NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO
ATTN OF: GP

October 15, 1970

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General
Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned
U.S. Patents in STAR

In accordance with the procedures contained in the Code GP to Code USI memorandum on this subject, dated June 8, 1970, the attached NASA-owned U.S. patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,286,630

Corporate Source : Langley Research Center

Supplementary
Corporate Source :

NASA Patent Case No.: XLA-02132

Gayle Parker

Enclosure:
Copy of Patent

Nov. 22, 1966 S. SALMIRS ET AL 3,286,630
SPACECRAFT SEPARATION SYSTEM FOR SPINNING VEHICLES AND/OR PAYLOADS
Filed May 4, 1965 3 Sheets-Sheet 1

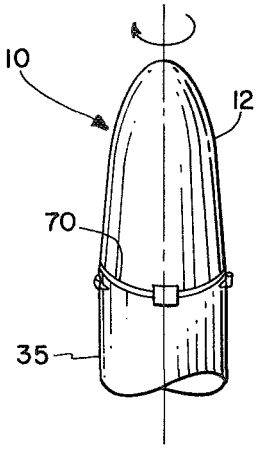


FIG. 1a

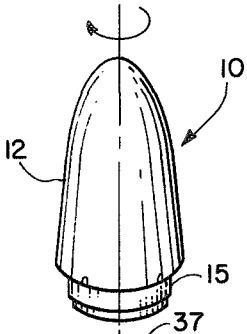
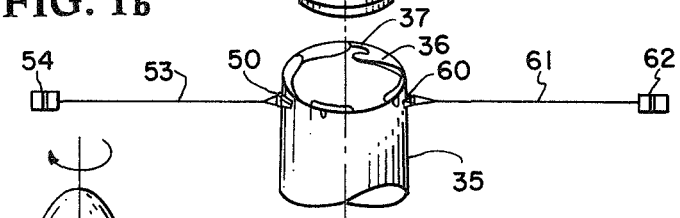
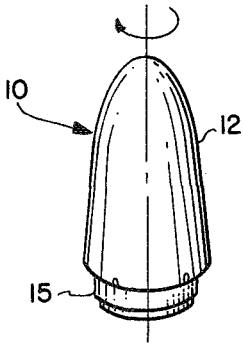


