Dec. 7, 1965 A. P. SUTTEN 3,221,656

APPARATUS FOR HIGH-VELOCITY RECOVERY

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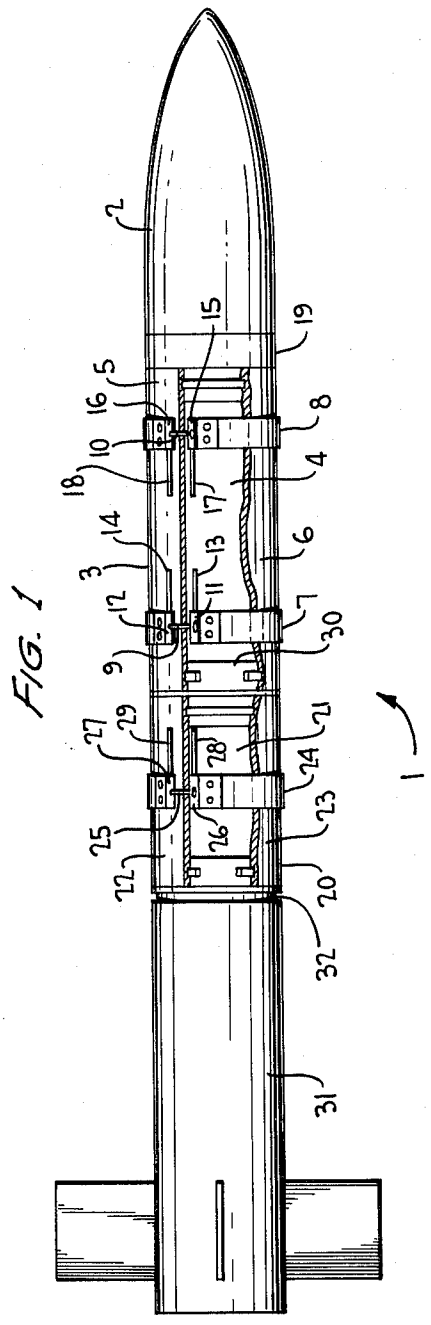


FIG. 1

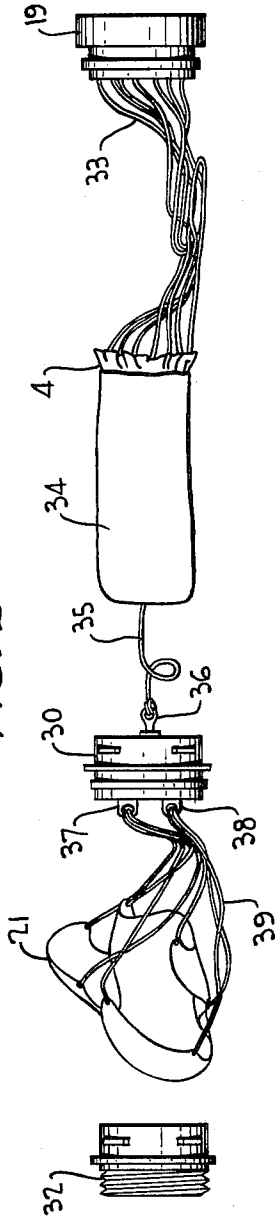


FIG. 2

INVENTOR,
ADRIAN P. SUTTEN

BY: Harry M. Saragovitz, Edward J. Kelly, Herbert Berl & J. P. Edgerton Attorneys.

