

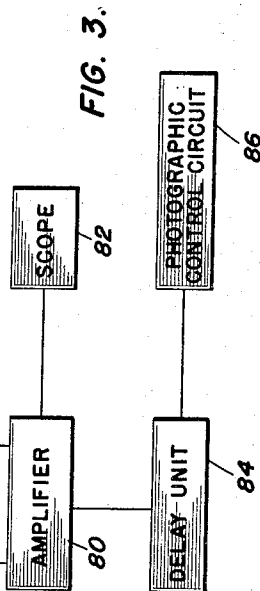
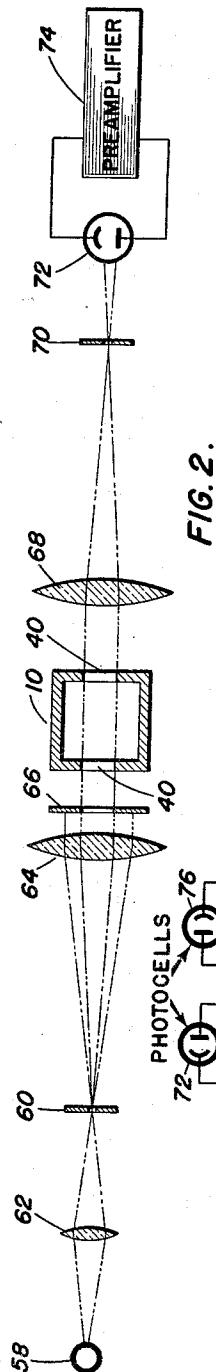
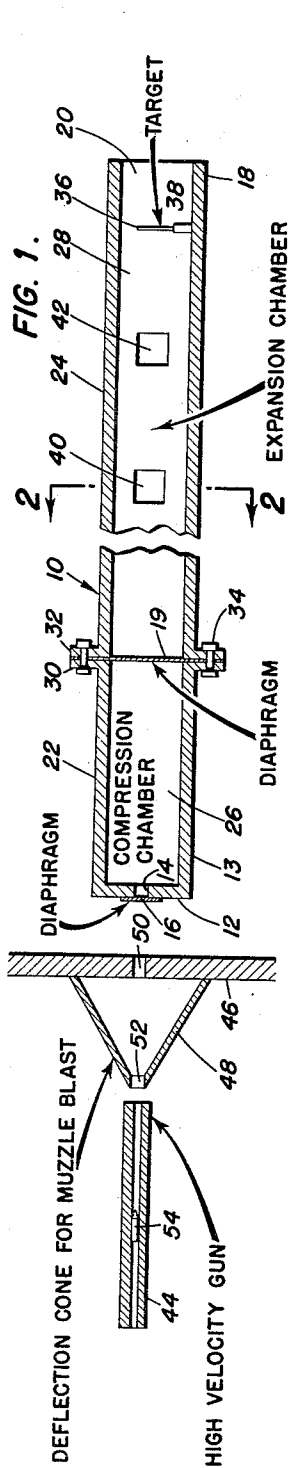
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SHOCK TUBE FOR STUDYING WARHEAD COMBINATION DAMAGE

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SHOCK TUBE FOR STUDYING WARHEAD COMBINATION DAMAGE

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This invention relates generally to apparatus for determining damage to a target, and more particularly it pertains to a shock tube for studying damage to a target caused by blast effect as well as by fragments from a warhead.

A warhead designed for an aerial missile envisages the use of an optimum ratio of charge weight to metal fragment weight to produce the maximum kill probability for the expected detonation distance. A term "combination damage" has arisen in connection with some observations of the damage inflicted in field tests of a fragmentation warhead against a SB2C airplane. It was found that the metal fragments from the warhead penetrated the airplane skin causing vaporific damage.

The subsequent action of the blast wave caused additional damage to the weakened elements of the airplane. The net effect was to produce a kill when neither the blast wave alone, nor the fragment pattern alone, could cause the damage. The term "combination damage" was coined to cover this type of damage. The most significant fact in the above field tests was that the effective damage radius of the fragmentation warhead was greater than that of an equal weight of bare charge.

Thus far significant combination damage has only been observed when the fragments cause vaporific damage. Vaporific damage has only been observed in tests with the obsolete SB2C airplane, and then just on the thinner air backed wing panels. It might be expected that the strength of the thick skin on a modern aircraft would be impaired by perforation and the associated low-order vaporific explosion. However, from a few tests on the SB2C airplane, it has been concluded that the subsequent blast wave would have no noticeable effect at the present average detonation range.

