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

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REPLY TO
ATTN OF: GP

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 agreed upon by Code GP and Code USI, 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.	: 3,465,638
Government or Corporate Employee	: Government
Supplementary Corporate Source (if applicable)	: N. A.
NASA Patent Case No.	: XAC-05902

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:
Yes ☐ No ☒

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

Dorothy J. Jackson

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Enclosure
Copy of Patent cited above

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Sept. 9, 1969 T. N. CANNING 3,465,638

HYPERVELOCITY GUN

Filed Aug. 23, 1967

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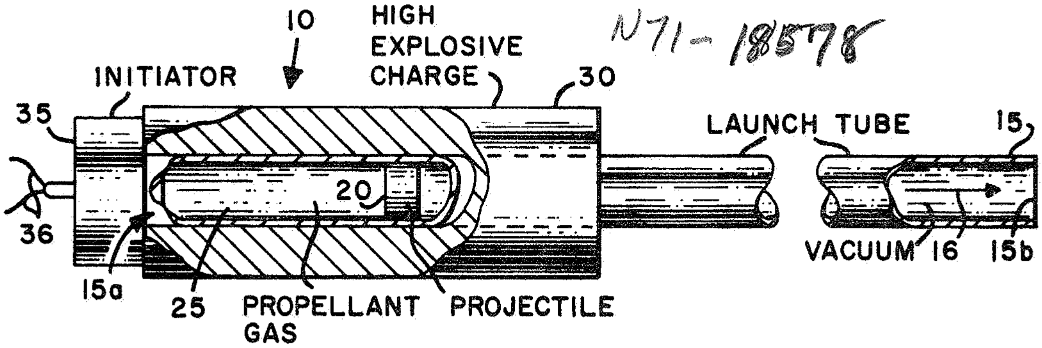

FIG. 1

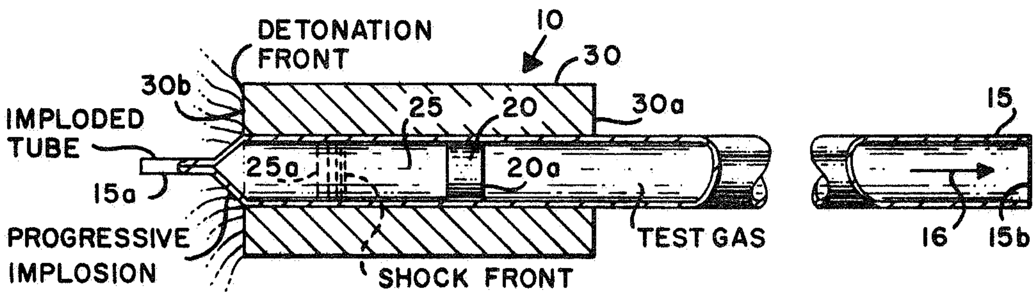

FIG. 2

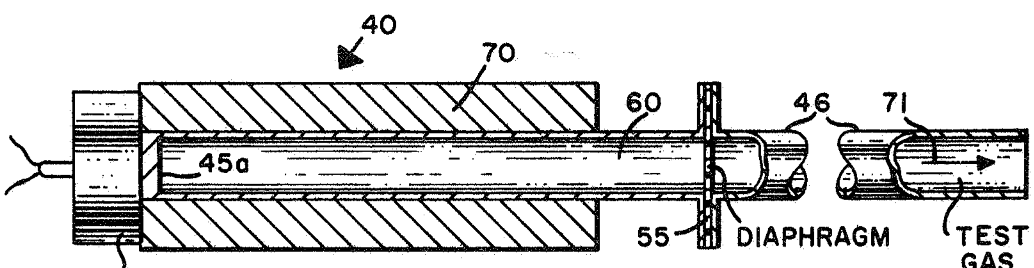

FIG. 3

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3,465,638
HYPERVELOCITY GUN

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Int. Cl. F41f *1/00, 17/00*
U.S. Cl. 89—8 14 Claims

ABSTRACT OF THE DISCLOSURE

The hypervelocity gun of the present invention is an implosion-driven, light-gas gun, which comprises a launching tube that is made of suitable ductile or yieldable material and is closed at one end thereof. Disposed within the launching tube and spaced from the closed end thereof is a projectile to be propelled along the tube and away from the closed end thereof. Contained within the launching tube between the closed end thereof and the projectile to be propelled is a well-known light propellant gas. Surrounding the launching tube commencing at the closed end thereof and extending to the portion of the launching tube intermediate the location of the projectile before firing and the open end of the tube is a suitable high explosive charge. An initiator or detonator is disposed at the closed end of the launching tube to detonate the high explosive charge.