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FIG. 3a

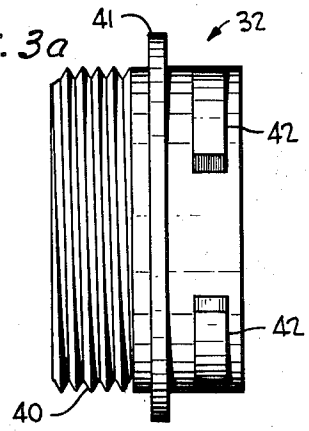


FIG. 3b

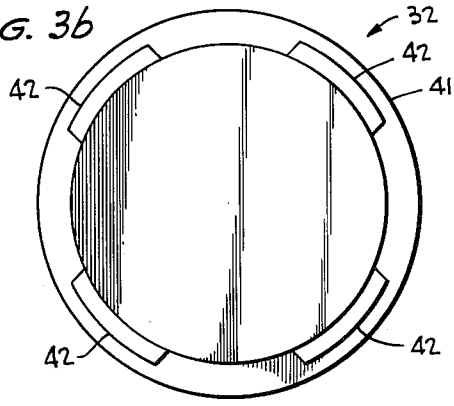


FIG. 4a

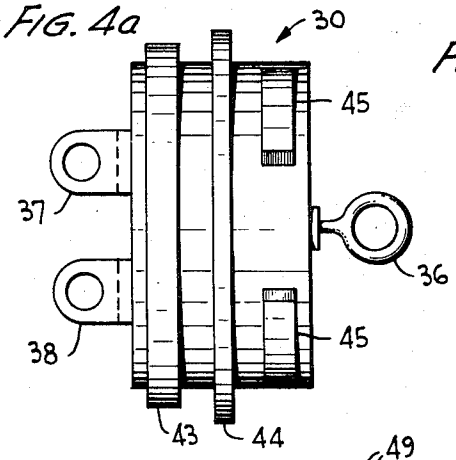


FIG. 4b

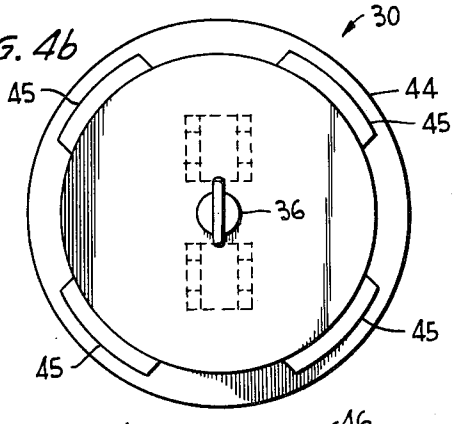


FIG. 5b

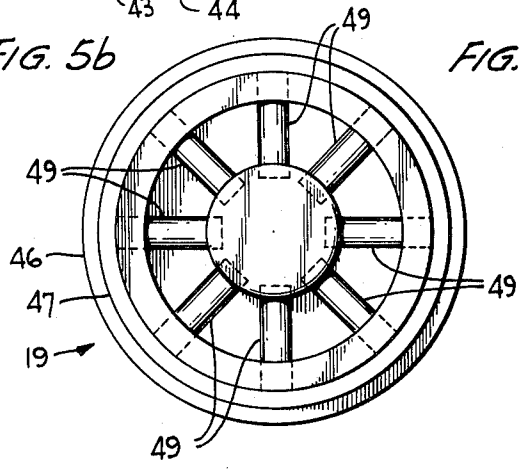
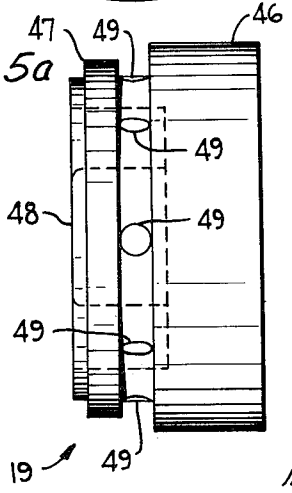


FIG. 5a



INVENTOR,

ADRIAN P. SUTTEN

BY: Harry M. Saragovitz, Edward J. Kelly, Herbert Berl & J. P. Edgerton Attorneys.