The tests were divided into two parts. First, the airplane was subjected to a given fragment pattern from a warhead, then examined, and later subjected to the equivalent associated blast wave from a bare charge. For the same warhead and charge, the distance from the airplane was varied to obtain other test results to determine the optimum weight ratio as previously mentioned. According to the damage criteria used, there was not noticeable additional damage from the blast wave to the thicker inboard wing paneling for the average detonation range.

With improved homing accuracy, a small increase in effective range for a warhead should become more significant, and a more extensive study of combination damage would be desirable. The current method for evaluating the effectiveness of a given fragmentation warhead is in actual field tests.

A conventional shock tube consists of a tube of uniform cross section closed at one end and open at the other. A thin diaphragm divides the tube into a compression chamber and an expansion chamber. By varying the relative lengths of the compression and expansion chambers, the impulse delivered by the tube can be varied. By varying the initial gas pressure in the compression chamber, the peak overpressure of the shock wave can be varied.

The method for initiating the shock wave is to puncture the diaphragm with a spring driven needle. The diaphragm material is such that it effectively disintegrates

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under the compression chamber pressure when punctured.

If instead of using a needle to puncture the diaphragm, a high velocity projectile is utilized (velocity 5,000-7,000 feet per second), all the elements necessary for studying the combination damage to a target at the mouth of the shock tube would be available. The parameters of the shock or simulated blast wave as well as the particle velocity, size and shape can be varied. In addition, since the velocity of the particle is larger than the velocity of the shock wave, the difference between their respective times of arrival at the target can be varied by varying the length of the expansion chamber. Thus, the shock tube and a high velocity gun which have both been widely used can be combined to study combination damage to a target.

It is, therefore, the principal object of this invention to provide apparatus for studying combination damage to a target.

Still another object of this invention is to provide a unique combination of a high velocity gun and a shock tube for studying damage to a target caused by a blast effect as well as by fragments from a warhead.

And another object of this invention is to provide apparatus that is flexible, efficient and reliable in operation for studying fragmentation and blast damage to a target.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which:

FIG. 1 is a longitudinal section through the apparatus comprising the present invention;

FIG. 2 is a cross section taken on line 2-2 of FIG. 1, showing a schlieren optical system; and

FIG. 3 is a diagrammatical representation of the electrical system used in connection with the apparatus and optical system of FIGS. 1 and 2.

In accordance with the invention, apparatus is provided for use in determining the damage to a target caused by a blast wave and fragments from a war head. This apparatus comprises a shock tube which includes structure defining a compression chamber and an expansion chamber, which are separated by a frangible diaphragm. A window is provided in the other end of the structure defining the compression chamber. In addition, means are provided for supporting a target to be studied at the opened end of the expansion chamber. A suitable gun is provided in conjunction with the shock tube for firing a high velocity projectile through the window of the compression chamber to rupture the frangible diaphragm to strike the target.

A schlieren optical system and an electrical circuit are provided to make measurements of the velocity of the shock wave as well as the velocity of the fragments of the warhead. The data obtained is then subsequently used to determine the optimum fragmentation warhead design.

Referring now to FIG. 1 of the drawing, there is illustrated a shock tube 10 which embodies the features of the present invention. This shock tube 10 is illustrated as being square in cross section as best seen in FIG. 2. However, the shock tube 10 can be circular or rectangular in cross section depending upon test requirements. This shock tube 10 is closed at one end 13 by a wall 12. This wall 12 has an aperture 14 provided thereon. This aperture 14 is covered by means of a diaphragm 16.

The other end 18 of the shock tube is open to the atmosphere, as indicated by reference numeral 20. A diaphragm 19 is utilized to divide the shock tube 10 into two sections 22 and 24. These sections 22 and 24 define structure for a compression chamber 26 and an expansion chamber 28, respectively. The diaphragm 19

is located between the two sections 22 and 24 of the tube by means of annular flanges 30 and 32 which are formed integrally with the tube sections 22 and 24. The diaphragm 19 is located between these flange members 30 and 32, and these elements are secured together by means of bolts 34.

A suitable target 36, mounted on a suitable stand or support 38 is located near the exit end 18 of the shock tube 10. Two pairs of opposing plate glass windows 40 and 42 are located in the side walls of the shock tube 10.

A gun 44 is located forward of the compression chamber 26. This gun is preferably of a high velocity type having a muzzle velocity of 5,000 feet per second, more or less. This gun 44 is separated from the shock tube 10 by means of a metal plate 46. This metal plate 46 has a deflecting cone 48 located thereon by means of suitable means to deflect the blast from the muzzle of the gun 44 and also to deflect any sabot that might be used in conjunction with a projectile 54.