The initiator is fired to cause the high explosive charge to explode progressively along the exterior of the launching tube in the axial direction of the launching tube and away from the closed end of the launching tube to produce a continuously advancing detonation front. This action results in the radial direction implosion of the launching tube that is progressive in the axial direction thereof and toward the open end thereof. As a consequence thereof, the propellant gas is continuously compressed to produce a continuously advancing shock wave front which impinges on the projectile and reflects therefrom to propel the projectile along the launching tube in the axial direction thereof and toward the open end thereof. After the projectile has started to move, the detonation wave and the shock-wave system between the detonation wave and the projectile follow the projectile to substantially the end of the launching tube.

The invention described herein was made by an employee of United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates in general to hypervelocity guns, and more particularly to an implosion-driven, light-gas gun.

Hypervelocity guns have employed a reservoir of compressible propellant gas to propel a projectile through a launching tube. However, such compressed gas is relatively stagnant so that its effectiveness in propelling a projectile is limited to relatively short distances in the launching tube. Such reservoirs of compressed gas is relatively static and has a relatively low speed of travel after the compression time. As a consequence thereof, a large pressure drop is present between the compressed gas and the projectile after the projectile has obtained a high velocity. There is no continuous acceleration of the reservoir of propellant gas after the projectile has attained a high speed.

An object of the present invention is to provide a hypervelocity gun wherein the acceleration of the projectile is sustained or increased after reaching a high velocity.

Another object of the present invention is to provide a hypervelocity gun in which acceleration of the projectile is achieved after attaining a high speed without structural damage to the projectile.

Another object of the present invention is to provide a hypervelocity gun wherein the explosive charge therefor detonates progressively along a launching tube to produce continuous compression of the propellant gas for propelling the projectile at higher velocities.

Another object of the present invention is to provide a hypervelocity gun wherein the propellant gas is continuously compressed to set up a continuously advancing shock-wave system to impel the projectile at higher velocities.

Another object of the present invention is to provide a hypervelocity gun wherein the launching tube is radially imploded progressively in the axial direction thereof to continuously compress the propellant gas for impelling the projectile at high velocities.

Another object of the present invention is to provide a hypervelocity gun wherein the compressed propellant gas is forced to advance along the launching tube at a high speed to accelerate the projectile along the launching tube.

Another object of the present invention is to provide a hypervelocity gun in which a continuously moving detonation front applies continuously additional energy and compressive force to the propellant gas for accelerating the travel of the projectile along a launching tube.

The hypervelocity gun of the present invention has a high explosive charge surrounding a ductile or yieldable launching tube which extends from a closed end of the launching tube to a portion of the launching tube between the location of the projectile before firing in the launching tube and an open end of the launching tube. Trapped between the closed end of the launching tube and the projectile is a compressible propellant gas. The high explosive charge is detonated and explodes progressively along the exterior of the launching tube in the axial direction and toward the open end thereof. This action causes a radial implosion of the launching tube progressively in the axial direction of the launching tube toward the open end thereof for continuously compressing the propellant gas to produce a continuously advancing shock wave front moving in the axial direction of the launching tube toward the open end thereof with the result that the projectile is propelled along the launching tube toward the open end thereof.

Other and further objects and advantages of the present invention will be apparent to one skilled in the art from the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a diagrammatic longitudinal cross-sectional of the hypervelocity gun of the present invention before firing.

FIG. 2 is a diagrammatic longitudinal cross-sectional view of the hypervelocity gun shown in FIG. 1 during firing.