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FIG. 7

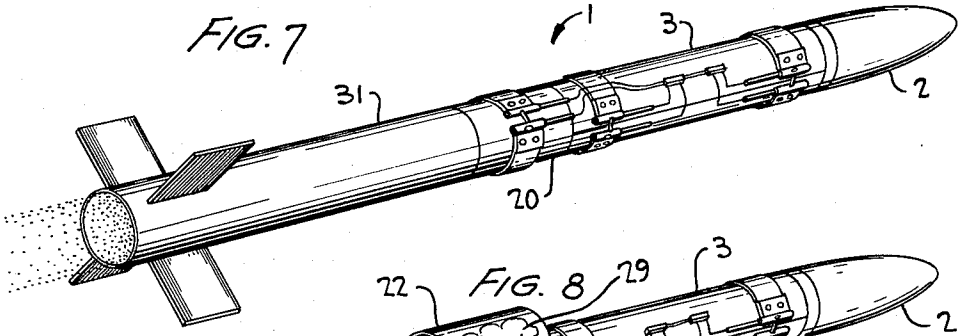


FIG. 8

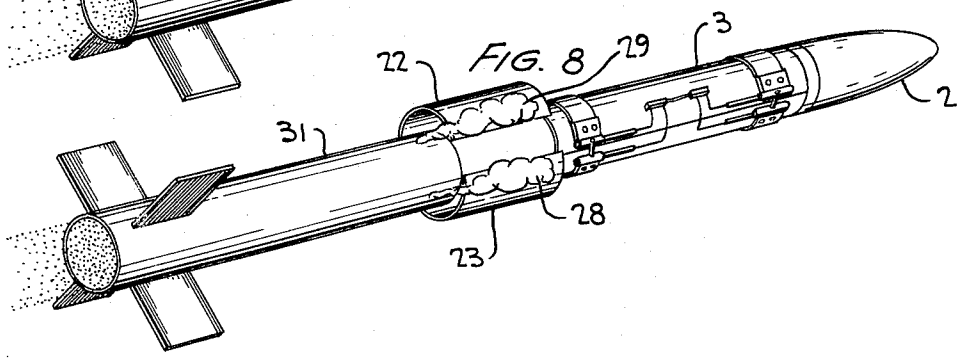
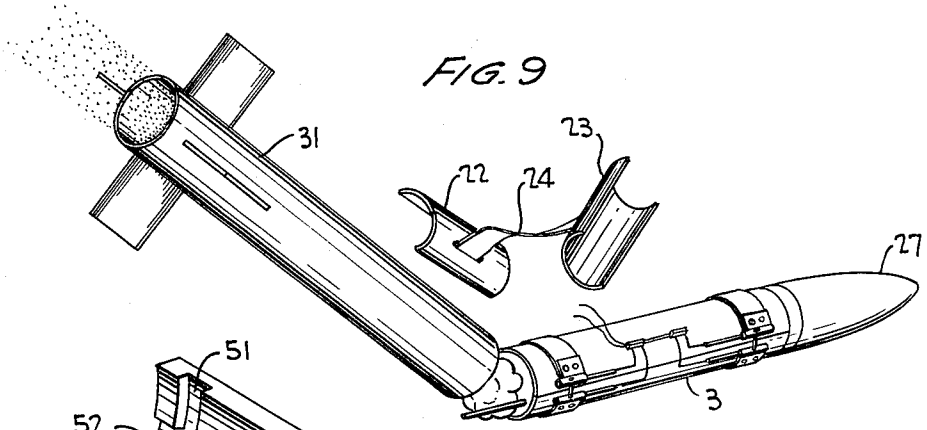


FIG. 9



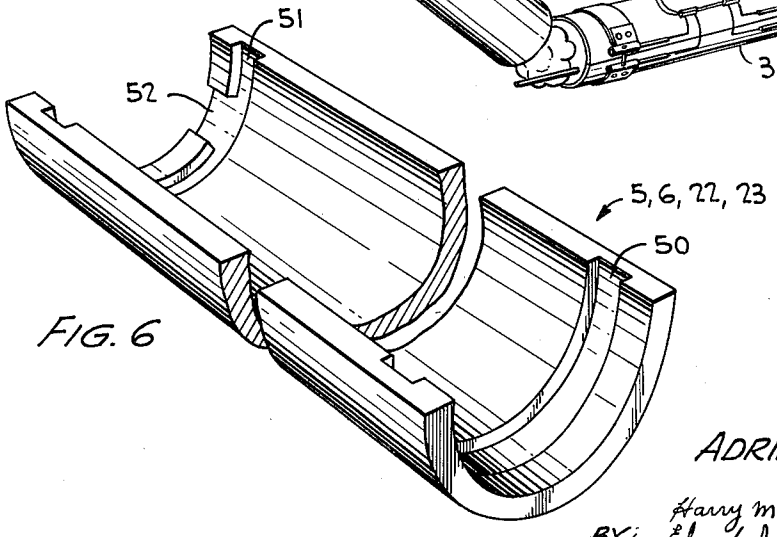


FIG. 6

INVENTOR,
ADRIAN P. SUTTEN

BY: Harry M. Saragovitz, Edward J. Kelly, Herbert Baldwin & J. P. Edenton Attorneys.

