TARGET APPARATUS

DESCRIPTION

BACKGROUND OF THE INVENTION

The invention relates to target apparatus for determining and indicating the location at which a projectile has penetrated a face of the target.

THE PRIOR ART

German Utility Model Application DE-GM No. 77 26 275, published Mar. 16, 1978, discloses a target system comprising a framework constituting an outer periphery of the target. The framework is provided with front and rear sheets of a flexible rubber-like material to form an anechoic chamber. A plurality of transducers is located within the chamber. A bullet fired at the target passes through the rubber-like sheets and, thus, through the anechoic chamber. As the bullet passes through the anechoic chamber, a shock or pressure wave is generated which expands radially outwardly from the path of the bullet between the two outer skins of the chamber. The shock or pressure wave impinges on the transducers. By measuring the time of arrival of the shock or pressure wave at each transducer, it is possible to calculate the position at which the bullet has passed through the target, provided that the precise position of each transducer is known, the speed of sound in air within the anechoic chamber is known, and the speed of the bullet is known.

SUMMARY OF THE INVENTION

The present invention provides improvements in the above-mentioned prior art target apparatus.

According to one aspect of the invention, there is provided a target apparatus comprising a framework covered by at least one sheet of material to form a chamber, the material being penetrable by a projectile. A plurality of transducers are positioned at respective spaced-apart locations within the chamber and lying on an arc of a circle, for detecting shock or pressure waves in the chamber caused upon penetration of the sheet of material by the projectile. Apparatus responsive to the transducers is provided for measuring time differences between instants of detection of a shock or pressure wave by the transducers. Further apparatus responsive to the time difference measuring apparatus determines and indicates a location at which the projectile has penetrated the sheet of material.

A significant over the above-mentioned prior art apparatus is provided by the disposition of the transducers on the arc of a circle. That is, a zone is created about the origin of the arc on which the transducers lie (i.e., the center of the circle of the arc) in which the determined projectile penetration locations are substantially independent of the propagation velocity of sound in air within the chamber. As a result, one variable in the calculation of projectile penetration location is eliminated, significantly improving the overall accuracy of projectile penetration location determination. Experimental results and computer modeling by the inventors suggest that the positioning of the transducers on the arc of a circle improves overall accuracy by a factor of two over the prior art target having transducers located along a straight line on a beam. The principal—and acceptable—penalty of placing the transducers on an arc of a circle lies in increased complexity and quantity of mathematics required to be performed in obtaining

"hit" positions (locations at which the projectile has penetrated the sheet of material defining a wall of the enclosed chamber). The mathematical operations required to obtain "hit" positions are preferably carried out by a suitably programmed general-purpose computer.

In the preferred form of the invention, three transducers are provided within the chamber for detecting the shock or pressure wave caused within the chamber upon penetration by a projectile such as a bullet. It is preferred that the center of the circle (along an arc of which the transducers are located) is aligned with a bull's-eye or aiming mark provided on the target. The bull's-eye or aiming mark may be printed on or otherwise affixed to or positioned adjacent a surface of the target defined by a sheet of material covering the framework.

Apparatus is preferably also provided for measuring the propagation velocity of sound in air within the target chamber. In one form of the invention, the propagation velocity measuring apparatus comprises a device for transmitting a sound pulse, apparatus spaced from the sound pulse transmitting device for detecting the sound pulse, and apparatus responsive to the sound pulse detecting apparatus for measuring a time taken for the sound pulse to travel a known distance and for determining therefrom the propagation velocity of sound in air within the chamber. The detecting apparatus most preferably comprises a pair of transducers spaced at the known distance from one another, within the chamber. Alternatively, the detecting apparatus may comprise a single transducer spaced at the known distance from the sound pulse transmitting means.

In another form of the invention, the propagation velocity measuring apparatus comprises apparatus for measuring either the temperature or temperature and relative humidity of air within the target chamber, and apparatus responsive thereto for calculating a value representing the propagation velocity of sound in air within the target chamber.

In one advantageous feature of the invention, compensation is made for variations of transducer locations with temperature, the transducers being mounted, for example, on a beam which has a known coefficient of expansion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a target assembly in accordance with the invention in partially cut-away perspective view;

FIG. **2** shows a front elevational view of a preferred target assembly construction, with a lower front cover panel removed;

FIG. **3** shows an exploded perspective view of one possible form of "position measuring" sensor construction;

FIG. **4** shows an assembled elevational cross-sectional view of the transducer construction of FIG. **3**;

FIG. **5** shows in schematic perspective view an acoustic decoupling mounting arrangement for the transducer of FIGS. **3–4**;

FIG. **6** shows in elevational cross-sectional view a "speed of sound" sensor assembly;

FIG. **7** shows in cross-sectional elevational view a preferred spark gap assembly construction;

FIG. **8** shows a preferred high voltage pulse generator circuit;