This metal plate 46 and deflecting cone 48 each have an aperture 50 and 52, respectively, provided thereon for the passage of the projectile 54 therethrough. These apertures 50 and 52 are placed in alignment with each other and with the aperture 14 provided in the closed end 13 of the shock tube 10. The tube of the gun 44 is also aligned with the apertures 52, 50 and 14, the windows 40 and 42, and the target 36 so that the projectile 54 will pass through the apertures 52 and 50, puncture the diaphragm 16 and then pass through the aperture 14 to puncture the diaphragm 19 and then pass by the windows 40 and 42 to strike the target 36.

In FIG. 2 of the drawing, there is illustrated a schematic layout of one of the two schlieren systems utilized with this shock tube 10. The schlieren system shown in FIG. 2 is arranged between the pair of windows 40 of the shock tube 10. An identical schlieren system (not shown) is arranged between the pair of windows 42 of the shock tube 10. It is believed sufficient to describe only one of the schlieren systems.

This schlieren system consists of a miniature schlieren optical arrangement in which light from a suitable source 53 falls upon a slit 60 passing through a convex lens 62. The light from slit 60 is passed to a collimating lens 64, where the rays are rendered parallel. The light beam is further limited to a rectangular shape by a slit 66 whose edges are arranged parallel to the plane of an oncoming shock front travelling down the tube 10. In addition to defining the parallel light beam crossing the shock tube 10 through the windows 40, the slit 66 is utilized to cut out much of the stray light.

A convex lens 68 is utilized to throw an image of the slit 60 on the plane of a slit 70, behind which is located a photocell 72. This photocell 72 is connected to a preamplifier 74. This photocell 72 is usually in the form of a photomultiplier tube and it is arranged to receive any light which is passed through the slit 70. It is essential that the elements of the schlieren optical system described be aligned so that the axis of the system is parallel to the plane of the shock front in order that optimum performance can be obtained.

The schlieren system can be adjusted by moving the slit 70 from an initial position centered on the light beam in a direction opposed to the direction of motion of the shock front until the light entering the photocell 72 is just cut off. As soon as the shock wave enters the side of the light beam, certain rays are refracted sufficiently to pass through the slit 70 and fall on the photocell 72. As the shock front traverses the width of the beam, the amount of light which will reach the photocell 72 remains substantially constant since the density gradients behind the shock front itself are usually small. In addition, it is to be noted that by means of this arrangement a suitable electrical signal is generated which is representative of the shock wave at the window 40. A similar signal will be

received when the shock wave passes the pair of windows 42. It is also to be noted that easily identifiable additional signals, representative of the position of the projectile with respect to time, can be obtained when the projectile 54 passes the pair of windows 40 and 42 and cuts off the light beam source 58.

Referring now to FIG. 3 of the drawing, there is illustrated an electrical arrangement for recording the signals mentioned above. As previously indicated, two identical schlieren systems such as the one illustrated in FIG. 2 are utilized. The schlieren system utilized with the pair of windows 42 has a photocell 76 and a preamplifier 78, corresponding to the photocell 72 and preamplifier 74 utilized in conjunction with the pair of windows 40. The two preamplifiers 74 and 78 are connected to a suitable amplifier 80. This amplifier 80 is connected, in turn, to an oscilloscope 82 which it utilized for observing the signals generated in the electrical system. The amplifier 80 is also connected to a suitable delay unit 84 which is utilized for triggering a photographic control circuit 86 for photographing the signals observed on the screen of the oscilloscope 82.

In operation, a projectile 54 is fired from the high velocity gun 44 at a desired muzzle velocity. This projectile 54 passes through apertures 52 and 50 in the deflection cone 48 and metal plate 46, respectively. The projectile then punctures the diaphragm 16 located at the closed end 13 of the shock tube, and passes through the aperture 14 provided therein. The projectile then punctures the diaphragm 19. When this occurs, the high pressure medium located in the compression chamber 26 are released and a shock wave is generated. In most cases, this shock wave may either proceed or follow the projectile 54 as it travels down the shock tube 10.

When the projectile 54 passes the two pairs of windows 40 and 42, a pair of signals will be generated in the electrical circuit as previously mentioned. The projectile 54 will continue to traverse the shock tube 10 until it strikes the target 36 and causes damage thereto. The shock wave which either proceeds or follows the projectile 54 will likewise generate a pair of signals in the electrical circuit when the shock wave passes the pairs of windows 40 and 42. The shock wave will inflict its own damage to the target 36 when it arrives at the target 36.

The signals generated in the electrical circuit are observed and photographed as previously mentioned. The oscilloscope tracing can be analyzed so that the velocity of the projectile 54 and the velocity of the shock wave can be determined. This information can then be correlated with the type of target and the combined damage inflicted to the target 36. The information from this study can then be used to assess the magnitude and the importance of the combination damage which is inflicted on a target 36.