FIG. 1b





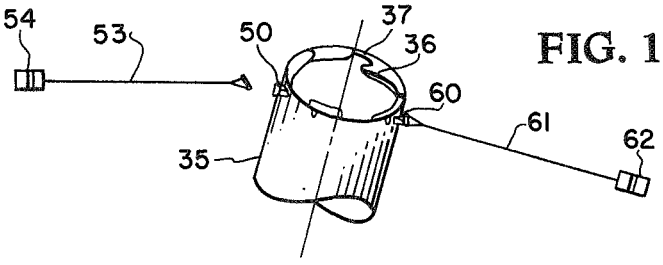


FIG. 1c

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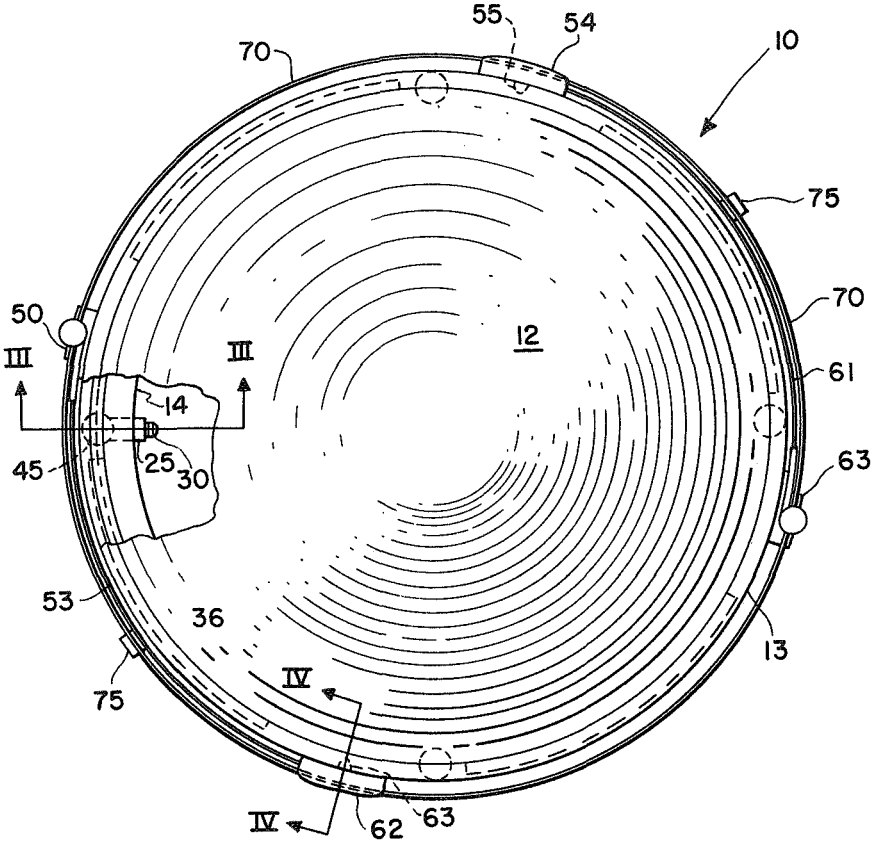

FIG. 2

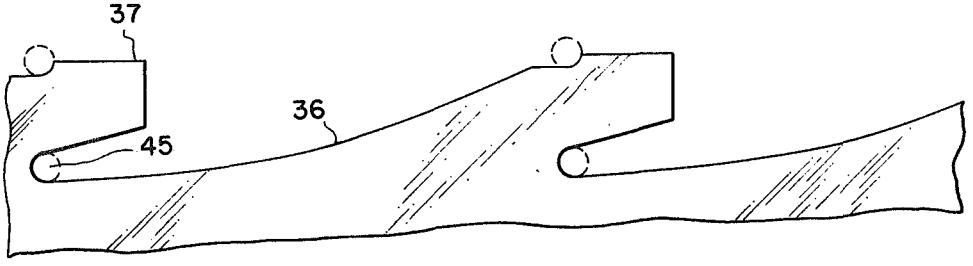

FIG. 5

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SPACECRAFT SEPARATION SYSTEM FOR SPINNING VEHICLES AND/OR PAYLOADS
Filed May 4, 1965 3 Sheets-Sheet 3