FIG. 3 is a diagrammatic longitudinal cross-sectional of a hypervelocity shock tube, which is a modification of the hypervelocity gun illustrated in FIGS. 1 and 2.

Illustrated in FIG. 1 is the hypervelocity gun **10** of the present invention, which comprises a launching tube or liner **15**. Such a launching tube may be a missile launching tube or a gun barrel. At one end **15*a*** thereof, the launching tube **15** is closed and at the opposite end **15*b*** thereof, the launching tube **15** is open. The launching tube **15**, which is of a cylindrical configuration, is made of a suitable ductile or yieldable material. It has been found that steel with a relatively high yield stress has been particularly suitable.

Disposed within the launching tube **15** for movement in the direction of an arrow **16** is a projectile or model **20**. The projectile **20** may be a cylindrical or spherical solid body or a compact assembly of solid bodies which taken together to form a cylindrical assembly with a diameter slightly greater than the inner diameter of the launching tube **15** so that the projectile **20** may move along the launching tube **15** and yet having sealing engagement therewith. The projectile **20** is initially placed at an appropriate distance away from the closed end **15***a* of the launching tube **15**, such as fifty times the diameter of the launching tube **15**.

Contained within the launching tube **15** between the closed end **15***a* of the launching tube **15** and the projectile **20** is a suitable compressible, light propellant gas **25**, such as helium or hydrogen. Surrounding the launching tube **15** is a suitable high explosive charge **30**. The high explosive charge **30** has a cylindrical configuration and is disposed along the exterior wall of the launching tube **15**. In the exemplary embodiment, the high explosive charge **30** is disposed adjacent to the closed end **15***a* of the launching tube **15**. According to the present invention, the explosive charge **30** extends to a portion of the launching tube **15** that is located intermediate the location of the projectile **20** before firing and the open end **15***b* of the launching tube **15**. In this regard, the forward end **30***a* of the explosive charge **30** is between the forward surface **20***a* of the projectile **20** before firing and the open end **15***b* of the launching tube **15**.

At the closed end **15***a* of the launching tube **15** is mounted a conventional initiator or detonator **35**. The detonator **35** serves to fire or explode the explosive charge **30**. For this purpose, a suitable electrical line **36** is connected to equipment, not shown, for operating the detonator **35**. At the forward end of the launching tube **15**, a vacuum is created (FIG. 1) in order to reduce the resistance to acceleration of the projectile to a minimum.

The implosion-driven, light-gas gun **10** of the present invention effects a controlled acceleration of the projectile **20** to achieve high velocities in the order of 40,000 feet per second without structural damage to the projectile **20**. In this manner, a study may be made or research may be performed to determine the reactions of space vehicles to their environment while in space and while travelling through atmospheres.

In the operation of the hypervelocity gun or implosion-driven, light-gas gun **10** of the present invention, the projectile **20** is placed within the launching tube an appropriate distance from the initiator **35** with a light propellant gas trapped between the closed end **15***a* of the launching tube **15** and the projectile **20**. The forward end of the launch tube is subject to a vacuum state. The initiator or detonator **35** is fired in a well-known manner. As a consequence thereof, the explosive charge **30** explodes progressively from the closed end **15***a* of the launching tube **15** in the axial direction thereof and toward the open end **15***b* of the launching tube **15**. This action produces a resulting annular and planar detonation front **30***b* (FIG. 2), which advances in the direction of the arrow **16** through the high explosive charge **30** surrounding the launching tube **15**. The resulting planar detonation front **30***b*, in turn, causes the launching tube **15** to implode radially and progressively in the direction of the arrow **16** as shown in FIG. 2.

The implosion of the launching tube **15** produces a chain of strong hydrodynamic shock waves from the continuous compression of the trapped propellant gas **25**. The chain of shock waves results in a continuously advancing shock front **25***a* which moves alternately from the implosion front to the projectile and returns. With the impact of the first shock wave at the closed end **15***a* of the launching tube **15**, the projectile **20** accelerates along the launching tube **15** in the direction of the arrow **16**. The pressure drop at the trailing surface of the projectile **20** resulting from the acceleration thereof is repeatedly minimized or offset by the continuously moving shock wave system **25***a* produced continuously in the light compressed propellant gas **25**. After the projectile **25** exceeds the detonation velocity of the high explosive **30**, the average pressure at the trailing surface of the projectile **20** begins to drop. The acceleration of the projectile **20** continues, however, to higher projectile speed as the compressible, light propellant gas expands to low pressure.

