or case, it will be apparent upon an understanding of the principles involved that the joint may be adapted to openings having a variety of shapes (including three dimensional) in fuselages or cases encompassing a variety of geometrical forms. Such a three dimensional joint may be employed in the removal of an arcuate longitudinal portion from a cylindrical fuselage or case, for example.

In the embodiment shown the portions 10A and 10B of generally cylindrical case 10 each have a cylindrical liner portion 10A′ and 10B′, respectively, generally concentric therewith in order to provide a substantially longitudinally smooth case interior such that when the parachute assembly, which may be contained therein, is extracted any tendency to snag is minimized. The right hand case portion 10A at its right hand end has a mounting cleat 20 for attaching "static line" 19. The cleat 20, as illustrated, is welded to the end of case 10A, but it is apparent that this or other "static line" attaching means may be fastened to the closed end by any suitable means.

Intermediate of the right and left hand portions of the cylindrical fuselage 10 are disposed the elements of the separable joint 11 per se. Three elments, generally ring-shaped and preferably made of aluminum or the like, generally comprise the grooved joint portion 13 attached to the left hand case portion 10B and the tongued joint portion 12 attached to the right hand case portion 10A. This attachment of the joint portions to their respective case portions including the liner portions 10A′ and 10B′ thereof may be by means of lap joints (as illustrated, FIGS. 3 and 4) secured by spaced machine screws 15 and 15′, for example. It will be evident, however, that this attachment and/or securement may be accomplished by other suitable means.

As may best be seen in FIG. 4, the annular groove 26 of joint portion 13 extends (in depth) generally perpendicular to the "plane" or boundary of separation of the joint. The groove 26 receives tongue 25 extending from joint portion 12 when joint portions 12 and 13 and associated case portions comprised thereof are brought into co-axially aligned abutting relationship. The tongue 25 and groove 26 are secured together by a number of transverse pins such as the one illustrated at 14 in FIG. 3. It is desirable that these pins are distributed about the joint in a manner such that shearing or cutting forces required to shear or cut them are balanced with respect to the joint centerline for reason as will appear.

It will be noted that the distal end of tongue 25 falls somewhat short of extending to the bottom of groove 26. The groove portion thus left unfilled provides power chamber 22 which extends circumferentially about the fuselage or case within the joint. If the groove 26 is thought of as an annular "cylinder" and the tongue 25 is thought of as an annular "piston" therein, it will be apparent that if sufficient fluid pressure is applied within the chamber 22 then shear pins 14 may be sheared and the "piston" or tongue 25 will be ejected from the groove and it, together with the right hand case portion 10A comprised thereof, will be projected translationally to the right with respect to case portion 10B.

Chamber 22 is adapted to distribute any pressure therein so that such pressure will be exerted uniformally over all portions of the "piston" area of tongue 25, i.e., the pressure force produced on the "piston" is balanced with respect to the longitudinal centerline of the joint. With this balance of pressure force and since the shearing resistance of retaining pins 14 is also balanced with respect to the joint centerline, when the pins shear and the "piston" and its associated case portion are separated from the other case portion the relative motion tends to be of a substantially pure coaxial translational nature, i.e., without objectionable cocking to one side and hence with a substantial absence of tumbling of one case portion with respect to the other. This absence of tumbling is of particular importance where the device is to be utilized for parachute deployment inasmuch as end-for-end tumbling motion would be likely to wind the "static line" 19 about the expelled case portion and tend to abort the proper deployment of the parachute assembly.

It will be noted (best seen in FIGS. 3 and 4) that the tongue 25 is overlapped to a lesser extent by the wall of groove 26 which comprises a part of the outer surface of the fuselage or case 10 than by the wall of groove 26 which comprises a portion of the inter-surface of the fuselage or case. This arrangement enables the hot gases produced in the combustion of detonating fuse 27 to be vented to the outside of the fuselage or case just prior to complete separation. This venting arrangement tends to protect the parachute or other cargo within the fuselage or case from damage by the hot gases as by burning or otherwise.

The joint 11 may be sealed with respect to the surroundings or not as desired. If desired such sealing may be accomplished by O ring seals 28 and 29 which may be located in suitable grooves in the tongued joint portion 12, as illustrated. Such grooves and O rings should, of course, be generally coextensive with the circumference of the joint and should be located such that the O rings are compressed against the abutting surfaces of the grooved joint member 13 in order to effect an initial seal, as is standard O ring design practice.