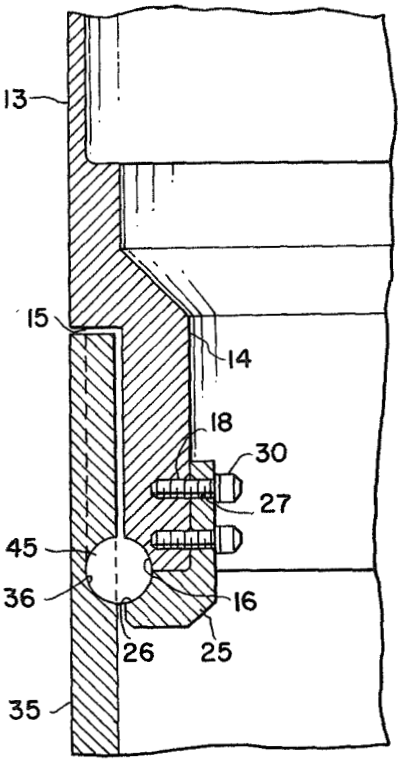

FIG. 3

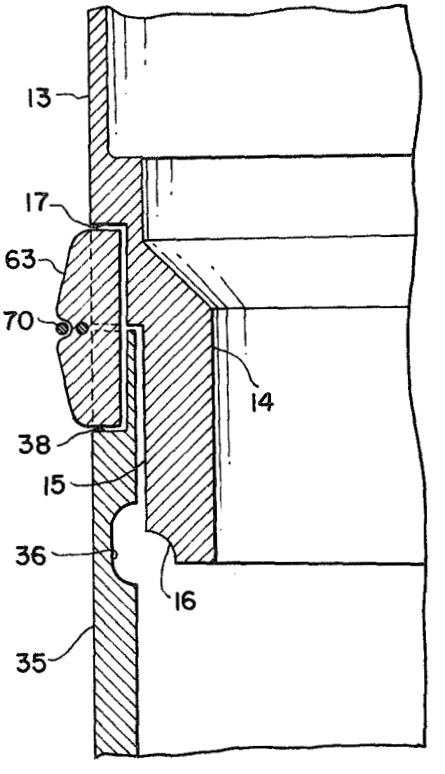

FIG. 4

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United States Patent Office 3,286,630 Patented Nov. 22, 1966

3,286,630

SPACECRAFT SEPARATION SYSTEM FOR SPINNING VEHICLES AND/OR PAYLOADS

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Filed May 4, 1965, Ser. No. 453,227
16 Claims. (Cl. 102—49)

This invention relates to mechanism for separating a spacecraft, and more particularly to a separation technique wherein the despin mechanism of one stage is utilized to cause separation of the stages and tumbling of one stage with respect to the other.

Various prior art techniques are available to perfect the separation between stages of a space vehicle. Among these prior art separation mechanisms are blowout diaphragms, Marmon bands, Marmon bands in combination with retrorockets or springs, shaped explosive charges and others. Although many of these separation mechanisms are operative for the purpose intended, they have many disadvantages particularly for certain types of vehicle missions. For instance, when it is necessary to separate the spacecraft, payload, or upper stage rocket (constituting the upper stage), from a lower stage and the upper stage must be stable, or it is necessary to sense or view from the aft end, or extension of antenna or other devices from the aft end is required, many difficulties occur using these structures. Under these conditions, diaphragms cause large disturbances and are comparatively heavy. Marmon bands and associated hardware are complex and relatively heavy. Explosive charges require extensive development for each configuration and are difficult to handle. All of these separation systems require long time delays after the lower stage burnout in order to avoid possible collision after separation due to the lower stage out-gassing. This invention overcomes the above-mentioned difficulties and will separate the upper stage from the lower stage with a minimum of delay utilizing a simple mechanical system which is light in weight and easy to construct.

It is, therefore, an object of this invention to provide stage separation mechanism wherein the relative movement (spin energy) between the stages due to despin of one of the stages is utilized for separation.

Another object of the invention is to provide vehicle stage separation mechanism wherein relative rotation between the stages upon separation is utilized to impart relative axial acceleration to the stages.

A further object of the invention is to provide stage separation mechanism wherein the structure utilized to despin one of the stages is also used to tumble one of the stages out of the path of the separated stage.

Still another object of the invention is to provide stage separation mechanism using rolling members to reduce breakout torques and friction upon separation.

An additional object of the invention is to provide stage separation mechanism utilizing despin weights and rollable members to lock the stages until time of separation, with no additional fastening equipment required.

A further object of the invention is to provide a stage separation mechanism which is primarily mechanical in nature, highly reliable, of simple design, lightweight, has a minimum number of moving parts, and is economical to construct and maintain.

These and other objects and advantages of the invention will become more apparent upon reading the specification in conjunction with the accompanying drawings.

In the drawings:

FIGS. 1*a*, 1*b* and 1*c* are perspective views showing a stage separation sequence utilizing the invention mechanism;

FIG. 2 is a plan view of the vehicle stages, partially cut away to reveal elements of the separation mechanism;

FIG. 3 is a cross-sectional view taken along the section lines III—III of FIG. 2;

FIG. 4 is a cross-sectional view taken along the section lines IV—IV of FIG. 2; and

FIG. 5 is an enlarged elevational view showing a portion of the vehicle raceway in an expanded position.