From the foregoing, it is to be observed that in the present invention, the high explosive charge **30** explodes progressively along the launching tube **15** to implode radially and progressively along the launching tube **15** to set up through the propellant gas **25** a continuously moving shock wave system **25** that travels at very high velocities back and forth in the propellant gas **25** to continuously exert a propelling force on the trailing surface of the projectile **20** to propel the projective **20** along the launching tube **15** in the direction of the arrow **16**. Hence, the implosion-driven, light-gas gun **10** can effect acceleration of the projectile **20** without structural damage thereto up to velocities of 40,000 feet per second.

During the initial acceleration of the projectile **20**, the detonative wave **30***b* and the shock wave front **25***a* will be moving at a higher speed than the projectile **20** and the pressure between the imploded portion of the launching tube **15** and the projectile **20** may be sufficiently high to tend to rupture the launching tube **15**. In such an event, the launching tube **15** may be reinforced by heavier walls at the critical locations.

Illustrated in FIG. 3 is a modification of the hypervelocity gun shown in FIGS. 1 and 2 for use as a driver **40** for a shock tube. In this regard, the driver **40** comprises a ductile or yieldable tube or barrel **45**, which includes an open end and a closed end. At the closed end of the tube **45***a* is located an initiator or detonator **50**, which operates in the same manner as does the detonator **35**. In lieu of a model or projectile, such as the projectile **20**, the driver member **40** employs a diaphragm **55** of minimum weight. The diaphragm **55** is in sealing engagement with the tube **45**. Between the diaphragm **55** and the closed end of the tube **45** is a supply of compressible, light propellant gas **60**. At the forward side of the diaphragm **55** is located a driven tube **46** containing a supply of selected test gas to furnish a desired atmosphere at a selected pressure to fit the needs of an experiment or research project. Surrounding the exterior of the tube **45** is a suitable high explosive charge **70** of a cylindrical configuration. The high explosive charge **70** commences from the closed end of the tube **45** and terminates at a portion of the tube **45** between the closed end thereof and the diaphragm **55**. The diaphragm **55** is made of a suitable material, such as Mylar, that will be puncturable but yet will not contaminate pure gas. It is apparent that metallic material, such as aluminum, may be employed equally as well.

In operaion, the initiator or detonator **50** is fired and the explosive charge **70** explodes progressively from the closed end of the tube in the axial direction thereof and toward the open end of the tube. This action produces a resulting plane detonation front which advances in the direction of an arrow **71** through the tubular explosive charge **70** surrounding the tube **45**. The resulting plane detonation front, in turn, causes the tube **45** to implode radially and progressively in the direction of the arrow **71**. It is desirable to implode the portion of the tube containing the propellant gas **60** at a constant rate. Stated otherwise, the speed of travel of the detonation front should be constant.

The implosion of the tube **45** produces a single strong hydrodynamic shock wave from the continuous compression of the trapped propellant gas **60**. When the first shock wave in the propellant gas **60**, produced by the progression implosion of the tube **45**, ruptures the diaphragm **55**, the propellant gas **60** expands into the driven tube **46** containing the test gas. The resulting shock wave in the test gas produces a high thermal energy state by physical shock compression. By virtue of this action, the qualities of the test gas may be studied under conditions difficult to achieve by any other method.

It is to be understood that modifications and variations of the invention disclosed herein may be resorted to without departing from the spirit of the invention and the scope of the appended claims.