Within the annular power chamber 22, which generally comprises a part of joint separating power means 21, is located a mild detonating cord or fuse 27, preferably of sufficient length as to be coextensive with the power chamber and joint. Fuse 27 is preferably comprised of commercially available ten grain per foot lead-sheathed low energy detonating cord or fuse, such as that produced by Du Pont, although any suitable producer of combustion gas may be used. It will be noted that the fuse in cross-section (FIG. 4) does not completely fill the chamber 22 so as to thus provide a sufficiently large annular space for pressure from gas generated upon the combustion of the fuse to equalize around the annular chamber 22 and thus exert equal pressure on all portions of the "piston" area of tongue 25, as aforementioned.

The fuse 27 is preferably located contiguous to the distal end or "piston" area portion of tongue 25 and is

preferably secured to the tongue by any suitable adhesive such as commercially available "Grip-tight" manufactured by the Lino-Paste Company of Chicago, Illinois, for example. This location and means of securement of the fuse **27** is highly desirable in that upon its detonation or combustion a compressive shock wave emanating therefrom is conducted along the tongue **25** into joint portion **12** where it is substantially dissipated. In conducting the shock wave it has been found that the tongue **25** undergoes a "plastic" deformation such that it is transversely expanded into tighter fitting relation against the walls of the groove **26**. This expansion may be of a magnitude sufficient to bring a tongue initially having as much as .030 inch clearance with each side of the groove into close operable fit therewith. Although such a loose fit would normally not be employed, this expansion effect permits unusually wide manufacturing tolerance in the machining of the tongue and groove.

This preferable location of the fuse **27** on the tongue **25** has another advantage in that it permits the walls of the groove **26** to be made much thinner and consequently of lighter construction than would be required if the fuse were in contact with the grooved joint member. It has been found that if the fuse **27** and the grooved member are in contact damage from spalling and rupture is likely and these failures naturally detract substantially from optimum operation and reliability of the device.

The mild detonating fuse **27** is adapted to be fired by a number of detonators **40** (4 as shown in FIG. 2). As shown, the detonators **40** are positioned in suitable holes **41** (FIG. 3) and are circumferentially spaced about and longitudinally extend within grooved joint portion **13**. As may best be seen in FIG. 3, the detonator **40** projects within the power chamber **22** where its end preferably contacts or is in close proximity to the fuse **27** for most effective firing thereof inasmuch as the lead sheathing of fuse **27** is to be burned or melted through in order to fire the fuse per se. Although this contacting relationship yields a more uniform firing response, it has been found that small air gap separations of detonator and fuse are workable.

The detonator **40** comprises an electrically fired initiator which ignites a time delay column which, in turn, ultimately ignites fuse **27**. In the interest of clarity and simplicity and in view of the well known character of such detonator elements or details, they are not shown in the drawings. The detonators for any particular application of the joint separation device may be selected to provide for actual ignition of fuse **27** at a predetermined delay time subsequent to the firing of the initiator, dependent on the slow-burning characteristic of the particular detonator **40** chosen. These selectable delay times may range from zero to upward of 1 second as desired.

Preferably each detonator **40** has its individual two-wire firing circuit which leads out of holes **41** through plastic detonator securing bushings **42** therein into a wiring retainer groove **43**. Groove **43** conducts all the individual two-wire circuits into a lead-out cable **44** which extends from the groove **43**. The lead-out cable **44** may then extend via a suitable passageway (not shown) in an internal flange **46** of the outer skin of case portion **10B** into the annular space between the skin and the liner **10B'** of the left hand case portion **10B** where the various individual circuits therein may be connected to a suitable electric power source (not shown) for independent firing of detonators **40** if desired.

Two detonators **40** of similar time delay characteristics may be oppositely disposed or equispaced along the length of fuse **27**, thus defining two equal length fuse portions therebetween. This use of dual detonators (comprising a detonator set) yields added reliability in firing the fuse **27**. One or more additional sets having different time delay characteristics than the first set may be employed. These additional detonator sets may be utilized to selectively (dependent on external switching, not shown) fire the fuse **27** at selected delay times subsequent to energization of the external firing circuit (not shown) and thus extend the range of application of a given joint separation device. The particular detonator set to be fired in any given application may be previously selected for firing by merely connecting the individual firing circuits associated therewith into the external firing circuit by means of suitable external switches.

