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METHOD AND APPARATUS USING AN EXPLODING  
PISTON IN A SHOCK TUNNEL  
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FIG. 1.

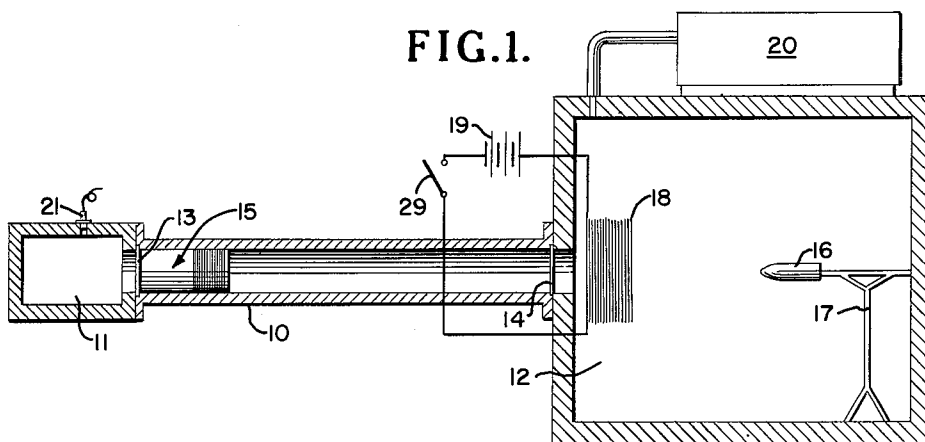
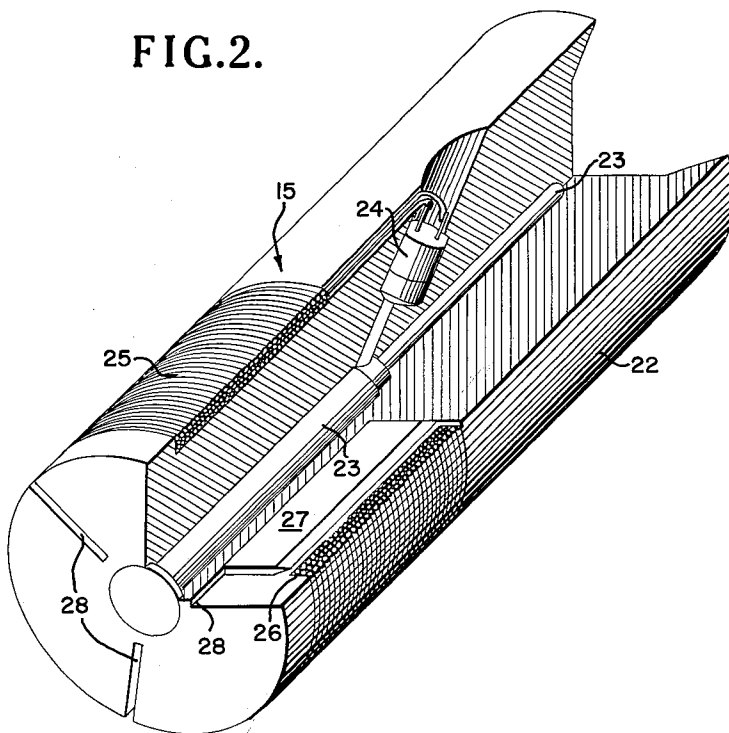


FIG. 2.



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## METHOD AND APPARATUS USING AN EXPLODING PISTON IN A SHOCK TUNNEL

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10 Claims. (Cl. 73-147)

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

This invention relates to an exploding piston and more particularly to the use of an exploding piston in a shock tunnel aerodynamic testing device.

The shock tunnel comprises a smooth bore barrel having an explosive chamber at one end thereof and a test chamber at the other end. In operation, the barrel is filled with air, and frangible diaphragms are fitted to both ends thereof to thereby seal a column of air within the barrel. A model of the aerodynamic shape to be tested is mounted within the test chamber in front of the bore. The explosive chamber is then filled with an explosive mixture of gases and ignited. The resulting explosion breaks the diaphragm at that end of the barrel, compresses the air column within the barrel, breaks the diaphragm at the other end thereof, and forces the column of air at high speed from the barrel to impinge upon the model within the test chamber. The shock tunnel arrangement provides a fairly simple, inexpensive means of attaining high speed air flows for use in aerodynamic testing.

In the prior art, however, certain disadvantages attended use of the shock tunnel device. When the exploding gases broke through the first diaphragm, the exploding gases mixed with the air column within the barrel thereby adulterating portions of the column of the air. These adulterated portions of the column are not useable for testing purposes since they will differ in density and temperature from the pure air portions of the column. Thus the overall testing period must be shortened to include only that portion of the column which has not become adulterated by the explosive gases; this in turn limits the amount of data which may be obtained from each operation or shot of the shock tunnel.