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FIG. 10

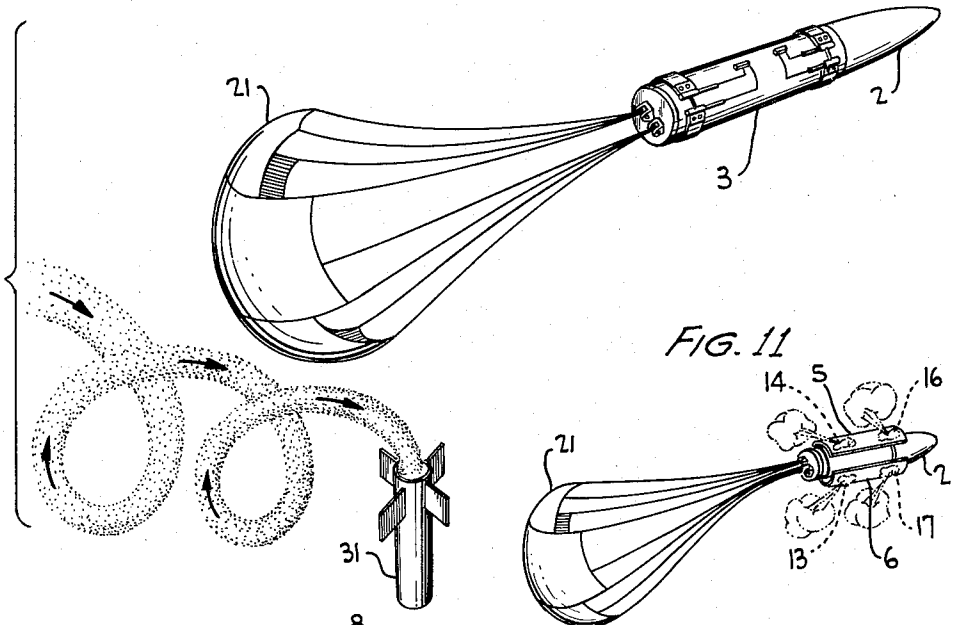


FIG. 11

FIG. 12

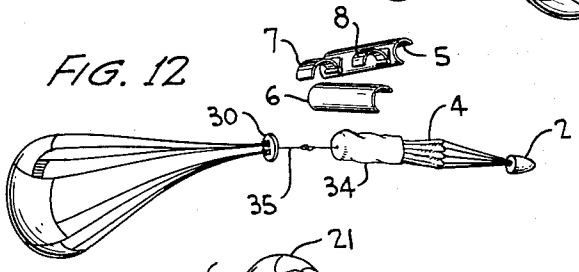
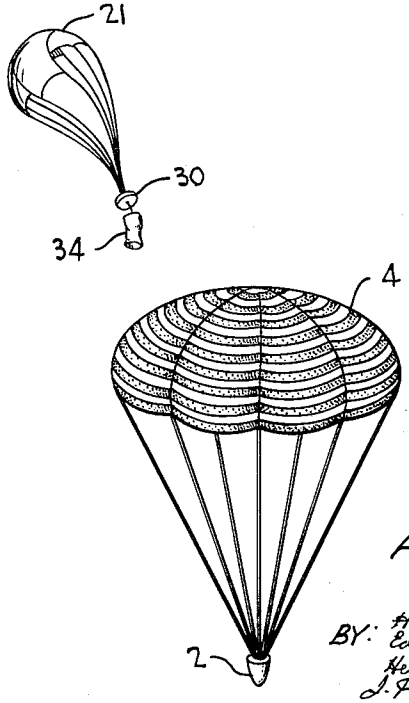


FIG. 13



INVENTOR,
ADRIAN P. SUTTEN

BY: Harry M. Saragovitz,
Edward J. Kelly,
Herbert Berl &
J. P. Edgerton Attorneys.

United States Patent Office

3,221,656

Patented Dec. 7, 1965

3,221,656

APPARATUS FOR HIGH-VELOCITY RECOVERY

Adrian P. Sutten, La Plata, Md., assignor to the United States of America as represented by the Secretary of the Army

Filed Mar. 23, 1964, Ser. No. 354,184
3 Claims. (Cl. 102—34.1)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment to me of any royalty thereon.

This invention relates generally to a method and apparatus for high velocity recovery, and more particularly to a method and apparatus for the recovery of a test payload from a vehicle which is traveling at a velocity in excess of Mach 2 in a substantially flat trajectory at sea level while subjecting the payload to a maximum "G" loading which is sufficiently low to prevent damage to the payload.