In order to secure maximum reliability of the joint separation device the firing circuitry thereof may be protected from the effects of moisture and shock by potting the circuit wiring. This may be done by filling the bushings **42** and the wiring groove **43** with a suitable plastic potting compound **45** in order to secure as well as cover the detonator circuit wires extending therein. An example of one compound suitable for this purpose is commercially available "PR 1201" manufactured by the Thiokol Chemical Corp.

Assuming previous selective switching to place the desired detonator circuits in connection with the external firing circuit, it will be apparent that energization of this external circuit will be completed through the selected individual detonators and that the initiator elements thereof will be ignited. The initiators start the slow-burning delay columns of the detonators which ultimately burn through or melt the lead sheathing of and ignite the fuse **27** at two oppositely disposed points. The fuse then burns with a detonating wave front advancing along its length from either side of each detonator. Two of these advancing wave fronts meet at points intermediate each fuse portion, as defined by detonator locations, to consummate the combustion.

The fuse combustion generates gases which are distributed along power chamber **22** and exert substantially uniform pressure on the "piston" area of tongue **25**. When this pressure rises to a sufficient value, the retaining pins **14** are adapted to shear and the right hand case portion **10A** will be thrust away from portion **10B** to accomplish separation of case **10**.

Inasmuch as the two case portions **10A** and **10B**, in separating, part with considerable relative velocity and force an unrestricted inadvertent separation would be dangerous to handling personnel and equipment. The device is therefore shown provided with removable joint separation safing means principally comprised of a pair of oppositely disposed joint separation safing devices **30**. Each of these safing devices **30** is fastened (as by socket head screws **34**) to each of joint portions **12** and **13** at points lengthwise disposed across joint **11** so that the joint may be said to be bridged thereby.

In a normal joint separation the maximum pressure rise in chamber **22** is limited to a value necessary to shear the retaining pins **14** and any continued combustion or gas generation is under condition of increasing volume as the tongue **25** retracts from groove **26** thereby continuously enlarging the volume of power chamber **22** as the case portions separate. If in safing the joint, the safing means employed were to hold joint portions **12** and **13** unmovably together it is apparent that the power chamber **22** would be held at constant volume during the complete combustion of the fuse **27** therein. To contain the high peak pressure which would be generated under this condition would require a joint having thicker stronger walls at either side of groove **26**, thus resulting in a bulkier and heavier joint. For this reason, a desirable safing means should permit the limiting of the peak pressure generated in the joint by the combustion of fuse **27** in order that joint design be kept to minimum size.

With the safing means of this invention, the pressures generated by the combustion gases are adapted to be limited in much the same manner as in a normal separation, i.e., by permitting joint movement, pin shearing, expanding power chamber volume, and ultimate exhaust of the combustion gases. The gases do work on tongue **25** and therethrough impart kinetic energy or velocity to the joint portion **12** and to the right hand case portion

10A comprised thereof. To prevent an unrestrained or normal separation, i.e., to safe the device, the joint portions are preferably restrained to limit and dissipate the relative velocity of the case portions by means which are adapted to constrain the kinetic energy of the separating case portions to do continuous work until the energy dissipation is complete and the relative velocity of the two case portions become zero. This, of course, is effective to prevent either case portion from becoming a free flying missile with attendant dangers to personnel and equipment. In the illustrated embodiment the energy dissipation is accomplished in the work of continuously cutting or shaving metal (in jack plane fashion) wherein the force of resistance is of such value as to accomplish complete energy dissipation within a relatively short movement distance. It will be apparent, however, that other working modes for working the illustrative or other material may be employed to accomplish the desired energy dissipation.

The energy dissipating means of safing device **30** is comprised of a shaving or cutting block **31** constrained to linear movement within a cutting guide way **32** in a guide way plate **33** which, as shown, is secured to grooved joint portion **13** by means of a socket head screw **34**. The cutting block **31** is secured to tongued joint portion **12** by means of another socket head screw **34**. As most clearly may be seen in FIG. 6 cutting block **31** has top and bottom laterally extending guide shoe projections **35** at either side for sliding engagement with both top and bottom surfaces of cutting guide way plate **33** marginal to guide way **32**. In addition, cutting block **31** has lateral cutting lips **36** extending at either side thereof intermediate the top and bottom lateral projections **35** at either side.

As may be best seen in FIG. 5 the cutting lips **36** are provided with suitable rake, cutting relief, and chip disposal means in accordance with good cutting tool practice. It may be further seen that the lips **36** extend such that movement of cutting block **31** more than a certain distance to the right necessarily entails that a portion of plate **33** at either side of way **32** be cut or shaved inasmuch as clearance for lips **36** is not provided in way **32**.