Basically, this invention relates to mechanism for joining and separating stages of a space vehicle. Generally, the lower stage has formed therein a raceway in the nature of a ramp. Associated with the raceways are arms which overlie a portion thereof. The upper stage or payload has a channel formed about the lower portion thereof which mates with the raceway structure. Arcuate recesses are formed in the channel and retaining brackets located at intervals thereabout and receive balls which nest in the arcuate recesses and roll on the raceways. When the stages are mated, they are positioned such that the balls are located under the arm structure, thus preventing axial or longitudinal separation. The stages are prevented from relative rotation by the despin weights which have keys engaged in keyways formed in the stages. The weights are lashed in position by a cable. When it is desired to separate the stages, a cable cutter severs the cable which loosens the weights allowing them to be flung from the spinning stage. The weights are attached to one of the stages by wires and this stage despun by the "Yo-yo" technique. This causes one of the stages to overrun the other, the balls rolling on the raceways and thereby separating the stages.

Referring now more specifically to the details of the invention, the spacecraft separation system is designated generally by the reference numeral **10** (FIG. 1).

Included in the spacecraft separation system **10** is a spacecraft or upper stage **12** having a housing **13**. The base **14** (FIGS. 3 and 4) of the housing is thicker than the remainder of the housing and offset inwardly. Formed in the outer face of the base is a channel **15**. Detents **16** are positioned at space intervals about the channel **15**. The detents **16**, of a generally arcuate design, being adapted to receive steel balls, to be explained more fully hereinafter. A base keyway **17** (FIG. 4) is formed in outer surface of the housing to receive the key of the despin weight, to be explained subsequently. Threaded screw apertures **18** are located in the base **14** adjacent the detents **16** to receive fasteners for securing the retainer bracket now to be described.

The retainer bracket **25** is located at each of the detents and is generally L-shaped in configuration. It has screw openings **27** in one leg thereof which receive screws **30** for securing the bracket to the housing base. The other leg of the retainer bracket projects under the base of the housing and has a pocket **26** formed therein which mates with the detent **16** formed in the channel. Thus, the combined detent **16** and pocket **26** form a generally hemispherical recess to receive the rollable ball, to be explained more fully hereinafter.

The lower stage is designated generally by the reference numeral **35**. Formed in the lower stage is a series of raceways **36**. As shown in FIG. 2, there are four raceways; however, it is to be understood that it is within the scope of the invention to have more or less as the situation might demand. FIG. 5 shows an expanded view of the raceway and illustrates that it is generally in the nature of a ramp with a gradual slope

from one end to the other and designed to transmit uniform accelerated axial motion. FIG. 3 also shows that the raceway is formed in a little over half the thickness of the lower stage casing and has an arcuate or rounded bottom which conforms generally to the configuration of the ball to be associated therewith. It is also clear from FIG. 5 that arms **37** are formed with the raceways and project over a portion thereof. The arms **37** cooperate with the balls to prevent movement along the longitudinal axis until despin occurs causing the upper stage to overrun the lower stage. Lower stage keyways **38** are notched in the outer periphery of the lower stage so as to be alined with the upper stage keyways.

The raceway balls **45** are constructed of stainless steel and are highly polished to eliminate excess friction. As is shown in FIG. 3, the balls **45** rest on the bottom of the raceways **36** and nest in the recess formed by the detents **16** and pockets **26**, located in the upper stage base and retainer bracket respectively.

The despin mechanism consists of a release **50**, release wire **53**, weight **54**, anchor **60**, anchor wire **61** and anchor weight **62**. These are best illustrated in FIG. 4, the release **50** being of the same type as described and illustrated in detail in Patent No. 3,128,845. The anchor **60** is of the same general design as the release **50** but has the release opening blocked to prevent release of the weight. The weights have keys **55** and **63** which engage the keyways **17** and **38** in the upper and lower stages (FIGS. 2 and 4).

A lashing cable **70** surrounds the stages and engages grooves formed in the weights **54** and **62**. The lashing cable **70** is threaded through a pyrotechnic or other form of cable cutter **75** which severs the cable and releases the weights upon despin to be explained more fully in the operation of the invention now to be described.

Operation

The upper and lower stages are joined or assembled by orienting the stages to their relative positions assumed upon separation. The balls are positioned on the raceways **26**, in the detents **16** and the retainer brackets secured to the housing base by the threaded fasteners **30** the pockets thereof also engaging the balls. The stages are then rotated until the balls **45** assume a position at the lowest portion of the raceway incline and under the arms **37**. In viewing FIGS. 3 and 5 simultaneously, it can be seen that the upper and lower stages are joined and prevented from movement in the longitudinal direction as long as relative rotation between the stages is prevented.