With the advent of high-velocity vehicles and delivery systems the forces caused by the large accelerations and decelerations and the temperatures due to air friction to which the vehicles and their systems are subjected must be accounted for in the design of vehicle-born equipment. Such equipment may for example be electronic devices and components, navigation systems and inertial sensors, fuzes, detonators and other components from ordnance systems. It is desirable to subject this equipment to simulated conditions for purposes of reliability and environmental testing. Ideally, a test might be performed by actually firing the equipment in a high-velocity vehicle such as a rocket. It is often desirable that the vehicle have a substantially flat trajectory for low altitude tests and realistic simulation of certain air-to-air and air-to-ground delivery systems. A flat trajectory additionally offers the advantage of requiring a minimum of the test area vertical air space. Horizontal test area space could be conserved by initiating recovery of the equipment under test during powered flight rather than waiting until motor burn out. The problems of recovering the equipment under test from such a vehicle without damage to the equipment are many and great. Conventional parachute recovery systems and techniques are totally inadequate under these severe conditions. When deployed at high velocity the parachute and its rigging become fouled, are subjected to friction burns, and sometimes tear. Successful deployment of the parachute is only one problem. It is also necessary that the shock of the canopy opening be relatively small to prevent damage to the equipment under test. Preferably, the opening shock should be substantially less than the acceleration test forces so as not to influence the test results.

In the past it has been usually to fire the high-velocity vehicle in a vertical trajectory, releasing the recovery parachute at the apex of the trajectory at which point the vertical velocity is equal to zero. This technique is not suitable for low altitude testing nor is it suitable for recovery during powered flight since motor burn out occurs considerably before the apex of the trajectory. It has also been usual to employ two parachutes in the recovery, the first parachute being a drag parachute which in turn deploys the second or main parachute. This technique has been used successfully at low velocities to velocities approaching sonic and supersonic velocities; however, this technique has not been used successfully at velocities substantially greater than Mach 1 velocities to and exceeding Mach 2 velocities. Furthermore, it has not heretofore been feasible to employ this technique during powered flight.

Accordingly it is an object of this invention to provide a method and apparatus for recovering a payload from a high-velocity vehicle.

Another object of the invention is to provide a system and technique for high-velocity recovery of a payload with a maximum "G" loading sufficiently low to preclude damage to the payload.

A further object of the present invention is to provide a method and apparatus for high-velocity recovery of equipment under test from a vehicle traveling in a flat trajectory.

Yet another object of this invention is to provide a method and apparatus for the recovery of a payload from a high-velocity vehicle during powered flight.

Still another object of the instant invention is the provision of a recovery system which employs a drag parachute and a main parachute, the deployment times of both parachutes being presettable before launch.

Another object of this invention is the provision of a high-velocity recovery system which is both simple and inexpensive to construct.

According to the present invention, the foregoing and other objects are attained by a recovery technique that uses a recovery package which consists of two sets of split sleeves connected to each other by a connecting block and connected to a rocket motor and nose cone by adapter blocks. The sleeves are held in place by metal bands fastened by a bolt which is severed by firing delay bolt cutting devices. The bolts are severed sequentially so that the first set of sleeves is removed at a first predetermined time and the second set of sleeves is removed at a second predetermined time. When the first set of sleeves is removed, the rocket motor is separated from the recovery package and nose cone, and a drag parachute is deployed. When the second set of sleeves is removed, the main parachute is deployed. At this time the recovery package and nose cone will have been slowed to approximately 500 feet per second. The total "G" loading using this method is between 50 and 70 "G's." The specific nature of the invention, as well as other objects, aspects, uses and advantages thereof, will clearly appear from the following description and from the accompanying drawings in which:

FIG. 1 is a partially cut-away side view of the rocket test vehicle;

FIG. 2 is an exploded view of part of the recovery apparatus;

FIGS. 3A, 3B, 4A, 4B, 5A, and 5B are detailed views of the connecting blocks for the several sections of the rocket test vehicle;

FIG. 6 is a detail view of one of the four split sleeves which house the parachutes in the recovery apparatus; and

FIGS. 7 to 13 are a sequence of views showing the recovery technique according to the invention.