To permit assembly of cutting block **31** with cutting guide way plate **33** the left hand end of guide way **32** may be enlarged to admit block **31** so that its right hand end may be inserted in the unenlarged way portion and so that the top and bottom projections **35** at either side thereof may straddle the thickness of plate **33**. It is apparent that the depth of insertion of block **31** in way **32** is limited by cutting lips **36**. After assembly in this manner a transverse pin **37** may be inserted in plate **33** to prevent inadvertent disassembly.

It will be noted that the safing devices **30** are secured to joint portions **12** and **13** such that the plate **33** and the guide way **32** therein are in substantially parallel alignment with the axis of joint **11**. This may be accomplished as in the instance of illustrated case **10** having a somewhat tapered exterior by spacing the plate **33** from the tapered exterior by means of suitable spacer blocks and/or shoulders. Parallelism of the safing devices with respect to the axis of the joint **11** tends to assure that there will be no binding or bending of the safing device elements in operation.

The materials of the cutting lip **36** and guide way plate **33** are made or selected for relative hardness to assure that the lip **36** will shave or cut plate **33** when the block is moved to the right in consequence to relative movement of joint portions **12** and **13**. Another factor in selection of these materials is that of securing enough shaving or cutting resistance so that the kinetic energy of the case portions may be dissipated within a given relatively short length of movement. A steel cutting lip **36** arranged to shave or cut an aluminum plate **33** has been found to be a highly satisfactory combination of materials which will dissipate the considerable energy of separation within a relatively short working length.

The two oppositely disposed joint separation devices **30** which may comprise a complete safing means are interconnected at either side thereof by flexible belts **38** to completely encircle the joint **11**. These flexible belts **38** may, as shown, be similar in manner and mode of attachment and connection to conventional aircraft seat safety belts. The belts **38**, aside from giving a unitary character to the safing means, serve to cover the external line of joint separation and to function as a deflector of radially escaping gases as the power chamber **22** is exteriorly vented when the tongue **25** in its movement to the right first clears the exterior wall of groove **26**. This gas deflection function tends to prevent injury to any personnel or equipment in line with the path of radial gas escape in event of inadvertent actuation of the joint separation means.

The guide way plates **33**, as illustrated, are covered by shields **39** to guard against foreign objects entering the ways **32** and interfering with the designed operation of the safing devices **30**. In circumstances wherein it is desired that a deliberately actuated separation go to unrestrained completion, the safing means would, of course, be removed by unscrewing the socket head screws **34** from the joint portions **12** and **13** and then disconnecting the buckles of belts **38** if necessary. In order to insert and unscrew socket head screws **34** a wrench may be conveniently operated through suitable holes in the shield **39**.

While the grooved portion **13** has been shown on what may be designated a "forward" section of an airframe and the tongued portion **12** on a section which is caused to move away in a rearward direction, it will be clear that the tongue and groove sections could be reversed so that the tongue is disposed on the forward section and the groove on the section which will be caused to move rearwardly.

Thus it has been seen that the present invention provides a case separation means which is compact, light in weight, positive and reliable in operation in response to external electrical initiation. It has also been seen that the case separation means is adaptable to a variety of case configurations and end purposes such as rocket stage separation and parachute deployment for example. In addition it has been seen that the separation means may be positively safed when desired to prevent injury to personnel and equipment in event of inadvertent actuation. It has further been seen that the safing means because of its energy dissipation principle of operation does not impose adverse design limitations on the separable joint per se with which it is to be used.

As various changes may be made in the form, construction and arrangement of the parts herein without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a case comprised of separable portions, spaced inner and outer extensions defining an annular groove in the first of said portions, an annular tongue on the other of said portions extending within and secured in said groove but overlapped to a lesser extent by said outside than said inside extension, a power chamber defined by portions of said tongue and groove, explosive means within said chamber continguous to the distal end of said tongue, and means to actuate said explosive means, whereby said case portions are adapted to be separated in response to actuation of said explosive means with consequent expulsion of said tongue from said groove by combustion products from said explosive means and with said combustion products being vented away from said case by virtue of said tongue first clearing said outer extension in its expulsive movement.

2. The combination as set forth in claim 1 with means

(References on following page)

removably attached to said portions and in general parallelism with said tongue and said groove for limiting separation of said portions.

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