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

1. A hypervelocity gun comprising a ductile tube, an explosive charge surrounding said tube and extending in the longitudinal direction of said tube, said tube comprising a closed end portion and an open end portion, detonator means disposed adjacent the closed end portion of said tube for firing said explosive charge to cause said explosive charge to explode progressively along said tube in the longitudinal direction of said tube and toward the open end portion of said tube for imploding said tube progressively in the longitudinal direction of said tube toward the open end portion of said tube, a projectile disposed within said tube for movement along said tube in the longitudinal direction, said charge being substantially longer than said projectile, said projectile, before said charge is fired, being near said closed tube portion and said charge extending beyond both longitudinal ends of said projectile, and a supply of propellant gas disposed in said tube between the closed end portion of said tube and said projectile, said propellant gas being continuously compressed and impelled by the progressive implosion of said tube to propel said projectile along said tube in the longitudinal direction thereof and toward the open end portion thereof.

2. A hypervelocity gun as claimed in claim **1** wherein said explosive charge has a cylindrical configuration and when fired produces a continuously advancing detonation front moving in the longitudinal direction and toward the open end portion of said tube for imploding said tube progressively in the longitudinal direction and toward the open end portion of said tube.

3. A hypervelocity gun as claimed in claim **1** wherein said tube is imploded radially and progressively in the longitudinal direction to continuously compress said propellant gas for producing a continuously advancing shock wave system moving in the longitudinal direction toward the open end portion of said tube to propel said projectile in the longitudinal direction and toward the open end portion of said tube.

4. A hypervelocity gun as claimed in claim **2** wherein said tube is imploded radially and progressively in the longitudinal direction to continuously compress said propellant gas for producing a continuously advancing shock wave system moving in the longitudinal direction toward the open end portion of said tube to propel said projectile in the longitudinal direction and toward the open end portion of said tube.

5. A hypervelocity gun as claimed in claim **1** wherein said propellant gas is a light gas.

6. A hypervelocity gun as claimed in claim **4** wherein said propellant gas is a light gas.

7. A hypervelocity gun as claimed in claim **1** wherein said projectile is in sealing engagement with said tube to contain the propellant gas between the closed end portion of said tube and said projectile.

8. A hypervelocity gun as claimed in claim **6** wherein

said projectile is in sealing engagement with said tube to contain the propellant gas between the closed end portion of said tube and said projectile.

9. A hypervelocity gun as claimed in claim **2** wherein said detonation front is a planar detonation front.

10. A hypervelocity gun as claimed in claim **4** wherein said detonation front is a planar detonation front.

11. A hypervelocity gun as claimed in claim **9** wherein said planar detonation front has an annular configuration.

12. A method of propelling a projectile along tube comprising the steps of, progressively firing an explosive charge in the longitudinal direction of the tube to produce a continuously advancing detonating front moving in the longitudinal direction of the tube, imploding the tube progressively in the longitudinal direction of the tube through the action of the continuously advancing detonation front, compressing continuously and moving all of the propellant gas contained in the tube through the progressive implosion of the tube to produce a continuously advancing shock wave front beyond the situs of the projectile prior to the firing of the explosive charge, and propelling the projectile along the tube in the longitudinal direction under the action of the coninuously advancing shock wave front.

13. In combination, a ductile tube, an explosive charge surrounding said ductile tube and extending in the longitudinal direction of said ductile tube, said ductile tube comprising a closed end and a diaphragm end portion, detonator means disposed adjacent the closed end of said ductile tube for firing sad explosive charge to cause said explosive charge to explode progressively along said ductile tube in the longitudinal direction of said ductile tube and toward the diaphragm end portion of said ductile tube for imploding said ductile tube progressively in the longitudinal direction of said ductile tube toward the diaphragm end portion of said ductile tube, a diaphragm disposed at the diaphragm end portion of said ductile tube, a supply of propellant gas contained by said ductile tube between the closed end thereof and said diaphragm, a coaxial tube on the opposite side of said diaphragm from said ductile tube, a supply of test gas in said coaxial tube, said implosion of said ductile tube compressing said propellant gas continuously to produce a shock wave for rupturing said diaphragm, whereby said propellant gas expands into said coaxial tube containing said supply of test gas.

14. The combination as claimed in claim **13** wherein said explosive charge has a cylindrical configuration to produce a detonation front advancing at a constant velocity to implode said ductile tube at a constant rate in the longitudinal direction toward the diaphragm end portion of said ductile tube.

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SAMUEL W. ENGLE, Primary Examiner

U.S. Cl. X.R.

89—14