Referring now to the drawings wherein like reference numerals designate indentical or corresponding parts throughout the several views, and more particularly to FIG. 1 wherein there is shown a side view of the rocket vehicle **1**. The vehicle consists of four sections. The first section or nose cone **2** houses the payload or equipment under test. The second section **3** houses the main parachute **4**. Section **3** is comprised of two split sleeves **5** and **6** held together by two metal bands **7** and **8**. Bands **7** and **8** are held in clamping position around sleeves **5** and **6** by bolts **9** and **10**, respectively. Bolt **9** is fitted through journals **11** and **12** at the ends of band **7**. Journals **11** and **12** hold pyrotechnic delay bolt cutting devices **13** and **14**. In a similar manner bolt **10** which connects band **8** is fitted through journals **15** and

16 which hold pyrotechnic delay bolt cutting devices 17 and 18. Section 3 is connected to the nose cone 2 by a connecting block 19. Main parachute 4 is attached to connecting block 19. The third section 20 houses the drag parachute 21 and is constructed in a manner similar to the second section 3. Section 20 is comprised of two split sleeves 22 and 23. Sleeves 22 and 23 are held together by a metal band 24. Band 24 is held in clamping position around sleeves 22 and 23 by a bolt 25. Bolt 25 is fitted in journals 26 and 27 which hold pyrotechnic delay bolt cutting devices 28 and 29. Section 20 is connected to section 3 by connecting block 30. Drag parachute 21 is attached to connecting block 30. The fourth section 31 houses the rocket motor which may be of any convention design. Section 31 is connected to section 20 by connecting block 32.

Pyrotechnic bolt cutting devices 13 and 14, 17 and 18, and 28 and 29 preferably takes the form of a tubular member threaded at one end to receive an end plug. A cylindrical time delay blasting cap of the type developed for ripple blasting in mining operations is inserted into the tubular member and retained therein by bolts 9, 10, and 25, respectively, and the threaded end cap. The end cap is provided with a hole through which electrical connection is made with the blasting cap. When the blasting cap is fired, the section of the bolt against which it is resting is blown out. The pyrotechnic blasting caps may be obtained with delays ranging from zero to ten seconds. Larger delays may be obtained by initiating the ignition of the delay blasting caps with a mechanical spring wound timer which may be housed in connecting block 19. Obviously, other suitable time delay devices may be used to produce similar results.

FIG. 2 shows more clearly the parachute assemblies of the recovery package which consists of sections 3 and 20. Main parachute 4 is folded into a bag 34 and attached to connecting block 19 by rigging lines 33. The bag 34 is attached to connecting block 30 by lanyard 35 and eye bolt 36. Drag parachute 21 is attached to connecting block 30 by anchors 37 and 38 and rigging lines 39. Connecting block 32 which adapts the rocket motor to the recovery package is shown in its spatial relationship to the rest of the elements.

FIGS. 3A, 3B, 4A, 4B, 5A, and 5B show in greater detail the structure of connecting blocks 32, 30, and 19, respectively. FIG. 3A shows a side view and FIG. 3B shows the front view of connecting block 32. The block 32 is a machined cylindrical element having screw threads 40 on the rear portion thereof for the purpose of screwing into section 31 which houses the rocket motor. A spacing flange 41 separates the threaded portion 40 from bayonet mounting flanges 42. FIG. 4A shows a side view and FIG. 4B shows the front view of connecting block 30. The block 30 is a machined cylindrical element having a spacing flange 44 which separates mounting flange 43 on the rear portion of the element from bayonet mounting flanges 45 on the forward portion of the element. Drag parachute anchors 37 and 38 are mounted on the rear face and eye bolt 36 is screwed into the front face of connecting block 30. FIG. 5A shows a side view and FIG. 5B shows the back view of connecting block 19. The block 19, similar to blocks 32 and 30, is a machined cylindrical element. The rear portion of the element has a mounting flange 47 while the forward portion 46 is the nose cone spacer. The nose cone may be connected to the connecting block 19 by a threaded hole (not shown) in the front face of the block. The back face of the connecting block 19 is machined to provide an annular hole having a central cylindrical element 48 therein. Holes are drilled perpendicular to tangents about the circumference of block 19 between flange 47 and spacer 46 through to the annular hole and into element 48. Metal dowels 49 are fitted into these holes and are held in place by a spring metal band (not shown) placed between flange 47 and spacer 46. The main parachute rigging lines are attached to dowels 49 in the assembled recovery package. FIG. 6 shows a detailed view of split sleeves 5, 6, 22, and 23. On the inside surface at one end of the split sleeve there is machined a groove 50 which is the female mate for flange 43 on connecting block 30 and for flange 47 on connecting block 19. On the inside surface at the other end of the split sleeve there is machined a groove 51 having notches 52 which are adapted to receive bayonet mounting flanges 42 and 45 on connecting blocks 32 and 30, respectively.