Locking of the stages from relative rotative movement is accomplished by the weights **54** and **62** which have the keys thereof **55** and **63** engaged in the keyways of the upper and lower stages (FIG. 4). The weights are maintained in position by the lashing cable **70**. The release and anchor wires **53** and **61** are attached to the respective weights and to the release **50** and anchor **60**.

The space vehicle is launched in a conventional manner, such as by booster, and at a desired point in space spun up by spin rockets also of conventional design (the detail of this structure not being shown). When it is desired to separate the stages the pyrotechnic cutter **75** is actuated severing the lashing cable **70**. The pyrotechnic cutter may be controlled remotely, by timer or by various other techniques known in the art.

When the lashing cable **70** is severed, the spinning of the stages will cause the weights **54** and **62** to fly out from the vehicle as is illustrated in FIG. 1*b*. As the weights and cables move away from the lower stage, the momentum primarily of the lower stage is transferred to these members according to the principle of the Yo-yo despin system causing the lower stage to rotate at a slower speed or despin. Since the weights are connected to the lower stage, they have little affect on the upper stage which continues to spin near the speed of initial release, the only coupling between stages being the friction of the balls. Consequently, the upper stage overruns the lower stage and the balls **45** associated therewith are carried thereby travel up the raceways **47**.

Once the balls **45** clear the end of the arms **37**, it is apparent that the upper and lower stages are free to separate in the longitudinal direction. Due to the weight of the upper stage, the balls may continue to ride on the raceway until they reach the upper extremity and ride off the top of the arms **37** or may separate depending on factors such as spin rate, etc. Due to the incline of the raceways and the momentum of the upper stage, the upper and lower stages are accelerated in the axial direction away from each other as the balls travel up the raceway.

Shortly after the stages separate, the release wire **53** and weight **54** have reached a position whereby the weight is released and moves away from the lower stage. The anchor weight, however, is permanently fixed to the lower stage and as it continues to spin causes the lower stage to tumble out of the path of the upper stage. This action is believed to be apparent from viewing FIG. 1*b*. The spinning of the lower stage is rather well stabilized as long as both weights are attached; however, as shown in FIG. 1*c*, when the one weight is released the spinning body immediately becomes unbalanced. Furthermore, the lower stage is spun in the opposite direction as the attached weight rewinds about the lower stage. Thus, the lower stage is not only tumbled, but its pointing direction is stabilized away from the path of the upper stage.

From the above description, it is believed apparent that a stage separation mechanism has been set forth which is of a simple, efficient and reliable design. Obviously, there is but a small time lapse between the time of actual separation and the time when the lower stage is tumbled out of the path of the upper stage. Therefore, it is not necessary to wait for the out-gassing of the lower stage before the aft end of the upper stage can be utilized for antenna erection or other sensing devices. If the upper stage has a rocket motor, it may be ignited immediately without disturbing its direction of firing. Certainly, there is no large disturbance due to separation as might be the case with a blowout diaphragm or other separation techniques. The separation mechanism consists of a minimum number of parts which are light in weight and therefore well suited for space use. The design of the raceway not only facilitates separation of the stages but utilizes the energy of the spinning upper stage to accelerate separation. The system provides mechanism for effectively separating the stages, as well as for joining the stages during the launch phase. Thus, the stages are properly joined and locked together until the despin phase without additional fastening and support structure.

Since there are, obviously, many modifications and variations of the present invention possible in the light of the above teachings, it is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. Space vehicle separation mechanism or the like for a spinning vehicle comprising: an upper stage; a lower stage in juxtaposition to said upper stage; balls engaging said upper and lower stages for joining said stages together; means for changing the relative speeds of rotation between the stages causing one stage to overrun the other; and means for accelerating separation of the stages.

2. Space vehicle separation mechanism or the like for a spinning vehicle as in claim 1 wherein one of said stages has raceway means for said balls to roll on and being arranged to increase axial acceleration of one of said stages upon separation.