The operation of the shock tunnel would be greatly enhanced by providing some means, such as a piston, within the barrel to keep the exploding gases from mixing with the air column. Ordinary pistons are not practical for this purpose, because of the great speed at which such a piston must travel.

If the piston were allowed to leave the barrel and continue its flight, the ensuing high speed trajectory would result in its striking the model thereby causing great damage or destruction thereto. Since these models are relatively expensive, allowing the piston to strike the model would result in a prohibitively high cost of operation. It would, however, be possible to place some manner of mechanical arresting means within the path of the piston to either stop or deflect the piston from striking the model. Such an arresting means would require structure placed in the path of the air flow which would cause unwanted divergences or turbulence in the column of air.

To avoid these difficulties this invention contemplates the use of an explosive charge to disperse the piston soon after it leaves the muzzle of the barrel thus maintaining separation of the explosive gases from the air column without damaging the model or seriously disturbing the flow of the column of air.

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An object of the present invention is to provide a piston for use within a shock tunnel barrel to maintain separation between the explosive gases and the column of air within the barrel which does not destroy the model.

Another object of the invention is to provide a shock tunnel arrangement whereby the testing period for each shock is extended by preventing the mixture of the explosive gases with the column of air within the shock barrel.

A further object of the invention is the provision of an explodable piston operating by induced voltage in which a desired fragmentation and dispersion pattern may be attained.

Various other objects and advantages will be apparent from the following description of one embodiment of the invention, and the novel features will be particularly pointed out hereinafter in connection with the appended claims.

In the accompanying drawing:

FIG. 1 illustrates a shock tunnel arrangement which has been constructed in accordance with this invention; and

FIG. 2 is a partially cut away view of the piston showing the arrangement of the different elements therein.

In the embodiment of the invention shown in FIGS. 1 and 2, a smooth bore barrel 10 is shown with its rear end connected to an explosive chamber 11 and its front end connected to a test chamber 12. Breakable diaphragms 13 and 14 seal the ends of the barrel 10 in order to trap a column of air therein. An explodable piston 15 is shown in firing position at the rear end of the barrel; the piston is slideable in the barrel and serves to separate the explosive gases behind the piston from the air column in front of the piston. Within the test chamber 12, a model 16 of the aerodynamic shape to be tested is mounted upon a mounting bracket 17 so as to be in the line of sight of the barrel 10. A field coil arrangement 18 is disposed at one end of the barrel 10 and attached to a D.C. power source 19 to create thereby an electromagnetic field at the muzzle or front end of the barrel 10. The field coil arrangement 18 consists of a coil wound concentrically with the barrel muzzle to produce a magnetic field thereat through which the piston must pass. A sufficient magnetic field might be produced by using any well known electromagnetic field producing means at the muzzle such as a pair of coils placed on opposite sides of the muzzle in series opposing relation. It is to be understood that the field coils are sufficiently protected from the effects of explosive forces during operation. The test chamber 12 is adapted to be connected through an opening to an evacuation pump 20 so that a near vacuum may be created within the test chamber. The explosive chamber 11 is adapted to be filled with a hydrogen, oxygen, and helium mixture or other explosive combination which may be fired by the spark plug 21 or other initiator.

Referring now to FIG. 2, the explodable piston 15 consists essentially of a solid material body 22 of cylindrical shape. At the center of the body is carried quick burning explosive charge 23 extending almost the full length of the piston and having attached thereto an initiator 24. An actuating coil 25 is carried externally by the body wound circumferentially in the slight depression 26 provided therefor. The ends of the coil 25 are connected to the terminals on the initiator 24 so that a voltage induced in the actuating coil 25 will be applied to the terminals of the initiator and will result in actuation of the initiator and explosion of the charge. A plurality of metal preferably aluminum cutting blades 27 are disposed radially within slots 28 provided in the

body with the cutting edge toward the actuating coil and the blunt rear edge toward the charge 23.