A better understanding of the recovery technique according to the invention may be had with reference to FIGS. 7 to 13. Launching of the test vehicle may be accomplished using a launching tube positioned with a low inclination angle. At the time of launch the ignition of pyrotechnic bolt cutting devices 13 and 14, 17 and 18, and 28 and 29 is initiated by a ground-based source of voltage by way of an umbilical cord. If a mechanical timer is used, it is set prior to launching. When using a mechanical timer, the source of ignition voltage is carried by the vehicle. FIG. 7 shows the rocket vehicle 1 consisting of sections 2, 3, 20, and 31 in powered flight. The velocity of the vehicle at this point may exceed Mach 2. At a first predetermined time pyrotechnic bolt cutters 28 and 29 fire causing split sleeves 22 and 23 to fall away from the vehicle as shown in FIG. 8. FIG. 9 shows the recovery package and nose cone 2 separating from the rocket motor section 31. Note that this occurs during powered flight. After the separation is complete drag parachute 21 is deployed which begins the deceleration of nose cone 2 and attached section 3. This is shown in FIG. 10. At a second predetermined time when the nose cone has slowed to about 500 feet per second pyrotechnic bolt cutters 13, 14, 15, and 17 fire causing split sleeves 5 and 6 to fall away as shown in FIG. 11. FIG. 12 shows sleeves 5 and 6 falling away and exposing main parachute 4 in bag 34. The bag 34 is pulled off main parachute 4 by lanyard 35 connected to connecting block 30 to which the drag parachute 21 is attached. The final stage of the recovery is shown in FIG. 13 wherein there is shown the canopy of main parachute 4 fully opened bearing nose cone 2 and the equipment under test to earth.

It will be apparent that the embodiments shown are only exemplary and that various modifications can be made in construction and arrangement within the scope of the invention as defined in the appended claims.

I claim as my invention:

1. A recovery package for safely recovering a payload from a high-velocity vehicle traveling in a substantially flat trajectory under powered flight comprising:
   (a) a first connecting block,
   (b) a main parachute attached to said first connecting block,
   (c) a bag enclosing said main parachute,
   (d) a second connecting block,
   (e) a lanyard connecting said bag and said second connecting block,
   (f) a first pair of split sleeves in mating connection with said first and second connecting blocks and enclosing said bag and said main parachute,
   (g) a drag parachute attached to said second connecting block,
   (h) a third connecting block, and
   (i) a second pair of split sleeves in mating connection with said second and third connecting blocks and enclosing said drag parachute.

2. The recovery package as set forth in claim 1 further comprising:
   (a) at least one retaining strap around each pair of split sleeves, each of said straps having two ends, each of said ends having a journal,
   (b) a plurality of bolts equal in number to the number of said straps, each of said bolts being threaded

through the two journals of a corresponding strap, and

(c) a plurality of pyrotechnic delay bolt cutting devices equal in number to the number of journals, said bolt cutting devices being held in juxtaposition to said bolts by said journals.

3. A high-velocity vehicle for environmental and reliability testing of air-borne equipment comprising:

(a) a nose cone for carrying the equipment to be tested,

(b) a recovery package comprising:

(1) a first connecting block, said nose cone being coaxially connected to said first connecting block,

(2) a main parachute attached to said first connecting block,

(3) a bag enclosing said main parachute,

(4) a second connecting block,

(5) a lanyard connecting said bag and said second connecting block,

(6) a first pair of split sleeves in mating connection with said first and second connecting blocks and enclosing said bag and said main parachute,

(7) a drag parachute attached to said second connecting block,

(8) a third connecting block,

(9) a second pair of split sleeves in mating connection with said second and third connecting blocks and enclosing said drag parachute,

(10) at least one retaining strap around each pair of split sleeves, each of said straps having two ends, each of said ends having a journal,

(11) a plurality of bolts equal in number to the number of said straps, each of said bolts being threaded through the two journals of a corresponding strap, and

(12) a plurality of pyrotechnic delay bolt cutting devices equal in number to the number of journals, said bolt cutting devices being held in juxtaposition to said bolts by said journals, and

(c) a propulsion motor, said propulsion motor being coaxially connected to said third connecting block of said recovery package.

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BENJAMIN A. BORCHELT, *Primary Examiner.*