3. Space vehicle separation mechanism or the like for a spinning vehicle as in claim 2 wherein the lower stage has the raceway means.

4. Space vehicle separation mechanism or the like for a spinning vehicle as in claim 1 wherein said means for changing the relative speeds of rotation between the stages is despin weights.

5. Space vehicle separation mechanism or the like for a spinning vehicle as in claim 1 wherein said lower stage has raceway means for said balls to roll on and being formed to increase axial acceleration between said stages; and means for changing the relative speed of rotation between said stages being despin weights.

6. Space vehicle separation mechanism or the like for a spinning vehicle as in claim 1 wherein said lower stage has raceway means for said balls to roll on and being formed to increase axial acceleration between said stages; means for changing the relative speed of rotation between said stages being despin weights; release means for at least one of said weights whereby the stage attached thereto is tumbled out of the path of the other stage.

7. Space vehicle separation mechanism or the like for a spinning vehicle comprising: an upper stage; a lower stage in juxtaposition to said upper stage; means for joining said stages together; despin weight means for changing the relative speed of rotation between the stages causing one stage to overrun the other; and means for accelerating separation of the stages.

8. Space vehicle separation mechanism or the like for a spinning vehicle as in claim 7 wherein there is release means for at least one of said weights; and means for retaining at least one of said weights whereby the stage attached thereto is tumbled out of the path of the other stage.

9. Space vehicle separation mechanism or the like for a spinning space vehicle as in claim 7 wherein there is cable means for lashing said weights to one of said stages prior to despin; and means for cutting said cable to release said weights.

10. Space vehicle separation mechanism or the like for a spinning vehicle as in claim 7 wherein there are weights having keys engaging keyways in said upper and lower stages prior to despin to prevent relative rotation between said stages.

11. Space vehicle stage separation mechanism or the like for a spinning vehicle comprising: an upper stage having a base; a channel formed in said base; a lower stage; raceways formed in said lower stage and being located adjacent said upper stage channel retainer brackets fixed to said channel at spaced intervals thereabout; arcuate recesses formed in said channel and said retainer brackets; balls nesting in said arcuate recesses and on said raceways; and means for rotating said stages relative to each other causing said balls to roll on said raceways to separate said stages.

12. Space vehicle separation mechanism or the like as in claim 11 wherein said raceways have formed therewith an arm overlying a portion thereof and said balls to prevent separation of said stages prior to relative rotation therebetween.

13. Space vehicle separation mechanism or the like as in claim 11 wherein said raceways are formed in the nature of a ramp to impart axial acceleration between said stages upon relative rotation and separation.

14. Space vehicle separation mechanism or the like as in claim 11 wherein said raceways have formed therewith an arm overlying a portion thereof and said balls to prevent separation of said stages prior to relative rotation therebetween; said raceway being formed in the nature of a ramp to impart axial acceleration to said upper stage upon relative rotation and separation.

15. Space vehicle stage separation mechanism or the like comprising: an upper stage having a base; a channel formed in said base; a lower stage; raceways formed in said lower stage and being located adjacent said upper stage channel; retainer brackets fixed to said channel at spaced intervals thereabout; arcuate recesses formed in said channel and said retainer brackets; balls nesting in said arcuate recesses and on said raceways; said raceways having formed therewith an arm overlying a portion thereof and said balls to prevent separation of said stages prior to relative rotation therebetween; despin weight means attached to said lower stage to cause said upper stage to overrun and said balls to move on said raceways; said raceways being formed in the nature of a ramp to impart axial acceleration between said stages upon relative rotation and separation; release means for one of said despin weights; and means for retaining another of said despin weights whereby the lower stage is tumbled out of the path of the upper stage and spin stabilized in another direction.

16. Space vehicle separation mechanism or the like as in claim 15 wherein said weights have keys engaging keyways formed in said upper and lower stages to prevent relative rotation therebetween prior to despin; cable means for lashing said weights to said space vehicle; and means for cutting said cable to release said weights to initiate despin and separation.

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