There are many design details which will depend on the specific performance requirements for the shock tube 10 and the high velocity gun 44, such as the desired target size and the range of parameters of interest. For example, the nature of the material to be utilized for the diaphragm 16 and 19 to a considerable extent, will depend on the total load on the diaphragm 16 and 19. A large target will require a shock tube whose cross section is of comparable size. High shock strengths of the shock wave will require a high pressure in the compression chamber. In either case, high diaphragm strength will be required. Thin metal diaphragms loaded almost to the rupture point may have to be utilized in test studies.

If metal diaphragms are used, a grid should be utilized downstream of diaphragm 19 in order to prevent diaphragm fragments from reaching the target 36. As the projectile 54 punctures either diaphragm 16 and 19, there might also be a vaporific explosion which can be eliminated by using an inert gas like nitrogen in the tube 10.

If the aperture 14 is made just large enough to admit the projectile 54, the performance of the shock tube 10

will not be very different from a conventional closed end shock tube. If the aperture 14 is made larger than the diameter of the projectile 54, peak shock waves can be produced which simulate more closely the actual blast waves.

Excessively thick metal diaphragms will be necessary if requirements call for both a large cross section shock tube and a high compression chamber pressure. In such a case, the compression chamber 26 and the diaphragm 16 and 19 can be replaced by lining the closed end of the shock tube with a sheet of explosive. In the experiment proposed here, the blast wave could still be initiated by the high velocity projectile 54 striking a detonator placed in the small window or aperture 14 in the closed end 13 of the tube or there could be allowance for a time delay with the explosive being fired separately.

Obviously many modifications and variations of the present invention are 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 specifically described.

What is claimed is:

1. Apparatus for use in determining the damage to a target due to a blast wave and fragments from a warhead, comprising, structure defining a shock tube having a closed end and an open end, a first frangible diaphragm located in said tube and dividing said tube for defining a compression chamber and an expansion chamber, an aperture located in the closed end of said tube, a second frangible diaphragm closing said aperture, two pairs of spaced windows located in the wall of said shock tube defining said expansion chamber, the windows of each pair of windows being positioned in alignment on opposite sides of said shock tube, means for supporting said target at the open end of said tube, means including a gun for firing a high velocity projectile through said second diaphragm and aperture to rupture said first diaphragm and strike said target, means including a schlieren optical system positioned in alignment with each pair of windows, an electrical circuit including a photocell associated with each schlieren optical system for generating signals corresponding to passage of said projectile and blast wave by each pair of said windows, and means for recording said signals so that the velocity of said shock wave as well as the velocity of said fragments from said warhead can be determined and utilized for determining the damage to said target.

2. Apparatus for use in determining the damage to a target due to a blast wave and fragments from a warhead, comprising, structure defining a shock tube having a closed end and an open end, a first frangible diaphragm located in said tube and dividing said tube for defining a compression chamber and an expansion chamber, an aperture located in the closed end of said tube, a second frangible diaphragm closing said aperture, two pairs of spaced windows located in the wall of said shock tube defining said expansion chamber, the windows of each

pair of windows being positioned in alignment on opposite sides of said shock tube, means for supporting said target at the open end of said tube, means including a gun for firing a high velocity projectile through said second diaphragm and aperture to rupture said diaphragm and strike said first target, means including a schlieren optical system positioned in alignment with each pair of windows, an electrical circuit including a photocell associated with each schlieren optical system for generating signals corresponding to passage of said projectile and blast wave by each pair of said windows, means for recording said signals so that the velocity of said shock wave as well as the velocity of said fragments from said warhead can be determined and utilized for determining the damage to said target, and means including a deflection cone positioned between the muzzle of said gun and said aperture for deflecting the gases from said gun.

3. Apparatus for use in determining the damage to a target due to a blast wave and fragments from a warhead, comprising, structure defining a shock tube having a closed end and an open end, a first frangible diaphragm located in said tube and dividing said tube for defining a compression chamber and an expansion chamber, an aperture including a second frangible diaphragm located in the closed end of said tube, two pairs of spaced windows located in the wall of said shock tube defining said expansion chamber, the windows of each pair of windows being positioned in alignment on opposite sides of said shock tube, means for supporting said target at the open end of said tube, means including a gun for firing a high velocity projectile through said second diaphragm in said aperture to rupture said first diaphragm and strike said target, means including a schlieren optical system positioned in alignment with each pair of windows, an electrical circuit including a photocell associated with each schlieren optical system for generating signals corresponding to passage of said projectile and blast wave by each pair of said windows, means for recording said signals so that the velocity of said shock wave as well as the velocity of said fragments from said warhead can be determined and utilized for determining the damage to said target, and a deflection cone positioned between the muzzle of said gun and said aperture for deflecting the gases from said gun.

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