In operation, the barrel 10 is filled with air and the piston 15 is placed at the rear thereof. Breakable diaphragms 13 and 14 are placed upon the ends of the barrel to seal the air therein. Next the model is mounted within the test chamber 12 and the chamber evacuated. The explosion chamber 11 has the explosive mixture introduced therein and is then sealed to the outside atmosphere. Sometime before firing the field coil 18 is actuated by closing the switch 29 to the D.C. power source 19. When the spark plug 21 is fired, an explosive force is generated within the explosion chamber 11 the pressure of which ruptures the rear diaphragm 13 and pushes the piston 15 forward in the chamber. The compression of the air in front of the piston ruptures the front diaphragm 14 thereby reeasing the air within the barrel. The piston moves forward at high speed forcing the column of air within the barrel 10 at equally high speed against the model 16, at which time various data concerning the behavior of the model in a high speed air flow may be recorded. The piston acts to prevent the explosive gases behind the piston from mixing with the air column being pushed against the model. As the piston 15 leaves the end of the barrel 10 it passes through the magnetic field produced by the field coil 18; thus a voltage is induced in the actuating coil 25 carried by the piston. The induced voltage is sufficient to fire the initiator 24 which in turn fires the explosive charge 23. The force of the explosive charge breaks the body of the piston and further acts to drive outward the three cutting blades 27 by the force being exerted on the blunt edge of the blades. The force upon the cutting blades causes them to be driven through the body of the piston and to sever the coil 25. Without the use of the cutting blades 27 to sever the coil 25, that portion of the body of the piston below the coil would be restrained against the outward force of the explosion, thus resulting in an incomplete fragmentation of that portion of the piston. The use of the cutting blades to sever the actuating coil 25 allows the entire piston to be rapidly fragmented and dispersed by the explosive charge 23 so that the material of the piston is deflected from the line of sight of the barrel before the piston can strike the model 16. The slots 28 also help to effect an orderly fragmentation and dispersion of that portion of the piston. Thus a piston may be used in the barrel of a shock tunnel to maintain a separation between the air column and the explosive gases and yet be deflected from striking the model and causing great damage thereto.

It will be understood that various changes in the details, materials, and arrangements of parts, which have been herein described and illustrated in this embodiment, in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention, as expressed in the appended claims.

What is claimed is:

1. In a shock tunnel having a barrel means to define a column of fluid therein, an explosive means for applying an explosive force to one end of said barrel to force the column of fluid from the other end thereof at high speed, and a model to be tested mounted at a distance from said other end and in the path of said column of fluid forced from said other end, the improvement comprising an explodable piston disposed between said explosive means and said column of fluid within the barrel, said piston forming a closure between said explosive means and said column, and actuating means for exploding said piston, said actuating means being disposed to explode said piston when it leaves said barrel, whereby the piston is fragmented and dispersed before reaching said model.

2. The improvement of claim 1 in which said actuating means comprises an actuating coil carried by said piston,

an explosive charge within said piston connected to said actuating coil, and field means at said other end of said barrel to produce an electromagnetic field thereat, whereby a voltage is induced in said actuating coil in passing through the electromagnetic field produced by said field means.

3. The improvement of claim 2 in which cutting means are contained within said piston, said cutting means communicating with said charge so as to be driven toward said coil by explosive force of said charge, whereby the said coil is cut into segments and said piston is selectively fragmented.

4. The improvement of claim 3 in which said piston is cylindrical in configuration, said charge is carried at the longitudinal axis of said piston, said actuating coil is carried externally of said piston wound around said piston, and said cutting means comprising a plurality of cutting blades disposed radially between said charge and said actuating coil.

5. An explodable piston comprising a piston body, an explosive charge contained within said body, an actuating coil carried by said body, said coil being connected to said charge, said charge being adapted to explode on energization of said coil, cutting means contained within said body, said charge communicating with said cutting means to drive said cutting means toward said coil upon explosion of said charge, whereby the cutting means is driven through and severs said coil by the explosion of said charge.

6. The piston of claim 5 in which said cutting means comprises a plurality of cutting blades disposed radially within said piston between said coil and said charge.

7. An explodable piston comprising a piston body, an explosive charge contained within said body, an energizing coil mounted on said body adapted to be energized when moved through an external electromagnetic field, said energizing coil being connected to said explosive charge to explode said charge on energization of said coil, cutting means positioned within said piston between said charge and said coil, whereby the cutting means is caused to cut the coil by the explosion of said charge.

8. The method of supplying a high speed flow of air to test an aerodynamic shape comprising confining a column of air within a smooth bore barrel with a piston at the rear end of the barrel, placing a model of the aerodynamic shape in an evacuated space in the line of sight of the barrel, applying an explosive force at the rear of the piston to drive the piston and column of air forward in the barrel toward the shape, and fragmenting and dispersing the piston as it leaves the barrel and before it strikes the model.

9. The method of claim 8 wherein the fragmenting and dispersing of the piston comprises actuating an explosive charge within the piston as the piston leaves the barrel.

10. The method of supplying a high speed flow of air to test an aerodynamic shape comprising confining a column of air within a smooth bore barrel, applying an explosive force at one end to compress the column of air, releasing the column of air to escape from the barrel at the other end thereof, maintaining a solid separation between said air column within the barrel and said explosive force, and fragmenting and deflecting the solid separation as it emerges from the barrel.

#### References Cited in the file of this patent

#### UNITED STATES PATENTS

1,739,921	Schuler et al. ....	Dec. 17, 1929
2,369,924	Sittig .....	Feb. 20, 1945
2,371,510	Fagerlund .....	Mar. 13, 1945
2,505,798	Skinner .....	May 2, 1950
2,537,096	Shreeve et al. ....	Jan. 9, 1951
2,640,417	Bjork et al. ....	June 2, 1953
2,836,063	Yoler et al. ....	May 27, 1958